UNIVERSITY OF FORT HARE

PHYSICAL CHEMISTRY 3 PAC 324

BSc CHEMISTRY/SUPPLEMENTARY EXAMINATIONS

JANUARY

2019

………………………………………………………………………………………

Time:	**3 HOURS**
Subject:	**PAC 324**
Marks:	**100**

This paper consists of 24 pages including the cover page

Internal Examiners
DR Z TYWABI-NGEVA

External Examiners
PROF I BAHADUR (NWU)

INSTRUCTIONS

1. **Non programmable calculators** may be used but **all working must be shown.**
2. You must write legibly in **black** or **blue** ink. **Pencils and Tipp-Ex are not allowed.**
3. This question paper consists of **24 pages** (including the cover page) and **3 questions**. Please check that you have them all.
4. Your answers must be written on the question paper in the spaces provided. The left-hand pages may be used for extra space or for rough work.
5. A **periodic table, graph paper** and a **data sheet** are provided.

University of Fort Hare

Together in Excellence

DEPARTMENT OF CHEMISTRY
UNIVERSITY OF FORT HARE, ALICE CAMPUS
PAC 324: PHYSICAL CHEMISTRY
JANUARY 2019 SUPPLEMENTARY EXAMINATION

STUDENT NO. | | | | | | | | | | | | **SEAT NUMBER:** | |

DURATION: 3 HOURS **TOTAL MARKS: 100**

External Examiner	***Internal Examiner:***
Prof I Bahadur	Dr. Z. Tywabi-Ngeva
North West University	University of Fort Hare

QUESTION NO.	**1 (44 Marks)**	**2 (18 Marks)**	**3 (38 Marks)**	**Total (100 Marks)**
INTERNAL MARK				
EXTERNAL MARK				

INSTRUCTIONS

1. **Non programmable calculators** may be used but **all working must be shown**.
2. You must write legibly in **black** or **blue** ink. **Pencils and Tipp-Ex are not allowed.**
3. This question paper consists of **24 pages** (including the cover page) and **3 questions**. Please check that you have them all.
4. Your answers must be written on the question paper in the spaces provided. The left-hand pages may be used for extra space or for rough work.
5. A **periodic table, graph paper** and a **data sheet** are provided.

QUESTION 1 (44 marks)

1.1 Describe the phase rule. (2)

1.2 Ammonium carbonate decomposes when heated.

i. State with reason how many components and phases are present when the ammonium carbonate is heated in an otherwise empty container?

ii. Now suppose that additional ammonia is also present. State with reason, how many components and phases are now present (5)

1.3 The phase diagram in **Fig. 1** is that for water (A) and 2-methyl-1-propanol (B). It is the case of a system with limited solubility in liquid state. A mixture of composition x_B =0.80 is heated following the isopleth "***a,d***". Describe, what will be observed in each of the four marked points on the isopleths, giving the number, composition, and relative amounts of the phases present (10)

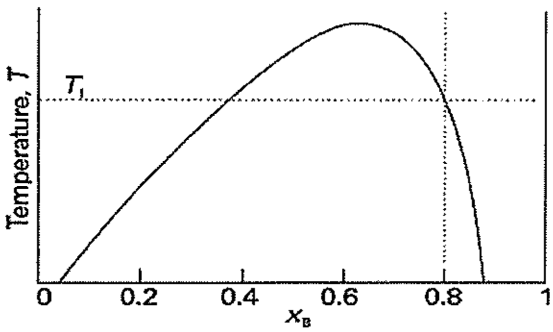


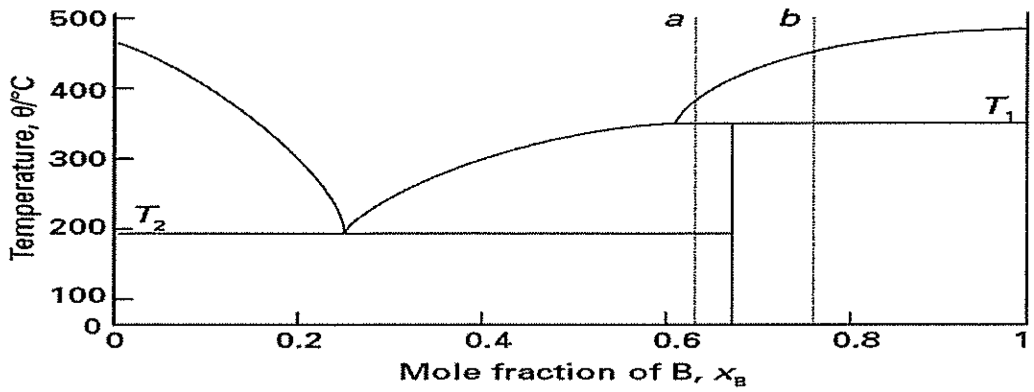
Fig.1

1.4 Calculate the melting point of ice under a pressure of 50 bar given that the melting point at 1 bar is 0°C. Assume that the density of ice under these conditions is 0.92 g/mL and the density of liquid water is 1.00 g/mL. The molar enthalpy of fusion of water is 6.01 kJ/mol. (6)

1.5 Calculate the pressure that must be applied to melt ice at -10 °C. Take the molar volumes of ice and liquid water to be 19.7 $cm^3.mol^{-1}$ and 18.0 cm3.mol^{-1}, respectively, and ΔH_{fus} =+6.008 $kJ.mol^{-1}$. (5)

1.6

Figure.1



i. Label the regions of the phase diagram in **Fig. 1** above

ii. State what substances exist in each region. Mark each phase in each region as solid, liquid, or gas.

iii. Mark the eutectic point on the diagram. What is the composition of the eutectic mixture and at what temperature does it melt? (8)

1.7 Discuss the fractional distillation.

i. Briefly explain the meaning of the term "theoretical plates" as refers to distillation.
ii. What factors determine the number of theoretical plates required to achieve a desired degree of separation in fractional distillation? (8)

Question 2 (18 marks)

2.1 The vapour pressures of two pure liquids, **M** and **N**, at 300 K is 76.7 kPa and 520 atm, respectively. The two liquids are mixed to form an ideal solution in equilibrium with its vapour. Given that the mole fraction of **M** in the vapour is 0.350, find:

i. The composition of the liquid mixture, and
ii. The total vapour pressure. Show all working clearly.
iii. The mixture described above is distilled. What will be composition of the first drop of distillate collected? (9)

2.2 Eugenol, the active ingredient in cloves, has a formula, $C_{10}H_{12}O_2$. What is the boiling point of a solution containing 0.154 g of this compound dissolved in 11.3 g of benzene? (K_{bp} = 2.53 °C m^{-1} and boiling point of benzene = 80.1 °C) (4)

2.3 Calculate the vapour pressure of a solution made by dissolving 82.4 g of Urea ($NH_2(CO)NH_2$), (molar mass of 60.06 g mol^{-1}) in 212 mL of water at 35°C (vapour pressure of water @ 35°C = 42.18 mmHg). Calculate the vapour-pressure lowering. (6)

Question 3 (38 marks)

3.1 A monolayer of N, molecules (effective area 0 .165 nm^2) is adsorbed on the surface of 1. 00 g of an Fe/Al_2O_3, catalyst at 77 K, the boiling point of liquid nitrogen. Upon warming up, when desorbed, the nitrogen occupies 2 .86 cm^3 at 0°C and 760 Torr. Determine the surface area of the catalyst (6)

3.2 The adsorption of benzene vapour on graphite at 25 °C closely follows the Langmuir isotherm, and at a pressure of 0.30 Torr, the fraction of surface covered is 0.050. The area occupied by a benzene molecule on the surface, assuming that it lies flat, is 0.30 nm^2.

a) Write down an equation of the Langmiur adsorption isotherm
b) List two assumptions on which the Langmuir adsorption model is based
c) At what pressure of benzene vapour will the surface be half-covered?
d) Calculate the specific area (m^2) of the graphite sample if 2.0 g of it has adsorbed 1.0 mmol of benzene to cover the surface completely with a monolayer. [R = 0.0821 dm^3 atm K^{-1} mol^{-1} and 1 atm = 760 Torr] (8)

3.3 The density of liquid mercury at 273 K is 13.6 g.cm^{-3} and the surface tension is 0.47 N/m, If the contact angle is 140°, calculate the capillary depression in a tube of 1 mm diameter (6)

3.4 The adsorption of solutes on solids from liquids often follows a Freundlich isotherm. Graphically check the applicability of this isotherm to the following data for adsorption of acetic acid on charcoal at 25°C, and find the values of the parameters c_1 and c_2.

[Acid]/M	0.05	0.10	0.50	1.0	1.5		
W_a/g	0.04	0.06	0.12	0.16	0.19		

[W_a = mass adsorbed per unit mass of charcoal] (14)

3.5 The values of γ_{LG} and γ_{SL} are 27.5 N.m^{-1} and 8.5 N.m^{-1} respectively for octanol and water at 20 °C, where γ_{SG} is 9.5 N.m^{-1}. With the aid of a calculation determine whether or not octanol will spread on a water surface. (4)

Periodic Table

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H 1.008																	2 He 4.003
3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc 98.91	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57* La 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89** Ac (227)	104 Db (261)	105 Jl (262)	106 Rf (263)	107 Bh (262)	108 Hn (?)	109 Mt (?)									

* Lanthanide Series	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (147)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.2	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
** Actinide Series	90 Th (232)	91 Pa (231)	92 U (238)	93 Np (237)	94 Pu (239)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (252)	99 Es (252)	100 Fm (257)	101 Md (256)	102 No (259)	103 Lr (260)

DATA SHEET

Physical Constants

Boltzmann constant	k	$= 1.381 \times 10^{-23}$ J K^{-1}
Planck constant	h	$= 6.626 \times 10^{-34}$ J s
Elementary charge	e	$= 1.602 \times 10^{-19}$ C
Speed of light in vacuum	c	$= 2.998 \times 10^{8}$ m s^{-1} $= 2.998 \times 10^{10}$ cm s^{-1}
Avogadro constant	L or N_A	$= 6.022 \times 10^{23}$ mol^{-1}
Gas constant	$R = kL$	$= 8.315$ J K^{-1} mol^{-1} $= 8.315$ L kPa K^{-1} mol^{-1} $= 0.08206$ L atm K^{-1} mol^{-1}
Molar volume of an ideal gas	V_m°	$= 22.414$ L mol^{-1} (at 1.000 atm and 273.2 K)
	V_m	$= 24.789$ L mol^{-1} (at 100.0 kPa and 298.2 K)
Faraday constant	$F = eL$	$= 9.6485 \times 10^{4}$ C mol^{-1}
Atomic mass unit (amu)	u	$= 1.661 \times 10^{-27}$ kg
Rest mass of electron	m_e	$= 9.109 \times 10^{-31}$ kg
Rest mass of proton	m_p	$= 1.673 \times 10^{-27}$ kg
Rest mass of neutron	m_n	$= 1.675 \times 10^{-27}$ kg
Vacuum permittivity	ε_o	$= 8.854 \times 10^{-12}$ J^{-1} C^{2} m^{-1}
Standard acceleration of free fall	g	$= 9.807$ m s^{-2}
Rydberg constant for the H atom	R_H	$= 109677$ cm^{-1}

Conversion Factors

1micron (μ)	$= 10^{-6}$ m $= 1$ μm
1 Ångstrom (Å)	$= 1 \times 10^{-10}$ m $= 0.1$ nm $= 100$ pm
1 L	$= 10^{-3}$ m^{3} $= 1$ dm^{3}
1 atm	$= 1.013 \times 10^{5}$ N m^{-2} $= 1.013 \times 10^{5}$ Pa $= 760$ mmHg $= 760$ torr
1 bar	$= 1.000 \times 10^{5}$ Pa
1J	$= 0.2390$ cal $= 1$ Pa m^{3} $= 1$ m^{2} kg s^{-2}
1 cal	$= 4.184$ J
1 eV	$= 1.602 \times 10^{-19}$ J
1 L atm	$= 101.3$ J
1 W	$= 1$ J s^{-1}
1 ppm	$= 1$ μg g^{-1} $=$ mg kg^{-1} $= 1$ mg L^{-1} (dilute aqueous solutions only)
1 tonne	$= 1000$ kg

Prefixes to Units

P	T	G	M	k	d	c	m	μ	n	p	f
peta	tera	giga	mega	kilo	deci	centi	milli	micro	nano	pico	femto
10^{15}	10^{12}	10^{9}	10^{6}	10^{3}	10^{-1}	10^{-2}	10^{-3}	10^{-6}	10^{-9}	10^{-12}	10^{-15}