FORM TP 2011156   MAY/JUNE 2011

C A R I B B E A N   E X A M I N A T I O N S   C O U N C I L

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. (a) Complete Table 1 by indicating simple test tube reactions used to distinguish between the pairs of compounds indicated. Record your expected observations in the spaces provided.

TABLE 1: TEST TUBE REACTIONS FOR DISTINGUISHING PAIRS OF CARBON COMPOUNDS

Compounds	Test	Observation
(i) $H_2C = CH - CH_3$ (A) and $CH_3 - CH_2 - CH_3$ (B)	Addition of Br_2(aq) to both A and B	Compound A decolourized Br_2(aq); colour changes from brown to colourless
(ii) $CH_3 - CH(OH) - H$ (A) and $H_3C - C(CH_3)(OH) - CH_3$ (B)		
(iii) $H_3C - C(=O) - CH_3$ (A) and $H - CH_2 - CH_2 - C(=O) - H$ (B)	Addition of Tollen's reagent to both A and B	
(iv) $H_3C - C(CH_3)(OH) - CH_3$ (A) and $H_3C - C(=O) - CH_3$ (B)		

[**5 marks**]

(b)   The structural formula of A (2-bromo-2-methylpropane) is given below.

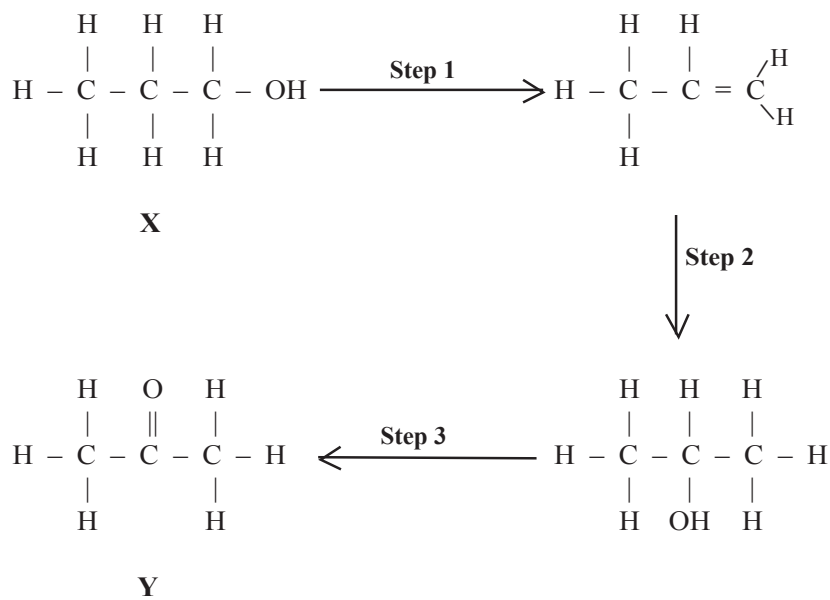$$CH_3$$
$$|$$
$$H_3C - C - CH_3$$
$$|$$
$$Br$$
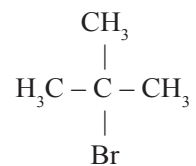
A

(i)   Show the steps involved in the mechanism of the reaction between A and sodium hydroxide. Use curved arrows and fish hook notation to show the movement of electrons.

[4 marks]

(ii)   State the name of the reaction mechanism outlined in (b) (i) above.

_____

[1 mark]

(c) The reaction scheme below shows the conversion of Compound X to Compound Y in three steps.

$$H-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-OH \xrightarrow{\textbf{Step 1}} H-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-\overset{\overset{\displaystyle H}{|}}{C}=C\overset{H}{\underset{H}{}}$$

X

Step 2 ↓

$$H-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-\overset{\overset{\displaystyle O}{\|}}{C}-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-H \xleftarrow{\textbf{Step 3}} H-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle OH}{|}}{C}}-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-H$$

Y

(i) State the reagent(s) used for the conversion at EACH step.

Step 1 _____

Step 2 _____

Step 3 _____

[4 marks]

(ii) Name the process which occurs in Step 3 of the reaction.

_____

[1 mark]

Total 15 marks

MODULE 2

ANALYTICAL METHODS AND SEPARATION TECHNIQUES

2. (a) Distinguish between the terms 'precision' and 'accuracy'.

_____

_____

_____

_____

[3 marks]

(b) A student was asked to measure 50 cm^3 of a liquid in order to carry out an experiment.

List THREE pieces of apparatus that could be used to accurately measure the required volume.

_____

_____

[2 marks]

(c) Each of four students carried out an experiment to determine the percentage of acetic acid in a vinegar sample. The procedure was repeated four times by each student and the results recorded in Table 2.

(i) Complete Table 2 by calculating the standard deviation (SD) of EACH of the four sets of results, using the formula

$$SD = \sqrt{\frac{\sum(x - \overline{x})^2}{n - 1}} \quad .$$

TABLE 2: RESULTS OF EXPERIMENT

Student	Volume 1 (cm^3)	Volume 2 (cm^3)	Volume 3 (cm^3)	Volume 4 (cm^3)	Mean, $\overline{x}$ (cm^3)	SD
1	24.15	24.20	24.10	24.05	24.13	
2	26.00	24.00	24.00	26.00	25.00	
3	29.15	24.95	33.25	27.75	28.78	
4	25.10	24.90	25.00	25.00	25.00	

[2 marks]

(ii)   Evaluate the results obtained by EACH student by commenting on the accuracy and precision of EACH set of titre volumes.

Student 1: _____

Student 2: _____

Student 3: _____

Student 4: _____

[4 marks]

(d)   A student was asked to calibrate a 10 cm^3 pipette. Outline the experimental steps that should be taken by the student to complete this exercise.

_____

_____

_____

_____

_____

_____

_____

_____

[4 marks]

Total 15 marks

MODULE 3

INDUSTRY AND THE ENVIRONMENT

3. (a) Outline the THREE principles of the primary distillation of crude oil.

_____

_____

_____

_____

_____

[3 marks]

(b) To meet the requirements of modern industry, secondary refining processes such as 'cracking' and 'reforming' are used.

Define the terms

   (i) Cracking

_____

_____

   (ii) Reforming

_____

_____

[2 marks]

(c) Octane undergoes cracking to produce two hydrocarbons, one of which is butane.

Write the **balanced** equation which represents this process.

_____

[2 marks]

(d) The products of cracking are widely used as raw materials in the manufacture of petrochemicals.

State THREE uses of these products.

_____

_____

_____

_____

[3 marks]

(e) Figure 1 shows the materials used to illustrate the process of fermentation.
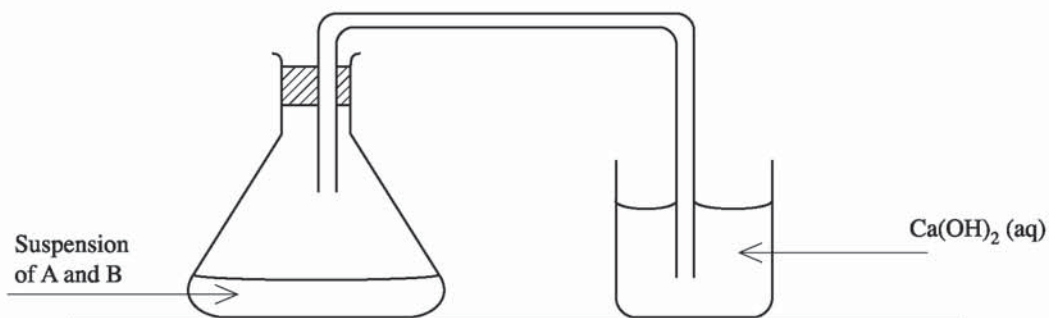

Figure 1. Fermentation process

    (i) State the names of the substances A and B in the suspension.

        A. _____

        B. _____

        [2 marks]

    (ii) State what would be observed after a period of time in the

        – conical flask

        _____

        – beaker.

        _____

        [2 marks]

    (iii) The fermentation process is carried out in surroundings where the temperature is controlled. Very high temperatures must be avoided. Give a reason for this condition.

        _____

        [1 mark]

        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)   (i)   Define the term 'structural isomerism'   **[2 marks]**

(ii)   Identify TWO types of structural isomers, giving an example of EACH.
[4 marks]

(b) 10 cm^3 of a gaseous hydrocarbon were mixed with 45 cm^3 of oxygen and exploded in a reaction chamber. After cooling to room temperature, the residual gases occupied 30 cm^3. By absorption with NaOH solution, a decrease in volume of 20 cm^3 was produced. The remaining gas was shown to be oxygen. Determine the molecular formula of the hydrocarbon. (Pressure remained constant at 1 atm.)   **[4 marks]**

(c)   Explain the difference in acidity of alcohols, phenols and carboxylic acids. In your response, make reference to acid strength, inductive and conjugative effects.
**[5 marks]**

Total 15 marks

MODULE 2

ANALYTICAL METHODS AND SEPARATION TECHNIQUES

5.   (a)   (i)   State the source of absorption in UV/VIS spectroscopy.   **[1 mark]**

(ii)   Use an energy level diagram to show the electronic transitions that can occur in UV/VIS spectroscopy.   **[3 marks]**

(b)   (i)   Define the term 'chromophore'   **[1 mark]**

Naphthalene, P, the formula for which is given below, is a constituent of coal tar, a crude oil residue.
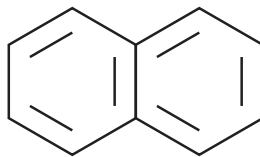
(ii)   Suggest the chromophore in P that is responsible for the absorption of UV radiation.   **[1 mark]**

A sample of coal tar was subjected to solvent extraction using ethanol. The volume of extract was reduced and a solution of P was obtained by separation techniques.

A sample of the solution in a cell of path 1 cm gave an absorbance of 1.2 at a wavelength of 312 nm and an extinction coefficient (molar absorptivity) of 288 $dm^3 mol^{-1} cm^{-1}$.

(iii)   Calculate the concentration of P in the solution.   **[3 marks]**

(c)   Explain the use of calibration curves and standard solutions in UV/VIS analysis.
[4 marks]

(d)   List TWO uses of UV/VIS spectroscopy in chemical analysis.   **[2 marks]**

Total 15 marks

MODULE 3

INDUSTRY AND ENVIRONMENT

6. Figure 2 presents a simplified version of the nitrogen cycle with some components, A, B, C and D, unlabelled.
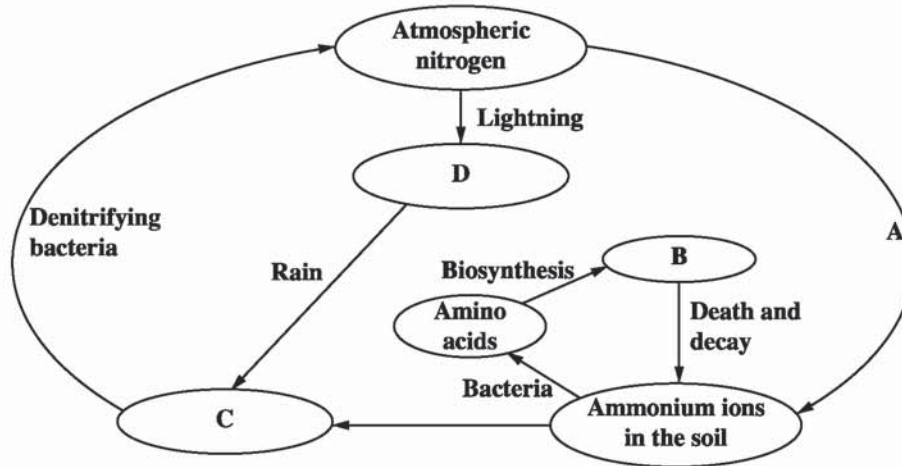

Figure 2. The nitrogen cycle

(a) Identify the unlabelled components, A, B, C and D, in Figure 2. **[4 marks]**

(b) The nitrogen and carbon cycles have natural sources which enable the maintenance of balance. However, the input of additional gases due to human activity has led to the disturbance of the existing balance.

State TWO human activities that have led to the disturbance of the balance of these cycles. **[2 marks]**

(c) Explain, with the use of relevant equations, the processes which allow for the maintenance of the concentration of ozone in the stratosphere.

In your answer, discuss the process of oxygen formation and decomposition. **[9 marks]**

Total 15 marks

END OF TEST