SCHEME OF VALUATION

(Scoring Indicators)

Revision: 2015 Course code: 6023

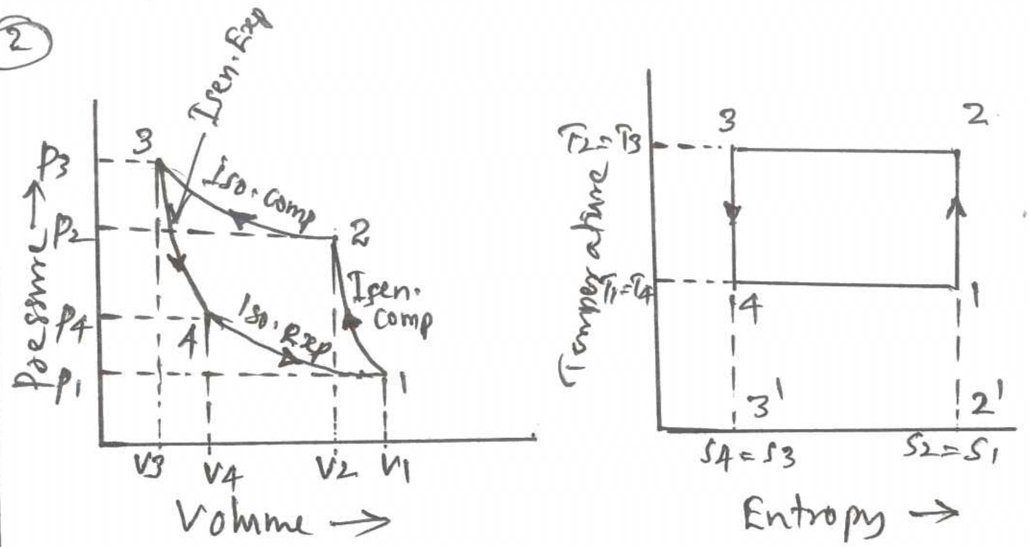
Course Title: Refrigeration & Air conditioning

Qst. No	Scoring Indicator	Split up score	Sub total	Total
	PART - A			
I	(1) A tone of refrigeration is defined as the amount of refrigeration effect produced by the uniform melting of one ton (1000kg) of ice from and at 0°C in 24 hours	2	2	
	(2) Coefficient of Performance of a refrigerating machine is the ratio of heat extracted in the refrigerator to the workdone on the refrigerant	2	2	
	(3) The refrigerants which directly take part in the refrigeration system are called primary refrigerant where as the refrigerants which are first cooled by primary refrigerants and then used for cooling purposes, are known as secondary refrigerants.	2	2	
	(4) The psychrometry is that branch of engineering science, which deals with the study of moist air.	2	2	
	(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 interconnected	2	2	10

Revision: 2015

Course Title: R&AC

Course code: 6023

Qst. No	Scoring Indicator	Split up score	Sub total	Total
	PART–B			
II	1) Ice refrigeration Dry ice refrigeration Evaporation refrigeration Refrigeration by expansion of air Steam jet water refrigeration Vapour compression refrigeration Vapour absorption refrigeration Liquid nitrogen refrigeration	6x1	6	
	2) 	1		
	A reversed Carnot cycle, using air as working medium. On p-v and TS diagrams At point 1, let p1, v1, T1 be the pressure volume and temperature of air respectively 1. Isentropic compression process : The air is compressed as shown by the curve 1-2 on p-v and T-s diagrams. During the process			

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	the pressure of air increases from P_1 to P_2 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 2. Isothermal compression process:- The air is now compressed isothermally as shown by the curve 2-3 on p-v and T-s-diagrams During the process, the pressure of air increases from p_2 to P_3, and sp. volume decreases from V_2 to V_3, heat rejected by the air during isothermal compression /kg of air. q_{2-3} = area 2-3-3'-2' $= T_3(s_2 - s_1) = T_2(s - s_3)$ 3) Isentropic expansion process : The air is now expanded isentropically as shown by 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 process no heat is absorbed or rejected by the air 4) Isentropic expansion process:- The air is now expanded isothermally as shown by the curve 4-1 on p-v and T-s diagrams			

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	The pressure of air decreases from P_4 to P_1, and specific volume increases from V_4 to V_1, isothermal expansion/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/kg of air = Heat rejected − Heat absorbed $= q_{2-3} - q_{4-1}$ $= T_2(s_2 - s_3) - T_1(s_2 - s_3)$ $= (T_2 - T_1)(s_2 - s_3)$ $COP = \frac{\text{Heat absorbed}}{\text{workdone}} = \frac{q_{4-1}}{q_{2-3} - q_{4-1}}$ $= \frac{T_1(s_2 - s_3)}{(T_2 - T_1)(s_2 - s_3)} = \frac{T_1}{T_2 - T_1}$	5	6	6
	3) Low boiling point, High critical temperature, High latent heat of vaporisation Non-flammable and non-explosive Non-toxic Low cost Low sp. heat of liquid Low sp. volume of vapour.	1x6=	6	6

(5)

Revision:	Course code:			
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Qst. No	Scoring Indicator	Split up score	Sub total	Total
5)	Dairy refrigeration is gaining popularity for preservation of dairy products like, milk butter etc in good condition for longer period. Milk preservation includes, blending, processing, packaging and destribution to the customers. This milk is usually mixed, processed and then blended to produce a milk of uniform quality of required fat percentage. After collection of milk from different sources, the first main step is "pasteurisation" in the milk preservation. All pathonic type of bacteria and nearly all other objectionable organisms are killed by proper pasteurization. Batch pasteurization is completed by filling a large container almost full with raw milk which is heated upto 62°C and hold for 30 minutes. The heating is carried out by hot water or steam from its outer surface. Then the milk is drawn from the container and the hot milk coming out is cooled to 4.4°C with the help of chilled water or direct refrigerant before filling the bottle. There after milk is			

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Qst. No	Scoring Indicator	Split up score	Sub total	Total
	distributed using suitable ~~trans~~ transportation. This process of heating and immediately cooling the milk controlling the bacteria growth is known as "pasteurization".	6	6	6
5	a) DPT : It is the temperature of air recorded by a thermometer, when the moisture present in it begins to condensate. b) WBT :- It is the temperature of air recorded by a thermometer, when its bulb is surrounded by a wet cloth exposed to the air c) RH :- 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.	3x2	6	6
6	Cryogenics is defined as a science that deals with how very low temperature (-100°c to -273°c) are produced and how they affect other things	2		
	Application 1. Space technology applications like rocket propulsion & space simulation chambers 2. Medical applications like - Food preservation, Cryo surgery & cell preservation			

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(7)

(Scoring Indicators)

Revision: Course Title:	Course code:			
Qst. No	**Scoring Indicator**	**Split up score**	**Sub total**	**Total**
	(3) Gas Idustry like. Liquifaction of gases, and separation of gases (4) High energy physics ie, ITER & CERN	4x1. =4	6	6
	(7) Effective temperature Heat production and regulation in human body Heat and moist losses from human body Moist content of air Quality and quantity of air Air motion Hot and cold surfaces	6x1 =6	6	6
	PART C			
III	a) 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 / ton on refrigeration is quite low 4. This system is used in air crafts	4x1 =4		
	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.	3x1 =3	7	

SCHEME OF VALUATION

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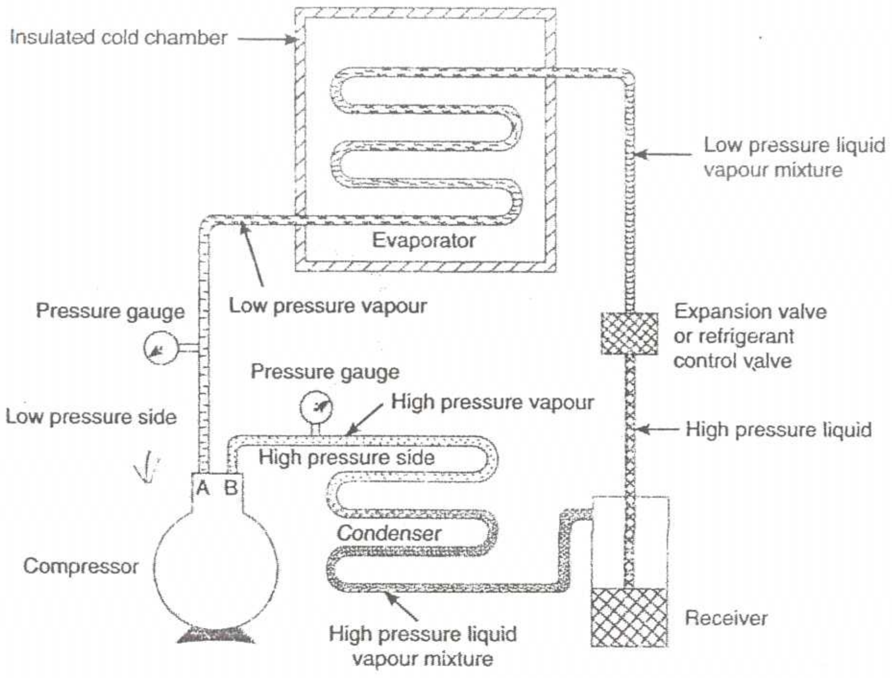
Course Title:

Qst. No	Scoring Indicator	Split up score	Sub total	Total
III (b)	$T_1 = -5 + 273 = 268^\circ K$, $P_1 = 1.03$ bar $T_3 = 15 + 273 = 288^\circ K$, $P_2 = 5.25$ bar $C_p = 1.004$ kJ/kg°K , $C_v = 0.717$ kJ/kg°K $\gamma = \frac{C_p}{C_v} = \frac{1.004}{0.717} = 1.4$ $\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} = \left(\frac{5.25}{1.03}\right)^{\frac{1.4-1}{1.4}} = 1.6$ where r_p is the ratio of pressures $T_2 = 268 \times 1.6 = 429^\circ K$			
	$\frac{T_3}{T_4} = r_p^{\frac{\gamma-1}{\gamma}} = 1.6$ $T_4 = \frac{288}{1.6} = 180^\circ K$	2		
	$COP = \frac{T_4}{T_3 - T_4} = \frac{180}{288 - 180} = 1.67$	2		
	Refrigeration effect of air $= C_p(T_1 - T_4)$ $= 1.004(268 - 180) = 88.352$ kJ/kg	2		
	$COP = \frac{\text{Refrigeration effect}}{\text{work done}}$ $\therefore$ workdone $= \frac{\text{Refrigeration effect}}{COP}$ $= \frac{88.352}{1.67} = 53$ kJ/kg	2	8	15

Revision:		Course code:		
Course Title:				
Qst No	Scoring Indicator	Split up score	Sub total	Total
IV	(b)  Fig. 4.1. Simple vapour compression refrigeration system.	3		
	A simple vapour compression systems consists of 1. Compressor :- The pressure and temperature vapour refrigerant from the evaporator is drawn into the compressor through the inlet or suction valve A, where its compressed to a high pressure and temperature. This high pressure and temperature vapour refrigerant is discharged into the condenser through the delivery valve or discharge valve B. 2. Condenser :- The condenser or cooler 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 medium which is normally air or water			

SCHEME OF VALUATION

(Scoring Indicators)

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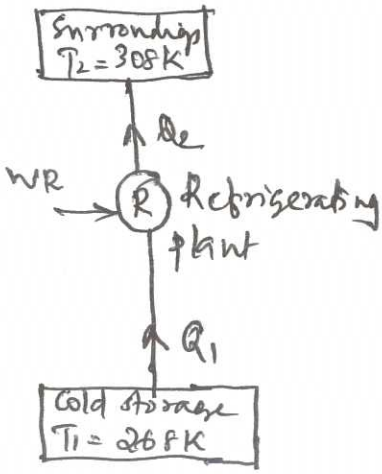
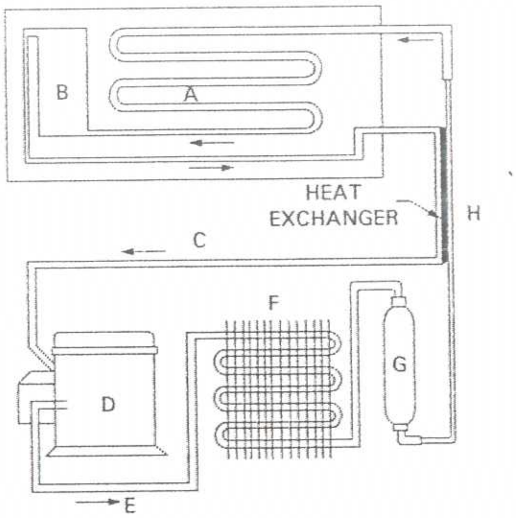
Qst. No	Scoring Indicator	Split up score	Sub total	Total
	3. Receiver:- The condensed liquid refrigerant from the condenser is stored in a vessel known as receiver from where it is supplied to the evaporator through the expansion valve or control valve 4. Expansion valve:- The function of expansion valve is to allow the liquid refrigerant under high pressure and temperature to pass at a controlled rate after reducing its pressure and temperature 5. Evaporator:- An evaporator consists of coils of pipe in which the liquid vapour refrigerant at low pressure and temperature is evaporated and changed into vapour refrigerant at low pressure and temperature. In evaporating, the liquid vapour refrigerant absorbs its latent heat of vaporisation from which is to cooled.	4	7	
IV	b) $T_1 = -5^\circ C = -5+273 = 268K$ $T_2 = 35^\circ C = 35+273 = 308K$ $Q_1 = 29\ kW$  $COP_{actual} = \frac{1}{3} COP_{ideal}$ $COP_{actual} = \frac{T_1}{T_2 - T_1} = \frac{268}{308-268} = 6.7$	2 2		

Revision: Course Title:		Course code:		
Qst. No	Scoring Indicator	Split up score	Sub total	Total
	$COP_{actual} = \frac{1}{3} COP_{ideal} = \frac{1}{3} \times 6.7 = 2.233$	2		
	$COP_{actual} = \frac{Q_1}{W_R}$ $\therefore W_R = \frac{Q_1}{COP_{actual}} = \frac{29}{2.233}$ $= 12.987$ kW	2	8	15
	UNIT – II			
V	a) Strainer :- It is a filter device that uses a perforated screen or basket to remove larger particles from a process stream	2		
	Drier :- It is a device containing desiccant, placed in the refrigerant circuit to remove moisture from refrigerant. It is usually placed in the liquid line. The desiccant remove moisture from solid, liquid or vapour.	2		
	Muffler :- Most refrigeration systems requires muffler to reduce noise due to gas propulsion in compressor and discharge line. The function of a discharge line muffler to reduce noise in the discharge line of refrigeration and air conditioning system.	3	7	

Revision: Course Title:		Course code:		
Qst. No	Scoring Indicator	Split up score	Sub total	Total
V b)	 A= EVAPORATOR, B= ACCUMULATOR, C= SUCTION LINE, D= COMPRESSOR, E= DISCHARGE LINE, F= CONDENSOR, G= DRIER CUMFILTER, H= CAPILLARY TUBE **Fig. 9.1**	4		
	The domestic refrigerator works on vapour compression cycle. Mainly consists of 1) Compressor :- A hermitically sealed rotary compressor is placed in the cabinet base. The refrigerant widely used in the domestic refrigerator is R-12. The Compressor compress the refrigerant vapours received from the evaporator through suction line. The compressed high pressure and temperature refrigerant enters into the condenser. 2) Condenser : The condenser is provided at the back side of the refrigerator. The condenser may be tube and wire type. The condenser tubes are held vertically tight under wire from both sides. The wires act as a heat transfer medium			

SCHEME OF VALUATION

(Scoring Indicators)

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Qst. No	Scoring Indicator	Split up score	Sub total	Total
	3) capillary tube :- The condensed refrigerant gets accumulated in a receiver from where it enters into capillary tube through the drier. The drier removes the moisture content it any present in the refrigerant capillary tube. The dia of the capillary tube is very narrow compare to liquid line and there fore expansion takes place 4) Evaporator :- The evaporator is placed on the top portion of inside cabinet. The low pressure liquid refrigerant absorbs heat from the refrigerant space and evaporates absorbining heat ~~equals~~ equivalent to its latent heat of vapourisation producing refrigerating effect. The evaporator coils can produce low temperature upto $-15^{\circ}c$. The refrigerant vapour is drawn through the suction line back to compressor. The accumulator placed between suction line and evaporator collects liquid refrigerant if any present and prevents liquid refrigerant entering into the compressor. The cycle gets repeated again and again	4	8	15

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Course Title:				
Qst. No	Scoring Indicator	Split up score	Sub total	Total
VI	a)			

Vapour Compression system	Vapour absorption systems
1. The systems has a compressor	1. The systems has minimum number of moving parts like pumps and controls
2. High grade mechanical energy produced	2. Low grade heat energy is supplied to the systems
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. More energy supplied
6. Charging of refrigerant is quite simple	6. Charging of the system is difficult
7. The chances of refrigerant leakage is more	7. No chance for leakage of refrigerant

Split up score: 1×7 = 7; Sub total: 7

b) The thermostatic expansion valve consists of a needle valve and a seat, a metallic diaphragm, spring and an adjusting screw. A feeler bulb or thermal bulb is mounted on the suction line near to the outlet of evaporator coil. The spring pressure acting on the bottom of the diaphragm and evaporator pressure acting on the bottom of the diaphragm.

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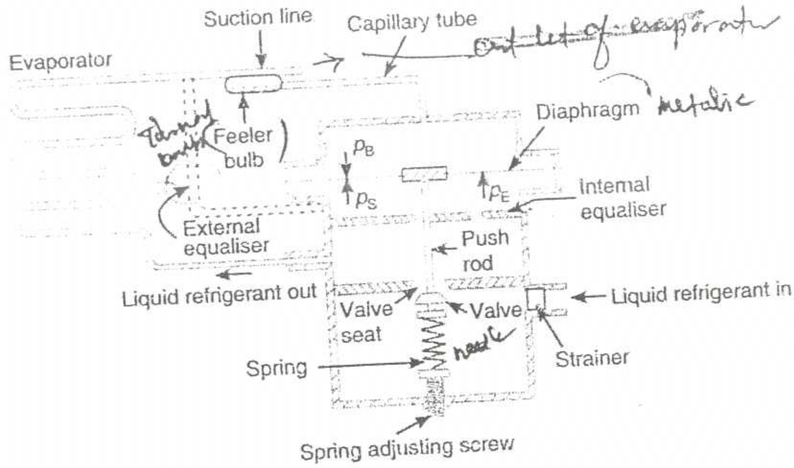
Revision: | Course code
Course Title:

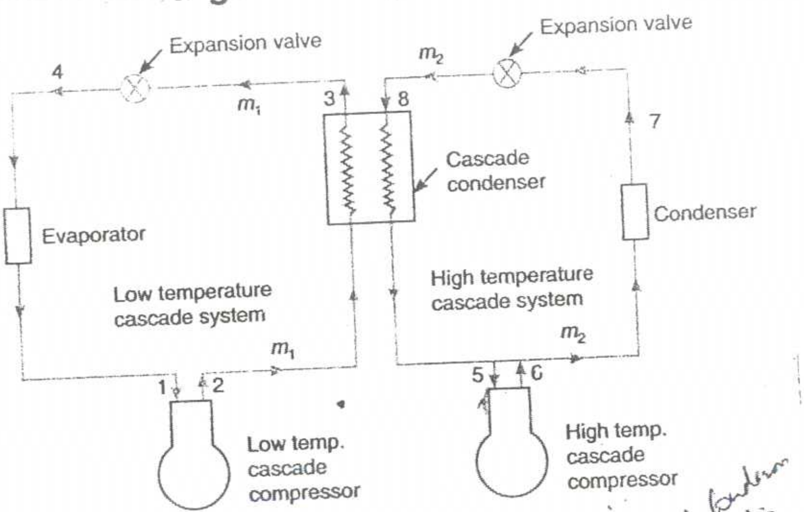
Qst No	Scoring Indicator	Split up score	Sub total	Total
	 Fig. 12.4. Thermostatic expansion valve.	4		
	When the cooling load increases, the refrigerant evaporates at a faster rate in the evaporator than the compressor can suck the refrigerant. Then the degree of superheat and its pressure in the bulb increases, it expands and transmits the pressure to the top of the diaphragm through capillary tube. This causes the valve to open more and admit more refrigerant into the evaporator When the cooling load decreases the refrigerant evaporates at slower rate, its pressure drops and its degree of super heat decreases. As the feeler bulb is cooled, the refrigerant contracts and it transmits less pressure on the diaphragm. This reduces the opening of the valve and thus flow of refrigerant into the evaporator. This continues till the spring pressure and evaporator pressure maintains equilibrium with feeler bulb temperature	4	8	15

Scoring Indicators

Revision : 2015

Subject Code:6023

Verson:

Qs No	Scoring indicators	Split score	Total score
VII	(a)  (a) Schematic diagram of a two stage cascade system.	fig 4	
	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	ex p. 3	7

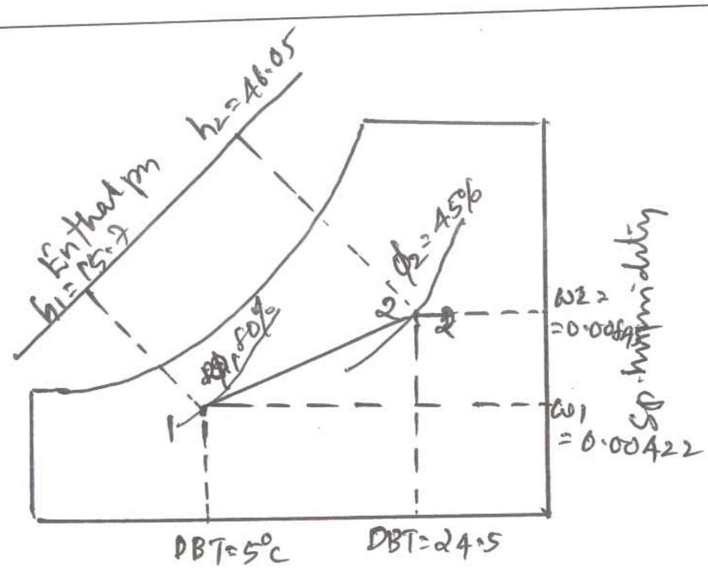
SCHEME OF VALUATION

(Scoring Indicators)

Course code:

Revision:

Course Title:

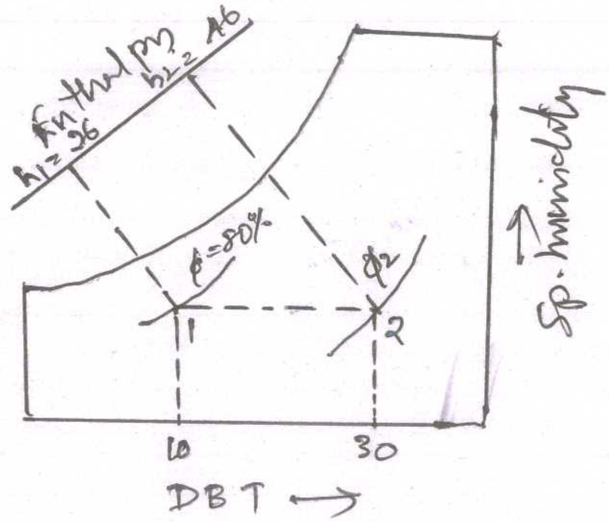
Qst. No	Scoring Indicator	Split up score	Sub total	Total
	b)  DBT →	4		
	from psychrometric chart $h_1 = 15.7$ kJ/kg of dry air $\omega_1 = 0.00425$ kJ/kg of dry air $h_2 = 46.05$ kJ/kg of dry air $\omega_2 = 0.00845$ kJ/kg of dry air Heating required $= h_1 - h_2 = (46.05 - 15.7)$ $= \underline{30.35}$ kJ/kg of dry air	2		
	Make up water required in water spray air washer $= (\omega_2 - \omega_1)$ $= 0.00845 - 0.00425$ $= \underline{0.0042}$ kg/kg of dry air	2	8	15

Scoring Indicators

Revision : 2015

Subject Code:6023

Verson:

Qs No	Scoring indicators	Split score	Total score
VIII	a) given $t_{d1} = 10°c$ $\phi = 80\%$ $V_1 = 150\ m^3/min$ $t_{d2} = 30°c$ $p = p_b = 1\ atm$ $= 1.013\ bar$ 	3	
	From the spsychrometric chart the relative humidity of air $\phi_2 = 23.5\%$ at point 1 sp. volume $V_s = 0.81\ m^3/kg$ of dry air enthalpy $h_1 = 26\ kJ/kg$ of dry air at point 2 enthalpy $h_2 = 46\ kJ/kg$ of dry air Amount of heat supplied $m_a = \frac{V_1}{V_{s1}} = \frac{150}{0.81}$ $= 185.2\ m^3/min$	2	
	∴ Rate of heat transfer $Q = m_a(h_2 - h_1)$ $= 185.2(46 - 26)$ $= 3704\ kJ/min$	2	7

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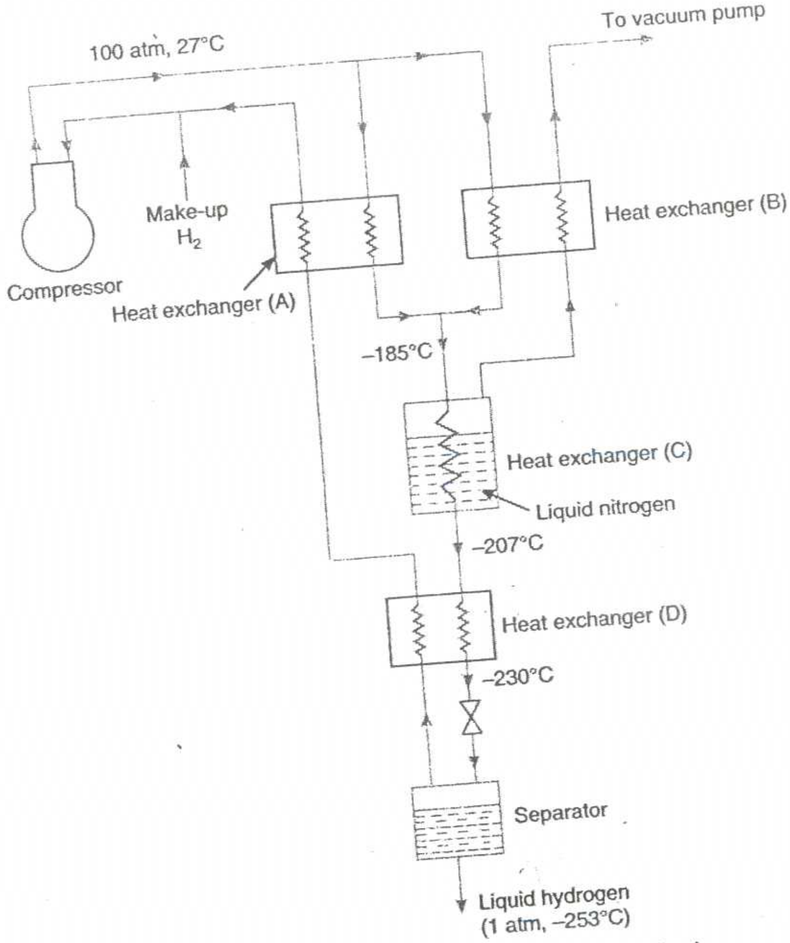
Qs No	Scoring indicators	Split score	Total score
VIII	b)  Fig. 14.17 Schematic diagram for hydrogen liquefaction.	5	
	The high pressure hydrogen gas from both the heat exchanger is passed through a third heat exchanger C where the hydrogen gas is further cooled to about −207°C by nitrogen boiling under reduced pressure. This hydrogen gas is further cooled to about −230°C in fourth heat exchanger D by the low pressure hydrogen gas returning from the seperator. The liquid hydrogen is produced by throttling the hydrogen gas from the heat exchanger D to atmospheric pressure	3	8

SCHEME OF VALUATION

(Scoring Indicators)

Course code:

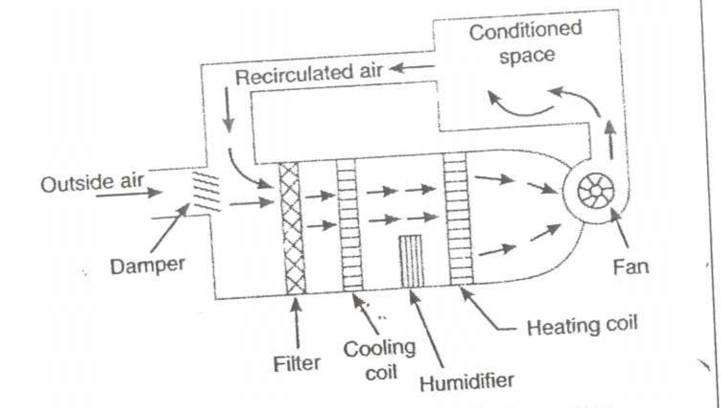
Revision:
Course Title:

Qst. No	Scoring Indicator	Split up score	Sub total	Total
IX	a) Effective temperature is a measure of feeling warmness or cold to human body upon comfort due to the combined effect of air temperature, moisture content and air motion. The effective temperature mainly depends on 1. Dry bulb temperature and wet bulb temperature 2. Relative humidity 3. Air motion The effective temperature can not be measured directly and it is to be evaluated with the combined effect of the above three factors It is defined as the index which correlates the combined effects of air temperature, relative humidity and air velocity. ET of 21.6°c which provides maximum comfort during summer and 20°c to provide same comfort feeling during winter.		7	7

Revision : 2015

Verson:

Subject Code:6023

Qs No	Scoring indicators	Split score	Total score
IX	b) The year round air conditioning system should have equipment for both the summer and winter air conditioning.	fig - 4	
	 Fig. 18.9. Year-round air conditioning system.		
	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	15
	c) [illegible]		

SCHEME OF VALUATION

(Scoring Indicators)

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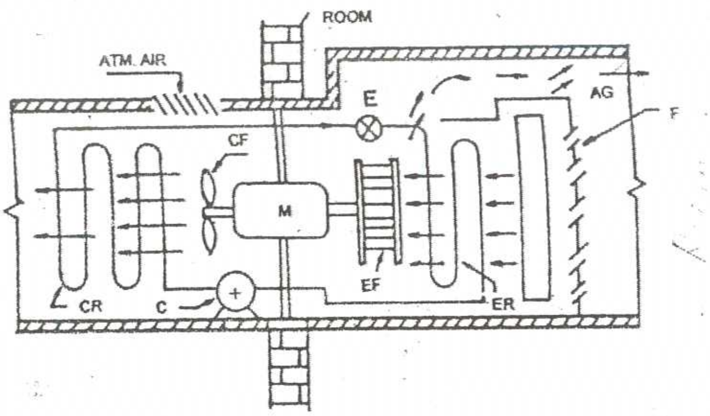
Revision: Course Title:		Course code:		
Qst. No	Scoring Indicator	Split up score	Sub total	Total
X.	(A) 1. Components of cooling load a. Sensible heat gain b. Latent heat gain 2. Heat flow due to conduction 3. Solar Radiation 4. Heat gain due to infiltration 5. Heat gain due to ventilation 6. Load from occupants 7. Heat gain from electrical appliances 8. Heat gain from products	7×1 =7	7	
	(b)  E. EXPN. VALUE ER : EVAPORATOR M : MOTOR CF : CONDENSER FAN EF : EVAPORATOR FAN F. FILTER G : GRILL AG : ADJUSTABLE GRILL C : COMPRESSOR CR : CONDENSER Fig. 11.2 WINDOW AIR CONDITIONER Window type air conditioner constructionally divided into two units ie one unit is indoor and other is out door.	5		

SCHEME OF VALUATION

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	Compressor, condenser, expansion valve and evaporator constitute a vapour compression systems. Expansion valve and evaporator are housed inside the room where as compressor and condenser are placed outside. A motor (M) drives both the fans, namely, a condenser fan (CF) and an evaporator fan (EF). Condenser fan is axial type while the evaporator fan is radial type flow. Evaporator fan draws warm air from the room through filter (F) and evaporator (ER). This air gets cooled while flowing over evaporator coils and is delivered back into the room through adjustable grill (AG) In the condenser circuit, the axial fan that sucks atmospheric air. It cools the refrigerant vapour circulating in the condenser coil (CR) and is discharged into the atmosphere. The atmospheric air act as cooling medium for condenser. The liquified cool refrigerant flows to evaporator and cools the warm air completing the thermodynamic cycle.	3	8	15

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