

INSTRUCTION: Answer ANY FOUR QUESTIONS

1. (a) What do you understand by the term "Transport phenomena"?
(b) State and discuss the three conservation laws that form the basis of transport accounting.
(c) State the law of conservation of mass in the form of a simple but generalized equation.
(d) Simplify the equation further stating your assumptions.

2. A membrane separation system is used to concentrate total solids in a liquid food from 9% to 31%. The concentration is accomplished in two stages with the first stage resulting in release of a low-total-solids liquid stream. The second stage separates the final concentration product from a low-total-solids stream, which is returned to the first stage. The recycle stream contains 2.5% total solids, the waste stream contain 0.5 % total solids and the stream between the stages 1 and 2 contains 24% total solids. The process is designed to produce 100 kg/min of 31% solids.
(a) Sketch the system.
(b) Hence or otherwise, determine the magnitude of the recycle stream.

3. Determine the amounts of lean beef, pork fat and water that must be used to make a stated quantity of frankfurter. The composition of the raw materials and frankfurter are as follows:

Lean beef: 14% fat; 67% water; 19% protein
Pork fat: 89% fat; 3% protein; 8% water
Frankfurter: 15% protein; 20% fat; 65% water

4. (a) A Food Engineer is working on the development of a new dryer. Describe how the following engineering terms relate to the machine development:
(i) model (ii) prototype (iii) actual system (iv) scale-up (v) similitude
(b) Results from experiments on a model can be applied to the prototype only if complete similarity exists between the two. Mention and briefly discuss each of these similarities.
(c) Discuss any two methods of dimensional analysis and highlight the inherent advantages and disadvantages of each of the methods.
(d) What is a non-dimensional number? Give two examples.

5. (a) State the Buckingham's Pi - theorem.

(b) Liquid flows through pipes and channels are affected by the following variables:

| Variable | Description | Units |
|----------|------------------------|---------------|
| P | Pressure drop | $M/L\Theta^2$ |
| V | Average fluid velocity | L/Θ |
| b | Slot depth | L |
| L | Slot length | L |
| w | Slot width | L |
| ρ | Fluid density | M/L^3 |
| μ | Fluid viscosity | $M/L\Theta$ |

Generate Pi - terms from the variables using the above theorem.