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) A simple Refrigerant "Tetrafluoroethane" is known as
(a) R12 (b) R22 (c) R717 (d) R134.

(ii) A Bell-Coleman cycle is a reversed
(a) Rankine cycle (b) Brayton cycle
(c) Atkinson cycle (d) Ericsson cycle.

(iii) A simple saturated refrigeration cycle has the following state points: enthalpy after compression = 425 kJ/kg; enthalpy before compression =375 kJ/kg; enthalpy after throttling = 125 kJ/kg. The C.O.P. of the cycle is
(a) 2 (b) 3.5 (c) 5 (d) insufficient data.

(iv) If room sensible heat is 55 kW, room latent heat is 60 kW, then the room sensible heat factor is
(a) 0.92 (b) 0.48 (c) 0.52 (d) 1.1.

(v) Water Lithium bromide vapour absorption system is used for achieving refrigeration
(a) temperatures > 0^0C (b) temperatures < 0^0C
(c) temperature = 0^0C (d) value not sufficient.

(vi) The function of a Psychrometer is to measure
(a) DBT (b) WBT (c) DPT (d) both DBT and WBT.

(vii) Maximum COP that is possible for a Vapour absorption refrigeration cycle (with T_R as evaporator temp., T_1 as generator temp and T_2 as absorber temp. is
(a) $T_R(T_1 - T_2)/T_1(T_2 - T_R)$ (b) $T_2(T_1 - T_2)/T_1(T_2 - T_R)$
(c) $T_R(T_1 - T_R)/T_1(T_2 - T_R)$ (d) none of the above.

(viii) In gas cycle refrigeration system, the throttle valve of a vapour compression refrigerant system is replaced by
(a) capillary tube (b) expander
(c) reverse throttle valve (d) absorber and pump.

(ix) An ideal refrigerant should have
(a) low boiling point (b) low freezing point
(c) high latent heat of vaporization (d) all of these.

(x) The refrigerant R-744 stand for
(a) Ammonia (b) Carbon dioxide
(c) Methyl chloride (d) Sulphur dioxide.

Group - B

2. (a) The machine circulates 4.5 kg ammonia/min. There is no undercooling. The temperature after isentropic compression is 75°C. Find (i) cop of the plant (ii) ice produced in kg/hr from water at 20°C and ice at -5°C. (iii) quality of refrigerant entering the compressor. Tale C_{pw} = 4.187 kJ/kg-K, C_{pice} = 2.1 kJ/kg-K, Latent heat of ice 336 kJ/kg, C_{pgNH3} = 2.82kJ/kg-K. Use the following properties of NH_3.

Saturation Temp(°C)	specific enthalpy(kJ/kg)		specific entropy(kJ/kg-K)		Specific volume (m^3/kg)	
	h_f	h_g	s_f	s_g	v_f	v_g
-15	112.3	1426	0.457	5.549	0.00152	0.509
30	323.1	1469	1.204	4.984	0.00158	0.111

[(CO2)(Evaluate/HOCQ)]

(b) With the help of T-s diagram, discuss the effect of changing evaporator temperature on the performance of the VCR cycles, keeping the condenser pressure constant.
[(CO2)(Understand/LOCQ)]

9 + 3 = 12

3. (a) In a simple vapour compression cycle, following are the properties of the refrigerant R-12 at various points:

Compressor inlet: h_2 =183.2 kJ/kg v2=0.0767 m^3kg
Compressor discharge: h_3 =222.6 kJ/kg v3=0.0164 m^3kg
Condenser exit: h_4 =84.9 kJ/kg v4=0.00083 m^3kg

The piston displacement volume for compressor is 1.5 liters per stroke and its volumetric efficiency is 80%. The speed of the compressor is 1600 r.p.m. Calculate:
(i) power rating of the compressor kW;
(ii) refrigerating effect kW [(CO2)(Analyze/IOCQ)]

(b) Discuss the advantages and disadvantages of cascade refrigeration system.
[(CO2)(Remember/LOCQ)]

8 + 4 = 12

Group - C

4. (a) In an aqua-ammonia absorption refrigeration system, heat is supplied to the generator by condensing steam at 0.2 MPa, 90% dry. The temperature to be maintained in the refrigerator is -10°C and the ambient temperature is 30°C. Estimate the maximum COP of the refrigerator.

If the actual COP is 40% of the maximum COP and the refrigeration load is 18 tonnes, what will the required steam flow rate be? Take latent heat of steam at 0.2 Mpa 2201.6 kJ/kg and saturation temperature is 120.2^{0}C. [(CO4)(Evaluate/HOCQ)]

(b) The speed of an aircraft flying at an altitude of 8000 meters, where the ambient air is at 0.35 bar pressure and 265 K temperature, is 980 km/h. The compression ratio of the air compressor is 5. The cabin pressure is 1 bar and temperature is 27°C. Determine the refrigeration capacity for simple aircraft refrigeration cycle on the basis of 1.2 kg/s flow of air. Find out the power require for compression. (Assume all the process are ideal, and specific heat of air 1.005 kJ/kg K and $\gamma = 1.4$.

[(CO3)(Analyse/IOCQ)]

5 + 7 = 12

5. (a) A Bell-Coleman refrigerator operates between pressure limits of 1 bar and 16 bar. Air is drawn from the cold chamber at 9^{0}C, compressed and then it is cooled to 29^{0}C before entering the expansion cylinder. Expansion and compression follow the law $pv^{1.3}$=constant. Draw the p-v and T-s diagram. Determine: (i) Work done per kg of air flow. (ii) Theoretical C.O.P. For air take $\gamma = 1.4$, cp = 1.003 kJ/kg-K.

[(CO3)(Evaluate/HOCQ)]

(b) Compare briefly Vapour Compression Refrigeration Cycle with Vapour Absorption Refrigeration Cycle. [(CO4)(Understand/LOCQ)]

6 + 6 = 12

Group – D

6. (a) Explain the working of a single stationary blade type rotary compressor.

[(CO5)(Remember/LOCQ)]

(b) Write a short note on methods of defrosting. [(CO5)(Apply/IOCQ)]

6 + 6 = 12

7. (a) Draw a neat sketch of a hand operated expansion valve and explain its working principle. [(CO5)(Remember/LOCQ)]

(b) Give the comparison of air-cooled condenser and water-cooled condenser.

[(CO5)(Understand/LOCQ)]

6 + 6 = 12

Group - E

8. (a) The atmospheric air at 25°C DBT and 12°C WBT is flowing at a rate of 100m^3/min through a duct. Water at 100°C is injected into the air stream at a rate of 72 kg/hr. Calculate the specific humidity, DBT, WBT, relative humidity and enthalpy of air leaving the duct. [(CO6)(Evaluate/HOCQ)]

(b) Write short notes on (i) WBT (ii) DBT (iii) Specific Humidity Ratio.

[(CO6)(Understand/LOCQ)]

6 + 6 = 12

9. An air conditioning plant is to be designed for a small office:
Outdoor Conditions: 43°C DBT and 28°C WBT

Required indoor conditions: 24°C DBT and 50% RH
Room sensible heat gain: 84000 kJ/h
Room latent heat gain: 21000 kJ/h
By pass factor of the coil = 0.2
The return air from the room is mixed with the outside air before entry to cooling coil in the ratio of 4:1 by mass. Determine (i) Apparatus dew point of the cooilng coil (ii) Entry and exit conditions of air for cooling coil. (iii) Fresh air mass flow rate and (iv) Refrigeration load on the cooling coil. [Use Psychrometric Chart]

[(CO6)(Remember/HOCQ)] **12**

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	38.54	21.88	39.58

Course Outcome (CO):

After the completion of the course students will be able to
CO1 Describe the term in the refrigeration system and various refrigerants used in the refrigeration system and its impact on the environment.
CO2 Analyze standard vapour compression cycle working principle and calculate COP of different systems.
CO3 Explain Air Refrigeration system, its advantages and limitations, and its applications, Aircraft refrigeration system.
CO4 Judge the different parts of vapour absorption refrigeration cycle, its advantages and disadvantages over VCRS.
CO5 Recognize the use of different components in refrigeration systems.
CO6 Calculate various properties of moist air, evaluate the various psychrometric processes.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question