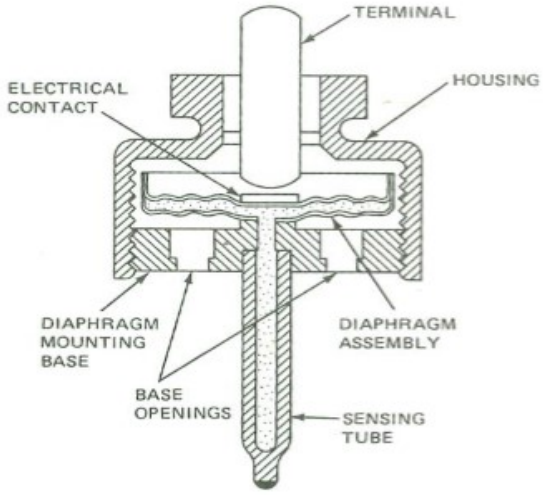
SUMMER – 19 EXAMINATION

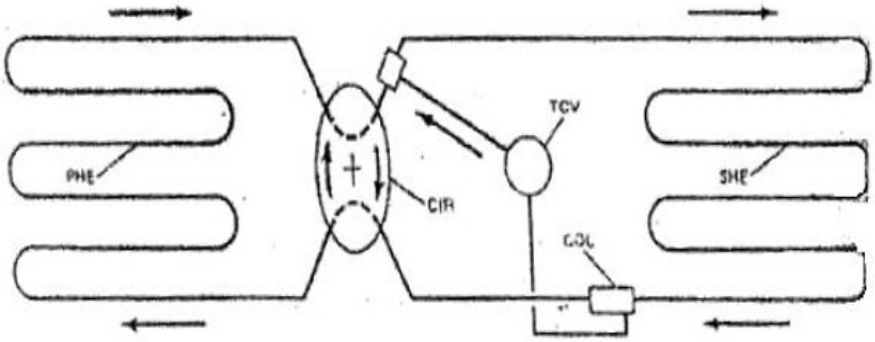
Subject Name: Automobile air conditioning **Model Answer** Subject Code: 17620

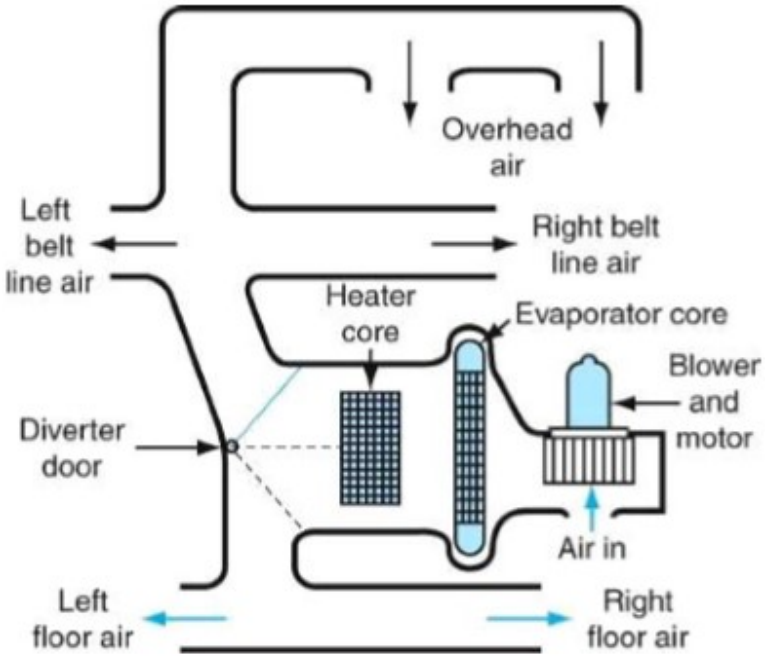
Important Instructions to examiners:

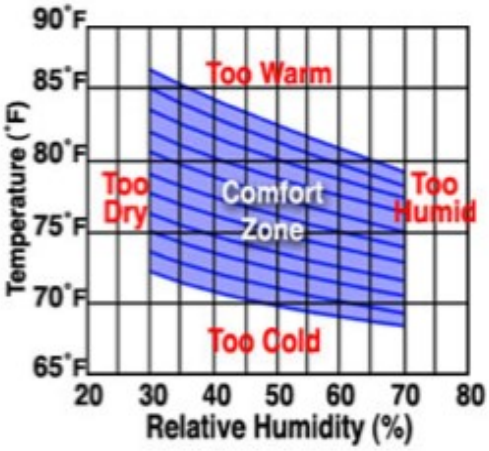
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling 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 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 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.

<table>
<tr><th>Q. No.</th><th>Sub Q. N.</th><th>Answer</th><th>Marking Scheme</th></tr>
<tr><td>1</td><td>(a)</td><td>Attempt any THREE of the following.</td><td>12</td></tr>
<tr><td></td><td>i)</td><td>Differentiate between controlled and uncontrolled ventilation (any four points).</td><td>04</td></tr>
<tr><td></td><td></td><td>Answer: Comparison of controlled and uncontrolled ventilation (Any four)
<table>
<tr><th>Sr.</th><th>Controlled Ventilation</th><th>Uncontrolled Ventilation</th></tr>
<tr><td>01</td><td>Forward movement of car and blower motor forces or rams air through the ducts and into the car.</td><td>Uncontrolled ventilation occurs when anyone opens window so that air can enter.</td></tr>
<tr><td>02</td><td>The air from outside enters the vehicle through openings in front grill.</td><td>The air from outside enters the vehicle through window.</td></tr>
<tr><td>03</td><td>This system does not provides any quantity of fresh air quickly</td><td>This system provides any quantity of fresh air quickly</td></tr>
<tr><td>04</td><td>This system does not allow wind, rain, dust and other airborne particles to enter inside the vehicle.</td><td>This system allows wind, rain, dust and other airborne particles to enter inside the vehicle.</td></tr>
<tr><td>05</td><td>Currently this method of ventilation is used in vehicles.</td><td>This method has been used for years</td></tr>
<tr><td>06</td><td>The entry of air is controlled by suitable valves or doors.</td><td>The entry of air is not controlled by suitable valves or doors.</td></tr>
<tr><td>07</td><td>This system includes heater and air conditioning system</td><td>This system does not include heater and air conditioner system.</td></tr>
</table></td><td>Any four points 1 mark each</td></tr>
</table>

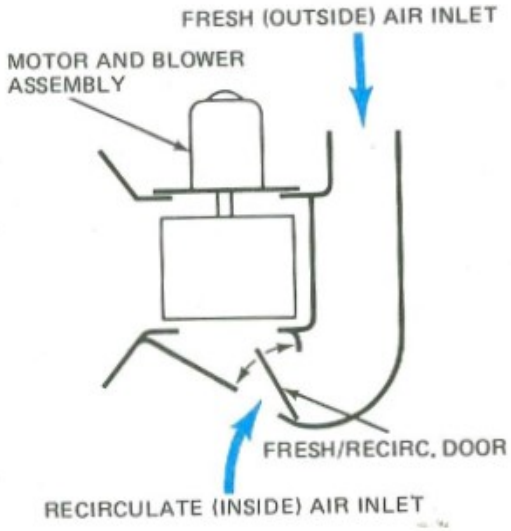
	ii)	**State desirable properties of refrigerant used in air conditioning system.**	**04**
		Desirable Properties of a Good Refrigerant:(Any four properties- 1 mark each) **Thermodynamic Properties:-** a) It should have Low Boiling Point. b) It should be below the evaporator temperature. c) It should be above atmospheric pressure. d) It should have low condensing pressure. e) It should have high latent heat of vaporization. f) It should be above the condensing temperature & pressure. **Chemical Properties:-** a) It should not be Poisonous or injurious. It should not be non-irritating to eyes. b) It should not be corrosive & should not have any effect on materials used in equipment. c) It should have fewer tendencies to leak & if it is leaking it should be easily detectable. d) It should not be Inflammable. **Physical properties:** 1. It should have low viscosity. 2. It should have high thermal conductivity. **Other Properties:-** a) It should be easy & safe to handle. b) It should be readily available at low cost. c) It should have high COP & low power requirement.	**Any four points 1 mark each**
	iii)	**Describe construction and working of superheat switch.**	**04**
		Construction and working of superheat switch: (Note: Equivalent credit shall be given to any other suitable sketch)  **Figure: Superheat switch** **Construction and Working:** The superheat switch is located in the rear head of some six cylinder compressors. This device is a temperature/pressure sensitive electrical switch which is normally in the open position. The switch remains open during the systems 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	**02** **02**

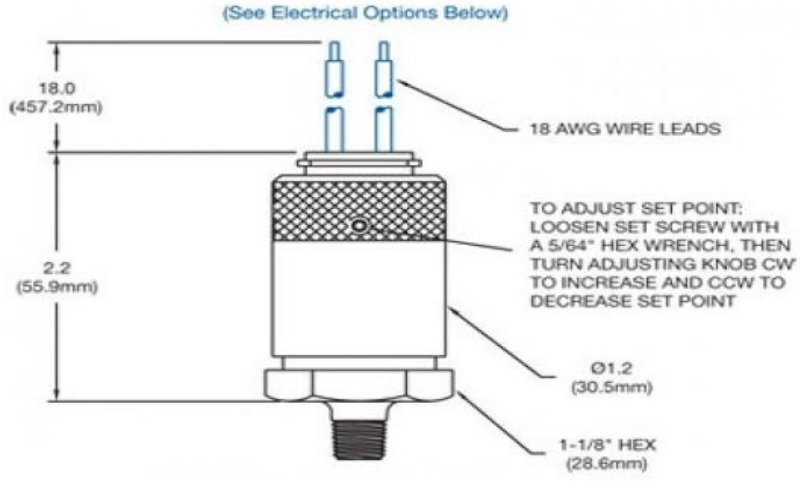
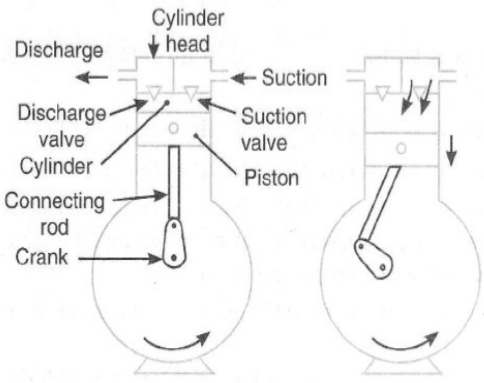
		compressor or system damage if air conditioning system remains in operation. The superheat switch offers a failsafe method of stopping the compressor until the problem is corrected. When superheat switch closes, a circuit is completed through a heater of thermal fuse. The fuse blows, opens the clutch circuit and stops the compressor.	
	iv)	**Explain rotary vane air cycle system with sketch.**	**04**
		Rotary vane air cycle system: The compressor of ROVAC system is called circulator. The condenser is called primary heat exchanger. The collector in the system serves in similar manner as an accumulator in conventional system. It separates liquid (hydrocarbon) from vapour (air). Unlike accumulator however the liquid is retained in the collector & is not metered back into the system. A small amount of oil circulates in the system at all times to provide lubrication for the circulator. Other liquid comprised of & hydrocarbons are vaporized in secondary heat exchanger as it pick up heat. Conversely this vapour changed back to the liquid in primary heat exchanger as its heat is given up to the outside air.	**02**
			**02**
		COL - Collector **SHE - Secondary heat exchanger** **CIR - Circulator** **TCV- Temperature Control Valve** **PHE - Primary heat exchanger**	
		Figure: Rotary vane air cycle system	
	(b)	**Attempt any ONE of the following.**	**08**
	i)	**Explain with block diagram the working of Rear heating and cooling system.**	**08**
		Rear heating system: Some trucks and vans are equipped with rear air distribution system to provide rear heating. 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. In this system second heater 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	**03**

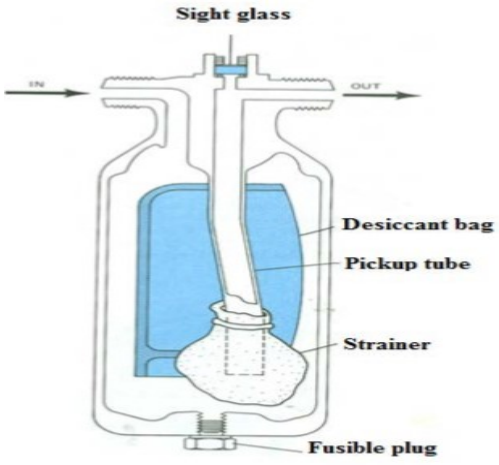
		rear blower forces the air into the second heater core from where heated air enters into the distribution section and finally delivered to the rear compartment.  **Figure: Rear heating & cooling system** **2. Rear Cooling system:** Some trucks and vans are equipped with rear air distribution system to 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.	**02** **03**
	ii)	**Define human comfort zone. Show comfort zone on psychrometric chart.**	**08**
		There is a range of combined temperatures and humidity's 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."	**03**

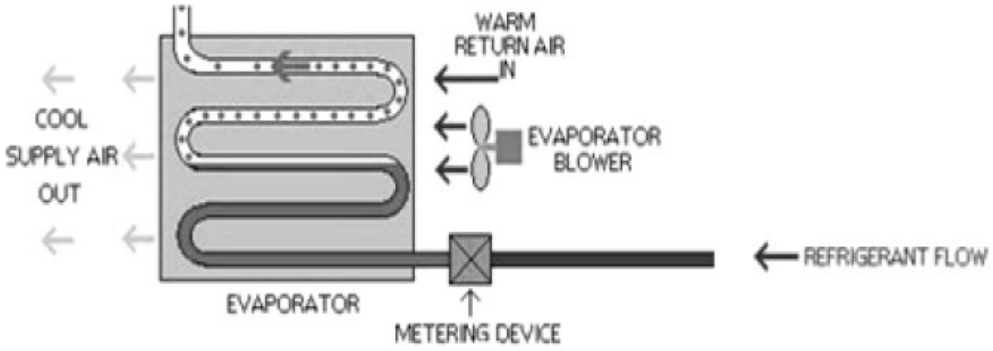
			05
2.		**Attempt any FOUR of the following.**	16
	(a)	**Compare thermostatic expansion valve and fixed orifice tube on any four aspects.**	04
		Answer: *(Six points – 1mark each)*	**Any four points 1 mark each**

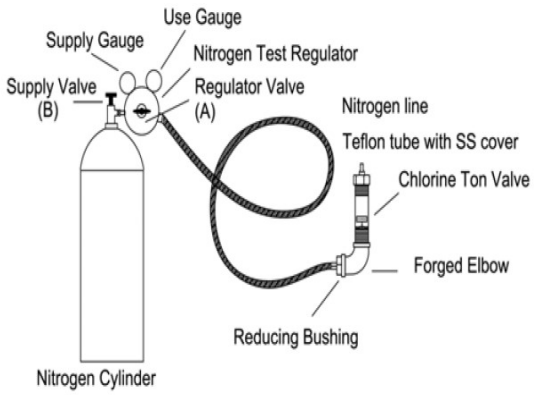
Sr.	Thermostatic expansion valve	Fixed orifice tube
01	It has moving parts	It has no moving parts
02	A system with thermostatic expansion valve has drier/receiver	A system with fixed orifice tube has no drier/receiver
03	The drying agent for the system is found in separate drier.	The drying agent for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

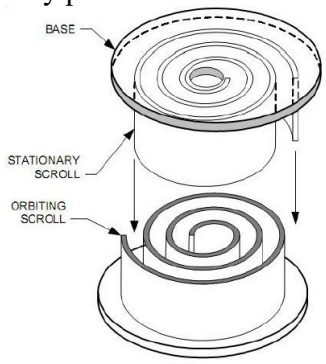
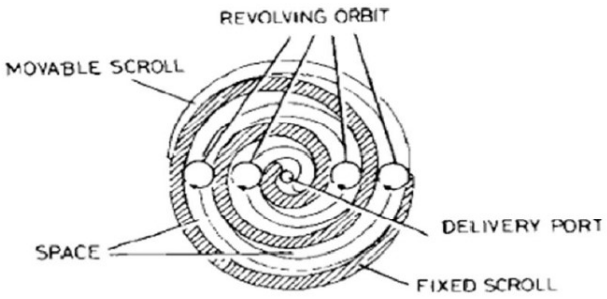
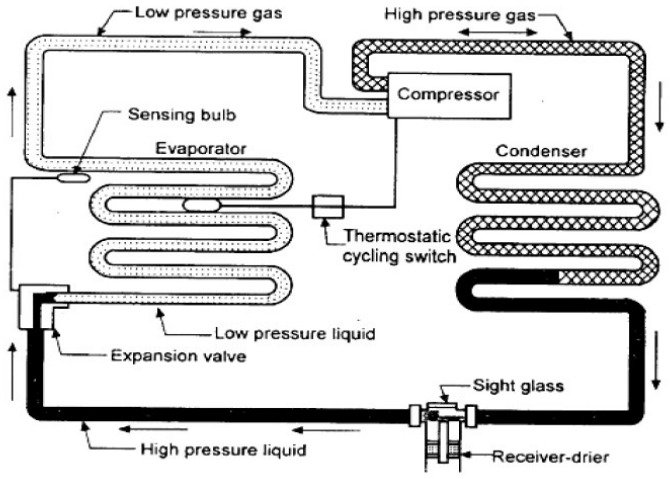
	b)	**Explain the construction of air intake section with neat sketch.**	**04**
		 **Figure: Air intake Section**	**02**
		Working of air intake section : Figure shows schematic sketch of air intake or inlet section. It consists of fresh (outside) air inlet; re-circulate (inside) air inlet, a fresh re-circulate 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. The position of vacuum motor operated fresh/re-circulate door depends on 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.	**02**
	c)	**Explain the terms** **i) Air movement and** **ii) Wind chill factor.**	**04**
		(Credit should be given to appropriate answer.) **1.Air movement:** Movement of air caused by temperature or pressure differences is wind. Where there are differences of pressure between two places, a pressure gradient exists, across which air moves: from the high pressure region to the low pressure region. Air movement starts with the relationship between static and total pressure together with the concept of kinetic energy for air in motion. The function of measurement devices such as manometers, pressure transducers, pitot tubes, anemometers is given, with illustrations. Fans normally power air movement and various fan types are described and illustrated, together with their characteristics. Fan laws for predicting performance at various conditions are introduced, and this leads on to the effects of speed control and variation of blade geometry. Key points concerning flow in ducts follows, with details of the effects of pressure drops, friction losses and behaviour of air flows at outlet points. Ducting and airflow patterns for various typical rooms are illustrated. Other important topics, grilles, return air handling, textile ducting, filtration, and cleanliness are included.	**02**

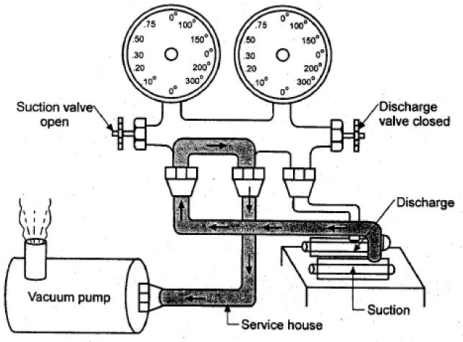
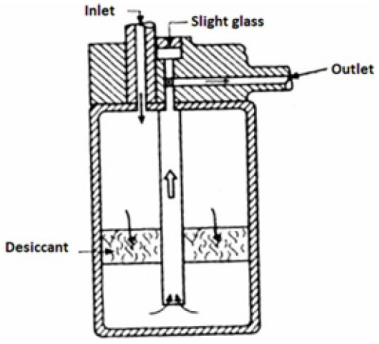
		2. Wind Chill factor: Wind chill is not a measure of temperature, it is a measure of comfort due to the rate of cooling. It has no impact on the actual temperature for the purpose of physical things like water freezing. Though wind in conjunction with cold air will increase the speed at which warm objects 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.	**02**
	d)	**Explain working of low pressure switch with sketch.**	**04**
		Working: This switch is normally closed and opens when low side pressure drops below 13.8-55.2 kPa. 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.  ***(Credit should be given to appropriate sketch.)***	**02** **02**
	e)	**Explain construction and working of reciprocating type compressor.**	**04**
		Construction and working of reciprocating type compressor: Constructional features of reciprocating compressors are as shown in the following figure. It consists of oil sump, crankshaft, piston and ring assembly, valve plate, cylinder head, service valve fitting, reed valve assembly and crankshaft seal assembly etc.  Figure: Reciprocating type Compressor *(Note: Credit shall be given to any other suitable sketch)*	**01** **02**

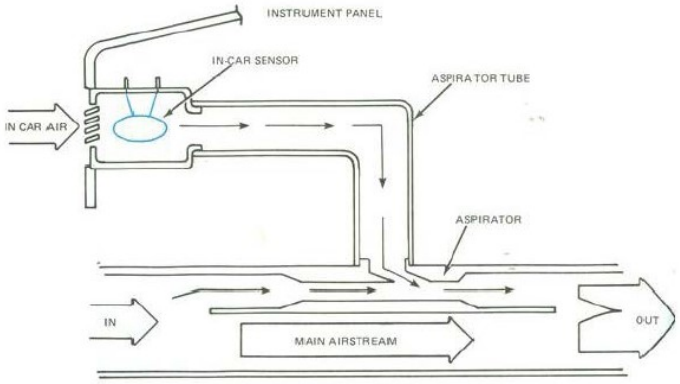
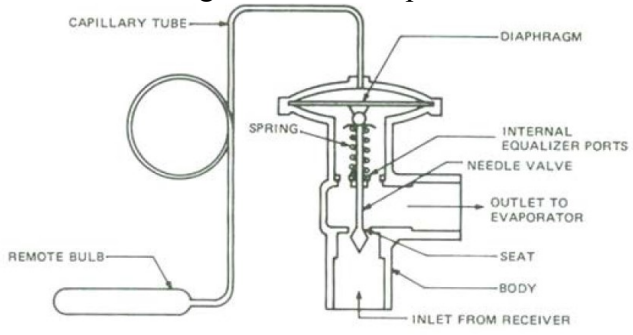
		Working: Piston type compressors go through an intake stroke and a compression stroke for each cylinder. On the intake stroke, the refrigerant from the low side (evaporator side) of the system is drawn into the compressor. The intake of refrigerant occurs through reed valves. These one-way valves control the flow of refrigerant vapors into the cylinder. During the compression stroke, the gaseous refrigerant is compressed. This increases both the pressure and the temperature of the heat-carrying refrigerant. The outlet (discharge) side reed valves then open to allow the refrigerant to move into the condenser. The outlet reed valves may be considered the beginning of the high side of the system.	**01**
	f)	**State the functions of "Drier". Explain its construction with neat sketch.**	**04**
		Function: The function of drier is to absorb moisture from the refrigerant with the help of drying agent. This agent, which is usually in the form of a silica gel, is known as "desiccant."	**01**
		Construction- A screen is placed in the receiver/drier to catch and prevent the circulation of any debris that may be in the system. The receiver or drier is a cylindrical metal can with two fittings and in most cases, a sight glass. The drier is located in the high pressure side of the air conditioning system. In general, the construction of receiver/drier is such that refrigerant vapor and liquid are separated to insure that 100% liquid is fed to the thermostatic expansion valve. The assembly can be divided into two parts: the receiver and the drier. The receiver section of the tank is storage compartment. This section holds the proper amount of extra refrigerant required by the system to insure proper operation. The receiver insures that a steady flow of liquid refrigerant can be supplied to the thermostatic expansion valve. The drier section of the tank is simply a bag of desiccant, such as silica gel, that can absorb and hold small quantity of moisture	**01**
		 **Figure: Receiver/Drier**	**02**

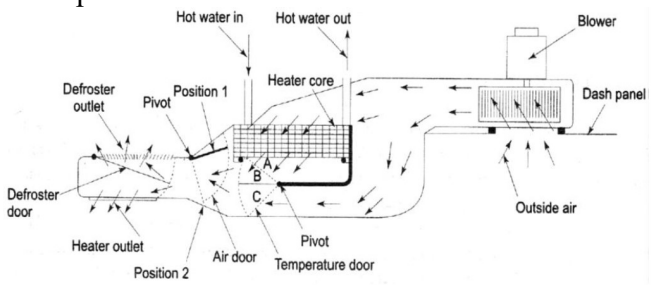
3.		**Attempt any FOUR of the following:**	12
	a)	**Explain construction and working of evaporator.**	**04**
		Construction and working of evaporator: Construction: The evaporator as shown in figure is the part of refrigeration system where the refrigerant vaporizes as it picks up heat. Heated air is forced through and past the fins and tubes of the evaporator. Heat from the air is picked up by the boiling refrigerant and is carried in the system to the condenser. The evaporator is usually installed in housing under the dash panel.	**01**
			**01**
		Figure: Evaporator	
		Working: When the air conditioning system is turned on, warm air from the passenger compartment is blown through the coils and fins of the evaporator. The evaporator receives refrigerant from the thermostatic expansion valve or orifice tube as a low pressure, cold atomized liquid. As the cold refrigerant passes through the evaporator coil, heat moves from the warm air into the cooler refrigerant. When the liquid refrigerant receives enough heat, a change of state - from a low pressure liquid into a low Pressure vapor - takes place The thermostatic expansion valve or orifice tube continually meters the precise amount of refrigerant necessary to maintain optimum heat transfer, which ensures that all of the liquid refrigerant will have changed to a vapour by the time it reaches the evaporator outlet. The vaporized refrigerant then continues on to the inlet (suction) side of the compressor.	**02**
	b)	**State the functions and locations of:** **(i) In car temperature sensor** **(ii) Sun load sensor**	**04**
		(i) In-car temp. sensor: Location : In car temp sensor is located in aspirator. Function: Its function is to monitor car inside temperature continually.	**02**
		(ii) Sun load sensor: Location : The sun load sensor is a photochemical diode (PCD) located on top of the dashboard. Function: 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 signalled 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.	**02**

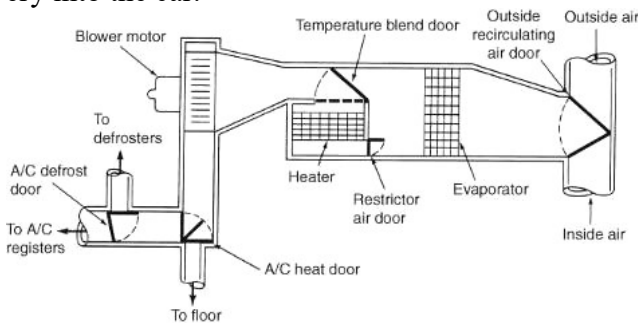
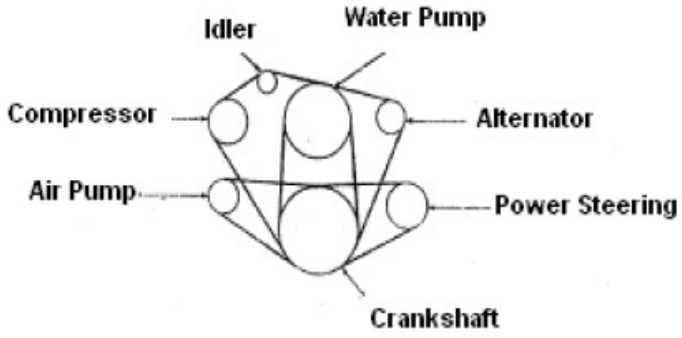
	c)	**State the environmental and safety aspects in automobile air-conditioning.**	
		Environmental aspects--(any4) 1. To avoid ozone depletion we can replace CFC-12 by HFC-134a. 2. In HVAC system less CO2 released. 3. Emissions to air: emissions like smoke, dust, odour, and fumes from automobile HVAV should be minimum. Efforts must Bb e taken to avoid these emissions. 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. **Safety aspects-(any4)** 1. Always wear eye protection when servicing air conditioning system or handling refrigerants. 2. Avoid breathing refrigerant and lubricant vapour or missed. 3. Do not allow refrigerant to come in contact with open flames and high temp surfaces. 4. Service equipment's should not be pressure tested or leak tested with compressed air.	**02** **02**
	d)	**Explain Nitrogen leak tester.**	**04**
		Nitrogen Leak test – Regulator Operations: 1. Turn valve A on regulator counter clockwise until loose. 2. Open valve B on nitrogen cylinder, supply gauge will read 2000/2200lb when full 3. Turn valve B on regulator r clockwise until gauge reads 175lbs 4. Close valve B on nitrogen cylinder. 5. Turn valve A on regulator clockwise until pressure reading on use gauge stops rising. This will usually be between 200- 250lbs. this will also cause the reading on supply gauge to drop to 200- 250lbs. 6. The system is now in test mode and any leak will cause the use gauge to drop.  **Figure: Nitrogen leak tester**	**02**
	e)	**Explain scroll type compressor.**	**04**
		Construction: Constructional features of scroll type compressors are as shown in the figure. It consists of refrigerant temperature sensor, moveable scroll, delivery port, intake port, low pressure service valve, front plate, needle bearing, stud pin, crankshaft, eccentric bushing, ball coupling, and fixed scroll etc.	**01**

		Working: 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 centre. The motion creates an increase in pressure toward the centre of the scroll. The refrigerant vapour moves in a circular pattern, and its pressure is increased as it moves toward the centre of the scroll. The high pressure refrigerant is released through a delivery port located at the centre 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.	**01**
			
		OR	
			**02**
		Figure: Scroll compressor	
4.	**a)**	**Attempt any THREE of the following:**	**12**
	i)	**Draw neat labeled layout of Automobile air-conditioning system.**	**04**
			**04**
		Figure: General layout of automobile A/c System	

	ii)	**Explain construction and working of typical vacuum system.**	**04**
		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.  Figure: Typical Vacuum system.	**02** **02**
	iii)	**Explain in detail the moisture removal procedure.**	**04**
		Moisture removal procedure: Liquid refrigerant enters through the inlet. Any dirt is filtered by the filter pads and moisture is absorbed from the refrigerant by the desiccant. Any refrigerant vapour 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 aluminium fins of cooler evaporator coil, the moisture content in the air condenses on its surface.  **Figure: Moisture control by receiver drier**	**02** **02**

	iv)	**Explain the concept of 'Aspirator'.**	**04**
		Concept of Aspirator: The aspirator is small duct system which is so designed that it causes small amount of in car air to pass through it, as shown in figure. The main air stream causes low pressure at inlet end of the aspirator. This causes in-car air to be drawn into the in-car sensor plenum. The in-car sensor, located in plenum, is continuously exposed to average in- car air to monitor the in-car air temperature.	**02**
		 **Figure: Concept of Aspirator**	**02**
	b)	**Attempt any ONE of the following:**	
	i)	**Explain with neat sketch the working of thermostatic expansion valve.**	**04**
		Working of thermostatic expansion valve: 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. Any increased in refrigerant temp. at the evaporator outlet increase the pressure in the remote bulb & tube system. This exerts downward pressure on the diaphragm is greater than the combination of the evaporator pressure & 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 & 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.	**02**
		 **Figure: Thermostatic expansion valve**	**02**
	ii)	**Explain the working of 'comfort heating' with neat sketch.**	**04**
		Working of 'comfort heating': 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	**02**

		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.  Figure: Comfort Heating System	**02**
5.		**Attempt any FOUR of the following:**	**16**
	a)	**Discuss the requirement of HVAC in:** **(i) Light motor vehicle** **(ii) Heavy goods vehicle**	**04**
		Requirement of HVAC system in light motor vehicle: • During summer, large amount of heat enters the passenger compartment. This heat comes from air outside the car solar radiation and engine etc. To get comfort the excess heat should be removed. Oftenly in warm and damp driving conditions, the windows of the vehicle fog up to much moisture inside the vehicle. Also in cold seasons heat is required to warm the inside environment of vehicle. So to meet the above mentioned requirements modern automobiles are equipped with ventilation heating cooling and dehumidification. • In most of the vehicles ventilation system is designed to allow fresh air into the passenger compartment, replacing stale air and to prevent entry of polluted air from outside. Hence to maintain human comfort and to provide clean and fresh atmosphere inside the vehicle, air conditioners are used in most of the vehicles **Requirements of HVAC in heavy goods vehicles.** 1. In Heavy goods vehicle, Ac system consume significant amount of engine power by the compressor so power consumption should be as less as possible so that it should not affect fuel efficiency of vehicle that much 2. Less power consumption & less load on engine does not affect acceleration of vehicle .during this period HVAC system should maintain proper temperature inside goods compartment 3. In goods compartment there should be equal circulation of air among all compartment 4. Noise & vibration of system should be as less as possible	**02** **02**
	b)	**Explain construction and working of downstream duct system.**	**04**
		Construction and working of downstream duct system: **Construction:** A schematic sketch of independent case system with downstream blower is as shown in the following figure. It consists of fresh (outside) air inlet, a re-circulate (inside) air inlet, fresh re-circulate air door, 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	**02**

		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.  **Fig :downstream duct system**	**02**
	c)	**Explain drive system for compressor.**	**04**
		Drive system for compressor in automobile air conditioning: 1. **Compressor driven off crankshaft pulley by one or two belts:** Compressors are driven by one or two belts of the engine crankshaft and have an idler pulley which is used to adjust the belt tension. Similarly, alternator or power steering pump can be used to adjust belt tension  Figure: Compressor driven off crankshaft pulley by one or two belts **OR** **Compressor driven off crankshaft by single belt:** Compressor can be driven off the crankshaft by single belt drive along with such other accessories as power steering pump, air pump, alternator and water pump. This system is known as serpentine drive as shown in figure. The belt called V-rib or serpentine is tensioned by spring loaded idler pulley which rides on the back side of the belt.	**04**

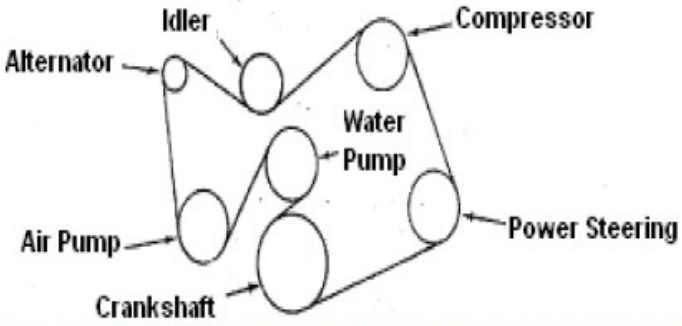


Figure: Compressor driven off crankshaft by Serpentine belt:

d) Give faults, causes and remedies of Electro-magnetic clutch. **04**

Answer: (Any 02 faults and their causes, remedies) (credit should be given to appropriate answer)

Fault	Cause	Remedies
Clutch engagement failure	• Air gap too large	Check the air gap and adjust it, if necessary. Install a new clutch, if required.
	• No voltage applied to clutch	Check the electrical connection and correct faults, if found.
	• Voltage applied to field coil too low	Check the field coil supply voltage and correct faults, if found.
	• Damaged rectifier	Check the rectifier and replace it, if necessary.
	• Damaged field coil	Check the resistance of the field coil. Install a new clutch, if necessary.
Delayed clutch engagement	• Air gap too large	Check the air gap and adjust it, if necessary. Install a new clutch, if required.
	• Voltage applied to field coil too low	Check the field coil supply voltage and correct faults, if found.
Clutch release failure	• Voltage applied to field coil in unpowered condition too high (residual voltage)	Check whether residual voltage is applied to the field coil and correct faults, if found.
	• Armature plate blocked mechanically due to fusing of armature and magnet body	Separate the armature from the magnet body. Install a new clutch, if necessary.
Delayed clutch release	• Voltage applied to field coil too high	Check the field coil supply voltage and correct faults, if found.
Clutch torque too low	• Air gap too large	Check the air gap and adjust it, if necessary. Install a new clutch, if required.
	• Clutch operating temperature too high	Reduce the clutch switching work / switching power. Cool the clutch, if necessary.
	• Voltage applied to field coil too low	Check the field coil supply voltage and correct faults, if found.
	• Friction lining projects from pole faces	Install a new clutch, if necessary.
	• Friction surface thermally overloaded	Install a new clutch.
	• Oily or greasy friction surfaces	Check the friction surfaces. Install a new clutch, if necessary.

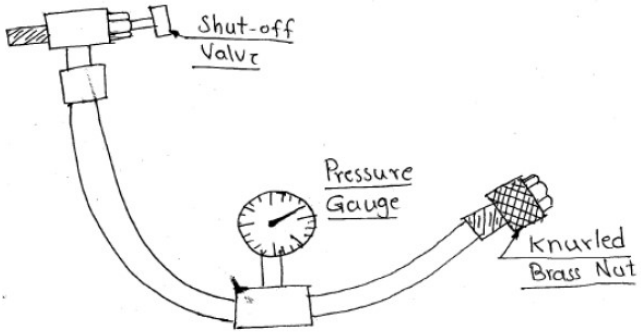
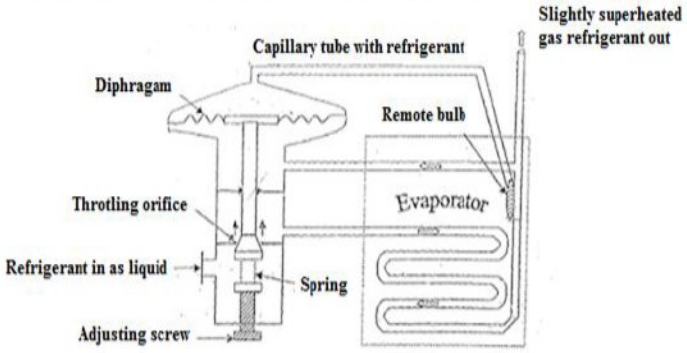
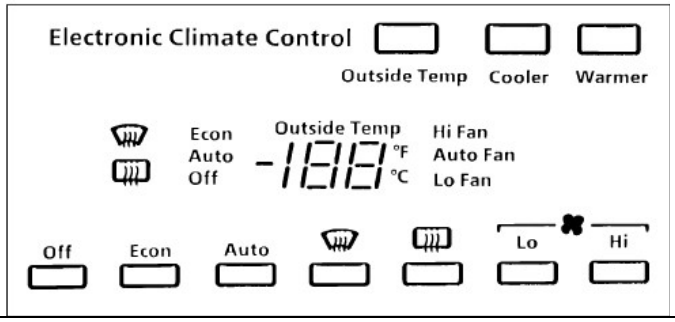
e) State the function of following components: **04**
(i) Vacuum reserve tank
(ii) Check relays

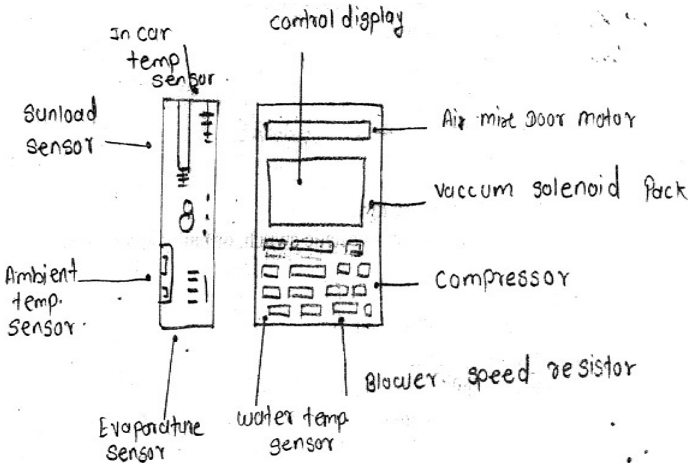
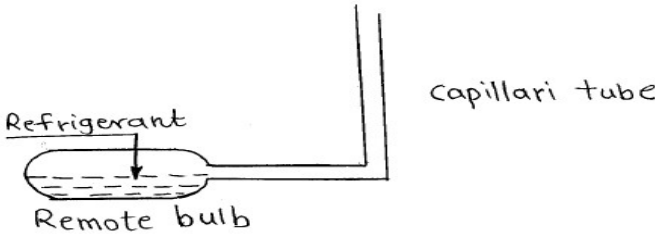
(i) **Vacuum reserve tank:** Function of vacuum reserve tank is to maintain maximum vacuum values to properly operate air conditioning and heater vacuum controls devices. **02**

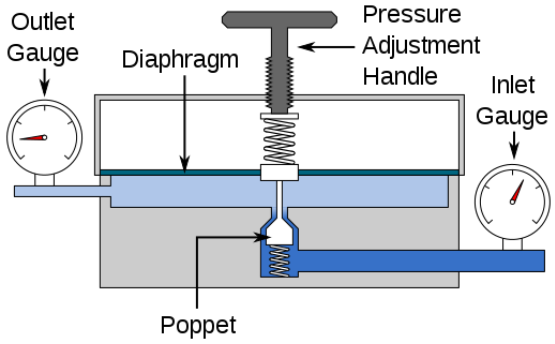
(ii) **Check Relay:** It prevents vacuum loss during low manifold vacuum conditions and maintain the sufficient vacuum in the system mode operations during these periods **02**

f) Explain charging hose with shut off valve. **04**

Construction of charging hose with shutoff valve: Features of charging hoses include: **02**
(i) Standard 870 psi working pressure, 3600 psi burst pressure making the charging hoses good for all refrigerants including R410A
(ii) Eight sided crimp ensures maximum hose life
(iii)Knurled brass nut for easy finger tightening
(iv)Multiple lengths available
(v) Color coded for convenience

		(vi)Available in packs of 3 (one red, one yellow and one blue hose) or individually  Figure: Charging hose with shutoff valve	02
6.		**Attempt any FOUR of the following:**	**16**
	a)	**Explain externally equalized thermostatic expansion valve.**	**04**
		Working of externally equalized thermostatic expansion valve:  Figure: Externally equalized thermostatic expansion valve 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.	**02** **02**
	b)	**Draw a neat labelled sketch of electronic climate control system.**	**04**
		Electronic Climate control system:*(Note: Credit shall be given to any other suitable sketch)*  	**04**

		OR  	
	c)	**Explain the procedure of charging refrigerant of system.**	**04**
		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 blower speed. 12. Open low side gauge valve which will admit refrigerant into the system. 13. Charge until proper weight of refrigerant has been added and sight glass clears. Close low pressure gauge valve. 14. Charge is complete and vehicle should be returned to idle speed and turned OFF. 15. Remove gauge set carefully 16. Install protective caps on valves. 17. As final check use the leak detector and check for leaks.	**04**
	d)	**Explain construction and working of remote bulb.**	**04**
		Construction and working of remote bulb: **Construction:** 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. It maintains pressure on diaphragm against evaporator pressure and spring pressure.  	**02**

		Working- 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.	**02**
	e)	**Describe construction and working of pressure regulator.**	**04**
		(credit should be given to appropriate answer) **(02 marks for sketch and two marks for explanation)**  **Construction & working:** A pressure regulator is a control valve that reduces the input pressure of a fluid or gases to a desired value at its output. Regulators are used for gases and liquids, and can be an integral device with an output pressure setting, a restrictor and a sensor all in the one body, or consist of a separate pressure sensor, controller and flow valve. A pressure regulator's primary function is to match the flow of gas through the regulator to the demand for gas placed upon it, whilst maintaining a constant output pressure. If the load flow decreases, then the regulator flow must decrease as well. If the load flow increases, then the regulator flow must increase in order to keep the controlled pressure from decreasing due to a shortage of gas in the pressure system. A pressure regulator includes a restricting element, a loading element, and a measuring element: The restricting element is a valve that can provide a variable restriction to the flow, such as a globe valve, butterfly valve, poppet valve, etc. • The loading element is a part that can apply the needed force to the restricting element. This loading can be provided by a weight, a spring, a piston actuator, or the diaphragm actuator in combination with a spring. • The measuring element functions to determine when the inlet flow is equal to the outlet flow. The diaphragm itself is often used as a measuring element; it can serve as a combined element. In the figure cut sectional view of regulator is shown, a force balance is used on the diaphragm to control a poppet valve in order to regulate pressure. With no inlet pressure, the spring above the diaphragm pushes it down on the poppet valve, holding it open. Once inlet pressure is introduced, the open poppet allows flow to the diaphragm and pressure in the upper chamber increases, until the diaphragm is pushed upward against the spring, causing the poppet to reduce flow, finally stopping further increase of pressure. By adjusting the top screw, the downward pressure on the diaphragm can be increased, requiring more pressure in the upper chamber to maintain equilibrium. In this way, the outlet pressure of the regulator is controlled	