

FORM TP 2005180



TEST CODE **02212020**

MAY/JUNE 2005

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

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SECTION A

Answer ALL questions in this section.

MODULE 1

1. (a) The blood is an important buffer that contains bicarbonate ions (HCO_3^-) (aq) and carbonic acid (H_2CO_3). Suggest how the blood responds in the presence of EACH of the following:

(i) Lactic acid that is produced as a result of

a) mild exercise

b) strenuous exercise.

[4 marks]

(ii) Excess alkalinity

[2 marks]

- (b) An on-the-job trainee technician is asked to prepare a buffer solution of known pH. Outline the steps needed to prepare the solution and to determine that the solution is of the pH required.

[4 marks]

Total 10 marks

MODULE 2

2. (a) The labels are accidentally removed from the bottles of four Group II metal sulphates (Mg, Ca, Sr, Ba). Outline a plan by which a chemist, who does not have access to flame test rods, could use physical properties to determine the identity of these sulphates.

[6 marks]

(b) The reaction of magnesium in air when heated was used by photographers in days gone by.

(i) Describe the environmental conditions under which the photographer would have decided to use this reaction.

[1 mark]

(ii) Suggest ONE disadvantage of using the reaction described above.

[1 mark]

(iii) Write the chemical equation to illustrate the reaction described above.

[2 marks]

Total 10 marks

MODULE 3

3. Fermentation has been used over the ages to incorporate some alcoholic content in home-made beverages. Many starting materials can be used including potatoes, grapes and corn.

(a) (i) What chemical feature do all of the mentioned starting materials possess?

[1 mark]

(ii) Give TWO differences in home-made alcoholic beverages resulting from the use of different starting materials.

[2 marks]

- (iii) Briefly describe a simple laboratory method to determine the relative percentage alcohol in TWO home-made beverages.

[2 marks]

- (b) Ethanol is described as the most common drug legally used by adults and illegally used by young people.

- (i) Explain why ethanol is classified as a drug.

[1 mark]

- (ii) Briefly describe FOUR consequences of alcohol abuse on the social and economic structures of our society.

[4 marks]

Total 10 marks

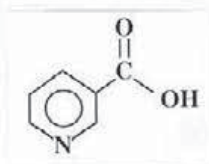
SECTION B

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

MODULE 1

Answer EITHER Question 4 OR Question 5.

4. Niacin, a member of the vitamin B group, has the molecular structure given below.



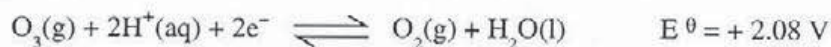
Niacin is a weak acid and experimental determination shows that a solution of the acid of concentration $0.020 \text{ mol dm}^{-3}$ has a pH of 3.26 at 298 K.

- (a) By reference to the Bronsted-Lowry theory and the molecular structure of niacin, explain the statement, "Niacin is a weak acid". [5 marks]
- (b) Use the information provided above to calculate the
- (i) concentration of H^+ ions in the $0.020 \text{ mol dm}^{-3}$ solution of niacin at 298 K [3 marks]
 - (ii) concentrations of niacin and the conjugate base in solution at 298 K [3 marks]
 - (iii) K_a for niacin at 298 K. [3 marks]
- (c) (i) What changes in the values of pH and K_a for niacin would be expected if the determination is carried out at 320 K? Suggest a reason for your answer based on molecular structure. [3 marks]
- (ii) Comment on the suitability of using a weak base to determine the concentration of niacin in solution by titration. [3 marks]

Total 20 marks

5. (a) In 1791, Luigi Galvani observed that muscles in frogs' legs contracted when touched simultaneously by two different metals. In 1794, Alessandro Volta showed that electricity could be produced when two metals are immersed in a conducting solution.
- (i) Explain the "muscle twitch" observed by Galvani. [1 mark]
- (ii) Describe with the aid of a diagram the experiment that Volta might have performed using TWO named metals. [3 marks]
- (iii) Describe how the apparatus in (ii) can be modified to determine the standard electrode potential. [5 marks]

- (b) Use the data on the standard electrode potentials below to answer the questions that follow:



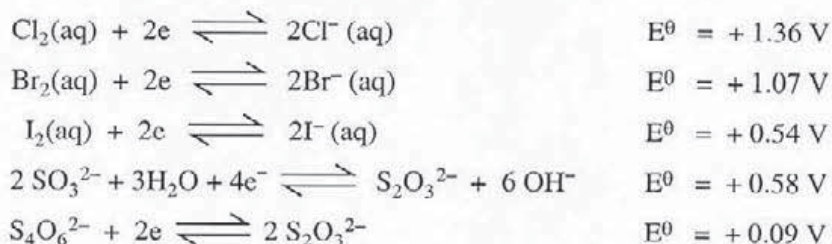
- (i) Stain removers often oxidize the coloured compound to a colourless complex. Suggest ONE reason why inventors believe that an ozone-producing formulation produces brighter, whiter clothes than bleach does. [2 marks]
- (ii) Comment on the suggestion that chlorine can be produced by bubbling ozone through sea water. [2 marks]
- (c) One of the most common and useful batteries is the lead-storage battery used in automobiles. The cathode of each cell is composed of lead (IV) oxide (PbO_2), and the anode is composed of lead. The electrolyte used is sulphuric acid.
- (i) Use the information in the data booklet to write equations for the reactions occurring at each electrode during discharge. [2 marks]
- (ii) Calculate the standard cell potential. [2 marks]
- (d) The fuel cell ($\text{H}_2 - \text{O}_2$) was a primary source of electrical supply on the Apollo moon flights. The fuel cell uses porous carbon electrodes into which pure streams of Hydrogen (at the cathode) and oxygen (at the anode) are introduced. By reference to standard electrode potentials in the data booklet, deduce the useful by-product of the reaction. Include relevant equations. [3 marks]

Total 20 marks

MODULE 2

Answer EITHER Question 6 OR Question 7.

6. (a) The temperature at which the reaction between chlorine and aqueous sodium hydroxide occurs determines the products of the reaction. Explain this phenomenon, using equations to illustrate your answer. [9 marks]
- (b) Use the redox potential values given to explain the similarities and differences in the behaviour of the halogens with the thiosulphate ($S_2O_3^{2-}$) ion.



[8 marks]

- (c) Describe how silver nitrate solution can be used to distinguish among the halides Cl^- , Br^- and I^- . [3 marks]

Total 20 marks

7. (a) Provide explanations for EACH of the following in terms of the characteristic properties of transition metals and their complexes:
- (i) Anhydrous copper (II) sulphate is a white solid that gradually turns blue on the dropwise addition of water. Further addition results in the solid dissolving with the formation of a blue solution. [4 marks]
- (ii) The gradual addition of a concentrated solution of sodium chloride to aqueous copper (II) sulphate leads to the formation of a green solution. A colour change from green to yellow is observed on further addition of the sodium chloride solution. [3 marks]
- (b) The complex ion X is obtained on adding a concentrated solution of NaCN to aqueous $NiCl_2$. The ion X has the percentage composition of 36.1 % Ni, 29.5 % C and 34.4 % N.
- (i) Determine the formula of the complex ion X. [4 marks]
- (ii) Draw the shape of the complex ion X. [1 mark]

GO ON TO THE NEXT PAGE

- (c) Account for EACH of the following statements: [Use E^{θ} values provided in the Data Booklet where appropriate]
- (i) Haemoglobin has a complex unit that affords the transportation of oxygen to the tissues. However, the carrying capacity of haemoglobin is reduced in the presence of carbon monoxide. [4 marks]
- (ii) The manganate (VII) ions (MnO_4^-) and dichromate (VI) ions ($\text{Cr}_2\text{O}_7^{2-}$) are powerful oxidizing agents. [4 marks]

Total 20 marks

MODULE 3

Answer EITHER Question 8 OR Question 9.

8. Sulphur dioxide is produced by industrial factories during the manufacture of sulphuric acid. Emissions of sulphur dioxide is a major environmental concern because these emissions contribute to the destruction of the environment by modification of the atmosphere.
- (a) (i) Describe the Contact Process for the manufacture of sulphuric acid. Include in your description the source of raw materials and the chemistry of the process. [8 marks]
- (ii) Explain how sulphur dioxide (SO_2) modifies the atmosphere. [2 marks]
- (b) One method applied in industry to minimise the release of environmentally harmful gases, like SO_2 , is the use of scrubbers. A scrubber is a chemical agent that reacts with the gas to extract it from the industrial emission.
- (i) CaCO_3 is utilized as a chemical scrubber in industry. Write an equation for the reaction between CaCO_3 and SO_2 , and explain the underlying principle of the action of the carbonate. [4 marks]
- (ii) Calculate the mass of CaCO_3 , in kg, needed in a slurry to extract the SO_2 present in 10 m^3 of industrial waste gases at r.t.p, if SO_2 comprises 10 % of this volume. [6 marks]

Total 20 marks

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9. The Montreal Protocol, on substances that deplete the ozone layer, was signed in 1987 by a number of nations with concern about the impact of low ozone levels on human health. The Protocol contains recommendations for phasing out the use of CFCs, chlorofluorocarbons.
- (a) (i) Explain the need for concern regarding ozone depletion and human health. [5 marks]
- (ii) Describe THREE properties of CFCs that contribute to their widespread use. [3 marks]
- (b) CCl_2F_2 (CFC-12) is a typical chlorofluorocarbon developed to replace ammonia in manufacturing applications.
- (i) Suggest TWO properties of ammonia that led to its replacement by CCl_2F_2 . [2 marks]
- (ii) Use CFC-12 as an example to write chemical equations that demonstrate the impact of CFCs on the ozone layer. [5 marks]
- (c) It has been estimated that every day 3×10^8 tons of stratospheric ozone are formed and an equal mass is destroyed.
- (i) Explain the underlying chemical principle in this natural process. [3 marks]
- (ii) Write chemical equations to represent the natural processes of the formation and destruction of ozone. [2 marks]

Total 20 marks

END OF TEST