



NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF APPLIED SCIENCES

DEPARTMENT OF APPLIED CHEMISTRY

PHYSICAL CHEMISTRY FOR ENGINEERING

SCH1120

First Semester Examination Paper

December 2016

This examination paper consists of 5 pages

Time Allowed: 3 hours

Total Marks: 100

Examiner's Name: Dr. S. Majoni

INSTRUCTIONS

1. Answer ALL questions in section A and any three (3) questions in section B
2. Each question in section A carries 10 marks and in section B carries 20 marks

ADDITIONAL INFORMATION

1. $R=8.314 \text{ JK}^{-1} \text{ mol}^{-1}$
2. $1 \text{ bar} = 1.0 \times 10^5 \text{ Pa}$
3. $1 \text{ atm} = 101325 \text{ Pa}$

MARK ALLOCATION

QUESTION	MARKS
A1.	10
A2.	10
A3.	10
A4.	10
B1	20
B2	20
B3	20
B4	20
TOTAL POSSIBLE	100

SECTION A:

- 1) At 25 °C, a 0.10 M KCl solution has a conductance (G) of 0.01178 S and molar conductivity of 128.96 S cm² mol⁻¹.
- a) Explain what is meant by the term “calibration of a conductance cell” and discuss its importance in conductivity measurements [3 Marks]
 - b) Find the cell constant for the conductance cell [3 Marks]
 - c) Using the above cell, the conductance of a 0.050 M solution of an electrolyte was measured to be 0.00824 S, what is the molar conductivity of the electrolyte? [4 Marks]
- 2) a) The oxidation of gaseous nitrogen can occur via the following reaction
 $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$. Given that
 $\Delta_r G^\circ$ for the reaction at 298 K = 173.4 kJ mol⁻¹
- i) Write down the equilibrium constant expression for the reaction. [1 Mark]
 - ii) Calculate $\Delta_f G^\circ$ for NO at 298 K [3 Marks]
 - iii) Calculate the thermodynamic equilibrium constant of the reaction at 298 K [3 Marks]
- b) Complete the table below. In cell reaction column state whether the cell reaction is spontaneous, non-spontaneous, or at equilibrium. [3 Marks]

E	ΔG	Cell reaction
>0		
	>0	
=0		

- 3) Determine the ionic strength of each of the following solutions
- a) 0.15 m KCl [1 Mark]
 - b) 0.15 m Na₂C₂O₄ [2 Marks]
 - c) 0.15 m CdCl₂ [2 Marks]
 - d) A mixture containing 0.15 m CdCl₂ and 0.15 m KCl [2 Marks]
 - e) The resultant solution formed by adding 15mL of a 0.15 M HCl solution to 25 mL of a 0.125 M NaOH solution. [3 Marks]

4) a) With the aid of a diagram discuss how a catalyst functions. [6 marks]

b) Two catalysts, catalyst A and catalyst B, are compared for their catalytic activity for the reaction $R \rightarrow P$. When catalyst A is present it takes 12.1 seconds for R to change from 2 to 0.5 moles and when catalyst B is present it takes 20 seconds for R to decrease from 5 to 2.5 moles at the same temperature and with the same quantities of catalyst.

Which is the more effective catalyst for the reaction concerned? [4 marks]

SECTION B:

- 1) A mixture consisting of 10 mol of CO (g), 1.0 mol H₂ (g) and 0.1 mol CH₃OH (g) at 300K is passed over a catalyst in a reactor at a total pressure = 11.1 bar. Given that $\Delta_R G^0$ for the reaction = 22.0 kJ mol⁻¹:

a) Evaluate whether the product is being produced in the reaction presented below.

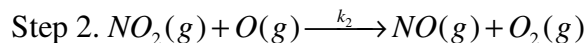
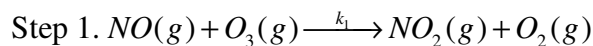


b) Evaluate the effects of doubling (i) the reaction pressure and (ii) the reaction temperature. [8 Marks]

c) At what temperature is the reaction at equilibrium for conditions of pressure and composition in “1 a” and “1 b” [5 marks]

d) Evaluate the equilibrium constants for the temperatures in 1 c above? [2 Marks]

- 2) It has been postulated that the catalytic decomposition of ozone occurs via the following steps:

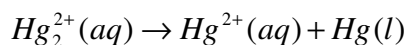


a) Write down the overall reaction, identify (if any) the catalyst(s) and intermediate(s). [5 Marks]

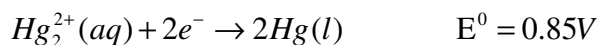
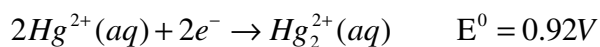
b) Using steady state approximation, show that the rate law can be obtained by using any of the species involved in the chemical reaction. [12 Marks]

c) In view of the above reaction, discuss measure that have been put in place to minimize the impacts of the identified catalyst in “a” above. [3 Marks]

- 3) a) Calculate ΔG^0 and K for the disproportionation reaction given below. [5 Marks]



Given the following data



- b) In a study of the reaction of pyridine (C_5H_5N) with methyl iodide (CH_3I), in a benzene solution the following set of initial reaction rates were measured at $25^\circ C$ for the different initial concentrations of the two reactants.

$[C_5H_5N]$ ($mol\ L^{-1}$)	$[CH_3I]$ ($mol\ L^{-1}$)	Rate ($mol\ L^{-1}\ s^{-1}$)
1.0×10^{-4}	1.0×10^{-4}	7.5×10^{-7}
2.0×10^{-4}	1.0×10^{-4}	3.0×10^{-6}
2.0×10^{-4}	3.0×10^{-4}	9.0×10^{-6}

- i) Determine the rate expression for this reaction. [8 marks]
- ii) What is the overall order of reaction? [1 marks]
- c) Define the terms triple point and critical point, and using relevant diagrammes explain what happens when a solid is heated at a pressure which is lower than its triple point. [6 marks]
- 4) a) Slow cookers are devices which cook food slowly. Discuss their principle of operation given that the rate of cooking food increases with cooking temperature. [7 marks]
- b) Discuss why it is common practice in countries where snow is a common occurrence for the road maintenance departments to spray salt on roads covered by snow. [8 marks]
- c) One of the assumptions of the Langmuir adsorption isotherm relates to monolayer coverage, discuss what this means and list the other assumptions. [5 marks]

END OF QUESTION PAPER!!!