

**Delmar's Test Preparation Series**

# Automobile Test

## Automotive Heating and Air Conditioning (Test A7)

2nd Edition

**DELMAR**



**THOMSON LEARNING**

Australia Canada Mexico Singapore Spain United Kingdom United States



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Automobile Test**

**Automotive Heating and Air Conditioning (Test A7)  
2nd Edition**

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# Preface

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This book is just one of a comprehensive series designed to prepare technicians to take and pass every ASE test. Delmar's series covers all of the Automotive tests A1 through A8 as well as Advanced Engine Performance L1 and Parts Specialist P2. The series also covers the five Collision Repair tests and the eight Medium/Heavy Duty truck tests.

Before any book in this series was written, Delmar staff met with and surveyed technicians and shop owners who have taken ASE tests and have used other preparatory materials. We found that they wanted, first and foremost, *lots* of practice tests and questions. Each book in our series contains a sample test and additional practice questions. You will be hard-pressed to find a test prep book with more questions for you to practice with. We have worked hard to ensure that these questions match the ASE style in types of questions, quantities, and level of difficulty.

Technicians also told us that they wanted to understand the ASE test and to have practical information about what they should expect. We have provided that as well, including a history of ASE and a section devoted to helping the technician "Take and Pass Every ASE Test" with case studies, test-taking strategies, and test formats.

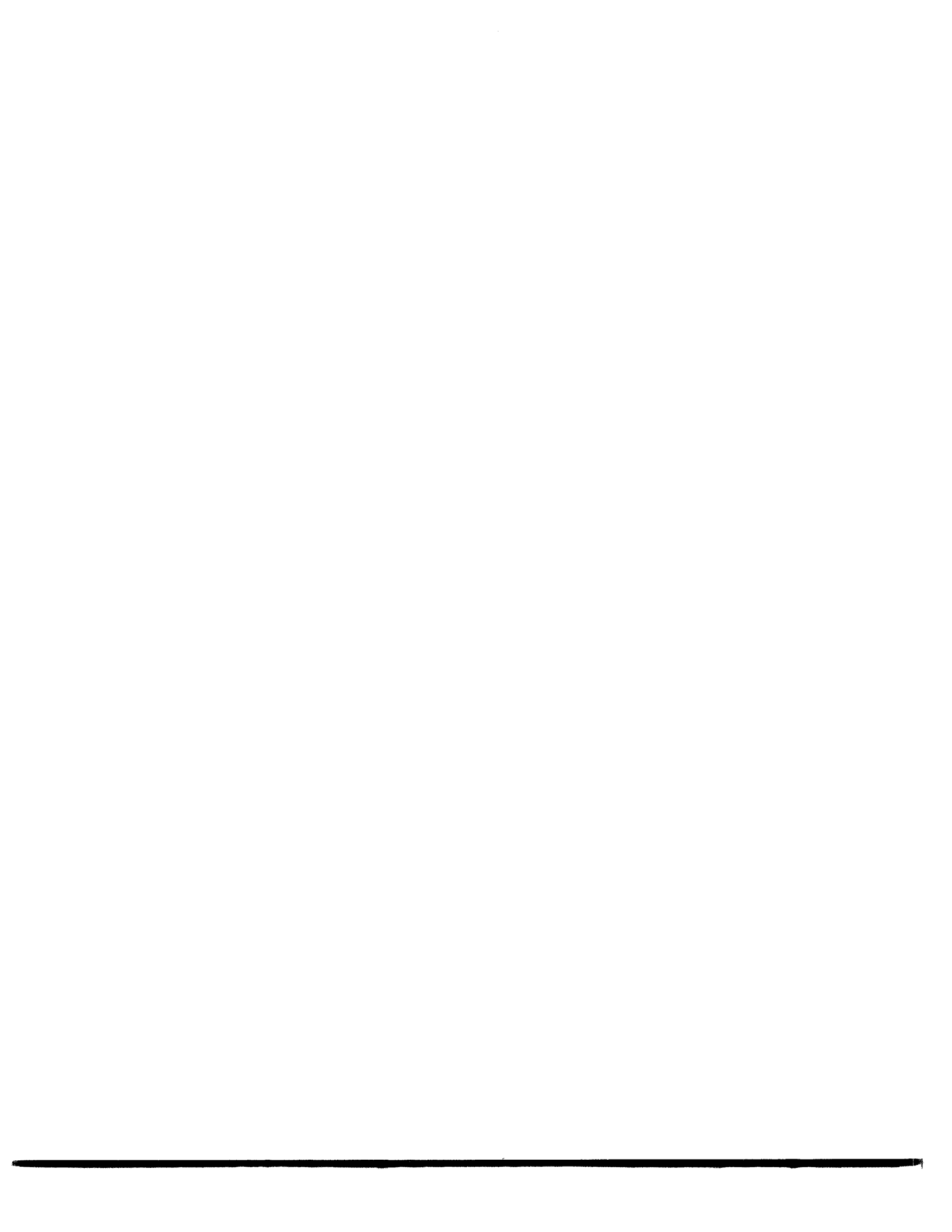
Finally, techs wanted refresher information and references. Each of our books includes an overview section that is referenced to the task list. The complete task lists for each test appear in each book for the user's reference. There is also a complete glossary of terms for each booklet.

So whether you're looking for a sample test and a few extra questions to practice with or a complete introduction to ASE testing, with support for preparing thoroughly, this book series is an excellent answer.

We hope you benefit from this book and that you pass every ASE test you take!

Your comments, both positive and negative, are certainly encouraged! Please contact us at:

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# 1

## The History of ASE

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### History

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Originally known as The National Institute for Automotive Service Excellence (NIASE), today's ASE was founded in 1972 as a non-profit, independent entity dedicated to improving the quality of automotive service and repair through the voluntary testing and certification of automotive technicians. Until that time, consumers had no way of distinguishing between competent and incompetent automotive mechanics. In the mid-1960s and early 1970s, efforts were made by several automotive industry affiliated associations to respond to this need. Though the associations were non-profit, many regarded certification test fees merely as a means of raising additional operating capital. Also, some associations, having a vested interest, produced test scores heavily weighted in the favor of its members.

From these efforts a new independent, non-profit association, the National Institute for Automotive Service Excellence (NIASE), was established. In early NIASE tests, Mechanic A, Mechanic B type questions were used. Over the years the trend has not changed, but in mid-1984 the term was changed to Technician A, Technician B to better emphasize sophistication of the skills needed to perform successfully in the modern motor vehicle industry. In certain tests the term used is Estimator A/B, Painter A/B, or Parts Specialist A/B. At about that same time, the logo was changed from "The Gear" to "The Blue Seal," and the organization adopted the acronym ASE for Automotive Service Excellence.

### ASE

ASE's mission is to improve the quality of vehicle repair and service in the United States through the testing and certification of automotive repair technicians. Prospective candidates register for and take one or more of ASE's many exams.

Upon passing at least one exam and providing proof of two years of related work experience, the technician becomes ASE certified. A technician who passes a series of exams earns ASE Master Technician status. An automobile technician, for example, must pass eight exams for this recognition.

The exams, conducted twice a year at over seven hundred locations around the country, are administered by American College Testing (ACT). They stress real-world diagnostic and repair problems. Though a good knowledge of theory is helpful to the technician in answering many of the questions, there are no questions specifically on theory. Certification is valid for five years. To retain certification, the technician must be retested to renew his or her certificate.

The automotive consumer benefits because ASE certification is a valuable yardstick by which to measure the knowledge and skills of individual technicians, as well as their commitment to their chosen profession. It is also a tribute to the repair facility employing ASE certified technicians. ASE certified technicians are permitted to wear blue and white ASE shoulder insignia, referred to as the "Blue Seal of Excellence," and carry credentials

listing their areas of expertise. Often employers display their technicians' credentials in the customer waiting area. Customers look for facilities that display ASE's Blue Seal of Excellence logo on outdoor signs, in the customer waiting area, in the telephone book (Yellow Pages), and in newspaper advertisements.

To become ASE certified, contact:

National Institute for Automotive Service Excellence  
13505 Dulles Technology Drive  
Herndon, VA 20171-3421





# 2

## Take and Pass Every ASE Test

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### ASE Testing

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Participating in an Automotive Service Excellence (ASE) voluntary certification program gives you a chance to show your customers that you have the “know-how” needed to work on today’s modern vehicles. The ASE certification tests allow you to compare your skills and knowledge to the automotive service industry’s standards for each specialty area.

If you are the “average” automotive technician taking this test, you are in your mid-thirties and have not attended school for about fifteen years. That means you probably have not taken a test in many years. Some of you, on the other hand, have attended college or taken postsecondary education courses and may be more familiar with taking tests and with test-taking strategies. There is, however, a difference in the ASE test you are preparing to take and the educational tests you may be accustomed to.

### Who Writes the Questions?

The questions on all ASE tests are written by service industry experts familiar with all aspects of the subject area. ASE questions are entirely job-related and designed to test the skills that you need to know on the job.

The questions originate in an ASE “item-writing” workshop where service representatives from domestic and import automobile manufacturers, parts and equipment manufacturers, and vocational educators meet in a workshop setting to share their ideas and translate them into test questions. Each test question written by these experts is reviewed by all of the members of the group.

All of the questions are pretested and quality-checked in a nonscoring section of tests by a national sample of certifying technicians. The questions that meet ASE’s high standards of accuracy and quality are then included in the scoring sections of future tests. Those questions that do not pass ASE’s stringent test are sent back to the workshop or are discarded. ASE’s tests are monitored by an independent proctor and are administered and machine-scored by an independent provider, American College Testing (ACT).

### Objective Tests

A test is called an objective test if the same standards and conditions apply to everyone taking the test and there is only one correct answer to each question. Objective tests primarily measure your ability to recall information. A well-designed objective test can also test your ability to understand, analyze, interpret, and apply your knowledge. Objective tests include true-false, multiple choice, fill in the blank, and matching questions. ASE’s tests consist exclusively of four-part multiple-choice objective questions.

Before beginning to take an objective test, quickly look over the test to determine the number of questions, but do not try to read through all of the questions. In an ASE test, there are usually between forty and eighty questions, depending on the subject. Read through each question before marking your answer. Answer the questions in the order they appear on the test. Leave the questions blank that you are not sure of and move on to the next question. You can return to those unanswered questions after you have finished the others. They may be easier to answer at a later time after your mind has had additional time to consider them on a subconscious level. In addition, you might find information in other questions that will help you to answer some of them.

Do not be obsessed by the apparent pattern of responses. For example, do not be influenced by a pattern like **d, c, b, a, d, c, b, a** on an ASE test.

There is also a lot of folk wisdom about taking objective tests. For example, there are those who would advise you to avoid response options that use certain words such as *all, none, always, never, must, and only*, to name a few. This, they claim, is because nothing in life is exclusive. They would advise you to choose response options that use words that allow for some exception, such as *sometimes, frequently, rarely, often, usually, seldom, and normally*. They would also advise you to avoid the first and last option (A and D) because test writers, they feel, are more comfortable if they put the correct answer in the middle (B and C) of the choices. Another recommendation often offered is to select the option that is either shorter or longer than the other three choices because it is more likely to be correct. Some would advise you to never change an answer since your first intuition is usually correct.

Although there may be a grain of truth in this folk wisdom, ASE test writers try to avoid them and so should you. There are just as many **A** answers as there are **B** answers, just as many **D** answers as **C** answers. As a matter of fact, ASE tries to balance the answers at about 25 percent per choice **A, B, C, and D**. There is no intention to use “tricky” words, such as outlined above. Put no credence in the opposing words “sometimes” and “never,” for example.

Multiple-choice tests are sometimes challenging because there are often several choices that may seem possible, and it may be difficult to decide on the correct choice. The best strategy, in this case, is to first determine the correct answer before looking at the options. If you see the answer you decided on, you should still examine the options to make sure that none seem more correct than yours. If you do not know or are not sure of the answer, read each option very carefully and try to eliminate those options that you know to be wrong. That way, you can often arrive at the correct choice through a process of elimination.

If you have gone through all of the test and you still do not know the answer to some of the questions, then guess. Yes, guess. You then have at least a 25 percent chance of being correct. If you leave the question blank, you have no chance. In ASE tests, there is no penalty for being wrong.

## Preparing for the Exam

The main reason we have included so many sample and practice questions in this guide is, simply, to help you learn what you know and what you don't know. We recommend that you work your way through each question in this book. Before doing this, carefully look through Section 3; it contains a description and explanation of the questions you'll find in an ASE exam.

Once you know what the questions will look like, move to the sample test. After you have answered one of the sample questions (Section 5), read the explanation (Section 7) to the answer for that question. If you don't feel you understand the reasoning for the correct answer, go back and read the overview (Section 4) for the task that is related to

that question. If you still don't feel you have a solid understanding of the material, identify a good source of information on the topic, such as a textbook, and do some more studying.

After you have completed the sample test, move to the additional questions (Section 6). This time answer the questions as if you were taking an actual test. Once you have answered all of the questions, grade your results using the answer key in Section 7. For every question that you gave a wrong answer to, study the explanations to the answers and/or the overview of the related task areas.

Here are some basic guidelines to follow while preparing for the exam:

- Focus your studies on those areas you are weak in.
- Be honest with yourself while determining if you understand something.
- Study often but in short periods of time.
- Remove yourself from all distractions while studying.
- Keep in mind the goal of studying is not just to pass the exam, the real goal is to learn!

## During the Test

Mark your bubble sheet clearly and accurately. One of the biggest problems an adult faces in test-taking, it seems, is in placing an answer in the correct spot on a bubble sheet. Make certain that you mark your answer for, say, question 21, in the space on the bubble sheet designated for the answer for question 21. A correct response in the wrong bubble will probably be wrong. Remember, the answer sheet is machine scored and can only "read" what you have bubbled in. Also, do not bubble in two answers for the same question.

If you finish answering all of the questions on a test ahead of time, go back and review the answers of those questions that you were not sure of. You can often catch careless errors by using the remaining time to review your answers.

At practically every test, some technicians will invariably finish ahead of time and turn their papers in long before the final call. Do not let them distract or intimidate you. Either they knew too little and could not finish the test, or they were very self-confident and thought they knew it all. Perhaps they were trying to impress the proctor or other technicians about how much they know. Often you may hear them later talking about the information they knew all the while but forgot to respond on their answer sheet.

It is not wise to use less than the total amount of time that you are allotted for a test. If there are any doubts, take the time for review. Any product can usually be made better with some additional effort. A test is no exception. It is not necessary to turn in your test paper until you are told to do so.

## Your Test Results!

You can gain a better perspective about tests if you know and understand how they are scored. ASE's tests are scored by American College Testing (ACT), a non-partial, non-biased organization having no vested interest in ASE or in the automotive industry. Each question carries the same weight as any other question. For example, if there are fifty questions, each is worth 2 percent of the total score. The passing grade is 70 percent. That means you must correctly answer thirty-five of the fifty questions to pass the test.

The test results can tell you:

- where your knowledge equals or exceeds that needed for competent performance, or
- where you might need more preparation.

The test results *cannot* tell you:

- how you compare with other technicians, or
- how many questions you answered correctly.

Your ASE test score report will show the number of correct answers you got in each of the content areas. These numbers provide information about your performance in each area of the test. However, because there may be a different number of questions in each area of the test, a high percentage of correct answers in an area with few questions may not offset a low percentage in an area with many questions.

It may be noted that one does not “fail” an ASE test. The technician who does not pass is simply told “More Preparation Needed.” Though large differences in percentages may indicate problem areas, it is important to consider how many questions were asked in each area. Since each test evaluates all phases of the work involved in a service specialty, you should be prepared in each area. A low score in one area could keep you from passing an entire test.

There is no such thing as average. You cannot determine your overall test score by adding the percentages given for each task area and dividing by the number of areas. It doesn’t work that way because there generally are not the same number of questions in each task area. A task area with twenty questions, for example, counts more toward your total score than a task area with ten questions.

Your test report should give you a good picture of your results and a better understanding of your task areas of strength and weakness.

If you fail to pass the test, you may take it again at any time it is scheduled to be administered. You are the only one who will receive your test score. Test scores will not be given over the telephone by ASE nor will they be released to anyone without your written permission.

# 3

## Types of Questions on an ASE Exam

ASE certification tests are often thought of as being tricky. They may seem to be tricky if you do not completely understand what is being asked. The following examples will help you recognize certain types of ASE questions and avoid common errors.

Each test is made up of forty to eighty multiple-choice questions. Multiple-choice questions are an efficient way to test knowledge. To answer them correctly, you must think about each choice as a possibility, and then choose the one that best answers the question. To do this, read each word of the question carefully. Do not assume you know what the question is about until you have finished reading it.

About 10 percent of the questions on an actual ASE exam will use an illustration. These drawings contain the information needed to correctly answer the question. The illustration must be studied carefully before attempting to answer the question. Often, techs look at the possible answers then try to match up the answers with the drawing. Always do the opposite; match the drawing to the answers. When the illustration is showing an electrical schematic or another system in detail, look over the system and try to figure out how the system works before you look at the question and the possible answers.

### Multiple-Choice Questions

One type of multiple-choice question has three wrong answers and one correct answer. The wrong answers, however, may be almost correct, so be careful not to jump at the first answer that seems to be correct. If all the answers seem to be correct, choose the answer that is the most correct. If you readily know the answer, this kind of question does not present a problem. If you are unsure of the answer, analyze the question and the answers. For example:

A rocker panel is a structural member of which vehicle construction type?

- A. Front-wheel drive
- B. Pickup truck
- C. Unibody
- D. Full-frame

Analysis:

This question asks for a specific answer. By carefully reading the question, you will find that it asks for a construction type that uses the rocker panel as a structural part of the vehicle.

Answer A is wrong. Front-wheel drive is not a vehicle construction type.

Answer B is wrong. A pickup truck is not a type of vehicle construction.

**Answer C is correct.** Unibody design creates structural integrity by welding parts together, such as the rocker panels, but does not require exterior cosmetic panels installed for full strength.

Answer D is wrong. Full-frame describes a body-over-frame construction type that relies on the frame assembly for structural integrity.

Therefore, the correct answer is C. If the question was read quickly and the words "construction type" were passed over, answer A may have been selected.

## EXCEPT Questions

Another type of question used on ASE tests has answers that are all correct except one. The correct answer for this type of question is the answer that is wrong. The word "EXCEPT" will always be in capital letters. You must identify which of the choices is the wrong answer. If you read quickly through the question, you may overlook what the question is asking and answer the question with the first correct statement. This will make your answer wrong. An example of this type of question and the analysis is as follows:

All of the following are tools for the analysis of structural damage EXCEPT:

- A. height gauge.
- B. tape measure.
- C. dial indicator.
- D. tram gauge.

Analysis:

The question really requires you to identify the tool that is not used for analyzing structural damage. All tools given in the choices are used for analyzing structural damage except one. This question presents two basic problems for the test-taker who reads through the question too quickly. It may be possible to read over the word "EXCEPT" in the question or not think about which type of damage analysis would use answer C. In either case, the correct answer may not be selected. To correctly answer this question, you should know what tools are used for the analysis of structural damage. If you cannot immediately recognize the incorrect tool, you should be able to identify it by analyzing the other choices.

Answer A is wrong. A height gauge *may* be used to analyze structural damage.

Answer B is wrong. A tape measure may be used to analyze structural damage.

**Answer C is correct.** A dial indicator may be used as a damage analysis tool for moving parts, such as wheels, wheel hubs, and axle shafts, but would not be used to measure structural damage.

Answer D is wrong. A tram gauge *is* used to measure structural damage.

## Technician A, Technician B Questions

The type of question that is most popularly associated with an ASE test is the "Technician A says. . . Technician B says. . . Who is right?" type. In this type of question, you must identify the correct statement or statements. To answer this type of question correctly, you must carefully read each technician's statement and judge it on its own merit to determine if the statement is true.

Typically, this type of question begins with a statement about some analysis or repair procedure. This is followed by two statements about the cause of the problem, proper inspection, identification, or repair choices. You are asked whether the first statement, the second statement, both statements, or neither statement is correct. Analyzing this type of question is a little easier than the other types because there are only two ideas to consider although there are still four choices for an answer.

Technician A, Technician B questions are really double true or false questions. The best way to analyze this kind of question is to consider each technician's statement separately. Ask yourself, is A true or false? Is B true or false? Then select your answer from the four choices. An important point to remember is that an ASE Technician A, Technician B question will never have Technician A and B directly disagreeing with each other. That is why you must evaluate each statement independently. An example of this type of question and the analysis of it follows.

Structural dimensions are being measured. Technician A says comparing measurements from one side to the other is enough to determine the damage. Technician

B says a tram gauge can be used when a tape measure cannot measure in a straight line from point to point. Who is right?

- A. A only
- B. B only
- C. Both A and B
- D. Neither A nor B

Analysis:

With some vehicles built asymmetrically, side-to-side measurements are not always equal. The manufacturer's specifications need to be verified with a dimension chart before reaching any conclusions about the structural damage.

Answer A is wrong. Technician A's statement is wrong. A tram gauge would provide a point-to-point measurement when a part, such as a strut tower or air cleaner, interrupts a direct line between the points.

**Answer B is correct.** Technician B is correct. A tram gauge can be used when a tape measure cannot be used to measure in a straight line from point to point.

Answer C is wrong. Since Technician A is not correct, C cannot be the correct answer. Answer D is wrong. Since Technician B is correct, D cannot be the correct answer.

## Most-Likely Questions

Most-likely questions are somewhat difficult because only one choice is correct while the other three choices are nearly correct. An example of a most-likely-cause question is as follows:

The most likely cause of reduced turbocharger boost pressure may be a:

- A. westgate valve stuck closed.
- B. westgate valve stuck open.
- C. leaking westgate diaphragm.
- D. disconnected westgate linkage.

Analysis:

Answer A is wrong. A westgate valve stuck closed increases turbocharger boost pressure.

**Answer B is correct.** A westgate valve stuck open decreases turbocharger boost pressure.

Answer C is wrong. A leaking westgate valve diaphragm increases turbocharger boost pressure.

Answer D is wrong. A disconnected westgate valve linkage will increase turbocharger boost pressure.

## LEAST-Likely Questions

Notice that in most-likely questions there is no capitalization. This is not so with LEAST-likely type questions. For this type of question, look for the choice that would be the least likely cause of the described situation. Read the entire question carefully before choosing your answer. An example is as follows:

What is the LEAST likely cause of a bent pushrod?

- A. Excessive engine speed
- B. A sticking valve
- C. Excessive valve guide clearance
- D. A worn rocker arm stud

Analysis:

Answer A is wrong. Excessive engine speed may cause a bent pushrod.

Answer B is wrong. A sticking valve may cause a bent pushrod.

**Answer C is correct.** Excessive valve clearance will not generally cause a bent pushrod.

Answer D is wrong. A worn rocker arm stud may cause a bent pushrod.

## Summary

There are no four-part multiple-choice ASE questions having “none of the above” or “all of the above” choices. ASE does not use other types of questions, such as fill-in-the-blank, completion, true-false, word-matching, or essay. ASE does not require you to draw diagrams or sketches. If a formula or chart is required to answer a question, it is provided for you. There are no ASE questions that require you to use a pocket calculator.

## Testing Time Length

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An ASE test session is four hours and fifteen minutes. You may attempt from one to a maximum of four tests in one session. It is recommended, however, that no more than a total of 225 questions be attempted at any test session. This will allow for just over one minute for each question.

Visitors are not permitted at any time. If you wish to leave the test room, for any reason, you must first ask permission. If you finish your test early and wish to leave, you are permitted to do so only during specified dismissal periods.

You should monitor your progress and set an arbitrary limit to how much time you will need for each question. This should be based on the number of questions you are attempting. It is suggested that you wear a watch because some facilities may not have a clock visible to all areas of the room.



# 4

## An Overview of the System

### Heating and Air Conditioning (Test A7)

---

The following section includes the task areas and task lists for this test and a written overview of the topics covered in the test.

The task list describes the actual work you should be able to do as a technician that you will be tested on by the ASE. This is your key to the test and you should review this section carefully. We have based our sample test and additional questions upon these tasks, and the overview section will also support your understanding of the task list. ASE advises that the questions on the test may not equal the number of tasks listed; the task lists tell you what ASE expects you to know how to do and be ready to be tested upon.

At the end of each question in the Sample Test and Additional Test Questions sections, a letter and number will be used as a reference back to this section for additional study. Note the following example: **B.2.11**.

#### Task List

##### **B. Refrigeration System Component Diagnosis and Repair (10 Questions)**

##### **2. Evaporator, Condenser, and Related Components (5 Questions)**

**Task**            Inspect and replace A/C system high-pressure relief device.  
**B.2.11**

Example:

29. An A/C compressor high-pressure release valve discharges refrigerant at approximately:

- A. 200 psi (1,379 kPa).
- B. 325 psi (2,240 kPa).
- C. 375 psi (2,585 kPa).
- D. 475 psi (3,275 kPa).

(B.2.11)

Analysis:

Question #29

Answer A is wrong. The valve is set to discharge at 475 psi (3,275 kPa).

Answer B is wrong. The valve is set to discharge at 475 psi (3,275 kPa).

Answer C is wrong. The valve is set to discharge at 475 psi (3,275 kPa).

**Answer D is correct.**

## Task List and Overview

### A. A/C System Diagnosis and Repair (12 Questions)

#### Task A.1

**Diagnose the cause of unusual operating noises of the A/C system; determine needed repairs.**

A defective clutch bearing may be the cause of a growling noise coming from the compressor when it is running. If the noise stops when the compressor is not running, the clutch bearing is not at fault. Most compressor clutch problems are generally obvious by a noisy operation; this noise tends to be more obvious when the clutch is disengaged. These problems are generally caused by a defective clutch, defective bearing, or insufficient current flow to the clutch coil. A bent pulley can also cause a growling or rubbing noise. Once the problem has been found, it must be corrected and the clutch checked for proper operation.

Refrigerant system blockage and extremely high refrigerant system pressures might cause a thumping noise in the compressor.

#### Task A.2

**Identify system type and conduct performance test on the A/C system; determine needed repairs.**

Performance testing provides a measure of air conditioning system operating efficiency. A manifold pressure gauge set is used to determine both high and low pressures in the refrigeration system. The desired pressure readings will vary according to temperature. Use temperature/pressure charts as a guide to determine the proper pressures. At the same time, a thermometer is used to determine air discharge temperature into the passenger compartment. Before making this test, it should be established that the air distribution (air door) portion of the system is functioning properly. This ensures that all air passing through the evaporator is being routed directly to the air outlet nozzles.

The typical procedure for a performance test follows:

1. Connect the manifold gauge set to the respective high- and low-pressure fittings. These fittings are found in various locations within the high- and low-pressure sides of the system.
2. Close the hood and all of the doors and windows of the vehicle.
3. Adjust the air conditioning controls to maximum cooling and high blower position.
4. Idle the engine in neutral or park with the brake on. For the best results, place a high volume fan in front of the radiator grille to insure an adequate supply of airflow across the condenser.
5. Increase engine speed to 1500 to 2000 rpm.
6. Measure the temperature at the evaporator air outlet grille or air duct nozzle (35 to 40°F).
7. Read the high and low pressures, and compare them to the normal range of the operating pressure given in the service manual.

Operating pressures vary with humidity as well as with outside air temperature. Accordingly, on more humid days, operating pressures will be on the high side of the range indicated in the service manual's performance chart. On less humid days, the operating pressures will read toward the lower side. If operating pressures are found to be within the normal range, the refrigeration portion of the air conditioning system is functioning properly. This can be further confirmed with a check of evaporator outlet air temperatures.

Always refer to the pressure charts given in the service manual when basing your diagnosis of the system on system pressures. Although the specifications will vary, here are some guidelines to help you interpret abnormal readings.

- If the high-side pressure is too high, suspect air in the system, too much refrigerant in the system, a restriction in the high side of the system, and poor airflow across the condenser.
- If the high-side pressure is too low, suspect a low refrigerant level or defective compressor.
- If the low-side pressure is higher than normal, suspect refrigerant overcharge, a defective compressor, or a faulty metering device.
- If the low-side pressure is lower than normal, suspect a faulty metering device, poor airflow across the evaporator, a restriction in the low side of the system, or the system is undercharged with refrigerant.

Evaporator outlet air temperature also varies according to outside (ambient) air and humidity conditions. Further variations can be found, depending on whether the system is controlled by a cycling clutch compressor or an evaporator pressure control valve. Because of these variations, it is difficult to pinpoint what evaporator outlet air temperature should be on all applications. In general, with low-side air temperatures (70°F) and humidity (20 percent), the evaporator outlet air temperature should be in the 35- to 40-degree range. On the other extreme of 80°F outside air temperatures and 90 percent humidity condition, the evaporator air outlet temperature might be in the 55- to 60-degree range.

Since it is impractical to provide a specific performance chart for all the different types of air conditioning systems, it is desirable to develop an experience factor for determining the correlation that can be anticipated between operating pressures and outlet air temperatures on the various systems. For example, feel the discharge line from the compressor to the condenser. The discharge line should be the same temperature along its full length. Any temperature change is a sign of restriction, and the line should be flushed or replaced. Perform this test carefully because the discharge line will be hot.

There are other tests that can be performed with the engine running.

- Check the condenser by feeling up and down the face or along the return bends for a temperature change. There should be a gradual change from hot to warm as you go from the top to the bottom. Any abrupt change indicates a restriction, and the condenser has to be flushed or replaced.
- If the system has a receiver/dryer, check it. The inlet and outlet lines should be the same temperature. Any temperature difference or frost on the lines or receiver tank are signs of a restriction. The receiver/dryer must be replaced.
- If the system has a sight glass, check it as previously described.
- Feel the liquid line from the receiver/dryer to the expansion valve. The line should be warm for its entire length.
- The expansion valve should be free of frost, and there should be a sharp temperature difference between its inlet and outlet.
- The suction line to the compressor should be cool to the touch from the evaporator to the compressor. If it is covered with thick frost, this might indicate that the expansion valve is flooding the evaporator.
- Typically the formation of frost on the outside of a line or component means there is a restriction to the flow of refrigerant.
- On vehicles equipped with the orifice tube system, feel the liquid line from the condenser outlet to the evaporator inlet. A restriction is indicated by any temperature change in the liquid line before the crimp dimples the orifice tube in the evaporator inlet. Flush the liquid line or replace the orifice tube if restricted.
- The accumulator as well as the suction line must be cool to the touch from the evaporator outlet to the compressor.

By combining the results of both the hands-on checks and an interpretation of pressure gauge readings, the technician has a good indication that some unit in the system is malfunctioning and that further diagnosis is needed.

**Task  
A.3****Diagnose A/C system problems indicated by refrigerant flow past the sight glass (for systems using a sight glass); determine needed repairs.**

The sight glass allows the technician to see the flow of refrigerant in the lines. A sight glass is normally found on systems using R-12 and a thermal expansion valve. It is not commonly found on R-134a systems. It can be located on the receiver/dryer or in-line between the receiver/dryer and the expansion valve or tube.

To check the refrigerant, open the windows and doors, set the controls for maximum cooling, and set the blower on its highest speed. Let the system run for about five minutes. Be sure the vehicle is in a well-ventilated area, or connect an exhaust gas ventilation system.

Use care to check the sight glass while the engine is running. If oil streaking is seen, this indicates the system is empty. Bubbles, or foam, indicate the refrigerant is low. A sufficient level of refrigerant is indicated by what looks like a flow of clear water, with no bubbles. A clouded sight glass is an indication of desiccant contamination with subsequent infiltration and circulation through the system.

Accumulator systems do not have a receiver-drier to separate the gas from the liquid as it flows from the condenser. The liquid line will always have a certain amount of bubbles in it. Therefore it would be useless to have a sight glass in these systems. Pressure and performance testing are the only ways to identify low refrigerant levels.

**Task  
A.4****Diagnose A/C system problems indicated by pressure gauge readings; determine needed repairs.**

A restriction in the low side will cause lower-than-normal low-side pressure, even into a vacuum. Such a restriction in the low side of the system would generally be accompanied by a lower-than-normal high-side pressure. This is also true if there is an undercharge of refrigerant. A restriction in the high side of the system will result in a higher-than-normal high-side pressure. This may generally be accompanied by a lower-than-normal low-side pressure. If the system is overcharged, however, the higher-than-normal high-side pressure will be accompanied with a higher-than-normal low-side pressure.

Air and moisture in the refrigerant system or a restricted thermal expansion valve (TXV) cause higher than specified system pressures. A defective compressor may cause low high-side pressure and high low-side pressure. A low refrigerant charge causes reduced low-side and high-side pressures.

A restricted TXV may cause low refrigerant pressures, this condition may also result in TXV frosting. Air in the refrigerant system may cause high system pressures.

The manifold gauge set is one of the most valuable air conditioning tools. It is used when discharging, charging, evacuating, and for diagnosing the system. With the new legislation on handling refrigerants, all gauge sets are required to have a valve device to close off the end of the hose so that the fitting not in use is automatically shut.

The low-pressure gauge is graduated into pounds of pressure from 1 to 120 (with cushion to 250) in 1-pound graduations, and, in the opposite direction, in inches of vacuum from 0 to 30. This is the gauge that should always be used in checking pressure on the low-pressure side of the system. The gauge at the right is graduated from 0 to 500 pounds pressure in 10-pound graduations. This is the high-pressure gauge that is used for checking pressure on the high-pressure side of the system.

The center manifold fitting is common to both the low and the high side and is for evacuating or adding refrigerant to the system. When this fitting is not being used, it should be capped. A test hose connected to the fitting directly under the low-side gauge is used to connect the low side of the test manifold to the low side of the system. A similar connection is found on the high side.

The gauge manifold is designed to control refrigerant flow. When the manifold test set is connected into the system, pressure is registered on both gauges at all times. During all tests, both the low- and high-side hand valves are in the closed position (turned inward until the valve is seated).

Refrigerant flows around the valve stem to the respective gauges and registers the system's low-side pressure on the low-side gauge and the system's high-side pressure on the high-side gauge. The hand valves isolate the low and high side from the central portion of the manifold. When the gauges are first connected to the gauge fittings with the refrigeration system charged, the gauge lines should always be purged. Purging is done by cracking each valve on the gauge set to allow the pressure of the refrigerant in the refrigeration system to force the air to escape through the center gauge line. Failure to purge lines can result in air or other contaminants entering the refrigeration system.

NEVER open the high-side hand valve with the system operating and a refrigerant can connected to the center hose. The refrigerant will flow out of the system under high pressure into the can. High-side pressure is between 150 and 300 psi and will cause the refrigerant tank to burst. The only occasion for opening both hand valves at the same time would be when evacuating the system or when reclaiming refrigerant with the system off.

Because R-134a is not interchangeable with R-12, separate sets of hoses, gauges, and other equipment are required to service vehicles. All equipment used to service R-134a and R-12 systems must meet SAE standard J1991. The service hoses on the manifold gauge set must have manual or automatic back-flow valves at the service port connector ends. This prevents the refrigerant from being released into the atmosphere during connection and disconnection. Manifold gauge sets for R-134a can be identified by one or all of the following: Labeled *FOR USE WITH R-134a*, Labeled *HFC-134* or *R-134a*, and/or have a light blue color on the face of the gauges.

For identification purposes, R-134a service hoses must have a black stripe along their length and be clearly labeled *SAE J2196/R-134a*. The low-pressure hose is blue with a black stripe. The high-pressure hose is red with black stripe and the center service hose is yellow with a black stripe. Service hoses for one type of refrigerant will not easily connect into the wrong system, as the fittings for an R-134a system are different than those used in an R-12 system.

## Task A.5

### **Diagnose A/C system problems indicated by sight, sound, smell, and touch procedures; determine needed repairs.**

The thermostatic expansion valve is the coldest part in the system, but heavy ice buildup is not normal. A clear sight glass indicates the system is either fully charged or empty. A restriction in the receiver/dryer would produce ice at that spot. The outlet of the metering device is the coldest part in the system. It is normal for frost or a light accumulation of ice to occur at the outlet of the metering device. If there is a restriction in the system, there would be heavy frost or ice buildup at the point of the restriction. If, for example, the receiver/dryer were clogged, there would be ice buildup at the outlet of the receiver/dryer.

A restricted receiver/dryer usually causes frosting of this component. A flooded evaporator causes frosting of the evaporator outlet and compressor suction pipes. A restricted TXV usually causes frosting of this component. A low refrigerant charge may cause faster than normal clutch cycling without frosting of any components.

## Task A.6

### **Leak test A/C system; determine needed repairs.**

Testing the refrigerant system for leaks is one of the most important phases of troubleshooting. Over a period of time, all air conditioners lose or leak some refrigerant. In systems that are in good condition, R-12 losses up to one-half pound per year are considered normal. Higher loss rates signal a need to locate and repair the leaks.

Leaks are most often found at the compressor hose connections and at the various fittings and joints in the system. Refrigerant can be lost through hose permeation. Leaks can also be traced to pinholes in the evaporator caused by acid, which forms when water and refrigerant mix. Since oil and refrigerant leak out together, oily spots on hoses, fittings, and components means there is a leak. Any suspected leak should be confirmed by using any one of these methods of detection. All leaks should be repaired before refrigerant is added to the system.

As mentioned before, the presence of oil around the fitting of an air conditioning line or hose is an indication of a refrigerant leak. Carefully check all system connections. This method of leak detection is the easiest to conduct but also the least effective.

Electronic leak detection is the preferred method of leak detection; it is safe, effective, and can be used with all types of refrigerants. The hand-held battery-operated electronic leak detector contains a test probe that is moved about one inch per second in areas of suspected leaks. (Remember that refrigerant gas is heavier than air, thus the probe should be positioned below the test point.) An alarm or a buzzer on the detector indicates the presence of a leak. On some models, a light flashes to establish the leak.

To find a refrigerant leak using the fluorescent tracer system, first introduce a fluorescent dye into the air conditioning system by means of a special infuser. Run the air conditioner for a few minutes, giving the tracer dye fluid time to circulate and penetrate. Wear the tracer protective goggles and scan the system with a black-light glow gun. Leaks in the system will shine under the black light as a luminous yellow-green. There are concerns about using this type of leak detection because it may create an oil viscosity problem.

Leaks can also be located by applying leak detector fluid around areas to be tested. There are dyes available for R-12 and R-134a systems; make sure you use the correct one for the refrigerant you are looking for. If a leak is present, it will form clusters of bubbles around the source. A very small leak will cause white foam to form around the leak source within several seconds to a minute. Adequate lighting over the entire surface being tested is necessary for an accurate diagnosis.

Regardless of which type of leak detector is used, the system should have a minimum of 70-psi pressure to accurately detect a leak. Be sure to check the entire system. If a leak is found at a connection, tighten the connection carefully and recheck. If the leak is still apparent, discharge the system. Replace the damaged components, evacuate, charge, and test the system for leaks.

## **Task A.7**

### **Identify and recover A/C system refrigerant.**

On older automotive air conditioning systems, the refrigerant was Refrigerant-12 (commonly referred to as R-12 and Freon). R-12 is dichlorodifluoromethane ( $\text{CCl}_2\text{F}_2$ ). An amendment to the United States' Clean Air Act and international agreements has mandated that R-12 be phased out as the refrigerant of choice. This came as a result of research that found the earth's ozone layer was being deteriorated by the chemicals found in R-12. The ozone layer is the earth's outermost shield of protection. This delicate layer protects against harmful effects of the sun's ultraviolet rays. The thinning of the ozone layer has become a worldwide concern. The ozone depletion is caused in part by release of chlorofluorocarbons (CFCs) into the atmosphere. R-12 is in the chemical family of CFCs. Since air conditioning systems with R-12 are susceptible to leaks, further damage to the ozone layer could be avoided by not using R-12 in air conditioning units. Of the many chemicals that could be used in place of R-12, the automobile manufacturers have decided to use R-134a. This refrigerant may also be referred to as SUVA. R-134a is a hydrofluorocarbon (HFC) that causes less damage to the ozone layer when released to the atmosphere.

Although R-134a air conditioners operate in the same way and with the same basic components as R-12 systems, the two refrigerants are not interchangeable. Because it is less efficient than R-12, R-134a must operate at higher pressures to make up for the loss of performance and requires new service techniques and system component designs. Basically, the higher system pressures of R-134a mean the system must be designed for those higher pressures.

Always use the same type of refrigerant and refrigerant oil that the system was designed for. If the system is being converted to accept an alternative refrigerant, make sure all old refrigerant and oil is removed from the system. Also make sure the vehicle is clearly labeled as to the type of refrigerant it was converted to use. The EPA has approved a number of refrigerants, other than R-134a. These can be used, but the sys-

tem must be modified to contain and effectively use these refrigerants. There are several disadvantages to using these alternative refrigerants. One is based on the future. If the system has been converted to use an alternative refrigerant and the vehicle needs service in the future, will the alternative refrigerant be available at that shop or at all? Another disadvantage is many air conditioning part manufacturers will not warrant their parts if something other than R-12 or R-134a is used.

Keep in mind that all EPA-accepted refrigerants that substitute for R-12, except R-134a, are blends that contain ozone-depleting HCFCs. Therefore the venting of any of these refrigerants into the atmosphere is prohibited.

When you are not sure of the refrigerant used in a system or if you suspect a mixing of refrigerants has occurred, you should run a purity test and/or use a refrigerant identifier. Equipment is available to do both of these. Knowing what refrigerant is in the system, or what condition it is in, will help you determine what steps you need to take to properly service the system.

To minimize the amount of refrigerant released to the atmosphere when A/C systems are serviced, always recover the refrigerant from the system being worked on if you need to open up the system for any service procedure. There are currently two types of refrigerant recovery machines, the single pass and the multipass. Both have the ability to draw the refrigerant from the vehicle, filter and separate the oil from it, remove moisture and air from it, and store the refrigerant until it's reused. In a single pass system, the refrigerant goes through each stage before being stored. In multipass systems, the refrigerant may go through all stages or some of the stages before being stored. Either system is acceptable if it has the UL approved label.

Use an approved recycling machine with shutoff valves within 12 inches of the hoses' service ends to recover/recycle the refrigerant. With the valves closed, connect the hoses to the vehicle's air conditioning service fittings. Always follow the equipment manufacturer's recommended procedures for use. Recover the refrigerant from the vehicle and continue the process until the vehicle's system shows vacuum instead of pressure. Turn off the recovery/recycling unit for at least five minutes. If the system still has pressure, repeat the recovery process to remove any remaining refrigerant. Continue until the A/C system holds a stable vacuum for two minutes. Close the valves in the recovery/recycling unit's service lines and disconnect them from the system's service fittings. You may now make repairs and/or replace parts in the system.

All recycled refrigerant must be safely stored in DOT CFR Title 49 or UL-approved containers. Containers specifically made for R-134a should be so marked. Before any container of recycled refrigerant can be used, it must be checked for noncondensable gases.

It must never be assumed that a system is charged with R-12 simply because it has 3/8-inch service valves. It should never be assumed that the lack of a label or labels is an indication that the system is charged with R-12 refrigerant. Other refrigerants have been used in automotive air conditioning systems without regard to product identification. This may even include some refrigerants that are considered flammable or otherwise hazardous and not approved for automotive service. It, therefore, should never be assumed that a system is charged with any particular type of refrigerant simply because of its service valves or the lack of labels.

R-12 is sold in white containers, and R-134a is marketed in light blue containers.

### **Evacuate A/C system.**

All of the refrigerant in the system must be recovered prior to evacuation. Evacuation is the name given to the process that pulls all traces of air, moisture, and refrigerant from the system. This is done by creating a vacuum in the system. A vacuum pump is connected to the system to do this. The vacuum pump should remain on and connected to the system for at least 30 minutes after 26 to 29 inches of mercury is reached.

Any air or moisture that is left inside an air conditioning system reduces the system's efficiency and eventually leads to major problems, such as compressor failure.

## **Task A.8**

Air causes excessive pressure within the system, restricting the refrigerant's ability to change its state from gas to liquid within the refrigeration cycle, which drastically reduces its heat absorbing and transferring ability. Moisture, on the other hand, can cause freeze-up at the cap tube or expansion valve, which restricts refrigerant flow or blocks it completely. Both of these problems result in intermittent cooling or no cooling at all. Moisture also forms hydrochloric acid when mixed with refrigerant, causing internal corrosion, which is especially dangerous to the compressor.

The vacuum pump reduces system pressure in order to vaporize the moisture and then exhausts the vapor along with all remaining air. The pump's ability to clean the system is directly related to its ability to reduce pressure—create a vacuum—low enough to boil off all the contaminating moisture.

An electronic thermistor vacuum gauge is designed to work with the vacuum pump to measure the last, most critical inch of mercury during evacuation. It constantly monitors and visually indicates the vacuum level so you know when the system has a full vacuum and will be moisture free. After the system is evacuated, it can be recharged. If the system will not pull down to a good vacuum, there is probably a leak somewhere in the system.

## **Task A.9**

### **Clean A/C system components and hoses.**

Compressor failure causes foreign material to pass into the system. The condenser must be flushed and the receiver/dryer replaced. Filter screens are sometimes located in the suction side of the compressor and in the receiver/dryer. These screens confine foreign material to the compressor, condenser, receiver/dryer, and connecting hoses. Use only recommended flushing solvents. Never use CFCs or methylchloroform for flushing. Some recommend instead of flushing the system, replacing the clogged components and installing a liquid line (in-line) filter just ahead of the expansion valve or orifice tube. If flushing is recommended by the manufacturer, use only the recommended flushing agent and follow the specified procedures. After the system has been flushed, be sure to oil all components that require it.

A stiff bristle brush may be used to clean a condenser. Condenser problems are often the result of clogging caused by dirt, bugs, or other foreign debris that collects in the fins, restricting the airflow. To clean the condenser, use a stiff bristle brush, such as a hair brush, and a strong stream of water. Do not, however, use steam, which may cause the system pressure to rise above a safe limit, causing a loss of refrigerant.

Some manufacturers recommend installing an in-line filter as an alternative to refrigerant system flushing. If this filter contains an orifice tube, the original orifice tube in the system must be removed.

## **Task A.10**

### **Charge A/C system with refrigerant (liquid or vapor).**

The importance of the correct charge cannot be stressed enough. The efficient operation of the air conditioning system greatly depends on the correct amount of refrigerant in the system. A low charge results in inadequate cooling under high heat loads, due to a lack of reserve refrigerant, and can cause the clutch cycling switch to cycle faster than normal. An overcharge can cause inadequate cooling because of a high liquid refrigerant level in the condenser. Refrigerant controls will not operate properly and compressor damage can result. In general, an overcharge of refrigerant will cause higher-than-normal gauge readings and noisy compressor operation.

The charging cylinder is designed to meter out a desired amount of a specific refrigerant by weight. Compensation for temperature variations is accomplished by reading the pressure on the gauge of the cylinder and dialing the plastic shroud. The calibrated chart on the shroud contains corresponding pressure readings for the refrigerant being used.

When charging an air conditioning system with refrigerant, the pressure in the system often reaches a point at which it is equal to the pressure in the cylinder from which the system is being charged. To get more refrigerant into the system to complete the charge, heat must be applied to the cylinder.



The A/C system may only be charged through the high side with the system off. Inverting the refrigerant container disperses liquid refrigerant. As a general practice, the system is vapor charged through the low side while it is running. If the system is charged through the high side (with the system off), the compressor should be turned a few times by hand afterward to ensure there is no liquid refrigerant on top of the piston. If liquid refrigerant enters the compressor, this component may be damaged. The vehicle should always be charged from the low-pressure side if the engine is on. If the engine is off, it can be charged from the high-pressure side.

## **Task A.11**

### **Identify lubricant type; inspect level in A/C system.**

Normally the only source of lubrication for a compressor is the oil mixed with the refrigerant. Because of the loads and speeds the compressor operates at, proper lubrication is a must for long compressor life. The refrigerant oil required by the system depends on a number of things, but it is primarily dictated by the refrigerant used in the system. R-12 systems use a mineral oil. Mineral oil mixes well with R-12 without breaking down. Mineral oil, however, cannot be used with R-134a. R-134a systems require a synthetic oil, polyalkylene glycol (PAG). There are a number of different blends of PAG oil; always use the one recommended by the vehicle manufacturer or compressor manufacturer. Failure to use the correct oil will cause damage to the compressor.

Most often when a system has been converted from R-12 to R-134a, ester oil will be recommended. Since there may be some mineral oil and R-12 still in the system, it is important to use oil that will mix well with the residue and not break down. Ester oil mixes well with mineral oil because it is hydrocarbon-based.

Generally, compressor oil level is checked only where there is evidence of a major loss of system oil that could be caused by a broken refrigerant hose, severe hose fitting leak, badly leaking compressor seal, or collision damage to the system's components.

When replacing refrigerant oil, it is important to use the specific type and quantity of oil recommended by the compressor manufacturer. If there is a surplus of oil in the system, too much oil circulates with the refrigerant, causing the cooling capacity of the system to be reduced. Too little oil results in poor lubrication of the compressor. When there has been excessive leakage or it is necessary to replace a component of the refrigeration system, certain procedures must be followed to assure that the total oil charge in the system is correct after leak repair or the new part is on the car.

When the compressor is operated, oil gradually leaves the compressor and is circulated through the system with the refrigerant. Eventually a balanced condition is reached in which a certain amount of oil is retained in the compressor and a certain amount is continually circulated. If a component of the system is replaced after the system has been operated, some oil goes with it. To maintain the original total oil charge, it is necessary to compensate for this by adding oil to the new replacement part. Because of the differences in compressor designs, be sure to follow the manufacturer's instructions when adding refrigerant oil to their unit.

R-12 based systems use mineral oil, while R-134a systems use synthetic polyalkylene glycol (PAG) oils. Using a mineral oil with R-134a will result in A/C compressor failure because of poor lubrication. Use only the oil specified for the system. Refrigerant oil is a wax-free, hygroscopic oil that will quickly absorb any moisture that it comes in contact with. The oil level of some compressors may be checked with the use of a dipstick. For others, the oil must be drained from the compressor and measured in a beaker. The lubricant used in automotive air conditioning systems is a nonfoaming, sulfur-free grade specially formulated for use in certain types of air conditioning systems. It must be noted that a mineral-based lubricant is used in R-12 systems while a glycol-based synthetic lubricant is used in an R-134a system.

## **B. Refrigeration System Component Diagnosis and Repair (10 Questions)**

### **1. Compressor and Clutch (5 Questions)**

#### **Task B.1.1**

**Diagnose A/C system problems that cause the protection devices (pressure, thermal, and control modules) to interrupt system operation; determine needed repairs.**

The ambient temperature switch senses outside air temperature and is designed to prevent compressor clutch engagement when air conditioning is not required or when compressor operation might cause internal damage to seals and other parts. The switch is in series with the compressor clutch electrical circuit and closes at about 37°F. At all lower temperatures, the switch is open, preventing clutch engagement.

In cycling clutch systems, a thermostatic switch is placed in series with the compressor clutch circuit so it can turn the clutch on or off. It deenergizes the clutch and stops the compressor if the evaporator is at the freezing point. When the temperature of the evaporator approaches the freezing point, the thermostatic switch opens the circuit and disengages the compressor clutch. The compressor remains inoperative until the evaporator temperature rises to the preset temperature, at which time the switch closes and compressor operation resumes.

A pressure cycling switch is electrically connected in series with the compressor electromagnetic clutch. Like the thermostatic switch, the turning on and off of the pressure cycling switch controls the operation of the compressor.

The low-pressure cutoff or discharge pressure switch is located on the high side of the system and senses any low-pressure conditions. It is tied into the compressor clutch circuit, allowing it to immediately disengage the clutch when the pressure falls too low.

The electronic cycling clutch switch prevents evaporator freeze-up by sending a signal to the engine control computer. The computer, in turn, cycles the compressor on and off by monitoring suction line temperature. If the temperature gets too low, the ECCS will open the input circuit to the computer, which causes the A/C clutch relay to open, which disengages the compressor clutch. Often this switch is the thermostatic switch at the evaporator.

The high-pressure relief valve is used to keep system pressures from reaching a point that may cause compressor lockup or other component damage because of excessive high pressures. When system pressures exceed a predetermined point, the pressure relief valve opens, reducing the system's pressure.

#### **Task B.1.2**

**Inspect, test, and replace A/C system pressure and thermal protection devices.**

If there are 12 volts at the compressor clutch, there is battery voltage supplied to the compressor clutch and connecting wire. If the clutch is inoperative, the compressor clutch coil, the wire from the coil, or the wire from the coil to the fuse is open. An open thermal switch may also be the cause.

In some A/C systems, a thermal switch is connected in series with the compressor clutch. This switch usually is mounted on the compressor. Many thermal switches open at 257°F (125°C) and close at 230°F (110°C).

#### **Task B.1.3**

**Inspect, adjust, and replace A/C compressor drive belts and pulleys.**

Always use the exact replacement size of belt. The size of a new belt is typically given, along with the part number, on the belt container. After replacing a belt, make sure it is adjusted properly. Some engines have an adjusting bolt that can be tightened to bring the belt tension to specifications. On other engines it may be necessary to use a pry bar

to move an accessory enough to meet tension specs. Be careful not to damage the part you are prying against. The belt's tension should be checked with a belt tension gauge.

When installing a serpentine belt, make sure it is fed in and around the accessories properly. Service manuals show the proper belt routing. Also make sure the belt tensioner is working properly. After any drive belt has been installed with the correct tension, tighten any bolts or nuts that were loosened to move the belt.

A loose A/C compressor belt will likely produce a squealing noise with the compressor clutch engaged. Since the air pump does not require much power to turn it, this belt is not likely to produce a squealing noise on acceleration. A worn compressor bearing produces a growling noise under all engine operating conditions with the clutch engaged. Because the power steering pump is always under load, a loose power steering belt may cause a squealing noise on acceleration.

If one V-belt breaks on a two-belt drive system, both belts should be replaced as a pair. The idler pulley need not be replaced unless it is defective. To ensure proper tension, belts are replaced as a pair in a two-belt drive system. The belts should be re-tensioned after a few hours of use. Often idler pulleys have a self-tensioning provision, and further attention is not required.

## **Task B.1.4**

### **Inspect, test, service, and replace A/C compressor clutch components or assembly.**

Every compressor is equipped with an electromagnetic clutch as part of the compressor pulley assembly. It is designed to engage the pulley to the compressor shaft when the clutch coil is energized. The purpose of the clutch is to transmit power from the engine to the compressor and to provide a means of engaging and disengaging the refrigeration system from engine operation.

The clutch is driven by power from the engine's crankshaft, which is transmitted through one or more belts (a few use gears) to the pulley, which is in operation whenever the engine is running. When the clutch is engaged, power is transmitted from the pulley to the compressor shaft by the clutch drive plate. When the clutch is not engaged, the compressor shaft does not rotate, and the pulley freewheels.

The clutch is engaged by a magnetic field and disengaged by springs when the magnetic field is broken. When the controls call for compressor operation, the electrical circuit to the clutch is completed, the magnetic clutch is energized, and the clutch engages the compressor. When the electrical circuit is opened, the clutch disengages the compressor.

Two types of electromagnetic clutches have been in use for many years. Early-model air conditioning systems used a rotating coil clutch. The magnetic coil, which engages or disengages the compressor, is mounted within the pulley and rotates with it. Electrical connections for the clutch operation are made through a stationary brush assembly and rotating slip rings, which are part of the field coil assembly. This older rotating coil clutch, now in limited use, has been largely replaced by the stationary coil clutch. The compressor clutch can be checked with an ohmmeter. Service manuals will give the acceptable resistance for the field coil of the clutch assembly.

With the stationary coil, wear has been measurably reduced, efficiency increased, and serviceability made much easier. The clutch coil does not rotate. When the driver first energizes the air conditioning system from the passenger compartment dashboard, the pulley assembly is magnetized by the stationary coil on the compressor body, thus engaging the clutch to the clutch hub that is attached to the compressor shaft. This activates the air conditioning system. Depending on the system, the magnetic clutch is usually pressure controlled to cycle the operation of the compressor (depending on system temperature or pressure). In some system designs, the clutch might operate continually when the system is turned on. With stationary coil design, service is not usually necessary except for an occasional check on the electrical connections.

Nearly all clutch assemblies have a clearance spec for the distance between the clutch and the pressure plate. This clearance is measured with a feeler gauge. If the clearance is

too great, the clutch may slip and cause a scraping or squealing noise. If the clearance is insufficient, the compressor may run when not electrically activated and the clutch may chatter at all times.

## **Task B.1.5**

### **Identify required lubricant type; inspect and correct level in A/C compressor.**

Normally the only source of lubrication for a compressor is the oil mixed with the refrigerant. Because of the loads and speeds the compressor operates at, proper lubrication is a must for long compressor life. The refrigerant oil required by the system depends on a number of things, but it is primarily dictated by the refrigerant used in the system. R-12 systems use a mineral oil. Mineral oil mixes well with R-12 without breaking down. Mineral oil, however, cannot be used with R-134a. R-134a systems require a synthetic oil, polyalkylene glycol (PAG). There are a number of different blends of PAG oil; always use the one recommended by the vehicle manufacturer or compressor manufacturer. Failure to use the correct oil will cause damage to the compressor.

Generally, compressor oil level is checked only where there is evidence of a major loss of system oil that could be caused by a broken refrigerant hose, severe hose fitting leak, badly leaking compressor seal, or collision damage to the system's components.

When replacing refrigerant oil, it is important to use the specific type and quantity of oil recommended by the compressor manufacturer. If there is a surplus of oil in the system, too much oil circulates with the refrigerant, causing the cooling capacity of the system to be reduced. Too little oil results in poor lubrication of the compressor. When there has been excessive leakage or it is necessary to replace a component of the refrigeration system, certain procedures must be followed to assure that the total oil charge in the system is correct after leak repair or the new part is on the car.

When the compressor is operated, oil gradually leaves the compressor and is circulated through the system with the refrigerant. Eventually a balanced condition is reached in which a certain amount of oil is retained in the compressor and a certain amount is continually circulated. If a component of the system is replaced after the system has been operated, some oil goes with it. To maintain the original total oil charge, it is necessary to compensate for this by adding oil to the new replacement part. Because of the differences in compressor designs, be sure to follow the manufacturer's instructions when adding refrigerant oil to their unit.

When replacing an A/C compressor, the recommended procedure is to measure the oil recovered from the system while discharging. Drain and measure the oil left in the old compressor. Drain the new compressor and refill it with the same amount of oil removed from the system and old compressor. If 2 oz. (59 ml) of oil are recovered from the system and 2 oz. (59 ml) of oil drained from the old compressor, drain the replacement compressor and then add 4 oz. (118 ml) of oil to the compressor before installation.

A small amount of lubricant is lost from the compressor due to circulation through the system. The lubricant must be drained from some compressors and measured in a beaker. The lubricant level in some compressors may be measured with a dipstick while others must be removed, drained, and measured in a beaker. The lubricant used in automotive air conditioning systems is a nonfoaming, sulfur-free grade specially formulated for use in certain types of air conditioning systems. It must be noted that a mineral-based lubricant is used in R-12 systems while a glycol-based synthetic lubricant is used in an R-134a system.

## **Task B.1.6**

### **Inspect, test, and service or replace A/C compressor.**

The compressor is the heart of the automotive air conditioning system. It separates the high-pressure and low-pressure sides of the system. The primary purpose of the unit is to draw the low-pressure and low-temperature vapor from the evaporator and compress this vapor into high-temperature, high-pressure vapor. This action results in the

refrigerant having a higher temperature than surrounding air and enables the condenser to condense the vapor back to a liquid. The secondary purpose of the compressor is to circulate or pump the refrigerant through the A/C system under the different pressures required for proper operation.

A piston compressor can have its pistons arranged in an in-line, axial, radial, or V design. It is designed to have an intake stroke and a compression stroke for each cylinder. On the intake stroke, the refrigerant from the low side of the system (evaporator) is drawn into the compressor. The intake of refrigerant occurs through intake reed valves. These one-way valves control the flow of refrigerant vapors into the cylinder. During the compression stroke, the vaporous refrigerant is compressed. This increases both the pressure and the temperature of the heat-carrying refrigerant. The outlet or discharge side reed valves then open to allow the refrigerant to move to the condenser. The outlet reed valves are the beginning of the high side of the system. Reed valves are made of spring steel, which can be weakened or broken if improper charging procedures are used, such as liquid charging with the engine running.

A common variation of a piston-type compressor is the variable displacement compressor. These compressors not only act as a regular compressor but they also control the amount of refrigerant that passes through the evaporator. The pistons are connected to a wobble-plate. The angle of the wobble-plate determines the stroke of the pistons and is controlled by the difference in pressure between the outlet and inlet of the compressor. When the stroke of the pistons is increased, more refrigerant is being pumped and there is increased cooling.

The rotary vane compressor does not have pistons. It consists of a rotor with several vanes and a carefully shaped housing. As the compressor shaft rotates, the vanes and housing form chambers. The refrigerant is drawn through the suction port into these chambers, which become smaller as the rotor turns. The discharge port is located at the point where the gas is completely compressed. No sealing rings are used in a vane compressor. The vanes are sealed against the housing by centrifugal force and lubricating oil. The oil sump is located on the discharge side, so the high pressure tends to force it around the vanes into the low-pressure side. This action ensures continuous lubrication. Because this type of compressor depends on a good oil supply, it is subject to damage if the system charge is lost. A protection device is used to disengage the clutch if pressure drops too low.

The scroll-type compressor has a movable scroll and a fixed or nonmovable scroll that provide an eccentric-like motion. As the compressor's crankshaft rotates, the movable scroll forces the refrigerant against the fixed scroll and toward the center of the compressor. This motion pressurizes the refrigerant. The action of a scroll-type compressor can be compared to that of a tornado. The pressure of air moving in a circular pattern increases as it moves toward the center of the circle. A delivery port is positioned at the center of the compressor and allows the high-pressure refrigerant to flow into the air conditioning system. This type of compressor operates more smoothly than other designs.

## **Task B.1.7**

### **Inspect and repair or replace A/C compressor mountings.**

A compressor noise problem is often difficult to localize. When the compressor is operating, a loose compressor mount or bracket may vibrate, giving the impression that the compressor itself is somehow defective. This type of noise usually stops when the compressor is disengaged.

If the compressor mount is loose, this can cause the compressor to move and make noise. If the A/C system does not have any refrigerant in it, the compressor clutch will not engage and therefore will not make any noise since it is not engaging.

## 2. Evaporator, Condenser, and Related Components (5 Questions)

### Task B.2.1

**Inspect and repair or replace A/C system mufflers, hoses, lines, filters, fittings, and seals.**

An air conditioning system is divided into two sides: the high side and the low side. High side refers to the side of the system that is under high pressure and high temperature. Low side refers to the low-pressure, low-temperature side of the system.

All the major components of the system have inlet and outlet connections that accommodate either flare or O-ring fittings. The refrigerant lines that connect between these units are made up of an appropriate length of hose or tubing with flare or O-ring fittings at each end as required. In either case the hose or tube end of the fitting is constructed with sealing beads to accommodate a hose or tube clamp connection.

There are three major refrigerant lines. Suction lines are located between the outlet side of the evaporator and the inlet side or suction side of the compressor. They carry the low-pressure, low-temperature refrigerant vapor to the compressor where it again is recycled through the system. Suction lines are always distinguished from the discharge lines by touch and size. They are cold to the touch. The suction line is larger in diameter than the liquid line because refrigerant in a vapor state takes up more room than refrigerant in a liquid state.

The other types of refrigerant lines are the discharge and liquid lines. Beginning at the discharge outlet on the compressor, the discharge or high-pressure line connects the compressor to the condenser. The liquid lines connect the condenser to the receiver/dryer and the receiver/dryer to the inlet side of the expansion valve. Through these lines, the refrigerant travels in its path from a gas state (compressor outlet) to a liquid state (condenser outlet) and then to the inlet side of the expansion valve where it vaporizes on entry to the evaporator. Discharge and liquid lines are always very warm to the touch and easily distinguishable from the suction lines.

Aluminum tubing is commonly used to connect air conditioning components where flexibility is not required. Where the line is subjected to vibrations, special rubber hoses are used. Typically the compressor outlet and inlet lines are rubber hoses with aluminum ends and fittings.

R-134a systems are required to be fitted with quick-disconnect fittings through the system. These also have hoses specially made for R-134a. They have an additional layer of rubber that serves as a barrier to prevent the refrigerant from escaping through the pores of the hose. Some late-model R-12 systems also use these barrier hoses to prevent the loss of refrigerant through the walls of the hoses.

Some refrigerant line connections are sealed with O-rings and retained with spring lock couplings. A special tool is used to release the spring lock couplings.

It is not necessary to replace the O-ring seals unless they are leaking. The accumulation of dirt around an A/C line connection is an indication of a leak in the system. When there is a leak in the system, dirt collects in the area of the leak due to some of the oil leaking out.

### Task B.2.2

**Inspect A/C condenser for airflow restrictions.**

The condenser consists of coiled refrigerant tubing mounted in a series of thin cooling fins to provide maximum heat transfer in a minimum amount of space. The condenser is normally mounted just in front of the vehicle's radiator. It receives the full flow of ram air from the movement of the vehicle or airflow from the radiator fan when the vehicle is standing still.

The purpose of the condenser is to condense or liquefy the high-pressure, high-temperature vapor coming from the compressor. To do so, it must give up its heat. The condenser receives very hot (normally 200 to 400°F), high-pressure refrigerant vapor from the compressor through its discharge hose. The refrigerant vapor enters the inlet

at the top of the condenser, and as the hot vapor passes down through the condenser coils, heat (following its natural tendencies) moves from the hot refrigerant into the cooler air as it flows across the condenser coils and fins. This process causes a large quantity of heat to be transferred to the outside air and the refrigerant to change from a high-pressure hot vapor to a high-pressure warm liquid. This high-pressure warm liquid flows from the outlet at the bottom of the condenser through a line to the receiver/dryer or to the refrigerant metering device if an accumulator instead of a dryer is used.

In an air conditioning system, which is operating under an average heat load, the condenser has a combination of hot refrigerant vapor in the upper two-thirds of its coils. The lower third of the coils contains the warm liquid refrigerant, which has condensed. This high-pressure, liquid refrigerant flows from the condenser and on toward the evaporator. In effect, the condenser is a true heat exchanger.

Ram airflow across the condenser is produced by vehicle movement or the action of the fan. A defective fan clutch generally causes the fan to run at maximum potential at all times, which will usually increase ram airflow. Reduced airflow across the condenser generally affects the ability of the condenser to cool the refrigerant, resulting in higher temperatures. The higher refrigerant temperatures increase suction pressure in the system, affecting system cooling abilities.

If the condenser air passages are severely restricted, this may result in high refrigerant system pressures and refrigerant discharge from the high-pressure relief valve. Restrictions will not allow enough air to cool down the condenser, causing higher temperatures and in turn higher pressures.

### **Task B.2.3**

#### **Inspect, test, and replace A/C system condenser and mountings.**

If the system were overcharged with refrigerant, the head pressure may be excessive but there would be no frosting at the condenser outlet. If the condenser is restricted, there would be frosting at the point of restriction. Frosting near the condenser outlet is a clear indication that there is a restriction in the condenser.

When frost is forming on one of the condenser tubes near the bottom of the condenser, the refrigerant passage is restricted at that location in the condenser.

### **Task B.2.4**

#### **Inspect and replace receiver/dryer or accumulator/dryer.**

Used on many early systems, the receiver/dryer is a storage tank for the liquid refrigerant from the condenser, which flows into the upper portion of the receiver tank containing a bag of desiccant (moisture-absorbing material such as silica alumina or silica gel). As the refrigerant flows through an opening in the lower portion of the receiver, it is filtered through a mesh screen attached to a baffle at the bottom of the receiver. The desiccant in this assembly is to absorb any moisture present that might enter the system during assembly. These features of the assembly prevent obstruction to the valves or damage to the compressor.

Depending on the manufacturer, the receiver/dryer may be known by other names such as filter or dehydrator. Regardless of its name, the function is the same. Included in many receiver/dryers are additional features such as high-pressure fitting, a pressure relief valve, and a sight glass for determining the state and condition of the refrigerant in the system.

The receiver/dryer is often neglected when the air conditioning system is serviced or repaired. Failure to replace it can lead to poor system performance or replacement part failure. It is recommended that the receiver/dryer and/or its desiccant be changed whenever a component is replaced, the system has lost the refrigerant charge, or the system has been open to the atmosphere for any length of time.

The desiccant draws moisture like a magnet and it can become contaminated in less than five minutes if it is exposed to the atmosphere. Keep it sealed. Once opened, put it under a vacuum quickly.

Most late-model systems are not equipped with a receiver/dryer; rather, they use an accumulator to accomplish the same thing. The accumulator is connected into the low

side, at the outlet of the evaporator. The accumulator also contains a desiccant and is designed to store excess refrigerant and to filter and dry the refrigerant. If liquid refrigerant flows out of the evaporator, it will be collected by and stored in the accumulator. The main purpose of an accumulator is to prevent liquid from entering the compressor.

## **Task B.2.5**

### **Inspect, test, and replace expansion valve.**

The refrigerant flow to the evaporator must be controlled to obtain maximum cooling, while ensuring complete evaporation of the liquid refrigerant within the evaporator. This is accomplished by a thermostatic expansion valve (TEV or TXV) or a fixed orifice tube.

The TEV is mounted at the inlet to the evaporator and separates the high-pressure side of the system from the low-pressure side. The TEV regulates refrigerant flow to the evaporator to prevent evaporator flooding or starving. In operation, the TEV regulates the refrigerant flow to the evaporator by balancing the inlet flow to the outlet temperature.

Both externally and internally equalized TEVs are used in air conditioning systems. The only difference between the two valves is that the external TEV uses an equalizer line connected to the evaporator outlet line as a means of sensing evaporator outlet pressure. The internal TEV senses evaporator inlet pressure through an internal equalizer passage. Both valves have a capillary tube to sense evaporator outlet temperature. The tube is filled with a gas, which, if allowed to escape due to careless handling, will ruin the TXV.

During stabilized conditions, the pressure on the bottom of the expansion valve diaphragm becomes equal to the pressure on the top of the diaphragm. This allows the valve spring to close the valve. When the system is started, the pressure on the bottom of the diaphragm drops rapidly, allowing the valve to open and meter liquid refrigerant to the lower evaporator tubes where it begins to vaporize.

Compressor suction draws the vaporized refrigerant out of the top of the evaporator at the top tube where it passes by the sealed sensing bulb. The bottom of the valve diaphragm internally senses the evaporator pressure through the internal equalization passage around the sealed sensing bulb. As evaporator pressure is increased, the diaphragm flexes upward pulling the pushrod away from the ball seat of the expansion valve. The expansion valve spring forces the ball onto the tapered seat and the liquid refrigerant flow is reduced.

As the pressure is reduced due to restricted refrigerant flow, the diaphragm flexes downward again, opening the expansion valve to provide the required controlled pressure and refrigerant flow condition. As the cool refrigerant passes by the body of the sensing bulb, the gas above the diaphragm contracts and allows the expansion valve spring to close the expansion valve. When heat from the passenger compartment is absorbed by the refrigerant, it causes the gas to expand. The pushrod again forces the expansion valve to open, allowing more refrigerant to flow so that more heat can be absorbed.

A defective capillary tube would most likely cause the thermal expansion valve (TXV) to remain closed, causing poor cooling at all times. An overcharged system will cause higher suction pressures and poor cooling at all times. A restricted condenser passage will cause low cooling at all times. Some symptoms indicate moisture freezing in the TXV. When the TXV freezes, refrigerant flow is reduced and cooling is also reduced. As the TXV thaws, refrigerant flow is restored and cooling is also restored until the TXV freezes again.

## **Task B.2.6**

### **Inspect and replace orifice tube.**

Like the thermostatic expansion valve, the orifice tube is the dividing point between the high- and low-pressure parts of the system. However, its metering or flow rate control does not depend on comparing evaporator pressure and temperature. It is a fixed orifice. The flow rate is determined by pressure difference across the orifice and by subcooling. Subcooling is additional cooling of the refrigerant in the bottom of the condenser after it has changed from vapor to liquid. The flow rate through the orifice is more sensitive to subcooling than to pressure difference.



When using the special tool to remove an orifice tube, pour a small amount of refrigerant oil on top of the tube and engage the notch in the tool in the orifice tube. Hold the T-handle and rotate the outer sleeve to remove the orifice tube.

A restricted orifice tube may cause lower-than-specified low-side pressure. A restricted orifice tube may cause frosting of the tube because of the low temperatures caused by the low pressure.

## **Task B.2.7**

### **Inspect, test, or replace evaporator.**

The evaporator, like the condenser, consists of a refrigerant coil mounted in a series of thin cooling fins. It provides a maximum amount of heat transfer in a minimum amount of space. The evaporator is usually located beneath the dashboard or instrument panel.

Upon receiving the low-pressure, low-temperature liquid refrigerant from the thermostatic expansion valve or orifice tube in the form of an atomized (or droplet) spray, the evaporator serves as a boiler or vaporizer. This regulated flow of refrigerant boils immediately. Heat from the core surface is lost to the boiling and vaporizing refrigerant, which is cooler than the core, thereby cooling the core. The air passing over the evaporator loses its heat to the cooler surface of the core, thereby cooling the air inside the car. As the process of heat loss from air to the evaporator core surface is taking place, any moisture (humidity) in the air condenses on the outside of the evaporator core and is drained off as water. A drain tube in the bottom of the evaporator housing leads the water outside the vehicle. This dehumidification of air is an added feature of the air conditioning system that adds to passenger comfort. It can also be used as a means of controlling fogging of the vehicle windows. Under certain conditions, however, too much moisture can accumulate on the evaporator coils. An example would be when humidity is extremely high and the maximum cooling mode is selected. The evaporator temperature might become so low that moisture would freeze on the evaporator coils before it can drain off.

Through the metering, or controlling, action of the thermostatic expansion valve or orifice tube, greater or lesser amounts of refrigerant are provided in the evaporator to adequately cool the car under all heat load conditions. If too much refrigerant is allowed to enter, the evaporator floods. This results in poor cooling due to the higher pressure (and temperature) of the refrigerant. The refrigerant can neither boil away rapidly nor vaporize. On the other hand, if too little refrigerant is metered, the evaporator starves. Poor cooling again results because the refrigerant boils away or vaporizes too quickly before passing through the evaporator.

The temperature of the refrigerant vapor at the evaporator outlet will be approximately 4 to 16°F higher than the temperature of the liquid refrigerant at the evaporator inlet. This temperature differential is the superheat that ensures that the vapor will not contain any droplets of liquid refrigerant that would be harmful to the compressor.

## **Task B.2.8**

### **Inspect, clean, and repair evaporator, housing, and water drain.**

A plugged evaporator case drain may cause windshield fogging, but this problem would not result in an oily film on the windshield. An oil film on the windshield may be caused by a refrigeration leak in the evaporator core that may allow some refrigerant oil to escape in the evaporator case.

The evaporator core should be removed from the case for proper cleaning. Most evaporators have no filter, therefore airborne debris, such as lint, hair, and other contaminants, enters the evaporator case and clings to the wet evaporator core. It is nearly impossible to adequately clean an evaporator core without first removing it from the case.

The evaporator water drain is an integral part of the evaporator housing assembly. A crack or break in the housing may reduce the cooling capacity of the air conditioner. If the evaporator (water) drain becomes clogged, it is easily cleaned with a stiff wire from the outlet in, provided the technician takes care not to puncture the delicate evaporator core. If the case has a crack or break on the engine side of the firewall, excessive engine heat may enter the case and thereby reduce the efficiency of the air conditioning system.

## **Task B.2.9**      **Inspect, test, and replace evaporator pressure/temperature control systems and devices.**

Evaporator controls maintain a backpressure in the evaporator. Because of the refrigerant temperature/pressure relationship, the effect is to regulate evaporator temperature. The temperature is controlled to a point that provides effective air cooling but prevents the freezing of moisture that condenses on the evaporator.

In this type of system the compressor operates continually when dash controls are in the air conditioning position. Evaporator outlet air temperature is automatically controlled by an evaporator pressure control valve. These types of valves throttle the flow of refrigerant out of the evaporator as required to establish a minimum evaporator pressure and thereby prevent freezing of condensation on the evaporator core.

In some refrigerant systems with an evaporator pressure regulator (EPR), pilot operated absolute valve (POA), or suction throttling valve (STV) valve, the compressor runs continually in the A/C mode. Excessive pressure drop across the EPR valve indicates this valve is sticking closed.

For sometime the (ETR) evaporator temperature regulator and suction throttling valve (STV) were popular methods of evaporator temperature control, but these have not been in use for several years. All were used in the suction line from the evaporator to the compressor to maintain evaporator pressure, thereby maintaining its temperature.

## **Task B.2.10**      **Identify, inspect, and replace A/C system service valves (gauge connections).**

System service valves, which incorporate a service gauge port for manifold gauge set connections, are provided on the low and high sides of most air conditioning systems. When making gauge connections, purge the gauge lines first by cracking the charging valve and allowing a small amount of refrigerant to flow through the lines, then connect the lines immediately.

The stem valve is sometimes used on two-cylinder reciprocating-piston compressors. Access to the high-pressure and low-pressure sides of the system is provided through service valves mounted on the compressor head. The low-pressure valve is mounted at the inlet to the compressor, while the high-pressure valve is mounted at the compressor outlet. Both these valves can be used to shut off the rest of the air conditioning system from the compressor when the compressor is being serviced. These valves have a stem under a cap with the hose connection directly opposite.

A special wrench is used to open the valve to one of three positions. The back-seated position is the normal operating position with the valve stem rotated counterclockwise to seat the rear valve face and seal off the service gauge port. The mid position is the test position with the valve stem turned clockwise (inward)  $1\frac{1}{2}$  to 2 turns. This connects the service gauge port into the system so that gauge readings can be taken with the system operating. A service gauge hose must be connected with the valve completely back seated. In the front-seated position, the valve stem has been rotated clockwise to seat the front valve face and to isolate the compressor from the system. This position allows the compressor to be serviced without discharging the entire system. The front-seated position is for service only. It is never used while the air conditioner is operating.

Systems that do not utilize stem service have Schrader service valves in both the high and low portions of the system for test purposes. Closely resembling a tire valve, Schrader valves are usually located in the high-pressure line (from compressor to condenser) and in the low-pressure line (from evaporator to condenser) to permit checking of the high side and low side of the system. All test hoses have a Schrader core depressor in them. As the hose is threaded into the service port, the pin in the center of the valve is depressed, allowing refrigerant to flow to the manifold gauge set. When the hose is removed, the valve closes automatically.

After disconnecting gauge lines, check the valve areas to be sure the service valves are correctly seated and the Schrader valves are not leaking.

**Task  
B.2.11**      **Inspect and replace A/C system high-pressure relief device.**

The high-pressure relief valve is used to keep system pressures from reaching a point that may cause compressor lockup or other component damage because of excessive high pressures. When system pressures exceed a predetermined point, the pressure relief valve opens, allowing excessive system pressures to be reduced. A high-pressure relief valve discharges refrigerant at approximately 475 psi (3,275 kpa).

If replacing the high-pressure relief valve, the system must be discharged before removing the valve. It is necessary to replace the high-pressure relief valve with one of the same relief pressure specifications unless the vehicle is going to be retrofitted to use R-134a refrigerant instead of R-12.

Some high-pressure relief devices are spring-loaded and self-resetting. Some high-pressure relief devices are made of fusible metal and are not self-resetting. Self-resetting high-pressure relief valves are usually found on the rear head of the compressor while fusible metal high-pressure relief devices are often found on the receiver/dryer, accumulator/dryer, or some other pressure vessel. Not all systems, however, have a pressure relief device—many aftermarket systems do not have one.

**C. Heating and Engine Cooling Systems Diagnosis and Repair (5 Questions)****Task  
C.1**      **Diagnose the cause of temperature control problems in the heater/ventilation system; determine needed repairs.**

In most cases, problems with the heating system are problems with the engine's cooling system. Therefore most service work and diagnosis is done to the cooling system. Problems that pertain specifically to the heater are few: the heater control valve and the heater. Most often if these two items are faulty, the engine's cooling system will be negatively affected. Both of these items are replaced, rather than repaired. In some cases, it is possible to make repairs to vacuum hose and electrical connections without removing the heater assembly. If it is necessary to remove the heater assembly, the cooling system must be drained before removing the heater core.

When there is a problem of insufficient heat, begin your diagnosis with a visual inspection and a check of the coolant level. If the level is correct, turn the heater controls on; run the engine until it reaches normal operating temperature. Then measure the temperature of the upper radiator hose. The temperature can be measured with a pyrometer. If one is not available, gently touch the hose. You should not be able to hold the hose long because of the heat. While doing this, make sure you stay clear of the area around the cooling fan. A spinning fan can chop off your hand. If the temperature of the hose is not within specifications, suspect a faulty thermostat.

If the hose is the correct temperature, check the temperature of the two heater hoses. They should both be hot. If only one of the hoses is hot, suspect the heater control valve or a plugged heater core.

The thermostat, which helps regulate the coolant temperature in the cooling system, plays a large part in the heating system. A malfunctioning thermostat can cause the engine to overheat or not reach normal operating temperature, or it can be the cause of poor heater performance.

A low coolant level can starve the heater resulting in little or no heat output. Check the coolant level in the radiator (not the overflow tank) to see if it is low. If low, adding coolant does not cure the problem until the problem of low coolant is found and fixed.

Air pockets can form in long heater hoses or where the heater is mounted higher than the radiator. To vent the trapped air, some vehicles have bleeder valves on the hoses. Opening the valves allows air to escape as the system is filled. The valves are then closed when coolant reaches their level. On vehicles that lack these special bleeder valves, it may be necessary to temporarily loosen the heater outlet hose so air can bleed out as the system is filled.

**Task  
C.2****Diagnose window fogging problems; determine needed repairs.**

A sticky film on the inside of the windshield may be caused by a coolant leak in the heater core. Under this condition, the coolant level in the radiator should be checked. The heater core should be repaired or replaced.

Windshield fogging may be caused by a plugged air conditioning/heater case drain, which allows water to collect in the case. This water can become stagnant and produce a very pungent odor in the passenger compartment. The windshield will not fog due to a low coolant level.

A leaking heater core is often the cause of a windshield fogging problem. Windshield fogging is the result of hot and humid air that condenses on the cooler glass. Cleaning a clogged evaporator/heater case drain tube often eliminates a windshield fogging problem. If the drain is clogged, a leaking heater core will allow engine coolant to accumulate in the housing. A clogged drain also allows condensed water vapor to accumulate. Both of these problems add moisture to the air, which tends to fog the windshield.

**Task  
C.3****Perform cooling system tests; determine needed repairs.**

Check the level of the coolant in the coolant recovery tank. If the level is too low, more coolant should be added through the cap of the tank not the radiator. Visually inspect all of the hoses in the cooling systems for signs of leakage and/or damage. If any of the hoses are swollen or cracked or show signs of leakage, they should be replaced.

The most common tool used to test a cooling system is the radiator pressure tester. A radiator pressure tester is really no more than a hand pump with a pressure gauge. The pressure tester is extremely handy for identifying the location of any leak within the cooling system. To use the tester, connect it to the radiator filler neck. Run until it is warm, then pump the handle of the tester until its gauge reads the same pressure that is noted on the radiator cap. Watch the gauge. If the pressure drops, carefully check the hoses, radiator, heater core, and water pump for leaks. Often the leak will initially be obvious because coolant will spray out of the leak. If the pressure drops but there are no external leaks, suspect an internal leak.

**Task  
C.4****Inspect and replace engine cooling and heater system hoses.**

There are many types of belts, including V-belts, serpentine belts, and scalloped and wrapped construction type belts.

The vacuum valve in a radiator cap is designed to reduce cooling system vacuum caused by the contraction as a hot system cools. A sticking vacuum valve in the radiator cap may cause a vacuum in the system and collapse the upper radiator hose after the engine is shut off.

**Task  
C.5****Inspect, test, and replace radiator, pressure cap, coolant recovery system, and water pump.**

There are three basic types of radiator caps: the constant pressure type, pressure vent type, and the closed system type. The closed system type-radiator cap is the one found on today's cars. The others are found on older model vehicles. The constant pressure type has a lower seal or pressure valve that is held closed until the coolant gets hot enough to build enough pressure to open the valve within the preset pressure range. The pressure vent type cap is similar to the constant pressure type. However, it has a vacuum-release valve that is opened by a weight and is kept open to the atmosphere until the pressure is great enough to move the weight and close the valve. This prevents atmospheric pressure from entering into the radiator. Like the constant pressure cap, this cap opens to release pressure when it builds to the specified amount.

The closed system type works in the same way as the constant pressure cap, except it is designed to keep the radiator full at all times. When the specified pressure is reached,

some coolant is released into the recovery tank. When there is a vacuum in the radiator (caused by less coolant), the vacuum is used to pull coolant from the recovery tank. These radiator caps are not designed to be removed for coolant checks. Coolant is checked and fluid is added through the recovery tank.

### **Task C.6**

#### **Inspect, test, and replace thermostat, bypass, and housing.**

The thermostat controls the minimum operating temperature of the engine. The maximum operating temperature is controlled by the amount of heat being produced by the engine at the time and the cooling system's ability to dissipate the heat.

If the thermostat is stuck open in a fuel-injected engine, the coolant never reaches normal operating temperature. Under this condition, the engine coolant temperature sensor sends a low coolant temperature signal to the powertrain control module (PCM). This sensor input results in a rich air:fuel ratio.

When the engine is running with the thermostat closed, the coolant is directed through a bypass system to be circulated again through the engine. Some systems use the heater core as a thermostat bypass.

### **Task C.7**

#### **Identify, inspect, and recover coolant; flush and refill system with proper coolant.**

The antifreeze concentration must always be a minimum of 44 percent, all year and in all climates. If the percentage is lower than 44 percent, engine parts may be eroded by cavitation, and cooling system components may be severely damaged by corrosion. Never fill the system with 100 percent ethylene glycol. This can cause extreme engine heat, which can cause serious engine damage. Also, the use of propylene glycol or mixtures of propylene glycol and ethylene glycol antifreeze is not typically recommended by automotive manufacturers. Check the service manual before using these chemicals.

When more antifreeze is added to the coolant, the boiling point is increased and coolant solutions must be recovered and recycled. Most ethylene glycol antifreeze contains rust and corrosion inhibitors. When the cooling system pressure is increased, the boiling point also increases.

Coolant is considered a hazardous waste and must be recovered. Coolant must be recycled according to local regulations. In no instance can it be disposed of in a landfill. Any coolant removed from an automotive cooling system may contain harmful engine residues, such as benzene and lead. If used coolant is to be disposed of, it must be done according to local regulations. Ideally, however, the coolant may be recycled by filtering out most of the contaminants. Some recycle machines use vacuum distillation or ion exchange technology for glycol-based coolants. After recycling, the coolant must be supplemented with an additive before being reused.

### **Task C.8**

#### **Inspect, test, and replace fan (both electrical and mechanical), fan clutch, fan belts, fan shroud, and air dams.**

A blown cooling fan fuse would prevent the engine cooling fan motors from operating even with the A/C on. A defective high-speed coolant fan relay only prevents high-speed fan operation. Since the cooling fans operate with the A/C on, the A/C pressure fan switch must be operating. A defective engine coolant temperature sensor that indicates low coolant temperature may cause the powertrain control module (PCM) not to ground the fan relay windings and thus prevent the operation of the cooling fans except when the A/C pressure switch closes.

An improperly positioned radiator shroud could cause overheating. The radiator shroud needs to be properly positioned to aid the fan in directing airflow through the radiator. The fan clutch being locked would not cause overheating.

**Task  
C.9****Inspect, test, and replace heater coolant control valve (manual, vacuum, and electrical types).**

The heater control valve (sometimes called the water flow valve) controls the flow of coolant into the heater core from the engine. In a closed position, the valve allows no flow of hot coolant to the heater core, keeping it cool. In an open position, the valve allows heated coolant to circulate through the heater core, maximizing heater efficiency.

Cable-operated valves are controlled directly from the heater control lever on the dashboard. Thermostatically controlled valves have a liquid-filled capillary tube located in the discharge airstream off the heater core. This tube senses air temperature, and the valve modulates the flow of water to maintain a constant temperature, regardless of engine speed or temperature.

Most heater valves utilized on today's cars are vacuum operated. These valves are normally located in the heater hose line or mounted directly in the engine block. When a vacuum signal reaches the valve, a diaphragm inside the valve is raised, either opening or closing the valve against an opposing spring. When the temperature selection on the dashboard is changed, vacuum to the valve is vented and the valve returns to its original position. Vacuum-actuated heater control valves are either normally open or normally closed designs. Some vehicles don't use a heater control valve; rather, a heater door controls how much heat is released into the passenger compartment from the heater core.

With cable-operated control valves, check the cable for sticking, slipping (loose mounting bracket), or misadjustment. With valves that are vacuum operated, there should be no vacuum to the valve when the heater is on (except for those that are normally closed and need vacuum to open).

On late-model vehicles, heater control valves are typically made of plastic for corrosion resistance and light weight. These valves feature few internal working parts and no external working parts. With the reduced weight of these valves, external mounting brackets are not required.

If the manual coolant control valve is incorrectly adjusted and does not close completely, hot coolant will be allowed to pass through the heater core when the A/C is on. If the coolant control valve does not open completely, it will not allow enough hot coolant to pass through the heater core to properly heat the air in the heat mode.

Rust discoloration at the heater control valve may indicate a malfunctioning valve. A defective heater control valve may result in a poor cooling condition by allowing hot coolant to enter the heater core. The heater control valve is used to control the flow of heated coolant through the heater core. The hot coolant is often used to "temper" the air for temperature control and to help maintain a desired in-car relative humidity. Heater coolant control valves may be electronically, mechanically, or vacuum controlled.

**Task  
C.10****Inspect, flush, and replace heater core.**

The heater core is generally designed and constructed much like a miniature radiator. It features an inlet or outlet tube and a tube and fin core to facilitate coolant flow between them.

Although all heater cores basically function in the same manner, several variations in design and materials are used by different automakers to achieve the same results. Although the core construction varies, this type has an aluminum core with plastic tanks.

Like the radiator, heater core tanks, tubes, and fins can become clogged over time by rust, scale, and mineral deposits circulated by the coolant. Heater core failures are generally caused by leakage or clogging. Feel the heater inlet and outlet hoses while the engine is idling and warm with the heater temperature control on hot. If the hose downstream of the heater valve does not feel hot, the valve is not opening.

If the heater core appears to be plugged, the inlet hose may feel hot up to the core but the outlet hose remains cool. Reverse flushing the core with a power flusher may

open up the blockage, but usually the core has to be removed for cleaning or replacement. Air pockets in the heater core can also interfere with proper coolant circulation. Air pockets form when the coolant level is low or when the cooling system is not properly filled after draining.

A gurgling noise in the heater core may be caused by a low coolant level in the cooling system or a restricted heater core. A low coolant level will allow too much air in the cooling system. The excessive air in the system will mix with the coolant and create the gurgling noise. A restricted heater core will also cause a gurgling noise from the coolant passing through the restricted area.

## **D. Operating Systems and Related Controls Diagnosis and Repair (16 Questions)**

### **1. Electrical (8 Questions)**

#### **Task D.1.1**

**Diagnose the cause of failures in the electrical control system of heating, ventilating, and A/C systems; determine needed repairs.**

Electrical problems can be classified as one of three types: shorts, opens, and high-resistance problems. All of these have different effects on the system and their locations are found differently. A short is no more than an unwanted parallel circuit. Sometimes the short is a connection to the power side of another circuit; other times it is a connection to ground. In either case, a short will increase current flow in the circuit. This typically will cause a fuse or circuit breaker to blow. An open is caused by a break or disconnected wire or component. No current will flow through the circuit. Unwanted high-resistance problems reduce the current flow through the circuit. They also reduce the amount of voltage available to the circuit's components. The most common high-resistance problem is a bad or loose ground.

An open circuit in the electronic door actuator circuit or a blown fuse would cause the temperature blend door actuator to be inoperative. An open circuit in the electronic temperature door actuator to the automatic temperature control circuit may cause an inaccurate temperature blend door position, but the door will move.

#### **Task D.1.2**

**Inspect, test, repair, and replace air conditioner/heater blower motors, resistors, switches, relay/modules, wiring, and protection devices.**

The blower motor/fan assembly is located in the evaporator housing. Its purpose is to increase airflow in the passenger compartment. The blower, which is basically the same type as those used in heater systems, draws warm air from the passenger compartment, forces it over the coils and fins of the evaporator, and blows the cooled, cleaned, and dehumidified air into the passenger compartment. The blower motor is controlled by a fan switch.

An open circuit at the blower switch ground or at the terminal causes the blower to be completely inoperative. An open circuit in the resistor or resistor terminals will cause the blower motor to operate at a speed not selected or not at all. An open at the switch terminal of the resistor will not allow the blower motor to operate at any speed selected by the switch. Keep in mind that some vehicles are equipped with blower fans that operate continuously even when off is selected.

A loose ground wire is often the cause of a no blower operating condition. A compressor clutch diode has no effect on the blower motor. A blower motor is used to force air through the heater core and air conditioner evaporator core. To function properly, the blower motor requires a complete electrical circuit. It is generally connected to the negative side of the battery via the frame of the vehicle and to the positive side of the battery via insulated wires, speed resistors, the switch, the fuse or circuit breaker, and the ignition switch.

**Task D.1.3**      **Inspect, test, repair, and replace A/C compressor clutch, relay/modules, wiring, sensors, switches, diodes, and protection devices.**

Alternating current produced by the alternator is rectified to direct current. There is no alternating current present in the electrical system. The purpose of the diode is to prevent spikes of high voltage from returning to the delicate electronic components of the computer. The clutch coil is an electromagnet with a strong magnetic field when current is applied. This magnetic field is constant as long as power is applied to the coil. When power is removed, the magnetic field collapses and creates high-voltage spikes. These are harmful to the delicate electronic circuits of the computer and must be prevented. The diode placed across the clutch coil provides an electrical path to ground, holding the spikes to a safe level.

A defective A/C pressure cutoff switch opens the compressor clutch circuit if the refrigerant system pressures are extremely high. A defective clutch control relay or clutch coil is not likely to cause the clutch to become deenergized in relation to temperature. A defective engine coolant temperature sensor may indicate engine overheating to the powertrain control module (PCM) when the engine is at normal operating temperature. This signal causes the PCM to open the ground circuit on the clutch control relay winding and deenergize the clutch.

**Task D.1.4**      **Inspect, test, repair, replace, and adjust A/C-related engine control systems.**

When the A/C compressor is engaged, it requires increased effort from the engine to run the compressor. This increased effort causes a lower rpm at idle. The throttle kicker is designed to increase engine idle speed while the A/C compressor is running. A leaking throttle kicker diaphragm or an inoperative kicker solenoid may cause lower than specified idle rpm and engine stalling with the A/C on.

The throttle kicker maintains engine idle speed when the engine accessory load is increased, such as during A/C compressor clutch operation. This kicker also maintains idle speed during warm-up.

**Task D.1.5**      **Inspect, test, repair, replace, and adjust load sensitive A/C compressor cutoff systems.**

Some vehicles have a power steering cutoff switch to disengage the air conditioning compressor when the power steering requires maximum effort. Load-sensitive electrical switches include the low-pressure switch, high-pressure switch, pressure cycling, and power steering. Not all of these switches, however, are used on all vehicles. They are, for the most part, used to provide additional engine power when maximum power is required. The pressure switches are used to prevent compressor or component damage in the event of extremely high or low system pressures.

Some compressor clutch circuits contain a thermal limiter switch that senses compressor surface temperature. Some A/C compressor clutch circuits also contain a low-pressure and high-pressure cutoff switch.

**Task D.1.6**      **Inspect, test, repair, and replace engine cooling/condenser fan motors, relays/modules, switches, sensors, wiring, and protection devices.**

A blown cooling fan fuse will obviously cause the cooling fans to be inoperative at all times. If the cooling fan operates only when A/C pressure is high, suspect an open A/C head pressure switch. If the system is equipped with high- and low-speed fan operations, an open circuit in one of the circuits may cause fan operation in only one speed.

Some cooling fan systems use a two fan system; they have a low-speed fan and a high-speed fan. An electric cooling fan usually is wired through a relay because of the amount of current drawn to run an electric fan.



**Task  
D.1.7**      **Inspect, test, adjust, repair, and replace electric actuator motors, relays/modules, switches, sensors, wiring, and protection devices.**

Some actuator motors are calibrated automatically in the self-diagnostic mode whereas other actuator motors must be calibrated manually. These actuators should only require calibration after motor replacement or misadjustment. Diagnostic trouble codes indicate a fault in a specific component.

If there is only one ground wire and it is loose or broken, neither blower speed will operate. The high-speed relay could be defective. The blower motor often receives its power through a high blower relay or a low blower relay. To determine when a blower motor is inoperative, it is necessary to bypass the other components in the circuit.

**Task  
D.1.8**      **Inspect, test, service, or replace heating, ventilating, and A/C control panel assemblies.**

The negative battery cable must be disconnected and the technician must wait a specified length of time before performing the A/C control panel removal. Self-diagnostic tests may indicate a defective A/C control panel. The refrigeration system does not require discharging before A/C panel removal.

The negative battery cable must be disconnected and the technician must wait a specified length of time before A/C control panel removal. The refrigeration system does not require discharging before A/C panel removal.

**2. Vacuum/Mechanical (4 Questions)****Task  
D.2.1**      **Diagnose the cause of failures in the vacuum and mechanical switches and controls of the heating, ventilating, and A/C systems; determine needed repairs.**

The purpose of the system is twofold. It is used to house the heater core and the air conditioner evaporator and to direct the selected supply air through these components into the passenger compartment of the vehicle. The supply air selected can be either fresh (outside) or recirculated air, depending on the system mode. After the air is heated or cooled, it is delivered to the floor outlet, dash panel outlets, or the defrost outlets.

There are two basic duct systems employed. In the stacked core reheat system the basic control is in the water valve. For maximum air the water valve is completely closed. All air enters the vehicle compartment through the heater core.

The access door, which is activated by a cable, controls only fresh or recirculated air. Recirculated air is used during maximum cold operation; the air conditioning unit is not operative and the evaporator will not be cold. The evaporator-only operation is used in the max air or maximum cold position. As the control level inside the car is moved, it controls the water valve by means of a vacuum or a cable to control the amount of hot water entering the heater core and the temperature of the air at the unit outlet.

In blend air reheat systems during heater-only operation, the air conditioning unit is shut off, and the evaporator performs no function in air distribution or temperature control. During maximum air or extreme cold air, the air conditioning system operates, the evaporator is cold, and the blend air door damper is completely closed. Only conditioned air enters the car.

As the control lever is moved in the vehicle from max air toward heat with the air conditioner on, the blend air door is moving. In maximum cold, it is completely shut. On maximum hot, it is completely open. The water valve on this unit is a vacuum on/off unit to regulate water flow. Normal position would be open. This type of blend air system is extremely popular and can be used with or without a water valve.

To check the proper functioning of the ductwork, move the temperature control lever to see if any change occurs. If it does not, shut off the air conditioner and turn on the

heater. Move the temperature control arm again to see if any change occurs. If not, check the cable and the flap door connected to the temperature control lever. You might be able to reach under the dash to reconnect the cable or free a stuck flap.

If no substantial airflow is coming out of the registers, check the fuses in the blower circuit. Remove the fan switch and test it. Check the blower motor by hot-wiring it directly to the battery with jumper cables.

### **Task D.2.2**      **Inspect, test, service, or replace heating, ventilating, and A/C control panel assemblies.**

The control panel assembly controls the compressor, heater valve, and plenum door. The control panel assembly has no control over the coolant temperature. The purpose of the control panel is to provide operator input for the air conditioning and heating system. Some control panels have provisions for displaying in-car and outside air temperatures. A microprocessor may be located in the control panel to provide input data to the programmer, based on operator-selected conditions.

The air conditioner (A/C) compressor operates with the control panel selector in the defrost position. The A/C compressor does not operate with the control panel selector in the vent position.

### **Task D.2.3**      **Inspect, test, adjust, and replace heating, ventilating, and A/C control cables and linkages.**

If the cable housing clamp is loose at the control head (panel) end, the valve may not function. If the cable were rusted in the housing, the control would not move freely.

A no heat condition in a Bowden cable controlled heater control valve system would not be caused by a binding cable holding the valve open. If the valve was held open, there would not be a no heat condition. The no heat condition could be caused by a kink in the cable holding the valve closed.

### **Task D.2.4**      **Inspect, test, and replace heating, ventilating, and A/C vacuum actuators (diaphragms/motors) and hoses.**

Transferring heated air from the heater core to passenger compartment heater and defroster outlets is the job of the heater and defroster ducts. The ducts are typically part of a large plastic shell that connects to the necessary inside and outside vents. This ductwork also has mounting points for the evaporator and heater core assemblies. Contained inside the duct are also the doors required to direct air to the floor, dash, and/or windshield. Sometimes the duct is connected directly to the vents; other times hoses are used.

A split, broken, or disconnected vacuum hose may affect the recirculation door operation. A clogged or blocked restrictor will not affect the recirculation door operation. A restricted or open check valve and cracked or broken vacuum tank may affect recirculation door operation. Vacuum motors move the various doors to direct the airflow to the proper vents. Vacuum air doors are controlled by a selector switch in the control head (panel). This unit directs the vacuum signal to the proper motor. If the selector switch is defective, vacuum will not be supplied to the proper door. If there is a leak in the vacuum system, the door will not move properly due to no or a low vacuum signal. A vacuum leak anywhere in the control circuit will affect the operation of the entire system.

When testing a vacuum actuated door, the vacuum gauge reading should remain steady for at least one minute. If the gauge reading drops slowly, the actuator is leaking and should be replaced.

### **Task D.2.5**      **Identify, inspect, test, and replace heating, ventilating, and A/C vacuum reservoir, check valve, and restrictors.**

A leaking panel door actuator could cause the air discharge to switch from the panel to the floor ducts at any time. A leaking temperature blend door actuator also causes the system to change temperature at any time. A leaking intake manifold gasket may

affect all the vacuum-operated mode doors because this condition causes low-source vacuum. A leaking check valve will not trap the vacuum in the reserve tank when climbing a long hill. This action may cause the temperature blend door to move to the warm air position and the air discharge to switch to the floor ducts.

Vacuum reservoirs are used to supply vacuum during periods of wide open throttle (WOT) when the manifold vacuum is very low. Most vacuum reservoirs are connected to the vacuum source through a check valve.

### **Task D.2.6**

#### **Inspect, test, adjust, repair, or replace heating, ventilating, and A/C ducts, doors, and outlets.**

When the outside recirculation door is in position A, only outside air is allowed to enter the air conditioner heater case. When the outside recirculation door is in position B, only inside air is allowed to enter the air conditioner heater case. If the outside recirculation door is stuck in position A, outside air is drawn into the air conditioner heater case and there is no leakage of in-car air past this door.

All the air doors in an air conditioner heater case should move freely. When the mix position is selected on the control panel, the heater/defroster door should open about halfway.

### **3. Automatic and Semiautomatic Heating, Ventilating, and A/C Systems (4 Questions)**

### **Task D.3.1**

#### **Diagnose temperature control system problems; determine needed repairs.**

Temperature control systems for air conditioners usually are connected with heater controls. Most heater and air conditioning systems use the same plenum chamber for air distribution. Two types of air conditioning controls are used: manual/semiautomatic and automatic.

Air conditioner manual/semiautomatic temperature controls (MTC and SATC) operate in a manner similar to heater controls. Depending on the control setting, doors are opened and closed to direct airflow. The amount of cooling is controlled manually through the use of control settings and blower speed.

An automatic or electronic temperature control system maintains a specific temperature automatically inside the passenger compartment. To maintain a selected temperature, heat sensors send signals to a computer unit that controls compressor, heater valve, blower, and plenum door operation. A typical electronic control system might contain a coolant temperature sensor, in-car temperature sensor, outside temperature sensor, high-side temperature switch, low-side temperature switch, low-pressure switch, vehicle speed sensor throttle position sensor, sun load sensor, and power steering cutout switch.

The control panel is found in the instrument panel at a convenient location for both driver and front-seat passenger access. Three types of control panels may be found: manual, push-button, or touch pad. All serve the same purpose. They provide operator input control for the air conditioning and heating system. Some control panels have features that other panels do not have, such as provisions to display in-car and outside air temperature in degrees.

Usually, a microprocessor is located in the control head to input data to the programmer, based on operator-selected conditions. When the ignition switch is turned off, a memory circuit remembers the previous setting. These conditions are restored the next time the ignition switch is turned on. If the battery is disconnected, however, the memory circuit is cleared and must be reprogrammed.

Many automotive electronic temperature control systems have self-diagnostic test provisions in which an on-board microprocessor-controlled subsystem displays a code. This code (number, letter, or alphanumeric) is displayed to tell the technician the cause

of the malfunction. Some systems also display a code to indicate which computer detected the malfunction. Manufacturers' specifications must be followed to identify the malfunction display codes, since they differ from car to car.

If the in-car temperature sensor is defective, it may be sending a temperature signal that is colder than requested. This would cause the A/C temperature to be reduced to compensate for the cooler reading and thereby raise the in-car temperature. A sticking temperature blend door will cause warm air to be mixed with cool air and result in the in-car temperature being lower than the driver-selected temperature.

### **Task D.3.2**

#### **Diagnose blower system problems; determine needed repairs.**

The blower motor is usually located in the heater housing assembly. It ensures that air is circulated through the system. Its speed is controlled by a multiposition switch in the control panel. The switch works in connection with a resistor block that is usually located on the heater housing.

On some vehicles, when the engine is running, the blower motor is in constant operation at low speed. On automatic temperature control systems, the blower motor is activated only when the engine reaches a predetermined temperature. The blower motor circuit is protected by a fuse located in the fuse panel. The fuse rating is usually 20 to 30 amperes.

The blower motor resistor block is used to control the blower motor speed. The typical resistor block is composed of three or four wire resistors in series with the blower motor, which control its voltage and current. The speed of the motor is determined by the control panel switch, which puts the resistors in series. Increasing the resistance in the system slows the blower speed.

If the blower does not operate, use a test light to make sure there is voltage on both sides of the fuse. Then, check to see if current is arriving at the motor. On cars where the blower motor is behind the inner fender shell, hunt out the wiring and check for current. If the blower motor is getting current, the problem is either a burned out blower motor or a bad ground on the motor. In situations where no current is available at the motor, backtrack to check for an open resistor. Check also for burned or corroded connections in the blower relays or bulkhead connectors. An open blower motor ground would cause the motor not to run at all. If the correct amount of voltage is available to the motor and the ground is good, suspect a bad motor.

### **Task D.3.3**

#### **Diagnose air distribution system problems; determine needed repairs.**

With the temperature selector in the cool position, the incoming air should be the same temperature as that of the outside air. A stuck blend door would cause the incoming air to be heated with the temperature selector in the cool position.

With VENT selected on the control panel, air is directed to the vents as normal. When the accelerator pedal is more than  $\frac{3}{4}$  depressed, the air is directed to the defrost vents. This would not be caused by a stuck air door. This could be caused by a bad check valve between the vacuum reservoir tank and the supply vacuum.

### **Task D.3.4**

#### **Diagnose compressor clutch control system; determine needed repairs.**

If the A/C pressure cutoff switch is stuck open, the compressor clutch will not engage. If the compressor clutch coil is shorted to ground, the compressor clutch will not engage. If the compressor clutch coil has an open in its windings, the compressor clutch will not engage. If the compressor clutch coil positive wire is shorted to a 12-volt source, the compressor clutch will not disengage.

If a compressor clutch circuit fuse is open, there is no voltage supplied to the circuit. The PCM grounds the clutch control relay winding. An open circuit would make it impossible for the PCM to ground a relay winding.

**Task  
D.3.5**      **Inspect, test, and adjust or replace climate control temperature and sun-load sensors.**

The in-vehicle sensor is a thermistor. As temperature increases, resistance decreases; as temperature decreases, resistance increases. Resistance is at a maximum when the temperature in the vehicle is cold. As the temperature of the in-vehicle sensor increases, the sensor resistance should decrease.

A sun-load sensor usually cannot be adjusted. The outside air temperature sensor does not affect the sun-load sensor calibration. Therefore, if the sun-load sensor does not function, its diagnosis would be simple.

**Task  
D.3.6**      **Inspect, test, adjust, and replace temperature blend door actuator.**

On vehicles with a blend air reheat system and during heater-only operation, the air conditioning unit is shut off, and the evaporator performs no function in air distribution or temperature control. During maximum air or extreme cold air, the air conditioning system operates, the evaporator is cold, and the blend air door damper is completely closed. Only conditioned air enters the car.

As the control lever is moved in the vehicle from max air toward heat with the air conditioner on, the blend air door is moving. In maximum cold, it is completely shut. On maximum hot, it is completely open. The water valve on this unit is a vacuum on/off unit to regulate water flow. Normal position would be open. This type of blend air system is extremely popular and can be used with or without a water valve.

To check the proper functioning of the ductwork, move the temperature control lever to see if any change occurs. If it does not, shut off the air conditioner and turn on the heater. Move the temperature control arm again to see if any change occurs. If not, check the cable and the flap door connected to the temperature control lever. You might be able to reach under the dash to reconnect the cable or free a stuck flap.

If no substantial airflow is coming out of the registers, check the fuses in the blower circuit. Remove the fan switch and test it. Check the blower motor by hot-wiring it directly to the battery with jumper cables.

In some systems, the temperature blend door is controlled by an electric door actuator that is controlled by an A/C computer. In some A/C systems, the temperature blend door is controlled by a vacuum actuator that may be called a power servo in which a varying vacuum is supplied. It operates the solenoid or solenoids controlled by the A/C computer.

**Task  
D.3.7**      **Inspect, test, and replace low engine coolant temperature blower control system.**

The engine coolant temperature sensor is a thermistor. The thermistor is a resistor whose value varies with its temperature. Resistors may be checked with either an analog or digital ohmmeter without harm, though a digital meter is suggested.

Some blower motor circuits have a low temperature cutoff switch that opens the blower motor circuit below a specific temperature. If the A/C controls are placed in the defrost mode, the low temperature cutoff switch is bypassed and the blower operates normally.

**Task  
D.3.8**      **Inspect, test, and replace heater water valve and controls.**

If the coolant control valve was defective, the hose between it and the heater core would not be hot. The indication is that hot coolant is passing the control valve but not exiting the heater core. Therefore, the heater core may be clogged and should be cleaned or replaced.

Coolant control valves are not hydraulically controlled and therefore could not be low on fluid. These valves are usually mechanically, electrically, or vacuum controlled. When the maximum A/C mode is selected, the valve is usually closed to maximize the cooling effect.

**Task  
D.3.9****Inspect, test, and replace electric and vacuum motors, solenoids, and switches.**

When a fault code is obtained representing the temperature blend door, the first step in the diagnostic procedure should be to check the temperature blend door for a sticking condition.

A seized water control valve, a plugged vacuum hose between the solenoid and the valve, or a jammed actuator linkage may cause the water control not to move with 16 in. Hg (47.3 kPa absolute) supplied to the solenoid. Since the solenoid provides an audible click, the solenoid plunger is not sticking.

If the throttle position solenoid is thought to be defective, it should be checked to determine if the engine idle speed changes when the transmission is shifted into any gear. The throttle position solenoid is used to increase the curb idle speed to compensate for extra loads placed on the engine, such as when the air conditioner is turned on or the transmission is shifted into gear. This is required to ensure smooth engine idle and adequate emission control.

**Task  
D.3.10****Inspect, test, and replace ATC control panel.**

If a code is pulled for a bad ambient temperature sensor, and the resistance reading in the temperature sensor and connecting wires is normal, the only other component in this circuit is usually the A/C control panel. This unit must be the problem.

ATC control panels are not repaired and are replaced as a unit. Care needs to be taken when replacing these units. Like the other electronic circuits on a vehicle, the control panel may be part of the BCM circuit. Follow all precautions to eliminate static and voltage spikes at the BCM.

**Task  
D.3.11****Inspect, test, adjust or replace ATC microprocessor (climate control computer/programmer).**

The electronic control module (ECM) is dedicated to the microprocessor-controlled climate control system. The body computer module (BCM) regulates all vehicle functions. The ECM is unlike the BCM, which regulates all vehicle functions. While most ECMs are located behind the control head, some may be located with the BCM.

If heat is required in a vehicle with automatic temperature control and an engine temperature below 120°F (49°C), the air is discharged from the defrost outlets at low blower speed until the engine warms up.

**Task  
D.3.12****Check and adjust calibration of ATC system.**

The specified voltage drop across computer ground wires usually is 0.1 V. Anything above that would indicate a bad ground or open wire causing a high resistance. With the low voltages used on computer controlled climate systems, a voltage drop that is higher could cause a problem with the system.

To adjust an electronic actuator on a computer-controlled air conditioning system, you have to place the air conditioner controls in the specified mode, move the slide link by hand to the specified door position, and rotate the actuator to the specified position.

The ATC system may be "out of calibration" due to a defective in-car sensor or a restricted aspirator. There are three main automatic temperature control (ATC) component groups: the sensors and control head (panel) resistors, the programmer, and the control servo motors. If any of these components are defective or out of specifications, overall performance of the ATC system may suffer.

## E. Refrigerant Recovery, Recycling, and Handling (7 Questions)

### Task E.1 **Maintain and verify correct operation of certified equipment.**

Air conditioning (A/C) recovery/recycling equipment must have a UL approval and SAE J1991 approval, and refrigerant oils for R-12 and R-134a must not be mixed. The refrigerant container specified by the recovery/recycling equipment manufacturer must be used in this type of equipment to ensure that the container has proper capacity and valving.

Refrigerant recovery/recycle equipment must have UL approval and meet SAE standard J1991. The federal Clean Air Act (CAA), Section 609, established the law that anyone who performs a service involving refrigerant in an automobile air conditioning system must be properly certified. In addition, all equipment used in this service must have a label certifying that it is UL approved and meets SAE standard J1991.

### Task E.2 **Identify and recover A/C system refrigerant.**

If, after the recovery process, the low-side gauge rises above 0 psi, there is still some refrigerant remaining in the system. The system should be evacuated until there is no pressure left in the system.

The container used for recycled refrigerant R-12 is stamped DOT4BA. The storage containers for recycled R-12 refrigerant must qualify for DOT CFR Title 49. Such a container is stamped DOT4BA or DOT4BW for identification.

### Task E.3 **Recycle or properly dispose of refrigerant.**

If the moisture warning light is yellow during the recycling process, the refrigerant contains excessive moisture and the filter/dryer cartridge in the recovery/recycling equipment must be changed.

When using refrigerant recovery systems and CPL is displayed on the recovery equipment, the display flashes the amount of refrigerant and oil recovered from the system.

A multipass system may not complete all recycling stages before storing the refrigerant. UL approval is required of all recovery/recycle equipment. SAE standard J1991 is also required. There are two types of UL-approved recycle equipment; single pass and multipass. A single pass system will not remove all contaminants. A multipass system will, however, clean and dry refrigerant to standards for reuse before dispensing it.

### Task E.4 **Label and store refrigerant.**

Refrigerant storage containers must be filled to 60 percent of their gross weight rating. Refrigerant storage containers must be evacuated to 17 in. Hg (43.9 kPa absolute) before refrigerant is placed in the container.

When storing recovered refrigerant, a DOT4BW cylinder needs to be used. Refrigerant should never be stored in anything else. A DOT 39 cylinder is not safe to use for storing recovered refrigerant.

### Task E.5 **Test recycled refrigerant for noncondensable gases.**

When checking a refrigerant container for noncondensable gases, the container should be stored out of the presence of sunlight at 65°F (18°C) for 12 hours, and a thermometer should be placed 4 inches (102 mm) from the container surface. If the container pressure is less than specified, the refrigerant is ready for use.

Before testing recycled refrigerant for noncondensable gases, the portable refrigerant cylinder should be placed in a relatively cool area, out of direct sunlight, for no less

than 12 hours. The ambient temperature may be as low as 65°F (18°C). Compare the temperature and pressure reading with an appropriate pressure limit chart.

## **Task E.6**

### **Follow federal and local guidelines for retrofit procedures.**

Converting a R-12 system to use R-134a can be done if all federal and local regulations are met. Typically the R-12 system must be thoroughly purged and flushed to remove all traces of R-12. Because R-134a operates at higher pressures than R-12, new refrigerant hoses, designed for those higher pressures, must be used. Different systems require that different components be changed as well.

After the conversion has been completed, the system must be labeled as a R-134a system. All standard or required service procedures (such as reclaiming) must be followed during conversion.



# 5

## Sample Test for Practice

### Sample Test

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*Please note the letter and number in parentheses following each question. They match the overview in section 4 that discusses the relevant subject matter. You may want to refer to the overview using this cross-referencing key to help with questions posing problems for you.*

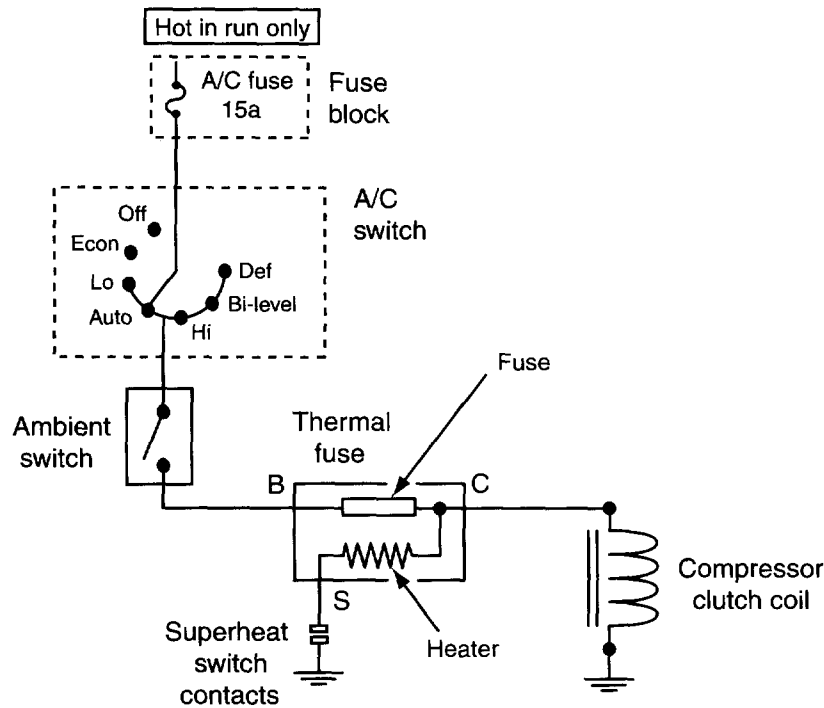
1. Technician A says that a defective clutch bearing may be the cause of a noise coming from the compressor when it is running. Technician B says if the noise stops when the compressor is not running, the clutch bearing is defective and should be replaced. Who is right?
  - A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B(A.1)
2. If the air conditioning system has an accumulator, it is a:
  - A. thermostatic expansion valve system.
  - B. fixed orifice tube system.
  - C. receiver dryer system.
  - D. throttling suction valve system.(A.2)
3. The sight glass in a R-12 refrigerant system contains bubbles. The ambient temperature is 75°F (23.9°C). Technician A says this is a normal condition at the present ambient temperature. Technician B says the refrigerant system charge might be low and/or the system might contain air. Who is right?
  - A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B(A.3)
4. A check of the A/C system with a manifold and gauge set indicates that, after 15 minutes of operation, the low side is in a vacuum with a below zero gauge pressure. Technician A says the low pressure switch is defective. Technician B says that the fixed orifice tube may be clogged. Who is right?
  - A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B(A.4)

5. A heavy ice buildup is noted on the thermostatic expansion valve. The sight glass appears to be clear. Technician A says the thermostatic expansion valve is the coldest part in the system and the condition is normal. Technician B says there is obviously a restriction in the receiver/dryer since no refrigerant is noted flowing in the sight glass. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (A.5)
6. Technician A says that a halogen leak detector may be used to pinpoint a minor R-12 refrigerant leak. Technician B says that the halogen leak detector cannot be used for an R-134a system. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (A.6)
7. Technician A says that if an air conditioning system is equipped with ¼-inch SAE service fittings, it is charged with R-12 refrigerant. Technician B says if the vehicle does not have labels to the contrary, it may be assumed that the system is charged with R-12 refrigerant. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (A.7)
8. System evacuation is being discussed. If the system pressure rises after the vacuum pump is turned off, Technician A says there may still be refrigerant in the system. Technician B says there may be a leak in the system. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (A.8)
9. Condenser cleaning is being discussed. Technician A says that a stiff bristle brush may be used to clean a condenser. Technician B says a steam cleaner is most effective for cleaning a condenser. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (A.9)
10. Technician A says the air conditioner may be charged through the high side with the system running as long as the refrigerant container is not inverted. Technician B says inverting the container causes low-pressure refrigerant vapor to be discharged into the system. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (A.10)

11. Technician A says that the oil level of some compressors may be checked with the use of a dipstick. Technician B says the oil must be drained from some compressors and measured in a beaker. Who is right?
  - A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B

(A.11)
  
12. There is oil around the high-pressure relief valve of the air conditioning system. Technician A says the air passages through the condenser may be restricted. Technician B says the refrigerant system may have been overcharged. Who is right?
  - A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B

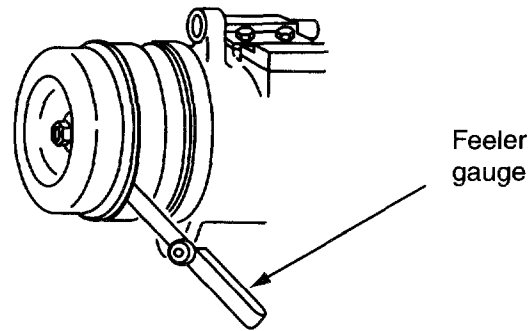
(B.1.1)



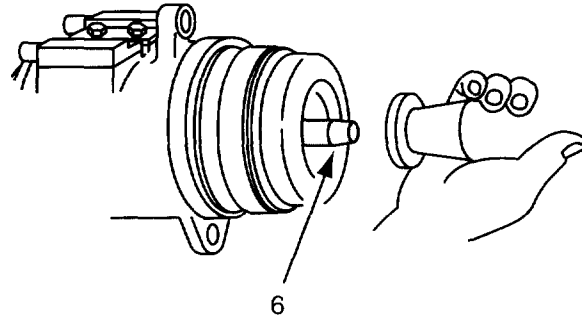
13. In the A/C system shown in the figure, the ignition switch is on, and the A/C switch is in the AUTO position. The ambient temperature is 75°F (24°C), and the compressor clutch is inoperative. There are 12 volts at Terminals B, C, and S on the thermal fuse. The cause of the inoperative compressor clutch could be:
  - A. an open thermal fuse.
  - B. an open compressor clutch coil.
  - C. a defective superheat switch.
  - D. a defective thermal fuse heater.

(B.1.2)
  
14. On a vehicle with V-belts, an intermittent squealing noise is heard on acceleration with the A/C control switch in the on or off position. The most likely cause of this problem is:
  - A. a loose power steering belt.
  - B. a loose A/C compressor belt.
  - C. a loose air pump belt.
  - D. a worn A/C compressor pulley bearing.

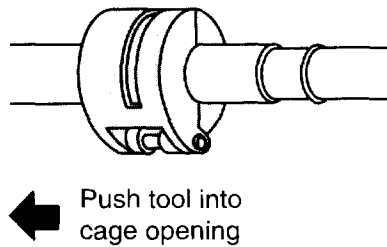
(B.1.3)



15. The measurement in the figure is above specification. Technician A says if this clearance is not within specs, an intermittent scraping noise may be noticed with the engine running and the compressor clutch engaged. Technician B says to correct this condition another shim should be added behind the pulley armature plate. Who is right?
- A only
  - B only
  - Both A and B
  - Neither A nor B
- (B.1.4)
16. When replacing an A/C compressor, the refrigerant system is discharged and 2 oz. (59 ml) of oil is recovered from the system. When the old compressor is removed, 2 oz. (59 ml) of oil is drained from the compressor. The amount of oil drained from the new compressor is 6 oz. (177.4 ml). When the new compressor is installed, the amount of oil added to the compressor should be:
- 1 oz. (29.6 ml)
  - 2 oz. (59 ml)
  - 4 oz. (118.3 ml)
  - 6 oz. (177.4 ml)
- (B.1.5)
17. A compressor is noisy when the clutch is engaged, and the noise stops when the clutch is disengaged. Technician A says the problem may be internal. Technician B says the problem may be external. Who is right?
- A only
  - B only
  - Both A and B
  - Neither A nor B
- (B.1.6)

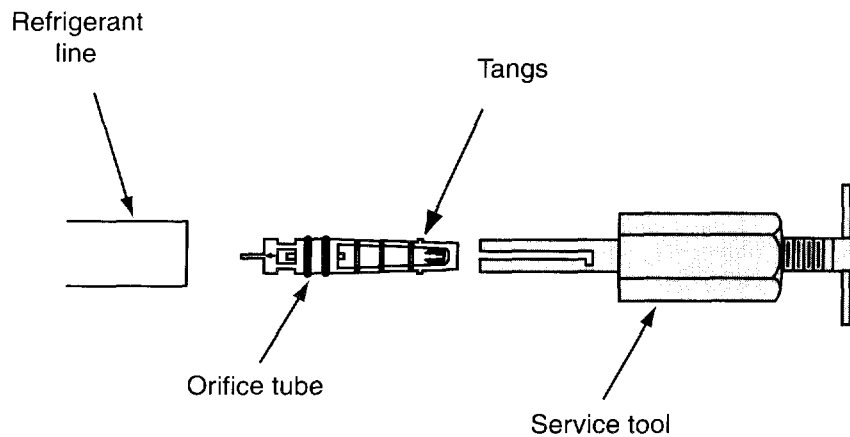


18. Technician A says that the component shown in the figure is a seal protector that is placed over the compressor shaft. Technician B says the seal seat O-ring must be installed before the compressor shaft seal. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (B.2.1)



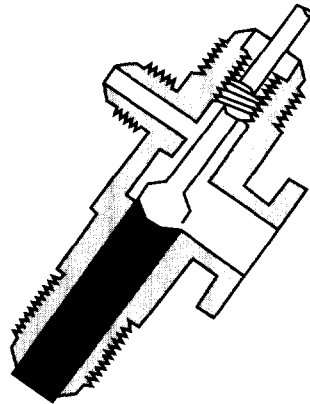
19. When servicing refrigerant lines, the tool shown in the figure is used to:
- A. disconnect spring lock couplings.
  - B. connect spring lock couplings.
  - C. connect and disconnect spring lock couplings.
  - D. crimp male bare-type fittings.
- (B.2.1)
20. Condenser airflow is being discussed. Technician A says a defective fan clutch will reduce ram airflow. Technician B says reduced airflow across the condenser results in low suction pressure in the system. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (B.2.2)
21. The head pressure is excessively high for a thermal expansion valve (TXV) system. There is frosting on the condenser before the receiver/dryer near the outlet of the condenser. Technician A says the system may be overcharged with refrigerant. Technician B says there may be a restriction in the condenser. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (B.2.3)

22. A receiver/dryer is located between the condenser and evaporator. Technician A says the receiver/dryer should be changed if the outlet is colder than the inlet. Technician B says the receiver/dryer should be changed if the refrigerant in the sight glass appears red. Who is right?
- A only
  - B only
  - Both A and B
  - Neither A nor B
- (B.2.4)
23. An A/C system blows cool air when the vehicle is started with an ambient temperature of 80°F (26.7°C). After the vehicle is driven for about 10 mi. (16 km), the system stops blowing cool air, and the thermal expansion valve (TXV) is frosted. When the A/C system is shut off for five minutes and turned on again, it blows cool air for another 10 mi. (16 km). The most likely cause of this problem is:
- a defective thermal expansion valve (TXV) capillary tube.
  - a refrigerant overcharge.
  - a restricted condenser refrigerant passage.
  - moisture in the refrigeration system.
- (B.2.5)



24. All of the following statements are true about using the tool shown in the figure to remove a complete orifice tube assembly EXCEPT:
- Pour a small amount of refrigerant oil on top of the orifice tube to lubricate the O-rings.
  - Rotate the T-handle to engage the notch in the tool in the orifice tube tangs.
  - Rotate the T-handle to remove the orifice tube from the evaporator inlet pipe.
  - Hold the T-handle and rotate the outer sleeve on the tool to remove the orifice tube.
- (B.2.6)
25. Technician A says that restricted refrigerant passages in the evaporator may cause frosting of the evaporator outlet pipe. Technician B says restricted refrigerant passages in the evaporator may cause much higher than specified low-side pressures. Who is right?
- A only
  - B only
  - Both A and B
  - Neither A nor B
- (B.2.7)

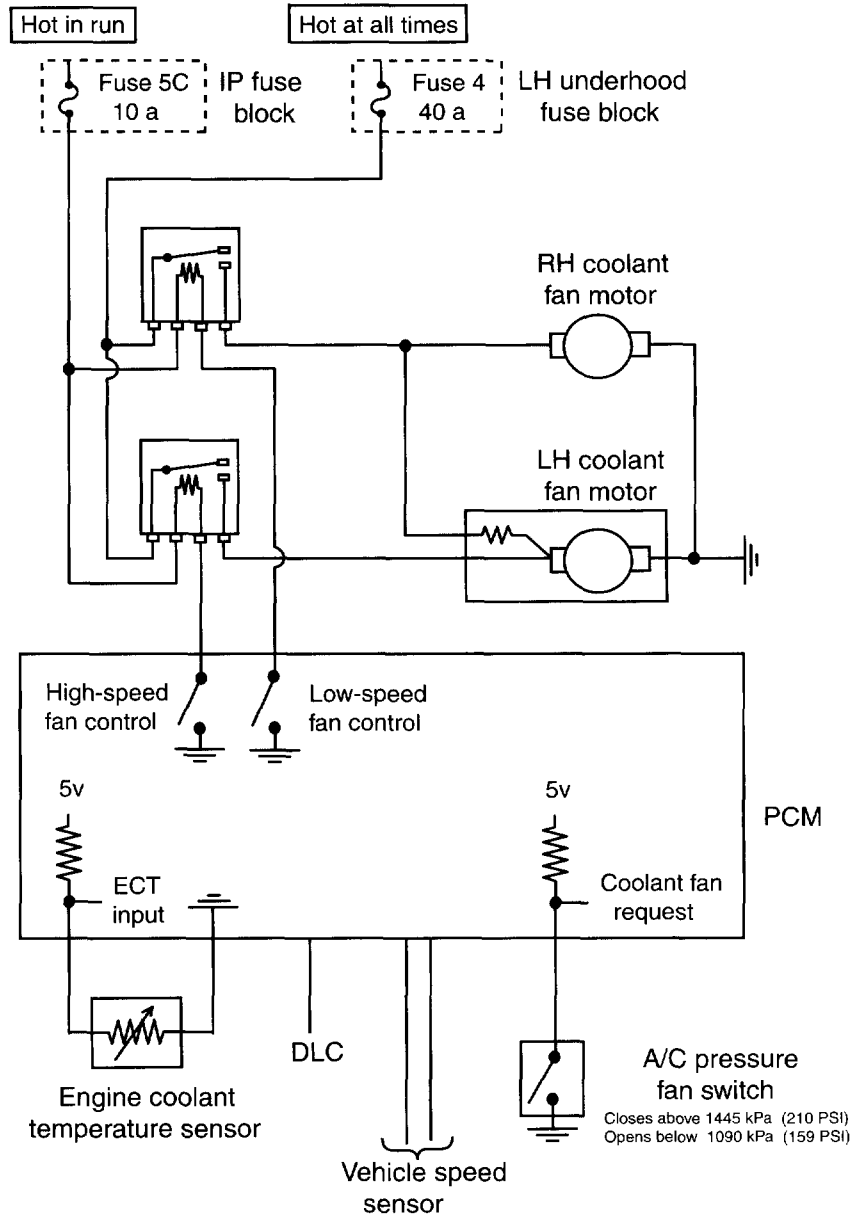
26. The inside of the windshield has an oily film, and the A/C cooling is inadequate. Technician A says this oily film may be caused by a plugged A/C heater case drain. Technician B says this oily film may be caused by a leak in the evaporator core. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (B.2.8)
27. While discussing refrigerant systems with a suction throttling valve (STV), pilot operated absolute (POA) valve, or evaporator pressure regulator (EPR) valve, Technician A says that on some of these refrigerant systems, the compressor runs continually in the A/C mode. Technician B says an excessive pressure drop across the EPR valve indicates that the valve is sticking open. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (B.2.9)



28. With a stem-type service valve in the position indicated in the figure:
- A. the refrigerant system may be diagnosed with a manifold gauge set.
  - B. the refrigerant system operates normally with no pressure at the gauge ports.
  - C. the refrigerant system is isolated from the compressor for compressor removal.
  - D. the refrigerant system may be discharged, evacuated, and recharged.
- (B.2.10)
29. An A/C compressor high-pressure release valve discharges refrigerant at approximately:
- A. 200 psi (1,379 kPa).
  - B. 325 psi (2,240 kPa).
  - C. 375 psi (2,585 kPa).
  - D. 475 psi (3,275 kPa).
- (B.2.11)
30. The discharge air temperature is higher than specified in an A/C heater system with a coolant flow control valve with the system operating in the maximum A/C mode. Technician A says the coolant flow control valve may be stuck open. Technician B says the coolant flow control valve vacuum hose may have a leak. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (C.1)

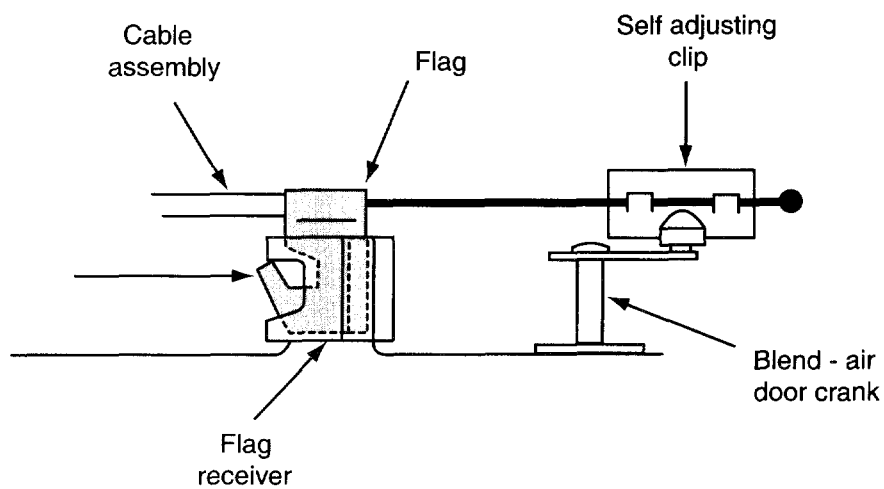
31. The inside of the windshield has a sticky film. Technician A says the engine coolant level should be checked. Technician B says the heater core may be leaking. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (C.2)
32. A customer complains about engine coolant loss. The cooling system is pressurized at 15 psi (103 kPa) for 15 minutes. There is no visible sign of coolant leaks in the engine or passenger compartments, but the pressure on the tester gauge decreases to 5 psi (34 kPa). This problem could be caused by any of the following defects EXCEPT:
- A. a leaking heater core.
  - B. a leaking transmission cooler.
  - C. a leaking head gasket.
  - D. a cracked cylinder head.
- (C.3)
33. The vacuum valve in the radiator cap is stuck closed. The result of this problem could be:
- A. an upper radiator hose collapsed after the engine was shut off.
  - B. excessive cooling system pressure at normal engine temperature.
  - C. engine overheating when operating under a heavy load.
  - D. engine overheating during extended idle periods.
- (C.4)
34. The coolant level in the coolant recovery container is normal when the engine is cold. This level becomes much higher than normal after the vehicle has been driven for 45 minutes. Technician A says some of the radiator tubes may be restricted. Technician B says the radiator cap may be defective. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (C.5)
35. A port-fuel-injected engine has an excessively rich air:fuel ratio. This problem could be caused by:
- A. engine overheating.
  - B. a defective radiator cap.
  - C. the engine thermostat being stuck open.
  - D. the coolant control valve stuck open.
- (C.6)
36. All the following statements about cooling system service are true EXCEPT:
- A. When the cooling system pressure is increased, the boiling point is decreased.
  - B. If more antifreeze is added to the coolant, the boiling point is increased.
  - C. A good quality ethylene glycol antifreeze contains antirust and corrosion inhibitors.
  - D. Coolant solutions must be recovered, recycled, or handled as hazardous waste.
- (C.7)



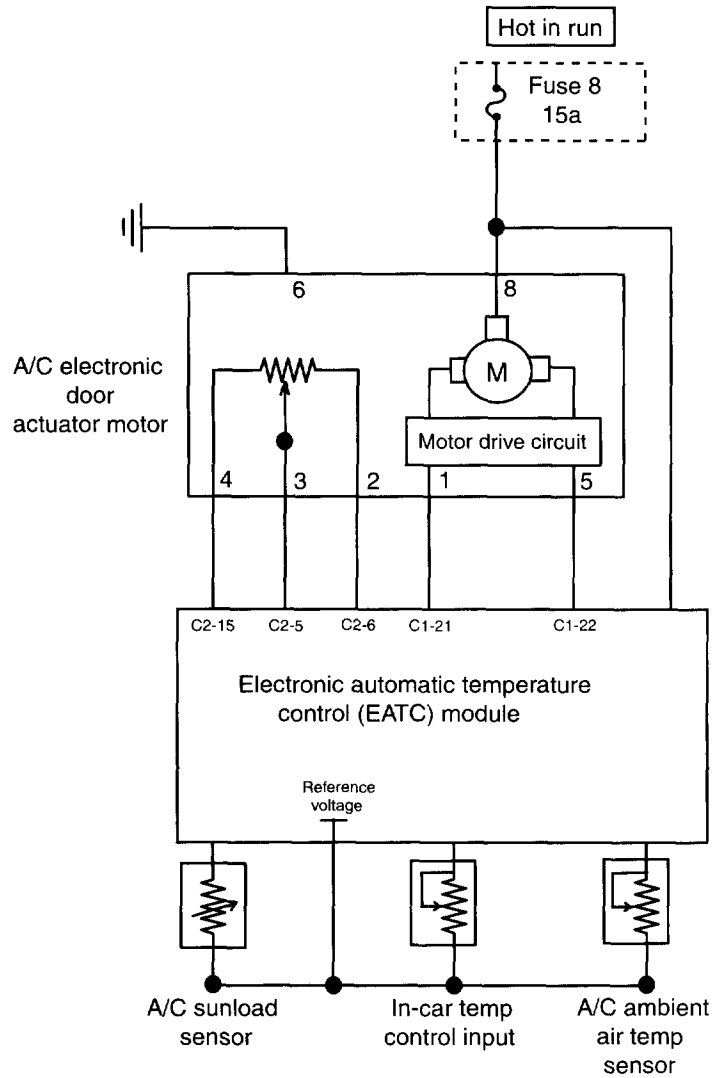


37. In the electric cooling fan circuit shown in the figure, the low-speed and high-speed fans do not operate unless the air conditioning is turned on. The cause of this problem could be:
- A. a blown 10A, 5C fuse in the instrument panel fuse block.
  - B. a defective engine coolant temperature sensor.
  - C. a defective high-speed coolant fan relay.
  - D. a defective A/C pressure fan switch.

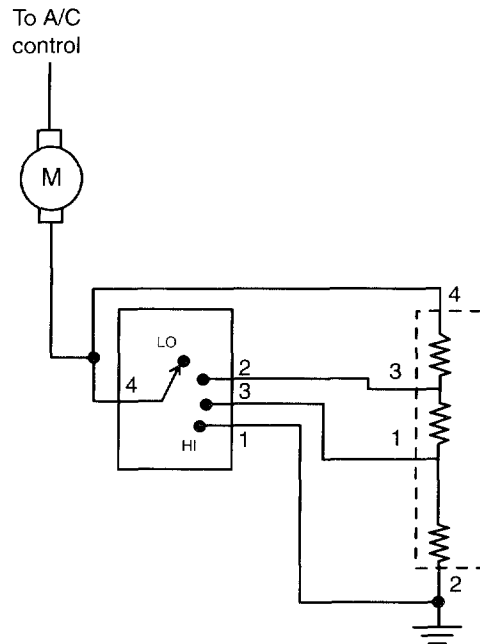
(C.8)



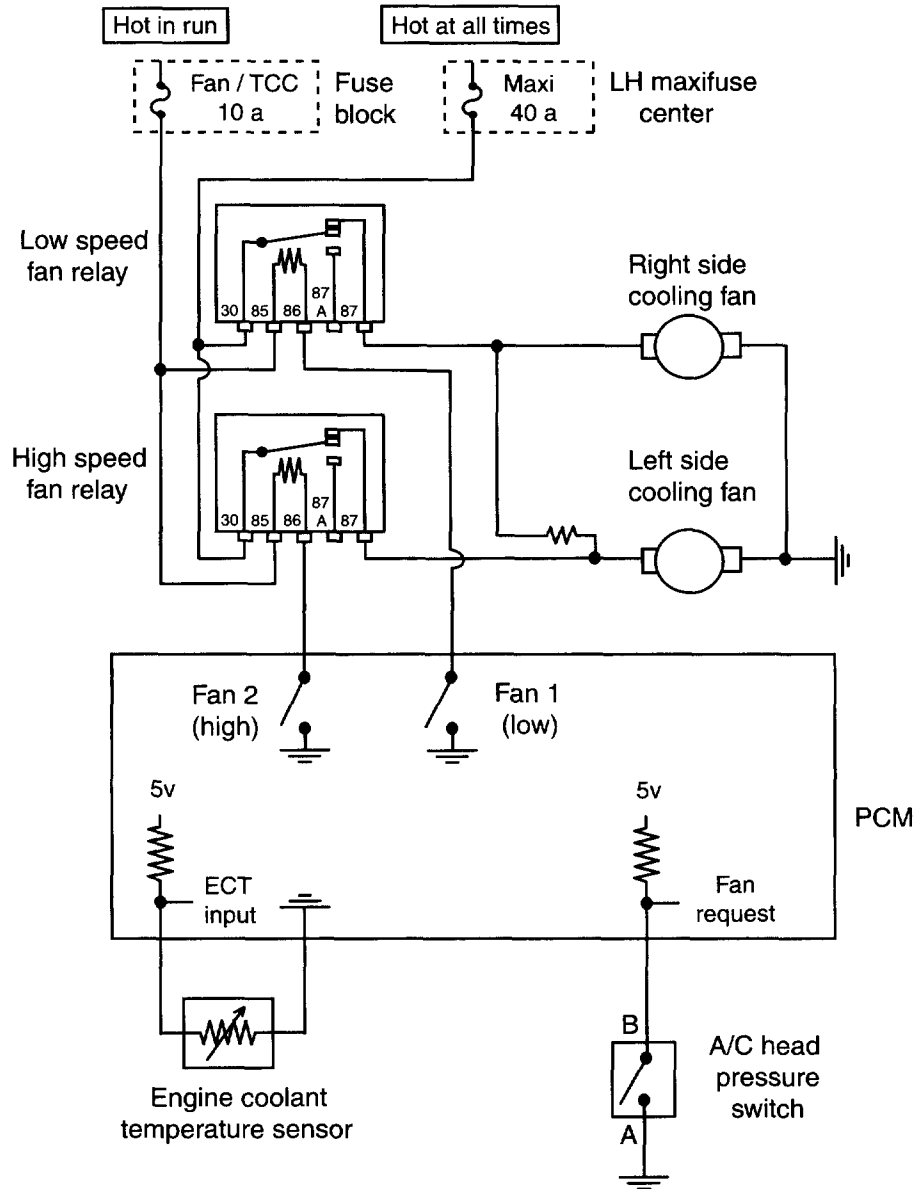
38. In the figure, the adjustment being performed is:
- A. the air mix door.
  - B. the manual coolant control valve.
  - C. the ventilation door control rod.
  - D. the defroster door control rod.
- (C.9)
39. A gurgling noise is heard inside the passenger compartment. The noise is coming from the A/C heater case. Technician A says the heater core coolant passages may be restricted. Technician B says the coolant level in the cooling system may be low. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (C.10)



40. The A/C heater system shown in the figure does not discharge cool air in the A/C mode. The refrigerant system pressures are normal. The temperature door does not move when the A/C heater controls are moved from maximum A/C to maximum heat, but the blower motor operation is normal. All of the following defects could be the cause of the problem EXCEPT:
- A. an open circuit at Terminal 6 on the electronic door actuator.
  - B. a blown 15A, 8 fuse in the fuse junction panel.
  - C. an open circuit at Terminal C2-15 in the automatic temperature control module.
  - D. an open circuit at Terminal 8 on the electronic door actuator motor. (D.1.1)

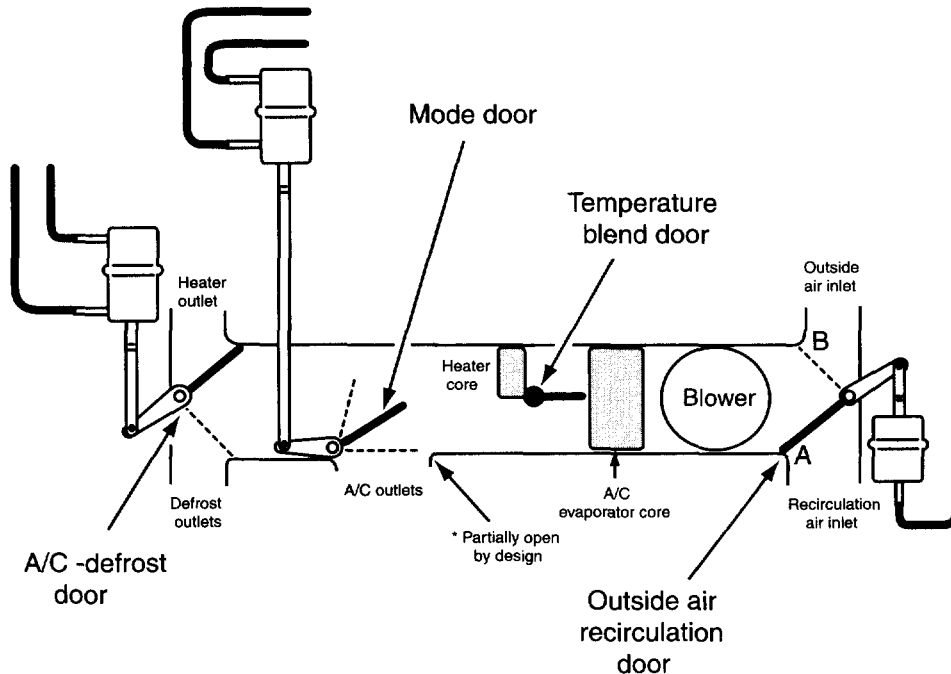


41. The blower motor shown in the figure operates at high speed but does not operate at any other speed. The cause of this problem could be:
- an open circuit at Terminal 2 in the resistor assembly.
  - an open circuit in the blower motor switch ground connection.
  - an open circuit at Terminal 4 in the blower switch.
  - an open circuit at Terminal 4 in the resistor assembly. (D.1.2)
42. The compressor clutch diode is being discussed. Technician A says its primary purpose is to prevent spikes of alternating current from the alternator from entering the coil, causing damage. Technician B says its primary purpose is to prevent spikes of high voltage from returning to delicate electronic components of the computer. Who is right?
- A only
  - B only
  - Both A and B
  - Neither A nor B (D.1.3)
43. All of the following statements are correct EXCEPT:
- When the A/C compressor engages, it requires increased effort from the engine to run the compressor. This increased effort causes a lower rpm at idle.
  - The throttle kicker is an electronic device that is typically part of the TP sensor.
  - A leaking throttle kicker diaphragm or an inoperative kicker solenoid may cause lower than specified idle rpm and engine stalling with the A/C on.
  - The throttle kicker maintains idle speed during warm-up. (D.1.4)
44. Load-sensitive compressor cutoff switches are being discussed. Technician A says that some vehicles have a rpm or throttle position sensor that disengages the A/C compressor during times of heavy load. Technician B says some vehicles have a power steering cutoff switch to disengage the A/C compressor when the power steering requires maximum effort. Who is right?
- A only
  - B only
  - Both A and B
  - Neither A nor B (D.1.5)



45. The cooling fan system shown in the figure, operates normally on high speed, but there is no low-speed fan operation under any operating condition. The cause of this problem could be:
  - A. an open circuit in the wire between the number 30 Terminals in the two fan relays.
  - B. a blown 40 amp maxifuse in the LH maxifuse center.
  - C. a blown 10 amp cooling fan/TCC fuse in the fuse block.
  - D. an open circuit at Terminal B on the A/C head pressure switch. (D.1.6)
  
46. All of the following statements about computer-controlled A/C system actuator motors are true EXCEPT:
  - A. Some actuator motors are calibrated automatically in the self-diagnostic mode.
  - B. A/C system and component problems do not produce diagnostic trouble codes.
  - C. The actuator motor control rods must be calibrated manually on some systems.
  - D. The actuator motor control rods should only require calibration after motor replacement or misadjustment. (D.1.7)

47. All of the following statements about A/C-heater control panel service are true EXCEPT:
- A. The negative battery cable must be disconnected before A/C control panel removal.
  - B. The refrigeration system must be discharged before the A/C control panel is removed.
  - C. If the vehicle is air-bag-equipped, wait the specified time period after negative battery cable disconnected.
  - D. Self-diagnostic tests may indicate a defective A/C control panel in a computer-controlled A/C system. (D.1.8)
48. While checking a problem with a particular vacuum control, it is noted that none of the vacuum controls are operational with the engine running at idle speed. Technician A says that the engine may have problems and has too much vacuum at idle speed. Technician B says the manifold vacuum fitting may be restricted. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B (D.2.1)
49. A typical control panel assembly controls all of the following EXCEPT the:
- A. compressor.
  - B. heater valve.
  - C. plenum door.
  - D. coolant temperature. (D.2.2)
50. An inoperative Bowden cable-controlled heater control valve is being discussed. The control moves freely, but the valve does not respond. Technician A says the cable housing clamp may be loose at the control head (panel) end. Technician B says the cable may be rusted in the housing. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B (D.2.3)
51. The recirculate door is inoperable. Any of the following may be the problem EXCEPT a:
- A. split, broken or disconnected hose.
  - B. clogged or blocked restrictor.
  - C. restricted or open check valve.
  - D. cracked or broken vacuum tank. (D.2.4)
52. An A/C system has a vacuum reservoir, a check valve, and a vacuum-operated mode door actuator including the blend-air door. While operating in the A/C mode and climbing a steep hill with the throttle nearly wide open, the air discharge temperature gradually becomes warm, and the air discharge switches from the panel to the floor ducts. The A/C system operates normally under all other conditions. The cause of this problem could be:
- A. a leaking panel door vacuum actuator.
  - B. a defective vacuum reservoir check valve.
  - C. a leaking blend-air door vacuum actuator.
  - D. a leaking intake manifold gasket. (D.2.5)

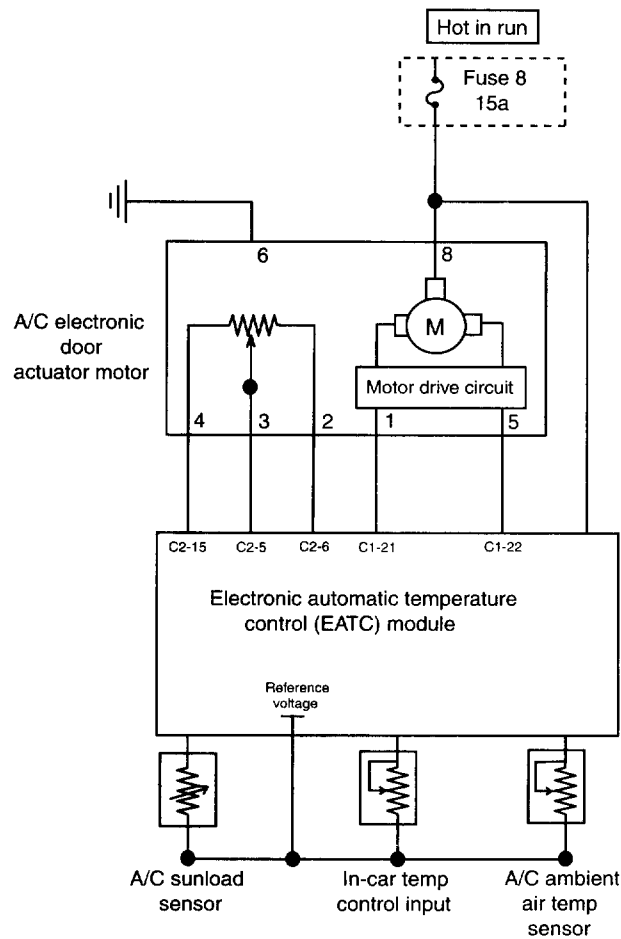


53. In the figure, the air-recirculation/fresh air door is stuck in position "A". Technician A says under this condition outside air is drawn into the A/C-heater case. Technician B says under this condition some in-vehicle air leaks past the door. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (D.2.6)
54. On a semiautomatic A/C system the temperature control is set at 70°F (21°C), and the in-car temperature is 80°F (27°C) after driving the car for 1 hour. The refrigerant system pressures are normal. Technician A says the in-car sensor may be defective. Technician B says the temperature door may be sticking. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (D.3.1)
55. The blower motor operates only on high speed. Technician A says the high blower relay may be defective. Technician B says the blower motor high-speed resistor may be defective. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (D.1.2)
56. In the vent position and with the temperature selector in the cool position, the incoming air is heated. What could be the problem?
- A. The cooling fan is inoperative.
  - B. There is low coolant in the radiator.
  - C. The heater core is clogged.
  - D. An air blend door is stuck.
- (D.3.3)

57. The compressor clutch will not disengage. The problem could be that:
- A. the A/C pressure cutoff switch is stuck open.
  - B. the compressor clutch coil is shorted to ground.
  - C. the low-pressure switch has an open wire.
  - D. the compressor coil positive wire is shorted to a 12 volt source. (D.3.4)
58. When discussing in-vehicle temperature sensor testing with an ohmmeter, Technician A says that as the sensor temperature increases, the sensor resistance should decrease. Technician B says at 50°F (10°C) the sensor should have minimum resistance. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B (D.3.5)
59. When filling an A/C system recovery container with recovered refrigerant, the percentage of capacity that the container may be filled to is:
- A. 50 percent
  - B. 60 percent
  - C. 70 percent
  - D. 80 percent (E.4)
60. Technician A says the engine coolant temperature sensor is a thermistor. Technician B says the engine coolant temperature sensor should not be tested with an analog meter. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B (D.3.7)
61. The heater water valve is being checked. The inlet hose between the control valve and heater core is hot, and the outlet hose is cool. Technician A says the coolant control valve may be defective and should be cleaned or replaced. Technician B says the heater core may be clogged and should be cleaned or replaced. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B (D.3.8)
62. When diagnosing a computer-controlled A/C system, a diagnostic trouble code (DTC) is obtained indicating a fault in the temperature blend door actuator motor. Technician A says the first step in the repair procedure is to replace the temperature blend door actuator. Technician B says to disconnect the battery and test the system again. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B (D.3.9)



63. The automatic temperature control (ATC) panel is being discussed. The computer does not remember previous settings when the vehicle is turned off and restarted. Technician A says the manufacturer's diagnostic tester must be used to determine the problem. Technician B says if the control panel is bad, it should be replaced. Who is right?  
 A. A only  
 B. B only  
 C. Both A and B  
 D. Neither A nor B (D.3.10)
64. Technician A says an electronic control module (ECM) is dedicated to the operation of a microprocessor-controlled climate control system. Technician B says the body computer module (BCM) serves the same functions as the ECM. Who is right?  
 A. A only  
 B. B only  
 C. Both A and B  
 D. Neither A nor B (D.3.11)



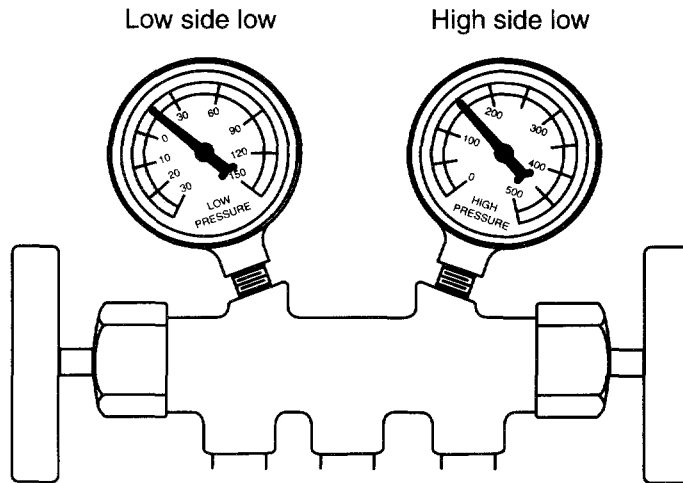
65. When measuring the resistance in the A/C computer ground shown in the figure, a voltmeter is connected from computer Terminal C1-24 to ground. With the ignition switch on, the maximum voltage reading should be:  
 A. 0.1V.  
 B. 0.2V.  
 C. 0.5V.  
 D. 0.8V. (D.3.12)

66. All of the following statements about A/C recovery/recycling equipment are true EXCEPT:
- A. The equipment label must indicate UL approval.
  - B. The equipment label must indicate SAE J1991 approval.
  - C. Any size and type of refrigerant storage container over 10 lb.(4.8 kg) may be used in this equipment.
  - D. R-12 and R-134a refrigerants or refrigerant oils must not be mixed in the recovery/recycling process. (E.1)
67. After the recovery process, the low-side pressure increases above zero after five minutes. This condition indicates:
- A. there is still some refrigerant in the system.
  - B. there is excessive oil in the refrigerant system.
  - C. the refrigerant system is leaking.
  - D. there is excessive moisture in the refrigerant system. (E.2)
68. The moisture warning light on the recovery/recycling equipment indicates yellow during the recycling process. This indicates:
- A. there is excessive oil in the refrigerant.
  - B. the filter/dryer cartridge on the tester must be changed.
  - C. there are excessive noncondensable gases in the refrigerant.
  - D. the vacuum pump is not producing enough vacuum. (E.3)
69. While discussing an inoperative blend air door, Technician A says to check the proper functioning of the ductwork, move the temperature control lever to see if any change at the doors occurs. If it does not, shut off the air conditioner and turn on the heater. Move the temperature control arm again to see if any change occurs. If not, check the cable and the flap door connected to the temperature control lever. Technician B says in some cases you can reach under the dash to reconnect the cable or free a stuck flap. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B (D.3.6)
70. When checking a refrigerant container for noncondensable gases:
- A. the container may be stored at 80°F (27°C) for six hours before the test.
  - B. the container may be stored near a shop window.
  - C. a thermometer should be placed against the container surface.
  - D. if the pressure is lower than specified, the refrigerant is ready for use. (E.5)
71. Technician A says if one drop of water leaks into or is added to the refrigerant, chemical changes of the refrigerant can start which may result in corrosion and the eventual breakdown of the chemicals in the system. Technician B says if refrigerant oil is mixed with the refrigerant, the system will not build up the necessary pressures to work efficiently. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B (A.6)

72. To test an air conditioning system for leaks, Technician A carefully checks all system connections and says the presence of oil around the fitting of an air conditioning line or hose is an indication of a refrigerant leak. Technician B uses a hand-held electronic leak detector that will make a buzzing noise when the probe senses refrigerant. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (A.6)
73. Technician A says if an air conditioning system has too much refrigerant oil, the performance of the system will suffer. Technician B says poor system performance can be caused by too much refrigerant in the system. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (A.2)
74. Technician A says a vacuum pump is used, before anything is disconnected, to remove the last trace of refrigerant that may be present in a system. Technician B says any air or moisture that is left inside an air conditioning system reduces the system's efficiency and eventually leads to major problems, such as compressor failure. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (A.8)
75. When the heating system delivers a low amount of heat, Technician A says the problem could be a faulty thermostat. Technician B says the problem could be an inoperative cooling fan. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (C.1)
76. All of the following statements are true EXCEPT:
- A. Refrigerant leaves the compressor as a high-pressure, high-temperature vapor.
  - B. Moisture and contaminants are removed by the receiver/dryer, where the moisture is stored until it is needed.
  - C. The expansion valve controls the flow of refrigerant into the evaporator.
  - D. Heat is absorbed from the air inside the passenger compartment by the low-pressure, warm refrigerant, causing the liquid to vaporize and greatly decrease its temperature.
- (A.5)
77. While conducting a visual inspection of an A/C system, Technician A says after the system has been on for a few minutes, check the condenser by feeling up and down the face or along the return bends for a temperature change. There should be a gradual change from cold to warm as you go from the top to the bottom. Any abrupt change indicates a restriction, and the condenser has to be flushed or replaced. Technician B says the liquid line from the receiver/dryer to the expansion valve should be warm for its entire length. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (A.5)

78. All of the following statements about refrigerants are true EXCEPT:
- A. Because R-134a is not interchangeable with R-12, separate sets of hoses, gauges, and other equipment are required to service vehicles.
  - B. Manifold gauge sets for R-134a can be identified by the light blue color on the face of the gauges.
  - C. R-134a service hoses have a black stripe along their length.
  - D. Proper identification of service equipment and hoses is important as the fittings for both R-134a and R-12 systems may be the same (A.7)
79. Which of the following oils can be used in a R-134a system?
- A. mineral oil
  - B. CCOT
  - C. ester oil
  - D. PAG (A.11)
80. Which of the following statements about possible heating system problems is NOT true?
- A. Feel the heater core inlet and outlet hoses while the engine is idling and warm with the heater temperature control on hot. If the hose downstream of the heater valve does not feel hot, the valve is not opening.
  - B. With cable-operated heater control valves, check the cable for sticking, slipping (loose mounting bracket), or misadjustment.
  - C. With valves that are vacuum operated, there should be vacuum to the valve when the heater is on.
  - D. Air pockets in the heater core can also interfere with proper coolant circulation. Air pockets form when the coolant level is low or when the cooling system is not properly filled after draining. (A.5)
81. Technician A says the desiccant in a receiver/dryer draws moisture like a magnet and it can become contaminated in less than five minutes if it is exposed to the atmosphere. Technician B says most late-model systems are not equipped with a receiver/dryer; rather, they use an **accumulator** to store excess refrigerant and to filter and dry the refrigerant. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B (B.2.4)
82. Which of the following is not recommended while converting an R-12 system to R-134a?
- A. Permanently install conversion fittings using new hose clamps around the fittings.
  - B. Install conversion labels and remove the R-12 label.
  - C. Recharge the system with R-134a to approximately 80 percent of the original R-12 charge.
  - D. Use a refrigerant identifier to make sure the system only contains R-12. (E.6)
83. To charge an air conditioning system while it is running, the refrigerant should be added to:
- A. the high side.
  - B. the low side.
  - C. both the high and low sides.
  - D. either the high or the low side. (A.10)

84. Technician A says if the suction line to the compressor is covered with thick frost, this might indicate that the expansion valve is flooding the evaporator. Technician B says the formation of frost on the outside of a line or component means there is a restriction to the flow of refrigerant. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (A.5)
85. All of the following statements about refrigerant lines are true EXCEPT:
- A. Suction lines are located between the outlet side of the evaporator and the inlet side or suction side of the compressor.
  - B. Suction lines carry the low-pressure, low-temperature refrigerant vapor to the compressor where it again is recycled through the system.
  - C. Suction lines are always distinguished from the discharge lines by touch; they are hot to the touch.
  - D. The suction line is larger in diameter than the liquid line because refrigerant in a vapor state takes up more room than refrigerant in a liquid state.
- (B.2.1)
86. Technician A says a container of refrigerant oil must be kept closed when not in use to prevent the oil from absorbing moisture. Technician B says anytime an A/C system has a leak, the system needs to be evacuated after the repair. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (A.11)
87. While converting an older R-12 system to use R-134a, Technician A replaces the compressor with one that is compatible with the new refrigerant. Technician B replaces the desiccant, hoses, gaskets, and seals with materials that are compatible with R-134a. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (E.6)
88. While connecting a manifold gauge set to an A/C system, Technician A connects the high-pressure hose to the line from the evaporator to the compressor. Technician B connects the low-pressure hose to the line from the compressor to the condenser. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (A.2)
89. All of these statements about refrigerant recovery are true EXCEPT:
- A. The recycling equipment must have shutoff valves within 12 inches of the hoses' service ends.
  - B. The shutoff valves should be open when connecting the hoses to the vehicle's air conditioning service fittings.
  - C. Recover the refrigerant from the vehicle and continue the process until the vehicle's system shows vacuum instead of pressure.
  - D. Turn off the recovery/recycling unit for at least five minutes, and then check the pressure of the system.
- (A.7)



90. While interpreting the readings on the gauges shown, Technician A says if the high-side pressure is too high, suspect air in the system, too much refrigerant in the system, a restriction in the high side of the system, and poor airflow across the condenser. Technician B says if the low-side pressure is lower than normal, suspect a faulty metering device, poor airflow across the evaporator, a restriction in the low side of the system, or the system is undercharged with refrigerant. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B

(A.2)

# 6

## Additional Test Questions for Practice

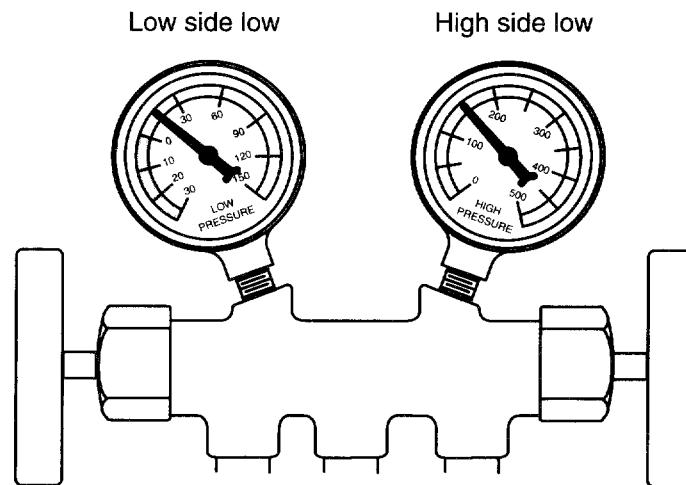
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### Additional Test Questions

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*Please note the letter and number in parentheses following each question. They match the overview in section 4 that discusses the relevant subject matter. You may want to refer to the overview using this cross-referencing key to help with questions posing problems for you.*

1. An A/C compressor has a thumping noise in the A/C mode. With the A/C off, the noise disappears. Technician A says the refrigerant system might be partially blocked. Technician B says the refrigerant system pressures might be very high. Who is right?
  - A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B(A.1)
2. An A/C compressor has a growling noise only with the compressor clutch engaged. The cause of this noise could be:
  - A. a defective internal compressor bearing.
  - B. a defective pulley bearing.
  - C. a low refrigerant charge.
  - D. excessive refrigerant pressure.(A.2)
3. The sight glass in an R-12 A/C system contains bubbles. This problem may be caused by:
  - A. moisture in the refrigerant system.
  - B. an excessive refrigerant charge.
  - C. excessive oil in the refrigerant system.
  - D. a low refrigerant charge.(A.3)



4. The gauge pressures shown in the figure occur on an R-12 thermal expansion valve (TXV), cycling clutch air conditioning (A/C) system with an ambient temperature of 80°F (26.7°C). The cause of these readings could be:
- air in the refrigerant system.
  - a defective A/C compressor.
  - a low refrigerant charge.
  - a restricted thermal expansion valve (TXV). (A.4)
5. In an R-12, thermal expansion valve (TXV), cycling clutch A/C system with an ambient temperature of 80°F (27.8°C), the low-side pressure is 55 psi (345 kPa) and the high-side pressure is 260 psi (1,793 kPa). There is no indication of frosting on any of the refrigerant system components, and the discharge air is slightly cool. Technician A says the cause of this problem may be air and moisture in the refrigerant system. Technician B says the cause of this problem may be a restricted thermal expansion valve (TXV). Who is right?
- A only
  - B only
  - Both A and B
  - Neither A nor B (A.4)
6. When a fixed orifice tube (FOT) cycling clutch A/C system is operating at 82°F (27.8°C) ambient temperature, the compressor clutch cycles seven times per minute and the evaporator outlet line is warm. There is no frost on any of the A/C system components. The cause of this problem could be:
- a low refrigerant charge.
  - a flooded evaporator.
  - a restricted accumulator.
  - an overcharge of refrigerant. (A.5)
7. An oily residue is present on the fittings of the hose connected from the compressor to the condenser. Technician A says this residue may be caused by excessive oil in the refrigerant system. Technician B says this residue may be caused by a leak at the hose fittings. Who is right?
- A only
  - B only
  - Both A and B
  - Neither A nor B (A.6)



8. Refrigerant identification is being discussed. Technician A says that R-12 is sold in white containers marked with a DOT code. Technician B says that R-134a refrigerant is sold in blue containers. Who is right?
  - A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B

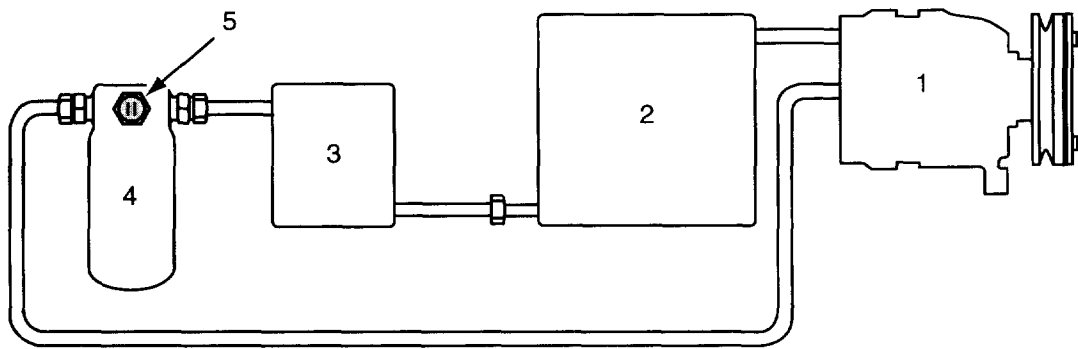
(A.7)
9. Evacuating a refrigerant system removes:
  - A. moisture from the system.
  - B. rust from the system.
  - C. dirt from the system.
  - D. desiccant particles from the system.

(A.8)
10. Technician A says that some manufacturers recommend the installation of an in-line filter between the evaporator and the compressor as an alternative to refrigerant system flushing. Technician B says an in-line filter containing a fixed orifice tube may be installed and the original orifice tube left in the system. Who is right?
  - A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B

(A.9)
11. Technician A says a high-side charging procedure should be completed with the engine running. Technician B says if liquid refrigerant enters the compressor, damage to the compressor may result. Who is right?
  - A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B

(A.10)
12. The oil required in most R-134a refrigerant systems is:
  - A. a polyalkylene glycol (PAG) oil.
  - B. a synthetic engine oil.
  - C. a synthetic mineral oil.
  - D. petroleum oil.

(A.11)

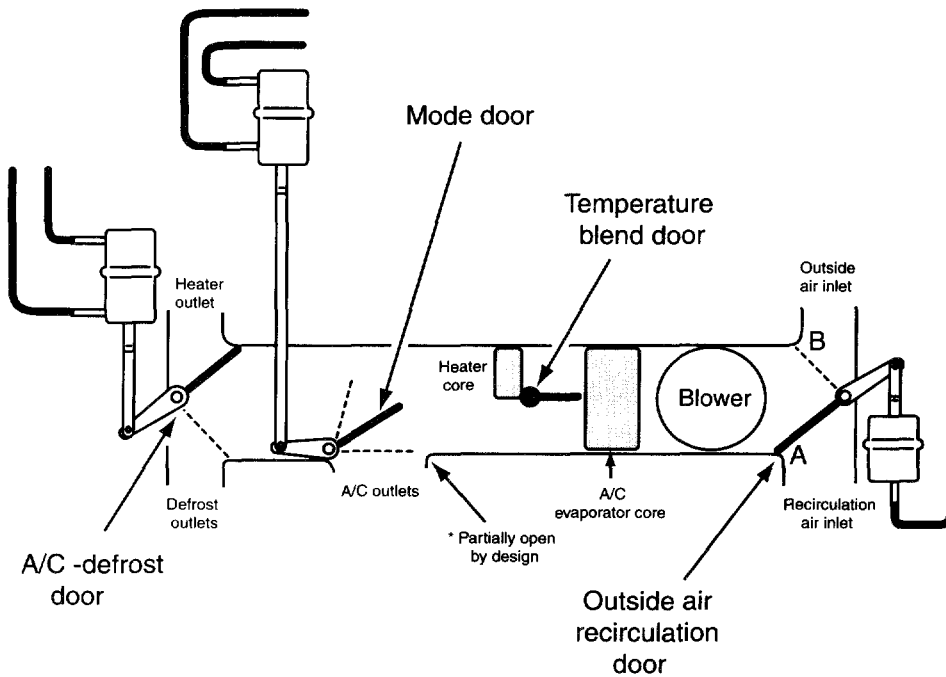


13. In the figure of the refrigerant system, Component 5 could be all of these EXCEPT:
  - A. low-pressure switch.
  - B. high-pressure cutoff switch.
  - C. cycling clutch switch.
  - D. thermal expansion valve switch.

(B.1.1)

14. A/C thermal switches are being discussed. Technician A says a thermal switch can be connected in series with the compressor clutch. Technician B says a thermal switch is usually mounted in the compressor. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (B.1.2)
15. Technician A says if one V-belt breaks on a two-belt drive system that both belts should be replaced as a pair. Technician B says that the idler pulley should also be replaced to ensure proper belt alignment. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (B.1.3)
16. On most late-model compressors all the following clutch components rotate when the clutch is energized EXCEPT the:
- A. armature.
  - B. bearing.
  - C. rotor.
  - D. clutch.
- (B.1.4)
17. Technician A says that a small amount of lubricant is lost from the compressor due to circulation through the system. Technician B says the lubricant must be drained from some compressors and measured in a beaker. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (B.1.5)
18. Technician A says a replacement compressor should have the same type of clutch and pulley as the old compressor. Technician B says the mounting brackets and other fasteners on a replacement compressor should be identical to those on the old compressor. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (B.1.6)
19. There is a noticeable noise coming from the engine compartment when the A/C is selected. Technician A says this could be caused by a loose compressor mount. Technician B says this could be caused by the system being empty of refrigerant. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (B.1.7)

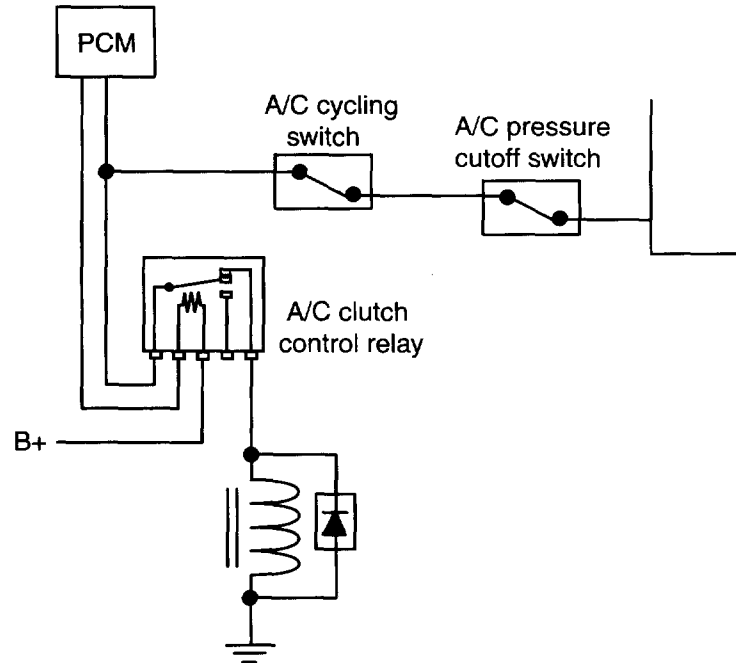
20. Technician A says while retrofitting an A/C system, it is not necessary to replace the O-ring seals unless they are leaking. Technician B says the accumulation of dirt around an A/C line connection is an indication of a leak in the system. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (B.2.1)
21. The refrigerant passages through an A/C condenser are severely restricted. Technician A says this may cause refrigerant discharge from the high-pressure relief valve. Technician B says this may cause excessive high-side pressure and low-side pressure. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (B.2.2)
22. Frost is forming on one of the condenser tubes near the bottom of the condenser. This problem could be caused by:
- A. restricted airflow passages in the condenser.
  - B. a refrigerant leak in the condenser.
  - C. a restricted refrigerant passage in the condenser.
  - D. a restricted fixed orifice tube.
- (B.2.3)
23. A receiver/dryer is located between the condenser and the evaporator. Technician A says the receiver/dryer should be changed if the outlet is colder than the inlet. Technician B says the receiver/dryer should be changed if the refrigerant in the sight glass appears red. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (B.2.4)
24. The low-side pressure is higher than normal. Warming the expansion valve remote bulb lowers the low-side pressure. Technician A says the expansion valve is defective. Technician B says the remote bulb may be improperly secured. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (B.2.5)
25. Technician A says a restricted orifice tube may cause higher-than-specified low-side pressure. Technician B says a restricted orifice tube may cause frosting of the orifice tube. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (B.2.6)



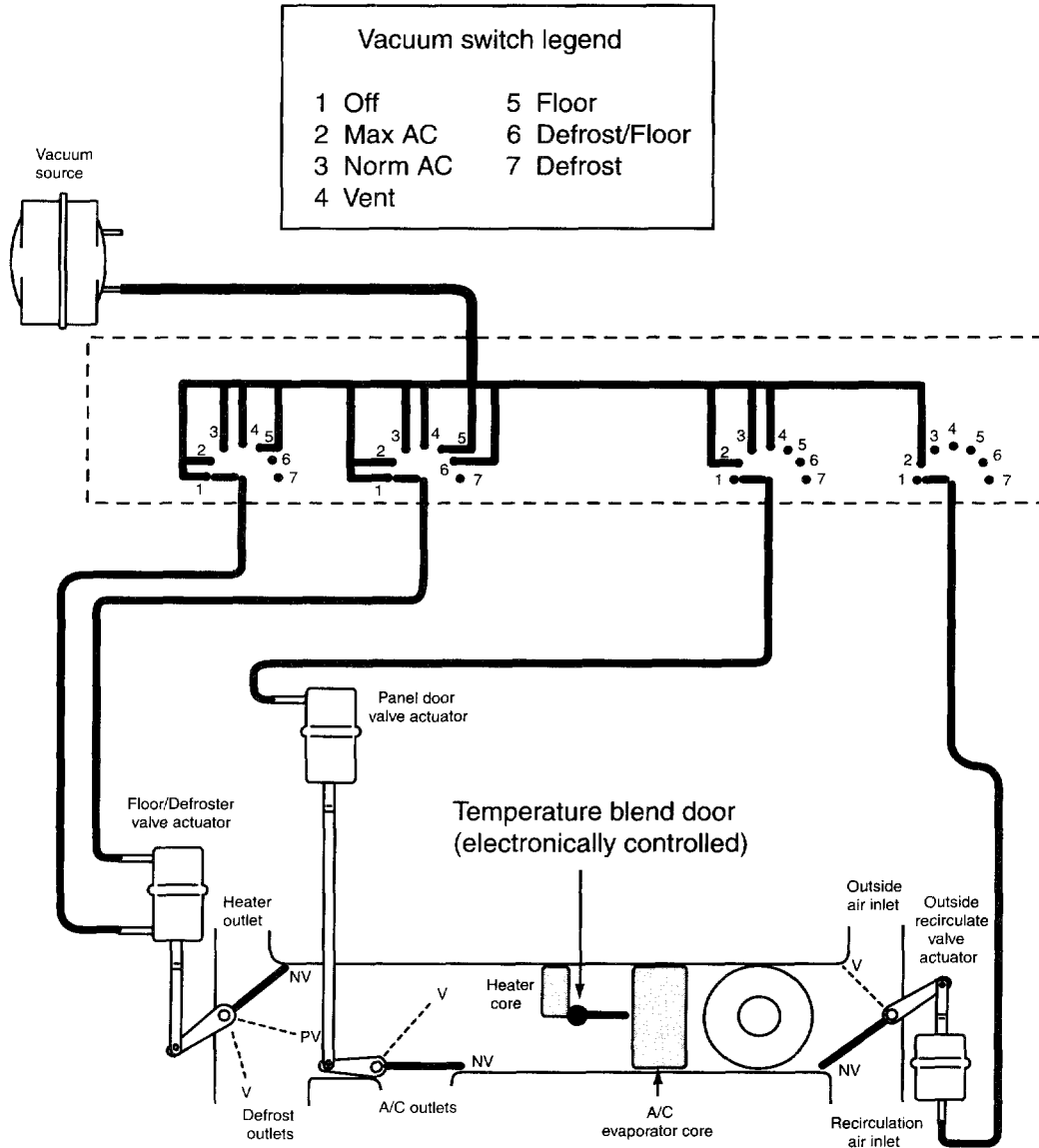
26. In the figure, Technician A says in order for the incoming air to be directed through the heater core, it must go through the evaporator core first. Technician B says the incoming air must go through the evaporator even if heat is selected. Who is right?
- A only
  - B only
  - Both A and B
  - Neither A nor B
- (B.2.7)
27. Technician A says an evaporator leak may be detected with an electronic leak detector. Technician B says an evaporator restriction is indicated by a low-side pressure that is considerably lower than specified and by inadequate cooling with a normal thermal expansion valve (TXV) or orifice tube. Who is right?
- A only
  - B only
  - Both A and B
  - Neither A nor B
- (B.2.7)
28. The fins and air passages of an evaporator are heavily clogged. Technician A says the evaporator core must be removed from the case for proper cleaning. Technician B says there would not have been a problem if the filter had been cleaned periodically. Who is right?
- A only
  - B only
  - Both A and B
  - Neither A nor B
- (B.2.8)

29. Technician A says that the evaporator housing and water drain are integral parts of the evaporator housing assembly. Technician B says that a crack or break in the housing may reduce the cooling capacity of the air conditioner. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (B.2.8)
30. Technician A says that the evaporator temperature regulator (ETR) and evaporator pressure regulators (EPRs) are often used for evaporator temperature control in recent years. Technician B says that the most popular of these devices is the suction throttling valve (STV). Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (B.2.9)
31. Technician A says a Schrader-type service valve and a stem-type service valve both have a dust cap over the valve. Technician B says when manifold gauge set hoses are connected to the service valves, a pin in the hose depresses the Schrader valve. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (B.2.10)
32. Technician A says the R-12 refrigeration system does not need to be discharged before the high-pressure relief valve is removed. Technician B says if replacing the high-pressure relief valve, in an R-134A system, it is necessary to replace it with one that has the same relief pressure specification as the original relief valve. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (B.2.11)
33. High-pressure relief valves are being discussed. Technician A says that some high-pressure relief devices are spring-loaded and self-resetting. Technician B says that some pressure relief devices are made of fusible metal and are not self-resetting. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (B.2.11)
34. No heat is coming from the heater outlets. Technician A says the heater core may be restricted, thus preventing flow of coolant. Technician B says the engine coolant thermostat may be of the improper heat range, thus preventing adequate coolant temperature. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (C.1)

35. Window fogging is being discussed. Technician A says that cleaning a clogged evaporator/heater case drain tube may eliminate a windshield fogging problem. Technician B says a leaking heater core is often the cause of windshield fogging. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (C.2)
36. All of the following will affect the engine cooling performance EXCEPT:
- A. a thermostat stuck closed.
  - B. a clogged heater core or hose.
  - C. a defective pressure cap.
  - D. an improperly positioned condenser.
- (C.3)
37. Technician A says when the engine is running with the thermostat closed, the coolant is directed through a bypass system to be circulated again. Technician B says some systems use the heater core as a thermostat bypass. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (C.6)
38. Technician A says coolant is considered a hazardous waste and must be recovered. Technician B says the coolant may be reused. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (C.7)
39. The engine overheats when the vehicle is parked, with the engine running. When the vehicle is driven at highway speeds, the engine operates at the normal temperature. Technician A says an improperly positioned radiator shroud could be the cause. Technician B says this could be caused by the fan clutch being locked. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (C.8)
40. Technician A says rust discoloration at the heater control valve may indicate a malfunctioning valve. Technician B says a defective heater control valve may result in a poor engine cooling condition. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (C.9)
41. Technician A says a loose ground wire may be the cause of a no blower operation condition. Technician B says a no blower operation may be caused by a defective compressor clutch diode. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (D.1.2)



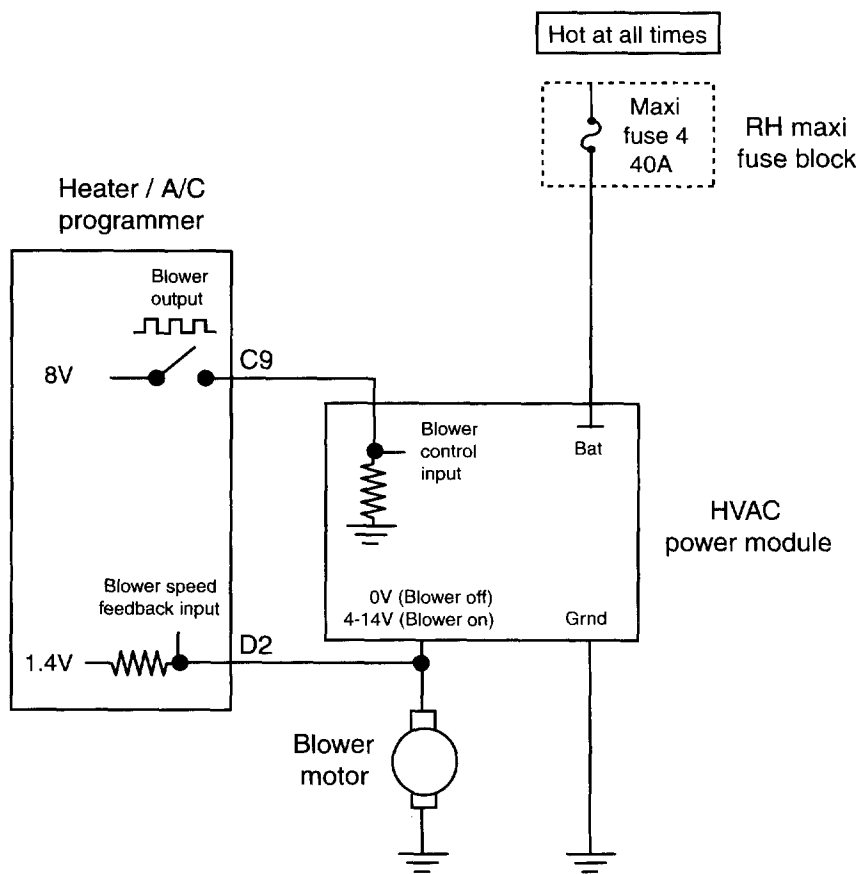
42. The A/C compressor clutch shown in the figure is deenergized after the vehicle is driven for about 30 minutes, and it does not engage again until the engine is shut off for a period of time. The refrigerant system pressures are normal. The most likely cause of this problem is:
- A. a defective compressor clutch coil.
  - B. a defective A/C pressure cutoff switch.
  - C. a defective clutch control relay.
  - D. a defective engine coolant temperature sensor. (D.1.3)
43. Technician A says some compressor clutch circuits contain a thermal limiter switch that senses compressor surface temperature. Technician B says some A/C compressor clutch circuits have a low-pressure cutoff switch. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B (D.1.5)
44. Technician A says some cooling fan systems have a low-speed fan and a high-speed fan. Technician B says an electric cooling fan usually is wired through a relay. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B (D.1.6)
45. The blower motor does not operate on high speed. All other speeds are operational. Technician A says the high-speed ground wire may be loose or broken. Technician B says the high-speed relay may be defective. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B (D.1.7)



46. When testing the A/C vacuum system shown in the figure, 18 in. Hg (40.5 kPa absolute) is supplied to the vacuum distribution hose connected to the A/C control vacuum valve. Under this condition, there should be 18 in. Hg (40.5 kPa absolute) supplied to:
- the panel door actuator with the switch in the OFF position.
  - the outside recirculate door actuator with the switch in the NORMAL A/C position.
  - the outside recirculate door actuator with the switch in the FLOOR position.
  - the panel door actuator with the switch in the MAX A/C position. (D.2.1)
47. A no heat condition is being discussed in a Bowden cable controlled heater control valve system. Technician A says this could be caused by a binding cable holding the valve open. Technician B says this could be caused by a kink in the cable holding the valve closed. Who is right?
- A only
  - B only
  - Both A and B
  - Neither A nor B (D.2.3)



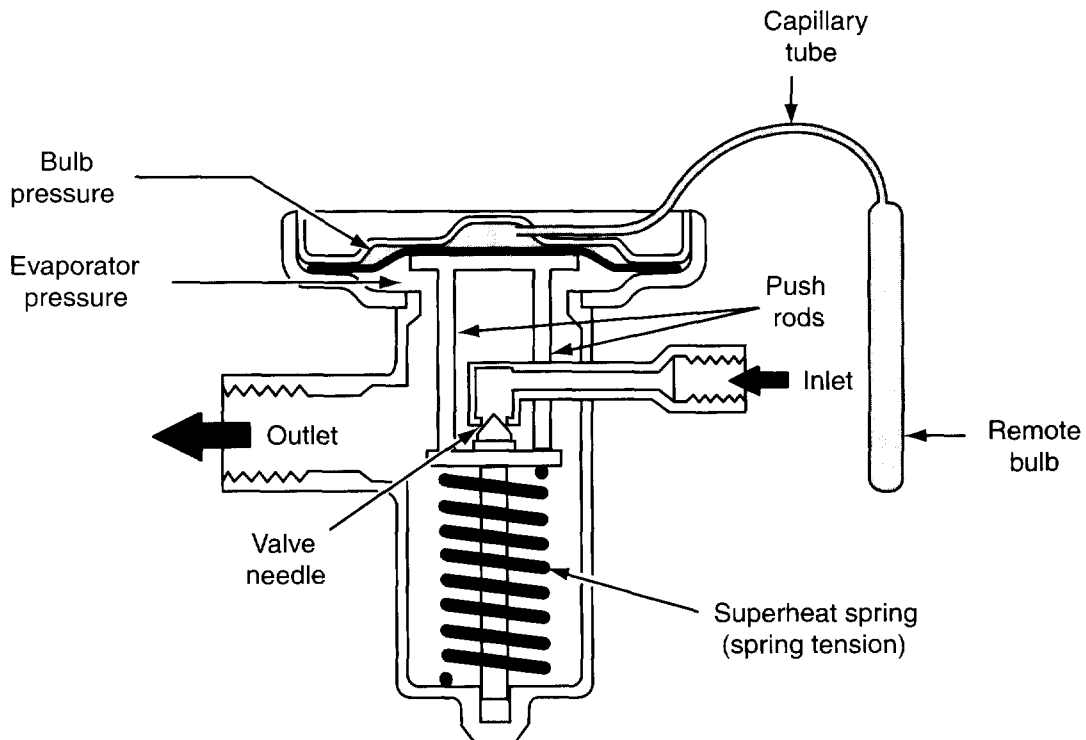
48. A vacuum actuator is being tested by applying 18 in. Hg. (40.5 kPa absolute) of vacuum to the vacuum actuator. Technician A says the gauge reading should remain steady for at least one minute. Technician B says if the gauge reading drops slowly, the actuator is leaking. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (D.2.5)



49. In the figure, the blower motor operates only at low speed. When the fan speed control on the A/C controls is changed from low speed to high speed, the voltage at blower motor changes from 4 volts to 13.5 volts. The cause of this problem could be:
- A. a defective blower motor.
  - B. an open blower motor ground.
  - C. a defective HVAC power module.
  - D. an open circuit at Programmer Terminal D2.
- (D.3.2)
50. The engine often stalls when the A/C is turned on. Technician A says the throttle position solenoid may be defective. Technician B says a quick check of the throttle position solenoid involves determining if the engine idle speed changes when the transmission is shifted from neutral to drive or reverse. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (D.3.9)

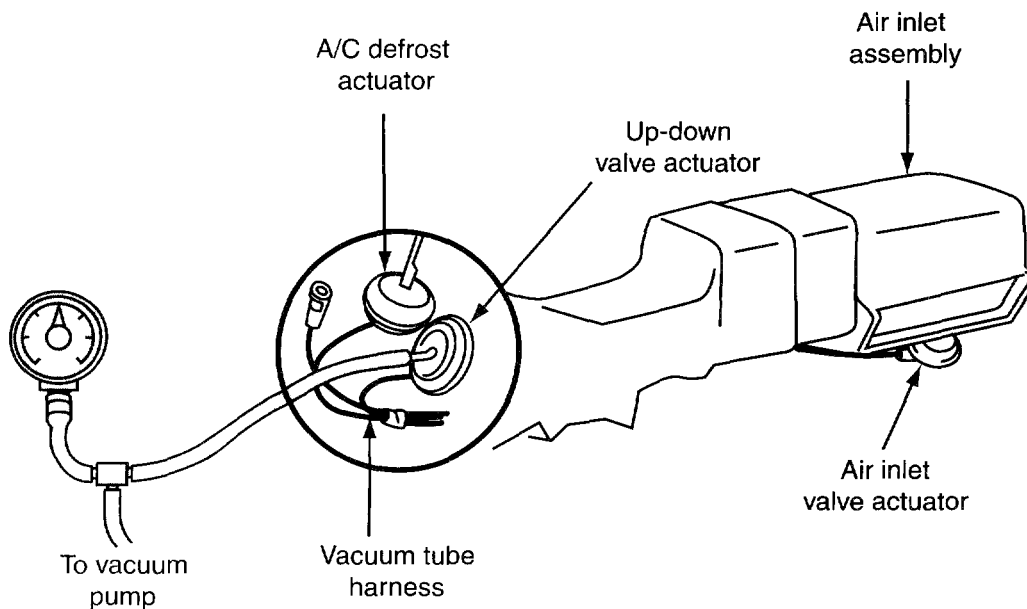
51. A damaged compressor clutch bearing will usually make:
- A. the same amount of noise whether or not the compressor is engaged.
  - B. more noise when the compressor is engaged.
  - C. less noise when the compressor is engaged.
  - D. noise only when the compressor is engaged. (A.1)
52. Technician A says that a fixed-orifice tube reduces pressure on the refrigerant and helps it evaporate. Technician B says a fixed-orifice type system has the accumulator between the evaporator outlet and compressor inlet. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B (A.2)
53. A customer complains that the air conditioning system cools satisfactorily during the early morning or late evening, but does not cool during the hot part of the day. During testing, the low-side gauge starts out reading normal, then drops into a vacuum. Technician A says that ice could be forming on the expansion valve. Technician B says that the dryer could be saturated with moisture. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B (A.5)
54. Technician A says that a system with  $\frac{1}{4}$  inch service valves can only be serviced with R-12. Technician B says that if no labels are on the vehicle indicating that it is to be serviced with R-134A, then it must contain R-12. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B (A.7)
55. A technician finds that an air conditioning system has excessive head pressure. The most likely cause of this problem is:
- A. the condenser is clogged by bugs.
  - B. a leaking thermostatic expansion valve.
  - C. an open bypass valve.
  - D. a malfunctioning vapor control switch. (A.9)
56. When charging an air conditioning system through the high-pressure side, all of the following are true EXCEPT:
- A. the system must be off.
  - B. the compressor must be turned by hand.
  - C. the refrigerant drum should be inverted.
  - D. the low-pressure valve should be held open. (A.10)
57. An air conditioning clutch does not engage the compressor. However, there is 12V at the clutch coil feed wire. Technician A says that the clutch coil could be bad. Technician B says that the clutch coil ground could be bad. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B (B.1.2)

58. Technician A says that a loose air conditioning belt can squeal whether or not the compressor clutch is engaged. Technician B says that a loose power steering belt will likely be the source of a squeal that occurs only at low speeds. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (B.1.3)
59. Which of the following would be considered the best compressor clutch air gap clearance?
- A. 0.0015 inches (0.038mm)
  - B. 0.015–0.025 inches (0.38–0.63 mm)
  - C. 0.5 inches (12.70 mm)
  - D. 1.0 inches (25.40 mm)
- (B.1.4)
60. While rebuilding a compressor, the ceramic seal and seat are being installed. All of the following procedures should be followed EXCEPT:
- A. Use a seal protector to protect the seal during installation.
  - B. Position the seal seat retainer ring into position by tapping it with a small hammer.
  - C. Avoid touching the seal seat face with your fingers.
  - D. Coat the seal face with clean compressor oil.
- (B.2.1)



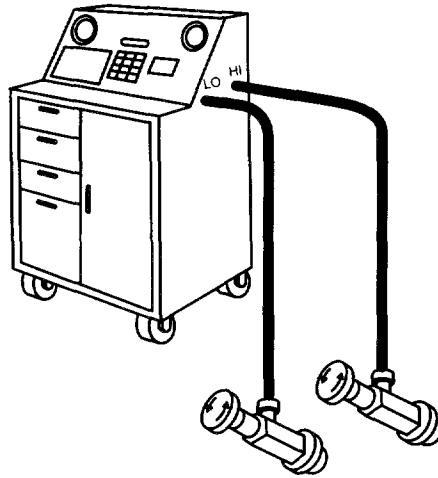
61. In the figure the capillary tube is broken. What is the vehicle symptom that will likely occur as a result?
- A. The air conditioning will always blow at full cold.
  - B. The air conditioning will not blow cold enough.
  - C. It will become impossible to charge the air conditioning.
  - D. It will not affect the air conditioning.
- (B.2.5)

62. A customer complains that the engine is overheating. While inspecting the vehicle when it is hot, it is found to have excess coolant in the coolant recovery container. After the engine cools, the container level returns to normal. Technician A says that this could be caused by a restriction in the radiator. Technician B says that a blown head gasket could also cause this. Who is right?
- A. A only  
 B. B only  
 C. Both A and B  
 D. Neither A nor B (C.3)
63. A vehicle that is stopped stalls when the steering wheel is turned to full lock only when the air conditioning is on. Technician A says that the vehicle may have a bad power steering cutoff switch. Technician B says this could occur if the air conditioning belt is loose. Who is right?
- A. A only  
 B. B only  
 C. Both A and B  
 D. Neither A nor B (D.1.5)
64. Technician A says that some computer-controlled A/C system actuator motors are automatically calibrated in the self-diagnostic mode. Technician B says that computer-controlled A/C system actuator motors only require manual calibration after replacement. Who is right?
- A. A only  
 B. B only  
 C. Both A and B  
 D. Neither A nor B (D.1.7)



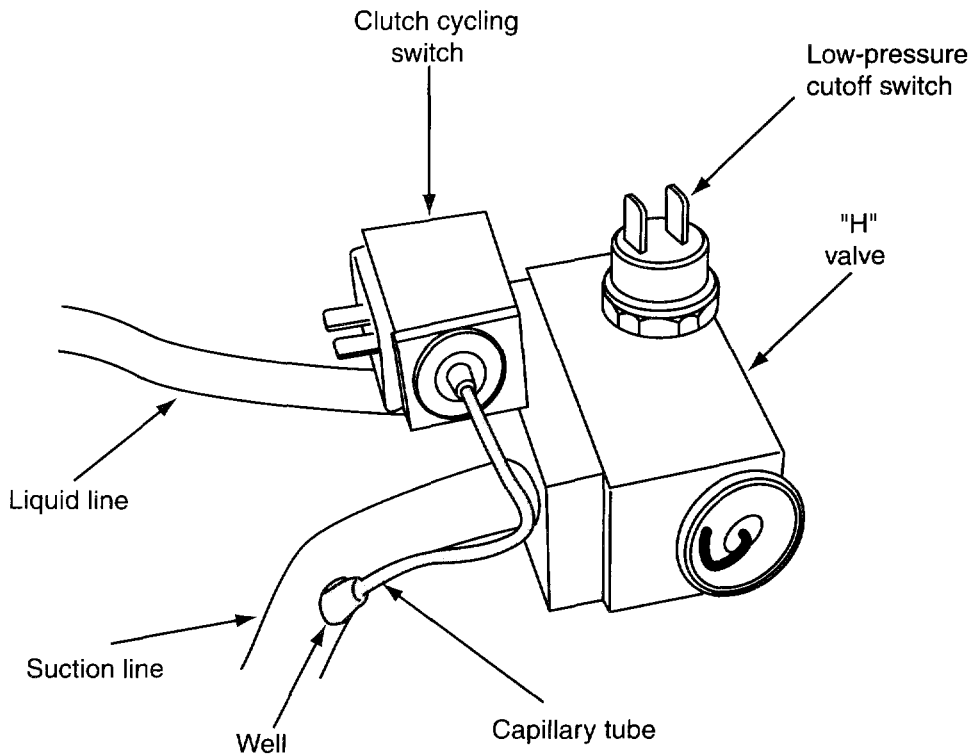
65. A blend door vacuum motor is being tested using the tool as shown. The tool is connected into the vacuum line going to the motor, and a zero vacuum reading is displayed. This would indicate:
- A. the door is restricted.  
 B. the line to the motor is plugged or kinked.  
 C. the vacuum motor is defective.  
 D. the motor should be operational. (D.2.1)

66. Technician A says that the control panel controls compressor operation. Technician B says that some electronic control panels contain microprocessors. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (D.2.2)
67. While testing a compressor, voltage is applied directly from the battery to the clutch coil connector. This does not cause the compressor clutch to activate. The LEAST likely cause of this is:
- A. an open compressor clutch coil.
  - B. a shorted compressor clutch coil.
  - C. an open wire in the vehicle compressor clutch circuit.
  - D. a damaged clutch coil connector at the compressor clutch housing.
- (D.3.4)
68. Refrigerant has just been recovered from a system. How long should the technician wait after turning off the recovery/recycling unit to see if the system still has pressure?
- A. At least 1 hour
  - B. At least 30 minutes
  - C. At least 10 minutes
  - D. At least 5 minutes
- (E.2)
69. Technician A says that A/C cycling pressure switches are used to prevent evaporator icing on fixed orifice systems. Technician B says that thermostatic de-icing switches prevent icing on the condensers of systems that use thermostatic expansion valves. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (B.1.1)
70. All of the following are accepted ways for flushing an A/C system after a compressor failure EXCEPT:
- A. The condenser must be flushed and the receiver/dryer replaced.
  - B. Filter screens are sometimes located in the suction side of the compressor and in the receiver/dryer. These screens confine foreign material to the compressor, condenser, receiver/dryer, and connecting hoses.
  - C. Use only CFCs or methylchloroform for flushing. After the system has been flushed, be sure to oil all components that require it.
  - D. Some manufacturers recommend, instead of flushing the system, replacing the clogged components and installing a liquid line (in-line) filter just ahead of the expansion valve or orifice tube.
- (A.9)
71. While discussing the conversion of a R-12 system to a R-134a system, Technician A says the R-12 system must be thoroughly purged and flushed to remove all traces of R-12. Technician B says because R-134a operates at higher pressures than R-12, new refrigerant hoses, designed for those higher pressures, must be used. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (E.6)



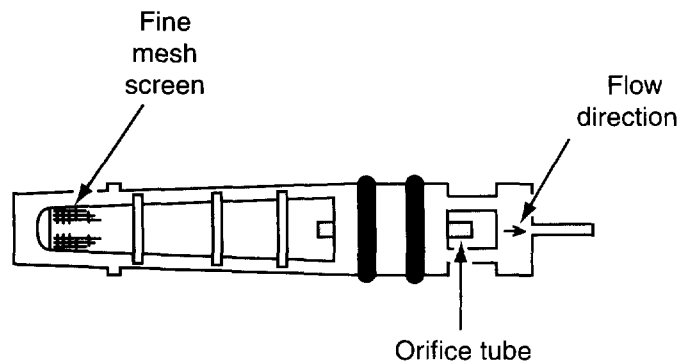
72. While discussing recycling equipment, Technician A says if the moisture warning light is yellow during the recycling process, the refrigerant contains excessive moisture and the desiccant bag in the accumulator or receiver/dryer must be changed. Technician B says when using refrigerant recovery systems and CPL is displayed on the recovery equipment, the display flashes the amount of refrigerant and oil recovered from the system. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (E.3)
73. In an A/C system, if the low-side pressure is lower than normal, which of the following is the LEAST likely cause?
- A. A faulty metering device
  - B. Poor airflow across the evaporator
  - C. A restriction in the low side of the system
  - D. The system is overcharged with refrigerant.
- (A.2)
74. While discussing ambient temperature switches, Technician A says this switch senses outside air temperature and is designed to prevent compressor clutch engagement when air conditioning is not required or when compressor operation might cause internal damage to seals and other parts. Technician B says the switch is in series with the compressor clutch electrical circuit and opens at about 37°F. At all lower temperatures the switch is closed, allowing clutch engagement. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (D.3.5)
75. All of the following statements about recycling equipment are true EXCEPT:
- A. Air conditioning recovery/recycling equipment must have UL approval and SAE J1991 approval.
  - B. The refrigerant container specified by the recovery/recycling equipment manufacturer must be used in this type of equipment to ensure that the container has proper capacity and valving.
  - C. It is recommended that anyone who performs a service involving refrigerant in an automobile air conditioning system be properly trained.
  - D. All equipment used in this service must have a label certifying that it is UL approved and meets SAE standard J1991.
- (E.3)

76. A very important part of a performance test on an A/C system is a pressure test. Pressure also is key to the operation of air conditioning. Which of the following statements is not true?
- A. Pressure on a substance, such as a liquid, changes its boiling point.
  - B. The greater the pressure on a liquid, the higher the boiling point.
  - C. If pressure is placed on a liquid, the liquid freezes at a higher-than-normal temperature.
  - D. The boiling point can be increased by increasing the pressure on the fluid. It can also be decreased by reducing the pressure or placing the fluid in a vacuum. (A.2)
77. Technician A says that the pressure cycling switch should cause the compressor to cycle OFF when the low-side pressure goes below about 25 psi. Technician B says that the pressure cycling switch will cause the compressor to cycle ON when the low-side pressure reaches about 47 psi. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B (B.2.9)
78. While conducting a pressure test on an A/C system, the ambient temperature is 80°F, the low-side gauge reads low (8 psi), and the high side also reads low (85 psi). Which of these could cause these readings?
- A. Low refrigerant level
  - B. Normal operation
  - C. Bad compressor
  - D. A high-side restriction (A.2)
79. The high-side pressure on a system with a cycling clutch and pressure cycling switch is 245 psi, the low-side pressure is 28 psi, and the ambient temperature is 78°F. What do these gauge readings indicate?
- A. The system is undercharged.
  - B. The system is overcharged.
  - C. The system is normal.
  - D. The evaporator pressure regulator is bad. (A.2)
80. An A/C compressor cycles off when the high-side pressure builds. Technician A says that the high-pressure cutoff switch is opening the circuit to the compressor clutch. Technician B says that the pressure release valve is opening the circuit to the compressor clutch. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B (B.2.9)
81. When checking an A/C system, the evaporator's inlet and outlet tubes feel like they are at the same temperature. Which of these could cause this?
- A. A plugged evaporator
  - B. Correct charge of refrigerant in the system
  - C. Restricted orifice tube
  - D. Leaking condenser (A.5)



82. Technician A says that holding the sensing bulb of a capillary tube should cause the system pressures to change. Technician B says that cooling the above sensing bulb should cause the system pressures to change. Who is right?
- A only
  - B only
  - Both A and B
  - Neither A nor B
- (B.2.5)
83. All of these are good reasons for replacing an accumulator unit EXCEPT:
- The accumulator/drier is punctured.
  - The accumulator/drier is saturated with water.
  - The A/C system has been open to the atmosphere for two or more hours.
  - The outer shell of the accumulator/drier is dented.
- (B.2.4)
84. Two technicians are discussing how comparing the temperature of a high-pressure line to that of a low-pressure line would help evaluate an A/C system when the system does not have a sight glass. Technician A says the high-pressure line will feel warmer than the low-pressure line if the system is operating normally. Technician B says both lines should feel cold after the system has been run for a while, if the system is working normally. Who is right?
- A only
  - B only
  - Both A and B
  - Neither A nor B
- (A.5)





85. The filter screen of an orifice tube is covered with aluminum particles. Which of these could be the cause?  
 A. A leaking desiccant bag  
 B. A plugged condenser  
 C. A damaged compressor  
 D. A damaged evaporator (B.2.6)
86. While diagnosing the cause of a blown fuse in the blower motor circuit, Technician A says a short in the circuit caused the fuse to blow. Technician B says an open field winding in the fan motor could have caused the fuse to blow. Who is right?  
 A. A only  
 B. B only  
 C. Both A and B  
 D. Neither A nor B (D.1.2)
87. While conducting an A/C system performance test, Technician A inserts a thermometer into the air duct at the center of the dash and monitors discharge temperature. Technician B begins the test with a complete visual inspection. Who is right?  
 A. A only  
 B. B only  
 C. Both A and B  
 D. Neither A nor B (A.2)
88. An A/C system is being tested with pressure gauges. The high-side pressure is low, and the low-side pressure is high. Which of these is the LEAST likely cause of these pressures?  
 A. Expansion valve stuck open  
 B. Restriction in the high side of the system  
 C. The compressor's head gasket is leaking.  
 D. The POA or STV is stuck closed. (A.2)

89. While diagnosing higher-than-normal-system pressures, Technician A checks the condenser for dirt buildup in the condenser's fins. Technician B tests the engine for indications of an overheating condition. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (A.2)
90. A car makes a hissing noise when the A/C system and engine are turned off. Technician A says that the noise could be caused by a refrigerant leak. Technician B says that the noise is caused by the system pressures equalizing. Who is right?
- A. A only
  - B. B only
  - C. Both A and B
  - D. Neither A nor B
- (A.1)

# 7

## Appendices

### Answers to the Test Questions for the Sample Test Section 5

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1. A	24. C	47. B	70. D
2. B	25. A	48. B	71. A
3. B	26. B	49. D	72. C
4. D	27. A	50. A	73. C
5. D	28. C	51. B	74. C
6. A	29. D	52. B	75. A
7. D	30. C	53. A	76. B
8. C	31. C	54. C	77. B
9. A	32. A	55. A	78. D
10. D	33. A	56. D	79. D
11. C	34. C	57. D	80. C
12. C	35. C	58. A	81. C
13. B	36. A	59. B	82. A
14. A	37. B	60. A	83. B
15. A	38. A	61. B	84. C
16. C	39. C	62. D	85. C
17. C	40. C	63. C	86. C
18. C	41. A	64. A	87. B
19. A	42. B	65. A	88. D
20. D	43. B	66. C	89. B
21. B	44. C	67. A	90. C
22. A	45. A	68. B	
23. D	46. B	69. C	

## Explanations to the Answers for the Sample Test Section 5

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1. Technician A is correct. A defective clutch bearing may be the cause of a noise coming from the compressor when it is running. If the noise stops when the compressor is not running, the clutch bearing is not at fault. Therefore Technician B is not correct. A defective compressor bearing causes a growling noise only when the compressor clutch is engaged. A bent pulley can also cause a growling or rubbing noise. Most compressor clutch problems are generally obvious by a noisy operation; this noise tends to be more obvious when the clutch is disengaged. These problems are generally caused by a defective clutch, defective bearing, or insufficient current flow to the clutch coil. **The correct answer is A.**
2. A fixed orifice tube system has an accumulator in the suction line. The system type is easily identified by checking to see if it has a receiver/dryer or an accumulator. If there is a receiver/dryer between the condenser outlet and the evaporator inlet, it is a thermostatic expansion valve system. If an accumulator is found between the evaporator outlet and compressor inlet, it is a fixed orifice tube system. **The correct answer is B.**
3. In older refrigerant systems using R-12 refrigerant, the sight glass may be used as a method of checking for low charge or air in the system. If the sight glass contains bubbles, the refrigerant system charge is low and/or air has probably entered the system. Check for leaks. If none are evident, the system should be charged until the bubbles disappear. **B is the correct answer.**
4. Neither technician is correct. A restriction in the low side will cause lower-than-normal low-side pressure, even into a vacuum. Such a restriction in the low side of the system would generally be accompanied by a lower-than-normal high-side pressure. This is also true if there is an undercharge of refrigerant. A restriction in the high side of the system will result in a higher-than-normal high-side pressure. This may generally be accompanied by a lower-than-normal low-side pressure. If the system is overcharged, however, the higher-than-normal high-side pressure will be accompanied with a higher-than-normal low-side pressure.  
Air and moisture in the refrigerant system or a restricted thermal expansion valve (TXV) cause higher-than-specified system pressures. A restricted TXV may cause low refrigerant pressures; this condition may also result in TXV frosting. A defective compressor may cause low high-side pressure and high low-side pressure. A low refrigerant charge causes reduced low-side and high-side pressures. Air in the refrigerant system may cause high system pressures. **D is the correct answer.**
5. Technician A says the TXV is the coldest part of the system and heavy ice buildup on it is normal. This is wrong. The thermostatic expansion valve is the coldest part in the system, but heavy ice buildup is not normal. Technician B is also wrong. A clear sight glass does not indicate there is no refrigerant flowing. It indicates that the system is either fully charged or empty. Also, a restriction in the receiver/dryer would produce ice at that spot. The outlet of the metering device is the coldest part in the system. It is normal for frost or a light accumulation of ice to occur at the outlet of the metering device. If there is a restriction in the system, there would be heavy frost or ice buildup at the point of the restriction. A restricted TXV usually causes frosting of this component. This is the most likely cause of the problem and **D is the correct answer.**
6. Halogen leak detectors may be used to detect R-12 and R-134 leaks. Technician A is correct but Technician B is wrong. Specific halogen leak detectors can be used on R-12 and R-134 systems. Leaks in the system can sometimes be found by inspecting for an oily residue on refrigerant system components. An oily residue indicates a refrigerant leak in that area where refrigerant is escaping along with some of the oil in the system. **The correct answer is A.**

7. It must never be assumed that a system is charged with R-12 simply because it has 1/4-inch service valves. It should never be assumed that the lack of a label or labels is an indication that the system is charged with R-12 refrigerant. Other refrigerants have been used in automotive air conditioning systems without regard to product identification. This may even include some refrigerants that are considered flammable or otherwise hazardous and not approved for automotive service. It, therefore, should never be assumed that a system is charged with any particular type of refrigerant simply because of its service valves or the lack of labels. **D is the correct answer;** both technicians are wrong.
8. Evacuating a refrigerant system removes moisture from the system. The moisture is boiled out because of the vacuum caused when evacuating the system. Technician A is right, if the system pressure rises after the vacuum pump is turned off, there may still be refrigerant in the system. Another likely cause of the same problem was suggested by Technician B. If the system pressure rises after the vacuum pump is turned off, there may be a leak in the system. The air conditioning system must be evacuated whenever it is serviced to the extent that the refrigerant has been removed. Proper evacuation not only eliminates all traces of refrigerant, it also rids the system of unwanted air and moisture that may have entered the system during service. **The correct answer is C.**
9. Condenser problems are often the result of clogging caused by dirt, bugs, or other foreign debris that collects in the fins, restricting the airflow. As suggested by Technician A, a good way to clean a condenser is to use a stiff bristle brush, such as a hair brush, and a strong stream of water. Never clean the condenser with high-pressure steam, as suggested by Technician B. The heat of the steam may cause the system pressure to rise above a safe limit, causing a loss of refrigerant. **A is the correct answer.**
10. Both technicians are wrong. An A/C system should only be charged through the high side with the system off. Inverting the refrigerant container disperses liquid refrigerant, which may cause damage to the compressor. The high-side charging procedure must be completed with the engine off. The vehicle should always be charged from the low-pressure side if the engine is on. If the engine is off, it can be charged from the high-pressure side. **The correct answer is D.**
11. Both technicians are correct. The oil level of some compressors may be checked with the use of a dipstick. On others, the oil must be drained from the compressor and measured in a graduated beaker. If the system had a leak, the measured amount of oil may be lower than specifications. Always refer to the guidelines given by the manufacturer before adding oil. **The correct answer is C.**
12. The presence of oil around any A/C fitting or component usually indicates a leak. However if oil is present around the high-pressure relief valve, this indicates the valve is opening. A high-pressure relief valve is used to keep system pressures from reaching a point that may cause compressor lockup or other component damage because of excessive high pressures. When system pressures exceed a predetermined point, the pressure relief valve opens, allowing excessive system pressures to be reduced. High-system pressures may be caused by restricted condenser air passages or an over-charged refrigerant system. Both technicians are correct and **the correct answer is C.**
13. The problem is an inoperative compressor clutch. The question asks you to identify the cause of the problem. Certain facts are also given: the ignition switch is on, the control switch is set to auto, and the ambient temperature is 75°F. Based on these facts and the figure shown with the question, you know that if there are 12 volts at terminals B, C, and S, battery voltage is available to the compressor clutch and connecting wire. Answer A suggests that the cause of the problem is an open thermal fuse. This cannot be correct. If it were open, there would not be voltage at terminal C. Choice B is correct. Because voltage is available to the clutch and the clutch is inoperative, the compressor clutch coil or the wire from the fuse to the coil is open. Answer C suggests that the superheat switch is defective. If it were, battery voltage would not be present at terminal S. Choice D is wrong because a thermal fuse does not have a heater. **The correct answer is B.**

14. A vehicle with V-belts has an intermittent squeal during acceleration. The noise is not dependent on whether the A/C is on or off. A loose A/C compressor belt will likely produce a squealing noise with the compressor clutch engaged. Therefore, choice B is not a likely cause of the problem. Nor is choice C. Since the air pump does not require much power to turn it, this belt is not likely to produce a squealing noise on acceleration. Answer D suggests a worn compressor bearing. This would cause a growling noise under all engine operating conditions with the compressor clutch engaged. The most likely cause of the noise is choice A. Because the power steering pump is always under load, a loose power steering belt may cause a squealing noise on acceleration, regardless of A/C system operation. **The correct answer is A.**
15. Technician A is correct. Compressors are equipped with an electromagnetic clutch as part of the compressor pulley assembly. The clutch is designed to engage the pulley to the compressor shaft when the clutch coil is energized. The purpose of the clutch is to transmit power from the engine to the compressor and to provide a means of engaging and disengaging the refrigeration system from engine operation. When the clutch is engaged, power is transmitted from the pulley to the compressor shaft by the clutch drive plate. When the clutch is not engaged, the compressor shaft does not rotate, and the pulley freewheels. Nearly all clutch assemblies have a clearance specification for the distance between the clutch and the pressure plate. This clearance is measured with a feeler gauge. If the clearance is too great, the clutch may slip and cause a scraping or squealing noise. If the clearance is insufficient, the compressor may run when not electrically activated and the clutch may chatter at all times. Placing a shim behind the pulley armature plate would not correct the problem of excessive clearance. Therefore Technician B is wrong. **The correct answer is A.**
16. When replacing an A/C compressor, the recommended procedure is to measure the oil recovered from the system while discharging. Drain and measure the oil left in the old compressor. Drain the new compressor and refill it with the same amount of oil removed from the system and old compressor. If 2 oz. (59 ml) of oil are recovered from the system and 2 oz. (59 ml) of oil are drained from the old compressor, drain the replacement compressor and then add 4 oz. (118 ml) of oil to the compressor before installation. **C is the correct answer.**
17. It is obvious that the compressor causes the noise problem, as the noise stops when the compressor is disengaged. Noises from an engaged compressor may be caused by an external or internal problem. A compressor noise problem is often difficult to localize. When the compressor is operating, a loose compressor mount or bracket may vibrate, giving the impression that the compressor itself is somehow defective. This type of noise usually stops when the compressor is disengaged. The compressor itself may have internal damage. Since the parts of the compressor rotate at relatively high speeds, an increase in engine speed may cause the noise to become louder or more noticeable. **The correct answer is C**, because both technicians are correct.
18. **C is the correct answer**, because both technicians are correct. A seal protector is used when replacing a compressor shaft seal. This reduces the possibility of damaging the shaft seal during installation. When replacing the shaft seal, the seal seat O-ring must be installed before the shaft seal.
19. The tool shown in the figure is a special tool used to release the spring lock couplings on refrigerant lines. Some line connections are sealed with O-rings and retained with spring lock couplings. These fittings are snapped together by hand but require this tool to disconnect them. **The correct answer is A.**
20. Ram airflow across the condenser is produced by vehicle movement and/or the action of the fan. A defective fan clutch generally causes the fan to run at maximum potential at all times, which will usually increase ram airflow. Technician A is wrong. So is Technician B. Reduced airflow across the condenser generally affects the ability of the condenser to cool the refrigerant, resulting in higher temperatures. The higher refrigerant temperatures increase suction pressure in the system, affecting system cooling abilities. **The correct answer is D** because neither technician is correct.

21. This vehicle is equipped with a TXV system and has excessive high pressure. Technician A suggests the system may be overcharged. If the system were overcharged, the head pressure may be excessive but there would be no frosting at the condenser outlet. Technician B looks at the high pressure and the frost. Frost will build up at the point of restriction. Frosting near the condenser outlet is a clear indication that there is a restriction in the condenser. When frost is forming on one of the condenser tubes near the bottom of the condenser, the refrigerant passage is restricted at that location in the condenser. A restriction in the condenser will also cause excessive high pressures. **B is the correct answer.**
22. Technician A is correct in saying if the receiver/dryer outlet is colder than the inlet, this unit is restricted and should be changed to restore efficient and proper system operation. Technician B is wrong. If the refrigerant in the sight glass appears red, all that is indicated is that some leak-detecting dye has been added to the refrigerant. This condition does not require any corrective action. **The correct answer is A.**
23. This question requires you to disprove the answer choices, and the one that cannot be disproved is the correct answer. Answer A suggests the cause of the problem is a defective TXV capillary tube. A defective capillary tube would most likely cause the TXV to remain closed, causing poor cooling at all times. Choice B suggests that the system is overcharged with refrigerant. An overcharged system will cause higher suction pressures and poor cooling at all times. Answer C is also wrong. A restricted condenser passage will cause poor cooling at all times. That leaves choice D, which is correct. It is likely that the problem is caused by moisture freezing in the TXV. When the TXV freezes, refrigerant flow is reduced and cooling is also reduced. As the TXV thaws, refrigerant flow is restored and cooling is also restored until the TXV freezes again. **The correct answer is D.**
24. This is an EXCEPT question. Your job is to identify which statement is not true. In this case, choice C is not a true statement but all of the others are. When using the tool to remove an orifice tube, pour a small amount of refrigerant oil on top of the tube and engage the notch in the tool in the orifice tube. Hold the T-handle and rotate the outer sleeve to remove the orifice tube. **The correct answer is C,** because it is wrong.
25. Technician A is right. Restricted evaporator refrigerant passages may cause frosting at the restriction or the evaporator outlet pipe. However, Technician B is wrong. A restriction in the evaporator will cause lower-than-specified low-side pressures, not higher low-side pressures. Only Technician A is correct and **A is the correct answer.**
26. The windshield has an oily film and the A/C system isn't cooling correctly. Technician A suggests a plugged A/C heater case drain causes the problem. This is wrong. A plugged evaporator case drain may cause windshield fogging, but this problem would not result in an oily film on the windshield. Technician B is correct in saying an oil film on the windshield may be caused by a refrigeration leak in the evaporator core that may allow some refrigerant oil to escape in the evaporator case. Keep in mind, the presence of oil on an A/C component or line is a good indication of a leak. Oil on the windshield could be caused by an evaporator leak. The oil is pushed off the evaporator by the fan. **The correct answer is B.**
27. For sometime the (ETR) evaporator temperature regulator and suction throttling valve (STV) were popular methods of evaporator temperature control, but these have not been in use for several years. All were used in the suction line from the evaporator to the compressor to maintain evaporator pressure, thereby maintaining its temperature. Technician A is correct. On some of the systems with an evaporator pressure regulator, pilot operated absolute valve, or suction throttling valve, the compressor runs continually in the A/C mode. Technician B is wrong. The opposite of what is stated is true. Excessive pressure drop across the EPR valve indicates this valve is sticking closed, not open. **A is the correct answer.**

28. A careful look at the pictured stem-type valve shows the valve closed. This is the proper position for isolating the compressor from the lines. Answer C is correct. The valve should be in this position to isolate the refrigerant system from the compressor for compressor removal. The other choices are wrong. When the valve is closed, no system pressure will be measured at the valve, the compressor is totally isolated from the lines, and service to the system is not possible. Except, of course, through the removal of the compressor. **C is the correct answer.**
29. On all vehicles, the high-pressure relief valve is used to keep system pressures from reaching a point that may cause compressor lockup or other component damage because of excessive high pressures. When system pressures exceed a predetermined point, the pressure relief valve opens, allowing excessive system pressures to be reduced. A high-pressure relief valve discharges refrigerant at approximately 475 psi (3,275 kpa). **D is the correct answer.**
30. Discharge air temperature on a system with a coolant flow control valve is too high when the A/C controls are set to maximum cooling. Normally, the coolant control valve is closed in the maximum A/C mode. If this valve is stuck open, heat from the heater core may reduce evaporator cooling to some extent. Technician A is correct. Technician B is also correct. If the vacuum hose connected to the coolant control valve leaks, the valve will remain open in the maximum A/C mode and will decrease the output from the A/C system. Both techs are correct and the **correct answer is C.**
31. A sticky film on the inside of the windshield may be caused by a coolant leak in the heater core. Under this condition, the coolant level in the radiator should be checked. The heater core should be repaired or replaced. Both techs are correct and **the correct answer is C.** A leaking heater core is also often the cause of a windshield fogging problem. Windshield fogging is the result of hot and humid air that condenses on the cooler glass.
32. The loss of pressure in the cooling system without an evident external leak is probably caused by internal leakage problems. Things such as a leaking transmission cooler, head gasket, or cracked cylinder head could result in coolant loss that is not visually verified. Therefore, all of the answers are valid, except A. A leaking heater core usually causes coolant to leak onto the front floor mat and is quite apparent. **The correct answer is A.** Keep in mind this is an except-type question.
33. This question gives you the problem and asks what the symptoms of the problem would be. To answer this you need to know the purpose of the vacuum valve in the radiator cap. This valve is designed to reduce the vacuum in the cooling system caused by contraction as the hot system cools. A sticking vacuum valve in the radiator cap may allow for a vacuum in the system and collapse the upper radiator hose after the engine is shut off. A malfunctioning vacuum valve would not cause overheating. Therefore **A is the correct answer.**
34. Both technicians are correct. A defective radiator cap or restricted radiator tubes may cause engine overheating. When the engine overheats, excessive cooling system temperatures and pressures result. This forces the excessive coolant flow into the recovery container causing the level to rise. As the system cools, it creates a vacuum and draws the coolant from the recovery container back into the radiator. **C is the correct answer.**
35. There are many reasons for a fuel-injected engine to run rich, one of which is a colder-than-normal engine. This makes sense. Since the air delivered to a cold engine is denser, more fuel is needed to achieve the ideal air:fuel ratio. Since all of the answers, except one, would cause the engine to run hotter than normal, they are wrong. If the thermostat is stuck open in a fuel-injected engine, the coolant never reaches normal operating temperature. Under this condition, the engine coolant temperature sensor sends a low coolant temperature signal to the powertrain control module (PCM). This sensor input results in a rich air:fuel ratio. Therefore, only **answer C is correct.** If the engine is overheating or running at higher-than-normal temperatures, the mixture will be lean.



36. Another EXCEPT question. The first answer is not correct. The others are. As pressure increases in the cooling system, the boiling point of the coolant is also increased. Similarly, when more antifreeze is added to the coolant, the boiling point is increased. Most ethylene glycol antifreeze contains rust and corrosion inhibitors. Coolant is considered a hazardous waste and must be recovered. Coolant must be recycled according to local regulations. In no instance can it be disposed of in a landfill. Any coolant removed from an automotive cooling system may contain harmful engine residues, such as benzene and lead. If used coolant is to be disposed of, it must be done according to local regulations. Ideally, however, the coolant may be recycled by filtering out most of the contaminants. Some recycle machines use vacuum distillation or ion exchange technology for glycol-based coolants. After recycling, the coolant must be supplemented with an additive before being reused. **Answer A is correct**, although it is not a correct statement.
37. The problem in this question is inoperative cooling fans when the engine is warm or hot, but the fans work when the A/C is turned on. To diagnose this problem, look at the schematic and determine the parts of the circuit that control the fans based on engine temperature. That is where the problem will be. The circuit ties to the A/C system appear to be working fine. Answer A is wrong. A blown cooling fan fuse would prevent the cooling fan motors from operating even with the A/C on. Choice C is also wrong. A defective high-speed coolant fan relay would only prevent high-speed fan operation. Likewise choice D is wrong. Since the cooling fans operate with the A/C on, the A/C pressure fan switch must be operating. The remaining choice, answer B, is correct. A defective engine coolant temperature sensor that indicates low coolant temperature may cause the powertrain control module (PCM) not to ground the fan relay windings and thus prevent the operation of the cooling fans except when the A/C pressure switch closes. **The correct answer is B.**
38. To answer this question look at the figure and identify the parts shown. Then identify what is being done. You will notice the linkage to the air mix or blend door is being adjusted. This adjustment is critical to the proper operation of the system. The blend system mixes heated air with cooled air to achieve the desired air temperature. When the A/C system is set to max, only cooled air should leave the air ducts. When full heat is selected, only heated air should be available. **The correct answer is A.**
39. A gurgling noise in the heater core may be caused by a low coolant level in the cooling system or a restricted heater core. A low coolant level will allow too much air in the cooling system. The excessive air in the system will mix with the coolant and create the gurgling noise. A restricted heater core will also cause a gurgling noise from the coolant passing through the restricted area. Both technicians are correct and **the correct answer is C.**
40. The problem: no cool air being discharged when the A/C is activated. The A/C system pressures and blower motor operation are normal. The temperature door does not move when the controls are moved from max heat to max cool. All of the answer choices are possible causes for the problem except choice C. The circuit mentioned here would only affect the system's ability to achieve and maintain a particular temperature. If there is an open in the circuit, the discharge cooling temperature may be inaccurate, but the blend door should still move when the control is moved. An open circuit in the electronic door actuator circuit or a blown fuse would cause the temperature blend door actuator to be inoperative. An open circuit in the electronic temperature door actuator to the automatic temperature control circuit would also prevent the door from moving in response to the position of the control. **The correct answer is C.**
41. Review the motor circuit shown for the question. Then apply logic to determine the most likely cause for the blower only operating at high speed. Answer B, an open circuit at the blower switch ground, would make the blower totally inoperative. Choices C and D would prevent the blower from running in its continuous mode, which is a very low speed. Other speeds would operate normally. The only possible cause would be an open in the resistor or resistor terminals. This would prevent the blower motor from operating at the lower speeds. The high-speed portion of the resistor would still work normally when high was selected. **The correct answer is A.**

42. Let's look at a little theory. The alternating current produced by the generator is rectified to a pulsating direct current. There is no alternating current present anywhere else in the electrical system. Technician A is wrong simply because when all things are normal, there is no A/C voltage to suppress or prevent from entering the clutch coil. The purpose of the diode in the compressor clutch circuit is to prevent spikes of high voltage from returning to the delicate electronic components of the computer. The clutch coil is an electromagnet with a strong magnetic field when current is applied. This magnetic field is constant as long as power is applied to the coil. When power is removed, the magnetic field collapses and creates high-voltage spikes. These are harmful to the delicate electronic circuits of the computer and must be prevented. The diode placed across the clutch coil provides an electrical path to ground, holding the spikes to a safe level. Technician B is right and **the correct answer is B.**
43. Let's review the purpose and function of a throttle kicker, then we can accurately answer this question. When the A/C compressor is engaged, it requires increased effort from the engine to run the compressor. This increased effort causes a lower rpm at idle. The throttle kicker maintains engine idle speed when the engine accessory load is increased, such as during A/C compressor clutch operation. A leaking throttle kicker diaphragm or an inoperative kicker solenoid may cause lower-than-specified idle rpm and engine stalling with the A/C on. This kicker also maintains idle speed during warm-up. The throttle kicker is controlled by switches, vacuum, or by the PCM. If controlled by the PCM, the primary inputs used to set the kicker are from the throttle position, engine coolant temperature, MAP, and engine speed sensors. Although its operation may depend on the TP sensor, it is not a part of that sensor. Therefore choice B is wrong. The other answers are correct. **Answer B is the correct answer.**
44. Both technicians are correct. Some vehicles have a power steering cutoff switch to disengage the air conditioning compressor when the power steering requires maximum effort. Load-sensitive electrical switches include the low-pressure switch, high-pressure switch, pressure cycling, and power steering. Not all of these switches, however, are used on all vehicles. They are, for the most part, used to provide additional engine power when maximum power is required. The pressure switches are used to prevent compressor or component damage in the event of extremely high- or low-system pressures. **The correct answer is C.**
45. The cooling fan operates normally on high speed but there is no low-speed fan operation under any operating condition. A look at the wiring diagram shows there are two separate relays and control circuits for low- and high-speed operation. We can assume that everything on the high-speed part of the circuit is fine, so let's analyze the answers. It is always easy when the first answer choice is correct. If there is an open circuit between the two # 30 terminals on the relays, the low-speed relay would not receive power and the low-speed fan would not work. This is a correct statement, but don't stop here. Make sure the rest of the answers are wrong. Choices B and C: a blown cooling fan fuse would obviously cause the cooling fans to be inoperative at all times. Therefore, both of these are wrong. Choice D suggests an open in the pressure switch circuit. If the cooling fan only operates when A/C pressure is high, suspect an open A/C head pressure switch. However, since the fan operates normally at high speed, the lack of low-speed operation is probably not caused by an open in the pressure switch circuit. **The correct answer is A.**
46. Another except-type question. Here is a summary of computer-controlled A/C system actuator motors. Some of these motors are calibrated automatically in the self-diagnostic mode, whereas other actuator motors must be calibrated manually. These actuators should only require calibration after motor replacement or misadjustment. Some systems have a self-diagnosis mode. The diagnostic trouble codes indicate a fault in a specific component or circuit. From this review, you can see that choice B is wrong. The rest are true. **The correct answer is B.**
47. Yet another except-type question. This question contains four statements about control panel service. Like the previous question, **B is the correct answer.** When inspecting, testing, servicing, or replacing heating, ventilating, and A/C control panel assemblies, disconnect the negative battery cable and wait the specified length of time before working on the control panel. This is especially true if you are working on a vehicle with an air bag system. The disconnecting of the battery and the wait helps

prevent unwanted air bag deployment. Self-diagnostic tests of the system may indicate a defective A/C control panel. The refrigeration system does not require discharging before A/C panel removal.

48. **The correct answer is B.** Too high of vacuum or a defective (open) vacuum check valve could not be the problem. If the manifold vacuum fitting is restricted, the controls will not operate. An inoperative vacuum motor could be due to a loss of the vacuum signal at the appropriate time. This could be the fault of a lack of the vacuum source (not too much vacuum), a defective vacuum switch, a clogged check valve, a leaking vacuum reserve tank, a disconnected or damaged hose, a clogged restrictor, a restriction in the system, or a defective vacuum motor.
49. An except-type question. The control panel assembly controls the compressor, heater valve, and plenum door. The control panel assembly has no control over the coolant temperature nor does it control the coolant temperature sensor. The purpose of the control panel is to provide operator input for the air conditioning and heating system. Some control panels have provisions for displaying in-car and outside air temperatures. A microprocessor may be located in the control panel to provide input data to the programmer, based on operator-selected conditions. **The correct answer is D.**
50. An inoperative Bowden cable-controlled heater control valve moves freely, but the valve doesn't respond to the change. Technician A is correct in saying the cable housing clamp may be loose at the control head (panel) end. Technician B is wrong. If the cable were rusted in the housing, the control would not move freely. Therefore, **the correct answer is A.**
51. All of the answer choices are true statements, but one. That one is choice B, therefore **B is the correct answer** to the question. A clogged or blocked restrictor will not affect the recirculation door operation. However, a split, broken, or disconnected vacuum hose may affect the recirculation door operation. Vacuum motors move the various doors to direct the airflow to the proper vents. The system's check valve holds the vacuum in the system, regardless of the amount of vacuum produced by the engine. If the check valve is restricted, vacuum may not be applied to the motor. If it is open, vacuum will not work to keep the flap open. If the vacuum tank leaks, there will be a loss in vacuum. If there is a leak in the vacuum system, the doors will not move properly due to no or a low vacuum signal. A vacuum leak anywhere in the control circuit will affect the operation of the entire system.
52. The situation is this: an A/C system with a vacuum reservoir, check valve, and vacuum operated mode door motor discharges warm air when the vehicle is placed under a load. Also the air discharge switches from the panel to the floor ducts under the same conditions. Besides this dilemma, the A/C system works fine. To answer this question, think about engine vacuum and how vacuum-operated devices work, then look through the answer choices. Choice A states that a leaking panel door vacuum actuator could be causing this problem. Close, but not correct. A leaking panel door actuator, as suggested in choice C, would cause the air discharge to switch from the panel to the floor ducts at any time and all of the time. Therefore this is not the correct answer. A leaking temperature blend door actuator also causes the system to change temperature at any time. Choice D is also wrong. A leaking intake manifold gasket may affect all the vacuum-operated mode doors because this condition causes low-source vacuum. That leaves choice B as the only possible cause. A leaking check valve will not trap the vacuum in the reserve tank when climbing a long hill. This action may cause the temperature blend door to move to the warm air position and the air discharge to switch to the floor ducts. **The correct answer is B.**
53. When the outside recirculation door is in position A, only outside air is allowed to enter the air conditioner heater case. When the outside recirculation door is in position B, only inside air is allowed to enter the air conditioner heater case. If the outside recirculation door is stuck in position A, outside air is drawn into the air conditioner heater case and there is no leakage of in-car air past this door. Only Technician A is right and **A is the correct answer.**
54. Both technicians are correct. If the in-car temperature sensor is defective, it may be sending a temperature signal that is colder than requested. This would cause the A/C temperature to be reduced to compensate for the cooler reading and thereby raise the in-car temperature. A sticking temperature

blend door will cause warm air to be mixed with cool air and result in the in-car temperature being lower than the driver-selected temperature. **The correct answer is C.**

55. Since the blower motor only operates at high speed, the problem must be in the high-speed circuit. The problem is probably not caused by the motor. If the high-speed relay contacts are stuck closed, the blower motor will only operate at high speeds. Therefore Technician A is right. If the high-speed resistor is open, current will not flow to the motor. However, in most systems high speed is accomplished by connecting battery voltage to the motor. This bypasses all resistors. Therefore the most likely cause of the problem is what Technician A said and **A is the correct answer.**
56. We are looking at the most likely cause of heated air coming out of the ducts when cool is selected. Answer A is not right. If the cooling fan was inoperative, the vehicle would overheat but the air would be somewhat cool because the A/C would be working. Choice B is wrong. If the coolant level was low, the vehicle would overheat and, like choice A, the A/C would still work and the air would be somewhat cool. C is also wrong. If the heater core were clogged, there would be little or no heat. Therefore the only possible cause of the problem is D and **D is the correct answer.**
57. The problem is a clutch that will not disengage. We are looking for the most likely cause. **The correct answer is D.** If the positive wire to the compressor clutch coil is shorted to a 12-volt source, the compressor clutch will not disengage. This is simply because there is no control of the power to the clutch. The other choices are wrong or at least very unlikely causes for the problem. A stuck A/C pressure cutoff switch would prevent the compressor clutch from engaging. As would a shorted clutch coil and open low-pressure switch.
58. Technician A is correct. The in-vehicle sensor is a thermistor. As temperature increases, resistance decreases; as temperature decreases, resistance increases. Contrary to what Technician B says, resistance is at a maximum when the temperature in the vehicle is cold. **The correct answer is A.**
59. **The correct answer is B.** Refrigerant storage containers must be filled to 60 percent of their gross weight rating.
60. Technician A is correct. An engine coolant temperature sensor is a thermistor. The thermistor is a resistor whose value varies with its temperature. Some increase resistance with an increase in temperature while others respond in the opposite way. Technician B is wrong. Thermistors may be checked with either an analog or digital ohmmeter without harm, though a digital meter is suggested. **The correct answer is A.**
61. **The correct answer is B,** because only Technician B is correct. If the coolant control valve were defective, the hose between it and the heater core would not be hot. The indication is that hot coolant is passing the control valve but not exiting the heater core. Therefore, the heater core may be clogged and should be cleaned or replaced.
62. Both technicians are wrong. When a fault code is obtained representing the temperature blend door, the first step in the diagnostic procedure should be to check the temperature blend door for a sticking condition. Disconnecting the battery will erase the code. Although the code may disappear for a short time, it will reappear a short while after the system is reactivated. **The correct answer is D.**
63. Careful diagnosis is the focus of this question. When diagnosing any electronic part, make sure you follow and complete all steps of the specified troubleshooting procedure. This includes using the appropriate diagnostic tester. This is especially true for those systems that do not record history-type trouble codes. Technician B is also correct. ATC control panels are not repaired and are replaced as a unit. Care needs to be taken when replacing these units. Like the other electronic circuits on a vehicle, the control panel may be part of the BCM circuit. Follow all precautions to eliminate static and voltage spikes at the BCM. **The correct answer is C.**
64. This question takes some very careful thinking. Before we go any further, let's say **the correct answer is A.** An electronic control module (ECM) is dedicated to the operation of a microprocessor-controlled

climate control system. While most ECMs are located behind the control head, some may be located within the BCM. The body computer module (BCM) regulates all vehicle functions. The ECM does not do the same things as a BCM; a BCM regulates all vehicle functions except for the powertrain.

65. **The correct answer is A.** The maximum allowable voltage drop across a computer ground wire is usually 0.1 V. Anything above that would indicate a bad ground or open wire causing a high resistance. With the low voltages used on computer-controlled climate systems, a voltage drop that is higher could cause a problem with the system.
66. An except-type question. Examine the following facts: A/C recovery/recycling equipment must have a UL and SAE J1991 approval, and refrigerant oils for R-12 and R-134a must not be mixed. The statement that is false is C. Not any type or size of container can be used with recovery/recycling equipment. The refrigerant container specified by the recovery/recycling equipment manufacturer must be used to ensure that the container has proper capacity and valving. **The correct answer is C**, because it is the false statement.
67. **The correct answer is A.** If, after the recovery process, the low-side gauge rises above 0 psi, there is still some refrigerant remaining in the system. The system should be evacuated until there is no pressure left in the system. Answer B is wrong because oil left in the system would not cause a pressure above zero. This is the same reason choices C and D are wrong.
68. **The correct answer is B.** If the moisture warning light is yellow during the recycling process, the refrigerant contains excessive moisture and the filter/dryer cartridge in the recovery/recycling equipment must be changed. The light does not indicate the presence of oil or noncondensable gases, nor does it give an indication of the efficiency of the vacuum pump.
69. In a blend air system during heater-only operation, the air conditioning unit is shut off, and the evaporator performs no function in air distribution or temperature control. During maximum A/C, the air conditioning system operates, the evaporator is cold, and the blend air door damper is completely closed. Only conditioned air enters the car. As the control lever is moved in the vehicle from max air toward heat with the air conditioner on, the blend air door is moving. In maximum cold, it is completely shut. On maximum hot, it is completely open. To check the proper functioning of the ductwork, move the temperature control lever to see if any change occurs. If it does not, shut off the air conditioner and turn on the heater. Move the temperature control arm again to see if any change occurs. If not, check the cable and the flap door connected to the temperature control lever. You might be able to reach under the dash to reconnect the cable or free a stuck flap. Both technicians are correct and **the correct answer is C.**
70. When checking a refrigerant container for noncondensable gases, the container should be stored out of the presence of sunlight at 65°F (18°C) for 12 hours, and a thermometer should be placed 4 inches (102 mm) from the container surface. If the container pressure is less than specified, the refrigerant is ready for use. Answer A recommends too high a temperature and too short a period of time. Therefore A is not correct. B is also incorrect. The container should never be stored in sunlight. C is also wrong. The thermometer should not be placed on the container; it should be held four inches away. **The correct answer is D.**
71. **A is the correct answer.** Air conditioning systems are extremely sensitive to moisture and dirt. Therefore, clean working conditions are extremely important. The smallest particle of foreign matter in an air conditioning system contaminates the refrigerant, causing rust, ice, or damage to the compressor. For this reason, all replacement parts are sold in vacuum-sealed containers and should not be opened until they are to be installed in the system. If, for any reason, a part has been removed from its container for any length of time, the part must be completely flushed using only recommended flush solvent to remove any dust or moisture that might have accumulated during storage. When the system has been open for any length of time, the entire system must be purged completely, and a new receiver/dryer must be installed because the element of the existing unit will have become saturated and unable to remove any moisture from the system once the system is recharged. Technician A is correct, just one drop of water added to the refrigerant will start chemical changes that can result in

- corrosion and eventual breakdown of the chemicals in the system. Hydrochloric acid is the result of an R-12 mixture with water. The smallest amount of moist air in the refrigerant system might start reactions that can cause malfunctions. Refrigerant and system oil travels through the system with the refrigerant. As it travels, it lubricates the moving parts of the system. Technician B is wrong.
72. Testing the refrigerant system for leaks is one of the most important phases of troubleshooting. Over a period of time, all air conditioners lose or leak some refrigerant. Leaks are most often found at the compressor hose connections and at the various fittings and joints in the system. Refrigerant can be lost through hose permeation. Leaks can also be traced to pinholes in the evaporator caused by acid, which forms when water and refrigerant mix. Since oil and refrigerant leak out together, oily spots on hoses, fittings, and components means there is a leak. Using an electronic leak detector is the preferred method of leak detection; it is safe, effective, and can be used with all types of refrigerants. The hand-held battery-operated electronic leak detector contains a test probe that is moved about one inch per second in areas of suspected leaks. (Remember that refrigerant gas is heavier than air, thus the probe should be positioned below the test point.) An alarm or a buzzer on the detector indicates the presence of a leak. On some models, a light flashes to establish the leak. The electronic leak detector is the more sensitive of the two types. Other methods of leak detection include fluorescent leak tracers and fluid-type leak detectors. All leaks should be repaired before refrigerant is added to the system. Both technicians are correct and **the correct answer is C.**
73. When replacing refrigerant oil, it is important to use the specific type and quantity of oil recommended by the compressor manufacturer. If there is a surplus of oil in the system, too much oil circulates with the refrigerant, causing the cooling capacity of the system to be reduced. Too little oil results in poor lubrication of the compressor. Therefore, Technician A is correct. Technician B is also correct. Efficient operation of the air conditioning system greatly depends on the correct amount of refrigerant in the system. A low charge results in inadequate cooling under high heat loads, due to a lack of reserve refrigerant, and can cause the clutch cycling switch to cycle faster than normal. An overcharge can cause inadequate cooling because of a high liquid refrigerant level in the condenser. Refrigerant controls will not operate properly and compressor damage can result. In general, an overcharge of refrigerant will cause higher-than-normal gauge readings and noisy compressor operation. **The correct answer is C.**
74. All of the refrigerant in the system must be recovered prior to parts replacement or evacuation. Evacuation is the name given to the process that pulls all traces of air, moisture, and refrigerant from the system. This is done by creating a vacuum in the system. A vacuum pump is connected to the system and should remain on and connected to the system for at least 30 minutes after 26 to 29 inches of mercury is reached. Any air or moisture that is left inside an air conditioning system reduces the system's efficiency and eventually leads to major problems, such as compressor failure. Air causes excessive pressure within the system, restricting the refrigerant's ability to change its state from gas to liquid within the refrigeration cycle, which drastically reduces its heat absorbing and transferring ability. Moisture, on the other hand, can cause freeze-up at the cap tube or expansion valve, which restricts refrigerant flow or blocks it completely. Both of these problems result in intermittent cooling or no cooling at all. Moisture also forms hydrochloric acid when mixed with refrigerant, causing internal corrosion, which is especially dangerous to the compressor. Both technicians are right and **the correct answer is C.**
75. Typically, problems with the heating system are problems with the engine's cooling system. Problems that pertain specifically to the heater are few: the heater control valve and the heater. When there is a problem of insufficient heat, begin your diagnosis with a visual inspection and a check of the coolant level. If the level is correct, turn the heater controls on and run the engine until it reaches normal operating temperature. Then measure the temperature of the upper radiator hose. The temperature can be measured with a pyrometer. If one is not available, gently touch the hose. You should not be able to hold the hose long because of the heat. While doing this, make sure you stay clear of the area around the cooling fan. A spinning fan can chop off your hand. If the temperature of the hose is not within specifications, suspect a faulty thermostat. If the hose is the correct temperature, check the temperature of the two heater hoses. They should both be hot. If only one of the hoses is hot, suspect the heater control valve or a plugged heater core. Technician A is correct. B, however, is not. If the cooling fans do not work, the coolant will quickly heat up and provide high heat until the engine's heat causes another problem. **The correct answer is A.**

76. An air conditioning system is a closed, pressurized system. It consists of a compressor, condenser, receiver/dryer or accumulator, expansion valve or orifice tube, and an evaporator. In a basic air conditioning system, the heat is absorbed and transferred in the following steps.
1. Refrigerant leaves the compressor as a high-pressure, high-temperature vapor.
  2. By removing heat via the condenser, the vapor becomes a high-pressure, high-temperature liquid.
  3. Moisture and contaminants are removed by the receiver/dryer, where the cleaned refrigerant is stored until it is needed.
  4. The expansion valve controls the flow of refrigerant into the evaporator.
  5. Heat is absorbed from the air inside the passenger compartment by the low-pressure, warm refrigerant, causing the liquid to vaporize and greatly decrease its temperature.
  6. The refrigerant returns to the compressor as a low-pressure, low-temperature vapor.
- From this description, you can see that all of the statements given in this question are true, except for B. Moisture is never needed by the system. **The correct answer is B.**
77. A careful visual inspection is an important start of any diagnostic work on an A/C system. However, you should know what to feel and look for. Technician A is wrong. After the system has been on for a few minutes, the condenser should be checked by feeling up and down the face or along the return bends for a temperature change. There should be a gradual change from hot to warm as you go from the top to the bottom. Technician B is correct. The liquid line from the receiver/dryer to the expansion valve should be warm for its entire length. Also, the expansion valve should be free of frost, and there should be a sharp temperature difference between its inlet and outlet. The suction line to the compressor should be cool to the touch from the evaporator to the compressor. On vehicles equipped with the orifice tube system, feel the liquid line from the condenser outlet to the evaporator inlet. A restriction is indicated by any temperature change in the liquid line before the crimp dimples the orifice tube in the evaporator inlet. **B is the correct answer.**
78. All of the statements are true except for D. All technicians should know the differences between R-12 and R-134a systems before working on these systems. Since R-134a is not interchangeable with R-12, separate sets of hoses, gauges, and other equipment are required to service vehicles. All equipment used to service R-134a and R-12 systems must meet SAE standard J1991. The service hoses on the manifold gauge set must have manual or automatic back-flow valves at the service port connector ends. This prevents the refrigerant from being released into the atmosphere during connection and disconnection. Manifold gauge sets for R-134a can be identified by one or all of the following: Labeled *FOR USE WITH R-134a*, *Labeled HFC-134 or R-134a*, and/or have a light blue color on the face of the gauges. For identification purposes, R-134a service hoses must have a black stripe along their length and be clearly labeled *SAE J2196/R-134a*. The low-pressure hose is blue with a black stripe. The high-pressure hose is red with black stripe and the center service hose is yellow with a black stripe. Service hoses for one type of refrigerant will not easily connect into the wrong system, as the fittings for an R-134a system are different than those used in an R-12 system. **The correct answer is D.**
79. The refrigerant oil required by the system depends on a number of things, but it is primarily dictated by the refrigerant used in the system. R-12 systems use a mineral oil. Mineral oil mixes well with R-12 without breaking down. Mineral oil, however, cannot be used with R-134a. R-134a systems require a synthetic oil, polyalkylene glycol (PAG). There are a number of different blends of PAG oil. Always use the one recommended by the vehicle manufacturer or compressor manufacturer. Failure to use the correct oil will cause damage to the compressor. **The correct answer is D.**
80. **The correct answer is C** because it is not true. With heater control valves that are vacuum operated, there should be no vacuum to the valve when the heater is on, except for those valves that are normally closed and need vacuum to open. Vacuum-operated valves are normally located in the heater hose line or mounted directly in the engine block. When a vacuum signal reaches the valve, a diaphragm inside the valve is raised, either opening or closing the valve against an opposing spring. When the temperature selection on the dashboard is changed, vacuum to the valve is vented and the valve returns to its original position. Vacuum-actuated heater control valves are either normally open or normally closed designs. Some vehicles don't use a heater control valve; rather, a

heater door controls how much heat is released into the passenger compartment from the heater core. The rest of the answer choices are true. Heater core failures are generally caused by leakage or clogging. If the heater core appears to be plugged, the inlet hose may feel hot up to the core but the outlet hose remains cool. Reverse flushing the core with a power flusher may open up the blockage, but usually the core has to be removed for cleaning or replacement. Air pockets in the heater core can also interfere with proper coolant circulation. Air pockets form when the coolant level is low or when the cooling system is not properly filled after draining. Feel the heater inlet and outlet hoses while the engine is idling and warm with the heater temperature control on hot. If the hose downstream of the heater valve does not feel hot, the valve is not opening. With cable-operated control valves, check the cable for sticking, slipping (loose mounting bracket), or misadjustment.

81. Both technicians are correct. The desiccant used in receiver/driers and accumulators does draw moisture like a magnet and it can become contaminated in less than five minutes if it is exposed to the atmosphere. When replacing the desiccant, keep the new bag sealed. Once opened, put it under a vacuum quickly. Most late-model systems are not equipped with a receiver/dryer; rather, they use an accumulator to accomplish the same thing as the drier. The accumulator is connected into the low side, at the outlet of the evaporator. The accumulator also contains a desiccant and is designed to store excess refrigerant and to filter and dry the refrigerant. If liquid refrigerant flows out of the evaporator, it will be collected by and stored in the accumulator. The main purpose of an accumulator is to prevent liquid from entering the compressor. **The correct answer is C.**
82. The systems need to be positively sealed when converting a R-12 system to use R-134a. Hose clamps do not provide this seal; therefore choice A is wrong. But **the correct answer is A.** The following guidelines should be followed when converting an older A/C system to R-134a. These guidelines should allow you to provide the customer with a cool vehicle and to meet current legislative mandates. The guidelines are list/ed in order and reflect the necessary steps for making this conversion.
- Visually inspect all air conditioning and heater system components.
  - Use a refrigerant identifier to make sure the system only contains R-12.
  - Leak check the system for leaks.
  - Run a performance test and record the temperature and pressure readings.
  - Remove all R-12 from the system with a recycling machine.
  - If the system uses a compressor with an oil sump, remove the compressor and drain all oil from it. Measure the amount of oil drained out.
  - Remove and inspect the expansion valve or the orifice tube; replace it if necessary. If either is contaminated, flush the condenser.
  - Remove the filter/drier or accumulator, drain it, and measure the amount of oil in it.
  - Before converting, make all necessary system changes, such as hoses, gaskets, and seals.
  - Install R-134a compatible oil into the system; put in the same amount you took out.
  - Install a new filter/drier or accumulator with the correct desiccant.
  - Permanently install conversion fittings using a thread-locking chemical.
  - Install a high-pressure cutoff switch if the system does not have one.
  - Install conversion labels and remove the R-12 label.
  - Connect R-134a system evacuation equipment and evacuate for at least 30 minutes.
  - Recharge the system to approximately 80 percent of the original R-12 charge.
  - Run a performance check and compare readings with those taken before the conversion.
  - Leak check the system.
83. To charge a system with the engine running, the refrigerant should be added to the low side of the system. **B is the correct answer.** Never open the high-side hand valve with the system operating and a refrigerant can connected to the center hose. The refrigerant will flow out of the system under high pressure into the can. High-side pressure is between 150 and 300 psi and will cause the refrigerant tank to burst. The only occasion for opening both hand valves at the same time would be when evacuating the system or when reclaiming refrigerant with the system off.
84. During a visual inspection of the system, the components are not only carefully looked at but certain parts are touched while the system is running. This technique can lead you toward a quick



diagnosis of the system. Technician A is correct. The suction line to the compressor should be cool to the touch from the evaporator to the compressor. If it is covered with thick frost, this might indicate that the expansion valve is flooding the evaporator. Technician B is also correct. Normally the formation of frost on the outside of a line or component means there is a restriction to the flow of refrigerant. **The correct answer is C.**

85. **The correct answer is C.** This statement is wrong. Suction lines are always distinguished from the discharge lines by touch and size. They are cold to the touch. Discharge and liquid lines are always very warm to the touch and easily distinguishable from the suction lines. The other statements are true. Suction lines are located between the outlet side of the evaporator and the inlet side or suction side of the compressor. They carry the low-pressure, low-temperature refrigerant vapor to the compressor where it again is recycled through the system. The suction line is larger in diameter than the liquid line because refrigerant in a vapor state takes up more room than refrigerant in a liquid state.
86. Both techs are correct. Refrigerant oil is as moisture-free as it is possible to make it. It is called a hygroscopic material because it quickly absorbs water or moisture. For this reason, the oil container should not be opened until ready for use and then it should be capped immediately after use. All air contains moisture. Air that enters any part of the system carries moisture with it, and the exposed surface collects the moisture quickly. To remove the moisture and air, an A/C system must be evacuated any time it has a leak or the system is exposed to air during service. **The correct answer is C.**
87. Retrofitting an older A/C system has legal guidelines but is not as involved as what Technician A does. The only reason the compressor should be replaced is if it is defective. Technician B is correct. The basic procedure for converting an older A/C system to R-134a includes: draining the system's oil and replacing it with R-134a compatible oil; making all necessary system changes, such as hoses, gaskets, and seals; installing a new filter/drier or accumulator with the correct desiccant; permanently installing conversion fittings using a thread locking chemical; installing a high-pressure cut-off switch if the system doesn't have one; installing conversion labels; and removing the R-12 label. **The correct answer is B.**
88. **The correct answer is D;** neither A nor B is correct. The high-pressure hose should be connected to the line that Technician B says is for low pressure. The low-pressure hose should be connected to where Technician A says the high pressure should be. In other words, the high-pressure hose should be connected to the line from the compressor to the condenser and the low-pressure hose to the line from the evaporator to compressor.
89. To minimize the amount of refrigerant released to the atmosphere when A/C systems are serviced, always follow these steps. The recycling equipment must have shutoff valves within 12 inches of the hoses' service ends. (Answer A is correct.) With the valves closed (not open like B states), connect the hoses to the vehicle's air conditioning service fittings. Recover the refrigerant from the vehicle and continue the process until the vehicle's system shows vacuum instead of pressure. (Choice C is correct.) Turn off the recovery/recycling unit for at least five minutes. (Answer D is also correct.) If the system still has pressure, repeat the recovery process to remove any remaining refrigerant. Continue until the A/C system holds a stable vacuum for two minutes. Close the valves in the recovery/recycling unit's service lines and disconnect them from the system's service fittings. **The correct answer is B.**
90. Interpreting manifold gauge readings is a crucial part of evaluating and diagnosing an A/C system. In the question, both techs are correct. What follows is a quick summary of what to suspect when the readings are abnormal. If the high-side pressure is too high, suspect air in the system, too much refrigerant in the system, a restriction in the high side of the system, and poor airflow across the condenser. If the high-side pressure is too low, suspect a low refrigerant level or defective compressor. If the low-side pressure is higher than normal, suspect refrigerant overcharge, a defective compressor, or a faulty metering device. If the low-side pressure is lower than normal, suspect a faulty metering device, poor airflow across the evaporator, a restriction in the low side of the system, or the system is undercharged with refrigerant. **The correct answer is C.**

## Answers to the Test Questions for the Additional Test Questions Section 6

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- |       |       |       |       |
|-------|-------|-------|-------|
| 1. C  | 24. B | 47. B | 70. C |
| 2. A  | 25. B | 48. C | 71. C |
| 3. D  | 26. C | 49. A | 72. B |
| 4. C  | 27. C | 50. C | 73. D |
| 5. A  | 28. A | 51. D | 74. A |
| 6. A  | 29. C | 52. C | 75. C |
| 7. B  | 30. D | 53. C | 76. C |
| 8. C  | 31. C | 54. D | 77. C |
| 9. A  | 32. B | 55. A | 78. A |
| 10. A | 33. C | 56. D | 79. C |
| 11. B | 34. A | 57. C | 80. A |
| 12. A | 35. C | 58. D | 81. B |
| 13. D | 36. B | 59. B | 82. C |
| 14. C | 37. C | 60. B | 83. D |
| 15. A | 38. A | 61. B | 84. A |
| 16. A | 39. A | 62. A | 85. C |
| 17. C | 40. C | 63. A | 86. A |
| 18. C | 41. A | 64. C | 87. C |
| 19. A | 42. D | 65. C | 88. B |
| 20. C | 43. C | 66. C | 89. C |
| 21. C | 44. C | 67. C | 90. B |
| 22. C | 45. B | 68. D |       |
| 23. A | 46. D | 69. A |       |

## Explanations to the Answers for the Additional Test Questions Section 6

1. Both technicians in this question are correct. Refrigerant system blockage and extremely high refrigerant system pressures might cause a thumping noise in the compressor. The noise is the result of the refrigerant "bumping" inside the compressor. If this noise were to continue for some time, damage to the system may result. **The correct answer is C.**
2. A defective compressor bearing may cause a growling noise only when the compressor clutch is engaged. A bent pulley can also cause a growling or rubbing noise; however, this noise will tend to be constant. Low refrigerant charge will cause a noise but will affect A/C system performance. Excessive pressures would cause a growling type noise. **The correct answer is A.**
3. In most older R-12 systems, the sight glass may be used as a method of checking the charge in the system. If the sight glass contains bubbles, the refrigerant system charge is low and/or air has probably entered the system. If oil streaking is seen, this indicates the system is empty. A sufficient level of refrigerant is indicated by what looks like a flow of clear water, with no bubbles. A clouded sight glass is an indication of moisture or desiccant contamination with subsequent infiltration and circulation through the system. **The correct answer is D.**
4. Air and moisture in the refrigerant system can cause higher-than-specified system pressures. A restricted TXV may cause low refrigerant pressures; this condition may also result in TXV frosting. A defective compressor may cause low high-side pressure and high low-side pressure. A low refrigerant charge causes reduced low-side and high-side pressures. A restriction in the low side will cause lower-than-normal low-side pressure, even into a vacuum. Such a restriction in the low side of the system would generally be accompanied by a lower-than-normal high-side pressure. This is also true if there is an undercharge of refrigerant. If the system is overcharged, however, the higher-than-normal high-side pressure will be accompanied with a higher-than-normal low-side pressure. **C is the correct answer.**
5. These gauge readings are too high. The cause of the readings could be air and moisture in the refrigerant system or an overcharged system. A restricted thermal expansion valve (TXV) may cause low refrigerant pressures; this condition may also result in TXV frosting. The vehicle has no signs or evidence of frosting, so Technician B is certainly not right. Technician A is right and **A is the correct answer.**
6. **The correct answer is A.** A low refrigerant charge may cause faster-than-normal clutch cycling without frosting of any components. That is exactly what the problem is so low charge is a very likely cause of the problem. A restricted receiver/dryer usually causes frosting of this component. A flooded evaporator causes frosting of the evaporator outlet and compressor suction pipes. A restricted TXV usually causes frosting of this component. Although all of these would affect the cooling efficiency of the system, they all would cause frosting except for A.
7. Technician A is wrong. The right idea is there but one fact is wrong. An oily residue indicates a refrigerant leak in that area where refrigerant is escaping along with some of the oil in the system. The oil is not caused by excessive oil. Technician B is correct. The oily residue could and probably is caused by a leak at the hose fittings. **The correct answer is B.**
8. Both techs are right and therefore **C is the correct answer.** R-12 is sold in white containers, and R-134a is marketed in light blue containers.
9. Proper evacuation not only eliminates all traces of refrigerant, it also rids the system of unwanted air and moisture that may have entered the system during service. The moisture is boiled out because of the vacuum caused when evacuating the system. **A is the correct answer.** Rust, dirt, and desiccant would probably not be pulled through the opening of the service valves. If these materials were present in the refrigerant, the system would have problems and parts would need to be replaced.

10. Technician A is correct, some manufacturers recommend installing an in-line filter as an alternative to refrigerant system flushing. Some of these filters contain an orifice tube. When these are installed, do not do what Technician B says. Remove the original orifice tube in the system when installing this type of filter. Failure to do this will cause very poor cooling ability because the system will have two control valves. **The correct answer is A.**
11. Technician A is supporting a very dangerous practice. If you connect a refrigerant can to the high side with the engine running, the high pressure from the system can cause the can to blow up. The high-side charging procedure must only be completed with the engine off. The vehicle should always be charged from the low-pressure side if the engine is on. If the engine is off, it can be charged from the high-pressure side. Technician B is correct. If liquid refrigerant enters the compressor, the compressor can be damaged. **The correct answer is B.**
12. The lubricant used in air conditioning systems is a nonfoaming, sulfur-free grade oil specially formulated for use in certain types of air conditioning systems. It must be noted that a mineral-based lubricant is used in R-12 systems while a glycol-based synthetic lubricant is used in an R-134a system. The oil required with R-134a refrigerant is a polyalkylene glycol (PAG) oil. Refrigerant oil is a wax-free oil that will quickly absorb any moisture that it comes in contact with. **The correct answer is A.** The other answer choices could destroy the A/C system.
13. Let's first look at the components that are numbered in the drawing for this question. 1 is the compressor, 2 is the condenser, 3 is the evaporator, 4 is the accumulator, and 5 is some type of switch located on the accumulator. Any type of pressure switch could be located there. Of the switches listed as answer choices, only D is likely to be found on the accumulator. **D is the correct answer.** A low-pressure switch could be found there. This switch senses any low-pressure conditions. It is tied into the compressor clutch circuit, allowing it to immediately disengage the clutch when the pressure falls too low. The high-pressure cutoff switch keeps system pressures from reaching a point that may cause compressor lockup or other component damage because of excessive high pressures. The purpose of the cycling switch is to cycle the compressor clutch on and off in relation to refrigerant system pressure.
14. A thermal switch is placed in the compressor clutch circuit so it can turn the clutch on or off. It deenergizes the clutch and stops the compressor if the evaporator is at the freezing point. When the temperature of the evaporator approaches the freezing point (or the low setting of the switch), the thermostatic switch opens the circuit and disengages the compressor clutch. The compressor remains inoperative until the evaporator temperature rises to the preset temperature, at which time the switch closes and compressor operation resumes. Technician A is right; the thermal switch may be connected in series with the compressor clutch. Technician B is also right. This switch may be mounted on the compressor. Many thermal switches open at 257°F (125°C) and close at 230°F (110°C). **The correct answer is C.**
15. Only Technician A is right. Whenever one V-belt breaks on a two-belt drive system, both belts should be replaced as a pair. This is done to ensure proper tension. Plus the belts should be re-tensioned after a few hours of use. Often idler pulleys have a self-tensioning provision, and further attention is not required. Technician B is wrong. An idler pulley does not need to be replaced when a belt breaks unless it is defective. The correct answer is A.
16. **The correct answer is A.** The armature of the clutch assembly does not rotate when the clutch is energized. The clutch is driven by power from the engine's crankshaft, which is transmitted through one or more belts (a few use gears) to the pulley, which is in operation whenever the engine is running. When the clutch is engaged, power is transmitted from the pulley to the compressor shaft by the clutch drive plate. When the clutch is not engaged, the compressor shaft does not rotate, and the pulley freewheels.
17. Both technicians are correct. A small amount of lubricant is lost from the compressor due to circulation through the system. The lubricant level of some compressors may be measured with a dipstick while others must have the oil drained and measured in a beaker. **The correct answer is C.**

18. **The correct answer is C.** A replacement compressor should have the same type of clutch and pulley as the old compressor. The mounting brackets and other fasteners on a replacement compressor should also be identical to those on the old compressor. Both technicians are correct.
19. A compressor noise problem is often difficult to locate. When the compressor is operating, a loose compressor mount or bracket may vibrate, giving the impression that the compressor itself is somehow defective. Technician A is right. This type of noise usually stops when the compressor is disengaged. Contrary to what Technician B says, if the A/C system does not have any refrigerant in it, the compressor clutch will not engage and therefore will not make any noise since it is not engaging. **A is the correct answer.**
20. When retrofitting an A/C system, it is not necessary to replace the O-ring seals unless they are leaking. Technician A is right. Leak testing the system is one of the first steps that are taken while converting a R-12 system to R-134a. Technician B is also right. The accumulation of dirt around an A/C line connection is an indication of a leak in the system. When there is a leak in the system, dirt collects in the area of the leak due to some of the oil leaking out. **The correct answer is C.**
21. Both techs are right. If the condenser air passages are severely restricted, this may result in high refrigerant system pressures and refrigerant discharge from the high-pressure relief valve. These restrictions will not allow enough air to cool down the condenser, causing higher temperatures and in turn higher pressures. **C is the correct answer.**
22. **The correct answer is C.** When frost is forming on one of the condenser tubes near the bottom of the condenser, the refrigerant passage is restricted at that location in the condenser. Frosting is a clear indication that there is a restriction in the condenser. Restricted airflow passages in the condenser would not cause frosting; it would limit the efficiency of the system because the refrigerant would not be cooled by the air flowing through the condenser. A leak would not cause frosting either; oil may be seen at the point of leakage. If the orifice tube were restricted, there would be frost around it.
23. The receiver/dryer is a storage tank for the liquid refrigerant from the condenser, which flows into the upper portion of the receiver tank containing a bag of desiccant. The purpose of the desiccant is to absorb any moisture that might enter the system during assembly. The receiver/dryer is often neglected when the air conditioning system is serviced or repaired. Failure to replace it can lead to poor system performance or replacement part failure. It is recommended that the receiver/dryer and/or its desiccant be changed whenever a component is replaced, the system has lost the refrigerant charge, or the system has been open to the atmosphere for any length of time. Most late-model systems are not equipped with a receiver/dryer; rather, they use an accumulator to accomplish the same thing. Technician A is correct. If the receiver/dryer outlet is colder than the inlet, this unit is restricted and should be changed to restore efficient and proper system operation. Technician B is not right. If the refrigerant in the sight glass appears red, leak-detecting dye has been added to the refrigerant. This condition does not require any corrective action. **The correct answer is A.**
24. Think about the situation here. The low-side pressure is higher than normal. But when the expansion valve's remote bulb or capillary tube is warmed up, the pressure decreases. Technician A is not right. If the expansion valve were faulty, it probably would not respond to the change in temperature. If the expansion valve were defective, warming the remote bulb would make little or no difference in the low-side pressure. If there was no difference in pressure, one may assume that the valve was stuck in an open position and not throttling down to properly meter refrigerant into the evaporator. If there is no indication that the expansion valve is defective, the remote bulb is most likely loose or improperly secured. Technician B is correct and the **correct answer is B.**
25. Technician A is wrong. A restricted orifice tube may cause lower- (not higher-) than-specified low-side pressure. Technician B is correct in saying a restricted orifice tube may cause frosting of the tube because of the low temperatures caused by the low pressure. **The correct answer is B.**

26. The purpose of a typical automotive heater/air conditioner/case and duct system is twofold. It is used to house the heater core and the air conditioner evaporator and to direct the selected supply air through these components into the passenger compartment of the vehicle. The supply air selected can be either outside or recirculated air, depending on the system mode. After the air is heated or cooled, it is delivered to the floor outlet, dash panel outlets, or the defrost outlets. All incoming air is directed through the evaporator core in all modes of the climate control system using the evaporator case, evaporator case doors, and the blower motor. Both technicians are correct and **the correct answer is C.**
27. Both technicians are right. An evaporator leak may be detected with an electronic leak detector. An oil film on the windshield may be caused by a refrigeration leak in the evaporator core that may allow some refrigerant oil to escape in the evaporator case. An evaporator restriction is indicated by a low-side pressure that is considerably lower than specified and inadequate cooling with a normal TXV or orifice tube. Upon receiving the low-pressure, low-temperature liquid refrigerant from the thermostatic expansion valve or orifice tube in the form of an atomized spray, the evaporator serves as a boiler or vaporizer. This regulated flow of refrigerant boils immediately. Heat from the core surface is lost to the boiling and vaporizing refrigerant, which is cooler than the core, thereby cooling the core. The air passing over the evaporator loses its heat to the cooler surface of the core, thereby cooling the air inside the car. As the process of heat loss from air to the evaporator core surface is taking place, any moisture in the air condenses on the outside of the evaporator core and is drained off as water. **The correct answer is C.**
28. When the fins and air passages of an evaporator are clogged with dirt, air will have a difficult time passing through the evaporator. Since the principles of air conditioning require the heated air around the evaporator to lose heat, a vehicle with a clogged evaporator will have poor A/C performance. Technician A is correct in saying an evaporator core should be removed from the case to properly clean it. Since most evaporators do not have filters, airborne debris, such as lint, hair, and other contaminants, enters the evaporator case and clings to the wet evaporator core. It is nearly impossible to adequately clean an evaporator core without first removing it from the case. Only Technician A is correct and **the correct answer is A.**
29. Both techs are right. The evaporator water drain is an integral part of the evaporator housing assembly. A crack or break in the housing may reduce the cooling capacity of the air conditioner. If the evaporator (water) drain becomes clogged, it is easily cleaned with a stiff wire from the outlet in, provided the technician takes care not to puncture the delicate evaporator core. If the case has a crack or break on the engine side of the firewall, excessive engine heat may enter the case and thereby reduce the efficiency of the air conditioning system. **The correct answer is C.**
30. Both techs are wrong. In the past, the evaporator temperature regulator (ETR) and suction throttling valve (STV) were popular methods of evaporator temperature control, but these have not been in use for several years. All were used in the suction line from the evaporator to the compressor to maintain evaporator pressure, thereby maintaining its temperature. **The correct answer is D.**
31. Schrader-type service valves and stem-type service valves both have a dust cap over the valve. When manifold gauge set hoses are connected to the Schrader-type, a pin in the hose depresses the Schrader valve so the valve will open, allowing refrigerant to flow into or out of the sealed A/C system. The stem type valve has a valve that can be opened once the manifold gauge set is installed and closed before removing the manifold gauge set. Both technicians are right and **the correct answer is C.**
32. A high-pressure relief valve is incorporated into many air conditioning systems. This valve may be installed on the receiver/dryer, compressor, or elsewhere in the high side of the system. It is a high-pressure protection device that opens (normally at 440 psi) to bleed off excessive pressure that might occur in the system. This is necessary to keep system pressures from reaching a point that may cause compressor lockup or other component damage. When replacing a high-pressure relief valve, the system must be discharged before removing the valve. It is necessary to replace the high-pressure relief valve with one of the same relief pressure specifications unless the vehicle is going to be retrofitted to use R-134a refrigerant instead of R-12. Only Technician B is right in this question and **the correct answer is B.**

33. Again, both techs are right. Some high-pressure relief devices are spring-loaded and self-resetting. Some high-pressure relief devices are made of fusible metal and are not self-resetting. Self-resetting high-pressure relief valves are usually found on the rear head of the compressor while fusible metal high-pressure relief devices are often found on the receiver/dryer, accumulator/dryer, or some other pressure vessel. Not all systems, however, have a pressure relief device—many aftermarket systems do not have one. **The correct answer is C.**
34. Only Technician A is right. If the heater core is restricted, coolant flow may be prevented. Any condition that will affect the proper flow of engine coolant through the heater core may affect proper heater performance. This includes a defective control valve or a blockage in the heater hoses or core. B is wrong because a faulty engine coolant thermostat or one with the wrong heat range would have little effect on the performance of the heater, unless it was stuck closed, thereby preventing the coolant from circulating through the heater core. The thermostat's primary purpose is to prevent engine overcooling. **The correct answer is A.**
35. Technician A is right. A leaking heater core is often the cause of a windshield fogging problem. Windshield fogging is the result of hot and humid air that condenses on the cooler glass. Under this condition, the coolant level in the radiator should be checked. The heater core should be repaired or replaced. Technician B is also right. Cleaning a clogged evaporator/heater case drain tube often eliminates a windshield fogging problem. If the drain is clogged, a leaking heater core will allow engine coolant to accumulate in the housing. A clogged drain also allows condensed water vapor to accumulate. Both of these problems add moisture to the air, which tends to fog the windshield. **The correct answer is C.**
36. This is an "except-type" question. **The correct answer is B** because it is wrong. A clogged heater core or hose will not affect overall engine cooling. It will affect the performance of the heating system. The other answer choices are true. A thermostat stuck in the closed position will cause engine overheating. A defective pressure cap may result in a loss of coolant or excessive damage caused by high pressure. An improperly positioned condenser may add a heat load to the cooling system. When a vehicle has a cooling system problem, check the coolant level. If it is low, check for leaks using a coolant system pressure tester. The pressure cap may also be tested with the same tool. To check the thermostat carefully, feel the upper radiator hose after the engine is warm. If the hose is not hot to the touch, the thermostat may be stuck open, an incorrect thermostat may be installed, or no thermostat may be installed.
37. **The correct answer is C** since both technicians are right. When the engine is running with the thermostat closed, the coolant is directed through a bypass system to be circulated again through the engine. In many cases, this prevents heat at the heater core. However, some systems use the heater core as a thermostat bypass.
38. This is a legal question and the answer depends on your knowledge of federal, state, and local laws. Technician B is not aware and is wrong in stating coolant can be reused. Coolant is considered a hazardous waste and must be recovered. Coolant must be recycled according to local regulations. In no instance can it be disposed of in a landfill. Any coolant removed from an automotive cooling system may contain harmful engine residues, such as benzene and lead. If used coolant is to be disposed of, it must be done according to local regulations. Ideally, however, the coolant may be recycled by filtering out most of the contaminants. Some recycle machines use vacuum distillation or ion exchange technology for glycol-based coolants. After recycling, the coolant must be supplemented with an additive before being reused. **The correct answer is A.**
39. Only Technician A is right on this one. An improperly positioned radiator shroud could cause overheating. The radiator shroud needs to be properly positioned to aid the fan in directing airflow through the radiator. Technician B is wrong. The fan clutch being locked would not cause overheating. A locked fan clutch would cause the fan to run at all times. This would cause an overcooling, if anything. The biggest problem with a locked fan clutch is the increased drag on the engine costing fuel and horsepower. **The correct answer is A.**

40. Technician A is right. Rust discoloration at the heater control valve may indicate a malfunctioning valve. Technician B is also right. A defective heater control valve may result in a poor cooling condition by allowing hot coolant to enter the heater core. The heater control valve is used to control the flow of heated coolant through the heater core. The hot coolant is often used to "temper" the air for temperature control and to help maintain a desired in-car relative humidity. Heater coolant control valves may be electronically, mechanically, or vacuum controlled. **The correct answer is C.**
41. To answer this question you need to think about what could cause the blower motor not to work. To do this, think about the blower circuit and only the blower circuit. To function properly, the blower motor requires a complete electrical circuit. It is generally connected to the negative side of the battery via the frame of the vehicle and to the positive side of the battery via insulated wires, speed resistors, the switch, the fuse or circuit breaker, and the ignition switch. An open circuit in the resistor or resistor terminals at the switch will cause the blower motor to operate at a speed not selected or not at all. An open at the switch terminal of the resistor will not allow the blower motor to operate at the speed selected by the switch. An open circuit at the blower switch ground or at the terminal causes the blower to be completely inoperative. As Technician A said, a loose ground wire will cause an inoperative blower motor. Technician B is wrong, a compressor clutch diode has no effect on the blower motor. **The correct answer is A.**
42. The most likely cause of the problem in this question is given in choice D, therefore **D is the correct answer.** A defective A/C pressure cutoff switch opens the compressor clutch circuit if the refrigerant system pressures are extremely high. A defective clutch control relay or clutch coil is not likely to cause the clutch to become deenergized in relation to temperature. A defective engine coolant temperature sensor may indicate engine overheating to the powertrain control module (PCM) when the engine is at normal operating temperature. This signal causes the PCM to open the ground circuit on the clutch control relay winding and deenergize the clutch.
43. Both techs are right. A/C systems have load-sensitive electrical switches, such as the low-pressure switch, high-pressure switch, pressure cycling, and power steering. Not all of these switches, however, are used on all vehicles. The pressure switches are used to prevent compressor or component damage in the event of extremely high- or low-system pressures. Some compressor clutch circuits contain a thermal limiter switch that senses compressor surface temperature. Some A/C compressor clutch circuits also contain a low-pressure and high-pressure cutoff switch. **The correct answer is C.**
44. There are many variations of electric cooling fans used on today's vehicles. Their operation depends on a number of things and they are controlled by a number of switches, relays, and control modules. Some cooling fan systems use a two-fan system; they have a low-speed fan and a high-speed fan. An electric cooling fan usually is wired through a relay because of the amount of current drawn to run an electric fan. Using a relay reduces the amount of current at the controlling switches. This reduces the chance of arcing. Both technicians are correct and **the correct answer is C.**
45. The problem is a blower motor that doesn't work in the high-speed mode. The cause must be something in that circuit and something that would affect the operation of the motor in only that switch position. This is where Technician A went wrong. If there is only one ground wire and it is loose or broken, the blower motor will not work at any speed. Technician B is right; if the high-speed relay were defective, only high-speed operation would be affected. The blower motor often receives its power through a high blower relay or a low blower relay. To determine when a blower motor is inoperative, it is necessary to bypass the other components in the circuit. **The correct answer is B.**
46. To answer this question, look carefully at the drawing and follow the vacuum lines. Then determine where full vacuum would be applied if it were present at the vacuum distributor. Of the answer choices only D is correct. With 18 in. Hg (40.5 kPa absolute) supplied to the control valve switch assembly, the same vacuum should be applied to the panel door actuator with the switch in the A/C max position. The other choices are not correct. In the OFF position, vacuum would not be applied to the panel door actuator. When the control is set to NORMAL A/C, no vacuum would be applied



to the outside recirculate door actuator. Also, vacuum would not be applied to the outside recirculate door actuator when the switch is in the MAX A/C position. **The correct answer is D.**

47. The problem is no heat from a system equipped with a Bowden cable-controlled heater control valve. Technician A says the cause could be a binding cable holding the valve open. When the valve is open, full coolant flow through the valve would provide plenty of heat. The problem caused by this would be heat at all times. Technician B is correct; the no heat condition could be caused by a kink in the cable holding the valve closed. With the valve held closed, coolant would not flow and there would be no heat. **The correct answer is B.**
48. Vacuum motors move the various doors to direct the airflow to the proper vents. Vacuum air doors are controlled by a selector switch in the control head (panel). This unit directs the vacuum signal to the proper motor. If the selector switch is defective, vacuum will not be supplied to the proper door. If there is a leak in the vacuum system, the door will not move properly due to no or a low vacuum signal. A vacuum leak anywhere in the control circuit will affect the operation of the entire system. If the system is sound, the vacuum motor should be checked. When testing a vacuum actuated door, the vacuum gauge reading should remain steady for at least one minute. If the gauge reading drops slowly, the actuator is leaking and should be replaced. Both techs are right and **the correct answer is C.**
49. The problem in this question is that the blower motor operates at low speed only. The voltage to the motor does increase when high is selected. This is the main point. The control for high speed must be working or else there would not be an increase in voltage. To answer this question, consider only those answer choices that would affect the motor's operation when full battery voltage is applied. Of the answer choices, only one is a possible cause of the problem; that would be A. If the motor is defective, it may not be able to rotate at high speeds regardless of the amount of voltage applied to it. A bad ground would prevent the motor from operating at any speed. A bad power module would not allow the voltage to change when high is selected. If there were an open in the circuit, the fan wouldn't work at all. **The correct answer is A.**
50. Both techs are right. When the engine stalls as the A/C system is turned on, it means the engine cannot handle the extra load. Raising the idle speed when the engine is experiencing increased load is the job of the throttle kicker. If the throttle position solenoid is thought to be defective, it should be checked to determine if the engine idle speed changes when the transmission is shifted into any gear. The throttle position solenoid is used to increase the curb idle speed to compensate for extra loads placed on the engine, such as when the air conditioner is turned on or the transmission is shifted into gear. This is required to ensure smooth engine idle and adequate emission control. **The correct answer is C.**
51. **The correct answer is D.** A defective clutch bearing may be the cause of a noise coming from the compressor when it is running. If the noise stops when the compressor is not running, the clutch bearing is not at fault. Most compressor clutch problems are generally obvious by a noisy operation; this noise tends to be more obvious when the clutch is disengaged. These problems are generally caused by a defective clutch, defective bearing, or insufficient current flow to the clutch coil. Once the problem has been found, it must be corrected and the clutch checked for proper operation.
52. A fixed orifice tube system has an accumulator in the suction line. The system type is easily identified by checking to see if it has a receiver/dryer or an accumulator. If there is a receiver/dryer between the condenser outlet and the evaporator inlet, it is a thermostatic expansion valve system. If an accumulator is found between the evaporator outlet and compressor inlet, it is a fixed orifice tube system. Both technicians are right and **the correct answer is C.**
53. The problem is that the A/C system seems to work fine in the early morning and evenings, but does not during the heat of the day. During a performance test, the low-side gauge reads normal and then drops dramatically. Both techs have identified possible causes. **The correct answer is C.**

54. Neither technician is right. It must never be assumed that a system is charged with R-12 simply because it has ¼-inch service valves. It should never be assumed that the lack of a label or labels is an indication that the system is charged with R-12 refrigerant. Other refrigerants have been used in automotive air conditioning systems without regard to product identification. This may even include some refrigerants that are considered flammable or otherwise hazardous and not approved for automotive service. It, therefore, should never be assumed that a system is charged with any particular type of refrigerant simply because of its service valves or the lack of labels. **The correct answer is D.**
55. Typically the causes for excessive high-side pressures are air in the system, too much refrigerant in the system, a restriction in the high side of the system, and poor airflow across the condenser. The only answer choice that fits that criterion is A. A leaking thermostatic expansion valve, open bypass valve, or a bad vapor control switch would cause the low-side pressure to be lower than normal. **The correct answer is A.**
56. The A/C system should only be charged through the high side with the system off. If the system is charged through the high side (with the system off), the compressor should be turned a few times by hand afterward to ensure there is no liquid refrigerant on top of the piston. Liquid could destroy the compressor. Inverting the refrigerant container disperses liquid refrigerant. As a general practice, the system should be charged through the low side while it is running. All of the answer choices for this question are correct and true, except D, but **D is the correct answer** to this EXCEPT question.
57. If there are 12 volts at the compressor clutch, there is battery voltage supplied to the compressor clutch and connecting wire. If the clutch is inoperative, the compressor clutch coil or the wire from the coil to ground is open. An open thermal switch may also be the cause. Both technicians are correct and **the correct answer is C.**
58. Both techs are close but are still wrong. A loose A/C compressor belt will likely produce a squealing noise only when the compressor clutch is engaged. A loose power steering belt may cause a squealing noise on acceleration, not just at low speeds. **The correct answer is D.**
59. Nearly all clutch assemblies have a clearance spec for the distance between the clutch and the pressure plate. This clearance is measured with a feeler gauge. If the clearance is too great, the clutch may slip and cause a scraping or squealing noise. If the clearance is insufficient, the compressor may run when not electrically activated and the clutch may chatter at all times. Of the answer choices, B is the most correct and **B is the correct answer.**
60. An except-type question with all statements true except for B. When replacing the ceramic seal and seat, use a seal protector to reduce the possibility of damaging the shaft seal during installation. Because the ceramic is quite fragile, it should be tapped into place. Also avoid touching the face of the seat while installing it. Skin oil can affect its efficiency. When replacing the shaft seal, the O-ring must be installed before the shaft seal. Apply a coat of clean refrigerant oil on the seal, seat, and O-ring while you are installing them. **The correct answer is B.**
61. The only probable result of a broken expansion valve capillary tube would be inadequate cooling. A defective or broken capillary tube would most likely cause the thermal expansion valve (TXV) to remain closed, causing poor cooling at all times. Therefore **B is the correct answer.** The other choices are problems, but these problems would not be caused by a broken or defective capillary tube.
62. Technician A is right. Restricted radiator tubes may cause engine overheating. The engine overheats and causes excessive cooling system temperatures and pressures, forcing excessive coolant flow into the recovery container. As the system cools, it creates a vacuum and draws the coolant from the recovery container back into the radiator (cooling system). Technician B is wrong. A blown head gasket would cause the engine to overheat but probably would not cause the coolant level in the recovery tank to increase. With a blown head gasket, coolant is drawn into the cylinders and burns with the combustion of the fuel. This would cause a coolant loss. **The correct answer is A.**

63. Technician A is right. If the vehicle has a bad power steering cutoff switch, the engine will stall at idle if the steering is moved to the full lock position. This is due to the increased load on the engine and the power steering pump is putting out too much pressure. Technician A is right. However B is wrong. A loose A/C belt would never cause the engine to stall. **The correct answer is A.**
64. Both techs are right. Some actuator motors are calibrated automatically in the self-diagnostic mode of the ECM, whereas other actuator motors must be calibrated manually. These actuators should only require calibration after motor replacement or misadjustment. **The correct answer is C.**
65. A hand-held vacuum pump is being used to test a blend door vacuum motor. Since vacuum is being applied but there is no reading on the gauge, one would assume there is a leak, a big leak. Using this assumption to decide which of the answer choices is correct, we find **the correct answer is C.** The motor could be bad because its diaphragm leaks or the housing is cracked. In either case, the motor will not work and won't hold a vacuum. Answers A and B are wrong because the system would be able to hold a vacuum, especially if it were plugged or if the door was restricted. Answer choice D is just wrong.
66. Both techs are right. The control panel assembly controls the compressor, heater valve, and plenum door. The control panel assembly has no control over the coolant temperature. The purpose of the control panel is to provide operator input for the air conditioning and heating system. Some control panels have provisions for displaying in-car and outside air temperatures. A microprocessor may be located in the control panel to provide input data to the programmer, based on operator-selected conditions. **The correct answer is C.**
67. The control circuit for the compressor clutch is being bypassed and it still does not work. The question asks for the LEAST likely cause. Answer A is very likely. If the clutch coil were open, the clutch would not engage. Choice B is also likely; if the coil were shorted, the clutch would not engage. Although this is true, the clutch may engage until the jumper wire burns. So may your hand if you are holding the jumper wire. Choice C, an open wire in the compressor clutch control circuit, would not cause this problem. By using the jumper wire, the control circuit is being bypassed. Answer D is also likely. A damaged or open clutch coil connector would prevent the clutch from engaging. **The correct answer is C** because it is the least likely.
68. To minimize the amount of refrigerant released to the atmosphere when A/C systems are serviced, always use the proper recovery/recycling equipment. The recycling equipment must have shutoff valves within 12 inches of the hoses' service ends. With the valves closed, connect the hoses to the vehicle's air conditioning service fittings. Always follow the equipment manufacturer's recommended procedures for use of the equipment. Recover the refrigerant from the vehicle and continue the process until the vehicle's system shows vacuum instead of pressure. Turn off the recovery/recycling unit for at least five minutes. If the system still has pressure, repeat the recovery process to remove any remaining refrigerant. Continue until the A/C system holds a stable vacuum for two minutes. Then close the valves in the recovery/recycling unit's service lines and disconnect them from the system's service fittings. Now the system is ready for repairs. **The correct answer is D.**
69. In cycling clutch systems with a fixed orifice tube, a thermostatic switch is placed in series with the compressor clutch circuit so it can turn the clutch on or off. It deenergizes the clutch and stops the compressor if the evaporator is at the freezing point. The compressor remains inoperative until the evaporator temperature rises to the preset temperature, at which time the switch closes and compressor operation resumes. Only Technician A is right; TXV systems do not use a de-icing or thermostatic switch. **The correct answer is A.**
70. **The correct answer is C** because it is wrong. Compressor failure causes foreign material to pass into the system. The condenser must be flushed and the receiver/dryer replaced. Filter screens are sometimes located in the suction side of the compressor and in the receiver/dryer. These screens confine foreign material to the compressor, condenser, receiver/dryer, and connecting hoses. Use

only recommended flushing solvents. *Never use CFCs or methylchloroform for flushing.* Some recommend, instead of flushing the system, replacing the clogged components and installing a liquid line (in-line) filter just ahead of the expansion valve or orifice tube. If flushing is recommended by the manufacturer, use only the recommended flushing agent and follow the specified procedures. After the system has been flushed, be sure to oil all components that require it.

71. Both techs are right. Converting a R-12 system to use R-134a can be done if all federal and local regulations are met. Typically the R-12 system must be thoroughly purged and flushed to remove all traces of R-12. Because R-134a operates at higher pressures than R-12, new refrigerant hoses, designed for those higher pressures, must be used. Different systems require that different components be changed as well. After the conversion has been completed, the system must be labeled as a R-134a system. All standard or required service procedures (such as reclaiming) must be followed during conversion. **The correct answer is C.**
72. Technician A is wrong. If the moisture warning light is yellow during the recycling process, the refrigerant contains excessive moisture and the filter/dryer cartridge in the recovery/recycling equipment must be changed. Technician B is right. When using refrigerant recovery systems and CPL is displayed on the recovery equipment, the display flashes the amount of refrigerant and oil recovered from the system. **The correct answer is B.**
73. **D is the correct answer.** If the low-side pressure is lower than normal, suspect a faulty metering device, poor airflow across the evaporator, a restriction in the low side of the system, or the system is *undercharged* with refrigerant.
74. An ambient temperature switch senses outside air temperature and is designed to prevent compressor clutch engagement when air conditioning is not required or when compressor operation might cause internal damage to seals and other parts. Technician A is correct, but B is wrong. The switch is in series with the compressor clutch electrical circuit. But it closes at about 37°F and stays closed at all lower temperatures. This prevents clutch engagement. **The correct answer is A.**
75. The wrong statement in this question is C and **C is the correct answer.** The federal Clean Air Act (CAA), Section 609, established the law that anyone who performs a service involving refrigerant in an automobile air conditioning system must be properly certified. This is not a recommendation, it is law. All other statements are right. All recovery/recycling equipment must have UL approval and SAE J1991 approval, and refrigerant oils for R-12 and R-134a must not be mixed. The refrigerant container specified by the recovery/recycling equipment manufacturer must be used in this type of equipment to ensure that the container has proper capacity and valving. Refrigerant recovery/recycle equipment must have UL approval and meet SAE standard J1991. In addition, all equipment used in this service must have a label certifying that it is UL approved and meets SAE standard J1991.
76. Pressure is what the operation of an A/C unit is all about. It also plays an important part in engine cooling and the heating system, as well as many other automotive systems. Certain principles must be known in order to understand and diagnose these systems. Some of these facts are: Pressure on a substance, such as a liquid, changes its boiling point. The greater the pressure on a liquid, the higher the boiling point. If pressure is placed on a vapor, the vapor condenses at a higher-than-normal temperature. In addition, as the pressure on a substance is reduced, the boiling point can also be reduced. For example, the boiling point of water is 212°F. The boiling point can be increased by increasing the pressure on the fluid. It can also be decreased by reducing the pressure or placing the fluid in a vacuum. Statement C is wrong. Pressure on a liquid would not cause it to freeze at a higher temperature. If it did, the coolant in the radiator might freeze because it is pressurized. **The correct answer is C.**
77. Both techs are right and **the correct answer is C.** A pressure cycling switch is electrically connected in series with the compressor electromagnetic clutch. Like the thermostatic switch, the turning on and off of the pressure cycling switch controls the operation of the compressor. When low-side pressure decreases to about 25 psi, the pressure cycling switch opens the clutch's coil circuit to

- disengage it. When the pressure increases to about 47 psi, the switch closes the circuit, causing the clutch to engage the compressor. System pressure is regulated by the cycling of the compressor.
78. Both pressure readings are low; this problem is probably caused by a low refrigerant charge, which is choice A. There are many other possible causes for low readings, but none of the other answer choices would cause them. Choice B says these readings are normal and is not true. Choice C suggests that a bad compressor is causing the problem. A bad compressor would typically cause equal pressure on both sides. Choice D sites a restriction on the high-pressure side of the system. If this were the case, both readings would be high. **The correct answer is A.**
79. The gauge readings stated in this question are normal for most systems, especially for a system with a cycling clutch and a pressure switch to cycle the compressor. **The correct answer is C.** The other answer choices are wrong. Low refrigerant level or an undercharge condition would cause the readings to be low. An overcharge condition would result in higher-than-normal pressures. And if the evaporator pressure regulator were bad, the high-side pressure would be low.
80. The high-side pressure cutoff switch is wired with the compressor clutch (in series). Designed to open (cut out) and disengage the clutch at 350 to 375 psi, it again closes and normally reengages the clutch when pressure returns to 250 psi (higher if the system uses R-134a). This prevents the venting of refrigerant into the atmosphere by the pressure relief valve. The high-pressure relief valve is a high-pressure protection device that opens (normally at 440 psi) to bleed off excessive pressure that might occur in the system. The relief valve is a simple poppet-type valve in the compressor and is not part of the electrical circuit. Therefore Technician B is wrong. **The correct answer is A.**
81. **The correct answer is B.** Using the sense of touch is a good way to diagnose problems within the A/C and heating systems. The temperature of an A/C system's hoses indicate the condition of the system. By combining the results of both the hands-on checks and an interpretation of pressure gauge readings, the technician has a good indication that some unit in the system is malfunctioning and that further diagnosis is needed. In the case of the situation in the question, all of the answer choices would not cause the situation except for B. Equal temperatures at the inlet and outlet of the evaporator indicates the system is working normally and to do that, it must have the correct charge of refrigerant in the system.
82. The capillary tube controls the amount the expansion valve is open. As the temperature of the outlet of the evaporator increases, the expansion valve opens to allow for more refrigerant flow. The temperature is sensed by a remote thermal bulb attached to the capillary tube of the valve. A decrease in outlet temperature will cause the valve to close, thereby restricting the flow of refrigerant. A quick test of the expansion valve involves warming and cooling the thermal bulb and watching the change in the pressures on the manifold gauge set. Both techs are right and **the correct answer is C.**
83. Most late-model systems are equipped with an accumulator. The accumulator is connected into the low side, at the outlet of the evaporator. The accumulator contains a desiccant and is designed to store excess refrigerant and to filter and dry the refrigerant. If liquid refrigerant flows out of the evaporator, it will be collected by and stored in the accumulator. The main purpose of an accumulator is to prevent liquid from entering the compressor. An accumulator/drier should be replaced only if there is a chance of excessive moisture in the A/C system or when the accumulator leaks. A dent in the case of the accumulator does not mean it is defective and replacement is not necessary. **The correct answer is D.**
84. By feeling the temperature of the lines and components of an A/C system, you can get a good start in your diagnosis whether or not the system has a sight glass. Feel the liquid line from the receiver/dryer to the expansion valve. The line should be warm for its entire length. The suction line to the compressor should be cool to the touch from the evaporator to the compressor. If it is covered with thick frost, this might indicate that the expansion valve is flooding the evaporator. On vehicles equipped with the orifice tube system, feel the liquid line from the condenser outlet to the

evaporator inlet. A restriction is indicated by any temperature change in the liquid line before the crimp dimples the orifice tube in the evaporator inlet. The accumulator as well as the suction line must be cool to the touch from the evaporator outlet to the compressor. Technician A is correct. The high-pressure side should feel hot to the touch, while the low-pressure side should feel cold. **The correct answer is A.**

85. **The correct answer is C.** The only possible source for aluminum is the compressor. If the filter of an orifice tube is covered with aluminum particles, the aluminum must be from the compressor. The compressor must be damaged. The other answer choices would not release aluminum particles into the refrigerant. Only C is correct.
86. Technician A is correct. Whenever a fuse blows, it is caused by excessive current flow. In this case, the most probable causes for a blown fuse are a short in the circuit or a binding motor. Technician B is wrong. An open field winding in the motor would not cause an increase in current flow and therefore would not blow the fuse. If a short is suspected, the motor should be checked first, then the circuit. If the motor is defective, replace it. If the circuit is shorted, repair it and then replace the fuse. **The correct answer is A.**
87. Performance testing provides a measure of air conditioning system operating efficiency. A manifold pressure gauge set is used to determine both high and low pressures in the refrigeration system. The desired pressure readings will vary according to temperature. Use temperature/pressure charts as a guide to determine the proper pressures. At the same time, a thermometer is used to determine air discharge temperature into the passenger compartment. The typical procedure for a performance test follows: Carefully look over all of the components and lines of the system. Connect the manifold gauge set to the respective high- and low-pressure fittings. These fittings are found in various locations within the high- and low-pressure sides of the system. Close the hood and all of the doors and windows of the vehicle. Adjust the air conditioning controls to maximum cooling and high blower position. Idle the engine in neutral or park with the brake on. For the best results, place a high volume fan in front of the radiator grille to insure an adequate supply of airflow across the condenser. Increase engine speed to 1500 to 2000 rpm. Measure the temperature at the evaporator air outlet grille or air duct nozzle (35 to 40 °F). Read the high and low pressures and compare them to the normal range of the operating pressure given in the service manual. Both techs identified steps for a valid performance test and **the correct answer is C.**
88. The question is looking for the LEAST likely cause for low high-side and high low-side pressure readings. This problem is typically caused by a stuck open expansion valve, a poorly or incorrectly positioned expansion valve's capillary tube, an internal leak in the compressor, a broken reed valve in the compressor, or a closed STV or POA. A restriction on the high side of the system will cause high high-side pressures. Therefore, choice B is wrong and **the correct answer is B.**
89. Both techs are right and **the correct answer is C.** If the high-side pressure is too high, suspect air in the system, too much refrigerant in the system, a restriction in the high side of the system, and poor airflow across the condenser. If the low-side pressure is higher than normal, suspect refrigerant overcharge, a defective compressor, or a faulty metering device. When both pressures are higher than normal, suspect poor airflow across the condenser, an overheating engine, or an overcharge condition. Good airflow through the condenser is necessary to remove heat from the refrigerant. Often this airflow is restricted by a buildup of dirt or bugs on the outside of the condenser. Not only will a dirty condenser cause insufficient cooling, it can also cause the engine to overheat, as the airflow across the radiator will also be reduced.
90. A refrigerant leak doesn't typically make a noise, except when the refrigerant blows out of the leak. This noise would happen suddenly and would not have a hissing sound. Technician A is wrong. Technician B, however, is right. On some systems, when the engine is turned off after the A/C system has been on, a hissing sound will be heard as the pressure within the system equalizes. This is a normal noise and **the correct answer is B.**

# Glossary

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- Access valve** A term used for service port and service valve.
- Accumulator** A tank located between the evaporator and compressor to receive the refrigerant that leaves the evaporator, so constructed as to ensure that no liquid refrigerant will enter the compressor.
- Actuator** A device that transfers a vacuum or electric signal to a mechanical motion, typically performs an on/off or open/close function.
- Adapter** A device or fitting that permits different size parts or components to be fastened or connected to each other.
- Aftermarket** A term given to a device or accessory that is added to a vehicle after original manufacture, such as an air conditioning system.
- Air gap** The space between two components, such between the rotor and armature of a clutch.
- Ambient sensor** A thermistor used in automatic temperature control units to sense ambient temperature.
- Armature** The part of the clutch that mounts onto the crankshaft and engages with the rotor when energized.
- Atmospheric pressure** Air pressure at a given altitude. At sea level, atmospheric pressure is 14.696 psia (101.329 kPa absolute).
- Back seat (service valve)** Turning the valve stem to the left (ccw) as far as possible back seats the valve. The valve outlet to the system is open and the service port is closed.
- Barb fitting** A fitting that slips inside a hose and is held in place with a gear-type clamp. Ridges (barbs) on the fitting prevent the hose from slipping off.
- BCM** An abbreviation for body control module.
- Blower relay** An electrical device used to control the function or speed of a blower motor.
- Boiling point** The temperature at which a liquid changes to a vapor.
- Break a vacuum** The next step after evacuating a system. The vacuum should be broken with refrigerant or other suitable dry gas, not ambient air or oxygen.
- Bypass** An alternate passage that may be used instead of the main passage.
- Bypass hose** A hose that is generally small and is used as an alternate passage to bypass a component or device.
- CAA** Clean Air Act.
- Can tap** A device used to pierce, dispense, and seal small cans of refrigerant.
- Can tap valve** A valve found on a can tap that is used to control the flow of refrigerant.
- Cap** (1) A protective cover. (2) An abbreviation for capillary (tube) or capacitor.
- Cap tube** A tube with a calibrated inside diameter and length used to control the flow of refrigerant such as rgat between the remote bulb to the expansion valve.
- Celsius (C)** A metric temperature scale using zero as the freezing point of water. The boiling point of water is 100°C (212°F).
- Certified** Having a certificate awarded or issued to those that have demonstrated appropriate competence through testing and/or practical experience.
- CFC-12** A term used for Refrigerant-12.
- Charge** A specific amount of refrigerant or oil by volume or weight.
- Check valve** A device that prevents refrigerant from flowing in the opposite direction when the unit is shut off.
- Clean Air Act (CAA)** A Title IV amendment signed into law in 1990 which established national policy relative to the reduction and elimination of ozone-depleting substances.
- Clockwise (cw)** A left to correct rotation or motion.
- Clutch** An electro-mechanical device mounted on the air conditioning compressor used to start and stop compressor action, thereby controlling refrigerant circulating through the system.
- Clutch coil** The electrical part of a clutch assembly. When electrical power is applied to the clutch coil, the clutch is engage to start and stop compressor action.
- Compound gauge** A gauge that registers both pressure and vacuum (above and below atmospheric pressure); used on the low side of the systems.
- Compressor shaft seal** An assembly consisting of springs, snap rings, O-rings, shaft seal, seal sets, and gasket, mounted on the compressor crankshaft to permit the shaft to be turned without a loss of refrigerant or oil.
- Contaminated** A term used when referring to a refrigerant cylinder or a system that is known to contain foreign substances such as other incompatible or hazardous refrigerants.
- Counterclockwise (ccw)** A direction, correct to left, opposite that which a clock turns.
- Cracked position** A mid-seated or open position.
- Cycle clutch time (total)** Time elapsed from the moment the clutch engages until it disengages, then reengages. Total time is equal to on-time plus off-time for one cycle.
- Cycling clutch pressure switch** A pressure-actuated electrical switch used to cycle the compressor at a predetermined pressure.
- Cycling clutch system** An air conditioning system in which the air temperature is controlled by starting and stopping the compressor with a thermostat or pressure control.
- Department of Transportation (DOT)** A federal agency charged with regulation and control of the shipment of all hazardous materials.
- Depressing pin** A pin located in the end of a service hose to press (open) a Schrader-type valve.
- Disarm** To turn off; to disable a device or circuit.
- Dry nitrogen** The element nitrogen (N) which has been processed to ensure that it is free of moisture.
- Dual system** Two systems; usually refers to two evaporators in an air conditioning system; one in the front and one in the rear of the vehicle, driven off a single compressor and condenser system.
- Duct** A tube or passage used to provide a means to transfer air or liquid from one point or place to another.

- EATC** Electronic Automatic Temperature Control.
- ECC** Electronic Climate Control.
- Environmental Protection Agency (EPA)** An agency of the U.S. government charged that is charged with the responsibility of protecting the environment and enforcing the Clean Air Act (CAA) of 1990.
- EPA** Environmental Protection Agency.
- Etch** An intentional or unintentional erosion of a metal surface generally caused by an acid.
- Evacuate** To create a vacuum within a system to remove all traces of air and moisture.
- Evaporator core** The tube and fin assembly located inside the evaporator housing. The refrigerant fluid picks up heat in the evaporator core when it changes into a vapor.
- Expansion tank** An auxiliary tank that is usually connected to the inlet tank or a radiator and which provides additional storage space for heated coolant. Often called a coolant recovery tank.
- External snap ring** A snap ring found on the outside of a part such as a shaft.
- Fan relay** A relay for the cooling and/or auxiliary fan motors.
- Fill neck** The part of the radiator on which the pressure cap is attached. Most radiators, however, are filled via the recovery tank.
- Filter** A device used with the dryer or as a separate unit to remove foreign material from the refrigerant.
- Filter dryer** A device that has a filter to remove foreign material from the refrigerant and a desiccant to remove moisture from the refrigerant.
- Flare** A flange or cone-shaped end applied to a piece of tubing to provide a means of fastening to a fitting.
- Forced air** Air that is moved mechanically such as by a fan or blower.
- Front seat** Closing off the line leaving the compressor open to the service port fitting. This allows service to the compressor without purging the entire system. Never operate the system with the valves front seated.
- Functional test** A term used for performance test.
- Fusible link** A type of fuse made of a special wire that melts to open a circuit when current draw is excessive.
- Gasket** A thin layer of material or composition that is placed between two machined surfaces to provide a leakproof seal between them.
- Gauge** A tool of a known calibration used to measure components. For example, a feeler gauge is used to measure the air gap between a clutch rotor and armature.
- Graduated container** A measure such as a beaker or measuring cup that has a graduated scale for the measure of a liquid.
- Ground** A general term given to the negative (-) side of an electrical system.
- Grounded** An intentional or unintentional connection of a wire, positive (+) or negative (-), to the ground. A shortcircuit is said to be grounded.
- Gross weight** The weight of a substance or matter that includes the weight of its container.
- HCFC** Hydrochlorofluorocarbon refrigerant.
- Header tank** The top and bottom tanks (downflow) or side tanks (crossflow) of a radiator. The tanks in which coolant is accumulated or received.
- Heater core** A radiator-like heat exchanger located in the case/duct system through which coolant flows to provide heat to the vehicle interior.
- Heat exchanger** An apparatus in which heat is transferred from one medium to another on the principle that heat moves to an object with less heat.
- HI** The designation for high as in blower speed or system mode.
- High side gauge** The correct side gauge on the manifold used to read refrigerant pressure in the high side of the system.
- High side hand valve** The high side valve on the manifold set used to control flow between the high side and service ports.
- High side service valve** A device located on the discharge side of the compressor; this valve permits the service technician to check the high side pressures and perform other necessary operations.
- High side switch** See Pressure switch.
- High-torque clutch** A heavy-duty clutch assembly used on some vehicles known to operate with higher-than-average head pressure.
- Hot knife** A knife-like tool that has a heated blade used for separating objects, such as evaporator cases.
- Hub** The central part of a wheel-like device such as a clutch armature.
- Hygiene** A system of rules and principles intended to promote and preserve health.
- Hygroscopic** Readily absorbing and retaining moisture.
- Idler** A pulley device that keeps the belt whip out of the drive belt of an automotive air conditioner. The idler is used as a means of tightening the belt.
- Idler pulley** A pulley used to tension or torque the belt(s).
- Idle speed** The speed (rpm) at which the engine runs while at rest (idle).
- In-car temperature sensor** A thermistor used in automatic temperature control units for sensing the in-car temperature. Also see Thermistor.
- Insert fitting** A fitting that is designed to fit inside, such as a barb fitting that fits inside a hose.
- Internal snap ring** A snap ring used to hold a component or part inside a cavity or case.
- Jumper** A wire used to temporarily bypass a device or component for the purpose of testing.
- Kilogram (kg)** A unit of measure in the metric system. One kilogram is equal to 2.205 pounds in the English system.
- KiloPascal (kPa)** A unit of measure in the metric system. One kilopascal (kPa) is equal to 0.145 pound per square inch (psi) in the English system.
- kPa** kiloPascal.
- Liquid** A state of matter; a column of fluid without solids or gas pockets.
- Low-refrigerant switch** A switch that senses low pressure due to a loss of refrigerant and stops compressor action. Some alert the operator and/or set a trouble code.
- Low side gauge** The left-side gauge on the manifold used to read refrigerant pressure in the low side of the system.
- Low side hand valve** The manifold valve used to control flow between the low side and service ports of the manifold.



- Low side service valve** A device located on the suction side of the compressor which allows the service technician to check low side pressures and perform other necessary service operations.
- Manifold** A device equipped with a hand shutoff valve. Gauges are connected to the manifold for use in system testing and servicing.
- Manifold and gauge set** A manifold complete with gauges and charging hoses.
- Manifold hand valve** Valves used to open and close passages through the manifold set.
- Manufacturer's procedures** Specific step-by-step instructions provided by the manufacturer for the assembly, disassembly, installation, replacement, and/or repair of a particular product manufactured by them.
- MAX** A mode, maximum, for heating or cooling. Selecting MAX generally overrides all other conditions that may have been programmed.
- Mid-positioned** The position of a stem-type service valve where all fluid passages are interconnected. Also referred to as "cracked."
- Motor** An electrical device that produces a continuous turning motion. A motor is used to propel a fan blade or a blower wheel.
- MSDS** Material Safety Data Sheet.
- Net weight** The weight of a product only; container and packaging not included.
- Neutral** On neither side; the position of gears when force is not being transmitted.
- Noncycling clutch** An electro-mechanical compressor clutch that does not cycle on and off as a means of temperature control; it is used to turn the system on when cooling is desired and off when cooling is not desired.
- OEM** Original equipment manufacturer.
- Off-the-road** Generally refers to vehicles that are not licensed for road use, such as harvesters, bulldozers, and so on.
- Ohmmeter** An electrical instrument used to measure the resistance in ohms of a circuit or component.
- Open** Not closed. An open switch, for example, breaks an electrical circuit.
- Orifice** A calibrated opening in a tube or pipe to regulate the flow of a fluid or liquid.
- O-ring** A synthetic rubber or plastic gasket with a round- or square-shaped cross-section.
- OSHA** Occupational Safety and Health Administration.
- Outside temperature sensor** A term used for ambient sensor.
- Overcharge** Indicates that too much refrigerant or refrigeration oil is added to the system.
- Overload** Anything in excess of the design criteria. An overload will generally cause the protective device such as a fuse or pressure relief to open.
- Ozone friendly** Any product that does not pose a hazard or danger to the ozone.
- Park** Generally refers to a component or mechanism that is at rest.
- PCM** Power train control module.
- Performance test** Readings of the temperature and pressure under controlled conditions to determine if an air conditioning system is operating at full efficiency.
- Piercing pin** The part of a saddle valve that is used to pierce a hole in the tubing.
- Pin-type connector** A single or multiple electrical connector that is round- or pin-shaped and fits inside a matching connector.
- Poly belt** A term used for serpentine belt.
- Polyol ester (ESTER)** A synthetic oil-like lubricant that is occasionally recommended for use in an HFC-134a system. This lubricant is compatible with both HFC-134a and CFC-12.
- Positive pressure** Any pressure above atmospheric.
- Pound** A weight measure, 16 ounces.
- Pound of refrigerant** A term often used by technicians when referring to a small can of refrigerant although it actually contains less than 16 ounces.
- Power module** Controls the operation of the blower motor in an automatic temperature control system.
- Predetermined** A set of fixed values or parameters that have been programmed or otherwise fixed into an operating system.
- Pressure gauge** A calibrated instrument for measuring pressure.
- Pressure switch** An electrical switch that is activated by a predetermined low or high pressure. A high-pressure switch is generally used for system protection; a low pressure switch may be used for temperature control or system protection.
- Propane** A flammable gas used as a propellant for the halide leak detector.
- PSIG** Pounds per square inch gauge.
- Purge** To remove moisture and/or air from a system or a component by flushing with a dry gas such as nitrogen (N) to remove all refrigerant from the system.
- Purity test** A static test that may be performed to compare the suspect refrigerant pressure to an appropriate temperature chart to determine its purity.
- Radiation** The transfer of heat without heating the medium through which it is transmitted.
- Ram air** Air that is forced through the radiator and condenser coils by the movement of the vehicle or the action of the fan.
- Receiver/dryer** A tank-like vessel having a desiccant and used for the storage of refrigerant.
- RECIR** An abbreviation for the recirculate mode, as with air.
- Recovery system** A term often used to refer to the circuit inside the recovery unit used to recycle and/or transfer refrigerant from the air conditioning system to the recovery cylinder.
- Recovery tank** An auxiliary tank, usually connected to the inlet tank of a radiator, which provides additional storage space for heated coolant.
- Refrigerant-12** The refrigerant used in automotive air conditioners, as well as other air conditioning and refrigeration systems.
- Relay** An electrical switch device that is activated by a low-current source and controls a high-current device.
- Reserve tank** A storage vessel for excess fluid. See Recovery tank, Receiver/dryer, and Accumulator.
- Resistor** A voltage-dropping device that is usually wire wound and provides a means of controlling fan speeds.

- Respirator** A mask or face shield worn in a hazardous environment to provide clean fresh air and/or oxygen.
- Restrictor** An insert fitting or device used to control the flow of refrigerant or refrigeration oil.
- Retrofitting** The name given to the procedure for converting R-12 A/C systems to be able to use R-134a refrigerant.
- Rotor** The rotating or freewheeling portion of a clutch; the belt slides on the rotor.
- RPM** Revolutions per minute; also, rpm or r/min.
- Running design change** A design change made during a current model/year production.
- Saddle valve** A two-part accessory valve that may be clamped around the metal part of a system hose to provide access to the air conditioning system for service.
- SAE** Society of Automotive Engineers.
- Schrader valve** A spring-loaded valve similar to a tire valve. The Schrader valve is located inside the service valve fitting and is used on some control devices to hold refrigerant in the system. Special adapters must be used with the gauge hose to allow access to the system.
- Seal** Generally refers to a compressor shaft oil seal; matching shaft-mounted seal face and front head-mounted seal seat to prevent refrigerant and/or oil from escaping. May also refer to any gasket or O-ring used between two mating surfaces for the same purpose.
- Seal seat** The part of a compressor shaft seal assembly that is stationary and matches the rotating part, known as the seal face or shaft seal.
- Serpentine belt** A flat or V-groove belt that winds through all of the engine accessories to drive them off the crankshaft pulley.
- Service port** A fitting found on the service valves and some control devices; the manifold set hoses are connected to this fitting.
- Service procedure** A suggested routine for the step-by-step act of troubleshooting, diagnosing and/or repairs.
- Service valve** See High side (Low side) service valve.
- Shaft key** A soft metal key that secures a member on a shaft to prevent it from slipping.
- Shaft seal** See Compressor shaft seal.
- Short of brief duration** e.g., short cycling. Also refers to an intentional or unintentional grounding of an electrical circuit.
- Shut-off valve** A valve that provides positive shut-off of a fluid or vapor passage.
- Snap ring** A metal ring used to secure and retain a component to another component.
- Society of Automotive Engineers** A professional organization of the automotive industry. Founded in 1905 as the Society of Automobile Engineers, the SAE is dedicated to providing technical information and standards to the automotive industry.
- Solenoid valve** An electromagnetic valve controlled remotely by electrically energizing and deenergizing a coil.
- Solid state** Referring to electronics consisting of semiconductor devices and other related nonmechanical components.
- Spade-type connector** A single or multiple electrical connector that has flat spade-like mating provisions.
- Specifications** Design characteristics of a component or assembly noted by the manufacturer. Specifications for a vehicle include fluid capacities, weights, and other pertinent maintenance information.
- Spike** In our application, an electrical spike. An unwanted momentary high-energy electrical surge.
- Spring lock fitting** A special fitting using a spring to lock the mating parts together forming a leak-proof joint.
- Squirrel-cage blower** A blower wheel designed to provide a large volume of air with a minimum of noise. The blower is more compact than the fan and air can be directed more efficiently.
- Stabilize** To make steady.
- Stratify** Arrange or form into layers. To fully blend.
- Subsystem** A system within a system.
- Sun load** Heat intensity and/or light intensity produced by the sun.
- Superheat switch** An electrical switch activated by an abnormal temperature-pressure condition (a superheated vapor); used for system protection.
- Tank** A term used for header tank and expansion tank.
- Tare weight** The weight of the packaging material.
- Temperature door** A door within the case/duct stem to direct air through the heater and/or evaporator core.
- Temperature switch** A switch actuated by a change in temperature at a predetermined point.
- Tension gauge** A tool for measuring the tension of a belt.
- Thermistor** A temperature-sensing resistor that has the ability to change values with changing temperature.
- Torque** A turning force; for example, the force required to seal a connection; measured in (English) foot-pounds (ft-lb) or inch-pounds (in-lb); (metric) newton-meters (N·m).
- Triple evacuation** A process of evacuation that involves three pump-downs and two system purges with an inert gas such as dry nitrogen (N).
- TXV** Thermostatic expansion valve.
- Ultraviolet (uv)** The part of the electromagnetic spectrum emitted by the sun that lies between visible violet light and X-rays.
- Vacuum gauge** A gauge used to measure below atmospheric pressure.
- Vacuum motor** A device designed to provide mechanical control by the use of a vacuum.
- Vacuum pump** A mechanical device used to evacuate the refrigeration system to rid it of excess moisture and air.
- Vacuum signal** The presence of a vacuum.
- V-belt** A rubber-like continuous loop placed between the engine crankshaft pulley and accessories to transfer rotary motion of the crankshaft to the accessories.
- Ventilation** The act of supplying fresh air to an enclosed space such as the inside of an automobile.
- V-groove belt** A term used for V-belt.
- Voltmeter** A device used to measure volt(s).
- Wiring harness** A group of wires wrapped in a shroud for the distribution of power from one point to another point.





