BOWEN UNIVERSITY, IWO, OSUN STATE
COLLEGE OF AGRICULTURE, ENGINEERING AND SCIENCE
INDUSTRIAL CHEMISTRY PROGRAMME
2022/2023 B.SC DEGREE SECOND SEMESTER EXAMINATION

Course Code: ICH 218 Course Title: Process Science II
Date: 23/06/2023 Credits: 3 Time Allowed: 2½hours

INSTRUCTION: **(a) Answer at least ONE question from each section.**
(b) Answer FOUR questions in all.
(c) Answer each question on a fresh page

SECTION A

QUESTION ONE

a. What do you understand by the term **"free moisture"** in drying? **3 marks**
b. Highlight steps for the design of packed tower **7 marks**
c. In an air-carbon dioxide mixture at 298 K and 202.6 kPa, the concentration of CO_2 at two planes (3 mm) apart are 30 vol.% and 20 vol.% respectively. The diffusivity of CO_2 in air at 298 K and 202.6 kPa is 8.2×10^{-6} m^2/s. Calculate the rate of transfer of CO_2 across the two planes, assuming:
   i. Equimolecular counter diffusion. **5 marks**
   ii. Diffusion of CO_2 through a stagnant air layer. **5 marks**

QUESTION TWO

a. Describe the standard drying techniques used nowadays. **5 marks**
b. Briefly describe the major characteristics of packing. **6 marks**
c. Mention the three major classes of packing materials and give two examples of each class **9 marks**

QUESTION THREE

a. Differentiate between drying and evaporation **5 marks**
b. Briefly describe how the efficiency of a membrane is being determined **4 marks**
c. Explain how the distillation process differs between the rectifying and stripping sections. **5 marks**
d. Ammonia gas is diffusing at a constant rate through a layer of stagnant air 1 mm thick. Conditions are such that the gas contains 40 percent by volume ammonia at one boundary of the stagnant layer. The ammonia diffusing to the other boundary is quickly absorbed and the concentration is negligible at that plane. The temperature is 295 K and the pressure atmospheric, and under these conditions, the diffusivity of ammonia in air is 0.18 cm^2/s. Estimate the rate of diffusion of ammonia through the layer. **6 marks**

QUESTION FOUR

a. Differentiate between bound and unbound moisture. **5 marks**

b. Strips of material 10mm thick are dried under constant drying conditions from 28 to 13 percent moisture in 25ks (7hrs). If the equilibrium moisture content is 7 percent, what is the time taken to dry 60mm planks from 22 to 10 percent moisture under the same conditions assuming no loss from the edges? All moistures are given in a wet basis.

The relationship between E, the ratio of the average free moisture content at time t to the initial free moisture content, and the parameter J is given by

E	1	0.64	0.49	0.38	0.295	0.22	0.14
J	0	0.1	0.2	0.3	0.5	0.6	0.7

It may be noted that $J = kt / (L/2)^2$, where k is a constant, t is time in ks and L is the thickness of the sheet of material in millimeters. **15 marks**

SECTION B

QUESTION FIVE

a. Discuss the following
   i. Liquid-solid separation
   ii. Coagulation
   iii. Flocculation
   iv. Filter aids **8 marks**

b. Filtration tests were carried out with a plate and frame filter press under the following conditions:

Solids: $\rho_s = 2710$ kg m^{-1}
Liquid: water at 20°C, $\mu = 0.001$ Ns m^{-2}
Suspension: concentration c = 10 kg m^{-3}
Filter: plate and frame press, 1 frame, dimensions 430 × 430 × 30 mm

The initial stages of filtration were controlled manually before constant pressure filtration at 150000 N m^{-2} was carried out.

Using the data obtained during the filtration experiment shown in the table below, answer the following questions;

i. Calculate $\frac{t-t_s}{V-V_s}$ for each point.

ii. Plot a graph of $\frac{t-t_s}{V-V_s}$ against *V*.

iii. Evaluate the constants 'a' and 'b' using the following equation

$$\frac{t-t_s}{V-V_s} = a(V+V_s) + b$$

iv. Determine the specific cake resistance α and the medium resistance R for this test.

$10^{-5}\,\Delta p$, N m^{-2}	t, s	V, m^3	$\frac{t-t_s}{V-V_s}$, s m^{-3}
0.4	447	0.04	
0.5	851	0.07	
0.7	1262	0.10	
0.8	1516	0.13	
1.1	1886	0.16	
1.3	2167	0.19	
1.3	2552	0.22	
1.3	2909	0.25	
1.5	3381	0.28	
1.5	3686	0.30	
1.5	4043	0.32	
1.5	4398	0.34	
1.5	4793	0.36	
1.5	5190	0.38	
1.5	5652	0.40	
1.5	6117	0.42	
1.5	6610	0.44	
1.5	7100	0.46	
1.5	7608	0.48	
1.5	8136	0.50	
1.5	8680	0.52	
1.5	9256	0.54	

The frame was full of cake at $V = 0.56$ m^3.
The value of 0.30 m^3 corresponding to 3686 s was chosen as a starting point for constant pressure operation, i.e. V_s =0.3 m^3, t_s = 3686 s **12 marks**

QUESTION SIX

a. A suspension of incompressible solids at a concentration of 300 kgm^{-3} of slurry is to be filtered at constant pressure drop. Estimate the filtration area necessary to produce 50 kgh^{-1} of dry solids.
Data:

pressure drop,	$\Delta p = 10^{-5}$ N m^{-2} (1 bar)
cake moisture content,	m = 1.2
cake specific resistance,	$\alpha = 10^{11}$ m kg^{-1}
medium resistance,	$R = 6.5 \times 10^{10}$ m^{-1}
liquid density,	$\rho_l = 1000$ kg m^{-3}
solids density,	$\rho_s = 2600$ kg m^{-3}
liquid viscosity,	$\mu = 0.001$ N s m^{-2}
time,	t = 3600s

5 marks

b. Sedimentation can be done in a thickener, in a clarifier or in a classifier. State one prime function of each. **3 marks**

c. In practice, particles will not settle as perfect spheres at their terminal velocity. Mention five conditions responsible for this and how can we accelerate settling. **3 marks**

d. With the aid of a simple diagram, briefly explain the principle of FILTRATION. **3 marks**

e. In the area of solid-liquid separation techniques, a diversity of equipment is available to chemical engineers. Mention just FOUR equipment. **4 marks**

f. State the main purpose for each of the following in any separation system.

I. pre-treatment of suspension

II. post-treatment of cake OR filtrate. **2 marks**