THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

FIRST SEMESTER EXAMINATION – 2022

MP215– PHYSICAL CHEMISTRY FOR ENGINEERS

MP213 TUESDAY 7th JUNE - 12:50 PM

TIME ALLOWED: 2 HOURS

INFORMATION FOR CANDIDATES:

1. You will have 10 minutes to read the question paper. You **MUST NOT** begin writing in the answer book during this time.
2. **ANSWER ALL QUESTIONS.**
3. All answers **MUST** be written on the answer book provided.
4. Calculators are permitted in the examination room. Lecture notes, notebooks, plain papers, and textbooks are **NOT** allowed.
5. Mobile phones are not allowed. **SWITCH OFF THE MOBILE PHONES.**
6. Show all working and calculations in the answer book.
7. **DRAW any FIGURES** clearly and visibly.
8. Write your name and number clearly on the front page of the answer book. **DO IT NOW.**

MARKING SCHEME: [TOTAL: 50 MARKS]

Question 1:

(a) Mention three key features of a first order kinetic reaction.

[3 marks]

(b) The following rates of reactions were obtained in FOUR experiments for the reaction $2A + 2B + C \rightarrow D + 3E$

Experiment	Initial [A] (mol/L)	Initial [B] (mol/L)	Initial [C] (mol/L)	Initial Rate Ms^{-1}
1	0.024	0.085	0.032	6.0×10^{-6}
2	0.096	0.085	0.032	9.6×10^{-5}
3	0.024	0.034	0.080	1.5×10^{-5}
4	0.012	0.170	0.032	1.5×10^{-6}

(i) Using a simple calculation, deduce the order of the reaction with respect to specie A. Show your deduction very clearly.

[2 marks]

(ii) As in (b) (i) above, deduce the order of the reaction with respect to specie B. Show your deduction very clearly.

[2 marks]

(iii) As in (b) (i) above, deduce the order of the reaction with respect to specie C. Show your deduction very clearly.

[2 marks]

(iv) From your results in (b) (i), (ii), (iii), write the full rate law for the reaction.

[1 mark]

(v) From (b) (iv) above, calculate the rate constant, k, for the reaction.

[2 marks]

(TOTAL: 12 MARKS)

GO TO THE NEXT PAGE FOR QUESTION 2

Question 2:

Consider the industrial reaction $CO(g) + H_2O(g) \leftrightarrow CO_2(g) + H_2(g)$. Engineers use the extent of the change from CO and H_2O to CO_2 and H_2 to regulate the proportions of synthetic fuel mixtures in the industrial reaction.

(a) If 0.250 mol of CO and 0.250 mol of H_2O gases are placed in a 125 mL Flask at 900 K, what is the equilibrium concentration of each specie in the reaction above? We are given that at 900 K the K_c for the reaction is 1.56. [Hint: You must set up an ICE table to be able to perform these calculations].

[12 marks]

(b) Based on information obtained on the reaction in (a) above, would you consider the reaction good enough for economic investment if H_2 gas is the fuel of interest? Why?

[3 marks]

(TOTAL: 15 MARKS)

Question 3:

Use the thermodynamic data presented in the table below to calculate $\Delta S°$ for the reaction: $NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$. All data are at 298 K. Show all calculations clearly.

	ΔH_f^o (kJ/mol)	ΔG_f^o (kJ/mol)
$NH_3(g)$	-46.11	-16.48
$HCl(g)$	-92.31	-95.30
$NH_4Cl(s)$	-314.4	-202.9

(TOTAL: 5 Marks)

GO TO THE NEXT PAGE FOR QUESTION 4

Question 4:

Consider the thermodynamic data below and use the data for parts (a), (b) and (c) below:

	ΔH_f^o (kJ/mol)	ΔG_f^o (kJ/mol)
$N_2O_4(g)$	9.16	97.89
$O_2(g)$	0	0
$N_2O_5(g)$	11.3	115.1

(a) Calculate ΔG^o at 298 K for the reaction, $2N_2O_4(g) + O_2(g) \rightarrow 2N_2O_5(g)$.

(b) Calculate K_p at 298 K for the reaction in (a) above. [R = 8.314 J/mol/K; $\Delta G^o = -RT\ln K_p$]

(b) Overall, is the reaction feasible? Why?

(TOTAL: 6 MARKS)

GO TO THE NEXT PAGE FOR QUESTION 5

Question 5:

(a) You are a Mineral Processing Engineer who has processed a mineral ore of Silver and converted the Silver present in the ore into Silver ions ($\underline{Ag^+}$) in aqueous solution, but the aqueous solution ends up with large quantities of $\underline{Ca^{2+}}$ and $\underline{Mg^{2+}}$ as impurities because of Ca and Mg present in the original ore from the earth's crust. Also, you have access to information in the table presented below:

Chemical Substance	**Solubility Product, K_{sp}**
Calcium phosphate, $Ca_3(PO_4)_2$	1.2×10^{-29}
Magnesium phosphate, $Mg_3(PO_4)_2$	5.2×10^{-24}
Silver phosphate, Ag_3PO_4	2.6×10^{-18}

You are advised by a Chemist to add aqueous Phosphoric acid, H_3PO_4, to the aqueous processed ore mixture while stirring to cause selective precipitation.

(i) Which of the ions in the aqueous solution from the processed aqueous ore will precipitate first on addition of aqueous H_3PO_4? Why?

[3 marks]

(ii) Which of the ions will precipitate next with addition of H_3PO_4? Why?

[3 marks]

(b) Given that the Ksp of Ag_2S is 8.0×10^{-48} calculate the molar solubility of Ag_2S in pure water.

[6 marks]

(TOTAL: 12 MARKS)

----------THE END. ----------