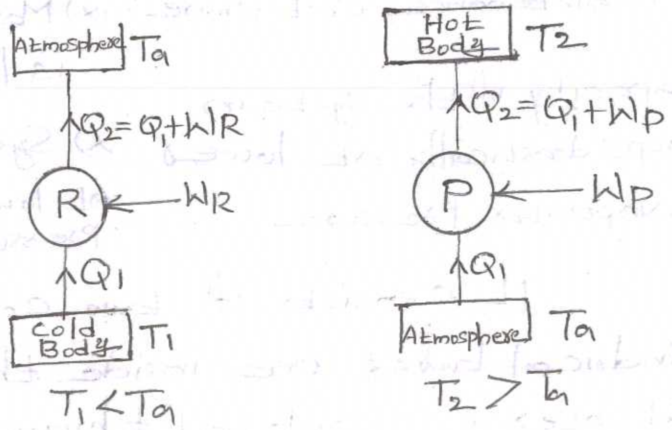
SCHEME OF VALUATION

(Scoring Indicators)

Revision - 2015

Course Code - 6023

Course Title - Refrigeration and Airconditioning

Qst No:	Scoring Indicator	Split up Score	Sub Total	Total
	PART-A			
I	1) The heat absorbed or rejected by a substance, which causes change of state (Phase change) with no change in temperature.	2		
	2) Trap liquid Particles if present in vapour refrigerant leaving the evaporator	2		10
	3) Refrigerants which do not take part directly in refrigeration system and absorbs heat in the form of sensible heat	2		
	4) Air which contains maximum amount of water vapour that it can hold at a Particular temperature.	2		
	5) i) comfort air conditioning ii) Industrial - air conditioning	2		
II	 Refrigerator Heat Pump	$1\frac{1}{2} + 1\frac{1}{2}$		

A refrigerator works between cold body temp. and Atmospheric temp and it's function is to maintain temperature of cold body lower than atmospheric temperature. 1½ 6

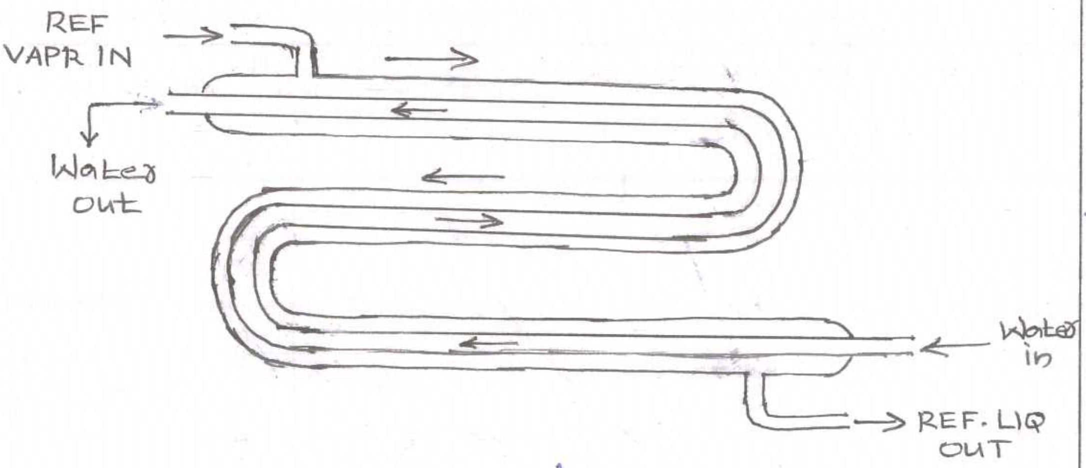
A heat pump works between Hot-body temp. and atmospheric temp. and its function is to maintain hot body temp. higher than atmospheric temperature. 1½

2)

Vapour Compression System	Vapour Absorption System
i) Work operated system	i) ~~Wo~~ Heat Operated System
ii) Compressor is required	ii) Compressor is not required
iii) Single fluid system	iii) multifluid system
iv) Charging is simple	iv) charging is difficult
v) Leakage tendancy is more	v) Less leakage tendancy
vi) Poor Part load performance	vi) Good Part load-Performance
vii) High COP	vii) Low COP
viii) System is compact	viii) System is Bulky
ix) Maintenance cost is more	ix) Maintenance cost is less.
x) Capacity of the system drops drastically at lower evaporator pressure	x) System can operate at lower evaporator pressure

1x6 6
Any six

3) It consists of two concentric cylindrical tubes one inside the other. Cold water is circulated through inner tubes while hot refrigerant flows in opposite



Double tube Condenser 3 6

direction to that of water in the space between inner and outer tubes. In this way certain air cooling effect is also obtained besides water cooling. 3

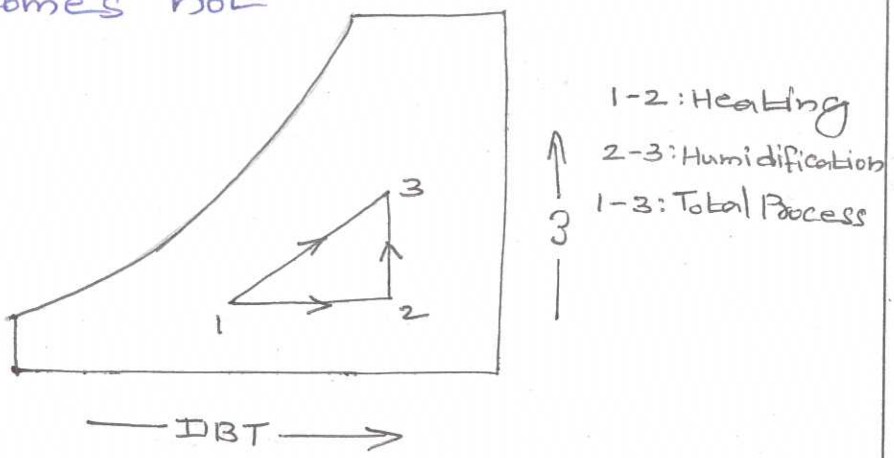
4) i. Dew Point temperature – It is the temperature of air recorded by a thermometer, when the moisture present in it begins to condense 2

ii) Absolute humidity – It is the mass of water vapour present in 1 m^3 of dry air, and is generally expressed in kg/m^3 of dry air. 2 6

iii) Relative humidity – It is the ratio of mass of water vapour present in ~~1m³ of~~ given volume of moist air to the mass of water ~~Vavou~~ vapour prent in same volume of saturated air, at same temperature. 2

5) Heating and humidification – Heating the air and adding moisture simultaneously is called Heating and humidification. This Process is generally used in winter air conditioning. It is done by passing air through a humidifier having spray water temperature higher than 3

the dry bulb temperature of the entering air, the unsaturated air will reach the condition of saturation and thus the air becomes hot. 6

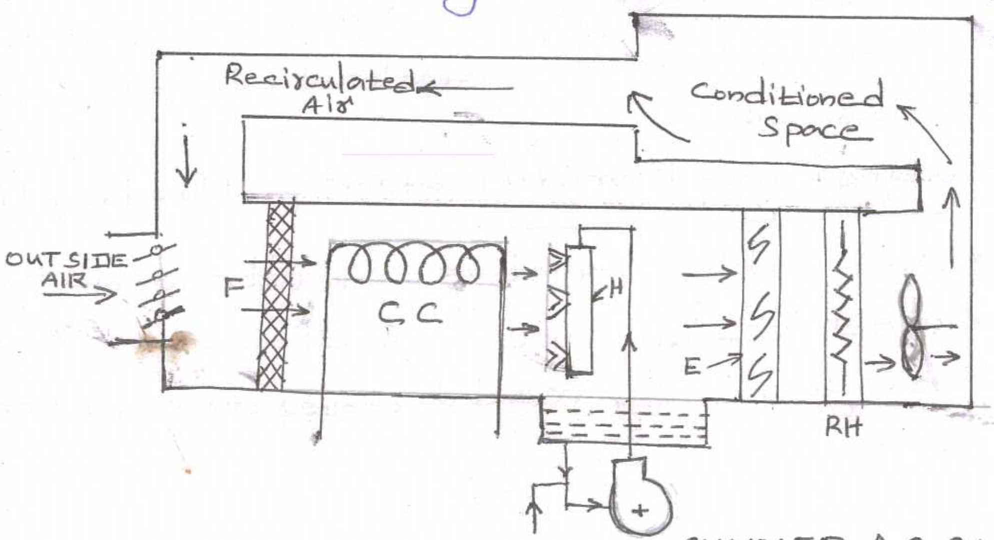


3

Heating & Humidification

6) i) Dry Bulb temperature
ii) Relative Humidity
iii) Air Velocity 1x6 6
iv) Quality and Quantity of air
v) Hot and Cold surfaces in conditioned space
vi) Air stratification
vii) Heat production and regulation in human body
viii) Heat and moisture losses from human body
(any six)

7) It involves cooling and dehumidification

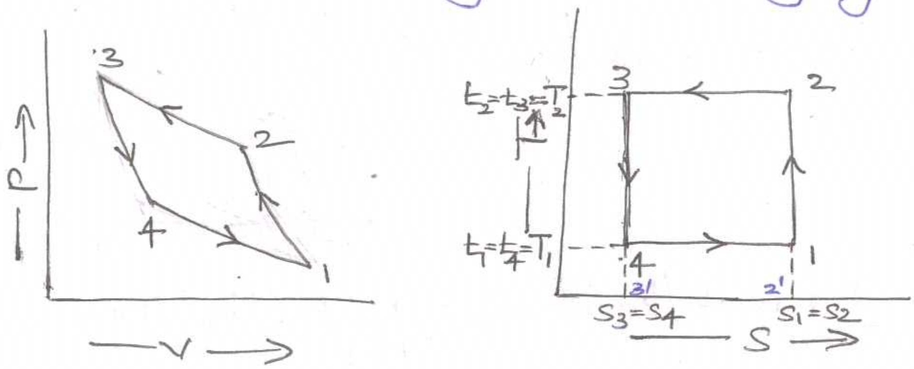


3

SUMMER A.C SYSTEM

Filtered outside atmosphere air is passed over a cooling coil, whose effective surface temperature is lower than dew point ~~tempe.~~ temperature of entering air. During this process air gets cooled and moisture in it is condensed thereby dehumidifying. 6 3

III a)



2 + 2

Isentropic Compression (1-2) - There is no heat transfer

Isothermal Compression (2-3) - Heat rejected/kg of air = Area 2-3-3'-2' 7

$= T_2(S_2-S_3)$

Isentropic expansion (3-4) - There is no heat transfer

Isothermal expansion (4-1 - Heat absorbed/kg of air = Area 1-4-3'-2' 3

$= T_1(S_1-S_4)$

$= T_1(S_2-S_3)$ $\because S_1=S_2$, $S_3=S_4$

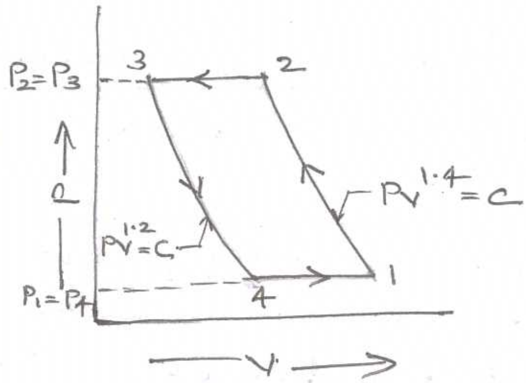
Work done/kg of air = Heat rejected - Heat absorbed

$= T_2(S_2-S_3) - T_1(S_2-S_3)$

$$COP = \frac{\text{Heat absorbed}}{\text{Work Done}} = \frac{T_1(S_2-S_3)}{T_2(S_2-S_3)-T_1(S_2-S_3)}$$

$$= \frac{T_1}{T_2-T_1}$$

where, T_1 = Lowest temp. in the cycle
T_2 = Highest temp. in the cycle.



$T_1 = -5°C$
$T_2 = 151.8°C$
$T_3 = 15°C$
$T_4 = -53°C$ 2

Compressor work /kg of air $= \frac{\gamma}{\gamma - 1} R (T_2 - T_1)$ 8

$= \frac{1.4}{0.4} \times 0.287 (151.8 - 5)$ 2

$= 157.5$ kJ/kg

Expander work /kg of air $= \frac{n}{n-1} R (T_3 - T_4)$

$= \frac{1.2}{0.2} \times 0.287 (15 + 53)$ 2

$= 117.1$ kJ/kg.

Network done/kg on the air = Compressor work − Expander work

$= 157.5 - 117.1$ 1

$= 40.4$ kJ/kg

$$COP = \frac{\text{Heat absorbed}}{\text{Net work Done}}$$ 1

$$= \frac{c_p (T_1 - T_4)}{40.4} = \frac{1(-5 + 53)}{40.4}$$

$$= \underline{1.18}$$

IV a) In Open air refrigeration cycle, the air is directly led to the space to be cooled, allowed to circulate ~~through the cooler~~ and sucked by the compressor. In this air comes in direct contact with the space to be cooled (ie, refrigerator) 2

In closed air refrigeration cycle, the air is passed through pipes and component parts of the system and the air does not come in direct contact with the space to be cooled. The air is used to absorb heat from other fluids like brine and cold brine is circulated through the space to be cooled. 2 7

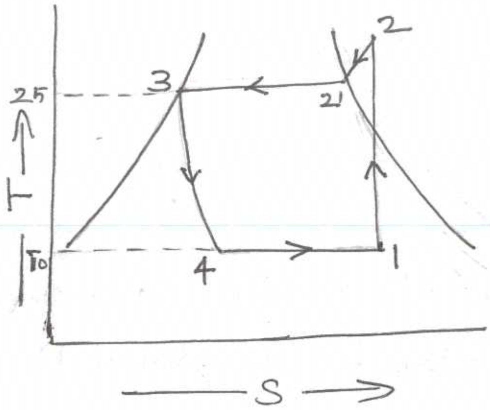
Advantages of closed ~~system~~ cycle over open cycle

i) The moisture is not carried by air

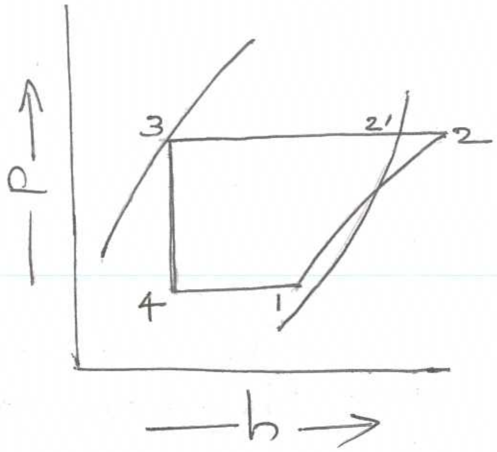
ii) Since it can work at a suction pressure higher than atmospheric, the volume of air handled by compressor and expander are less 3

iii) Operating pressure ratio is less and hence COP is higher

b)



T-s diagram.



p-h diagram

2 + 2

Heat absorbed $= h_1 - h_4$

$$h_1 - h_4 = (1433.05 - 135.37)(x_1 - x_4)$$ 2

$$= 1297.68 \times 0.87$$ 8

$$= 1129 \text{ kJ/kg}$$

$$h_2 = h_{2'} + (Cp_v \times 30)$$

$$= 1465.84 + (2.8 \times 30)$$ 1

$$= 1549.84 \text{ kJ/kg}$$

$h_{fg_1} = 1433.05 - 135.37$

$h_1 = h_{f_1} + (x_1 \times h_{fg_1})$

$= 135.37 + (0.97 \times 1297.68)$

$= 1394.12$ KJ/kg 1

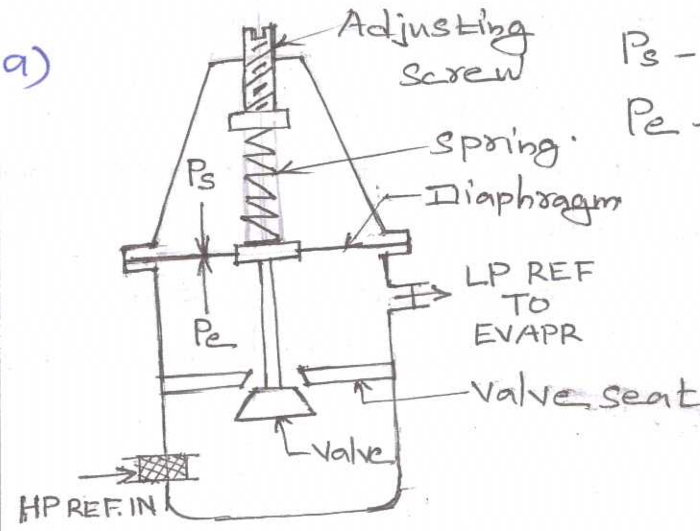
$$COP = \frac{h_1 - h_4}{h_2 - h_1}$$

$$= \frac{1129}{1549.84 - 1394.12}$$

$$= \frac{1129}{155.72}$$

$$= \underline{7.25}$$

V a)



Ps - Spring Pressure

Pe - Evaporator Pressure

4

Automatic expansion Valve 7

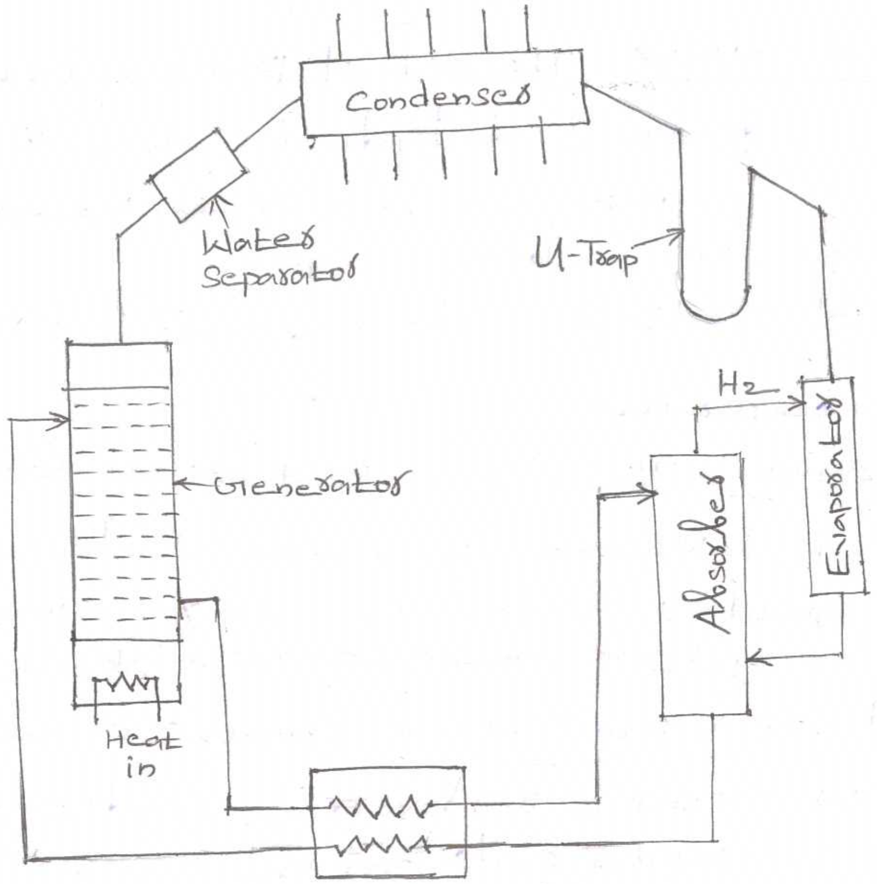
It maintains constant evaporator Pressure regardless of the load on the evaporator. The opening and closing of the valve depends upon the spring pr (Ps) and evaporator Pr. (Pe) When load on evaporator increases, evaporator Pr. reduces, the valve opens more till desired evaporator Pr. is reached. When load on the evaporator reduces, the evaporator Pr. increases and closes the valve more, till the desired evaporator Pr. is reached. 3

b) It employs vapour absorption refrigeration System with three fluids.

Ammonia as refrigerant

Water as absorbent and

Hydrogen as Pumping agent



Electrolux Refrigerator

4

Ammonia circuit - Refrigerant ammonia is circulated through generator & condenser only. Ammonia vapour generated in generator is condensed in condenser. The liquid ammonia and hydrogen enters evaporator and ammonia evaporates by absorbing heat. The mixture of ammonia vapour and hydrogen enters the absorber 4

Water circuit - Water separated out from ammonia vapour in separator flows down to generator and acts as absorbent and absorbs ammonia

Hydrogen circuit - Hydrogen is liberated from ~~condenser~~ absorber and enters the evaporator along with liquid ammonia and promotes evaporation of ammonia

8 15

VI

a) Freeze drying - The actual process during freeze drying is dehydration by sublimation and it is a modern food preservation method. It involves the following stages.

i) Initial freezing - The food stuff is freezed to a temperature of around $-60°c$ 1½

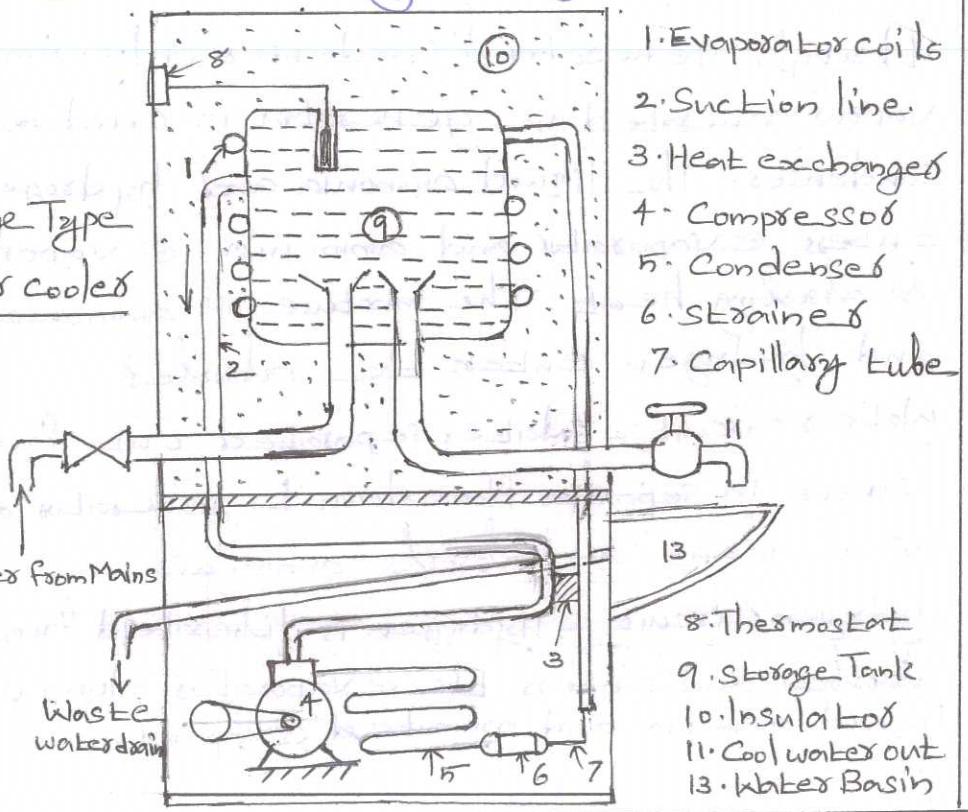
ii) Drying - The frozen Products are taken to a high vacuum drying chamber, where heat is supplied to remove ice crystals formed. The ice crystals directly changes to vapour 1½ 7

iii) Water vapour removal - Enormous amount of water vapour is removed by condensation using refrigerator coils and ice crystals formed are removed by heating with steam. 1½

iv) Storage and Packing - The packing is done either in vacuum or in presence of inert gases. Generally nitrogen is used. 1½

b)

Storage Type Water cooler



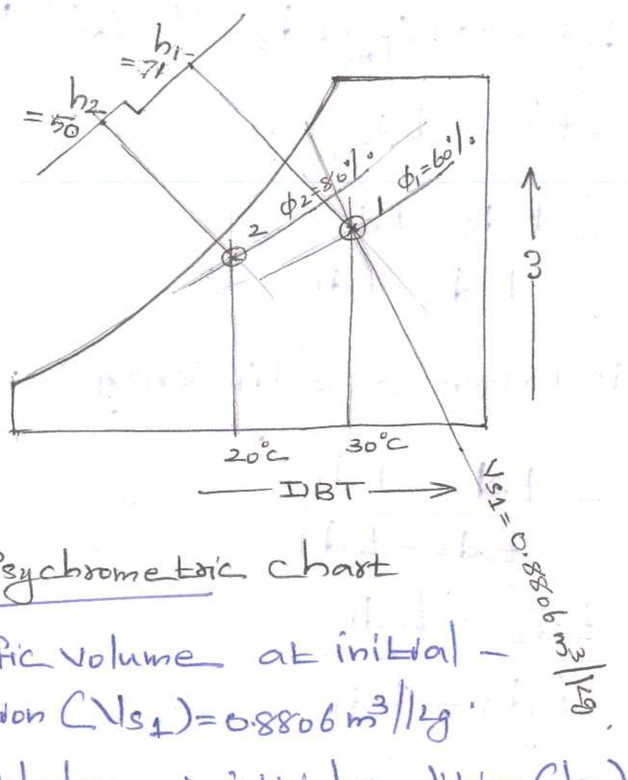
1. Evaporator coils
2. Suction line
3. Heat exchanger
4. Compressor
5. Condenser
6. Strainer
7. Capillary tube
8. Thermostat
9. Storage Tank
10. Insulator
11. Cool water out
13. Water Basin

4

It employs Vapour Compression refrigeration system and evaporator coil is wrapped around Storage tank. The refrigerant abstracts heat from water and evaporates. Water is cooled to about 7 to 13°c. The vapour refrigerant is then Sucked by compressor and compressed to high pr. and delivers it to air cooled condenser. Here vapour ref. is condensed to liquid and passes throug capillary tube through a strainer. In heat exchanger the refrigerant loses its heat to Suction vapour to compressor. In capillary tube the high pr. liquid ref. expands and low pr ~~va~~ liquid ref. circulates through evaporator coil 8

4

VII a)



2

From Psychrometric chart

Specific volume at initial condition (V_{s_1}) = $0.8806\ m^3/kg$. 1

Sp. enthalpy at initial condition (h_1) = 71 kJ/kg 1

Sp. enthalpy at final condition (h_2) = 50 kJ/kg. 1

Mass of air (m) = $\frac{120}{V_{s1}} = \frac{120}{0.8806} = 136.27$ kg/min 7

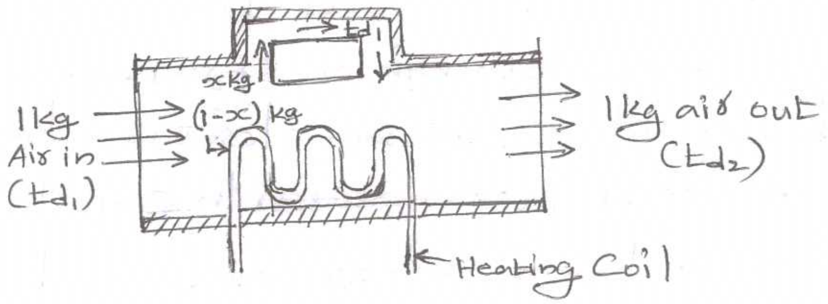
Ref. effect to be Produced = $m(h_1 - h_2)$

$= 136.27(71-50)$ 2

$= 2861.67$ kJ/min

$\therefore$ TR required = $\frac{2861.67}{210} = \underline{\underline{13.63 \text{ TR}}}$ | 1 TR = 210 kJ/min

b)



<u>By-Pass Factor</u> 3

15

Balancing enthalpies

$$x \cdot C_{p_m} \cdot td_1 + (1-x) C_{p_m} \cdot td_3 = 1 \times C_{p_m} \times td_2$$ 3 8

$$x(td_3 - td_1) = td_3 - td_2.$$

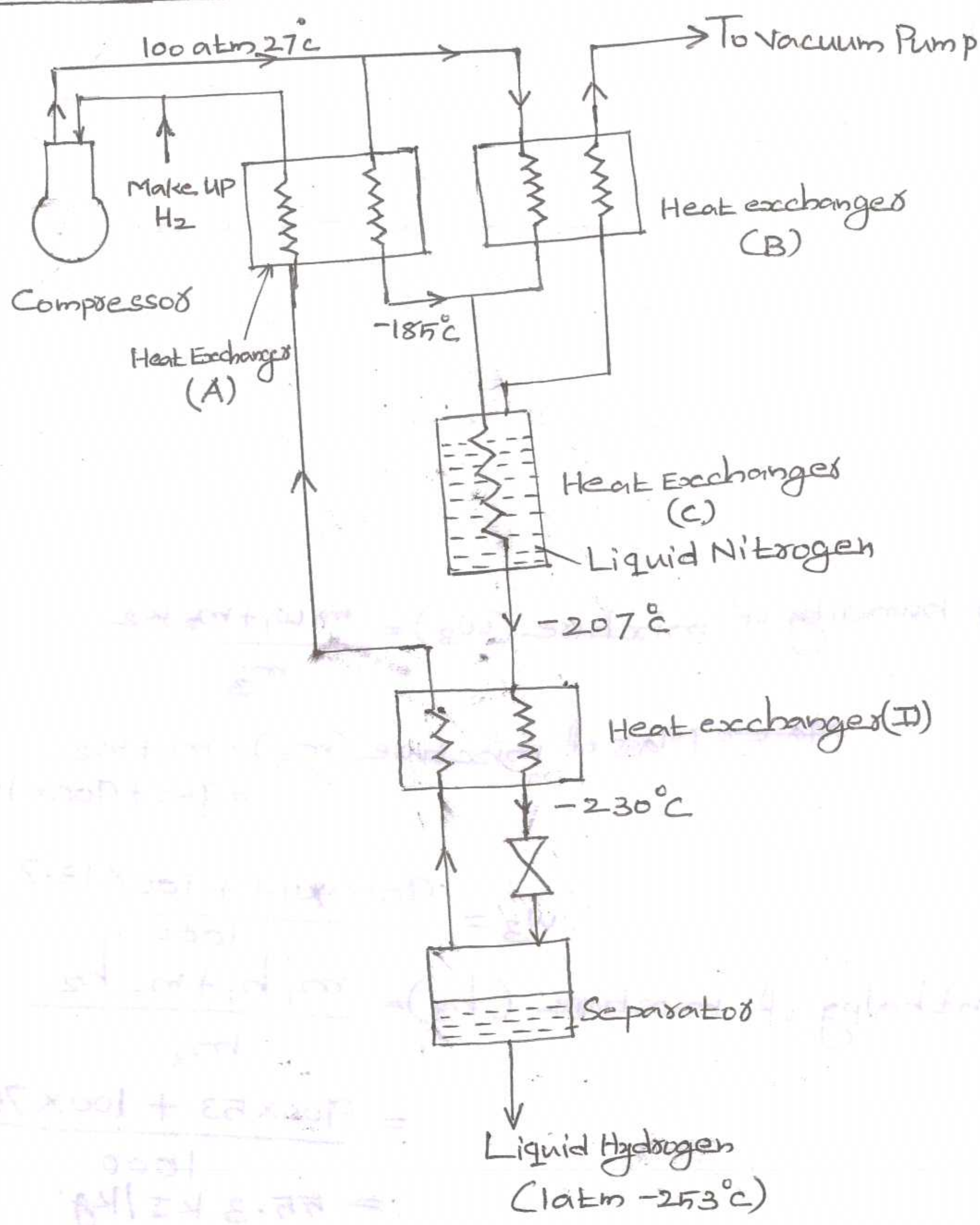
$$\text{BPF } (x) = \frac{td_3 - td_2}{td_3 - td_1}$$

1 − BPF is known as efficiency.

$$\eta_H = 1 - \frac{td_3 - td_2}{td_3 - td_1}$$ 2

$$= \frac{td_2 - td_1}{td_3 - td_1}$$

VIII a)



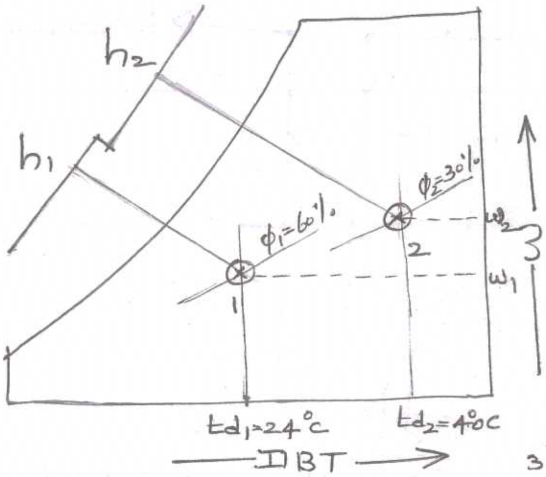
4

7

Hydrogen Liquefaction

Pure hydrogen gas at a pressure of 100 atm and 27°c from compressor is precooled in two heat exchangers A and B. In HEA, the (incoming) hydrogen is cooled by low pr. outgoing hydrogen and in HE(B) it is cooled by nitrogen. Then the ~~by~~ high pressure precooled hydrogen is is passed through HE(C) where it is further cooled to -207°c by liquid ~~nitr~~ nitrogen. The hydrogen is again cooled to -230°c in HE(D) by low pr. hydrogen returning from separator. The liquid hydrogen is produced by throttling hydrogen gas from HE(D) to atmospheric pressure. 3

b)



return air ①

Fresh air ②

From Psychrometric chart

1) Sp. humidity of return air $(\omega_1) = 11.1$ gm/kg

2) Specific enthalpy of return air $(h_1) = 53$ kJ/kg

3) Sp. humidity of fresh air $(\omega_2) = 13.7$ gm/kg

4) Sp. enthalpy of fresh air $(h_2) = 76$ kJ/kg

5) Sp. humidity of mixture $(\omega_3) = \dfrac{m_1\omega_1 + m_2\omega_2}{m_3}$

~~Mass~~ Mass of mixture $(m_3) = m_1 + m_2$

$= 900 + 100 = 1000$ kg/hr.

$\therefore \omega_3 = \dfrac{900 \times 11.1 + 100 \times 13.7}{1000} = 11.36$ gm/kg

6) Enthalpy of mixture $(h_3) = \dfrac{m_1 h_1 + m_2 h_2}{m_3}$

$= \dfrac{900 \times 53 + 100 \times 76}{1000}$

$= 55.3$ kJ/kg

Psycho. chart - 2
1x6 = 6 | 8 | 15

IX a) Room Volume $= 21 \times 11 \times 5 = 1155\ m^3$ | 1

Volume of fresh air infiltrated/hr $= 1155 \times 0.5$

$= 577.5\ m^3/hr$ | 1

Density of air $(\rho) = \dfrac{P}{RT}$

$= \dfrac{1.0132 \times 10^2}{0.287 \times 313} = 1.128\ kg/m^3$ | 2 | 7

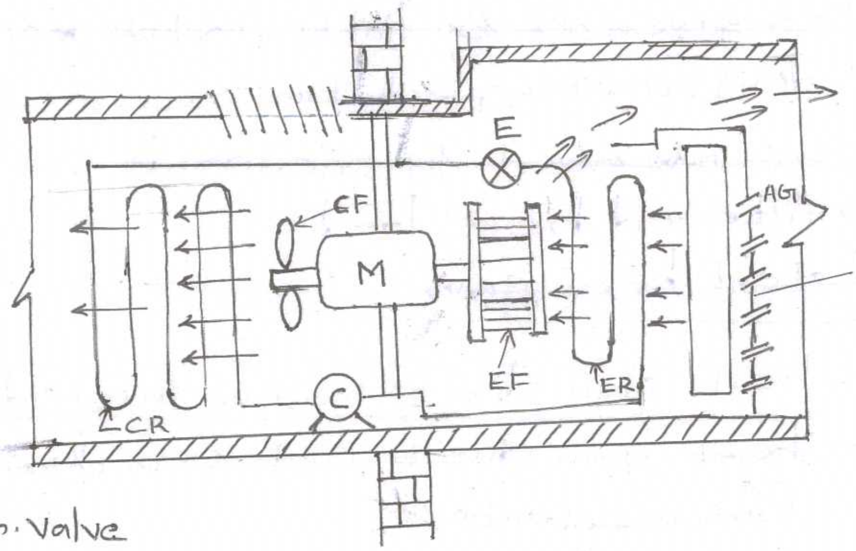
Mass of air infiltrated/hr (m_a) = Volume × Density

$= 577.5 \times 1.128 = 651.42$ kg/hr | 1½

Infiltrated heat load/hr $= m_a \times Cp_{air} \times \Delta t = 651.42 \times 1\ (40-20)$

$= 13028.4$ kJ/hr | 1½

b)



E - Expn. Valve
ER - Evaporator
M - Motor
CF - Condenser Fan
EF - Evaporator Fan
F - Filter
AG - Adjustable Grill
C - Compressor
CR - Condenser

Window Type Air Conditioner

It mainly consists of a vapour compression refrigeration system and is divided into two units. It is installed in window sill. The two units are indoor unit and outdoor unit. Expansion valve and evaporator of vapour ~~compre~~ compression system are housed inside the room where as compressor and condenser are placed outside. A motor drives both condenser and evaporator fan. Condenser fan is axial while evaporator fan is of radial type.

Evaporator fan draws warm air from room through filter and evaporator. This air gets cooled while flowing over evaporator coil and is delivered back into room through adjustable grill. The condenser fan sucks atmospheric air and forces over condenser. The air cools and ~~condenses~~ condenses the refrigerant vapour

4

8

4

X a) i. Sensible heat gain

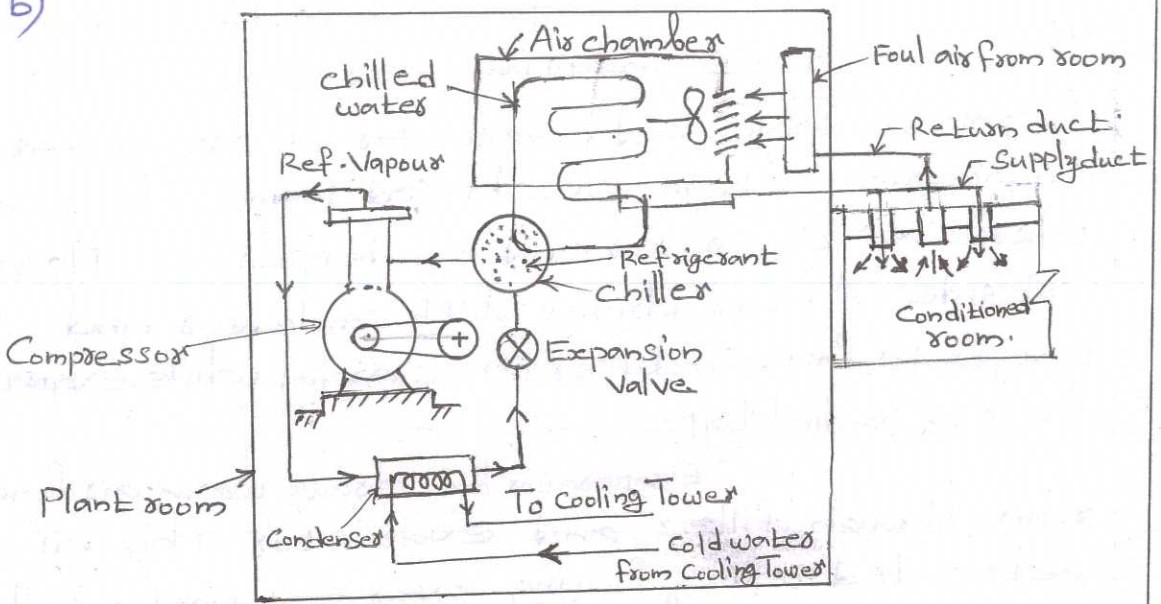
- By conduction through exterior walls, floors, ceiling, doors and windows.

- Heat received from solar radiation
- Heat given off by lights, motors, machinery, cooking operations, industrial process etc.
- Heat liberated by occupants
- Infiltrated heat load

ii) Latent heat gain

- heat gain due to moisture in outside air
- heat gain due to condensation of moisture from occupants
- heat gain due to condensation of moisture from any process such as cooking
- heat gain due to moisture passing directly into the conditioned space through permeable walls or partitions 7

b)



4

Central A.C System

All components of AC system are grouped together in Plant room. Conditioned air is distributed from Plant room to required places through ducts. This system is adopted for large capacity plants (25 TR and above) chiller is a cylindrical vessel in which cold refrigerant absorbs heat from water under circulation. Chilled water is then circulated through coils placed ~~in~~ in an air chamber. Foul air coming from other rooms is passed over these coils. chilled water absorbs heat from this air and cools it. Water return to chiller and cold air is ~~is~~ distributed to rooms to be conditioned

8

4