25

Scoring Indicators

Revision : 2015

Subject Code:6023

Verson: A

Qs No	Scoring indicators	Split score	Total score
	Part A		
I			
1.	First law of thermodynamics states that heat and work are mutually convertible. (or) Energy can neither be created nor destroyed through it can be transformed from one form to another.		2
2.	It is the ratio of heat extracted in the refrigerator to the work done on the refrigerant $COP = Q/W$		2
3.	Ammonia, Carbon dioxide, sulphur dioxide, freon.		2
4.	It states, The total pressure exerted by the mixture of air and water vapour is equal to the sum of the pressures, which each constituent would exert, if it is occupied the same space by itself. $P = P_a + P_v$ P_a - partial pressure of dry air P_v - partial pressure of water vapour		2

Scoring Indicators

Revision : 2015

Subject Code:6023 Verson:

Qs No	Scoring indicators	Split score	Total score
5.	HVAC is defined as the mechanical systems that provide thermal comfort and air quality in an indoor space are often grouped together and are generally inter connected		2
	Part. B		
II 1)	(a) Sensible heat When a substance is heated and the temperature rises as the heat is added, the increase in heat is called sensible heat	2	
	(b) Latent heat The latent heat is the amount of heat required to change the state of a substance without change of temperature.	2	
	(c) Critical temperature The critical pressure of a substance is the temperature at and above which vapour of the substance cannot be liquefied, no matter how much pressure is applied	2	6

Scoring Indicators

Revision : 2015

Subject Code:6023 Verson:

Qs No	Scoring indicators	Split score	Total score
2	**Advantages** 1. Air is available freely in nature 2. It is non-flamable and there is no danger of fire as in NH_3 machine 3. The weight of air refrigeration per ton of refrigeration is quite low 4. The system is used in air crafts	3	
	Disadvantages 1. ~~Heat~~ is carried out from the refrigerator in the form of sensible heat. 2. COP of the system is very low 3. The moisture present in the air freezes during expansion	3	6
3.	1. Low boiling point 2. High critical temperature 3. High latent heat of vapourisation 4. Non-corrosive to metal 5. Non-flammable and non-explosive 6. Non-toxic		6
4.	The frost formation ~~of~~ on evaporator coils of low temperature installations		

Scoring Indicators

Revision : 2015

Subject Code:6023

Verson:

Qs No	Scoring indicators	Split score	Total score
	should be melted out periodically. The process of removing the frost by melting is called defrosting evaporator	3	
	Methods 1. Manual defrosting method 2. Pressure control defrosting method 3. Temperature control defrosting method 4. Water defrosting method 5. Electric defrosting method	3×1 = 3	6
(5)	Sling psychrometer consists of a dry bulb thermometer and a wet bulb thermometer mounted side by side in a protective case that is attached to a handle by swivel connection so that the case can be easily rotated. The dry bulb thermometer		

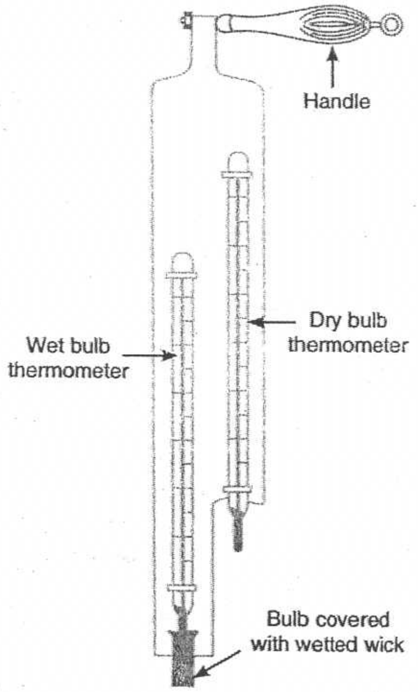


Fig. 16.2. Sling psychrometer.

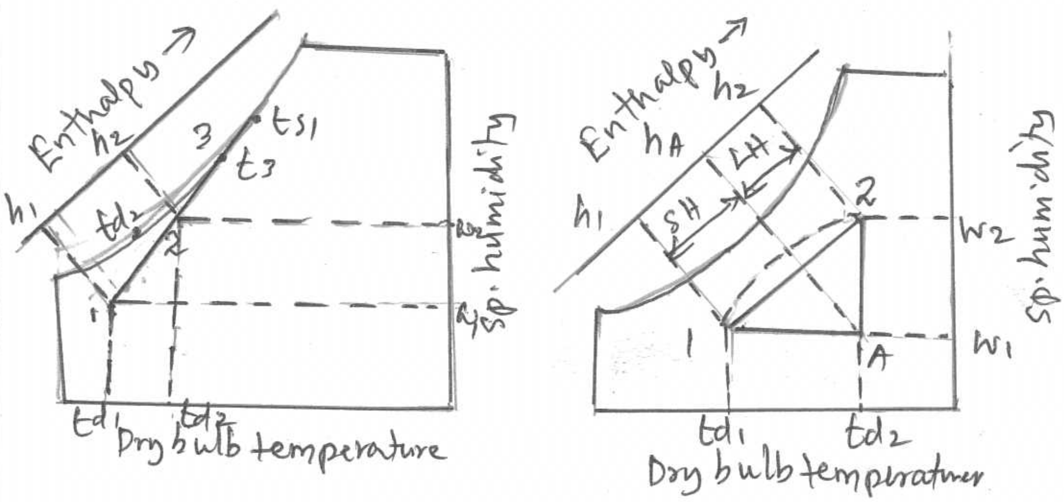
is directly exposed to air and measures the actual temperature of air. The bulb of the wet bulb thermometer is covered by a wick

Scoring Indicators

Revision : 2015

Subject Code:6023

Verson:

Qs No	Scoring indicators	Split score	Total score
	thoroughly wetted by distilled water. The temperature measured by this wick covered bulb of a thermometer is the temperature of liquid water in the wick and is called wet bulb temperature. The sling psychrometer is rotated in the air for approximately one minute after which the readings from both the thermometers are ~~taken~~. This process is repeated several times to assure that the lowest possible wet bulb temperature is recorded	fig.3 +3	6
6.	 This process is generally used in winter air conditioning systems to warm and humidify the air. when air is passed through a humidifier having spray water temperature higher than dry bulb temperature of entering air, the		

Scoring Indicators

Revision : 2015

Subject Code:6023

Verson:

Qs No	Scoring indicators	Split score	Total score
	unsaturated air will reach the condition of saturation and thus the air becomes hot. The heat of vapourisation of water is ~~[illegible]~~ absorbed from the spray water itself and hence it gets cooled. In this way, the air becomes heated and humidified. The process of heating and humidification is shown by the line 1-2 on the psychrometric chart. The air enters ~~the~~ at condition 1 and leaves at condition 2. In this process, the dry bulb temperature as well as specific humidity of air increases. The final relative humidity of the air can be lower or higher than that ~~of~~ the entering air	fig-3 +3	6
7.	factors 1. Effective temperature 2. Heat production and regulation in human body 3. Heat and moisture losses losses from the human body 4. Moisture content of air 5. Quality and quantity of air 6. Air motion 7. Hot and cold surface 8. Air stratification	6×1 =6	6

Revision : 2015

Subject Code:6023

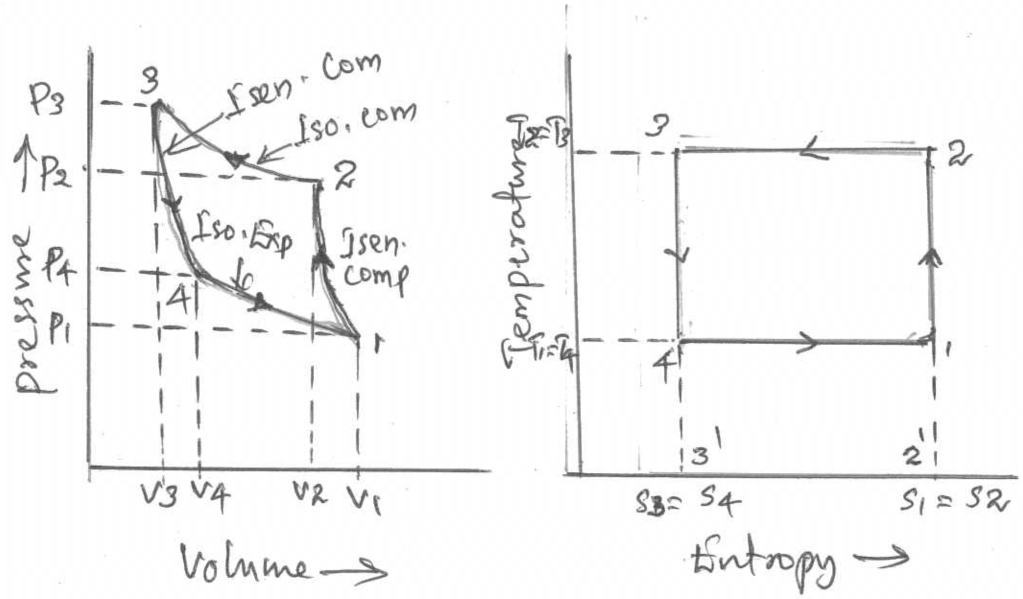
Verson:

Qs No	Scoring indicators	Split score	Total score

Part - C

UNIT - 1

III (a)



A reversed Carnot cycle using air as refrigerant as shown in p-V and T-s diagram.

The four process of the cycle are as follows

1. Isentropic compression process:- The air is compressed isentropically as shown by the curve 1-2 on p-V and T-s diagrams. During this process, the pressure of air increases from p_1 to p_2 and specific volume decreases from v_1 to v_2 and temperature increases from T_1 to T_2. During the process no heat is absorbed or rejected by the air

Revision : 2015

Subject Code:6023 Verson:

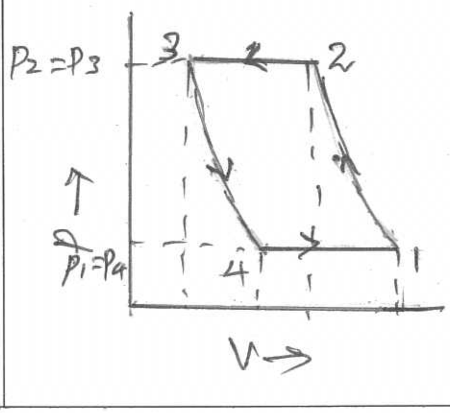
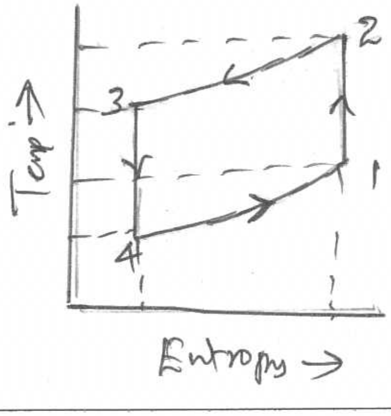
Qs No	Scoring indicators	Split score	Total score
	2. Isothermal compression process:- The air is compressed isothermally (ie at constant temperature $T_2 = T_3$) as shown by the curve 2-3 on p-v and T-s diagrams. During this process, the pressure of air increases from p_2 to p_3 and specific volume decreases from v_2 to v_3. In this process heat rejected by the air during isothermal compression per kg of air q_{2-1} = Area 2-3-3'-2' $= T_3(s_2 - s_3) = T_2(s_2 - s_3)$ ~~3. Isothermal~~ 3. Isentropic expansion process:- The air is now expanded isentropically as per the curve 3-4 on p-v and T-s diagrams. The pressure of air decreases from p_3 to p_4 specific volume increases from v_3 to v_4 and the temperature decreases from T_3 to T_4. During the isentropic compression process no heat is absorbed or rejected by the air. 4. Isothermal expansion process:- The air is now expanded isothermally (ie $T_4 = T_1$) as shown by the curve 4-1 on p-v and T-s diagrams. The pressure of air decreases from p_4 to p_1 and specific volume increases from		

Scoring Indicators

Revision : 2015

Subject Code:6023

Verson:

Qs No	Scoring indicators	Split score	Total score
	V_4 to V_1: The heat absorbed by the air during isothermal expansion per kg of air. q_{4-1} = area 4-1-2'-3' $= T_4(s_1 - s_4) = T_4(s_2 - s_3)$ $= T_1(s_2 - s_3)$		
	workdone during the cycle per kg of air = Heat rejected - Heat absorbed $= q_{2-3} - q_{4-1}$ $= T_2(s_2 - s_3) - T_1(s_2 - s_3)$ $= (T_2 - T_1)(s_2 - s_3)$		
	$(COP)_R = \frac{\text{Heat absorbed}}{\text{work done}} = \frac{q_{4-1}}{q_{2-3} - q_{4-1}}$ $= \frac{T_1(s_2 - s_3)}{(T_2 - T_1)(s_2 - s_3)} = \frac{T_1}{T_2 - T_1}$	fig 3 + Exp-5	8
(b)	 		

Scoring Indicators

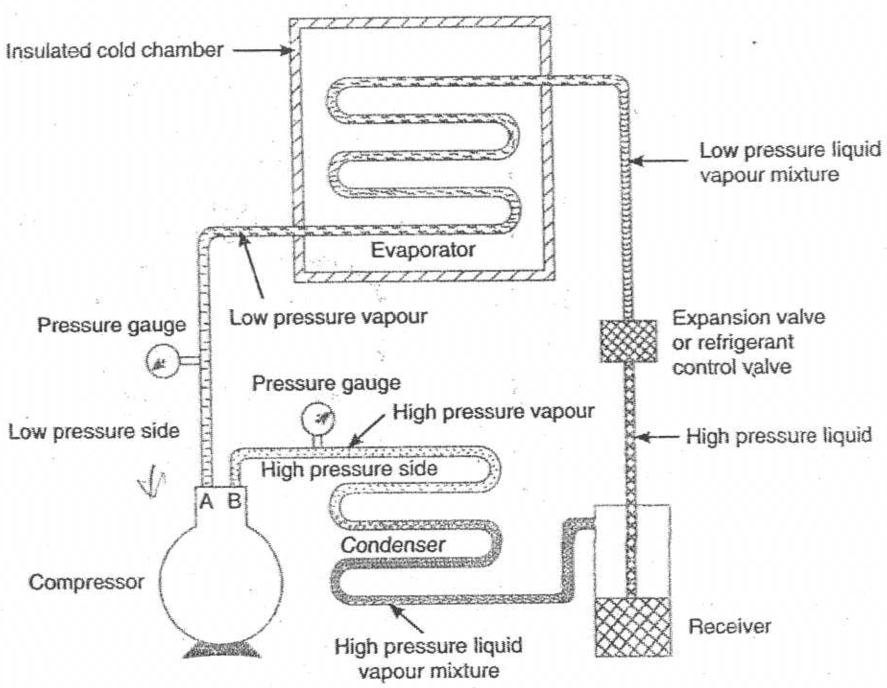
Revision : 2015

Subject Code:6023 Verson:

Qs No	Scoring indicators	Split score	Total score
	given		
	$T_1 = 10^0 = 10+273 = 283\,k$, $P_1 = 1bar$		
	$T_2 = 15^0 = 15+273 = 288\,k$, $P_2 = 5bar$		
	$C_p = 1.005\,kJ/kg\,k$, $C_v = 0.718\,kJ/kg\,k$		
	Isentropic index for compression & expansion		
	$\gamma = \frac{C_p}{C_v} = \frac{1.005}{0.718} = 1.4$	1	
	for Compression		
	$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} = \left(\frac{5}{1}\right)^{\frac{1.4-1}{1.4}} = 1.584$		
	$\therefore T_2 = T_1 \times 1.584 = 283 \times 1.584$		
	$= 448.27\,k$	2	
	for expansion		
	$\frac{T_3}{T_4} = \left(\frac{P_3}{P_4}\right)^{\frac{\gamma-1}{\gamma}} = 1.584$		
	$T_4 = \frac{T_3}{1.584} = \frac{288}{1.584} = 181.82\,k$		
	(i) Theorifical COP $= \frac{(T_1 - T_4)}{(T_2 - T_3) - (T_1 - T_4)}$		
	$= \frac{(283 - 182)}{(448 - 288) - (283 - 182)}$	2	
	$= 1.71$		

Revision : 2015

Subject Code:6023 Verson:

Qs No	Scoring indicators	Split score	Total score
	(ii) Refrigerating effect = Heat absorbed during Constant pre-process 4-1 for unit mass $= m\,C_p(T_1 - T_4)$ $= 1 \times 1.005\,(283 - 182)$ $= \underline{101.5\,KJ}$	1 =7	7
IV (a)	 **Fig. 4.1.** Simple vapour compression refrigeration system. A simple vapour compression refrigeration system consists of compressor, condenser, receiver, Expansion valve and evaporator		

Scoring Indicators

Revision : 2015

Subject Code:6023 Verson:

Qs No	Scoring indicators	Split score	Total score
	1. Compressor:- The low pressure and temperature vapour refrigerant from evaporator is drawn into the compressor through inlet or suction valve A. Where it is compressed to a high pressure and temperature. This high pressure and temperature vapour refrigerant is discharged into the condenser through the delivery or discharge valve B. 2. Condenser:- The condenser consists of coils of pipe in which the high pressure and temperature vapour refrigerant is cooled and condensed. The refrigerant, while passing through the condenser, gives up its latent heat to the surrounding condensing medium which is normally air or water 3. Receiver:- The condensed liquid refregerant from the condenser is stored in a vessel known as receiver from where it is supplied to the evaporator through the expansion valve. 4. Expansion valve:- The expansion valve is to allow the liquid refrigerant under high pressure and temperature is passed at a controlled rate after reducing its pressure and temperalure 5. Evaporator:- The liquid refrigerant then flows through an evaporator. It absorbs heat from the refrigerated space. It evaporates and changes its state from liquid to vapour and produce coldness	fig 4 + Exp 4	8

Scoring Indicators

Revision : 2015

Subject Code:6023

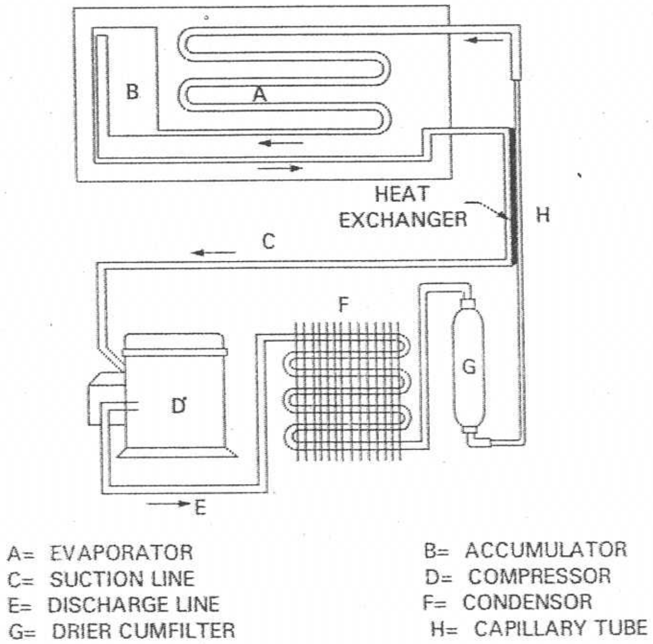
Verson:

Qs No	Scoring indicators	Split score	Total score
(b)	$T_1 = 273 - 10 = 263\,k$ $T_2 = 273 + 30 = 303\,k$ (a) $COP = \frac{T_1}{T_2 - T_1} = \frac{263}{303 - 263} = 6.575$	2	
	(b) $COP = \frac{\text{Refrigerating effect}}{\text{Work input}}$ Work input $= \frac{\text{Refrigerating effect}}{COP} = \frac{10 \times 12600}{6.575} = 19163.5$ kJ/hr Heat rejected / hr = Refrigerating effect / hr + work input / hr. $= 10 \times 12600 + 19163.5$ $= 145163.5$ kJ/hr	3	
	(c) Power in kw $= \frac{19163.5}{3600} = 5.3$ kw	2	
		7	7
V (a)	A domestic refrigerator mainly consists of compressor, condenser, evaporator and capillary tube Compressor :- Hermitically sealed rotary compressor is placed in the cabinet base.		

Scoring Indicators

Revision : 2015

Subject Code:6023 Verson:

Qs No	Scoring indicators	Split score	Total score
	 Fig. 9.1		
	The refrigerant widely used in the domestic refrigeration is R-12, The compressor compresses the refrigerant vapours received from the evaporator through the suction line. The compressed high pressure and temperature refrigerant enters into condenser. Condenser :- The condenser is provided at the back side of the refrigerator. The condenser may be tube and wire type. The condenser tube are held vertically tight under wire from both side. The refrigerant condenses to high pressure liquid and looses its heat equivalent to latent heat. Capillary tube:- The condenser refrigerant gets accumulated in the receiver from where		

Scoring Indicators

Revision : 2015

Subject Code:6023 Verson:

Qs No	Scoring indicators	Split score	Total score
	it enters into capillary tube through the drier. The drier removes the moisture content. The diameter of the capillary tube is very narrow compare to liquid line and expansion takes place. The capillary tube is attached to the suction line ad heat exchanger. Evaporator:- The evaporator placed on the top portion of the inside cabinet. The low pre- liquid refrigerant absorbs heat from the refrigerated space and evaporates absorbing heat equivalent to its latent heat of vaporisation producing refrigerating effect.	fig 4 + exp 4	8
(b)			

Vapour compression system	Vapour absorption system
1. The system has compressor	1. The system has minimum number of moving parts.
2. High grade mechanical energy is supplied	2. Low grade heat energy is supplied
3. Cost for large tonnage system is more	3. Less costly
4. Maintenance cost is more	4. Comparatively less
5. Energy supplied is less	5. Energy supplied is more
6. Charging the refrigerant is quite simple	6. Charging of the system is difficult

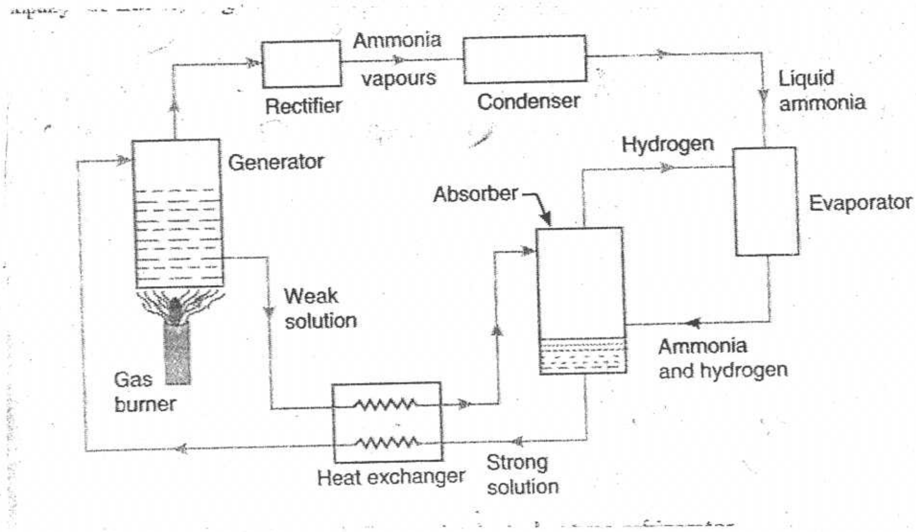
Split score: 1x6 — Total score: 6

Scoring Indicators

Revision : 2015

Subject Code:6023

Verson:

Qs No	Scoring indicators	Split score	Total score
VI (a)	 The Electrolux refrigerator is called three fluid absorption system. The main purpose of the system is to eliminate the pump. The three fluids are ammonia, hydrogen and water. The strong ammonia solution from the absorber through heat exchanger is heated in the generator by applying heat from an external source usually gas burner. During the heating process ammonia vapours are removed from the solution and passed to the condenser. A rectifier fitted before the condenser removes water vapour carried with the ammonia vapours. The hot weak solution left behind in the generator flow to the absorber through the heat exchanger and is cooled. The heat removed by the weak solution is utilised in raising the temperature of strong solution passed through the heat exchanger. The ammonia vapour in the condenser		

Scoring Indicators

Revision : 2015

Subject Code:6023 Verson:

Qs No	Scoring indicators	Split score	Total score
	are condensed by using external cooling source. The liquid refrigerant leaving the condenser flows under gravity to the evaporator where it meets the hydrogen gas. The hydrogen gas which is being fed to the evaporator permit the liquid ammonia to evaporates at a low pressure and temperature according to Dalton's principle. During the process of evaporation, the ammonia absorbs latent heat from the refrigerated space and thus producing cooling effect.	fig 5 + exp 3	8
(b)	~~natural convection Evaporators~~ 1) Natural convection evaporators are used where low air velocity and minimum hydration of the product is desired, and forced convection evaporators the air is forced over the refrigerant coils and fins by electric motor 2) Natural convection evaporators are less efficient and forced convection evaporators are more efficient than natural convection evaporator. 3) In natural convection evaporator surface area of the coil is increased by providing fins. 4) Natural convection are used smaller application and forced convection are provided in large cabinets.		7

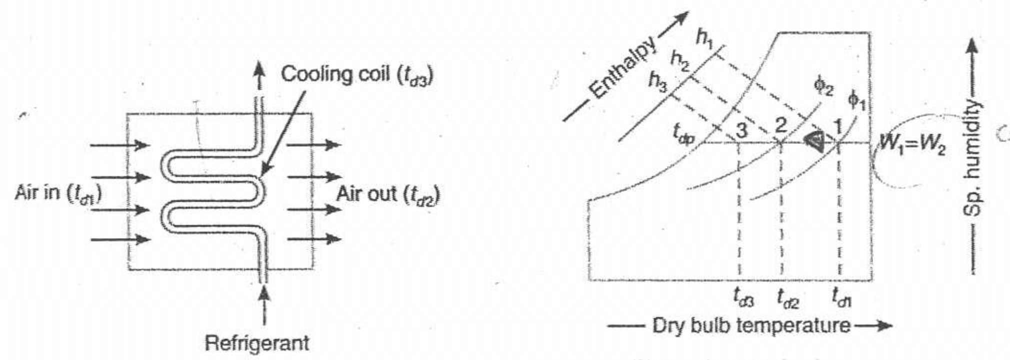
Scoring Indicators

Revision : 2015

Subject Code:6023

Verson:

Qs No	Scoring indicators	Split score	Total score
VII (a)	cooling coil.		



(*a*) Psychrometric process. (*b*) Psychrometric chart.

Fig. 16.17. Sensible cooling.

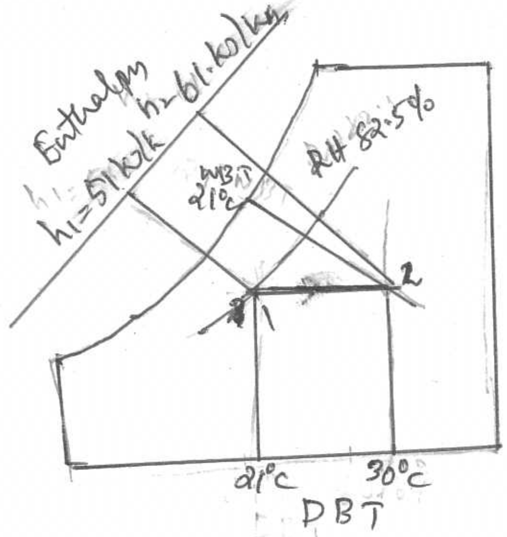
During sensible cooling air is passed over the cooling coils. Cooling coils may consists of refrigerant at low temperature or cooling water or cool gas flowing through them.

The process can be represented on the chart by horizontal straight line 1-2 extending from right to left. The air at temperature t_{d1}, passes over the cooling coil of temperature t_{d3}. The temperature of the air leaving the cooling coil is t_{d2} which is more than t_{d3}. Point 3 represents the surface temperature of the cooling coil.

The heat removed from air during sensible cooling may be obtained from the enthalpy scale of Psychrometric chart as $h_1 - h_2$. The specific humidity remains constant during this process i.e $\omega_2 = \omega_1$

Revision : 2015

Subject Code:6023 Verson:

Qs No	Scoring indicators	Split score	Total score
	The dry bulb temperature decreases from td_1 to td_2 and RH increases from ϕ_1 to ϕ_2. The amount of heat rejected during sensible cooling may also be calculated from the equation $h = h_1 - h_2 = 1.022(td_1 - td_2)$ kJ/kg.	fig 3 + exp - 5	8
(b)		fig. 3	
	Locate DBT and WBT on the psychrometric chart.. From the chart final RH = 82.5% DPT = 17°C	2	
	h_2 = 61 kJ/kg of dry air h_1 = 51 kJ/kg of dry air Change in enthalpy = $h_2 - h_1$ = 61 − 51 = 10 kJ/kg of dry air	2	7

Scoring Indicators

Revision : 2015

Subject Code:6023

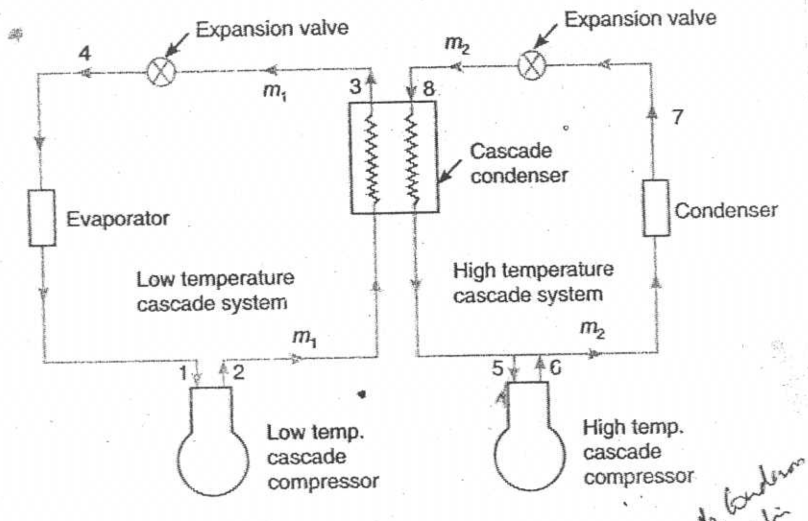
Verson:

Qs No	Scoring indicators	Split score	Total score
VIII			
(a)	(i) Specific humidity :- It is the mass of water vapour present in 1kg of dry air and is generally expressed in g/kg of dry air. It may also defined as the ratio of mass of water vapour to the mass of dry air in a given volume of the air vapour mixture.	2	
	(ii) Relative humidity :- It is the ratio of actual mass of water vapour in a given volume of moist air to the mass of water vapour in the same volume of saturated air at the same temperature and pressure.	2	
	(iii) Absolute humidity :- It is the mass of water vapour present in $1m^3$ of dry air. It is expressed in g/m^3.	2	
	(iv) Degree of saturation :- It is the ratio of actual mass of water vapour in a unit mass of dry air to the mass of water vapour in the same mass of dry air when it is saturated at the same temperature	2	8
(b)	The Cascade refrigeration system consists of two or more vapour compression refrigeration system in series which use refrigerants with progressively lower cooling temperature.		

Scoring Indicators

Revision : 2015

Subject Code:6023 Verson:

Qs No	Scoring indicators	Split score	Total score
		fig 4	

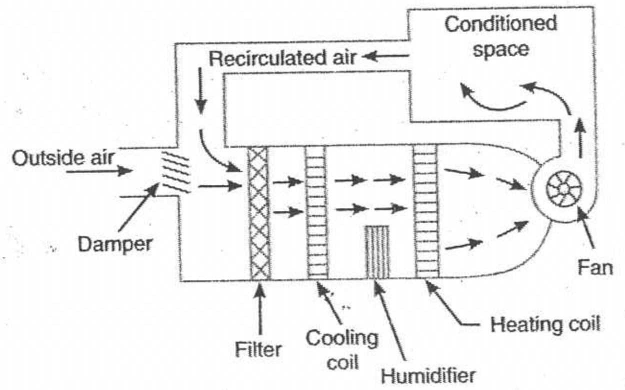
(*a*) Schematic diagram of a two stage cascade system.

In this system, a cascade condenser serves as an evaporator for the high temperature cascade system and a condenser for the low temperature cascade system. The only useful refrigerating effect is produced in the evaporator of the low temperature cascade system. The principal advantage of the cascade system is that it permits the use of two different refrigerants. The high temperature cascade system uses a refrigerant with high boiling temperature such as R-12 or R-22. The low temperature cascade system uses a refrigerant with low boiling temperature such as R-13 or R-13B1. These low boiling temperature refrigerants have extremely high pressure which ensures a smaller compressor displacement in the low temperature cascade system and is higher coefficient of performance

Split score	Total score
ex-p 3	7

Revision : 2015

Subject Code:6023 Verson:

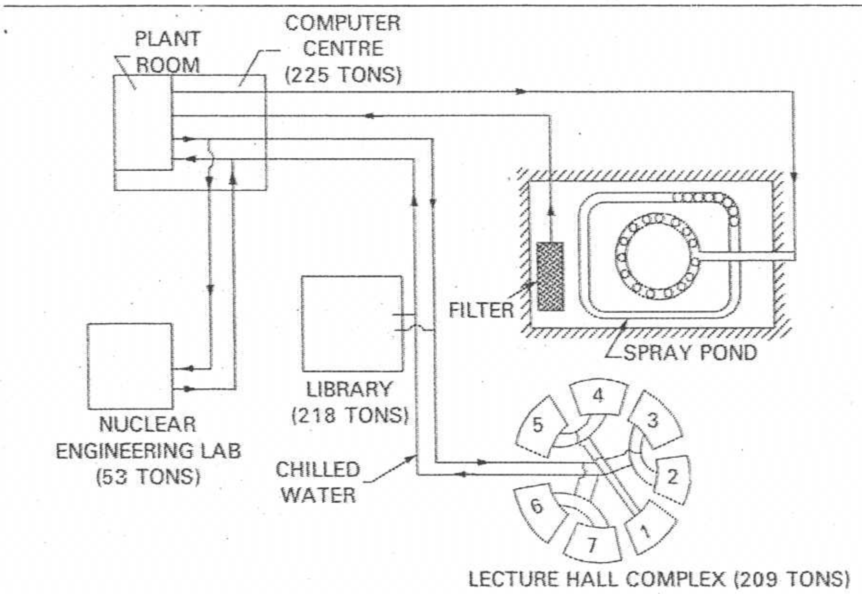
Qs No	Scoring indicators	Split score	Total score
IX (a)	The year round air conditioning system should have equipment for both the summer and winter air conditioning.  Fig. 18.9. Year-round air conditioning system.	fig - 4	
	The outside air flows through the damper and mixes up with the recirculated air (which is obtained from the conditioned space) The mixed air passes through a filter to remove dirt, dust and other impurities. In summer air conditioning, the cooling coil operates to cool the air to desired value. The humidification is obtained by operating the cooling coil at a temperature lower than the dew point temperature. In winter, the cooling coil is made inoperative and the heating coil operates to heat the air. The spray type humidifier is also made use in the dry season to humidify the air	exp - 4	8
(b)	The total quantity of heat required to be removed from the space to be kept at		

Scoring Indicators

Revision : 2015

Subject Code:6023

Verson:

Qs No	Scoring indicators	Split score	Total score
	desired temperature by the refrigerating and air conditioning equipment is known as cooling load	3	
	Components of a cooling load are (i) Sensible heat gain :- When there is direct addition of heat into the air conditioned space by any one or all the modes of heat transfer conduction convection or radiation. (ii) Latent heat gain:- when there is an addition of water vapour to the air in the enclosed space. The heat is to be removed during the process of summer air conditioning system	4	7
X (a)	 **Fig. 13.6** *Central Air Conditioning System of an Academic Institution* Central plants are universally employed in most of the air conditioning system		

Scoring Indicators

Revision : 2015

Subject Code:6023 Verson:

Qs No	Scoring indicators	Split score	Total score
	The central air conditioning system is adopted when the equipment capacity is more than 25 tons. The system consists of the compressor, condenser evaporator along with pumps, control panels are assembled and installed at one place called plant room. As the central plants are used for large cooling capacities, the condensers used for them are water cooled. The heat carried by water during its circulation through the condenser is rejected in the cooling tower. The cooling tower which is used to cool the condenser water is installed on the roof. The conditioned air is supplied to different rooms or halls through ducts or grills with individual control.		
(b)	~~1 According to~~ Air conditioning systems are broadly classified as 1. According to the function a. Comfort AC system b. Industrial AC. System	2	

Scoring Indicators

Revision : 2015

Subject Code:6023

Verson:

Qs No	Scoring indicators	Split score	Total score
	(2) According to the season (a) Winter AC system (b) Summer AC system (c) Year-round AC system	3	
	(3) According to the arrangement of equipment (i) Unitary AC system (ii) Central AC system	2	7