

the stages, the compression and expansion index is 1.25. Neglecting the effect of clearance, determine the minimum number of stages required.

- (b) Explain flood type evaporator with the help of a neat sketch.

6 + 6 = 12

Group – E

8. (a) 800 m³/min of recirculated air at 22°C DBT and 10°C dew point temperature is to be mixed with 300 m³/min of fresh air at 30°C DBT and 50% RH. Determine the enthalpy, specific volume, humidity ratio and dew point temperature of the mixture.

- (b) Write a short note on (i) degree of saturation (ii) bypass factor.

7 + 5 = 12

9. An air conditioned hall is to be maintained at 27°C dry bulb temperature and 21°C wet bulb temperature. It has a sensible heat load of 46.5 kW and latent heat load 17.5 kW. The air supplied from outside atmosphere at 38°C DBT and 27°C WBT is 25 m³/min, directly into the room through ventilation and infiltration. Outside air to be conditioned is passed through the cooling coil whose apparatus dew point is 13°C. The quantity of recirculated air from the hall is 60%. This quantity is mixed with the conditioned air after cooling coil. Determine (i) Condition of air after the coil and before the recirculated air mixes with it; (ii) Condition of air entering the hall, i.e after mixing with recirculated air; (iii) Mass of fresh air entering the cooler; (iv) By-pass factor of the coil; and (v) Refrigerating load on the cooling coil.

(2 + 2 + 3 + 2 + 3) = 12

REFRIGERATION & AIR CONDITIONING (MECH 3132)

Time Allotted : 3 hrs

Full Marks : 70

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A (Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**
- (i) Tetrafluoro ethane is the chemical name of which of these refrigerants?
(a) R-12 (b) R 22 (c) R-134a (d) R 11.
- (ii) Keeping the evaporator temperature constant, if the condenser temperature is increased, then,
(a) refrigerating effect decreases (b) compressor work increases
(c) both (a) & (b) (d) compressor work decreases.
- (iii) 70000 kJ/h heat removal is equivalent to
(a) 2 tonnes of refrigeration (b) 5 tonnes of refrigeration
(c) 2.5 tonnes of refrigeration (d) 7 tonnes of refrigeration.
- (iv) Name of R 717 refrigerant is
(a) water (b) carbon dioxide
(c) ammonia (d) none of these.
- (v) ODP of which of the following refrigerants is zero
(a) R-12 (b) R 22 (c) R-134a (d) R 11.
- (vi) If the pressure ratio in a reciprocating compressor becomes high, then,
(a) the volumetric efficiency drops (b) FAD increases
(c) FAD decreases (d) both (a) and (c).
- (vii) In aqua-ammonia and Li-Br water absorption refrigeration systems, the refrigerant are respectively
(a) water and water (b) water and Li-Br
(c) ammonia and Li-Br (d) ammonia and water.
- (viii) Flash gas production in VCR system
(a) reduces RE (b) increases RE
(c) increases evaporator size (d) both (a) & (c).

- (ix) Vapour absorption refrigeration system uses all the components used in VCR system except
 (a) condenser (b) evaporator
 (c) expansion device (d) compressor.
- (x) If Q_l and Q_s are the latent heat load and sensible heat load respectively, the Sensible Heat Factor is
 (a) $SHF = Q_l / (Q_l + Q_s)$ (b) $SHF = Q_s / (Q_l + Q_s)$
 (c) $SHF = 1 - (Q_s / Q_l)$ (d) $SHF = 1 + (Q_s / Q_l)$.

Group – B

2. (a) Mention six important properties of refrigerant and explain why they are important.
 (b) The following results were obtained in a test conducted on a vapour compression refrigerator:
 Evaporator temperature = -28°C, condenser pressure = 2.75 bar, refrigerant entering the compressor is superheated by 3°C, refrigerant leaving the condenser is at 12.8°C.
 Determine the C.O.P. of the system. The properties of the refrigerant is given below:

Pressure (bar)	Sat. Temp. (°C)	Enthalpy (kJ/kg)		Entropy (vapour) (kJ/kg-K)	Sp. Heat	
		Liquid	vapour		Liquid	Vapour
2.75	14	438.48	802.9	5.5287	1.381	0.669
0.412	-28	381.58	783.24	5.6852	-	-

4 + 8 = 12

3. An ammonia vapour compression refrigeration plant has two stages of compression and one evaporator. After leaving the condenser at 11.666 bar as saturated liquid without under cooling it passes the first throttle valve from which it emerges at 4.975 bar to enter a flash chamber. The liquid from flash chamber is then throttled to 2.909 bar and passes to the evaporator while the dry saturated vapour is passed to a receiver connecting the L.P and H.P cylinders. Determine (i) the amount of vapour-bled off at the flash chamber and (ii) the COP. Draw p-h diagram of the cycle.

Properties of ammonia:

Pressure (bar)	Temperature (°C)	Enthalpy(kJ/kg)		Entropy (kJ/kgK)		c_p (kJ/kgK)
		h_f	h_g	s_f	s_g	
11.665	30	332.9	1467.9	1.2028	4.9805	2.958
4.975	4	199.6	1447.6	0.7815	5.2852	2.958
2.909	-10	135.2	1432.0	0.5440	5.4730	2.958

12

Group – C

4. (a) Discuss the advantages and disadvantages of air refrigeration system over vapour compression refrigeration system.
 (b) A dense air refrigeration system operating on Bell Coleman cycle operates between 3.4 bar to 17 bar. The temperature of air after cooler is 15°C and after refrigerator is 6°C. For a refrigeration capacity of 6 tonnes, find
 (i) Air circulation required in cycle per minute.
 (ii) Work in compressor and expander.
 (iii) Theoretical C.O.P. For air take $\gamma=1.4$, $C_p = 1.005$ kJ/kg.K.
 (Assume compression and expansion process are isentropic.)
- 4 + (2 + 4 + 2) = 12
5. (a) Draw a neat sketch of a lithium bromide water absorption system and explain its working principle.
 (b) In aqua ammonia absorption refrigeration system, evaporator, absorber, condenser and generator temperature are 233 K, 303 K, 313 K and 373 K respectively. The properties of aqua-ammonia are as follows

Particulars	Concentration Kg of NH ₃ /kg solution	Enthalpy(kJ/kg)
Strong solution leaving absorber	0.40	30
Weak solution leaving generator	0.35	340
Vapour leaving generator	0.95	1870
Liquid leaving condenser	0.95	470
Vapours leaving evaporator	0.95	1388

- (i) Draw schematic diagram of the system.
 (ii) For 10 TR capacity, determine the mass flow rate of the solution in evaporator.
 (iii) Determine mass flow rates of strong and weak solutions.

6 + 6 = 12

Group – D

6. (a) Describe the working of an evaporative condenser with neat sketch.
 (b) Draw a neat sketch of a constant pressure expansion valve. Explain its working principle.
- 6 + 6 = 12
7. (a) A multi-stage reciprocating air compressor admits air at 1 bar, 300 K and delivers the compressed air at 160 bar. The intercooling between stages is at optimum intercooler pressure and perfect intercooling and the maximum discharge temperature at any stage is limited to 425 K. For all