

FORM TP 2019176



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MAY/JUNE 2019

CARIBBEAN EXAMINATIONS COUNCIL

CARIBBEAN ADVANCED PROFICIENCY EXAMINATION®

CHEMISTRY

UNIT 2 – Paper 02

2 hours 30 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of THREE questions. Answer ALL questions.
2. Write your answers in the spaces provided in this booklet.
3. Do NOT write in the margins.
4. Where appropriate, ALL WORKING MUST BE SHOWN in this booklet.
5. A data booklet is provided.
6. You may use a silent, non-programmable calculator to answer questions.
7. If you need to rewrite any answer and there is not enough space to do so on the original page, you must use the extra lined page(s) provided at the back of this booklet. **Remember to draw a line through your original answer.**
8. **If you use the extra page(s) you MUST write the question number clearly in the box provided at the top of the extra page(s) and, where relevant, include the question part beside the answer.**

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO.

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02212020/MJ/CAPE 2019



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Answer ALL questions.

MODULE 1: THE CHEMISTRY OF CARBON COMPOUNDS

1. (a) The compound $(\text{CH}_3)_2\text{CHCBr}(\text{CH}_3)\text{CH}_2\text{CH}_2\text{CH}_3$ reacts with aqueous sodium hydroxide to produce an alcohol.

(i) State the name of the starting compound.

.....
[1 mark]

(ii) State the type of reaction which takes place when the compound reacts with sodium hydroxide.

.....
[1 mark]

(iii) Outline a mechanism for the reaction, using curved arrows to show the movement of electrons. Show clearly the structure of any intermediates formed as well as the final product.

[3 marks]

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- (b) (i) State the reagents and condition(s) used to convert benzene into nitrobenzene.

Reagents

Condition(s)

[3 marks]

- (ii) Outline the mechanism for the reaction described in (b) (i).

[5 marks]

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(c) A synthetic route from nitrobenzene to the Compound E is shown in Figure 1.

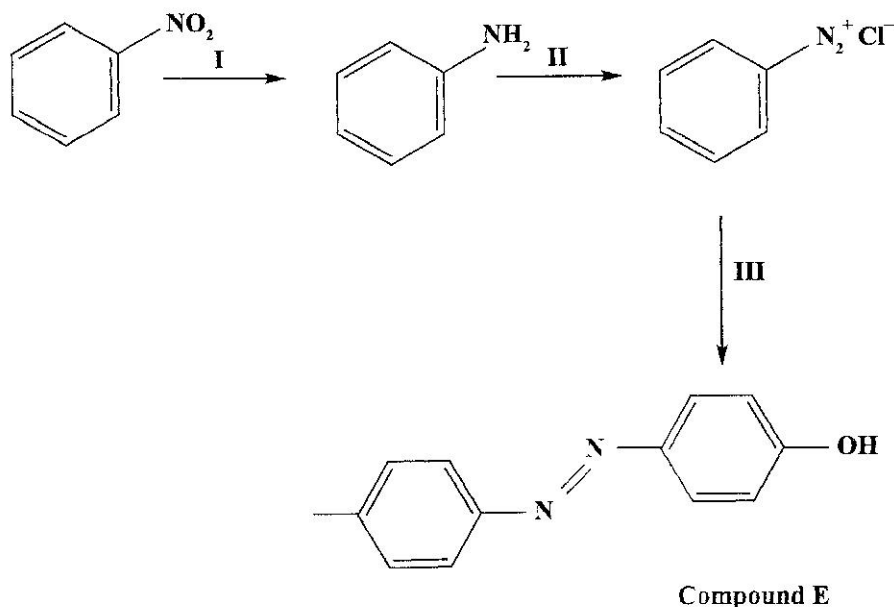


Figure 1. Synthetic route from nitrobenzene to Compound E

(i) Write the reagents used for the reactions I, II and III.

Reaction I

Reaction II

Reaction III

[3 marks]

(ii) State the class of compounds to which E belongs, giving the commercial significance of such compounds.

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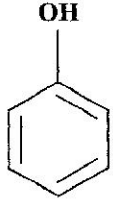
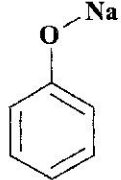
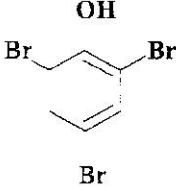
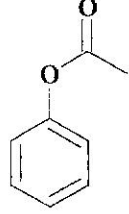
[2 marks]

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- (e) The table below shows some reactions of phenol. Complete the table by inserting the appropriate observations and reagents.

TABLE 1: REACTIONS OF PHENOL

Phenol	Reagents	Observations	Structure of Organic Product Formed
	(i)		
	(ii)	(iii) (iv)	
	(v)		

[5 marks]

Total 30 marks

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MODULE 2: ANALYTICAL METHODS AND SEPARATION TECHNIQUES

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

- Electromagnetic radiation

.....
.....

- Wavelength

.....
.....

- Frequency

.....
.....

[3 marks]

(b) (i) Write the formula which relates the speed of light (c), the wavelength of light (λ) and its frequency (ν).

.....
.....

[1 mark]



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- (ii) Using the formula from (b) (i), calculate the missing frequencies and wavelengths in Table 2 AND identify the corresponding type of electromagnetic radiation. ($c = 3.0 \times 10^8 \text{ ms}^{-1}$)

TABLE 2: PROPERTIES OF ELECTROMAGNETIC RADIATION

Wavelength (m)	Frequency (Hz)	Type of Electromagnetic Radiation
1×10^{-5}	(i)	(ii)
(iii)	9.49×10^7	(iv)

[4 marks]

- (c) When a covalent molecule absorbs UV-visible radiation, electrons are promoted. This phenomenon forms the basis for UV-VIS spectroscopy.
- (i) Complete Figure 2 by inserting arrows to show ALL possible electron transitions in the molecular orbitals indicated.

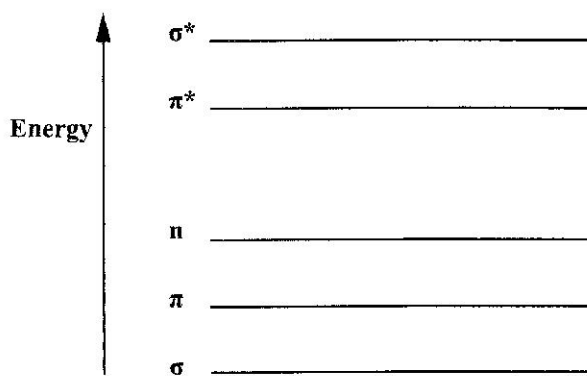


Figure 2. Electron transitions

[3 marks]



- (ii) List the transitions from (c) (i) which will normally produce absorption in the ultraviolet and visible regions of the electromagnetic spectrum.

.....

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.....

.....

[3 marks]

- (iii) The absorbance of an iron thiocyanate solution containing 0.005 mol Fe/mL was reported as 0.4900 at 540 nm.

Using Beer–Lambert’s law, $A = \epsilon cl$, calculate the specific absorptivity, including units, of iron thiocyanate, assuming that a 1.00 cm cuvette was used.

[4 marks]

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- (d) The IR spectra in Figures 3, 4 and 5 belong to the compounds 3-methylbutanol $[(\text{CH}_3)_2\text{CHCH}_2\text{CH}_2\text{OH}]$, heptanone $[\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{COCH}_3]$, and methylpentanoate $[\text{CH}_3(\text{CH}_2)_3\text{COOCH}_3]$.

Identify EACH of the compounds from the IR spectra provided in Figures 3, 4 and 5. Justify your choice by indicating the band(s) on the spectra used to verify the identity of the compounds and indicate the functional groups responsible for the band(s) in EACH case.

(i)

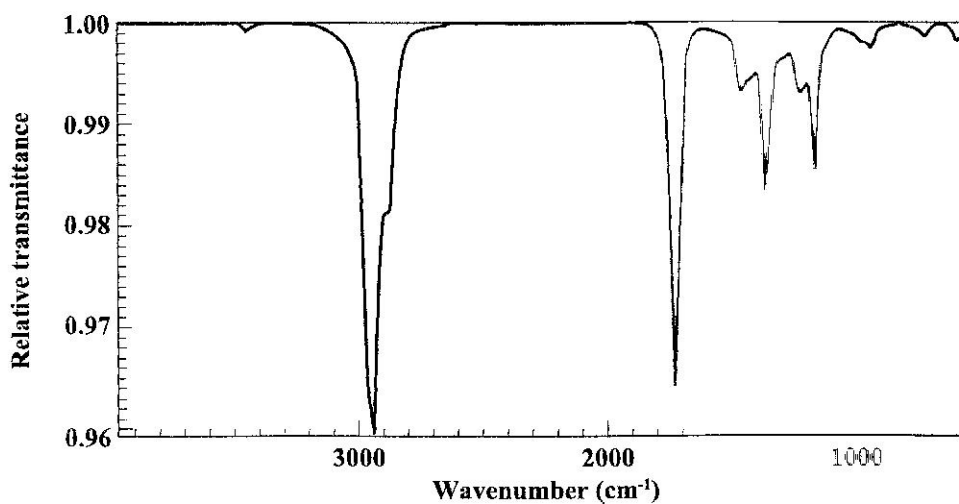


Figure 3. IR spectra

Identity of compound

Justification

.....
.....
.....

[3 marks]

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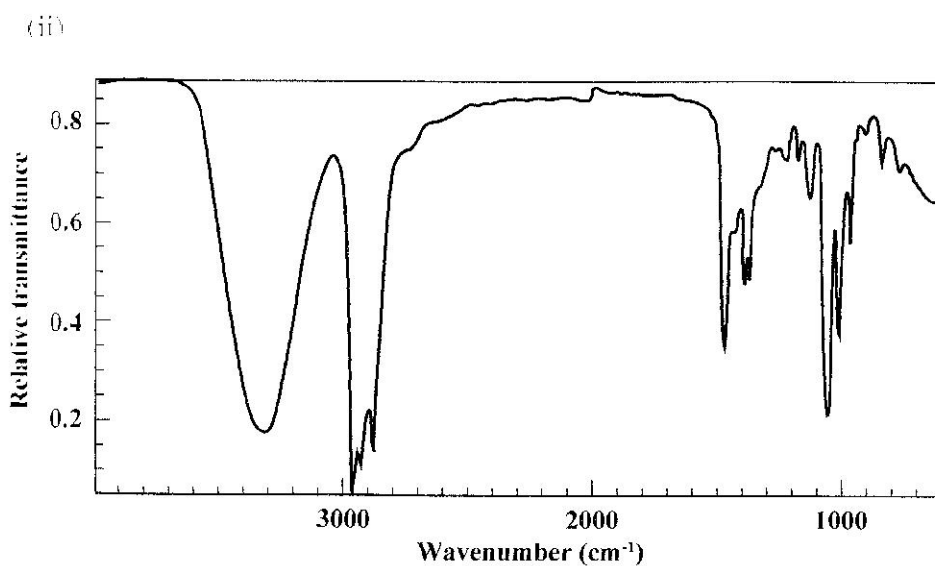


Figure 4. IR spectra

Identity of compound

Justification

.....
.....
.....

[2 marks]



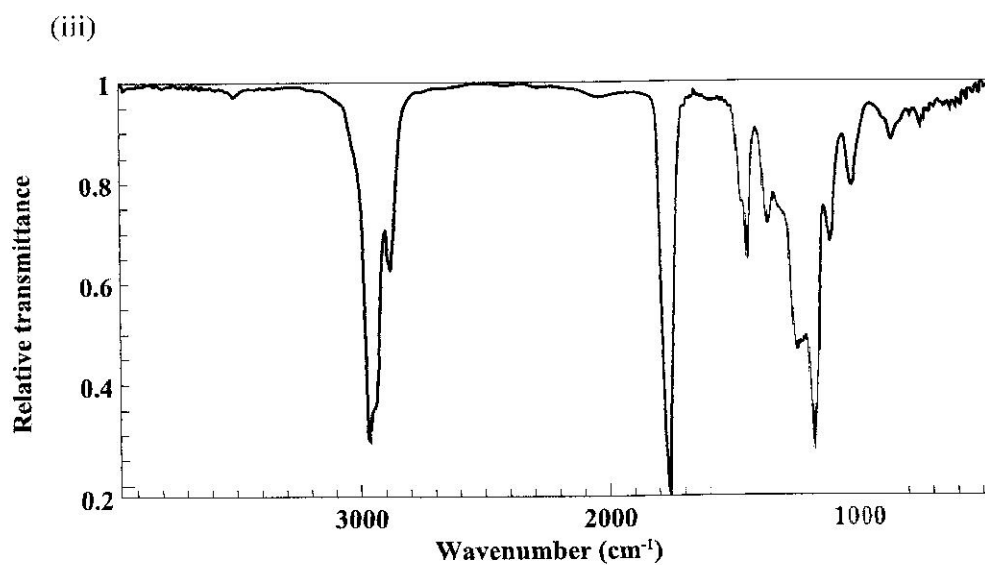


Figure 5. IR spectra

Identity of compound

Justification

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[2 marks]



(e) A student is asked to prepare a solid sample for analysis using IR spectroscopy.

(i) Describe FOUR steps to be taken by the student in preparing the sample for analysis.

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[4 marks]

(ii) Give ONE reason why the plates used for IR spectroscopy are made from NaCl.

.....
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[1 mark]

Total 30 marks

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MODULE 3: INDUSTRY AND THE ENVIRONMENT

3. (a) In the production of aluminium from bauxite, alumina is first produced and is then processed to produce aluminium.

Figure 6 is a diagram of the cell used for the conversion of alumina to aluminium.

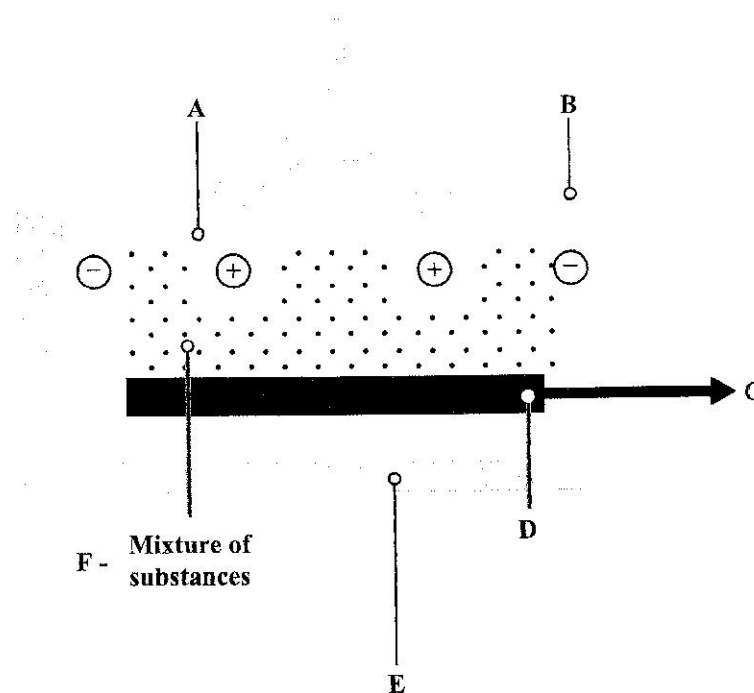


Figure 6. Diagram of cell for the conversion of alumina to aluminium

- (i) Identify EACH of the following components in Figure 6.

- A
B
C
D
E

[3 marks]

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(ii) Write the formulae of the substances in the mixture **F** in Figure 6.

.....
.....

[3 marks]

(iii) Write an equation to represent the reaction at EACH electrode during the production of aluminium.

-
-

[2 marks]

(iv) Suggest THREE factors which may influence the location of a bauxite plant.

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.....
.....
.....

[3 marks]

(b) The production of sulfuric acid in the contact process provides many useful products, but there are adverse impacts of the industry on the environment.

(i) Starting with sulfur, list the THREE **main** processes which occur during the production of sulfuric acid.

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.....
.....

[3 marks]



(ii) Using an appropriate equation, apply the principles of chemical equilibrium to deduce the theoretical conditions for the formation of sulfur trioxide.

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[5 marks]

(iii) Discuss the **actual conditions** used in the formation of sulfur trioxide in the contact process. Your response should include

- conditions of temperature
- conditions of pressure
- suitability of any catalyst(s) used.

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[5 marks]

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(iv) State ONE impact of the sulfuric acid industry on the environment.

.....
[1 mark]

(c) A student collected samples of water from a garbage dump and carried out several tests to identify the pollutants present in the water samples.

Describe laboratory tests which would confirm the presence of EACH of the following pollutants:

(i) PO_4^{3-}

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.....
.....
.....
[3 marks]

(ii) CN^-

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.....
.....
.....
[2 marks]

Total 30 marks

END OF TEST

IF YOU FINISH BEFORE TIME IS CALLED, CHECK YOUR WORK ON THIS TEST.



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