B.TECH/ME/5TH SEM/MECH 3132/2016

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 <u>any 5 (five)</u> from Group B to E, taking <u>at least one</u> 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) Refrigerant flow in a vapour compression refrigeration cycle happens in the following sequence
(a) boiler-condenser-turbine-pump
(b) condenser-evaporator-throttle valve-compressor
(c) compressor-condenser-throttle valve-evaporator
(d) condenser- compressor- evaporator- throttle valve.

(ii) Power input to a reciprocating compressor becomes minimum when the compression is
(a) isenthalpic (b) isochoric
(c) adiabatic (d) isothermal.

(iii) The ambient temperature recorded by an ordinary thermometer is known as
(a) Wet Bulb Temperature (b) Dew Point Temperature
(c) Dry Bulb Temperature (d) Saturated Temperature.

(iv) Refrigerant "Tetrafluoroethane" is known as
(a) R12 (b) R22 (c) R134a (d) R134.

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

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

(vii) Inter-stage cooling is required for multi-stage compression in order to
(a) reduce the work input to the compressor
(b) bring the process of compression to isothermal process
(c) increase the efficiency of the compressor
(d) all of the above.

(viii) In an vapour absorption refrigeration cycle, the driver of the cycle is
(a) a boiler (b) a turbine
(c) a compressor (d) a pump.

(ix) 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. is:
(a) 5 (b) 3.5 (c) 6 (d) insufficient data.

(x) The ratio of sensible heat transfer rate to total heat transfer rate in a psychrometric process is known as
(a) Plant load factor (b) Bypass Factor
(c) C.O.P. (d) Sensible Heat Factor.

Group – B

2. (a) A refrigeration plant is required to produce ice at 0°C from water at 20°C. The machine has a condenser temperature of 298 K, while the evaporator temperature is 268 K. The relative efficiency of the machine is 50% and 6.0 kg of Freon-12 is circulated through the machine per minute. The refrigerant enters the compressor with a dryness fraction of 0.6. Specific heat capacity of water is 4.187 $\frac{kJ}{kgK}$ and the latent heat of ice is 335 $\frac{kJ}{kg}$. Calculate the amount of ice produced in 24 hours. The properties of Freon-12 is given below:

Temperature (K)	Liquid enthalpy $\left(\frac{kJ}{kg}\right)$	Latent heat $\left(\frac{kJ}{kg}\right)$	Entropy of liquid $\left(\frac{kJ}{kgK}\right)$
298	59.7	118.0	0.2232
268	31.4	154.0	0.1251

(b) With reference to a simple vapour compression cycle, discuss the effect of (i) suction pressure and (ii) discharge pressure, on the cycle performance (Draw suitable thermodynamic plots).

6 + (3 + 3) = 12

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

Compressor inlet:	$h_2 = 183.2\ kJ/kg$	$v_2 = 0.0767\ m^3/kg$
Compressor discharge:	$h_3 = 222.6\ kJ/kg$	$v_3 = 0.0164\ m^3/kg$
Condenser exit:	$h_4 = 84.9\ kJ/kg$	$v_4 = 0.00083\ m^3/kg$

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)

(b) A cold storage plant is required to store 20 *tonnes* of fish. The temperature of the fish, when supplied, is 25°C. The required storage temperature of fish is −8°C. The specific heat of fish above the freezing point is 2.93 kJ/kg°C, while the specific heat of fish below the freezing point is 1.25 kJ/kg°C. The freezing point of fish is −3°C and the latent heat of fish is 232 kJ/kg.
If the cooling is achieved within 8 hours, find:
(i) Capacity of the refrigerating plant;
(ii) Carnot cycle $C.O.P.$ between this temperature range;
(iii) If the actual $C.O.P.$ is $\frac{1}{3}rd$ of the Carnot $C.O.P.$ find the power required to run the plant.

6 + (2 + 2 + 2) = 12

Group – C

4. (a) In an absorption type refrigerator the heat is supplied to NH_3 generator by condensing steam at 2 bar and 90% dry to saturated liquid state after condensation. The temperature to be maintained in the refrigerator is -5°C. The temperature of the atmosphere is 30°C. Find the maximum C.O.P possible. If the refrigeration load is 20 tonnes and actual C.O.P is 70% of maximum C.O.P, find the mass flow of steam required per hour.

(b) With the help of a neat diagram, explain the working of a vapour absorption refrigeration system.

6 + 6 = 12

5. (a) An air refrigeration open system operating between 1 MPa and 100kPa is required to produce a cooling effect of 2000 kJ/min. Temperature of the air leaving the cold chamber is −5°C and the air temperature leaving the cooler is 30°C. Neglect losses and clearance in the compressor and the expander and assume the compression and expansion processes as isentropic. Determine:
(i) Mass of air circulated per minute;
(ii) Compressor work, expander work, and the cycle work;
For air take λ = 1.4 and C_P = 1.005 kJ/kgk

(b) Compare briefly Vapour Compression Refrigeration Cycle with Vapour Absorption Refrigeration Cycle.

6 + 6 = 12

Group – D

6. (a) Derive an expression for the volumetric efficiency of a single stage single acting reciprocating compressor.

(b) In a triple stage reciprocating compressor of single acting type the air enters at 1 bar, 27°C. The compressor has low pressure cylinder with bore of 30 cm and stroke of 20 cm. Clearance volume of LP cylinder is 4% of the swept volume. The final discharge from compressor takes place at 20 bar. The expansion and compression index may be taken uniformly as 1.25 for all the stages. The intercooling between the stages may be considered to be at optimum intercooling pressure and perfect intercooling. Determine, the interstage pressures, effective swept volume of low pressure cylinder, temperature and volume of air delivered in each stroke and the work done per kg of air.

5 + 7 = 12

7. (a) Compare the reciprocating compressor with centrifugal compressor with respect to the following parameters.
(i) Vibration (ii) Mechanical Efficiency (iii) Pressure ratio per stage (iv) cost (v) Maintenance Expenses.

(b) With the help of a typical characteristic curve, describe "surging" and "choking" in a centrifugal compressor.

6 + (2 + 2 + 2) = 12

Group – E

8. (a) Prove that the specific humidity of air is given by
$\omega = \frac{0.622\ P_v}{P_t - P_v}$: Where P_v = partial pressure of water vapour. & P_t = total pressure of air.

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(b) Write short notes on (i) WBT (ii) DPT (iii) Specific Humidity Ratio (iv) Relative Humidity.

6 + 6 = 12

9. (a) 142 m^3/min moist air at 5°C with specific humidity of 0.002 kg/kg of dry air is mixed adiabatically with 425 m^3/min of moist air stream at 24°C and 50% relative humidity. If the pressure is constant throughout at 1bar, determine:
(i) the humidity ratio and (ii) the temperature of the mixed stream .

(b) Describe the various Room Sensible Heat(RSH) and Room Latent Heat (RLH) that must be considered for estimating cooling load in an air-conditioned space.

6 + 6 = 12