

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  $727^{\circ}\text{C}$  and  $127^{\circ}\text{C}$ . 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  $900^{\circ}\text{C}$ . The wall is 60cm thick, 1cm wide and 1.5m broad. The K value of wall material is  $0.4\text{W/mK}$ . The temperature of the outer wall is  $200^{\circ}\text{C}$ . 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

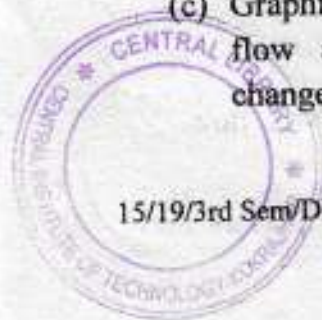
(c) Explain Kirchhoff's Law with mathematical expression. 3

(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

$$(\text{COP})_p = 1/(\text{COP})_E = (\text{COP})_R + 1.$$

(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 =  $880\text{kg/m}^3$ ; Thermal conductivity =  $1.5\text{W/mK}$ ; Temperature of the surrounding medium =  $-30^\circ\text{C}$ . Consider the meat block of the infinite slab where shape constants P and R are  $1/2$  and  $1/8$  respectively. 8

