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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

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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) $2Fe^{3+} + 3Ca \longrightarrow 3Ca^{2+} + 2Fe$ [2 marks]
(ii) $Cl_2 + 2Na \longrightarrow 2Na^+ + 2Cl^-$ [2 marks]

(c) Write expressions that correspond to the following;
(i) Solubility product (K_{sp}) for barium hydroxide, $Ba(OH)_2$. [3 marks]
(ii) pK_a for the following reaction
$HA \rightleftharpoons H^+ + A^-$ [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, ($CH_3CH_2CH_2CH_3$) 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 x 10^5 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 $Cu^{2+}(aq)$ / Cu(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:

A $NH_4^+ + OH^- \rightleftharpoons NH_3 + H_2O$

B $HCl + H_2O \rightleftharpoons H_3O^+ + Cl^-$ [2x4 marks]

(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 $Cl_2(g)/Cl^-$ and $Na^+(aq)/Na(s)$. [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 $N_2(g) + O_2(g) \longrightarrow 2NO(g)$ $\Delta H = +180Kj/mol$

II $NO(g) + 1/2O_2(g) \longrightarrow NO_2(g)$ $\Delta H = -57Kj/mol$

III $2NO_2(g) + 1/2O_2(g) \longrightarrow N_2O_5(g)$ $\Delta H = -55Kj/mol$

(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 $mol.dm^{-3}/s$
	[L] / mol/dm^3	[M] / mol/dm^3	
1	0.20	0.10	$1.6x10^{-7}$
2	0.30	0.10	$1.6x10^{-7}$
3	0.40	0.40	$6.4x10^{-7}$

(b) For the following reaction;

$$A + B \longrightarrow C + D \qquad \Delta H < 0$$

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