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

COURSE: DC003/DCH005 PHYSICAL CHEMISTRY

Time 2 HOURS

ANSWER QUESTION ONE AND TWO QUESTIONS FROM SECTION A AND ANOTHER TWO QUESTIONS FROM SECTION B. EACH QUESTION CARRIES 20 MARKS

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1 (a) Define the following terms:

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(i) Ideal gas
(ii) Ionic product of water (K_w)
(iii) Autocatalysis
(iv) Rate determining step
(v) Activation energy [5x2 marks]

(b) Calculate pH for the following solutions:
(i) 0.1 M HNO_3 [2 marks]
(ii) 0.1 M H_2SO_4 [3 marks]
(iii) 0.1 M KOH [3 marks]

(c) Describe the function of a salt bridge in an electrochemical cell. [2 marks]

SECTION A: ANSWER ANY TWO QUESTIONS

2 (a) TNT ($C_7H_5N_3O_6$) is used as an explosive and it decomposes according to the following equation:

$$2\ C_7H_5N_3O_6(s) \longrightarrow 7CO(g) + 7C(s) + 5H_2O(g) + 3N_2(g)$$

(i) Calculate the M_r of TNT. [2 marks]
(ii) Calculate the number of moles in 27 g of TNT. [3 marks]
(iii) How many moles of gas are produced from one mol of TNT? [3 marks]
(iv) Given that Vm at 500 ^{0}C and 1 atm is 57 dm^3, calculate the volume of gas produced from 27 g of TNT at this temperature and pressure. [6 marks]

(b) Construct a well labelled heating curve diagram for substance R which boils at 40 ^{o}C and melts at 10 ^{o}C. [6 marks]

3 (a) Use the examples given in brackets to write equations that illustrate what is meant by the following terms:

(i) Standard enthalpy change of combustion (C_6H_6). [2 marks]
(ii) Standard enthalpy change of formation (H_2SO_4). [2 marks]
(iii) Standard enthalpy change of atomisation (P_4). [2 marks]

(b) Construct a Born Haber cycle for the formation of sodium chloride, NaCl. [7 marks]

(c) Define the following terms:

(i) Endothermic reaction. [2 marks]
(ii) Exothermic reaction. [2 marks]

(d) Construct an energy profile diagram for an endothermic reaction. [3 marks]

4 (a) Explain how the following factors affect the nature of the product discharged at the electrodes during electrolysis;

(i) Concentration. [3 marks]
(ii) Nature of the electrode. [3 marks]

(b) Give an outline of the electrolysis of brine using a diaphragm cell. [8 marks]

(c) Use appropriate data from the Data Booklet to predict the feasibility of the following chemical reactions;

(i) $Cu(s) + 2V^{3+}(aq) \longrightarrow Cu^{2+}(aq) + 2V^{2+}(aq)$ [3 marks]
(ii) $2K^{+}(aq) + Pb(s) \longrightarrow 2Na(s) + Pb^{2+}(aq)$ [3 marks]

SECTION B: ANSWER ANY TWO QUESTIONS.

5. (a) Define the following terms:

(i) Position of equilibrium. [2 marks]
(ii) Reversible reaction. [2 marks]
(iii) Dynamic equilibrium. [2 marks]

(b) The key stage in the manufacture of nitric acid (HNO_3) is the reaction of ammonia with air in the presence of a platinum-rhodium catalyst.

$$4NH_3(g) + 5O_2(g) \longrightarrow 4NO(g) + 6H_2O(g)$$

(i) Calculate the oxidation number of N in NH_3 and NO[2marks]

(ii) Use the enthalpy changes of formation given below to calculate the enthalpy change of reaction for the above reaction. [5 marks]

	$\Delta H_{(formation)}$kJ/mol
NH_3	-52
H_2O	-242
NO	+120

(iii) Suggest with explanations what would be the optimum industrial conditions of temperature and pressure for the reaction. [6 marks]

(c) It is said that the air used for this reaction has to be cleaner than in a hospital operating theatre. Suggest a reason for this. [1 mark]

6 (a) (i) Write an equation corresponding to the standard enthalpy of combustion of hydrogen (H_2). [3 marks]

(ii) Given that the standard enthalpy change of formation of water is -286 kJ/mol, what is the standard enthalpy change of reaction for the following reaction? [3 marks]

$$2H_2O(l) \longrightarrow 2H_2(g) + O_2(g)$$

(b) (i) What do you understand by the term anodizing aluminium? [3 marks]

(ii) What is its importance? [2 marks]

(c) Both aluminium fluoride (AlF_3) and aluminium chloride ($AlCl_3$) sublime when heated, (i.e. they change directly from solid to gas and to solid again). AlF_3 sublimes at 1270 °C and $AlCl_3$ sublimes at 178 °C.

(i) What do these figures suggest about the nature of bonding in each of the two compounds? [4 marks]

(ii) In light of your answer to c(i), draw dot and cross diagrams for the two compounds. [2+3 marks]

7. (a) The decomposition of sulphur trioxide is reversible and endothermic.

$$2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g) \quad \Delta H > 0$$

Describe how increasing each of the following factors would affect the rate of reaction:

(i) Pressure. [3 marks]

(ii) Temperature. [3 marks]

(b) Draw a concentration - time graph to illustrate the half-life of a first order reaction. [2 marks]

(c) Use data in the following Table to find answers to the questions that follow.

Experiment No.	Concentration		Rate of loss of W $mol.dm^{-3}/s$
	[W] in mol/dm^3	[X] in mol/dm^3	
1	0.010	0.010	1×10^{-5}
2	0.010	0.030	1×10^{-5}
3	0.030	0.030	9×10^{-5}

(i) Order of reaction with respect to W and X. [2 marks]

(ii) Overall order of reaction. [1 mark]

(iii) Rate expression. [2 marks]

(iii) A value for the rate constant, (k) including the units. [3 marks]

(d) Draw a Boltzmann distribution curve to show the effect of a catalyst on the rate of a chemical reaction. [4 marks]

END OF PAPER