



**NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY**  
**DEPARTMENT OF APPLIED CHEMISTRY**  
**BACHELOR OF SCIENCE HONOURS DEGREE**  
**END OF SECOND SEMESTER EXAMINATIONS – AUGUST 2009**  
**PRINCIPLES OF PROCESS ENGINEERING – SCH 2218**  
**TIME: 3 HOURS**

**Instructions and notes to Candidates**

1. There are two sections to this paper: A and B.
  2. Answer ***all*** questions in Section A (40 marks).
  3. Answer ***any three*** questions in Section B (60 marks).
  4. Section A carries 5 questions while Section B carries 4 questions.
  5. Show all your working steps logically.
  6. Write legibly.
  7. Start answers for each question on a fresh page.
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**SECTION A (40 Marks)**

1. (a) List the three fundamental transport processes. (3 marks)  
(b) In A gas mixture contains the following components and partial pressures: CO<sub>2</sub>, 75mm Hg; CO, 50 mm Hg; N<sub>2</sub>, 595 mm Hg; O<sub>2</sub>, 26 mm Hg. Calculate the total pressure and the composition in mole fraction. (6 marks)
2. (a) What is a dimensionally homogenous equation? Give an example of a dimensionally inhomogeneous equation. (2 marks)  
(b) If sodium chloride solution, at a temperature of 40°C, has a concentration of 50% when the solubility of sodium chloride at this temperature is 36.6 g / 100 g water, calculate the quantity of sodium chloride crystals that will form once crystallization has been started. (6 marks)
3. (a) Explain what is meant by a steady state process. (2 marks)  
(b) In the concentration of orange juice, a fresh extracted and strained juice containing 7.08 wt % solids is fed to a vacuum evaporator. In the evaporator, water is removed and the solids content increased to 58 wt % solids. For 1000 kg/h entering, calculate the amounts of the outlet streams of concentrated juice and water. (6 marks)

4. (a) State the law of conservation of energy and explain why it is important in preparing heat balances. (3 marks)

(b) Complete the table below;

Process	Driving Force	Resistance
Fluid flow		Viscosity, density of fluid
Heat transfer		
	Concentration	Diffusivity
Bouyancy		Viscosity, density of fluids

(5 marks)

5. (a) Define the following terms

- (i) shear stress (2 marks)
- (ii) washing (2 marks)
- (iii) evaporation (2 marks)
- (iv) laminar flow (2 marks)

### **SECTION B (60 Marks)**

Answer ***any three*** questions. All questions carry equal marks.

6. (a) Answer any two questions.

- (i) Define:
  - 1. Evaporator economy
  - 2. Raoult's law
- (ii) Define:
  - 1. Boiling point elevation
  - 2. Reflux splitter
- (iii) Define:
  - 1. HETP
  - 2. Diffusion battery

(4 marks)

(b) With the aid of diagrams, using Webre's experiment, describe the effect of feed temperature on the economy and the evaporation in each effect for a backward feed triple effect evaporator. (12 marks)

(c) Describe the effect of impurities on crystal formation, giving examples where possible. (4 marks)

7. (a) (i) What is the difference between pasteurization and sterilization? (2 marks)
- (ii) Discuss the process of freeze-drying. In your discussion include the principles, advantages and disadvantages and industrial application of freeze drying. (8 marks)
- (b) (i) State two types of separation processes. (2 marks)
- (ii) With the aid of a diagram describe how a Bollman bucket type extractor is used in the leaching process. (8 marks)
8. (a) What is flash distillation? (3 marks)
- (b) Steam jets are used to compress the vapour in a thermal vapour compression unit. State two disadvantages steam jets. (2 marks)
- (c) Define the following terms:  
 (i) equilibrium moisture  
 (ii) free moisture  
 (iii) bound moisture (6 marks)
- (d) (i) Define leaching. (3 marks)
- (ii) Give two examples of a membrane separation process. (2 marks)
- (iii) Give four factors that may influence the rate of extraction. (4 marks)
9. (a) What are thickeners generally used for? (4 marks)
- (b) A food containing 80% water is to be dried at 100°C down to moisture content of 10%. If the initial temperature of the food is 21°C, calculate
- (i) the quantity of heat energy required per unit weight of the original material, for drying under atmospheric pressure. The latent heat of vaporization of water at 100°C and at standard atmospheric pressure is 2257 kJ kg<sup>-1</sup>. The specific heat capacity of the food is 3.8 kJ kg<sup>-1</sup> °C<sup>-1</sup> and of water is 4.186 kJ kg<sup>-1</sup> °C<sup>-1</sup>. (5 marks)
- (ii) the energy requirement/kg water removed. (5 marks)
- (c) Compare and contrast capillary theory and diffusion theory in the drying process. (6 marks)

*End of question Paper!!!*