



Subject Name: Auto. Air Conditioning

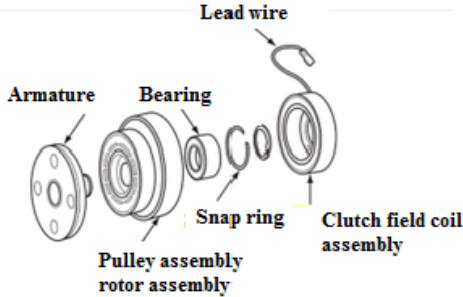
SUMMER – 19 EXAMINATION  
Model Answer

Subject **17620**

**Important Instructions to examiners:**

- 1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
- 2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
- 3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills).
- 4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for anyequivalent figure drawn.
- 5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
- 6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
- 7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q. No.	Sub Q. N.	Answer	Marking Scheme
1	(A)	<b>Attempt any THREE of the Following</b>	<b>12</b>
	(a)	<b>Write the major safety aspects in HVAC system.</b>	<b>04</b>
	Ans.	<p><i>(Any two of each 01 Mark each)</i></p> <p><b>Environmental Aspects--(Any4)</b></p> <ol style="list-style-type: none"> <li>1. To avoid ozone depletion we can replace CFC-12 by HFC-134a.</li> <li>2. In HVAC system less CO<sub>2</sub> released.</li> <li>3. Emissions to air: emissions like smoke, dust, odour, and fumes from automobile HVAC should be minimum. Efforts must be taken to avoid these emissions.</li> <li>4. Vibrations and Noise: HVAC adds number of components; fuel cost is more in operating HVAC. In vehicle vibrations and sound developed due to friction and shocks. Proper use of dampers and shock resistant is used to avoid vibration and sound. it will affect environment.</li> </ol> <p><b>Safety Aspects--(Any4)</b></p> <ol style="list-style-type: none"> <li>1. Always wear eye protection when servicing air conditioning system or handling refrigerants.</li> <li>2. Avoid breathing refrigerant and lubricant vapour or missed.</li> <li>3. Do not allow refrigerant to come in contact with open flames and high temp surfaces.</li> <li>4. Service equipment should not be pressure tested or leak tested with compressed air.</li> </ol>	<p><i>Any Two of each 01 Mark each</i></p>
	(b)	<b>State the function of duct system. Give its classification. Name the duct system used in heavy passenger vehicle.</b>	<b>04</b>
	Ans.	<p><i>(Function 01 Mark, Classification 02 Marks and its use 01 Mark)</i></p> <p><b>Function of Duct System:</b></p> <p>To deliver and remove air. The needed airflows include, for example, supply air, return air, and exhaust air. Ducts commonly also deliver ventilation air as part of the supply air.</p>	<p><i>Function 01 Mark, Classification 02 Marks and</i></p>

	<p><b>Classification:</b></p> <ol style="list-style-type: none"> <li>1. Independent case system with upstream blower.</li> <li>2. Independent case system with downstream blower.</li> <li>3. Split case system.</li> <li>4. Hybrid case system.</li> </ol> <p>Split Case Duct System is used in Heavy passenger Vehicle</p>	<p><i>its use</i> <i>01 Mark</i></p>
<p>(c)</p>	<p><b>State the functions of;</b></p> <ol style="list-style-type: none"> <li>(i) Thermostatic Expansion Valve.</li> <li>(ii) Fixed orifice tube.</li> <li>(iii) Accumulator.</li> <li>(iv) Receiver.</li> </ol>	<p><b>04</b></p>
<p>Ans.</p>	<p><b>(One Function of Each 01 Mark each)</b></p> <p><b>Thermostatic Expansion Valve:</b></p> <ol style="list-style-type: none"> <li>a) The expansion valve separates the high side of the air conditioning system from low side.</li> <li>b) To vaporize refrigerant as it passes through the evaporator or coils, absorbing heat from the vehicle's interior.</li> </ol> <p><b>Fixed Orifice Tube:</b></p> <ol style="list-style-type: none"> <li>a). The refrigerant entering into the evaporator is controlled by the fixed orifice tube in manner which is based on pressure difference and sub cooling characteristics of the refrigerant.</li> <li>b) Fixed orifice tube replaces thermostatic expansion valve to meter refrigerant into the evaporator The old and new expansion tubes as shown in figure are not interchangeable.</li> </ol> <p><b>Accumulator:</b></p> <ol style="list-style-type: none"> <li>a) To store excess refrigerant and</li> <li>b) Remove moisture from the system. If any liquid refrigerant is passed out of the evaporator it is stored by accumulator because liquid cannot be compressed. Liquid refrigerant can damage the compressor. Like the receiver drier the accumulator also uses desiccant to remove moisture from the system.</li> </ol> <p><b>Receiver:</b></p> <ol style="list-style-type: none"> <li>a) It maintain sufficient amount of refrigerant in system</li> <li>b) It condensate vapour refrigerant &amp; convert it into liquid refrigerant which further passes to thermostatic valve.</li> <li>c) It removes moisture, dust dirt from liquid refrigerant.</li> </ol>	<p><i>One Function</i> <i>of</i> <i>Each</i> <i>01 Mark</i> <i>each</i></p>
<p>(d)</p>	<p><b>Explain the construction and working of Electromagnetic Clutch.</b></p>	<p><b>04</b></p>
<p>Ans.</p>	<p><b>(Sketch 02 Marks and Working 02 Marks)</b></p> <p><b>Construction:</b></p>  <p><b>Figure: Electromagnetic Clutch</b></p> <p><b>Working:</b></p>	<p><i>Sketch</i> <i>02 Marks</i> <i>and</i> <i>Working</i> <i>02 Marks</i></p>

The air conditioning compressor has an electromagnetic clutch that can engage or disengage the compressor pulley. The compressor pulley always turns when the engine is running, but the compressor only runs when the pulley is engaged to the compressor driving shaft. When this system is activated, current runs through the electromagnetic coil. The current attracts it to the armature plate. The strong magnetic pull draws the armature plate against the side of the turning pulley. This locks the pulley and the armature plate together; the armature plate drives the compressor. When the system is deactivated, and current stops running through the electromagnetic coil, flat springs pull the armature plate away from the pulley. The magnetic coil does not turn since its magnetism is transmitted through the pulley to the armature. The armature plate and hub assembly are fastened to the compressor drive shaft. When it's not driving the compressor, the clutch pulley turns on a double row of ball bearings.

1 (B) Attempt any ONE of the Following

06

(a) List the factors which controls the human comfort. Explain the importance of comfort zone with comfort chart.

06

Ans. (Factors 02 Marks, Importance 02 Marks and Comfort Chart 02 Marks)

Factors which controls the Human Comfort:

[1] Humidity [2] Temperature [3] Purity of Air

Importance of Comfort Zone:

There are a ranges of combined temperatures and humidity that provides comfort to most people. This ComfortZone Chart shows "Indoor Air Temperature" on the vertical axis, "Relative Humidity" on the horizontal axis, and a shaded area known as the "Comfort Zone."

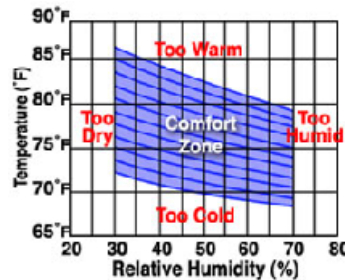


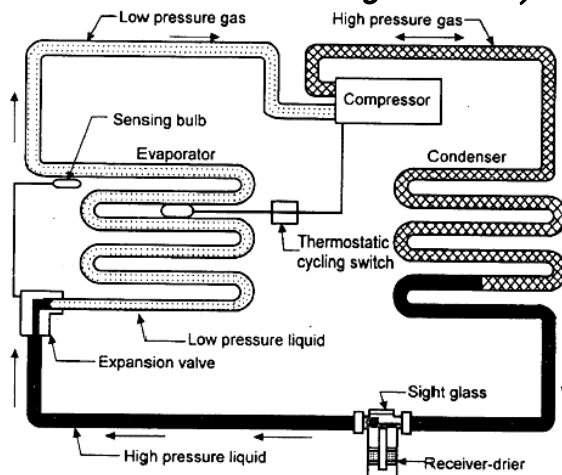
Figure: Comfort Zone Chart

Factors  
02 Marks,  
Importance  
02 Marks  
and Comfort  
Chart  
02 Marks

(b) Draw the layout automotive air conditioning system. Name the components and explain its working.

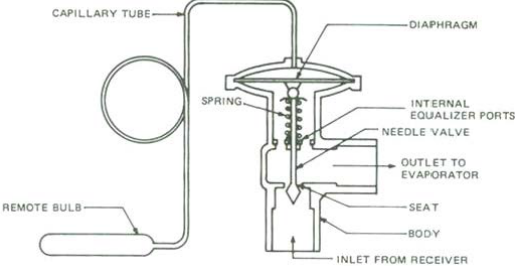
06

Ans. (Layout and names 03 Marks and its working 03 Marks)

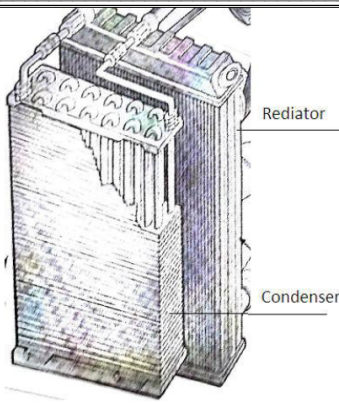


Layout  
and  
names  
03 Marks  
And  
its  
working  
03 Marks

	<p align="center"><b>Figure: Layout of Automotive Air Conditioning System.</b></p> <p><b>Working:</b></p> <ol style="list-style-type: none"> <li><b>1. Compressor:</b> It is used to compress vapour refrigerant coming from the evaporator and supply high pressure vapour refrigerant to condenser.</li> <li><b>2. Condenser:</b> The function of the condenser is to condense vapour refrigerant into liquid.</li> <li><b>3. Expansion Valve:</b> The function of expansion valve is to meter and control the flow rate of liquid refrigerant and reduce the temperature of liquid refrigerant.</li> <li><b>4. Evaporator:</b> The function of the evaporator is to give refrigerant effect by exchanging heat to the liquid refrigerant.</li> <li><b>5. Accumulator or Receiver Drier:</b> The receiver drier act as storage tank for the liquid refrigerant and also absorbs the moisture from the refrigerant.</li> </ol>	
2	<p><b>Attempt any FOUR of the Following</b></p>	16
	<p>(a) <b>What is controlled ventilation? Give its application.</b></p>	04
Ans.	<p><b>(Explanation 03 Marks and its Application 01 Mark)</b></p> <p><b>Controlled ventilation:</b></p> <p>Controlled ventilation is of two types, namely ram air type and power type.</p> <p><b>(i). Ram Air Ventilating System:</b> Forward movement of car forces or rams air through the ducts and into the car. The air from outside enters the vehicle through openings in front grill. The entry of this air is controlled by suitable valves or doors. This is done either manually by cables or by vacuum motors. This basic system is used on many vehicles, including those with heaters and air conditioners.</p> <p><b>(ii) Power Ventilating System:</b> In this system, blower motor is provided additionally to ensure sufficient circulation of outside air through the car. The blower motor can be operated at various speeds to suit the ventilating needs of the occupants in car. Normally this system includes heater and an air conditioner system.</p> <p><b>Application:</b> This method is currently used in vehicles</p>	<p align="center"><i>Explanation 03 Marks and its Application 01 Mark</i></p>
	<p>(b) <b>Explain the construction and working of Air Intake Section.</b></p>	04
Ans.	<p><b>(Construction 02 Marks and Working 02 Marks)</b></p> <p><b>Construction:</b></p> <p>Figure shows schematic sketch of air intake or inlet section. It consists of fresh (outside) air inlet; re circulates (inside) air inlet, a fresh re circulates air door, a blower with motor, and an air outlet. The fresh air inlet provides the system with fresh outside air supply; the re- circulate air inlet provides re circulated in-car air supply.</p> <div data-bbox="609 1549 958 1869" data-label="Diagram"> </div> <p align="center"><b>Figure: Air Intake Section</b></p> <p><b>Working:</b></p> <p>The position of vacuum motor operated fresh/re circulate door depends on</p>	<p align="center"><i>Construction 02 Marks and Working 02 Marks</i></p>

	<p>system mode. Actually in all modes except maximum cooling, the air supply is from outside. In maximum cooling, the air supply is from inside. Even in the maximum cooling mode, some systems provide for up to 20% fresh air. This is to provide for a slightly positive in-car pressure</p>	
(c)	<p><b>Explain construction and working of Thermostatic Expansion Valve.</b></p>	<b>04</b>
Ans.	<p><b>(Constructional Details 02 Marks and its Working 02 Marks)</b></p> <p><b>Construction:</b> The capillary tube, tube end and upper diaphragm chamber form a closed system filled with a temperature sensing gas. (Refrigerant- carbon dioxide, similar gas). The capillary remote bulb is clamped on to the evaporator outlet pipe and it is insulated from the outside air with special tape and it measures only the temperature of refrigerant, as it leaves the evaporator.</p>  <p><b>Figure: Thermostatic Expansion Valve</b></p> <p><b>Working:</b> Any increased in refrigerant temp. at the evaporator outlet increase the pressure in the remote bulb &amp; tube system. This exerts downward pressure on the diaphragm is greater than the combination of the evaporator pressure &amp; the superheat spring pressure, as a result valve is open and increase flow of refrigerant to evaporator coil. As the temp. of refrigerant decrease, it decreases pressure in the remote bulb and tube system. This decreases pressure on the diaphragm &amp; this pressure less than combination of evaporator pressure and superheat spring pressure and allowing the valve tube close and control flow of refrigerant to the evaporator coil.</p>	<p><i>Constructional Details 02 Marks and its Working 02 Marks</i></p>
(d)	<p><b>Which type of condenser is used in Car Air Conditioning System? Explain its working in brief.</b></p>	<b>04</b>
Ans.	<p><b>(Name 01 Mark &amp; Sketch with its working 03 Marks)</b> <b>[NOTE: Credit should be given to any other suitable sketch]</b> Evaporative type condenser is used in car AC system.</p> <p><b>Construction:</b> These are usually made of aluminium or sometimes made of copper or brass. It look very much like radiator, just little thinner and since they also depend on air flowing through them, they are usually located in front of radiator as shown in the figure. Condensers can be constructed as a series of tubes with fins around them.</p>	<p><i>Name 01 Mark &amp; Sketch with its working 03 Marks</i></p>





**Figure: Condenser**

**Working:**

Its main function is to condense the refrigerant vapour from compressor. The refrigerant enters the condensers as a high pressure vapour, but as it flows through the condenser refrigerant rejects the heat to flow air over it and gets converted into high pressure refrigerant liquid.

**(e) State the function of metering devices. Explain the working of fixed orifice tube.**

**04**

**Ans. (Function 01 Mark and Working 03 Marks)**

**Functions:** To control the refrigerant flow



**Figure: Old and new style fixed orifice tube**

**Working:** The refrigerant entering into the evaporator is controlled by the fixed orifice tube in manner which is based on pressure difference and sub cooling characteristics of the refrigerant. Fixed orifice tube replaces thermostatic expansion valve to meter refrigerant into the evaporator. The old and new expansion tubes as shown in figure are not interchangeable.

*Function  
01 Mark  
and  
Working  
03 Marks*

**(f) Compare the Internally Equalized Valve with Externally Equalized Valve.**

**04**

**Ans. (Any four Points 01 Mark each)**

S. N.	Internally Equalized Valve	Externally Equalized Valve
1	Internally equalized expansion valves permit refrigerant pressure from the outlet side of the orifice to pass through an internal passage and push against the underside of the diaphragm.	Externally equalized expansion valves have a line connected to the outlet side of the evaporator and refrigerant pressure passes through this line to push against the underside of the diaphragm
2	An internally equalized TXV senses its outlet pressure, using it as a closing force on the underside of the powerhead's diaphragm to offset the opening force of the pressure from the temperature sensing bulb on the top side of the powerhead. These valves are	An externally equalized valve senses the pressure at the evaporator outlet through an external equalizer tube, which runs to the same location as the valves temperature sensing bulb, compensating for any pressure drops of the evaporator, the refrigerant distributor and distributor tubes.

*Any  
four  
Points  
01 Mark  
each*

		<p>typically used on evaporators with a relatively low pressure drop i. e. the outlet pressure is nearly the same as the inlet pressure.</p>						
	<b>3</b>	<p>An internally equalized valve used on an evaporator with a high pressure drop, the valve will tend to control at a higher superheat, starving the coil</p>	<p>An externally equalized valve should be used on any evaporator with a multiple refrigerant circuits and a distributor because the typical refrigerant distributor and distributor tubes will have approximately a 35 psi pressure drop.</p>					
	<b>4</b>	<p><b>Fig:</b></p> <div style="text-align: center;"> </div>	<p><b>Fig:</b></p> <div style="text-align: center;"> </div>					
<b>3</b>		<b>Attempt any FOUR of the Following</b>		<b>16</b>				
	<b>(a)</b>	<b>State the requirements for HVAC System in heavy passenger vehicles.</b>		<b>04</b>				
	<b>Ans.</b>	<p><b>(correct answer 04 Marks)</b>  <b>Requirements for HVAC System in Heavy Passenger Vehicles:</b>          Providing drivers and passengers with an adequate comfort level is a critical design objective. Automotive HVAC climate control is a critical element in the highly influential. Cabin cool-down and warm-up times are not only key design requirements, but are often regulated. Increasing globalization of brands means vehicles must be designed to operate in an ever wider range of environmental conditions with very high or very low ambient temperatures and strong solar radiation, and sometimes under extreme conditions with heavy loads on the engine. Vehicle electrification is adding additional efficiency requirements on the design of HVAC systems. Cabin comfort assessment traditionally depends heavily on testing physical prototypes. Physical testing is very expensive, time consuming, and inflexible. Solar radiation is a critical component that can be reproduced only to a limited degree in climatic wind tunnels. Measuring surface and fluid temperatures is not sufficient. Passenger comfort is a complex physiological function of temperature, heat transfer rates, air velocity, clothing, body type, body mass, and other factors. With physical testing, such evaluations are very subjective.</p>		<p><i>Correct Answer 04 Mark</i></p>				
	<b>(b)</b>	<b>Compare the downstream duct system with upstream duct system.</b>		<b>04</b>				
	<b>Ans.</b>	<p><b>(Correct Answer 04 Mark)</b></p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 50%; text-align: center;">Downstream Duct System</th> <th style="width: 50%; text-align: center;">Upstream Duct System</th> </tr> </thead> <tbody> <tr> <td> <p><b>Construction:</b> It consists of fresh (outside) air inlet, a re-circulate (inside) air inlet, fresh recirculate air door,</p> </td> <td> <p><b>Construction:</b> This system is used to house the heater core and the air conditioner evaporator, and to direct the selected supply air</p> </td> </tr> </tbody> </table>		Downstream Duct System	Upstream Duct System	<p><b>Construction:</b> It consists of fresh (outside) air inlet, a re-circulate (inside) air inlet, fresh recirculate air door,</p>	<p><b>Construction:</b> This system is used to house the heater core and the air conditioner evaporator, and to direct the selected supply air</p>	<p><i>Correct Answer 04 Mark</i></p>
Downstream Duct System	Upstream Duct System							
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evaporator, heater, temperature blend door, restricted air door, blower motor and conditioned air outlets for defrosters, panel, floor etc.

**Working:**

The heater water valve is open to allow hot engine coolant to flow through the heater core. Cool outside fresh air is heated as it passes through the heater core. The air conditioner is not operational; therefore, it has no effect on the air temperature as the air first passes through evaporator.

The desired temperature level is achieved by the position of the blend door. This allows a percentage of the cool outside air to bypass the heater core. The heated air and cool air are then blended in plenum to provide desired temperature level before passing on to the air distribution section. From the plenum this air is passed to distribution section with the help of blower. Depending upon the position of mode door conditioned air may be delivered to the floor outlets, the defrost outlets, or the dash panel outlets, or any combination of outlets. In other than maximum cooling (MAX A/C), fresh outside air passes through the air conditioning evaporator and is cooled before delivery into the car

through these components into the passenger compartment of the car. An upstream integral blower or an independent blower is used on split case system. This system is used on larger cars and located on both sides of engine fire wall.

**Working:**

The outside fresh air is forced to the evaporator with the help of blower. Since the air conditioner is not operational, it has no effect on the air temperature as the air first passes through evaporator. The desired temperature level is achieved by the position of the blend door. This allows a percentage of the cool outside air to bypass the heater core. The heated air and cool air are then blended in plenum to provide desired temperature level before passing on to the air distribution section. This tempered air is then directed to the air distribution section. Depending upon the position of mode door conditioned air may be delivered to the floor outlets, the defrost outlets, or the dash panel outlets, or any combination of outlets.

(c) Name the compressor used in car air-conditioning system. Explain its working with neat sketch.

04

Ans. (Types 01 Marks and Explanation 03 Marks)

**Types of Compressor:**

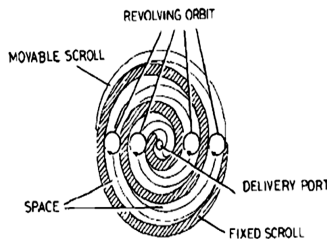
- i Reciprocating compressor
- ii Rotary Vane compressor
- iii Scroll compressor
- iv Screw compressor
- v. Hermetically Sealed Compressor.

Types  
01 Marks  
and  
Explanation  
03 Marks

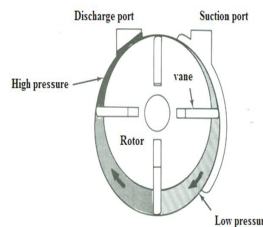


**Working:**

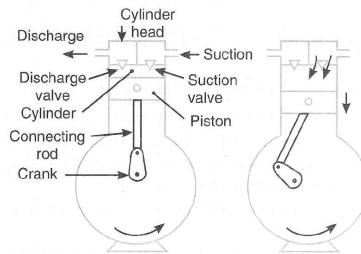
Compressor is heart of the refrigeration system as it circulates the refrigerant in the system like the heart of a human being circulating the blood in the body. Two different pressures exist in the refrigeration cycle. The evaporator or low pressure, and the condenser, or high pressure. These pressure areas are divided by the other two components. On one end, is the metering device which controls the refrigerant flow, and on the other end, is the compressor. It compresses the low pressure refrigerant vapor from the evaporator and compresses it into a high pressure vapor. The inlet to the compressor is called the "Suction Line". It brings the low pressure vapor into the compressor. After the compressor compresses the refrigerant into a high pressure Vapor, and the outlet of the compressor is called the "Discharge Line".



**Figure: Scroll Type Compressor**



**Figure: Rotary Vane Type Compressor**



**Figure: Reciprocating Compressor**

(d) Describe the term of modulating and controlling action as a function of thermostatic expansion valve.

04

Ans. (Description 02 Mark Each)

**1. Throttling Action:** The expansion valve separates the high side of the air conditioning system from low side. Since there is pressure drop across the valve, the flow of refrigerant is restricted, or throttled. The state of liquid entering the valve is high pressure liquid. The refrigerant leaving the valve is low pressure liquid. A drop in refrigerant pressure is accomplished without changing the state of refrigerant.

**2. Modulating Action:** A thermostatically-controlled valve located inside the expansion valve body fluctuates toward an open or closed position as required to control the liquid refrigerant passing through the orifice. This ensures that the evaporator receives the proper amount of refrigerant. The low pressure created at the expansion valve makes it possible for the liquid refrigerant to vaporize as it passes through the evaporator or coils, absorbing heat from the vehicle's interior.

Description  
02 Mark  
Each

(e) List the different control system used in HVAC system of vehicle. Explain the climate control system.

04

Ans. (List 01 Marks and Explanation 03 Marks)  
[Note: Credit Should be given to suitable Answer]

List  
01 Marks



		<p><b>Climate Control Systems are:</b> (1) Humidity Control System. (2) Temperature Control System (3) Air Control System (4) Motion Control System</p> <p><b>Climate Control:</b> Most automotive air conditioning and heating systems are integrated into a "climate control" system that controls the temperature, humidity and air circulation by cooling the air inside the passenger compartment when it's hot outside and heating it when the outside air is cold. Climate control automatically maintains a desired temperature within the car's cabin by continuously adjusting the air-con and heater settings.</p>	<p><i>and Explanation 03 Marks</i></p>
4	(A)	<b>Attempt any THREE of the Following</b>	12
	(a)	<b>Explain the mode of heat transfer, by which heat is transferred in car-air conditioning system.</b>	04
	Ans.	<p><i>(Correct Answer 04 Marks)</i></p> <p><b>Conduction Heat Transfer:</b> The conduction is considered as transfer of heat within the substance from high temperature region to low temperature region. Conduction of heat is due to the vibration of molecules. In conduction there must be physical contact or touch. <b>Example of Conduction:</b> When solid bar of metal is heated from one end, we find other end of the metal is getting hot</p> <p><b>Convection Heat Transfer:</b> When fluid flows over hot solid body, heat will be transferred from hot body to flowing fluid. Thus convection is transfer of heat due to fluid flowing or due to transfer of molecules. <b>Example of Convection:</b> Heat transfer in water tube boiler where water is heated by hot flue gases.</p> <p><b>Radiation Heat Transfer:</b> Conduction and convection heat transfer need some medium. In radiation there is no need of any medium for transfer of heat. It can take place in space also, from body at high temperature to body at low temperature in the form of electromagnetic waves emitted by vibrating electrons at surface of body. The quantity of heat radiated depends upon absolute temperature of body. <b>Example of Radiation:</b> Energy emitted by sun reaches the earth through radiation</p>	<p><i>Correct Answer 04 Marks</i></p>
	(b)	<b>State the refrigerants used in car air- conditioning system. Give the colour codes used for different refrigerants in practice. State its significance.</b>	04



<b>Ans.</b>	<table border="1"><thead><tr><th>Refrigerant No.</th><th>Colour Code</th><th>Chemical Name</th></tr></thead><tbody><tr><td>R-13B1</td><td>Coral</td><td>Bromotrifluoromethane</td></tr><tr><td>R-124</td><td>Deep Green</td><td>Chlorotetrafluoroethane</td></tr><tr><td>R-12</td><td>White</td><td>Dichlorodifluoromethane</td></tr><tr><td>R-114</td><td>Dark Blue</td><td>Dichlorotetrafluoroethane</td></tr><tr><td>R-123</td><td>Light Gray</td><td>Dichlorotrifluoroethane</td></tr><tr><td>R-22</td><td>Light Green</td><td>Monochlorodifluoromethane</td></tr><tr><td>R-13</td><td>Light Blue</td><td>Monochlorotrifluoromethane</td></tr><tr><td>R-404A</td><td>Orange</td><td>R-125 + R-143a + R-134a</td></tr><tr><td>R-402A</td><td>Light Brown</td><td>R-22 + R-125 + R-290</td></tr><tr><td>R-402B</td><td>Green Brown</td><td>R-22 + R-125 + R-290</td></tr><tr><td>R-401A</td><td>Coral Red</td><td>R-22 + R-152a + R-124</td></tr><tr><td>R-401B</td><td>Mustard Yellow</td><td>R-22 + R-152a + R-124</td></tr><tr><td>R-410A</td><td>Rose</td><td>R-32 + R-125</td></tr><tr><td>R-407C</td><td>Chocolate Brown</td><td>R-32 + R-125 + R-134a</td></tr><tr><td>R-507</td><td>Light Brown</td><td>Refrig. 125/143a</td></tr><tr><td>R-500</td><td>Yellow</td><td>Refrig. 152A/12</td></tr><tr><td>R-502</td><td>Light Purple</td><td>Refrig. 22/115</td></tr><tr><td>R-503</td><td>Aquamarine</td><td>Refrig. 23/13</td></tr><tr><td>R-134a</td><td>Light Sky Blue</td><td>Tetrafluoroethane</td></tr><tr><td>R-11</td><td>Orange</td><td>Trichloromonofluoromethane</td></tr><tr><td>R-113</td><td>Purple</td><td>Trichlorotrifluoroethane</td></tr><tr><td>R-23</td><td>Light Gray</td><td>Trifluoromethane</td></tr></tbody></table>	Refrigerant No.	Colour Code	Chemical Name	R-13B1	Coral	Bromotrifluoromethane	R-124	Deep Green	Chlorotetrafluoroethane	R-12	White	Dichlorodifluoromethane	R-114	Dark Blue	Dichlorotetrafluoroethane	R-123	Light Gray	Dichlorotrifluoroethane	R-22	Light Green	Monochlorodifluoromethane	R-13	Light Blue	Monochlorotrifluoromethane	R-404A	Orange	R-125 + R-143a + R-134a	R-402A	Light Brown	R-22 + R-125 + R-290	R-402B	Green Brown	R-22 + R-125 + R-290	R-401A	Coral Red	R-22 + R-152a + R-124	R-401B	Mustard Yellow	R-22 + R-152a + R-124	R-410A	Rose	R-32 + R-125	R-407C	Chocolate Brown	R-32 + R-125 + R-134a	R-507	Light Brown	Refrig. 125/143a	R-500	Yellow	Refrig. 152A/12	R-502	Light Purple	Refrig. 22/115	R-503	Aquamarine	Refrig. 23/13	R-134a	Light Sky Blue	Tetrafluoroethane	R-11	Orange	Trichloromonofluoromethane	R-113	Purple	Trichlorotrifluoroethane	R-23	Light Gray	Trifluoromethane	
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<b>Ans.</b>	<p><b>(Function and Location of each 01 Mark each)</b></p> <p><b>(i). High Side Temperature Switches :</b> <b>Function:</b>It provides temperature data to the processor of temperature controller which further controls electromagnetic clutch of compressor. <b>Location:</b>It is located in between Condenser outlet &amp; Expansion valve or orifice tube inlet.</p> <p><b>(ii) Low Side Temperature Switches:</b> <b>Function:</b>It Provides data to processor to disengage compressor clutch circuit to prevent compressor operation during low pressure conditions. Low pressure condition may result due to loss of refrigerant or clogged orifice tube. <b>Location:</b>It is located in the low side of air conditioning system, usually on</p>	<p><i>Function and Location of each 01 Mark each</i></p>																																																																					



		accumulator.	
	(d)	List the different equipment and tools used in repair and maintenance of HVAC system of vehicles	04
	Ans.	<b>(Any Four 04 marks)</b> <b>Service and diagnosis tools:</b> 1. Manifold gauge set 2. Service adapters 3. Thermometers 4. Vacuum pumps a) Air power vacuum pump b) Rotary vane type vacuum pump 5. Charging tools and equipments 6. Leak testers a) Halide torch leak detector b) Halogen leak tester 7. Bubble detectors 8. The sight glass (non-accumulator systems)	Any Four 04 marks
4	(B)	Attempt any ONE of the Following	06
	(a)	For a particular car air – conditioning system, how will you select the refrigerant?	06
	Ans.	<b>(Any Six 01 Mark each)</b> <b>Selection criteria of Refrigerants for Car Air – Conditioning;</b> 1. It should have low boiling point. 2. It should be above atmospheric pressure. 3. It should have high latent heat of vaporization 4. Toxicity should be low. 5. It should be corrosive. 6. It should not be inflammable. 7. It should be stable in nature. 8. It should have low viscosity. 9. It should have high thermal conductivity. 10. It should be easy and safe to handle. 11. It should be easily available at low cost.	Any Six 01 Mark each
	(b)	<b>Write the Function And Location of following:</b> (i) Sun Load Sensor. (ii) Outside Temperature Sensor. (iii) Car Temperature Sensor.	06
	Ans.	<b>(i) Sun Load Sensor:</b> <b>Function:</b> This sensor send signal to the electrical climate control module (ECCM) indicating the strength of the sunlight (sun load) which influences the vehicle interior temperature. If the sun load is high as signaled by the sun load sensor the ECCM will activate the highest lower fan speed and max cooling to compensate for this additional radiated heat load. Likewise if the sun load is low (cloud cover) as sensed by the sun load sensor the ECCM will reduced the blower fan speed and the system will not operate at max cooling. <b>Location:</b> The sun load sensor is a photochemical diode (PCD) located on top of the dashboard. <b>(ii) Outside Temperature Sensor:</b> <b>Function:</b> Its purpose is to sense the outside temperature condition to	

provide data to processor. This sensor circuit has several programmed memory features to prevent false ambient temp data input during the period of low speed driving or when stopped such as when waiting for traffic control.

**Location:** It is usually located just behind the radiator grille and in front of condenser.

**(iii) Car Temperature Sensor:**

**Function:** It monitors the air temperature of the passenger compartment.

**Location:** It is located behind aspirator blower vent grill.

**5 Attempt any FOUR of the Following**

**16**

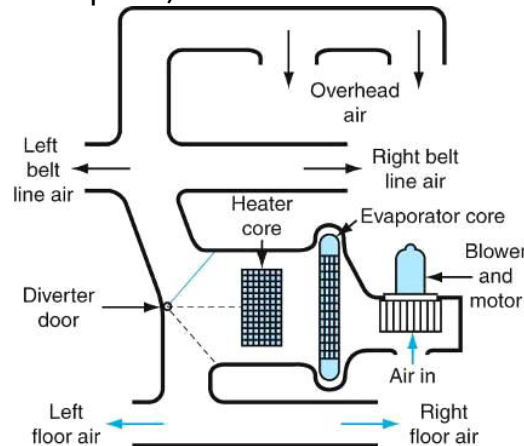
**(a) Explain construction and working of rear heating system.**

**04**

**Ans. (Sketch with Construction and Working 04 Marks)**

**Construction:**

A schematic sketch of rear heating system is as shown in figure. Depending on design it may have major components; blower and motor, temperature door, evaporator core with metering device, heater core with flow control, outlet mode door, control panel, and controller.



**Figure: Rear Heating System**

*Sketch with Construction and Working 04 Marks*

**Working:**

In this system second heater core is located at the rear of passenger compartment. Driver controls overall operation. Some system allows the rear passenger to control the temperature. For control of rear blower switch is provided at the front or at rear or sometimes at both places. In this system rear blower forces the air into the second heater core from where heated air enters into the distribution section and finally delivered to the rear compartment.

**(b) Explain the role of blower clutch control and heater control in automotive air-conditioning system.**

**04**

**Ans. (Explanation of each 02 Marks)**

**Role of Blower Clutch Control:**

The means used to convert low current signals from control panel to high current feed to the blower motor. Blower speeds with this control are infinitely variable. The speed is controlled through a resistor strip on temperature door actuator. The resistor strip then functions same as rheostat to input data to the control panel. The control panel in turn inputs the blower speed signal to the blower control.

**Role of Heater Control:**

When warm engine coolant passes through the heater control valve and into

*Explanation of each 02 Marks*

the heater core, so that hot air can be produced from the vehicle's vents.

© Explain the electronic climate control system with block diagram.

04

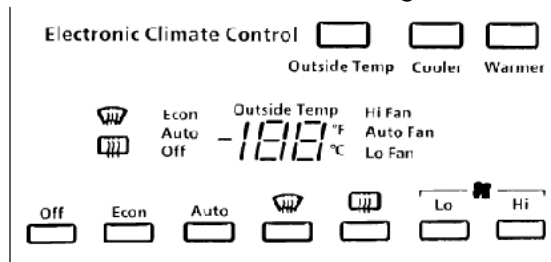
Ans. (Block Diagram 02 Marks and its Explanation 02 Marks)  
(Note: Credit shall be given to any other suitable sketch)

**Construction:**

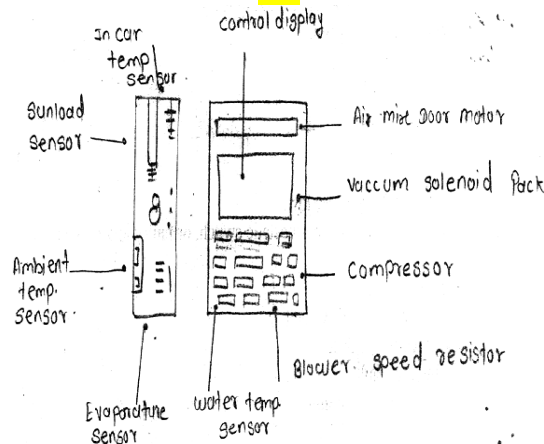
The electronic climate control (ECC) System offers automatic control of the front and rear rooftop air conditioners and furnace/s in the motor home. The system includes an energy management system that shuts off the air conditioners when necessary to prevent electrical over load. It also includes a number of features that provide the owner with the most comfortable temperature controlled environment possible.

**Working:**

The System contains two major components, the ECC Thermostat and the ECC module, along with additional external sensors which are connected to these modules. The Thermostat allows the owner to set the front and rear air conditioning and heating systems' modes and temperatures. The electronics in this panel measure ambient temperatures via two external temperature probes (front and rear). Based on the mode and set point temperature settings, the probes send appropriate control signals to the ECC module. The Control Module performs the timing, sequencing, switching, and load shedding functions for the furnace/s and air conditioner fans and compressors. It is often located under the refrigerator.



OR



OR

Block Diagram  
02 Marks  
and  
its  
Explanation  
02 Marks



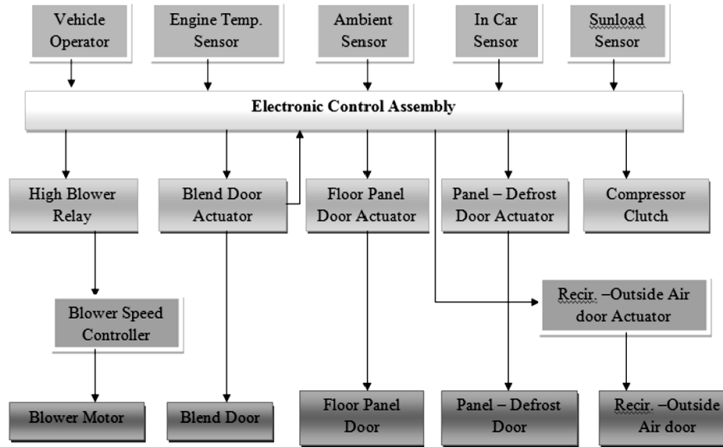


Figure: Block Diagram of Electronic Climate Control System

(d) How will you carry out the following tests in automotive air-conditioning system? (i) Leak Test (ii) Temperature Test.

04

Ans.

(i). Procedure to carry out Leak Test:

1. Install the gauges and gauge manifold. Note the pressure and the temperature in the beginning.
2. Close the manifold valves.
3. Now, attach the refrigerant cylinder at the center of the gauge manifold. Do not open the refrigerant cylinder valves. Do not operate the compressor.
4. Start halide leak detector.
5. Now open the refrigerant cylinder valve.
6. Now open the gauge manifold valves slowly. Raising the pressure to about  $1.75\text{kgf/cm}^2$ .
7. Check the leaks with torch. Any leak detected should be repaired properly.
8. Raise the system pressure to about  $3.75\text{kgf/cm}^2$  and check leaks at various joints and surfaces. Repair the leakage.
9. Now Raise the pressure about  $5.0\text{kgf/cm}^2$  in the gauges and check the leaks.
10. Close refrigerant cylinder valve after completing the job, close gauge manifold valves

(ii) Procedure to carry out Temperature Test:

1. Connect manifold gauge set at high and low side valves.
2. Turn on engine and allow temperature to reach  $210\text{C}$  or high.
3. Take tachometer and run engine at  $1500\text{rpm}$ .
4. Turn on AC for  $5\text{min}$  and close all windows and doors.
5. Before that place thermometer at the centre outlet of AC panel.
6. Compare readings as per specifications.

Ambient Temperature ( $^{\circ}\text{C}$ )	$21^{\circ}\text{C}$	$26^{\circ}\text{C}$	$32^{\circ}\text{C}$	$37.5^{\circ}\text{C}$	$45^{\circ}\text{C}$
Temperature raised by thermometer ( $^{\circ}\text{C}$ )	$2 - 8^{\circ}\text{C}$	$4 - 10^{\circ}\text{C}$	$10 - 17^{\circ}\text{C}$	$17 - 21^{\circ}\text{C}$	$18 - 21^{\circ}\text{C}$

© Explain the moisture removal procedure used while servicing the A/C system.

04

Ans.

(Explanation 02 Marks sketch 02 Marks)

Moisture Removal Procedure Used While Servicing The A/C System:

Liquid refrigerant enters through the inlet. Any dirt is filtered by the filter pads

Explanation  
02 Marks  
sketch

and moisture is absorbed from the refrigerant by the desiccant. Any refrigerant vapor that does not liquefy in the condenser, is trapped and held until it condenses. Finally, clean and dry liquid refrigerant leaves the receiver dehydrator and goes to expansion valve. Evaporator also helps in dehumidification, as warmer air travels through the aluminum fins of cooler evaporator coil, the moisture content in the air condenses on its surface.

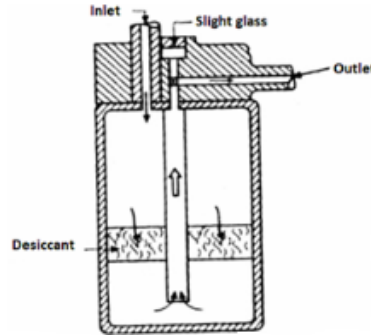


Figure: Moisture Control by Receiver Drier

02 Marks

(f) State the function of comfort heating system. Explain its construction and working with block diagram.

04

Ans. (Any two functions ½ mark each, Sketch with construction and working 03 Marks)

**Functions of Comfort Heating System:**

1. To provide the desired air temperature inside the passenger compartment.
2. To circulate the hot water from an engine.
3. To heat the air coming from outside atmosphere.
4. To control the temperature by using temperature door.
5. To control the air flow by using air door.
6. To supply heated air on the inside of windshield by using defroster door.

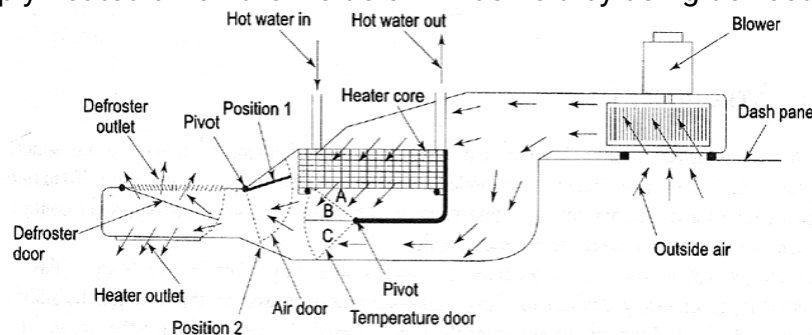


Figure: Comfort Heating System

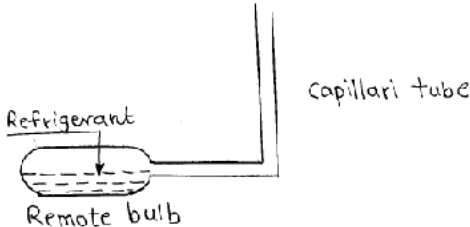
**Construction & Working:**

The comfort heating system in vehicle is able to provide desired air temperature inside the vehicle. It operates with ventilating system. Figure shows comfort heating system in a vehicle. It consists of heater core which is a small radiator as like engine radiator. Hot coolant from the engine is circulating through this heater core by using engine water pump. This heats the heater core. Air from the outside flows through the heater core air passages. This heats the air.

This heating system has three doors-

1. Temperature door- It is used to permit more or less air to flow through heater corer.
2. Air door- It can be operated to allow full air flow or no air flow or any

Any two functions ½ mark each, Sketch with construction and working 03 Marks

	<p>position in between.</p> <p>3. Defroster door- It can be used to supply the heated air on the inside of the windshield or to the outlet of the heater in the car.</p> <p>All these doors are operated manually by control levers or knobs on the instrument panel.</p>	
6	<b>Attempt any FOUR of the Following</b>	<b>16</b>
	<b>(a) Explain the construction and working of remote bulb.</b>	<b>04</b>
Ans.	<p><b>(Sketch with Construction and working 04 Marks)</b></p> <p><b>Construction of Remote Bulb:</b> Figure shows remote bulb. One end of capillary tube is connected to remote bulb and other end is connected to thermostatic expansion valve. A remote bulb filled with refrigerant same like refrigerant in A/C system. It is located at evaporator outlet.</p>  <p><b>Figure: Remote Bulb.</b></p> <p><b>Working of Remote Bulb:</b> It maintains pressure on diaphragm against evaporator pressure and spring pressure. As temperature of refrigerant at the outlet of evaporator increases, the temperature in the remote bulb also increases and get vaporized and vapour exerts pressure on diaphragm and diaphragm get open.</p>	<p><i>Sketch with Construction and working 04 Marks</i></p>
	<b>(b) List the vacuum operated devices used in control system. Give the function and location of check valve and check relay.</b>	<b>04</b>
Ans.	<p><b>Vacuum Operated Devices:</b></p> <p><b>Check Valve</b> <b>Function:</b>It allows vacuum from control to reach the vacuum motor. <b>Location:</b>Check valve is located in the vacuum line between the reserve tank and the vacuum source.</p> <p><b>Check Relay</b> <b>Function:</b>It prevents vacuum loss during low manifold vacuum conditions and maintain the sufficient vacuum in the system mode operations during these periods <b>Location:</b></p>	
©	<p><b>State the functions of:</b></p> <p>(i) Halide Torch. (ii) Nitrogen Leak Tester. (iii) Gauge Calibration Recovery Unit. (iv) Vacuum Pump.</p>	<b>04</b>
Ans.	<p><b>Halide Torch:</b>To find out the type of refrigerant leakage in air- conditioning system.</p> <p><b>Nitrogen Leak Tester:</b> To find out the leakage, if any, of the refrigerant in air-conditioning system.-</p> <p><b>Gauge Calibration Recovery Unit:</b> To charge the air conditioning system with new refrigerants.</p>	



	<b>Vacuum Pump:</b> To remove refrigerant, moisture & air from AC system																													
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Ans.	<p><i>(Any two Faults and any two remedies over it 01 Mark each)</i></p> <table border="1"> <thead> <tr> <th>S. N.</th> <th>Faults</th> <th>Causes</th> <th>Remedies</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>Noise in Compressor</td> <td>1. Loose components 2. Lack of oil 3. Piston 4. Loose Floor Mounting.</td> <td>1. Tightening 2. Replenish the oil level &amp; check the bearing. 3. check debris on piston 4. Tightening the bolts.</td> </tr> <tr> <td>2</td> <td>Compressor not Working</td> <td>1. Broken Belt 2. Broken Clutch Wire 3. Bad Thermostat 4. Bad Clutch oil</td> <td>1. Replace Belt 2. Repair Wire 3. Repair it 4. Replace</td> </tr> <tr> <td>3</td> <td>Low Compressor Discharge Pressure</td> <td>1. Leakage in system 2. Defective Expansion Valve 3. Suction Valve Closed</td> <td>1. Repair Leakage. 2. Repair Valve. 3. Open it.</td> </tr> <tr> <td>4</td> <td>High Compressor Discharge Pressure</td> <td>1. Air in System 2. Clogged Condenser 3. Discharge Valve Closed.</td> <td>1. Recharge System. 2. Clean Condenser. 3. Open it.</td> </tr> <tr> <td>5</td> <td>Low Suction Pressure</td> <td>1. Refrigerant Shortage. 2. Worn Compressor Piston 3. Compressor Suction Valve Leakage.</td> <td>1. Add Refrigerant 2. Replace Compressor. 3. Change Valve.</td> </tr> <tr> <td>6</td> <td>High Suction Pressure</td> <td>1. Loose expansion valve 2. Overcharged System 3. Expansion Valve Stack Open.</td> <td>1. Tight it. 2. Remove some Refrigerant 3. Replace Expansion Valve</td> </tr> </tbody> </table>	S. N.	Faults	Causes	Remedies	1	Noise in Compressor	1. Loose components 2. Lack of oil 3. Piston 4. Loose Floor Mounting.	1. Tightening 2. Replenish the oil level & check the bearing. 3. check debris on piston 4. Tightening the bolts.	2	Compressor not Working	1. Broken Belt 2. Broken Clutch Wire 3. Bad Thermostat 4. Bad Clutch oil	1. Replace Belt 2. Repair Wire 3. Repair it 4. Replace	3	Low Compressor Discharge Pressure	1. Leakage in system 2. Defective Expansion Valve 3. Suction Valve Closed	1. Repair Leakage. 2. Repair Valve. 3. Open it.	4	High Compressor Discharge Pressure	1. Air in System 2. Clogged Condenser 3. Discharge Valve Closed.	1. Recharge System. 2. Clean Condenser. 3. Open it.	5	Low Suction Pressure	1. Refrigerant Shortage. 2. Worn Compressor Piston 3. Compressor Suction Valve Leakage.	1. Add Refrigerant 2. Replace Compressor. 3. Change Valve.	6	High Suction Pressure	1. Loose expansion valve 2. Overcharged System 3. Expansion Valve Stack Open.	1. Tight it. 2. Remove some Refrigerant 3. Replace Expansion Valve	<p><i>Any two Faults and any two remedies over it 01 Mark each</i></p>
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Ans.	<p><i>(Any two Cause and its Remedies 01 Mark each)</i></p> <p><b>(1) Little or No Heat:</b></p> <p><b>Causes:</b></p> <ol style="list-style-type: none"> <li>Air circulation not enough.</li> <li>Air in the heater core.</li> <li>Heat core is clogged</li> <li>Thermostat of engine cooling system is stuck open.</li> </ol> <p><b>Remedies:</b></p> <ol style="list-style-type: none"> <li>Blower motor or switch is at fault. Temperature door or cable may be adjusted. Leakage of air from heater housing may be stopped.</li> <li>Bleed air out.</li> <li>Core should be repaired or replaced.</li> <li>Replace the thermostat.</li> </ol>	<p><i>Any two Cause and its Remedies 01 Mark each</i></p>																												



**(2)Defrosting Insufficient:**

**Causes:**

- a. Control cable of defrost door is out of adjustment.
- b. Defrost outlets blocked.

**Remedies:**

- a. Cable should be readjusted.
- b. Remove the obstructions