FORM TP 2006186

TEST CODE 02212020

MAY/JUNE 2006

CARIBBEAN EXAMINATIONS COUNCIL

# ADVANCED PROFICIENCY EXAMINATION

## CHEMISTRY

## UNIT 2 – PAPER 02

*2 hours 15 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. Section A consists of THREE questions, ONE question from each Module. Answer ALL questions. Answers for this section must be written in this booklet.
3. Section B consists of SIX questions. Answer ONLY THREE questions from this section, ONE question from EACH Module. Answers for this section must be written in the booklet provided.
4. ALL working MUST be CLEARLY shown.
5. The use of non-programmable calculators is permitted.

Materials provided:

- A data booklet
- Graph paper
- Answer booklet

## SECTION A

**Answer ALL questions in this section.**

## MODULE 1

**1.** (a) The rate equation for the reaction between hydrogen, $H_2$, and nitrogen monoxide, NO, is as follows:

$$\text{Rate} = k\,[H_{2\,(g)}]\,[NO_{(g)}]^2$$

Predict quantitatively what would happen to the rate of the reaction when the following changes are made. Give a reason for your answer in (i) and (ii).

(i) The concentration of $H_{2(g)}$ is doubled.

Effect on Rate:

_____

Reason:

_____

**[ 2 marks]**

(ii) The concentration of $NO_{(g)}$ is halved.

Effect on rate:

_____

Reason:

_____

**[ 2 marks]**

(iii) The concentration of $H_{2(g)}$ and $NO_{(g)}$ are both tripled.

Effect on rate:

_____

**[ 1 mark ]**

(b) (i) The equation for the reaction between $H_2$ and NO at 25°C, 1 atm is as follows:

$$2NO_{(g)} + 2H_{2(g)} \rightarrow N_{2(g)} + 2H_2O(l)$$

The rate of the reaction was monitored by measuring the volume of products formed. Sketch a suitable graph representing the data collected.

**[ 2 marks]**

(ii) Apart from volume measurement, state ONE other method of monitoring the rate of this reaction.

_____

**[ 1 mark ]**

(iii) Suggest TWO precautions that should be taken when performing the experiment in (b) (ii) above.

_____

_____

_____

_____

**[ 2 marks]**

**Total 10 marks**

## MODULE 2

**2.** (a) The products of the reaction between chlorine and aqueous sodium hydroxide depend on temperature and concentration. Chlorine also exhibits variable oxidation states in its many compounds.

(i) Write a balanced equation for the reaction that occurs when chlorine is bubbled through cold aqueous dilute sodium hydroxide.

_____

**[ 2 marks]**

(ii) Calculate the oxidation number of chlorine in $NH_4ClO_4$.

_____

**[ 1 mark ]**

(b) State the observation that is made for EACH of the following reactions involving metal halides.

(i) Aqueous chlorine is added to aqueous potassium bromide and the mixture is shaken.

_____

**[ 1 mark ]**

(ii) Aqueous silver nitrate is added to a sample of aqueous sodium chloride followed by ammonia solution.

_____

**[ 2 marks]**

(iii) Warm concentrated sulphuric acid is added to solid potassium iodide.

_____

**[ 1 mark ]**

(c) Write an ionic equation for the reaction occurring in (b) (i).

_____

**[ 2 marks]**

(d) What precaution must be taken when performing the reaction in (b) (iii) in the laboratory?

_____

**[ 1 mark ]**

**Total 10 marks**

NOTHING HAS BEEN OMITTED

## MODULE 3

**3.** The raw materials used to obtain the elements nitrogen and hydrogen for the industrial synthesis of ammonia are obtained from varied sources. The industrial synthesis provides ammonia that is subsequently used in the manufacture of nitrogen-based commercial products.

Figure 1 below shows a flow chart of a general scheme for the industrial production of ammonia.

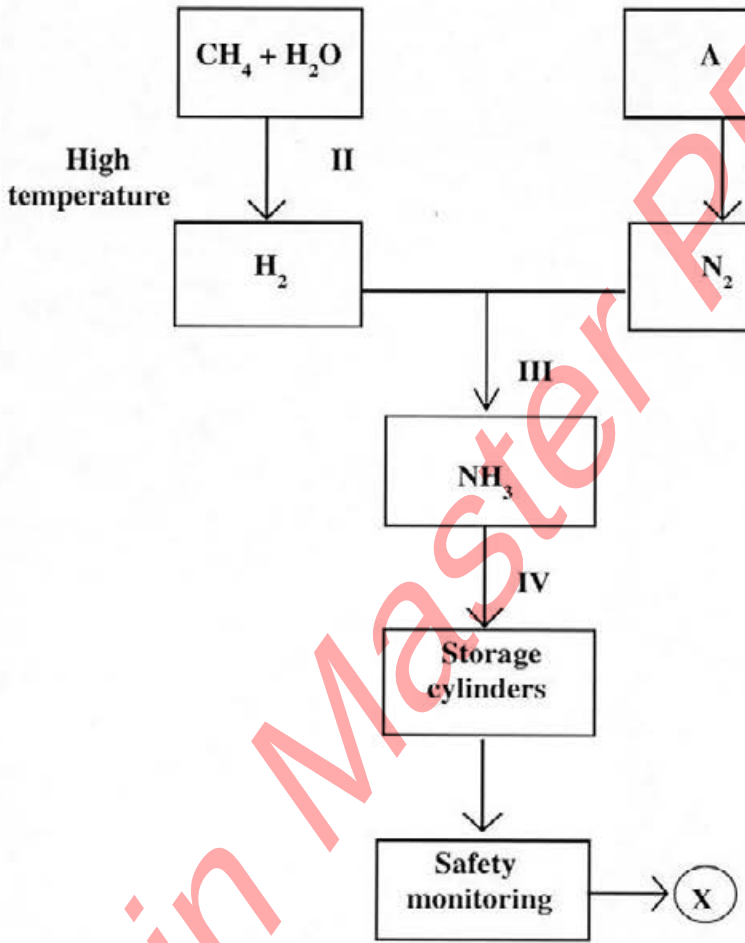



**Figure 1**

(a) Identify the source **A** and the process **I** used obtain the nitrogen gas.

_____

_____

**[ 2 marks]**

(b) (i) Suggest another condition required at process **II** which is used to yield hydrogen gas.

_____

**[ 1 mark ]**

(ii) Write a balanced equation for the reaction.

_____

**[ 2 marks]**

(c) Identify the condition at **III** that minimizes the time taken to produce a batch of ammonia from the starting materials. Give a reason for your answer.

_____

_____

_____

_____

**[ 2 marks]**

(d) Under what conditions would ammonia be held in the storage cylinders?

_____

_____

**[ 2 marks]**

(e) Describe a simple laboratory test that could be carried out at point X to test for a leak in a storage cylinder.

_____

**[ 1 mark ]**

**Total 10 marks**

## SECTION B

**Answer THREE questions from this section, ONE question from EACH module.**

### MODULE 1

**Answer EITHER Question 4 OR Question 5.**

**4.** In some chemical reactions, the reactants are not converted completely to products. Instead, an equilibrium system, comprising reactants and products, is formed. One such equilibrium system can be formed in the reaction between $SO_2(g)$ and $O_2(g)$, as shown in the equation below:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H = -197 \text{ kJ mol}^{-1}$$

(a) Le Chatelier's principle can be used to predict how the position of an equilibrium may change in a system that is in dynamic equilibrium.

(i) State Le Chatelier's principle. **[ 2 marks]**

(ii) Give TWO characteristic features of a system in dynamic equilibrium. **[ 2 marks]**

(iii) Write an expression for the equilibrium constant, $K_p$, for the equilibrium system described above. **[ 1 mark ]**

(iv) The equilibrium constant, $K_p$, for this reaction is $4.0 \times 10^{19}$ $Pa^{-1}$ at 25°C.

Use the value of $K_p$ to comment on the position of equilibrium at 25°C and the relative equilibrium concentration of the reactants and products. **[ 2 marks]**

(b) Using Le Chatelier's principle, predict how the position of this equilibrium and hence the concentration of reactants and products may be affected by EACH of the following changes.

Explain EACH answer.

(i) The temperature is increased while the pressure is kept constant. **[ 3 marks]**

(ii) The pressure is increased while the temperature is kept constant. **[ 3 marks]**

(iii) Using a catalyst. **[ 2 marks]**

(c) When a 2:1 mixture of $SO_2(g)$ and $O_2(g)$ at a total initial pressure of 5 atm is passed over a catalyst at 425°C, the partial pressure of $SO_3(g)$ at equilibrium is found to be 3 atm.

Calculate the value of $K_p$. **[ 5 marks]**

**Total 20 marks**

**5.** Buffer solutions are used to provide suitable media for a variety of activities, ranging from those that are recreational to essential life processes. The underlying chemical principles, however, are the same.

(a) Define the term 'buffer solution'. **[ 2 marks]**

(b) Sodium hydrogen carbonate is often added to the water in swimming pools to act as a buffer.

(i) Suggest a reason for adding a buffer to the pool. **[ 1 mark ]**

(ii) Use the following equation to explain how the aqueous hydrogen carbonate ion acts as a buffer.

$$HCO_3^-(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + CO_3^{2-}(aq)$$ **[ 2 marks]**

(c) (i) Explain how the molecular structure of amino acids relates to their function as buffers in human blood. **[ 3 marks]**

(ii) State ONE industry in which buffers are used. **[ 1 mark ]**

(d) A buffer solution is made by adding 6.56 g of sodium ethanoate, $CH_3COONa$, to 1 $dm^3$ of 0.02 M ethanoic acid, $CH_3COOH$.

(i) Calculate the concentration of the sodium ethanoate solution in mol $dm^{-3}$. **[ 2 marks]**

(ii) $K_a$ for ethanoic acid is equal to $1.8 \times 10^{-5}$ mol $dm^{-3}$.

Write the expression for $K_a$ and use it to calculate the pH of the buffer solution. State any assumptions made in the calculation. **[ 5 marks]**

(e) 0.005 moles of solid sodium hydroxide are added to the buffer solution in part (d). Assuming that there is no change in volume:

(i) Find the new concentrations of the sodium ethanoate and ethanoic acid. **[ 2 marks]**

(ii) Comment on the pH of the new solution and explain your answer. **[ 2 marks]**

**Total 20 marks**

## MODULE 2

**Answer EITHER Question 6 OR Question 7.**

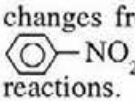
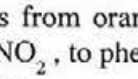
**6.** The chemistry of the Group IV elements reflects the gradual change in the nature of the elements down the group, and the variation in the properties of their compounds in the +2 and +4 states.

(a) Explain EACH of the following:

(i) The trend in the bonding and acid/base character of the oxides in the + 2 state **[ 6 marks]**

(ii) The trend in the behaviour of the tetrachlorides on reacting with water **[ 2 marks]**

(b) (i) A brown solid, J, when heated with concentrated sulphuric acid reacts to give a white solid, K, and a colourless, odourless gas, L, which relights a glowing splint. J reacts with aqueous manganese (II) nitrate in the presence of dilute nitric acid to give a purple solution, M. When dilute hydrochloric acid is added to solution M a white precipitate, O, is formed in the purple solution. O dissolves when the solution is heated and is reformed when the solution is cooled. Identify EACH of the substances, J to O, and state the nature of J. **[ 6 marks]**

(ii) When acidified potassium chromate (VI) is added to an aqueous chloride, P, it changes from orange to green. P can also be used to change nitrobenzene,  , to phenylamine,  . Identify P and explain its role in both reactions. **[ 4 marks]**

(iii) Suggest what would be observed when aqueous P reacts with aqueous iron (III) chloride. Explain your answer. **[ 2 marks]**

**Total 20 marks**

7. Selected physical properties of FIVE inorganic substances are given in Table 1.

**TABLE 1: PHYSICAL PROPERTIES OF SUBSTANCES A, TO E**

| Substance | Melting point in °C | Conductivity | Reaction with water at 25°C |
|---|---|---|---|
| A | 2054 | Conducts electricity in the molten state | Insoluble |
| B | 101 | Does not conduct | Insoluble |
| C | 1410 | Does not conduct | Insoluble |
| D | 650 | Conducts electricity in the solid state | Insoluble |
| E | 162 | Conducts electricity in aqueous solution | Hydrolysis |

(i) Suggest the structure for EACH of A to E. **[ 5 marks]**

(ii) A to E may be a Period 3 element or its oxide or chloride. Suggest the identity of the substances, A to E. **[ 5 marks]**

(b) (i) Describe the reaction of EACH of the following substances with water:

a) Sodium
b) Magnesium
c) Chlorine **[ 8 marks]**

(ii) Write an equation for ONE of the reactions described in (b) (i) above. **[ 2 marks]**

**Total 20 marks**

## MODULE 3

**Answer EITHER Question 8 OR Question 9.**

**8.** Synthetic polymeric materials have found widespread use globally and have contributed to difficulties with solid waste management worldwide. PVC, polyvinylchloride and PET, polyethyleneterapthalate (a polyester) are two organic synthetic polymers with varied applications. Methods of recycling these polymers have been developed to provide solutions to solid waste disposal problems.

(a) Give ONE use for EACH of these polymers and suggest why these polymers do not respond to natural degradative processes. **[ 4 marks]**

(b) Chemical methods of degradation have been developed to allow the waste polymer to be used as feedstock in the development of new materials, including fibres. The chemical process is often referred to as depolymerization.

(i) Suggest the meaning of the term 'depolymerization.' **[ 1 mark ]**

(ii) State TWO chemicals that could be used in the depolymerization of PET and explain the chemical process occurring. **[ 5 marks]**

(c) In one fibre-producing process, collected PVC material is converted to fine chips and then dissolved in a solvent before conversion into extrusion fibres. The fibres are subsequently used in textile production.

(i) What would be a suitable solvent for this process? **[ 1 mark ]**

(ii) Suggest a reason for the use of fine chips. **[ 1 mark ]**

(iii) Give TWO safety precautions that should be enforced during this recycling process. **[ 2 marks]**

(iv) Suggest a use or property of any clothing produced from these recycled fibres. **[ 1 mark ]**

(d) Attempts have been made to dispose of PVC material via incineration. Discuss the advantages and disadvantages of using this method of disposal. **[ 5 marks]**

**Total 20 marks**

**9.** (a) Crude oil is a raw material that has many uses in modern society. The two main processes in the initial refining of crude oil and the processing of the fractions are fractional distillation and cracking.

Briefly describe the principles involved in

(i) fractional distillation **[ 3 marks]**

(ii) cracking. **[ 2 marks]**

(b) Give a balanced equation to illustrate cracking. **[ 2 marks]**

(c) Explain the importance of EITHER fractional distillation OR cracking. **[ 1 mark ]**

(d) Suggest ONE adverse effect associated with the extraction of crude oil and comment on the environmental problems that result. **[ 3 marks]**

(e) Emissions from vehicles contain carbon monoxide, carbon dioxide, nitrogen oxides, water vapour and lead compounds. Because of the health risks associated with the use of leaded petrol, increasing use is being made of unleaded petrol.

(i) State TWO reasons why the use of leaded petrol is hazardous to human health. **[ 2 marks]**

(ii) Account for the presence of carbon monoxide and nitrogen oxides in the exhaust gases of cars. Write a balanced equation for the formation of ONE oxide of nitrogen. **[ 5 marks]**

(iii) In order to minimize pollution levels in your country, it would be best to reduce the amount of carbon monoxide and nitrogen oxides in the exhaust fumes of cars. Suggest TWO means by which this may be achieved. **[ 2 marks]**

**Total 20 marks**

**END OF TEST**