Total No. of printed pages = 6

FPT-302/EFE-I/3rd Sem/2017/M

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) Fill in the blanks : 1×10=10

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

(ii) The series of states through which a system passes during a process is called the _____ of the process.

(iii) For a closed system undergoing a cycle, the energy change of a system is equal to _____.

[Turn over

2. (a) Define a system, surrounding and its boundary. 3

(b) Name any four forms of energy. What do you mean by 'internal energy' and 'enthalpy' ? 2+4=6

(c) During one cycle the working fluid in an engine engages in two work interactions : 15 kJ from the fluid and 44 kJ to the fluid, and three heat interactions, two of which are known : 75 kJ from the fluid and 40 kJ to the fluid. Evaluate the magnitude and the directions of the third heat transfer. 3

3. (a) Explain briefly the working principle of a refrigerator with diagram. 6

(b) A heat engine with a thermal efficiency of 40% rejects 1000 kJ/kg of heat. How much heat does it receive ? 2

(c) A Carnot refrigerator operates in a room in which the temperature is 22°C and consumes 2 kW of power when operating. If the food compartment of the refrigerator is to be maintained at 3°C, determine the rate of heat removal from the food compartment. 4

4. (a) Distinguish between the saturated liquid and compressed liquid. 4

(b) What do you mean by quality of a pure substance ? 2

(c) Explain briefly the phase-change process of water with (T-v) property diagram. 6

5. (a) What are the three modes of heat transfer ? 3

(b) State the following laws : 2+2=4

(i) Newton's law of cooling

(ii) Stefan's-Boltzmann law of radiation.

(c) A composite wall consists of 1·5 mm of steel sheet and 10 mm of plywood separated by 2 cm of glass wool in between them. Calculate the rate of heat flow per unit area if the temperatures on the steel and plywood sides are 25°C and 15°C respectively. 5

Thermal conductivity for steel sheet = 23·23 W/m°C

" " for plywood = 0·052 W/m°C

" " for glass wool = 0·014 W/m°C

6. (a) Define convective heat transfer coefficient. How will you compare the thermal resistance of convection of a solid surface with electrical resistance ? 2+2=4

(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 convective heat transfer coefficient is 30 W/m^2K. Calculate the heat transfer if the plate is maintained at a temperature of 300°C. Also determine the heat flux. 2+1=3

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

$$\dot{Q} = \frac{4\pi r_o r_i k(T_i - T_o)}{(r_o - r_i)}$$ 5

where, r_i, r_o = Inner and outer radius of hollow spherical layer respectively.

T_i, T_o = Inner and outer surface temperature of the layer ($T_i > T_o$)

k = Average thermal conductivity.

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

(b) Ethylene glycol is cooled from 80°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 figure. The overall heat transfer coefficient of heat exchanger is 0.250 kW/m² °C. Calculate –

(i) Log mean temperature difference (LMTD)

(ii) Heat transfer surface area of the heat exchanger if the rate of heat transfer is 358·4 kW. 7