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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 any equivalent 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 judgment 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.

*

M	larks	
1. a) Attempt any <u>THREE</u> of the following :	12	
i) Define radiation and evaporation with one example each.	04	
Answer: <i>Definition – 1 mark each, example – 1 mark each</i>		
1. Radiation heat transfer:		
Radiation is mode of heat transfer in which heat is transferred from body at high temperature to body at low temperature in the form of electromagnetic waves emitted by vibrating electrons at surface	1	
of body.	1	
Example of radiation: Energy emitted by sun reaches the earth through radiation.	1	
2. Evaporation: Evaporation is the process by which moisture becomes a vapour. As moisture vaporizes from a warm surface, it removes heat and thus cools the surface. This process takes place constantly on the surface of the body.	1	
<i>Example of evaporation:</i> Sweat appearing as drops of moisture on the body indicates that the body producing more heat than can be removed by convection, radiation, and normal evaporation.		
ii) Explain with neat sketch core section.	04	
Answer: Core Section:	2	

Fig:- Core Section



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1

1

1

04

2

Figure shows schematic sketch of core section. It is the central section of duct system. It is also called the plenum section. It consists of heater core, the air conditioning evaporator, and a blend door. Air flow is from right to left in the figure. The blend door usually Bowden cable operated, provides full range control of airflow either through or bypassing the heater core. All air passes through airconditioning evaporator. In this section full range temperature conditions are provided for in-car comfort

iii) State the function of the following automobile A.C. system.	04

- 1) Evaporator
- 2) Compressor
- 3) Accumulator
- 4) Condenser

Answer:

- 1. **Evaporator:** The function of the evaporator is to give refrigerant effect by exchanging heat to the liquid refrigerant.
- 2. **Compressor**: It is used to compress vapour refrigerant coming from the evaporator and supply high pressure vapour refrigerant to condenser
- 3. Accumulator: It act as storage tank for the vapour refrigerant and also absorbs the moisture from the refrigerant. It also converts low pressure liquid & vapour mixture into vapour form and deliver to compressor.
- 4. Condenser: The function of the condenser is to condense vapour refrigerant into liquid.

iv) Explain construction and working of high side temperature switch.

Answer:

High side temperature switch is located in between Condenser outlet & Expansion valve or orifice tube inlet. It is a thermocouple and its resistance varies according to temperature of liquid refrigerant. As it is temperature sensing device, provides temperature data to the processor of temperature controller which further controls electromagnetic clutch of compressor.



Figure: Location of high side temperature switch and low side temperature switch.



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b) Attempt any ONE of the following :	06
i) Explain the following terms in human comfort control.	06
1) Effects of humidity	
2) Wind chill factor	
3) Comfort zone	
Answer:	
 Effects of humidity;- Moisture in the air is measured in terms of humidity. Relative Humidity (RH) is the ratio of amount of water vapor in the air to the amount of water vapor in the air at specific temperature and pressure. The control of humidity is not only necessary for human comfort but it is also important from point of view of efficiency of driver. For human comfort, relative humidity is kept within a range of 35% to 60%. A RH more than 60% will lead to sweating, while a RH below 35% will cause dry sensation and affect the mucous membranes, leading to extreme discomfort. 	2
2. Wind Chill factor:	
Wind chill is not a measure of temperature, it is a measure of comfort due to the rate of cooling. It has no impact on the actual temperature for the purpose of physical things like water freezing. Though wind in conjunction with cold air will increase the speed at which warm objects cool down, the number associated with wind chill is not related to this. The wind chill factor (WCF) is measure of the effect of air temperature and wind speed on human comfort and safety.	2
3. Comfort Zone:-	
There is a range of combined temperatures and humidities that provides comfort to most people. This Comfort Zone Chart shows "Indoor Air Temperature" on the vertical axis, "Relative Humidity" on the horizontal axis, and a shaded area known as the "Comfort Zone."	
90'F 85'F 00 Warm 00 Warm	
ii) Explain construction and working of vacuum restrictor with neat sketch.	06
Answer: Vacuum restrictor:	
Construction: Restrictor has a small orifice which sometimes becomes clogged with lint or other airborne debris. Vacuum restrictor is located in the vacuum line between the reserve tank and the vacuum source. Vacuum restrictor is opened whenever manifold vacuum is greater than reserve	2

vacuum source. Vacuum restrictor is opened whenever manifold vacuum is greater than reserve vacuum. In this position the vacuum restrictor connects the source the tank. The normal engine vacuum also opens the diaphragm & allows vacuum from control to reach the vacuum motor.



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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 position in between. 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. All these doors are operated manually by control levers or knobs on the instrument panel.	2
f) Explain the working principle of electromagnetic clutch with neat sketch.	04
Answer: Working principle of electromagnetic clutch:	
When the 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.	2
Lead wire	
Ś	2
Armature Bearing Armature Bearing Clutch field coil assembly rotor assembly Figure: Assembly of electromagnetic clutch	
3. Attempt any FOUR of the following:	16
a) Describe with neat sketch working of accumulator.	04
Answer: Working of accumulator: Unlike the receiver-drier, which is mounted on the high side of the system, the accumulator is located on the low side of the system, usually right at the evaporator outlet. However, its two-fold function - to store excess refrigerant and remove moisture from the system - is the same as that of the receiver- drier. If any liquid refrigerant is passed out of the evaporator, it's stored by the accumulator. Because liquids cannot be compressed, liquid refrigerant can damage the compressor. And, like the receiver-drier, the	2



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d) State the causes and remedies for the following faults in comfort heating system	04
i) Little or no heat	04
i) Defrosting in-sufficient	
Answer: Causes and remedies for the faults in comfort heating system:	
1. Little or no heat:	
Causes:	
a. Air circulation not enough.	
b. Air in the heater core.	2
c. Heat core is clogged	
d. Thermostat of engine cooling system is stuck open.	
Remedies:	
a. Blower motor or switch is at fault. Temperature door or cable may be adjusted. Leakage of air	
b Blood air out	
c. Core should be repaired or replaced	
d. Replace the thermostat.	
2. Defrosting insufficient:	
Causes:	
a. Control cable of defrost door is out of adjustment.	
b. Defrost outlets blocked.	
Remedies:	2
a. Cable should be readjusted.	
b. Remove the obstructions	
e) Explain with neat sketch working of scroll type compressor used in A.C. System.	04
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Scroll-type compressors have two metal scrolls, one fixed and one moveable, which provide an eccentric motion. As the compressor shaft rotates, an eccentric bushing on the shaft drives the moveable scroll, and refrigerant is forced against the fixed scroll, and towards its center. The motion creates an increase in pressure toward the center of the scroll. The refrigerant vapor moves in a circular pattern, and its pressure is increased as it moves toward the center of the scroll. The high pressure refrigerant is released through a delivery port located at the center of the scroll. Scroll-type compressors provide a longer effective compression stroke, and a smoother start-up than other compressor designs, and they produce less vibration.

4. a)	Attempt any <u>THREE</u> of the following:		12
i) Cor	i) Compare controlled and uncontrolled ventilation with any four aspects.		04
Answ	er: Comparison of controlled and uncontrolled	ventilation (Any four)	
Sr.	Controlled Ventilation	Uncontrolled Ventilation	
01	Forward movement of car and blower motor	Uncontrolled ventilation occurs when anyone	4
	forces or rams air through the ducts and into	opens window so that air can enter.	
	the car.		
02	The air from outside enters the vehicle	The air from outside enters the vehicle	
	through openings in front grill.	through window.	
03	This system does not provides any quantity	This system provides any quantity of fresh air	
	of fresh air quickly	quickly	
04	This system does not allow wind, rain, dust	This system allows wind, rain, dust and other	
	and other airborne particles to enter inside	airborne particles to enter inside the vehicle.	
	the vehicle.		
05	Currently this method of ventilation is used	This method has been used for years	
	in vehicles.		
06	The entry of air is controlled by suitable	The entry of air is not controlled by suitable	
	valves or doors.	valves or doors.	
07	This system includes heater and air	This system does not include heater and air	
	conditioning system	conditioner system.	



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04

06

06

Any increase in refrigerant temperature at the evaporator outlet increases the pressure in the remote bulb and tube system. This in turn exerts a downward pressure on the diaphragm. This downward pressure on diaphragm is greater than combination of the evaporator pressure and the superheat spring pressure. As a result, the valve will open. Similarly, a decrease in refrigerant temperature decreases the pressure in the remote bulb and tube system. This decreases the pressure on the diaphragm and this pressure is less than combination of the evaporator pressure and the superheat spring pressure and allowing the valve to close. 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

iv) Distinguish between manual climate control and electronic climate control system (any four points)

Answer: (Any four points each carry $\overline{1 \text{ mark}}$)

Sr.	Manual climate control system	Electronic climate control system
0.1	It is also called manual temperature control	It is also called automatic temperature control
01	system	system
^	It does not use an electronic control unit to	This system uses an electronic control unit to
02	monitor the vehicles interior temperature.	monitor the vehicles interior temperature.
	It does not use an electronic control unit to	This system uses an electronic control unit to
03	adjust the vehicles interior temperature.	d adjust the vehicles interior temperature.
	The system does not have the ability to	The system has the ability to maintain vehicle
04	maintain vehicle comfort settings throughout	comfort settings throughout a variety of
-	a variety of conditions	conditions
05	Sensors are not used in this system	Different sensors are used in this system
06	Maintenance cost is low.	Maintenance cost is high.

b) Attempt any **<u>ONE</u>** of the following:

i) Explain with neat sketch construction and working of split case system.





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Construction: This system 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 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. A schematic sketch of split case system with upstream blower is as shown in the following figure.

Working: The outside fresh air is forces 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.

ii) Differentiate between thermostatic expansion valve and fixed orifice tube with six aspects.

Sr.	Thermostatic expansion valve	Fixed orifice tube	
01	It has moving parts	It has no moving parts	
02	A system with thermostatic expansion valve	A system with fixed orifice tube has no	
	has drier/receiver	drier/receiver	
03	The drying agent for the system is found in	The drying agent for the system is found in	
	separate drier.	an accumulator	
04	Refrigerant flow through the thermostatic	Refrigerant flow through the fixed orifice	
	expansion valve is controlled by a spring-	tube is controlled by a orifice tube	
	loaded valve		
05	Refrigerant flow through spring loaded valve is	Refrigerant flow through fixed orifice tube	
	controlled by pressure difference above and	is controlled by pressure difference and sub	
	below the diaphragm	cooling characteristics of refrigerant.	
06	High initial & Maintenance Cost	Low initial & Maintenance Cost	
		1	
. Att	tempt any FOUR of the following:		
) Giv	e the procedure to charging the A.C. System.		(

Answer : **Procedure of charging:**

- 1. Gauge set attached to the service valves.
- 2. Gauge valves closed.
- 3. System should be under vacuum.
- 4. Attach centre gauge hose to refrigerant supply.
- 5. Open valve on refrigerant container.
- 6. Purge air from centre hose by loosening the hose at gauge end.
- 7. With system off, open high pressure gauge valve. Refrigerant can be added as a vapour or liquid at this time.
- 8. As the gauge pressure both reach 60-80psi no further charging will occur.
- 9. Close high pressure gauge valve.
- 10. Place refrigerant supply upright so as to allow vapor to enter system.
- 11. Operate engine at 1500 rpm and turn on the air conditioner at maximum cooling and highest



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put out.

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d) Explain the	d) Explain the concepts of time delay relay with neat sketch.		04
Answer: Conc The time de unit until the e capacitors, and	Answer: Concepts of time delay relay: The time delay control unit is designed to prevent the heat cycle from coming on in the automatic unit until the engine coolant has reached temperature of 43.34 ⁰ C. The unit consists of two resistors, capacitors, and transistors. Following figure shows time delay circuit of the wiring diagram.		
	IGNITION SWITCH	TEMP SWITCH IN CAR	2
	Figure	e: Time delay relay	
e) State the ca i) Noise in ii) Compres	uses and remedies for followin compressor ssor not working.	ng faults in compressor:	04
Fault	Causes	Remedies	
Noise in	Loose Components	Tightening	
compressor	Lack of oil	Replenish the oil level and check the bearings	2
1	Piston	Check debris on piston	
	Loose floor mounting	Tightening of bolts	
Compressor	Broken belt	Replace belt	
not working	Broken clutch wire	Repair wire	
	Bad thermostat	Repair thermostat	2
	Bad clutch coil	Repair	
f) Write mage	adume of Emoon look data atom to	at	04
1) write proc	edure of Freon leak detector te	St.	04
Answer: Leak1. Install t2. Close th3. Now atrefriger	 Answer: Leak Test Procedure: Install the gauges and gauge manifold. Note the pressure and temperature in the beginning. Close the manifold valves A and B. Now attach the refrigerant cylinder at the centre of the gauge manifold. Do not open the refrigerant cylinder valves. Do not operate compressor. 		4
4. Start ha	lide/freon leak detector.		
5. Now op	5. Now open the refrigerant cylinder valve.		
6. Open gauge manifold valves A and B slowly raising the pressure to about 1.75kgf/cm ² .			
7. Check t	7. Check the leaks with torch. Any leak detected should be repaired properly.		
8. Raise the any leal	8. Raise the system pressure to about 3.75kgf/cm^2 and check leaks at every joint and surface. If any leak is found place should be repaired immediately.		
9. INOW, IS	ioints surfaces and repair the	givent in the gauges and check the leaks in the system at leaks	
10 If the fl	ame colour is blue, there is no	leak if the flame colour is vellow-green the leak is small	
if the fl	ame colour is bright blue pur	ple the leak is large. If the leakage is severe, the flame is	



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11. Close refrigerant cylinder valve after completing the job, close gauge manifold valves A and B.	
6. Attempt any <u>FOUR</u> of the following.	16
a) Explain the rear cooling system with neat sketch.	04
Answer: Rear Cooling system: Some trucks and vans are equipped with rear air distribution system to provide rear cooling. A schematic sketch of rear cooling system is as shown in following figure. Depending on design it may have following major components; blower and motor, temperature door, evaporator core with metering device, heater core with flow control, outlet mode door, control panel, and controller. In this system second evaporator core is located at the rear of passenger compartment. Driver controls overall operation. Some systems allow 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 evaporator core from where cooled air enters into the distribution section and finally delivered to the rear compartment.	2
Left belt line air Diverter door Left t floor air	2
Figure: Rear cooling system	
b) Discuss throttling action and modulation action as function of thermostatic expansion valve.	04
Answer :	
 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. 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 pressure 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 vabiale's interior. 	2



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c) Explain construction and working of typical vacuum system.

Answer : Construction and working of typical vacuum system:

The various components used in vacuum system are reserve tank, check valve, vacuum pump and vacuum motor. Connection for evacuation of system is shown in figure. Whenever opened, a/c system must be evacuated by using a vacuum pump. Connect low and high charging hoses of manifold gauge set respectively as follows-

High charging hose ---- Compressor delivery hose. Low charging hose ----- Compressor suction hose.

Attach central charging hose of manifold gauge set to vacuum pump. Operate vacuum pump and then open suction side valve of manifold gauge set. If there is no blockage in the system, there will be an indication on high pressure gauge. When this occurs, open the other side valve of the set.

Approximately 10 minute later, low pressure gauge should show a vacuum lower than 760 mm of Hg providing no leakage exists. Evacuation should be carried out for a total of at least 15 minutes. Continue evacuation until low pressure gauge indicates vacuum less than 760mm of Hg and then close both the valves. Stop vacuum pump, disconnect central charging hose from pump inlet. Now the system is ready for charging refrigerant.





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Figure: Superheat switch

This device is a temperature/pressure sensitive electrical switch which is normally in the open position. The switch remains open during the system high pressure and high temperature conditions or low pressure and low temperature conditions. The switch closes when the system experiences high temperature and low pressure conditions. The high temperature and low pressure condition of the system is usually caused by loss of refrigerant. This loss may result in compressor or system damage if air conditioning system remains in operation.

The superheat switch offers a failsafe method of stopping the compressor until the problem is corrected. When superheat switch closes, a circuit is completed through a heater of thermal fuse. The fuse blows, opens the clutch circuit and stops the compressor.