Total No. of printed pages = 8

END SEMESTER EXAMINATION – 2019

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 : $1 \times 10 = 10$

   (a) 230°F is equal to ____ Kelvin.

   (b) The SI unit of coefficient of thermal conductivity is ____.

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

[Turn over

(d) _____ process is the constant temperature process.

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

(f) Carnot engine is not an _____ heat engine.

(g) The unit of energy in SI unit is _____.

(h) When there is no net heat change a thermodynamic process then it is known as _____ process.

(i) The specific heat at constant volume (C_v) is mathematically expressed as _____.

(j) The formula of R 134a is _____.

2. Write true or false : 1×10=10

(a) Evaporator, compressor, condenser and expansion valve belong to vapour compression refrigeration cycle.

(b) Fourier's law governs heat transfer by radiation.

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

(d) Heat engine and heat pump are different.

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

(f) Universal gas constant can be calculated from C_p and C_v.

(g) Heat pump and refrigerator are different.

(h) Liquid ammonia is used in heating purpose.

(i) Nusselt number is associated with convective heat transfer.

(j) Work is thermodynamic state variable.

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 not the intensive variable of a thermodynamic system ?

(i) Pressure (ii) Temperature

(iii) Entropy (iv) None 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) All 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 and explain first law of thermodynamics mathematically. 3

(b) How work done can be calculated from first law of thermodynamics ? 2

(c) In a given thermodynamic process there is a heat transfer gain of 1055 KJ and an internal energy increase of 210 KJ. Determine the work done and state whether the process is an expansion or compression. 4

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

(b) Explain heat capacities and their relationship. 2

(c) A refrigerator maintains a food compartment at 2°C by removing heat from it at a rate of 420 kJ/min. If the required power input to the refrigerator is 2.5 kW. Determine

(a) COP of the refrigerator

(b) The rate of heat rejection to the room that houses the refrigerator. 4

6. (a) State and explain the Second law of thermodynamics. What is Carnot engine ? 2+1=3

(b) State and explan the function of a heat engine and heat pump in context to Second law of thermodynamics. 3

(c) Find the COP of a refrigeration system if work input is 75 KJ/Kg and refrigeration effect produced is 150 KJ/Kg of refrigerant flowing. 3

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) An interior wall of a furnace is maintained at a temperature of 900°C. The wall is 60 cm thick, 1 cm wide and 1.5m broad. The K value of wall material is 0.4 W/mK. The temperature of the outer wall is 200°C. Determine the following : 4

(i) Heat flow through the wall

(ii) Thermal conductance to heat flow.

8. A cold storage has a wall comprising 11 cm brick on the outside, then 7.5 cm of concrete and then 10 cm cork. The mean temperature within the store is maintained at –18°C and mean temperature of the outside surface of the wall is 20°C. The thermal conductivites for brick, concrete and cork are 0.69, 0.76 and 0.043 W/m°C respectively. By considering unit area determine :

(i) The thermal resistance

(ii) Thermal conductance and

(iii) Rate of heat loss through the wall. 9

9. (a) Define Nusselt number. Is it dimensionless quantity ? Draw and explain the concurrent flow and counter current flow heat exchanger with (T-X) diagrams. 1+1+3=5

(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 0.20 m^2 and the rate of heat transfer from the flat surface to the fluid is 800W, calculate the convective heat transfer coefficient. 4

10. (a) A pipeline of 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 of 1m of pipe line. The temperature of the inside surface is given as 120°C. 5

(b) State and explain Stefan-Boltzmann's law of radiation. What is black body ? Express mathematically LMTD. 2+1+1=4

11. (a) Explain Vapour Compression Refrigeration Cycle. What are tons of refrigeration ? 4+1=5

(b) Prove the following relationship : 4

$(COP)_p = 1/(COP)_E = (COP)_R + 1.$

12. Estimate the convective heat transfer coefficient of a meat block being frozen between refrigerated plates with plate temperature at 30°C. It took a product 23 minutes to freeze in the plate freezer. The following data are available.

Initial freezing temperature = −2°C

Latent heat of fusion = 280 KJ/Kg

Thickness of the food product = 20 mm

Density of the food material = 880 Kg/m³

Thermal conductivity = 1.5 W/mK

Temperature of the surrounding medium = −30°C.

Consider the meat block of infinite slab where shape constants P and R are 1/2 and 1/8 respectively. 9