

NOV 2023

BINDURA UNIVERSITY OF SCIENCE EDUCATION
SCIENCE AND MATHEMATICS EDUCATION DEPARTMENT
DIPLOMA IN SCIENCE EDUCATION

COURSE: DC003/DCH005 PHYSICAL CHEMISTRY

TIME

2 HOURS

ANSWER QUESTION 1 AND TWO QUESTIONS FROM SECTION A AND TWO OTHER QUESTIONS FROM SECTION B. EACH QUESTION CARRIES 20 MARKS

- 1 (a) Define the following terms:
- (i) pOH.
 - (ii) Homogeneous catalysis.
 - (iii) Half-life.
 - (iv) Rate determining step. [4x2 marks]
- (b) Identify the oxidizing and reducing agent in the following reactions:
- (i) $2\text{Fe}^{3+} + 3\text{Ca} \longrightarrow 3\text{Ca}^{2+} + 2\text{Fe}$ [2 marks]
 - (ii) $\text{Cl}_2 + 2\text{Na} \longrightarrow 2\text{Na}^+ + 2\text{Cl}^-$ [2 marks]
- (c) Write expressions that correspond to the following;
- (i) Solubility product (K_{sp}) for barium hydroxide, $\text{Ba}(\text{OH})_2$. [3 marks]
 - (ii) pK_a for the following reaction

$$\text{HA} \rightleftharpoons \text{H}^+ + \text{A}^-$$
 [3 marks]
 - (iii) pK_w [2 marks]

SECTION A: ANSWER ANY TWO QUESTIONS

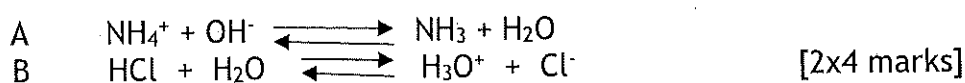
- 2 A canister of gas, of the type used in camping stoves, contains mainly butane, ($\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$) under sufficient pressure to cause it to liquefy partially.
- (a) (i) What do you understand by the term ideal gas? [3 marks]
- (ii) State the conditions for ideality [2 marks]
- (iii) To which group of organic compounds does butane belong to? [1 mark]
- (iv) What type of intermolecular forces exist between the molecules of butane? [2 mark]
- (b) Would you expect the gas in the canister to behave ideally? Explain. [3 marks]
- (c) Describe how increasing the pressure on a gas can sometimes cause it to liquefy. [3 marks]

- (d) 0.23 g of a gas took up 149.0 cm^3 at 363 K and $1.01 \times 10^5 \text{ Pa}$.
Use the general gas equation $PV = nRT$ to calculate the average M_r of the gas. [3 marks]
- (e) Suggest a reason why ethane (CH_3CH_3) is a better option than butane for gas stoves in cold climates. [3 marks]
- 3 (a) Use the examples given in brackets to illustrate what is meant by the following terms:
- (i) Standard enthalpy change of combustion (CH_3OH). [2 marks]
 - (ii) Standard enthalpy change of formation (CH_3CH_3). [2 marks]
 - (iii) Standard enthalpy change of atomisation (Al_2O_3). [2 marks]
 - (iv) Standard enthalpy change of solution (NaCl). [2 marks]
- (b) (i) Define Hess' law. [2 marks]
- (ii) Construct the Born Haber cycle for magnesium oxide (MgO). [8 marks]
- (iii) Explain why the 2nd electron affinity of oxygen is positive. [2 marks]
- 4 (a) By means of a diagram show how you would use the standard hydrogen electrode, (SHE), to measure the standard electrode potential of the $\text{Cu}^{2+}(\text{aq}) / \text{Cu}(\text{s})$ system. [6 marks]
- (b) Explain how the following factors affect the nature of the product discharged at the electrodes during electrolysis:
- (i) Nature of electrode. [3 marks]
 - (ii) Concentration. [3 marks]
- (c) With the aid of a well labelled diagram, show how the electrolysis of water is carried out. Your answer should include the following:
- Electrodes used
 - The electrolyte used and products
 - Electrode reactions [8 marks]

SECTION B: ANSWER ANY TWO QUESTIONS.

5. (a) Explain the meanings of the following terms;
- (i) Weak base [2 marks]
 - (ii) Strong acid [2 marks]
 - (iii) Amphoteric compound [2 marks]

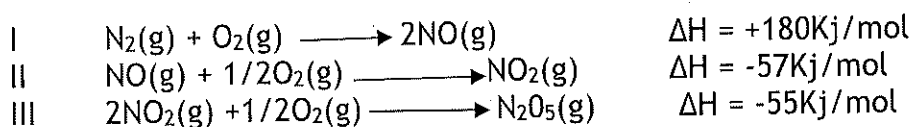
(b) Identify the conjugate acid-base pairs in the following reactions:



(c) Outline the manufacture of ammonia by the Haber process paying particular attention to reaction conditions and how they affect yield. [6 marks]

- 6 (a) (i) Draw a diagram to show how you would measure the standard cell potential of an electrochemical cell containing $\text{Cl}_2(\text{g})/\text{Cl}^-$ and $\text{Na}^+(\text{aq})/\text{Na}(\text{s})$. [6 marks]
 (ii) Calculate the standard cell potential of this electrochemical cell. [3 marks]

(b) Dinitrogen pentoxide, (N_2O_5), can be produced by the following sequence;



- (i) Explain why reaction I occurs in car engines. [2 marks]
 (ii) Suggest why reaction I is endothermic. [3 marks]
 (iii) Write an equation that corresponds to the standard enthalpy change of formation of N_2O_5 . [2 marks]
 (iv) Use the data given above to calculate the enthalpy of formation of N_2O_5 . [4 marks]

7. (a) Use the data in the following table to find:
 (i) Order of reaction with respect to L and M. [2 marks]
 (ii) Overall order of reaction. [1 mark]
 (iii) Rate expression. [2 marks]
 (v) A value for the rate constant, (k) including the units. [2 marks]

Experiment No.	Concentration		Rate of loss of L $\text{mol.dm}^{-3}/\text{s}$
	[L] / mol.dm^{-3}	[M] / mol.dm^{-3}	
1	0.20	0.10	1.6×10^{-7}
2	0.30	0.10	1.6×10^{-7}
3	0.40	0.40	6.4×10^{-7}

- (b) For the following reaction;



Draw an energy profile diagram to show how the activation energy, (E_a), varies for a catalyzed and uncatalyzed reaction.

[4 marks]

- (c) What do you understand by the following terms?

(i) Homogeneous catalysis.

(ii) Enzyme.

[2x2 marks]

- (d) Draw a Maxwell-Boltzmann distribution curve to show the effect of a catalyst on the rate of a chemical reaction

[5 marks]

END OF PAPER