MANICALAND STATE UNIVERSITY OF APPLIED SCIENCES

FACULTY OF ENGINEERING, SCIENCE AND TECHNOLOGY

DEPARTMENT: CHEMICAL AND PROCESSING ENGINEERING

MODULE: MASS TRANSFER PROCESSES 1B

CODE: CHEP223

SESSIONAL EXAMINATIONS
JULY 2023

DURATION: 3 HOURS

EXAMINER: ENG P. SIGAUKE

INSTRUCTIONS

1. *Answer **All** questions.*
2. *Start a new question on a fresh page.*
3. *Show all your steps clearly in your calculations.*
4. *Total marks 100.*

Additional material(s): *Graph papers, Calculator*

QUESTION 1

a) Give **two** examples of adsorption processes. [2]

b) Give **three** differences between physical and chemical adsorption. [3]

c) List and explain **three** features of a good adsorbent. [6]

d) Give **two** factors that affect adsorption and explain how each one affects adsorption. [4]

e) Langmuir isotherm is given by the equation: $\frac{C_{As}}{C_{As(max)}} = \frac{KP_A}{KP_A+1}$.

Explain the meaning of the following symbols C_{As} , $C_{As(max)}$, K, P_A [4]

f) State and explain the factors that affect efficiency of solid-liquid extraction process? [4]

g) Explain how distillation and leaching processes are connected in most chemical plants. [2]

QUESTION 2

a) Define the following terms

i. *Bound moisture* [2]

ii. *Unbound moisture* [2]

iii. *Equilibrium moisture* [2]

iv. *Free moisture* [2]

v. *Critical moisture* [2]

b) A wet solid is dried from 23 to 8 percent moisture under constant drying conditions in 15 ks (4.16 h). You are given that the critical and the equilibrium moisture contents are 13 and 2 percent respectively, how long

will it take to dry the solid from 28 to 6 percent moisture under the same conditions? [15]

QUESTION 3

a) Define the following terms

i. *Molal absolute humidity* [2]

ii. *Adiabatic saturation temperature* [3]

b) Silica gel is a common adsorbent used to dehumidify air, by adsorbing water vapour in air. The equilibrium data at 20 ℃ is given in Table 1.

Table 1

kg water/kg dry silica gel (X^*)	0	0.05	0.10	0.15	0.20
kg water/kg dry air (Y^*)	0	0.0018	0.0036	0.0050	0.0062

i. Fit this data into a Freundlich isotherm which is given by:

$X^* = \alpha(Y^*)^{1/n}$ where α and *n* are constants. [15]

ii. Calculate the values of α and *n*. [5]

QUESTION 4

Acetic acid (*C*) is to be extracted from a 45% aqueous solution using isopropyl ether (*B*) as the solvent. The feed supplied to the single stage extractor is 1000 kg. The solvent is fed to the extractor is 800 kg and contains 0.5% acetic acid. The equilibrium and tie-line data at 20 ºC are given in **Table 2**:

Table 2

Water layer (*Raffinate*)			**Ether layer (*Extract*)**		
Water	Ether	Acetic acid	Water	Ether	Acetic Acid
x_A	x_B	x_C	y_A	y_B	y_C
0.981	0.012	0.0069	0.005	0.993	0.0018
0.971	0.015	0.0141	0.007	0.989	0.0037
0.955	0.016	0.0289	0.008	0.984	0.0079
0.917	0.019	0.0642	0.01	0.971	0.0193
0.844	0.023	0.133	0.019	0.933	0.0482
0.711	0.034	0.255	0.039	0.847	0.114
0.589	0.044	0.367	0.069	0.715	0.216
0.451	0.106	0.443	0.108	0.581	0.311
0.371	0.165	0.464	0.151	0.487	0.362

a) Determine the

i. composition of the extract and raffinate phases. [5]

ii. amount of the raffinate and extract phases formed. [5]

iii. fraction of acetic acid extracted. [5]

iv. minimum amount of solvent that can be used. [5]

b) Calculate the amount of solvent required if 90% of the acetic acid is to be removed. [5]

END OF EXAMINATION
FORMULAE SHEET

$$t = \frac{Q}{R_c A}\left[\frac{f_1 - f_c}{f_c} + ln\left(\frac{f_c}{f}\right)\right]$$

$f_1 = (w_1 - w_e)$

$f_c = (w_c - w_e)$

$f = (w - w_e)$