Total No. of printed pages = 7

FPT-302/EFE-I/3rd Sem/2014/N

ELEMENTS OF FOOD ENGINEERING-I

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) Choose the correct answer : 1×5=5

(i) Which of the following is the extensive property of a thermodynamic system ?

(a) Pressure

(b) Volume

(c) Temperature

(d) Density

(ii) Which of the following is not a refrigerant ?

(a) R-143a

(b) R-19 Fe

(c) R-22

(d) Ammonia

[Turn over

(iii) Heat transfer is

(a) Proportional to the thickness of the plane layer through which heat flows.

(b) Inversely proportional to normal surface area.

(c) Proportional to the temperature difference.

(d) None of these.

(iv) Which one of the following is not a heat exchanger ?

(a) Boiler

(b) Condenser

(c) Pump

(d) Car radiator

(v) Emissivity (ξ) lies between

(a) $-1 < \xi < 1$

(b) $-1 < \xi < 0$

(c) $0 < \xi$ 1

(d) $0.5 < \xi < 1$

(b) Fill in the blanks : 1×5=5

(i) The working fluid used in the refrigerator is known as ..... .

(ii) The S.I unit of power is ..... .

(iii) ..... is the driving force of heat transfer.

(iv) The amount of energy absorbed during melting of ice is called the ..... .

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

2. (a) What are the thermodynamic system and thermodynamic cycle ? 2+2=4

(b) Differentiate between the following : 2+2=4

(i) Closed system and isolated system.

(ii) Isothermal process and isobaric process.

(c) Heat is transferred to a heat engine from a furnace at a rate of 80 MW. If the rate of waste heat rejection to a nearby river is 50 MW, determine 4

(i) the net power output and

(ii) the thermal efficiency for this heat engine.

3. (a) State first law of thermodynamics. 2

(b) What is the main objective of a refrigerator ? Define the coefficient of performance of a heat pump in words. Prove the following relation : $COP_{HP} = COP_{R} + 1$. 1+2+2=5

(c) A heat pump is used to heat a house and maintain it at 24°C. On a winter day when the outdoor air temperature is –5°C, the house is estimated to lose heat at a rate of 80,000 kJ/h. Determine the minimum power required to operate this heat pump. 5

4. (a) Define convection heat transfer. State Stefan-Boltzmann's law of radiation. 2+3=5

(b) A flat plate of length 1m and width 0.5m is placed in an air stream at 30°C blowing parallel to it. The plate is maintained at a temperature of 300°C. Calculate the convective heat transfer coefficient if the heat transfer rate is 4.05 kW. Also determine heat flux. 4

(c) Consider a 20 cm×20 cm×20 cm cubical body at 1000K suspended in the air. Assuming the body closely approximates a black body, determine the rate at which the cube emits radiation energy in watt. Take Stefan-Boltzmann's constant = 5.67×10^{-8} w/m^2. k^4. 3

5. (a) How does transient heat transfer differ from steady heat transfer ? 2

(b) Find the thermal resistance of conduction of the following composite slabs. 4

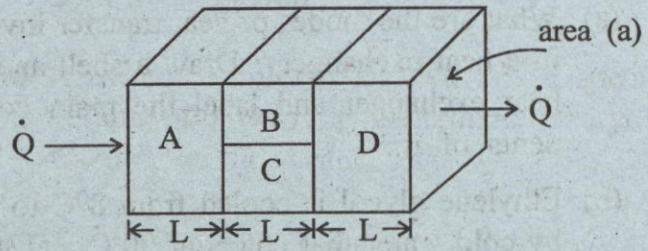

Figure 5(b)

where A, B, C, D are the composite slabs.

$\dot{Q}$ = rate of heat transfer

a = area of the slabs

L = thickness of each slabs.

Assume thermal conductivity of all slabs are equal.

(c) Prove that one dimensional steady state heat conduction through a cylindrical wall is

$$\dot{Q}_{cond,\,cyl} = 2\pi\, KL\, \frac{T_i - T_o}{\ln\left(\frac{r_o}{r_i}\right)}$$ 6

where r_i, r_o = inner and outer radius of long cylindrical layer respectively.

L = length of the cylinder

T_i, T_o = inner and outer surface temperatures of the layer ($T_i > T_o$)

K = average thermal conductivity.

6. (a) What are the modes of heat transfer involved in a heat exchanger ? Draw a shell-and-tube heat exchanger and label the main components of it. 2+3=5

(b) Ethylene glycol is cooled from 8°C to 40°C by cold water that enters at 20°C and leaves 55°C in a double pipe counter flow heat exchanger as shown in Fig. 6(b). The overall heat transfer coefficient of heat exchanger is 0.2J kW/m² °C. Calculate

(i) long mean temperature difference (LMTD).

(ii) Heat transfer surface area of the heat exchanger if the rate of heat transfer is 358.4 kW. 7

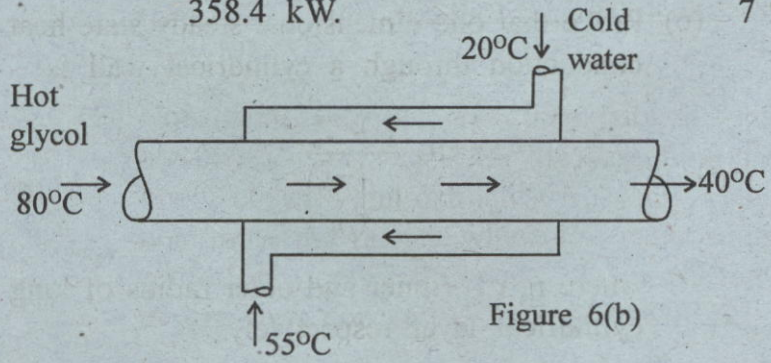

Figure 6(b)

7. (a) What are the saturated pressure, saturated temperature and critical point of pure substance ? 3

(b) Discuss the phase change process of water with neat diagram. 6

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

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

(a) Compact type heat exchanger.

(b) Overall heat transfer coefficient of heat exchanger.

(c) Food freezing by direct contact of refrigerant.

(d) Vapour compression refrigeration.

(e) Nusselt number. 3×4=12