WINTER-19 EXAMINATION

Model Answer

Subject title: Plant Utilities Subject code 22311

Important Instructions to examiners:

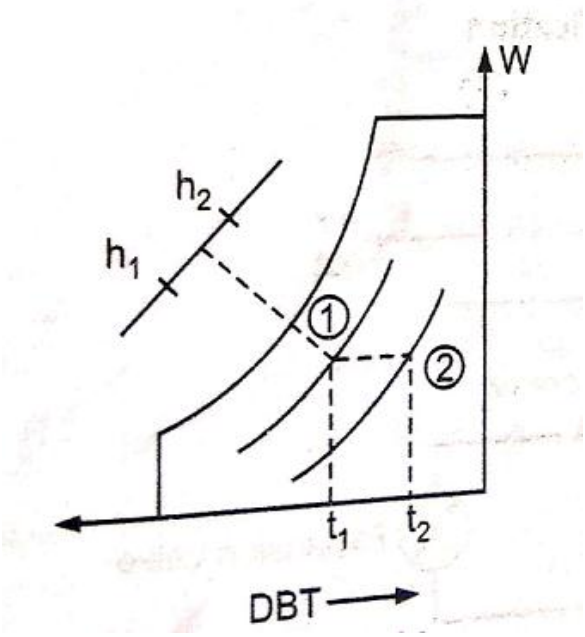
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling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

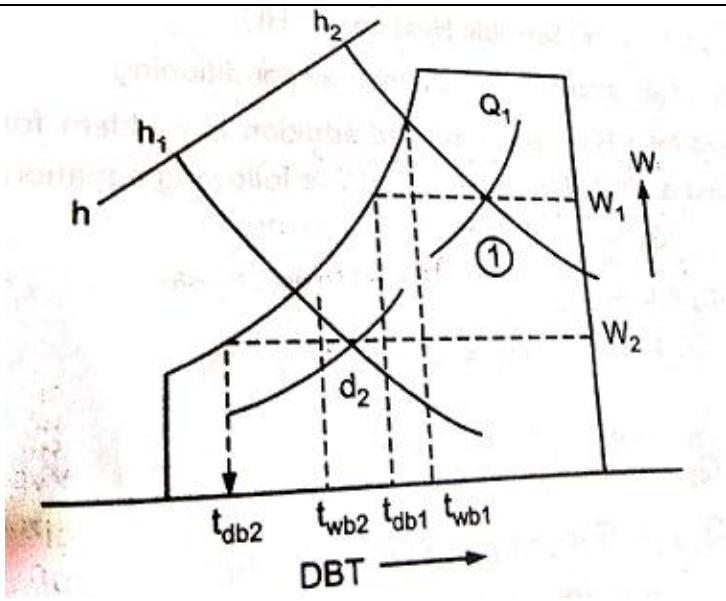
Q No.		Answer	Marking scheme
1		**Attempt any five**	**10**
1	a	**Uses of industrial water: (any 4)** 1. In chemical reaction 2. Utility(cooling agent) 3. Steam production 4. Cleaning 5. In cooling tower	½ mark each
1	b	**Hard water**: Contains dissolved salts of calcium and magnesium. It does not produce lather with soap solution. **Soft water:** Does not contain dissolved salts of calcium and magnesium. It produces lather or foam with soap	1 1
1	c	**Enthalpy of dry saturated steam.** It is the quantity of heat required to raise the temperature of 1 kg of water from the freezing point to the boiling point and then convert it into dry saturated steam at that temperature and pressure. **Unit:** kJ/kg	1 1
1	d	**Different thermic fluids (any 4)** 1. Dowtherm A 2. Dowtherm E 3. Therminol FR 4. Oil mobiltherm 600 5. Oil Mobiltherm light	½ mark each

		6. Hydrotherm 750-200	
1	e	**Uses of air in industry: (any 4)** i) To clean work shop ,generators and machine. ii) For cooling of furnace. iii) Compressed air used in oxidation of acetaldehyde to acetic acid in liquid phase reactor. iv) Oxidation of nitrogen oxide to nitrogen dioxide in nitric acid plant. v) To exhaust the fumes of HCl gas, by exhaust blower. vi) fan air used in solid fuel boiler.	½ mark each
1	f	**Coefficient of Performance**.: Working performance of any machine is usually expressed by output/input ratio known as efficiency. In refrigeration it is denoted by C.O.P. (β). COP= refrigeration effect/ work input to produced R.E. β =RE/W	2
1	g	**i)Dry bulb temperature:** Temperature recorded by ordinary thermometer is called dry bulb temperature. **(ii)Wet bulb temperature:** It is the temperature indicated by thermometer whose bulb is covered with cotton or muslin wire wetted with moisture	1 1
2		**Attempt any three**	**12**
2	a	**Reactions take place in lime soda process: (any 4)** $2HCl + Ca(OH)_2 \rightarrow CaCl_2 + 2H_2O$ $H_2SO_4 + Ca(OH)_2 \rightarrow CaSO_4 + 2H_2O$	1 mark each

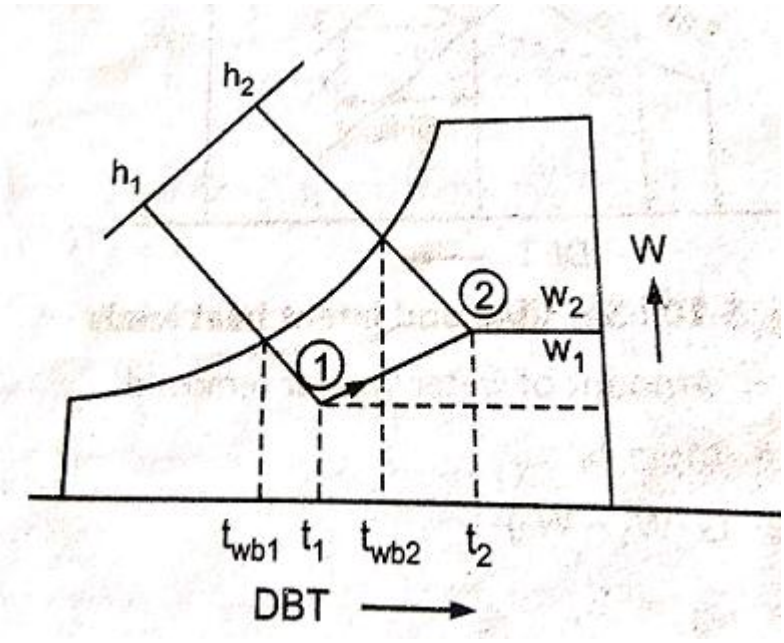
		$Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2CaCO_3 + 2H_2O$ $Mg(HCO_3)_2 + 2\ Ca(OH)_2 \rightarrow 2CaCO_3 + Mg(OH)_2 + 2H_2O$ $MgCl_2 + Ca(OH)_2 \rightarrow Mg(OH)_2 + CaCl_2$ $MgSO_4 + Ca(OH)_2 \rightarrow Mg(OH)_2 + CaSO_4$ $CaCl_2 + Na_2CO_3 \rightarrow CaCO_3 + 2NaCl$ $CaSO_4 + Na_2CO_3 \rightarrow CaCO_3 + Na_2SO_4$	
2	b	**Classifications of boilers(any 4)** 1.**Use** a. stationary b. mobile 2. **Tube contents** a. fire tube boiler b. water tube boiler 3**. Tube shape and position** a. Tube shape (Form) –i. Straight ii. Bent iii. sinuous b. Inclination(position) – i. horizontal ii. Inclined iii. Vertical 4. **furnace position**	1 mark each

		a. Externally fired boiler b. Internally fired boiler 5. **Circulation** a. natural circulation b. forced circulation 6. **Heat source** a. Fuel b. hot wastergaes c. electrical energy d. nuclear energy	
2	c	**Working of Super heater:** Superheater header mounted against the tube sheet in the smoke box.The steam is then passed through a number of superheater elements—long pipes which are placed inside special, widened fire tubes, called flues. Hot combustion gases from the locomotive's fire pass through these flues just like they do the fire tubes, and as well as heating the water they also heat the steam inside the super heater elements they flow over. The super heater element doubles back on itself so that the heated steam can return; most do this twice at the fire end and once at the smoke box end, so that the steam travels a distance of four times the header's length while being heated. The superheated steam, at the end of its journey through the elements, passes into a separate compartment of the super heater header and then to the cylinders as normal.	4

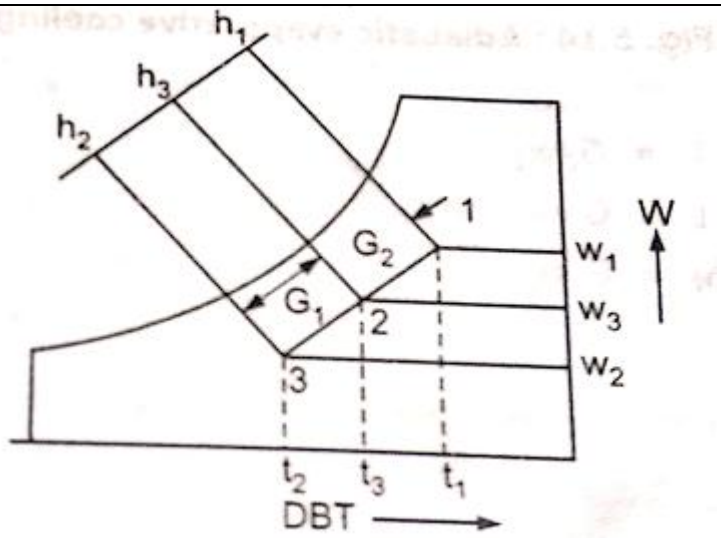
2	d	**Psychrometric process and their representation on psychrometric chart: (any 4)** **1. Sensible heating or cooling**  2.**Cooling and dehumidification:**	1 mark each



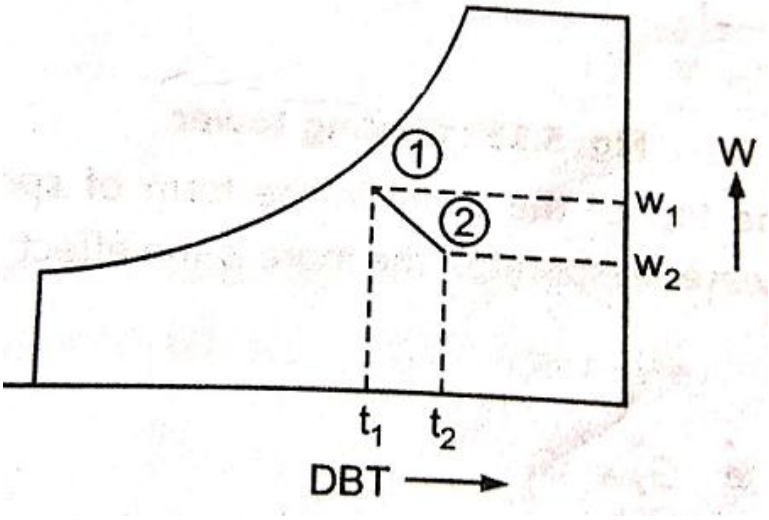
3.Heating and humidification



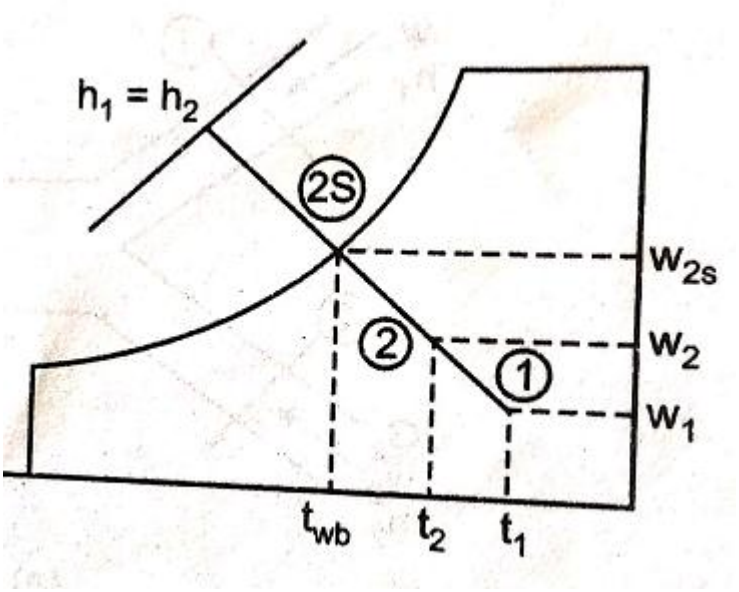
4.Adiabatic mixing of two streams

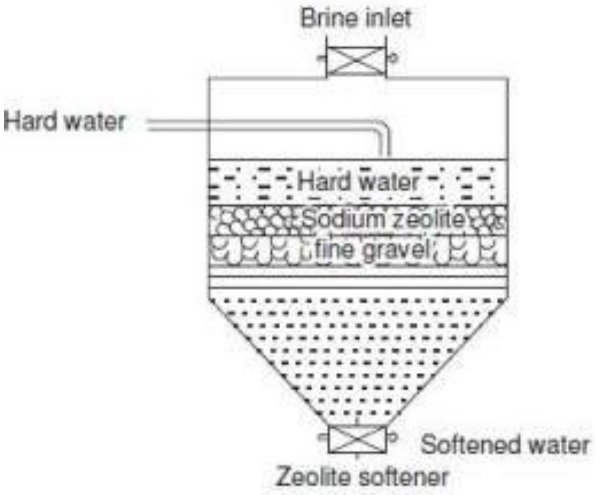


5. Chemical Dehumidification

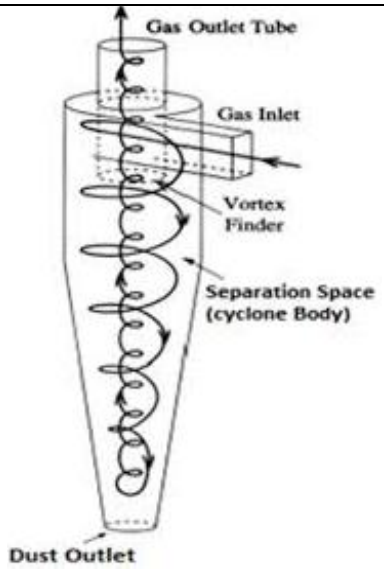


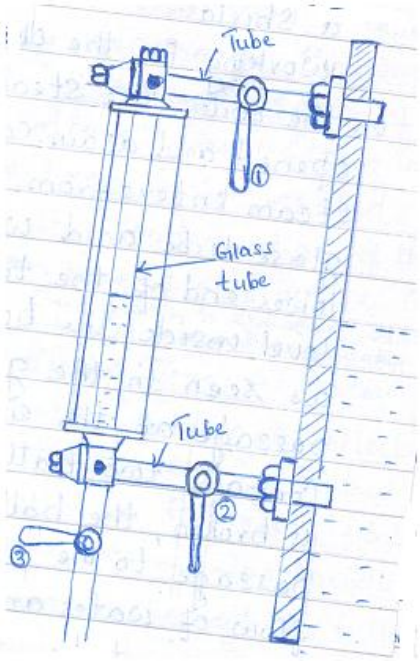
6.Adiabatic evaporative cooling



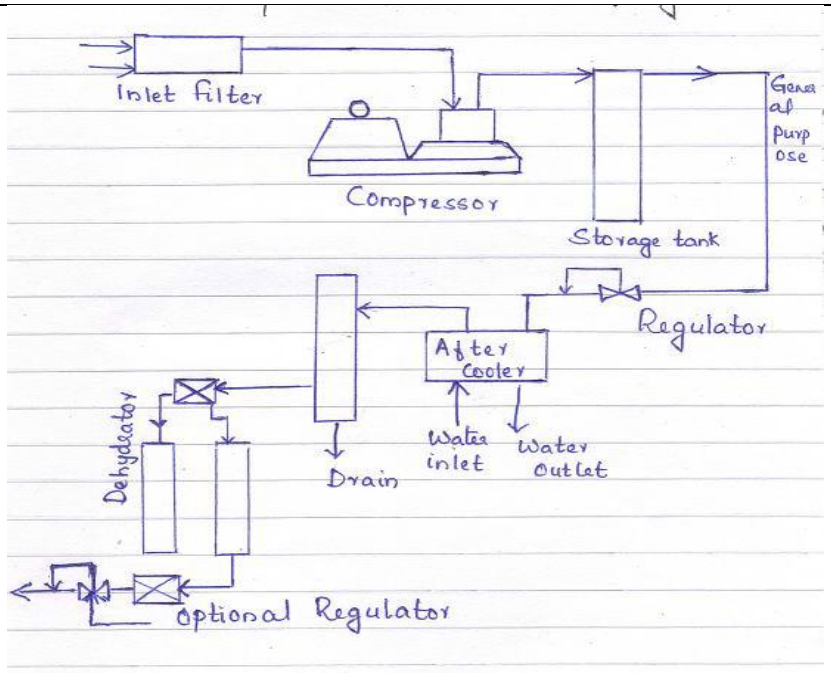
3		**Attempt any three**	**12**
3	a	**Zeolite process:** 	4

<table>
<tr><td>3</td><td>b</td><td>Rate of softening of water in ion exchange method is high because, cation exchange beds and anions exchange beds are used this process, which remove all the hardness causing substances.It also removes alkali metals. This process is useful for acidic as well as alkaline water.</td><td>4</td></tr>
<tr><td>3</td><td>c</td><td>Differentiate between fire tube boiler and water tube boiler: (any4)
<table>
<tr><td>Fire tube boiler</td><td>Water tube boiler</td></tr>
<tr><td>In Fire-tube boilers hot flue gases pass through tubes and water surrounds them.</td><td>In Water-tube boilers water passes through tubes and hot flue gasses surround them.</td></tr>
<tr><td>These are operated at low pressures up to 20 bar</td><td>The working pressure is high enough, up to 250 bar in super critical boilers.</td></tr>
<tr><td>The rate of steam generation and quality of steam are very low, therefore, not suitable for power generation.</td><td>The rate of steam generation and quality of steam are better and suitable for power generation.</td></tr>
<tr><td>It requires more floor area for a given output.</td><td>It requires less floor area for a given output</td></tr>
<tr><td>Load fluctuations cannot be handled.</td><td>Load fluctuations can be easily handled.</td></tr>
<tr><td>In Fire-tube boilers hot flue gases pass through tubes and water surrounds them.</td><td>In Water-tube boilers water passes through tubes and hot flue gasses surround them.</td></tr>
</table></td><td>1 mark each</td></tr>
<tr><td>3</td><td>d</td><td>Cyclone separator:</td><td></td></tr>
</table>

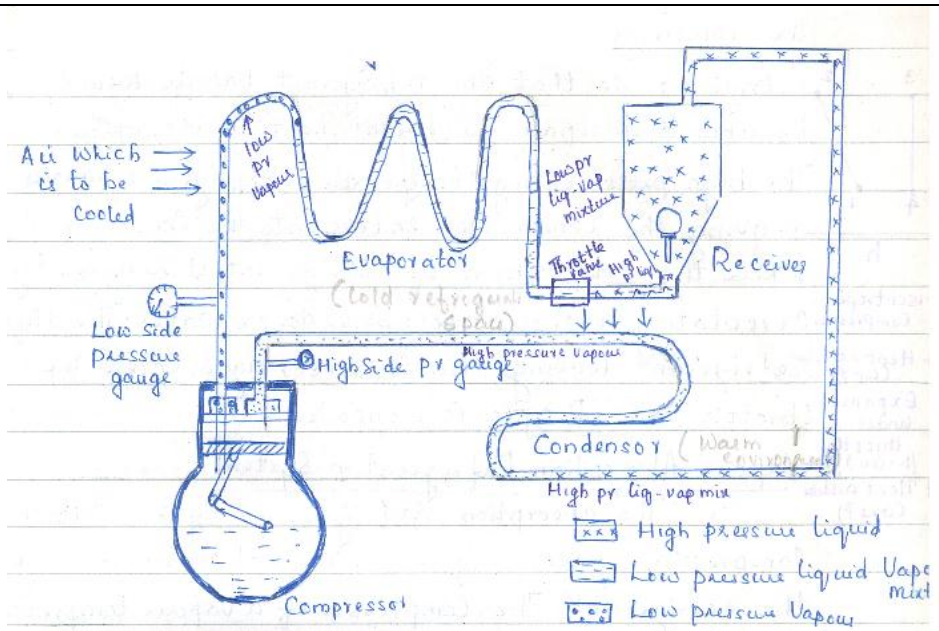
		 **Working**: Cyclone separators work much like a centrifuge, but with a continuous feed of dirty air. In a cyclone separator, dirty flue gas is fed into a chamber. The inside of the chamber creates a spiral vortex. This spiral formation and the separation is shown in Figure. The lighter components of this gas have less inertia, so it is easier for them to be influenced by the vortex and travel up it. Contrarily, larger components of particulate matter have more inertia and are not as easily influenced by the vortex. Since these larger particles have difficulty following the high-speed spiral motion of the gas and the vortex, the particles hit the inside walls of the container and drop down into a collection hopper. These chambers are shaped like an upside-down cone to promote the collection of these particles at the bottom of the container. The cleaned flue gas escapes out the top of the chamber.	2 2
4		**Attempt any three**	**12**
4	a	**Methods of scale and sludge removal:**	1 mark each

		With the help of scrapper, knife ,blades or piece of wood or by wire brushing, if the scale is loosely adhering. By giving thermal shocks. By heating the boiler and then suddenly cooling with cold water. By dissolving them in some chemicals. By frequent blow-down operation.	for any 4
4	b	**Water level indicator:**  **Working:** Its function to indicate water level in boiler. usually two water level indicator are fitted to in front of boiler. WLI shows the water level in in the boiler drum and warns to operator it by chance the water level goes below a fixed mark , so that corrosive action may be taken in time to avoid accident.	2 marks for diagram and 2 marks for working

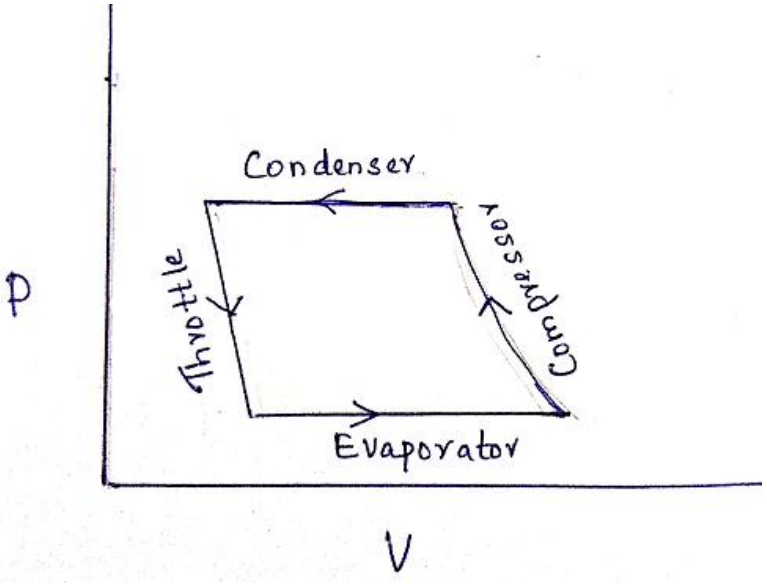
4	c	**Boiler act:** **Duties of chief inspector**: Maintain records of registered boilers. Examine boiler inspection reports produced by inspectors. Decide whether to issue the certificate for the operation of boiler or not. Supervise and control the work of inspectors. **Registration of boiler:** Boilers have to be registered before they can be used. The owner of the boiler shall give an application for the same. The inspector shall examine the boiler and find maximum pressure at which the boiler may be operated.	2 2
4	d	**Instrument air:** Air is passed through a filter to remove suspended impurities. The filtered air issupplied to the compressor. Discharge from the compressor will be at a pressure of 100 to 150 psi, which is stored in a storage tank. When required it is passed through a regulator and then through an after cooler to remove the heat. It is then passed through a stone filter to remove traces of oil if present. Filtered air is passed through dehydrator to remove the moisture. Silica gel, activated alumina, calcium chloride, glycol etc are used for removing the moisture. A second pressure regulator is sometimes added to provide a constant reduced pressure in the supply line.	2

			2
4	e	**Advantages of multistage compression:** 1. Reduction in power required to drive compressor 2. Better mechanical balance and uniform torque. 3. Reduced leakage loss swing to reduce pressure difference in either side of piston and valves. 4. Less difficulty in lubrication 5. Lighter cylinders	1 mark each for any 4
5		**Attempt any two**	**12**
5	a	**Vapour compression refrigeration cycle:** The vapor-compression uses a circulating liquid refrigerant as the medium which absorbs and removes heat from the space to be cooled and subsequently rejects that heat elsewhere. Figure shows a typical, single-stage vapor-compression system. All such systems have four components: compressor,	

		condenser, thermal expansion valve, and an evaporator. Circulating refrigerant enters the compressor and is compressed to a higher pressure, resulting in a higher temperature as well. The hot, compressed vapor is then in the thermodynamic state known as a superheated vapor and it is at a temperature and pressure at which it can be condensed with either cooling water or cooling air. That hot vapor is routed through a condenser where it is cooled and condensed into a liquid by flowing through a coil or tubes with cold water or cold air flowing across the coil or tubes. This is where the circulating refrigerant rejects heat from the system and the rejected heat is carried away by either the water or the air The condensed liquid refrigerant next routed through an expansion valve where it undergoes an abrupt reduction in pressure. The cold mixture is then routed through the coil or tubes in the evaporator. A fan circulates the warm air in the enclosed space across the coil or tubes carrying the cold refrigerant liquid and vapor mixture. That warm air evaporates the liquid part of the cold refrigerant mixture. At the same time, the circulating air is cooled and thus lowers the temperature of the enclosed space to the desired temperature. The evaporator is where the circulating refrigerant absorbs and removes heat which is subsequently rejected in the condenser and transferred elsewhere by the water or air used in the condenser. To complete the refrigeration cycle, the refrigerant vapor from the evaporator is again a saturated vapor and is routed back into the compressor.	4

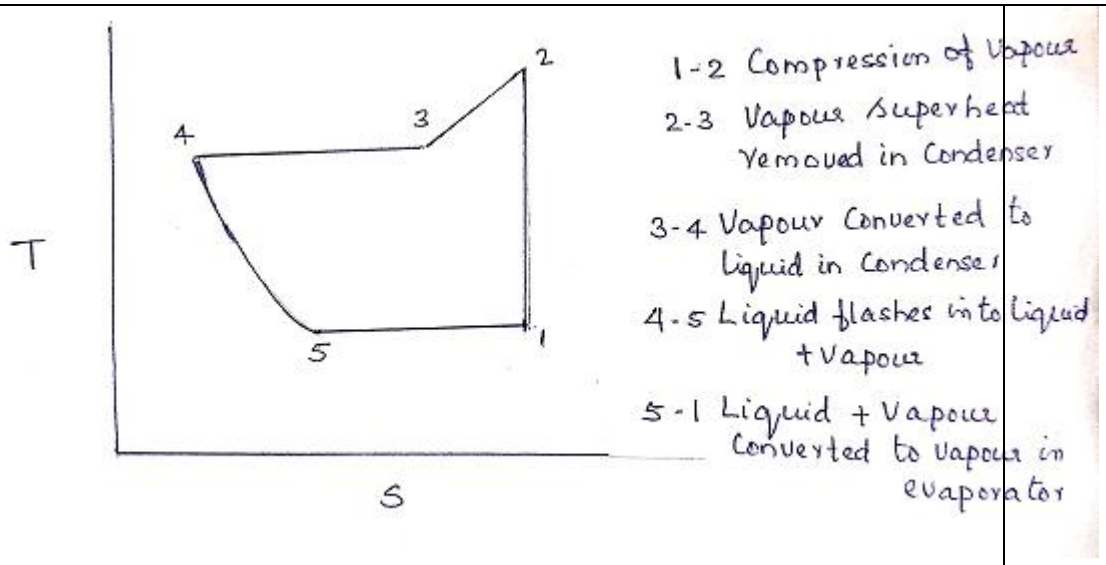


P-V Diagram

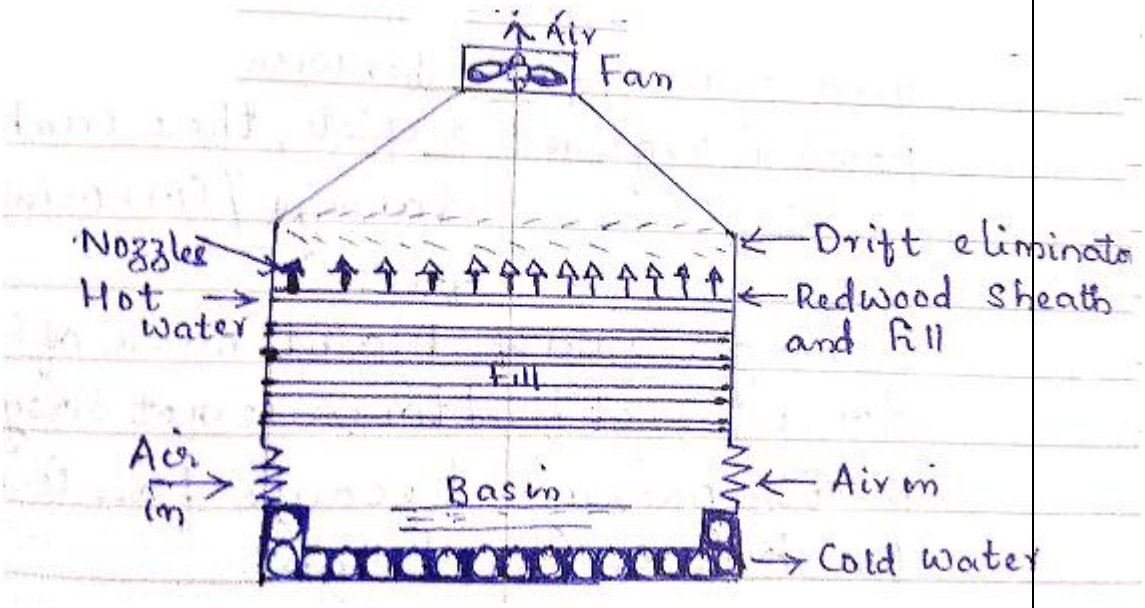


1

T-S diagram:

			1
5	b	**Selection criteria for refrigerant (any six):** 1. Working pressure range and pressure ratio. The pressure required to be maintained in the evaporator and condenser should be low enough to reduce the material cost and must be positive to avoid leakage of air into the system. 2. Corrosiveness and flammability: Non corrosive to mechanical components. It should be safe to operate(including non-toxic, nonflammable) 3. Space limitations: It should have low specific volume to reduce the size of the compressor. 4. Temperature required in the evaporator: It should have low boiling point and low freezing point. 5. Oil miscibility. It should have high miscibility with lubricating oil and it should not have reacting property with lubricants.	1 mark each

		6. It should not have any bad effect on the stored material or food when any leak develops in the system. 7. It should have low thermal conductivity to reduce the area of heat transfer in the evaporator and condensers. 8. It should have high critical pressure and temperature to avoid large power requirement. **9.** It must have low specific heat and high latent heat. **10.** It should have moderate density in liquid form, a relatively high density in gaseous form.	
5	c	DBT = 30^0C WBT = 22^0C (i) Dew point temperature = 18^0C (ii) Relative humidity = 50%	 3 3
6		**Attempt any TWO of the following**	**12**
6	a	From steam table, corresponding to a pressure of 10 bar, h_f = 762.6 kJ/ kg h_{fg} = 2013.6 kJ/ kg (i) When steam is dry and saturated Enthalpy of 1 kg of steam = $h_f + h_{fg}$ = 2776.2 kJ /kg Enthalpy of 5 kg of steam = 2776.2 *5 = **13881kJ** (ii) When steam is 80% dry Enthalpy of 1 kg of steam = h_f + x h_{fg} = 762.6 + 0.8* 2013.6 = 2373.48 kJ /kg Enthalpy of 5kg of steam = 5* 2373.48 = **11867.4 kJ**	 3 3

6	b	**Induced draft cooling tower:** **Diagram:**  **Construction and working:** Cooling towers are employed to cool utility cooling water by direct contact with air. The parts of a cooling tower are Water spray nozzle: water is sprayed in the cooling tower at the top with the help of nozzles. The spray helps to atomize the water in small droplets which results in increase in surface area of water and hence faster cooling. Mist eliminator: They are placed just above the spray nozzle to reduce the loss of water and thus protect the fan blades from corrosion in the case of induced draft tower. Cold water basin: It is the basin below the cooling tower where the cooled water accumulates and from where it is send to various heat exchange units.	2 4

		Fill or packing: They are provided in the cooling tower to increase the surface area for heat transfer and evaporation. They create obstacles in the path of water and air flow due to which thorough mixing of air and water takes place which results in attaining adiabatic equilibrium. Fan: Fan is mounted at the top portion of the cooling tower. Hot water is sprayed into the cooling tower through the spray nozzle. As it passes through the fills through mixing of water and air takes place and heat is removed from the water. The fan mounted at the top pulls the hot air through the fills and cooled water gets collected in the cold water basin.	
6	c	(i) $T_1 = 30+ 273 = 303K$ $T_2 = -10 + 273 = 263K$ C.O.P. $= T_2/(T_1 - T_2) = 263 / (303- 263) =$ **6.575**	2
		(ii) **Ton of refrigeration**: It is defined as the quantity of heat required to be removed from 1Ton water at 0^oC to get ice at 0^oC in one day	2
		(iii) **Industrial applications of refrigeration (any four)**: 1. Comfort air conditioning of auditorium, hospital, offices, residences etc. 2. Manufacture and preservation of medicine 3. Preservation of blood and human tissues 4. Storage and transportation of food stuff such as meat, fruit, fruit juice, vegetables etc. 5. Ice cooling of concrete for dam.	½ mark each