

Time: Two (02) hours

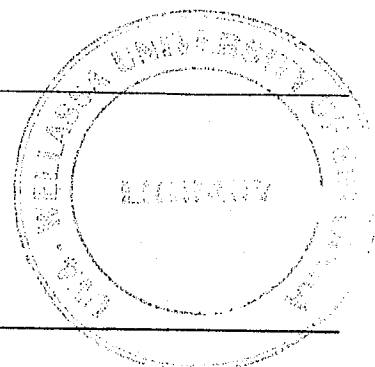
Total 04 questions

Answer all questions

Clearly state any assumptions made

You can assume any missing data

Tables of properties are provided in the exam hall



- 01) I. Briefly discuss the importance of doing material and energy balance calculations for a processing industry. (08 marks)
- II. If 5 kg of sucrose are dissolved in 20 kg of water estimate the concentration of the solution in (a) w/w, (b) w/v, (c) mole fraction, (d) molar concentration. The density of a 20% sucrose solution is 1070 kgm^{-3} , molecular weight of sucrose 342 g. (08 marks)
- III. It is convenient to add salt to butter, produced in a continuous butter making machine, by adding slurry of salt with water containing 60% of salt and 40% of water by weight. If the final composition of the butter is to be 15.8% moisture and 1.4% salt, estimate the original moisture content of the butter prior to salting. (09marks)
- 02) I. Air originally at 14°C and 70% saturation, is heated to 48°C and then passed consecutively over 2 shelves in a tray drier. In passing over each shelf the air regains its original percentage humidity but is reheated again to 48°C by heaters between the shelves. Assuming that the material on each shelf reaches the wet bulb temperature and that heat losses can be neglected, determine the temperature of the material on each shelf and the rate of removal of water if $3 \text{ m}^3\text{min}^{-1}$ of moist air enters the drier. (08 marks)
- II. Calculate the settling velocity of dust particles of (a) $60 \mu\text{m}$ and (b) $10 \mu\text{m}$ diameter in air at 21°C and 100 kPa pressure. Assume that the particles are spherical and of density 1280 kgm^{-3} , and that the viscosity of air = $1.8 \times 10^{-5} \text{ Nsm}^{-2}$ and density of air = 1.2 kgm^{-3} . (08 marks)
- III. Briefly discuss about the mechanical separation methods used in the food industry. (09 marks)

03)

- I. A U-tube manometer containing mercury (density $13,600 \text{ kgm}^{-3}$) is connected to a pipe through which water flows. The difference in height of mercury between the two legs is 55 mm. What is the pressure drop in the pipe?

(05 marks)

- II. Olive oil of specific gravity 0.92 is flowing in a pipe of 2 cm diameter. Calculate the flow rate of the olive oil, if an orifice is placed in the pipe so that the diameter of the pipe in the constriction is reduced to 1.2 cm, and if the measured pressure difference between the clear pipe and the most constricted part of the pipe is 8 cm of water.

(10marks)

- III. Calculate the pressure drop along 170 m of 5 cm diameter horizontal steel pipe through which olive oil at 20°C is flowing at the rate of $0.1 \text{ m}^3\text{min}^{-1}$. Viscosity of olive oil at $20^\circ\text{C} = 84 \times 10^{-3} \text{ Nsm}^{-2}$ and density = 910 kgm^{-3} . For streamline flow friction factor = $16/(\text{Re})$.

(10 marks)

04)

- I. An aqueous sucrose solution flowing at a velocity of 1 m/s in a 0.025 m diameter tube is heated to a mean bulk temperature of 30°C . The tube wall is at 70°C . The properties of the solution at 30°C are: $\mu = 0.0928 \text{ Nm}^{-2}\text{s}$, $c_p = 3800 \text{ Jkg}^{-1}\text{K}^{-1}$ and $k = 0.434 \text{ Wm}^{-1}\text{K}^{-1}$, $\rho = 1282 \text{ kgm}^{-3}$. At 70°C μ of water (μ_w) = $0.0388 \text{ Nm}^{-2}\text{s}$. Calculate the film heat transfer coefficient.

Data:

- $$Nu = 0.023 \text{ Re}^{0.8} \text{ Pr}^{0.33} \left(\frac{\mu}{\mu_w} \right)^{0.14}$$
- $$\text{Re} = \frac{\rho v d}{\mu}$$
- $$\text{Pr} = \frac{c_p \mu}{k}$$
- $$Nu = \frac{hD}{k}$$

(10 marks)

- II. Orange juice, flowing at 3600 kgh^{-1} , is to be pasteurized by heating it from 10°C to 80°C in a shell and tube exchanger. Water enters at 90°C and flows counter currently to the orange juice, leaving at 34°C . The heat exchanger consists of tubes 1.5 m in length and 0.026 m external diameter. If the overall heat transfer coefficient (based on the external area of the tubes) is $1700 \text{ Wm}^{-2}\text{K}^{-1}$, determine the necessary mass flow rate of water and the number of tubes required. Assume the mean heat capacity of orange juice and water to be 3.80 and 4.18 $\text{kJkg}^{-1}\text{K}^{-1}$, respectively.

(15 marks)