THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

FIRST SEMESTER EXAMINATION – 2022

CH211 – APPLIED PHYSICAL CHEMISTRY

FRIDAY 10th 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 Second 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 0.500 mol of CO and 0.500 mol of H_2O gases are placed in a 250 mL flask at 900 K. When equilibrium is achieved, what concentration of each specie will be present in the reaction vessel? You are given that at 900 K the K_c for the reaction is 1.56.

[12 marks]

(b) As a Chemist you proposed that increasing pressure will favour the production of more $H_2(g)$ as the key fuel of interest. Must a company invest in a high-pressure chemical plant for this industrial process?

[3 marks]

(TOTAL: 15 MARKS)

Question 3:

Use the thermodynamic data presented in the table below to calculate ΔS° Universe for the reaction: $PCl_3(g) + Cl_2(g) \rightarrow PCl_5(g)$. All data are at 298 K.

Show all calculations clearly. [ΔS°(universe) = ΔS°(surrounding) + ΔS°(system)]

	ΔH_f^o (kJ/mol)	ΔG_f^o (kJ/mol)
$PCl_3(g)$	-287	-268
$Cl_2(g)$	0	0
$PCl_5(g)$	-402	-323

(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) Calculate K_c for the reaction at 298 K? [$K_p = K_c(RT)^{\Delta n}$]

(TOTAL: 6 MARKS)

GO TO THE NEXT PAGE FOR QUESTION 5

Question 5:

(a) You are an Industrial Chemist in charge of a municipal wastewater plant. You have found the wastewater to contain lots of the following ions:
Cadmium (Cd^{2+}), Nickel (Ni^{2+}), Manganese (Mn^{2+}), and Calcium (Ca^{2+}).
These ions need to be removed by selective precipitation (one ion precipitating at a time) using aqueous NaOH to precipitate them as hydroxides. Therefore, you found the following information presented in the table below.

Chemical Substance	**Solubility Product, K_{sp}**
Calcium hydroxide, $Ca(OH)_2$	6.5×10^{-6}
Cadmium hydroxide, $Cd(OH)_2$	7.2×10^{-15}
Nickel (II) hydroxide, $Ni(OH)_2$	6.0×10^{-16}
Manganese (II) hydroxide, $Mn(OH)_2$	1.6×10^{-13}

(i) Which of the ions in the wastewater will precipitate first on addition of the aqueous NaOH? Why?

[3 marks]

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

[3 marks]

(b) Given that the Ksp of $Ca_3(PO_4)_2$ is 1.2×10^{-29} calculate the molar solubility of $Ca_3(PO_4)_2$ in pure water.

[6 marks]

(TOTAL: 12 MARKS)

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