NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF APPLIED SCIENCES

DEPARTMENT OF APPLIED CHEMISTRY

PHYSICAL CHEMISTRY FOR CHEMICAL ENGINEERS

SCH1120

Supplementary Examination Paper

August 2015

This examination paper consists of 4 pages

Time Allowed: 3 hours

Total Marks: 100

Examiner's Name: Dr. Stephen Majoni

INSTRUCTIONS

1. Answer ALL questions
2. Each question carries 25 marks

MARK ALLOCATION

QUESTION	MARKS
1.	**25**
2.	**25**
3.	**25**
4.	**25**
TOTAL	**100**

1. (a) The equilibrium constant for the reaction A+B →2C is reported as 3.4×10^4.

   What would it be for the reaction written as: [10 marks]

   i) $2\,C \rightarrow A + B$,

   ii) $2\,A + 2\,B \rightarrow 4\,C$,

   iii) $^1/_2\,A + {}^1/_2\,B \rightarrow C$?

   (b) Discuss how molar conductivities can be used to differentiate different classes of electrolytes. [10 marks]

   (c) Calculate the ionic strength in a solution that is 0.0750 *m* in K_2SO_4, 0.0085 m in Na_3PO_4, and 0.0150 m in $MgCl_2$. [5 marks]

2. (a) Using the Debye-Hückel limiting law given below, calculate the mean ionic activity coefficient in a 0.00225 m solution of $CaHPO_4$.

   $$\log \lambda_{\pm} = -0.5092\left|z_{+}z_{-}\right|\sqrt{I}$$ [5 marks]

   (b) The following data were obtained for the reaction A + B + C → *products*:

Experiment	**$[A]_0$**	**$[B]_0$**	**$[C]_0$**	**Initial rate/ $molL^{-1}\,s^{-1}$**
1	1.25 x 10^{-3} M	1.25 x 10^{-3} M	1.25 x 10^{-3} M	0.0087
2	2.50 x 10^{-3} M	1.25 x 10^{-3} M	1.25 x 10^{-3} M	0.0174
3	1.25 x 10^{-3} M	3.02 x 10^{-3} M	1.25 x 10^{-3} M	0.0508
4	1.25 x 10^{-3} M	3.02 x 10^{-3} M	3.75 x 10^{-3} M	0.457
5	3.01 x 10^{-3} M	1.00 x 10^{-3} M	1.15 10^{-3} M	?

   (c) Write the rate law for the reaction. Explain your reasoning in arriving at the rate law.

d) What is the overall order of the reaction?

e) Determine the value of the rate constant.

f) Use the data to predict the reaction rate for experiment 5. [20 marks]

3. (a) A student gets the following results in a kinetic experiment. After studying the curve of the graph of concentration versus time, she declares that the reaction is second order, with a corresponding rate law of $Rate = k[A]^2$. Is she correct in her statement that the reaction must be second order? If she is wrong what is the order of reaction and the rate constant. Data collected from her experiment is shown below:

Time (s)	**[A]/M**
0.0	1.0
1.0	0.14
3.0	4.9×10^{-3}
7.0	6.5×10^{-6}
9.0	1.3×10^{-7}

[12 marks]

(b) The data below relates to the adsorption of carbon monoxide on charcoal at 273K. Confirm that they fit the Langmuir isotherm, and determine:

(i) The constant k.

(ii) The volume corresponding to complete coverage.

In each case V has been corrected to 1 atm.

P/Torr	100	200	300	400	500	600	700
V/cm^3	10.3	19.3	27.3	34.1	40.0	45.5	48.0

[13 marks]

4. (a) The mean activity coefficients of HBr in 5.0 and 20.0 mmol kg^{-1} are 0.930 and 0.879 respectively. Consider a hydrogen electrode in HBr(aq) solution at 25 °C operating at 1.15 atm.

Calculate the change in the electrode potential when the molality of the acid solution is changed from 5.0 and 20.0 mmol kg^{-1}. [6 marks]

(b) Given that for the Langmuir isotherm the fractional coverage is given by:

$\theta = \frac{KP}{KP+1}$ and also $\theta = \frac{V_{ad}}{V_M}$; show that θ can be expressed as $\frac{1}{V_{ads}} = \left(\frac{1}{KV_m}\right)\frac{1}{P} + \frac{1}{V_m}$

[6 marks]

(c) For a second order reaction represented by the rate equation rate $= k[A]^2$. Show that at constant temperature;$t_f = \frac{1}{k} \times \frac{f}{(1-f)[A]_o}$; Where ($t_f$) is the time taken for a given fraction (f) of the reactant, A, to react. And hence give the expression for the half-life. [8 marks]

End of Question Paper!!!