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) In a standard vapour compression refrigeration cycle, the state of the refrigerant after expansion is
(a) sub cooled liquid (b) saturated liquid
(c) wet vapour (d) saturated vapour.

(ii) Elements which are responsible for having high ozone depleting potential in a refrigerant is/are
(a) Chlorine only (b) Bromine only
(c) Fluorine only (d) Both Chlorine & Bromine.

(iii) Function of the intercooler in a reciprocating compressor is to
(a) bring the temperature down to inlet temperature
(b) to bring the process to isothermal
(c) to increase the volumetric efficiency
(d) all of the above.

(iv) Flash gas production during expansion process in a VCR cycle
(a) reduces refrigerating effect
(b) enhances refrigerating effect
(c) reduces COP
(d) both (a) and (c).

(v) Frictional pressure drop in an air distribution duct is
(a) proportional to the dynamic head
(b) proportional to the length only
(c) inversely proportional to the diameter of the duct
(d) all of the above.

(vi) R 134a refrigerant is preferred over R 12 as
(a) it's ODP is zero (b) it has no chlorine or bromine
(c) both (a) and (b) (d) neither (a) nor (b)

(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) In closed or dense air refrigeration cycle, the operating pressure ratio can be reduced, which results in _____ coefficient of performance
(a) lower (b) higher (c) same (d) none.

(ix) Vapour absorption refrigeration uses
(a) Mechanical energy (b) Electrical energy
(c) Heat energy (d) None.

(x) Heat Rejection Rate (HRR) of a condenser is given by
(a) $HRR=1+\frac{1}{COP}$ (b) HRR = 1+ COP
(c) $HRR= 1-\frac{1}{COP}$ (d) HRR = 1- COP

Group – B

2. (a) A food storage locker requires a refrigeration capacity of 12 TR and works between the evaporating temperature of -8°C and condensing temperature of 30°C. The refrigerant R-12 is sub cooled by 5°C before entry to expansion valve and the vapour is superheated to -2°C before leaving the evaporator coils. Determine: (i) coefficient of performance (ii) theoretical power per tonne of refrigeration
Use the following data for R-12

Saturation temperature, °C	Pressure bar	Enthalpy, kJ/kg		Enthalpy, kJ/kg K	
		Liquid	Vapour	Liquid	Vapour
-8	2.354	28.72	184.07	0.1149	0.7007
30	7.451	64.59	199.62	0.2400	0.6853

The specific heat of liquid R-12 is 1.235 kJ/kg K, and of vapour R-12 is 0.733 kJ/kg K.

(b) Discuss the effect of variation of suction pressure and discharge pressure on the performance of standard vapour compression refrigeration system with p-h diagram.

8 + 4 = 12

3. (a) Write the chemical name, formulae and type of refrigerants (CFC/HCFC/HFC etc) the following refrigerants describe.

(i) R 113 (ii) R 123 (iii) R 134 (iv) R 22

(b) A vapour compression refrigeration system operates between -10°C and 45°C.The refrigerant is dry saturated at the entry to the compressor and attain 102°C after compression. The compressor bore and stroke is 8 cm and runs at 480 rpm with 80% volumetric efficiency. The temperature of liquid refrigerant at the entry to the throttle valve is 35°C.Specific heat of liquid refrigerant is 1.62kJ/kg°C. Determine (a) COP (b) mass flow rate of refrigerant per min.
Take the following properties of the refrigerant.

Sat. temp (°C)	Sp. vol. of vapour	Specific enthalpy		Specific entropy	
		h_f(kJ/kg)	h_g(kJ/kg)	s_f(kJ/kg-K)	s_g(kJ/kg-K)
-10°C	0.233	45.4	460.7	0.183	1.762
45°C	0.046	133	483.6	0.485	1.587

4 + 8 = 12

Group – C

4. (a) State the difference between open air refrigeration cycle and closed air refrigeration cycle.

(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 γ=1.4, C_P = 1.005 kJ/kg.K.
(Assume compression and expansion process are isentropic.)

4 + 8 = 12

5. (a) Draw a neat sketch of a practical vapour absorption refrigeration cycle and explain its working principle.

(b) In aqua ammonia absorption refrigeration system of 12TR capacity,the vapours leaving the generator are 100% pure NH_3 saturated at 36°C. The evaporator, absorber, condenser and generator temperatures are -20°C, 26°C,36 °C, 70°C respectively. At absorber exit (strong solution), the concentration of ammonia is solution is x = 0.4 and enthalpy h = 22 kJ/kg. At generator exit weak solution x = 0.09 and h = 695 kJ/kg.
(i) determine mass flow rate of ammonia in the evaporator.
(ii) determine the mass flow rates of weak and strong solutions in absorber.

NH_3 thermodynamic properties		
Temperature(°C)	Enthalpy(kJ/kg)	
	Saturated Liquid	Saturated vapour
-20°C	89.7	1419.0
26°C	303.6	1465.6
36°C	352.1	1470.8

6 + 6 = 12

Group – D

6. (a) A two stage double acting reciprocating air compressor running at 200 rpm has air entering at 1 bar, 25°C. The low pressure stage discharges air at optimum intercooling pressure into intercooler after which it enters at 2.9 bar, 25°C into high pressure stage. Compressed air leaves HP stage at 9 bar. The LP cylinder and HP cylinder have same stroke lengths and equal clearance volumes of 5% of respective cylinder swept volumes. Bore of LP cylinder is 30 cm and stroke is 40 cm. Index of compression for both stages may be taken as 1.2.
Determine, (i) the heat rejected in intercooler, (ii) the bore of HP cylinder, (iii) the hp required to drive the HP cylinder.

(b) Draw the "Plate surface type" and "Finned tube type" natural convection type surface condensers and briefly explain how they work.

8 + 4 = 12

7. (a) Show that the optimum intermediate pressure of a two stage reciprocating compressor for minimum work is the geometric mean of the suction and discharge pressures.

(b) With a neat diagram explain how Automatic expansion valve and Thermostatic expansion valve operate.

6 + 6 = 12

Group – E

8. (a) Moist air at 32°C DBT and 50% RH enters a cooling coil at 10,000 m^3/h. It is desired that the air leaving the coil has a DBT of 20°C and WBT of 18°C. Determine the following:
(i) mean effective surface temperature of the coil
(ii) bypass factor of the coil
(iii) sensible heat factor of the coil
(iv) total heat removed from air
(v) mass of water vapour condensed.

(b) An air stream of 7000m^3/h at DBT of 27° C and humidity ratio of 0.010 kg/kg of dry air is adiabatically mixed with 120,000 m^3/h of air having 35°C DBT and 55% RH. Find the DBT and WBT of mixed air.

7 + 5 = 12

9. (a) A retail shop located in a city at 30°N latitude has the following loads:
Room sensible load : 58.15 Kw
Room latent Heat : 14.54 Kw
The summer outside and inside design conditions are;
Inside : 25°C DBT,50% RH
Outside : 40°C DBT, 27°C WBT
70cmm (cubic meter per min) of ventilation air is used. Determine the following:
(i) Ventilation load (ii) Grand total heat (iii) Effective sensible heat factor (iv) Apparatus dew point (v) Dehumidified air quantity (vi) Condition of air entering and leaving the apparatus.
Assume a suitable bypass factor of the cooling coil as 0.15.

(b) Prove that, a circular duct of diameter D is related to a rectangular duct of sides "a" and "b" with the relation $D=1.265[(ab)^3/(a+b)]^{1/5}$ when both the ducts handle the same volumetric flow rate of air.

8 + 4 = 12