FORM TP 2005179

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MAY/JUNE 2005

CARIBBEAN EXAMINATIONS COUNCIL

ADVANCED PROFICIENCY EXAMINATION

CHEMISTRY

UNIT 2 – PAPER 01

1 hour 45 minutes

Candidates are advised to use the first 15 minutes for reading through this paper carefully. Writing may begin during this time.

READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of NINE questions.
2. There are THREE questions from each Module. Answer ALL questions.
3. Write answers in this booklet.
4. ALL working must be shown in this booklet.
5. The use of non-programmable calculators is permitted.
6. A Data Booklet is provided.

MODULE 1

Answer ALL questions.

1. (a) Explain how the following factors may affect the rate of a chemical reaction:

(i) Surface area

_____

_____

_____

[2 marks]

(ii) Catalysts

_____

_____

_____

[2 marks]

(b) The reaction between peroxodisulphate ($S_2O_8^{2-}$) and iodide (I^-) ions yields the species I_3^- in accordance with the following equation:

$$S_2O_8^{2-} + 3\,I^- \rightarrow 2SO_4^{2-} + I_3^-$$

Table 1 gives some experimental data from an investigation of the rate of reaction between peroxodisulphate ions and iodide ions. The rate equation can be represented as Rate = $k\,[S_2O_8^{2-}]^m\,[I^-]^n$.

TABLE 1: EXPERIMENTAL DATA FOR THE REACTION BETWEEN $S_2O_8^{2-}$ and I^-

Experiment number	Initial concentrations (mol dm^{-3})		Initial rate of reaction (mol dm^{-3} s^{-1})
	$[S_2O_8^{2-}]$	$[I^-]$	
1	0.05	0.10	$R_1 = 1.5 \times 10^{-5}$
2	0.10	0.10	$R_2 = 3.0 \times 10^{-5}$
3	0.10	0.05	$R_3 = 1.5 \times 10^{-5}$

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Use the data in Table 1 on page 2 to determine EACH of the following:

(i) The order of reaction with respect to both $S_2O_8^{2-}$ and I^-

[4 marks]

(ii) The overall order of the reaction

_____

_____

[2 marks]

Total 10 marks

2 (a) State Le Châtelier's principle.

_____

_____

[2 marks]

(b) Using the equation, $2\ SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$, explain the effect of EACH of the following on the equilibrium system:

(i) Change in pressure

_____

_____

_____

[2 marks]

(ii) A catalyst

[4 marks]

(c) The equation for the decomposition of limestone can be represented as:
$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$.

(i) Write the equilibrium constant for this system in terms of partial pressures.

[1 mark]

(ii) What is the effect on the equilibrium system of adding a small quantity of solid calcium carbonate?

[1 mark]

Total 10 marks

3. Gypsum ($CaSO_4 \cdot 2H_2O$) is a common calcium mineral that is found worldwide. It is slightly soluble in water, and ground water that is in contact with gypsum often contains some calcium sulphate ($CaSO_4$).

(a) (i) Write the equation which represents the equilibrium between $Ca^{2+}(aq)$ and $SO_4^{2-}(aq)$, and undissolved $CaSO_4$.

[1 mark]

(ii) Explain the meaning of the term 'solubility product'.

[2 marks]

(iii) State ONE physical factor which affects the value of the solubility product constant.

_____

[1 mark]

(b) In bronzing and ornamental work requiring a golden colour, lead iodide (PbI_2), which can be described as a dense, golden yellow "insoluble" solid, is used.

Calculate the solubility of lead iodide in water at 25 °C, using the solubility product constant (K_{sp}) = 7.1×10^{-9} mol^3 dm^{-9}.

[5 marks]

(c) How is the solubility of a slightly soluble ionic compound affected when a second solute that furnishes a common ion is added?

_____

_____

[1 mark]

Total 10 marks

MODULE 2

Answer ALL questions.

4. The pH of the oxides of the Period 3 elements are given in Table 2.

TABLE 2

	Na	Mg	Al	Si	P	S
Typical pH of aqueous solution of the oxide	13	8	7	7	2	3

(a) Account for the difference in pH of the aqueous solutions of the oxides of Na and Mg.

[4 marks]

(b) Describe the trend in acid / base character of the oxides of Period 3.

[1 mark]

(c) (i) Explain in terms of bonding why aluminium oxide is described as an amphoteric oxide and NOT as a neutral oxide.

[3 marks]

(ii) Write ONE chemical equation to illustrate either the acidic or basic character of aluminium oxide.

[2 marks]

Total 10 marks

5. (a) A solid compound Y is analysed qualitatively by reaction of its aqueous solution with NaOH (aq) and the results are recorded in Table 3. Complete Table 3 by inserting the inferences that may be made, based on the observations given.

TABLE 3: RESULTS OF TESTS ON COMPOUND Y

	Test	Observation	Inference
(i)	A small quantity of NaOH is added dropwise.	A white precipitate.	**[1 mark]**
(ii)	More NaOH is added to the mixture from (i), until there is no further change.	Colourless solution.	**[1 mark]**
(iii)	The mixture from (a) (ii) is warmed.	Gas produced with a pungent smell turns red litmus blue.	**[2 marks]**

(b) Explain the chemical principles upon which the reactions in (a) (i) and (a) (iii) are based.

(a) (i) _____

_____

[2 marks]

(a) (iii) _____

_____

[2 marks]

(c) Write the ionic equation for the reaction described in (a) (iii).

_____

[2 marks]

Total 10 marks

6. Table 4 shows the variation in some properties of the Group IV elements.

TABLE 4: SOME PROPERTIES OF GROUP IV ELEMENTS

Element	C(d)	Si	Ge	Sn	Pb
m.p. / °C	3550	1410	937	232	328
Electrical conductivity $ohm^{-1}\ m^{-1}$	—	1×10^6	2×10^6	8×10^6	5×10^6
m.p. of XO_2 X = Group IV element	– 56	1610	1115	1630	290

C(d) = diamond

(a) (i) Describe the trend in electrical conductivity from silicon to tin.

_____

_____

(ii) Suggest a reason for the trend described in (a) (i) above.

_____

_____

[2 marks]

(b) Account for the variation in the melting points from C to Sn in terms of structure and bonding.

_____

_____

_____

_____

_____

[4 marks]

GO ON TO THE NEXT PAGE

(c) By reference to the melting point data for the +4 oxides of elements C – Sn, suggest the type of structure and bonding exhibited by the oxides.

_____

_____

_____

_____

[2 marks]

(d) Suggest an explanation for the relatively low melting point value for PbO_2 compared to the oxides of Si – Sn.

_____

_____

_____

_____

[2 marks]

Total 10 marks

MODULE 3

Answer ALL questions.

7. Chlorine is an industrially important chemical, finding use in many manufacturing industries. On an industrial scale, chlorine is produced using the flowing mercury cathode cell. Brine, concentrated NaCl, is electrolysed and products of chlorine, sodium hydroxide and hydrogen gas are obtained.

(a) Figure 1 illustrates the key features of the flowing mercury cathode cell.

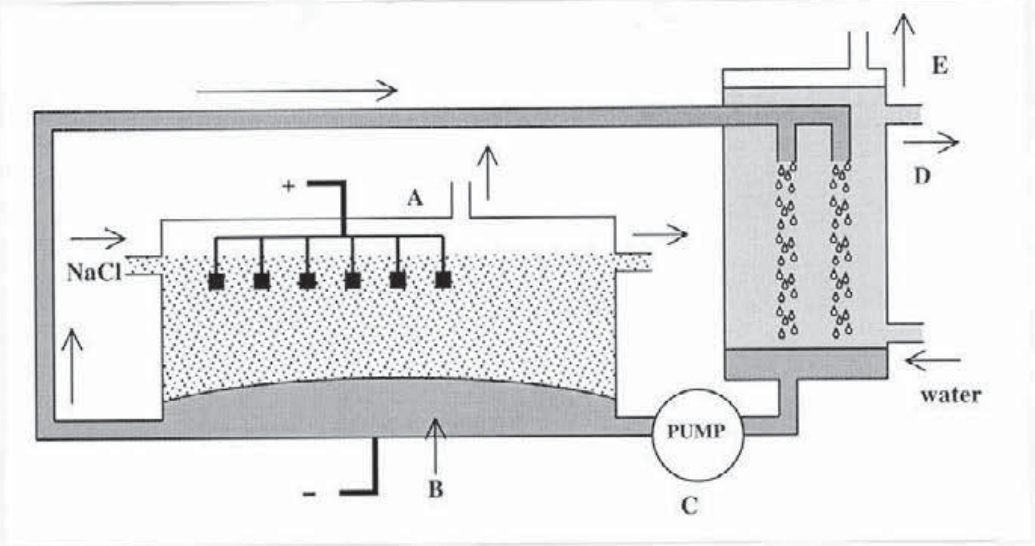

Figure 1. Features of the flowing mercury cathode cell

(i) Identify the substances collected at points A, D and E in the diagram.

_____

_____

_____

[3 marks]

(ii) Identify the component of the cell labelled B.

_____

[1 mark]

(iii) What is the purpose of the pump in the cell?

_____

_____

[1 mark]

GO ON TO THE NEXT PAGE

(iv) Write an equation for the overall process occurring in the cell.

_____

[2 marks]

(b) (i) Name ONE manufacturing industry for which the chlorine produced acts as a raw material.

_____

[1 mark]

(ii) a) Describe how mercury is released from the sodium-mercury amalgam produced during electrolysis.

_____

_____

b) Give ONE reason why careful consideration should be given to the siting of such a chlorine-producing plant.

_____

_____

[2 marks]

Total 10 marks

8. The Haber process for the industrial manufacture of ammonia involves processes of distillation, compression, catalysis, condensation and recycling.

(a) Identify the steps in the production for which EACH of the following processes is relevant.

Distillation: _____

Compression: _____

Catalysis: _____

Condensation: _____

Recycling: _____

[5 marks]

(b) Ammonia is used in the production of the compound urea, $NH_2–CO–NH_2$, that is used as a fertilizer. Carbon dioxide is also a reactant in the formation of urea, and water is the other product.

(i) Write a balanced equation for the formation of urea from ammonia.

_____

[2 marks]

(ii) Urea is susceptible to the temperature and moisture in the environment and can be hydrolysed by these conditions. State the products of hydrolysis of urea.

_____

[1 mark]

(iii) Describe what would be detected on a plot of land to which urea has been applied during moist, warm weather.

_____

_____

[2 marks]

Total 10 marks

9. Educational institutions discard large masses of paper every academic year. It would be environmentally useful if the administrations of schools, colleges and universities would implement programs to recycle the paper. Students of chemistry departments could devise chemical means of obtaining the glucose molecules from the cellulose fibres and then use the monomers to manufacture other products.

(a) (i) Suggest a chemical treatment for cellulose that would release the glucose monomers. State the reagents and conditions.

_____

_____

[2 marks]

(ii) Give ONE possible product that could be made from the monomers of the cellulose fibres.

_____

[1 mark]

(iii) Suggest ONE OTHER strategy for waste paper management that would be useful for an academic institution.

[1 mark]

(b) Recycling is also used as a strategy in the management of plastic solid waste. Polyethylene terephthalate, PET, is commonly recycled. One process involves heating the plastic under reduced pressure until the polymer is broken down into the monomers.

(i) Suggest a reason for the use of low pressures in the recycling process mentioned.

[1 mark]

(ii) Suggest ONE use for the monomers obtained from the plastic.

[1 mark]

(iii) Describe the advantages of recycling plastic over other methods of management including incineration and biodegradation.

[4 marks]

Total 10 marks

END OF TEST