ELEMENTS OF FOOD ENGINEERING-1

Full Marks – 70

Pass Marks – 28

Time – Three hours

The figures in the margin indicate full marks for the questions.

Answer question No.1 and any *five* from the rest.

1. (a) Fill in the blanks : $1 \times 5 = 5$

   (i) In isothermal process, the ——— remains constant.

   (ii) In refrigerator, the device called ——— absorbs heat from food component.

   (iii) Water boils at ———$^{\circ}C$ at 1 atm pressure.

   (iv) A system in mechanical equilibrium if there is no change ——— at any point of the system with time.

   (v) Convection heat transfer takes place between the solid surface and ———.

[Turn over

(b) State true or false of the following :

$1 \times 5 = 5$

(i) R134a is used in domestic refrigerator.

(ii) Heat engine operates on a cycle.

(iii) A liquid that is about to vapour is called saturated vapour.

(iv) The energy of the sun reach the earth by convection.

(v) Heat can be flow from a low temperature medium to high medium by doing external work.

2. (a) Define a thermodynamic property. Distinguish between the intensive and extensive property.

3

(b) Name any four forms of energy. What do you mean by enthalpy ? $2 + 2 = 4$

(c) What is a heat engine ? Prove that the thermal efficiency of a heat engine $1 + 4 = 5$

$$\eta_{th} = 1 - \frac{Q_L}{Q_H}$$

where, Q_H = amount of heat supplied to the heat engine from a high-temperature source.

Q_L = amount of heat rejected from heat engine to a low temperature sink.

3. (a) State Kelvin-Plank's statement of second law of thermodynamics. 2

   (b) What is the main objective of a heat pump ? Explain the working principle of a refrigerator with diagram. 1+5=6

   (c) A household refrigerator with a COP of 1·2 removes heat from the refrigerated space at a rate of 60 kJ/min. Determine

      (i) the electric power consumed by the refrigerator and

      (ii) the rate of heat transfer to the kitchen air. 4

4. (a) State Fourier's law of heat conduction. 3

   (b) A heat flux meter attached to the inner surface of a 3cm thick refrigerator door indicates a heat flux of 25 w/m² through the door. Also, the temperature of the inner and the outer surfaces of the door are measured to be 7°C and 15°C respectively. Determine the average thermal conductivity of the refrigerator door. 4

   (c) What do you mean by the term 'radiation' ? State Stefan-Boltzmann law of radian. 2+3=5

5. (a) How will you compare the thermal resistance of conduction of a plane layer with electrical resistance ? 2

(b) Consider a 3m high, 5m wide and 0·17m thick wall whose thermal conductivity is K=0·9 w/m.k. On a certain day, the temperature of the inner and the outer surfaces of the wall are measured to be 16°C and 2°C, respectively. Determine

(i) The thermal resistance and

(ii) Rate of heat loss through the wall on that day. 5

(c) A hollow cylinder 5cm I.D (inner diameter) and 10 cm O.D (outer diameter) has an inner surface temperature of 200°C and an outer surface temperature of 100°C. If the thermal conductivity of the cylinder material is 70 w/m.k, determine the heat flow through the cylinder per linear metre. 5

6. (a) How does a cross-flow heat exchanger differ from a counter flow one ? What is the difference between mixed and unmixed fluids in cross heat exchanger ? 3+2=5

(b) A dilute pine apple juice is heated in a double pipe heat exchanger from 28°C to 75°C by heat exchanging with hot water which enters

the heat exchanger in counter current direction and is cooled from 95°C to 85°C. Calculate the log mean temperature difference (LMTD).

5

(c) Define effectiveness of a heat exchanger.

2

7. (a) Distinguish between the sub-cooled liquid and superheated vapour. What is a critical point ?

$4+2=6$

(b) What do you mean by degree of superheat and dryness fraction of steam ? $1+2=3$

(c) A steam sample at 2MPa has a specific volume of $0.09 \text{ m}^3/\text{kg}$. Determine the dryness fraction of the steam.

3

8. Write short notes on any *three* of the following :

$3 \times 4 = 12$

(a) Shell and tube heat exchanger

(b) Reversible and irreversible processes

(c) Food freezing by direct contact of refrigerant

(d) Heat pump.