Total No. of printed pages = 7

END SEMESTER EXAMINATION, NOVEMBER-2018

Semester : 3rd

Subject Code : FPT-302

ELEMENTS OF FOOD ENGINEERING-I

Full Marks – 70

Time – Three hours

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

Instructions :

1. *All* questions of PART–A are compulsory.
2. Answer any *five* questions from PART–B.

PART – A

Marks – 25

1. Fill in the blanks : 1×10=10

   (a) 586K (Kelvin) is equal to _____°C.

   (b) The SI unit of thermal conductivity is _____.

   (c) The SI unit of heat flux is _____.

[Turn over

(d) _____ process is the constant volume process.

(e) No net change of heat indicates _____ process.

(f) Carnot engine is _____ heat engine

(g) Triple point of pure water is at _____ K temperature and _____ Pa pressure.

(h) When pressure is constant in a thermodynamic process then it is known as _____ process.

(i) The specific heat at constant pressure (C_p) is mathematically expressed as _____.

(j) The formula of R134a is _____.

2. Write true or false : 1×10=10

(a) Evaporator, compressor, condenser and expansion valve belong to Carnot cycle.

(b) Stefan Boltzmann Law governs heat transfer by conduction.

(c) Constant temperature process is known as isothermal process.

(d) Heat engine and heat pump are same.

(e) Temperature gradient and thickness of slab are driving force of conductive heat transfer.

(f) Universal gas constant cannot be calculated from C_p and C_v.

(g) Heat pump and refrigerator are same.

(h) Liquid ammonia is used in refrigeration purpose.

(i) Nusselt number is not associated with convective heat transfer.

(j) Work is thermodynamic path function.

3. Choose the correct answer : 1×5=5

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

(i) Pressure (ii) Volume

(iii) Density (iv) Temperature

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

(i) Pressure (ii) Temperature

(iii) Density (iv) All of these

(c) Rate of heat transfer is

(i) inversely proportional to the temperature gradient

(ii) directly proportional to the normal surface area

(iii) inversely proportional to the thickness of the plain slab through which the heat flows

(iv) None of these

(d) Thermodynamic state functions are

(i) Internal energy (ii) Pressure

(iii) Volume (iv) All of these

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

(i) Boiler (ii) Condenser

(iii) Pump (iv) Car radiator

PART – B

Marks – 45

4. (a) State First Law of Thermodynamics. 1

(b) Give the mathematical expression of it. 2

(c) How work done can be calculated from First Law of Thermodynamics ? 6

5. (a) State Zeroeth Law of Thermodynamics. 2

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

(c) State and explain Second Law of Thermodynamics. 4

6. (a) What is heat engine ? 2

(b) What is heat pump ? 2

(c) Prove that the thermal efficiency of a heat engine $\eta = 1-Q_2/Q_1$, 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 an external reservoir or source. 5

7. (a) State and explain Fourier's Law of heat transfer. 3

(b) Give the mathematical expression of thermal resistance and thermal conductance. 2

(c) Find the rate of heat loss through a stainless-steel slab 10cm thick which is maintained 120°C on hot side and 50°C on the cold side. The thermal conductivity of steel is 16.37w/m/°C. 4

8. (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. 4

(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). 5

9. (a) Draw a shell and tube heat exchanger with component parts. 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 $0.20m^2$ and the rate of heat transfer from the flat surface to the fluid is 800W, calculate the convective heat transfer coefficient. 5

10. (a) Define absorptivity, transmissivity and reflectivity of the body. What are their correlations ? 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 $= 5.67\times10^{-8}w/m^2k^4$. 5

11. (a) Explain Carnot Cycle mathematically. 5

(b) Prove the following relationship :

$$(COP)_P=1/(COP)_E=(COP)_R+1$$ 4

12 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 $20w/m^2K$. Calculate the freezing time in hour required to freeze the fish blocks. Assume density of unfrozen fish as $1050kg/m^3$, thermal conductivity of the frozen fish (k) as 1.025w/mK, latent heat of water to ice as 335kJ/kg and shape factors for infinite slab, P = 1/2 and R=1/8. 9