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MAY/JUNE 2010

CARIBBEAN EXAMINATIONS COUNCIL

ADVANCED PROFICIENCY EXAMINATION

CHEMISTRY

UNIT 2 – Paper 02

2 hours 30 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of SIX compulsory questions in TWO sections.
2. Section A consists of THREE structured questions, one from each Module. Section B consists of THREE extended response questions, one from each Module.
3. For Section A, write your answers in the spaces provided in this booklet. For Section B, write your answers in the answer booklet provided.
4. All working must be shown.
5. The use of silent, non-programmable calculators is permitted.
6. A data booklet is provided.

SECTION A

Answer ALL questions in this section.

Write your answers in the spaces provided in this booklet.

MODULE 1

THE CHEMISTRY OF CARBON COMPOUNDS

1. Figure 1 shows a reaction scheme.

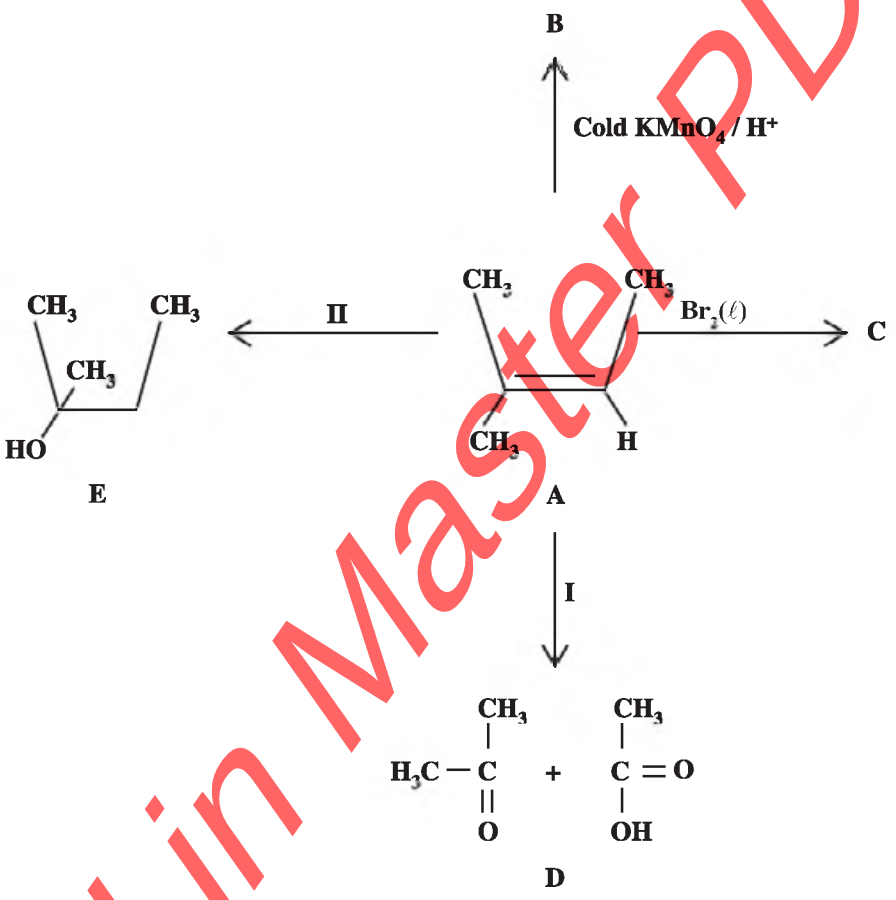

Figure 1. Reaction scheme

(a) State the reagents and/or conditions necessary for EACH of the following reactions:

(i) I (from **A** to **D**)

_____

_____

[2 marks]

(ii) II (from **A** to **E**)

_____

_____

[2 marks]

(b) Draw the structure for EACH of the following compounds:

(i) **B**

(ii) **C**

[2 marks]

(c) **A** can theoretically be used to make a polymer.

(i) What is meant by a 'polymer'?

_____

_____

[1 mark]

(ii) Identify the type of polymerisation **A** would MOST likely undergo.

_____

[1 mark]

(iii) Name any ONE industrial polymer which could result from the polymerisation process named at (c) (ii) above.

_____

[1 mark]

(iv) Suggest the repeat unit for a polymer made from **A**.

[1 mark]

(v) Can compounds such as those in **D** undergo addition polymerisation? Justify your answer.

_____

_____

[2 marks]

(d) Write the general structure of an amino acid.

[1 mark]

(e) Nylon 6.6 and proteins are macromolecules formed from the condensation of smaller molecules.

State the similarity and the difference between the structures of these macromolecules.

Similarity

_____

_____

_____

Difference

_____

_____

_____

[2 marks]

Total 15 marks

MODULE 2

ANALYTICAL METHODS AND SEPARATION TECHNIQUES

2. (a) State the meaning of EACH of the following terms:

(i) Electromagnetic radiation

_____

_____

_____

(ii) Wavelength

_____

_____

(iii) Frequency

_____

_____

[3 marks]

(b) Using the formula, $\upsilon = c / \lambda$, calculate the missing frequencies and wavelengths in Table 1 and identify the corresponding type of electromagnetic radiation.
($c = 3.0 \times 10^8$ m s^{-1})

TABLE 1: PROPERTIES OF ELECTROMAGNETIC RADIATION

Wavelength (m)	Frequency (Hz)	Type of Electromagnetic Radiation
(i) _____	3×10^{13}	(iii) _____
3.16	(ii) _____	(iv) _____

[4 marks]

(c) In the UV/VIS spectroscopic analysis of an organic compound, X, a beam of light of wavelength 200 nm is passed through the compound.

(i) State THREE steps that must be followed in preparing the sample of Compound X for UV/VIS spectroscopic analysis.

[3 marks]

(ii) Complexing reagents are sometimes used in the UV/VIS spectral analysis of compounds.

State TWO properties of complexing reagents which make them suitable for use in UV/VIS analysis.

[2 marks]

(d) Calculate EACH of the following:

(i) The amount of energy absorbed by one molecule of a compound where $\upsilon = 1.5 \times 10^{15}\ s^{-1}$

(Use $E = h\upsilon$, where $h = 6.63 \times 10^{-34}$ J s)

[1 mark]

(ii) The energy absorbed by one mole of the compound

[2 marks]

Total 15 marks

MODULE 3

INDUSTRY AND THE ENVIRONMENT

3. (a) Rain water in an unpolluted atmosphere has a pH of 5.6.

(i) Identify TWO gases in the atmosphere which contribute to this pH.

_____

_____

[2 marks]

(ii) Identify a natural source of EACH of the gases in (a) (i) above.

_____

[2 marks]

(iii) Write a suitable equation to show the reaction of any ONE of the gases in (a) (i) with water.

_____

[2 marks]

(b) Acid rain is a term used to describe rain water which has a pH less than 5. The occurrence of acid rain is more prevalent in industrialized, heavily populated areas.

(i) Briefly outline TWO factors that are responsible for acid rain in industrialized, heavily populated areas.

_____

_____

_____

_____

[2 marks]

(ii) Suggest TWO effects of acid rain on the environment.

_____

_____

_____

_____

[2 marks]

(c) A potable water supply is suspected to be contaminated with Pb^{2+} and NO_3^- ions and you are required to test if this is true.

(i) Suggest a precaution you would take to ensure that there is no external contamination of your water sample.

_____

_____

[1 mark]

(ii) Name ONE reagent that you would use, to confirm the claim of contamination by EACH of the following:

Pb^{2+} _____

NO_3^- _____

[2 marks]

(iii) State the expected results of the tests using the reagents named in (c) (ii) above, if the water is contaminated by Pb^{2+} and NO_3^-.

Pb^{2+} _____

NO_3^- _____

[2 marks]

Total 15 marks

SECTION B

Answer ALL questions in this section.

Write your answers in the separate answer booklet provided.

MODULE 1

THE CHEMISTRY OF CARBON COMPOUNDS

4. **A** and **B** are structural isomers.

$CH_2(OH)CH_2CH(CH_3)CH_2CH_2CH = CH(CH_3)$
A

$CH_3CH(CH_3)CH_2CH_2CH_2CH = CH(CH_2OH)$
B

(a) Explain why **A** and **B** are structural isomers. **[2 marks]**

(b) Name TWO functional groups present in BOTH molecules. **[2 marks]**

(c) **A** and **B** also show stereoisomerism.

(i) Draw the displayed formula of **A** and circle a chiral carbon atom on the molecule. **[2 marks]**

(ii) Draw geometrical isomers of **B**, AND suggest why **B** has NO optical isomers. **[3 marks]**

(d) (i) Explain what is meant by the term 'cracking'. **[2 marks]**

(ii) The gaseous compound octane, C_8H_{18}, undergoes cracking to produce two hydrocarbon fragments, each containing the same number of carbon atoms.

a) Write the equation to represent the above process.

b) Describe a simple laboratory test to distinguish between these two hydrocarbon fragments. **[4 marks]**

Total 15 marks

MODULE 2

ANALYTICAL METHODS AND SEPARATION TECHNIQUES

5. (a) Mass spectrometry is used to measure particular characteristics of a given molecular sample. State THREE characteristics of a molecule that mass spectral data can be used to determine. **[3 marks]**

(b) Figure 2 shows the mass spectrum for a haloalkane containing chlorine.

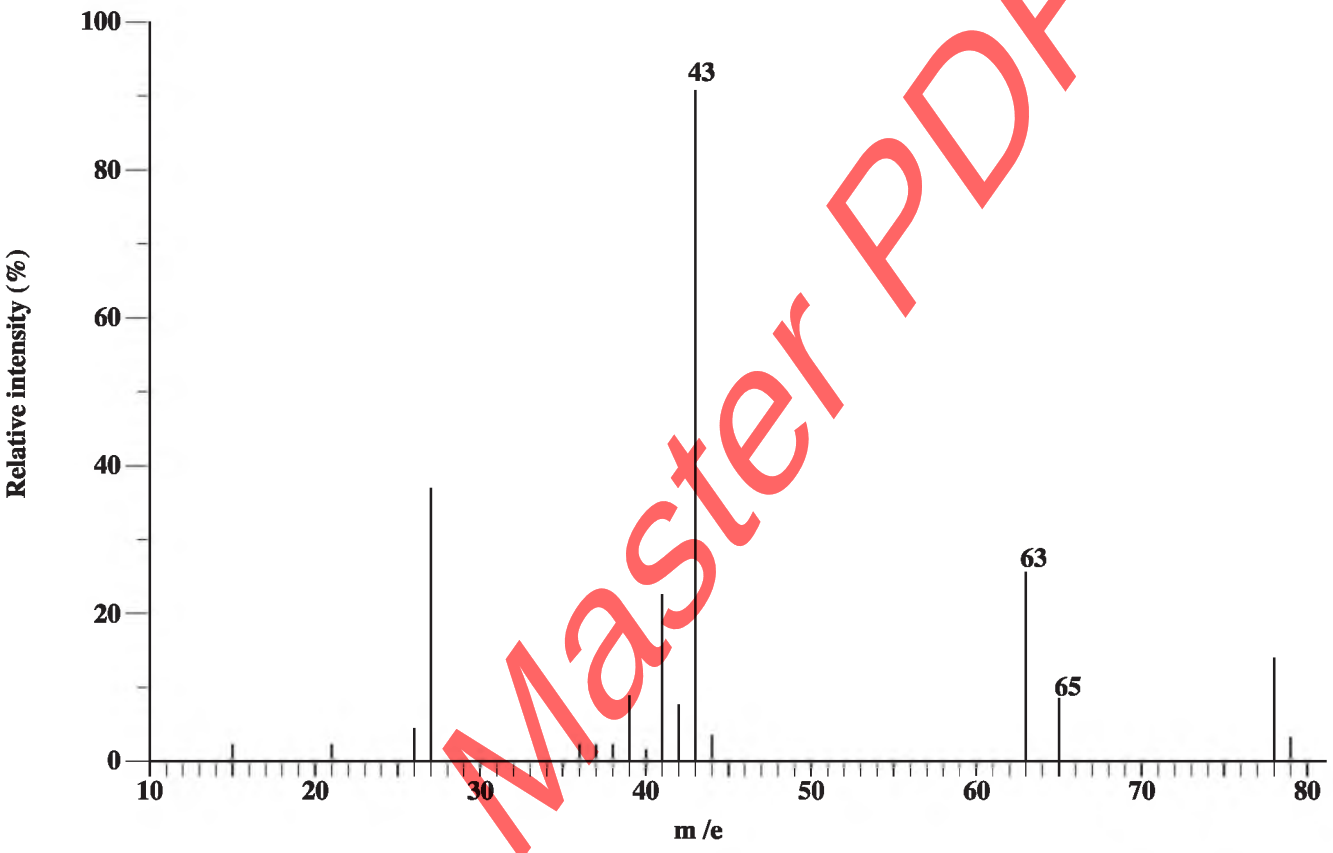

Figure 2. Mass spectrum for a haloalkane containing chlorine

(i) What is the m / e ratio of the M and M + 1 peak? **[2 marks]**

(ii) Deduce the formula of the fragments at m / e ratios: 43, 63 and 65. **[3 marks]**

(iii) Hence, deduce the formula of the M and M + 1 molecular ion species and name the compound. **[3 marks]**

(c) Chlorine has two isotopes with relative atomic masses of 34.97 and 36.96, and relative abundance of 75.77% and 24.23% respectively.

Deduce the average relative atomic mass of naturally occurring chlorine. **[2 marks]**

(d) Another separation technique used in industry is chromatography.

State TWO applications of chromatography. **[2 marks]**

Total 15 marks

MODULE 3

INDUSTRY AND ENVIRONMENT

6. Ammonia is manufactured from its elements by the Haber Process. The process taking place in the reaction chamber is represented by the equation

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g); \quad \Delta H^{\theta} = -92 \text{ kJ mol}^{-1}$$

(a) Identify the source and the process used to produce nitrogen. **[2 marks]**

(b) Hydrogen is obtained from natural gas by reaction with steam.

(i) State the name of the process. **[1 mark]**

(ii) Write the equation for its production. **[2 marks]**

(c) Using Le Chatelier's principle, describe the conditions under which optimal yields of ammonia can be obtained. **[2 marks]**

(d) Account for the differences between the conditions of (c) above with those used in the Haber Process. **[2 marks]**

(e) Water's ability to dissolve a wide range of substances accounts for it being easily polluted. The Showerdem River runs through the Niceness Valley. Drains from houses as well as crops enter the river directly. Three possible pollutants – nitrates, phosphates and lead – have been suggested by the Environmental Management Council (EMC) within the village.

Complete Table 2 to suggest ONE source for EACH pollutant and ONE effect of EACH pollutant.

TABLE 2: POLLUTANT, SOURCE AND EFFECT

Pollutant	Source	Polluting Effect
NO_3^-		
PO_4^{3-}		
Pb^{2+}		

[6 marks]

Total 15 marks

END OF TEST