Total No. of printed pages = 6

19/3rd Sem/DFET302

2021

ELEMENTS OF FOOD ENGINEERING - I

Full Marks – 100

Time – Three hours

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

Answer any *five* questions.

1. (a) Write two extensive and two intensive properties of a thermodynamic system with their symbols. 2+2=4

   (b) Differentiate between open system, closed system, and isolated system with diagram. 4

   (c) Mention two thermodynamic states and path functions with their symbols. 2+2=4

   (d) How work done can be calculated from the First Law of Thermodynamics ? 4

   (e) State and explain Zeroth Law of Thermodynamics. 4

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2. (a) State and explain the First Law of Thermodynamics mathematically. 4

(b) What is specific heat ? Explain two different heat capacities and their relationship. 1+3=4

(c) A system releases 225 kJ of heat while 140 kJ of work is done by the system. Calculate the change in internal energy. 3

(d) In a non-flow process, there is a heat transfer loss of 1055kJ and an internal energy increase of 210kJ. Determine the work transfer and state whether the process is expansion or compression 3+1=4

(e) State and explain the Second Law of Thermodynamics. Describe briefly Carnot Cycle. 2+3=5

3. (a) Explain enthalpy and entropy with their mathematical expressions. 2+2=4

(b) Differentiate between reversible and irreversible processes with examples. 4

(c) Define isothermal, isobaric, isochoric, and adiabatic processes in a thermodynamic system. 4

(d) Define and explain the efficiency of heat engines. Define and explain the coefficient of performance (CoP) of the refrigerator. 2+2=4

(e) An engine operates between 727°C and 127°C. The engine's heat input is 6000 Joule. What is the efficiency of the engine and work done by the engine each cycle? 4

4. (a) State and explain Fourier's Law of heat transfer. 4

(b) How mean area of a hollow cylinder can be calculated? 4

(c) Give the mathematical expression of thermal resistance and thermal conductance. 4

(d) An interior wall of a furnace is maintained at a temperature of 900°C. The wall is 60cm thick, 1cm wide and 1.5m broad. The K value of wall material is 0.4W/mK. The temperature of the outer wall is 200°C. Determine the following : 8

(i) Heat flow through the wall

(ii) Thermal conductance to heat flow.

5. (a) A pipeline of 150/160mm diameter carries steam. The pipe is insulated with a 0.03m thick layer of material with thermal conductivity of 0.20W/mK, where the thermal conductivity of the pipe material is 50W/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 the pipeline. The temperature of the inside surface is given as 120°C. 8

(b) State and explain Stefan-Boltzmann's Law of Radiation. What is a black body? 4+2=6

(c) Explain Kirchhoff's Law with mathematical expression. 3

(d) Express mathematically LMTD. 3

6. (a) Define Nusselt number. Is it dimensionless quantity ? 2+1=3

(b) Explain any heat exchanger with a diagram. 4

(c) Graphically represent and explain the Parallel flow and Counter-current flow heat exchanger with (T-X) diagrams. 3+3=6

(d) 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 a counter-current direction and is cooled from 95°C to 85°C. Calculate the log mean temperature difference (LMTD). 7

7. (a) Prove the following relationship : 3

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

(b) Find the COP of a refrigeration system if work input is 75kJ/kg and refrigeration effect produced is 150kJ/kg of refrigerant flowing. 3

(c) Explain the different food freezing processes. 6

(d) 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= 280kJ/kg; Thickness

of the food product = 20mm; Density of the food material = 880kg/m^3; Thermal conductivity=1.5W/mK; Temperature of the surrounding medium= –30°C. Consider the meat block of the infinite slab where shape constants P and R are 1/2 and 1/8 respectively. 8