Total No. of printed pages = 8

FPT-302/EOFI-I/3rd Sem/2017/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.

Attempt questions from PART – A and PART – B as per the following instructions.

PART – A

Attempt *all* questions. 5×5=25

1. (a) MCQ type questions : 1×5=5

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

(a) Pressure (b) Volume

(c) Density (d) Temperature

[Turn over

(ii) Which of the following is the intensive variable of a thermodynamic system ?

(a) Internal energy (b) Volume

(c) Total mass (d) Temperature

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

(a) Boiler (b) Condenser

(c) Pump (d) Car radiator

(iv) Heat transfer is

(a) Inversely proportional to the temperature gradient

(b) Directly proportional to the normal surface area

(c) Inversely proportional to the thickness of the plain slab through which the heat flows

(d) None of these

(v) Thermodynamic state functions are

(a) Internal energy (b) Pressure

(c) Volume (d) All of these

(b) Fill up the gap : 1×5=5

(i) 486K (Kelvin) is equal to ——— °C.

(ii) The S.I unit of thermal conductivity is ———.

(iii) The S.I unit of heat flux is ———.

(iv) ——— is the driving force of heat transfer.

(v) No net change of heat indicates ——— process.

(c) Objective type questions : 1×5=5

(i) What is the formula of R134a ?

(ii) Define isobaric process.

(iii) What is isochoric process ?

(iv) What is the correlation between C_p and C_v ?

(v) What is refrigeration load ?

(d) One word questions : 1×5=5

(i) Evaporator, compressor, condenser and expansion valve belongs to which cycle ?

(ii) Which law governs heat transfer by conduction ?

(iii) Energy in which form is reached from the sun to the earth's surface ?

(iv) Which fluid is used in the refrigerator ?

(v) What is the driving force of heat transfer ?

(e) Match the columns : 1×5=5

Group I	Group II
A. Heat engine	1. Refrigeration
B. Convection	2. Emissivity
C. Radiation	3. 2nd law of thermodynamics
D. Liquid Ammonia	4. Nusselt number

	A	B	C	D
(i)	1	3	4	2
(ii)	2	3	2	4
(iii)	3	4	2	1
(iv)	3	4	1	2

PART – B

Attempt any *five* questions from the following : 5×9=45

2. (a) State First law of Thermodynamics and give the mathematical expression of it. How work done can be calculated ? 4+2=6

   (b) Define enthalpy and entropy of a thermodynamic system. 3

3. (a) State Zeroeth law of thermodynamics. State and explain second law of thermodynamics. 4

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

$$\eta = 1 - Q_2/Q_1$$

Where Q_2 = total amount of heat released from heat engine to external heat reservoir or sink and Q_1 = total amount of heat absorbs or supplied to the heat engine from a external reservoir or source.

4. (a) Find the rate of heat loss through a stainless steel slab 10 cm thick which is maintained 100°C on hot side and 30°C on the cold side. The thermal conductivity of steel is 16.37 w/m/° C. 4

(b) A pipeline, 150/160 mm diameter carries steam. The pipe is insulated with a 0.03m thick layer of material with a thermal conductivity of 0.20 w/mK where thermal conductivity of the pipe material is 50 w/mk. Insulation of pipe reduces the external temperature of insulation to 80°C. Find the rate of heat loss from a length 1m of pipeline. Given that the temperature of the inside surface is 120°C. 5

5. (a) What is Nusselt number? Draw the concurrent flow and counter current flow heat exchanger. Draw also the temperature profile (T-X) diagrams of concurrent and counter current flow heat exchanger. 1+2+2=5

(b) A dilute orange 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). 4

6. (a) What are the main components of a shell and tube heat exchanger ? Draw a shell and tube heat exchanger. 2+2=4

(b) A fluid of temperature 15°C is flowing over a flat surface maintained at 152°C. If the cross sectional area of the flat surface is $0.20m^3$ and the rate of heat transfer from the flat surface to the fluid is 800W, calculate the convective heat transfer coefficient. 5

7. (a) Define absorptivity, trasmittivity and reflectivity of the body. What are their correlations ? 3+1=4

(b) A piece of meat cube is kept in a deep freezer maintained at −18°C. Calculate the radiative heat transfer if the meat cube is at 25°C and has an average area of $0.045m^2$. The emissivity of the meat cube is taken as 0.82. Take Stefan-Boltzmann's constant = $5.67 \times 10^{-8} w/m^2K^4$. 5

8. (a) Prove the following relationship : 2

$(COP)_P = 1 / (COP)_E = (COP)_R + 1$

(b) A machine working on a Carnot cycle operates between 308K and 268K. Determine the COP when it is operated as the following : 3

(i) A refrigerating machine

(ii) A heat pump

(iii) A heat engine

(c) In an air blast freezer operating at −30°C, blocks of fish is −2.2°C and the moisture content of fish is 82%. The thickness of the fish block is 0.0508m and the convective heat transfer coefficient (h) is 20 w/m²K. Calculate the freezing time in hour required to freeze the fish blocks. Assume density of unfrozen fish as 1050 kg/m³, thermal conductivity of the frozen fish (k) as 1.025 w/mK, latent heat of water to ice as 335 KJ/kg and shape factors for infinite slab, P = 1/2 and R = 1/8. 4