Pearson Edexcel International Advanced Level

Tuesday 10 October 2023

Morning (Time: 1 hour 30 minutes) | **Paper reference** **WCH11/01**

Chemistry
International Advanced Subsidiary/Advanced Level
UNIT 1: Structure, Bonding and Introduction to Organic Chemistry

You must have:
Scientific calculator, ruler

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need*.

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question*.
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Show all your working in calculations and include units where appropriate.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

Answer ALL the questions in this section.

You should aim to spend no more than 20 minutes on this section.
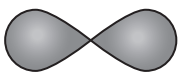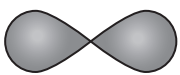
For each question, select one answer from A to D and put a cross in the box ⊠. If you change your mind, put a line through the box ⊠ and then mark your new answer with a cross ⊠.

1   An atom of $^{27}_{13}Al$ forms the ion, Al^{3+}.
    What are the numbers of protons, electrons and neutrons in this ion?

		protons	electrons	neutrons
⊠	**A**	13	13	14
⊠	**B**	10	13	14
⊠	**C**	14	10	13
⊠	**D**	13	10	14

(Total for Question 1 = 1 mark)

2   What is the shape of a p orbital and the maximum number of electrons it can hold?

		shape	maximum number of electrons
⊠	**A**		2
⊠	**B**		6
⊠	**C**		2
⊠	**D**		6

(Total for Question 2 = 1 mark)

3 The formula of calcium carbide is CaC_2.

(a) What is the formula of the carbide ion?

(1)

- ☒ **A** C_2^-
- ☒ **B** C_2^+
- ☒ **C** C_2^{2-}
- ☒ **D** C_2^{2+}

(b) Excess calcium carbide and 10 g of water react to form the hydrocarbon ethyne, C_2H_2.

$$CaC_2 + 2H_2O \rightarrow C_2H_2 + Ca(OH)_2$$
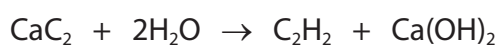
What is the mass of ethyne that forms, assuming a yield of 100%?

[M_r values: $H_2O = 18.0$ $C_2H_2 = 26.0$]

(1)

- ☒ **A** 7.22 g
- ☒ **B** 14.4 g
- ☒ **C** 23.4 g
- ☒ **D** 28.9 g

(Total for Question 3 = 2 marks)

Use this space for any rough working. Anything you write in this space will gain no credit.

4 Which diagram best represents the electron density map of sodium chloride?

A

B

C

D
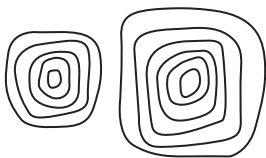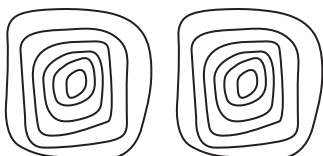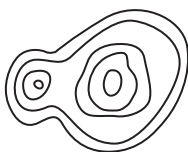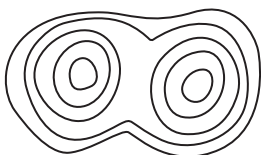
(Total for Question 4 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

5 What types of bonding are present in the compound ammonium chloride, NH_4Cl?

	Ionic	Covalent	Dative covalent
☒ **A**	✓	✗	✓
☒ **B**	✗	✓	✗
☒ **C**	✓	✓	✗
☒ **D**	✓	✓	✓

(Total for Question 5 = 1 mark)

6 The electronic configurations of the atoms of four elements are shown.

What is the electronic configuration of the atom of element which has the **lowest** first ionisation energy?

☒ **A** $1s^2 2s^2 2p^6 3s^2$

☒ **B** $1s^2 2s^2 2p^6 3s^2 3p^1$

☒ **C** $1s^2 2s^2 2p^6 3s^2 3p^2$

☒ **D** $1s^2 2s^2 2p^6 3s^2 3p^3$

(Total for Question 6 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

7 A direct electrical current was passed through a green solution of copper(II) chromate(VI) in the apparatus shown.

Negative electrode   Positive electrode

Copper(II) chromate(VI) solution
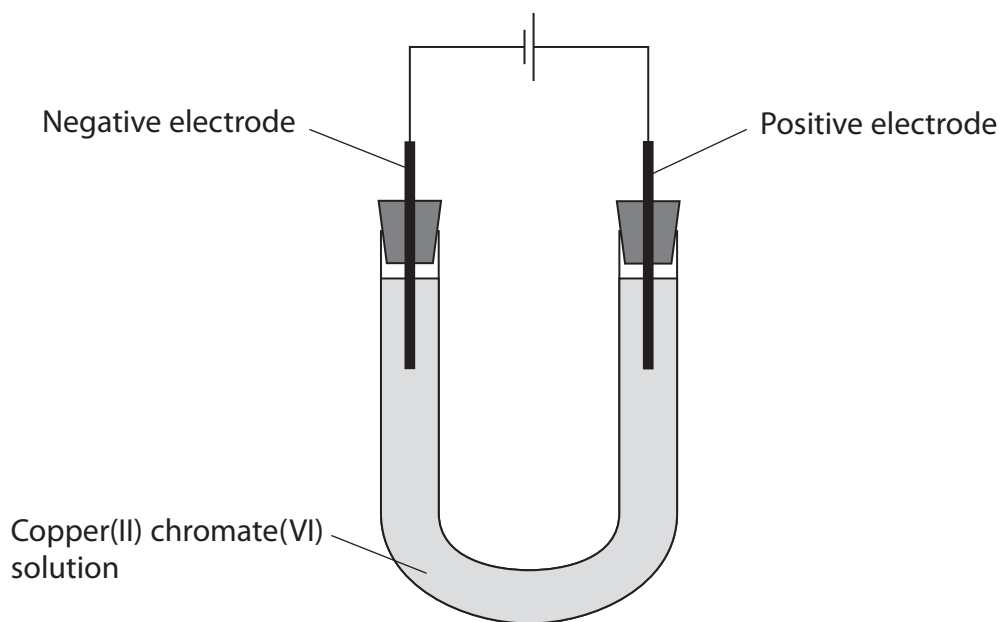
Which colours would be seen at each electrode after several minutes?

	Negative electrode	Positive electrode
☒ **A**	blue	green
☒ **B**	green	blue
☒ **C**	blue	yellow
☒ **D**	yellow	blue

(Total for Question 7 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

8   In which region of a mass spectrometer are particles ionised?

P   Q   +
              R

recorder

amplifier

S
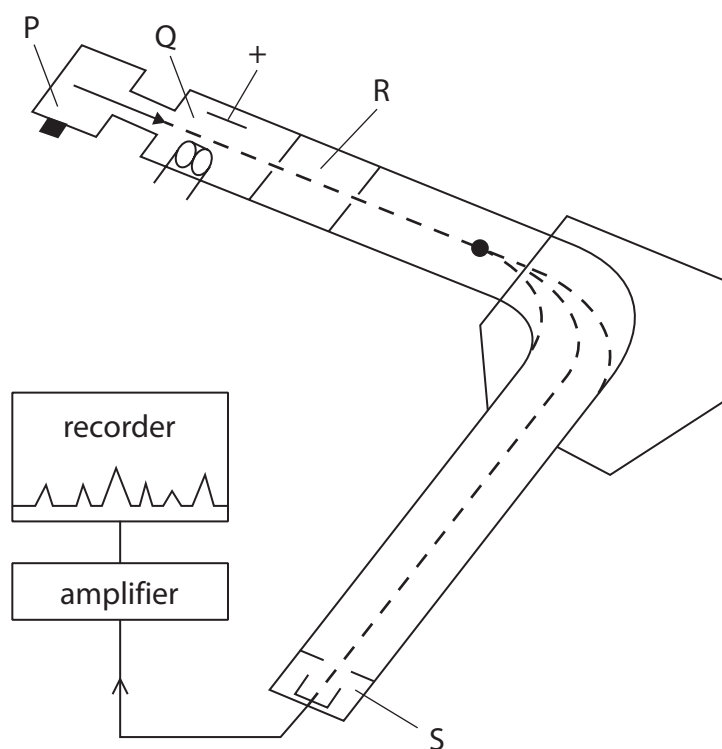
☒   **A**   region P

☒   **B**   region Q

☒   **C**   region R

☒   **D**   region S

(Total for Question 8 = 1 mark)

9   A sample of the element chlorine, Cl_2, was analysed in a mass spectrometer.
Chlorine has **two** isotopes.

What is the **total** number of peaks, due to ions with a single positive charge, which could be seen in the mass spectrum?

☒   **A**   two

☒   **B**   four

☒   **C**   five

☒   **D**   six

(Total for Question 9 = 1 mark)

10 Propene, $CH_3CH=CH_2$, reacts with hydrogen chloride, HCl, to form halogenoalkanes.

(a) Which of these steps is most likely to occur in the reaction?

(1)

A
```
     H   H   H
     |   |   |
 H—C—C—C⁺
     |   |   |
     H   H   H     :Cl⁻
```

B
```
     H   H   H
     |   |   |
 H—C—C—C⁺
     |   |   |
     H   H   H
                  :Cl⁻
```

C
```
          :Cl⁻
     H         H
     |         |
 H—C—C⁺—C—H
     |    |    |
     H   H   H
```

D
```
          :Cl⁻
     H         H
     |         |
 H—C—C⁺—C—H
     |    |    |
     H   H   H
```
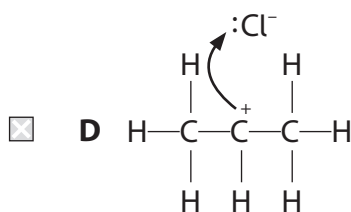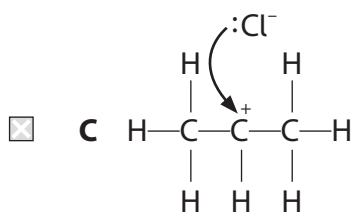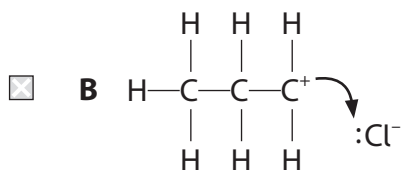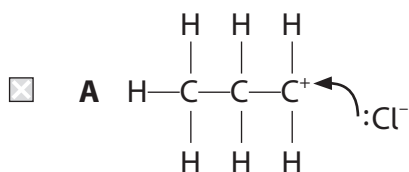
(b) The reaction of propene with hydrogen chloride is an example of

(1)

☒ **A** free radical substitution

☒ **B** free radical addition

☒ **C** electrophilic substitution

☒ **D** electrophilic addition

(Total for Question 10 = 2 marks)

11 Ethene reacts with acidified potassium manganate(VII). A student makes four statements about the reaction.

- the organic product can show geometric isomerism

- the type of reaction that takes place is oxidation

- the bond angles around each carbon atom are greater in the product than in ethene

- the acidified potassium manganate(VII) decolourises in the reaction

How many of these statements are correct?

☒ **A** one

☒ **B** two

☒ **C** three

☒ **D** four

(Total for Question 11 = 1 mark)

12 Concentrations in mixtures can be given in units of parts per million (ppm).

(a) A sample of a gaseous mixture contains 2.19% carbon dioxide by mass.

What is the concentration of carbon dioxide in parts per million (ppm) by mass in this sample?

(1)

☒ **A** 2.19×10^6

☒ **B** 2.19×10^4

☒ **C** 2.19×10^{-4}

☒ **D** 2.19×10^{-6}

(b) A solution of lead nitrate has a concentration of 15 ppm by mass.

What is the mass of lead nitrate in 400 g of this solution?

(1)

☒ **A** 6.00×10^{-3} g

☒ **B** 6.00×10^{-6} g

☒ **C** 6.00×10^{-3} kg

☒ **D** 6.00×10^{0} kg

(Total for Question 12 = 2 marks)

13 Which solution contains chloride ions with a concentration of $0.0500 \, mol \, dm^{-3}$?

[A_r values: Ca = 40.1 Cl = 35.5 Na = 23.0]

		Solute	Mass of solute / g	Volume of solution / cm^3
☒	**A**	calcium chloride	1.39	250
☒	**B**	calcium chloride	1.39	500
☒	**C**	sodium chloride	1.46	250
☒	**D**	sodium chloride	1.46	1000

(Total for Question 13 = 1 mark)

14 The formula of phosgene is $COCl_2$.
What is the total number of **atoms** in 9.9 g of phosgene?

[Avogadro constant (L) = $6.02 \times 10^{23} \, mol^{-1}$ M_r value: $COCl_2$ = 99.0]

☒ **A** 1.51×10^{22}

☒ **B** 6.02×10^{22}

☒ **C** 1.81×10^{23}

☒ **D** 2.41×10^{23}

(Total for Question 14 = 1 mark)

15 What is the number of structural isomers with the molecular formula C_5H_{12}?

☒ **A** six

☒ **B** five

☒ **C** four

☒ **D** three

(Total for Question 15 = 1 mark)

16 A cyclic hydrocarbon has the structure shown.
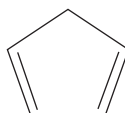
How many pi (π) and sigma (σ) bonds are present in the molecule?

		pi (π) bonds	sigma (σ) bonds
☒	**A**	2	11
☒	**B**	2	5
☒	**C**	4	3
☒	**D**	4	10

(Total for Question 16 = 1 mark)

17 A technician is asked to store four reagent bottles safely. The only information about each substance is the hazard label on the bottle.
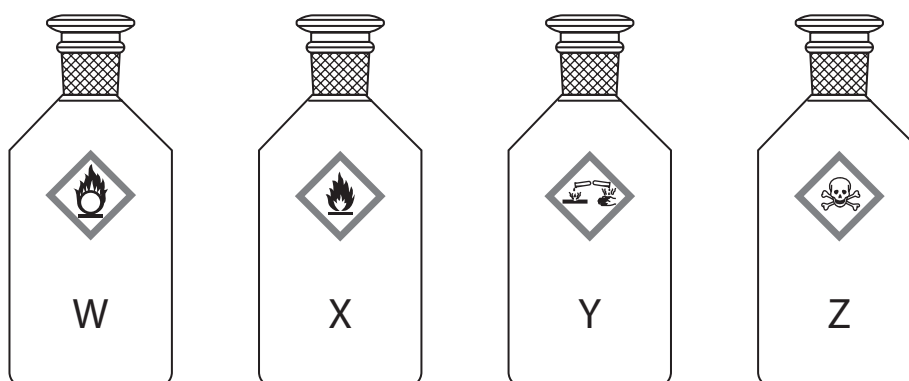
Based on the hazard labels alone, which two bottles should **never** be stored together?

☒ **A** W and Z

☒ **B** Y and Z

☒ **C** W and X

☒ **D** Y and X

(Total for Question 17 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

18 This question is about the elements in Period 2 of the Periodic Table.

(a) The first ionisation energies of some elements in Period 2 are shown.

Element	Li	Be	B	C	N	O	F	Ne
First ionisation energy / kJ mol^{-1}	520	900	801	1086	1402		1681	2081

(i) Explain the **general** trend in first ionisation energy across Period 2.

(2)

....

....

....

....

....

....

(ii) Predict a value for the first ionisation energy of oxygen.
Justify your answer.

(3)

....

....

....

....

....

....

....

....

(b) The second ionisation energy of lithium, Li, is $7298 \, kJ \, mol^{-1}$.

(i) Write the equation for the second ionisation energy of lithium. Include state symbols.

(2)

(ii) Explain the large difference between the first and second ionisation energies of lithium.

(2)

....

....

....

....

....

....

(c) Beryllium reacts with chlorine to form beryllium chloride.

In the gas phase, beryllium chloride exists both as a simple molecule, $BeCl_2$, and as a dimer, Be_2Cl_4.

(i) Draw a dot-and-cross diagram of the molecule, $BeCl_2$.

(1)

(ii) Explain the shape and bond angle in the molecule $BeCl_2$.

(4)

Shape

....

Bond angle

....

Explanation

....

....

....

....

....

(iii) Draw a diagram to show how two beryllium chloride molecules bond together to form the dimer, Be_2Cl_4, stating the type of bond involved.

(2)

Type of bond

....

(Total for Question 18 = 16 marks)

19 Many cars use fuels containing ethanol as well as hydrocarbons. The E numbers of these fuels show the percentage by volume of ethanol in the fuel. For example, an E5 fuel contains 5% ethanol and 95% hydrocarbons by volume.

(a) A brand of E10 fuel contains 92.2% hydrocarbons and 7.80% ethanol **by mass**.

The energy density is the amount of energy released per kg of a fuel burned. The energy densities of the two components of this brand of fuel are shown.

energy density of hydrocarbons $= 46.5\ MJ\,kg^{-1}$

energy density of ethanol $= 29.7\ MJ\,kg^{-1}$

(i) Calculate the **mean** energy density of this E10 fuel in $MJ\,kg^{-1}$. Give your answer to an appropriate number of significant figures.

(2)

(ii) The density of the E10 fuel is $0.729\,g\,cm^{-3}$.

Calculate the mass of $1500\,cm^3$ of the fuel.

(1)

(iii) Calculate the energy released when $1500\,cm^3$ of the E10 fuel is burned in excess oxygen, using your answers from (a)(i) and (a)(ii).

[If you did not calculate a value for the **mean** energy density of the E10 fuel in (a)(i), use a value of $38.1\,MJ\,kg^{-1}$. This is not the correct value.]

(1)

(b) Many countries are gradually replacing E5 fuels with E10 fuels.

Explain how this change might result in a more sustainable fuel.

(3)

....

....

....

....

....

....

....

....

....

....

....

(c) The straight-chain alkane hexane can be reformed to give a range of products.
It was suggested that one such reaction may produce a cyclic hydrocarbon and
hydrogen gas as the only products.
The cyclic hydrocarbon contains a ring of five carbon atoms.

(i) Write the equation for this reaction using molecular formulae.
State symbols are not required.

(1)

(ii) Draw the structure of the cyclic hydrocarbon formed in this reaction.

(1)

P 7 5 0 7 0 A 0 1 7 2 8

(d) Hexane will react with chlorine in the presence of ultraviolet light to form a number of products.

(i) Describe the role of the ultraviolet light in the initiation step of this reaction.

(2)

....

....

....

....

(ii) The alkane dodecane, $C_{12}H_{26}$, is formed in this reaction.
Write equations for the propagation step and for the termination step for the formation of this product.
Use molecular formulae in your equations.
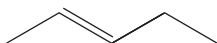
(2)

Propagation step

Termination step

(Total for Question 19 = 13 marks)

20 This question is about alkenes.

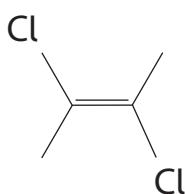(a) A straight-chain alkene, **X**, has the structure shown.

(i) Draw the skeletal formulae of the four structural isomers of **X** that are alkenes.
Do not include geometric isomers.

(4)

(ii) Explain why **X** can exist as **geometric** isomers.

(2)

....

....

....

....

(b) Another compound, **Y**, has the structure shown.

(i) Give the IUPAC name for **Y**.

(1)

....

(ii) A student stated that

'Compound **Y** has polar bonds so it is a polar molecule'.

Comment on this statement.

(3)

....

....

....

....

....

....

....

....

P 7 5 0 7 0 A 0 2 0 2 8

(c) Bisabolenes are a group of compounds found in plants and fungi.
Bisabolene molecules contain several carbon–carbon double bonds.

5.51 g of α-bisabolene reacted with 1873 cm^3 of hydrogen gas, H_2.
The reaction occurred at a temperature of 150 °C and a pressure of 152 000 Pa.

[M_r value: α-bisabolene = 204.0]

(i) Calculate the amount, in mol, of α-bisabolene in 5.51 g.

(1)

(ii) Calculate the amount, in mol, of hydrogen gas that reacted with α-bisabolene.
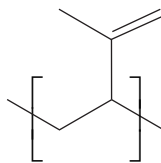Use the ideal gas equation, $pV = nRT$.

[$R = 8.31 \, J \, mol^{-1} \, K^{-1}$]

(3)

(iii) Deduce the number of carbon-carbon double bonds in a molecule of
α-bisabolene, using your answers to (c)(i) and (c)(ii).

(1)

(d) The repeat unit of the polymer polyisoprene is shown.

polyisoprene

(i) Draw the **skeletal** formula of the monomer of polyisoprene.

(1)

(ii) A sample of polyisoprene has a relative molecular mass of 50 250.
Calculate the number of repeat units in the sample.

(2)

(e) Incinerators used to dispose of polymer waste have a system to remove waste gases.
Suggest why these systems contain solid calcium hydroxide and why it is finely powdered.

(2)

....

....

....

....

....

....

(Total for Question 20 = 20 marks)

21 This question is about minerals containing metallic elements.

(a) The green mineral zaratite contains basic nickel(II) carbonate, $Ni_3CO_3(OH)_4 \cdot 4H_2O$.

Basic nickel(II) carbonate can be formed by the reaction of nickel(II) sulfate with sodium carbonate under alkaline conditions, as shown.

$$3NiSO_4(aq) \ + \ Na_2CO_3(aq) \ + \ 4NaOH(aq) \ + \ 4H_2O(l) \ \rightarrow \ Ni_3CO_3(OH)_4 \cdot 4H_2O(s) \ + \ 3Na_2SO_4(aq)$$
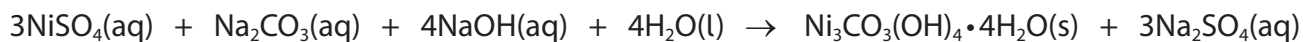
[A_r values: H = 1.0   C = 12.0   O = 16.0   Na = 23.0   S = 32.1   Ni = 58.7]

(i) Calculate the relative formula mass of basic nickel(II) carbonate, $Ni_3CO_3(OH)_4 \cdot 4H_2O$.

(1)

(ii) Calculate the atom economy by mass for the formation of basic nickel(II) carbonate by the reaction shown.

(2)

(iii) Give the reason why use of the term 'relative molecular mass' is not appropriate in (a)(i).

(1)

....

....

....

....

(b) Chemists often simplify full chemical equations into ionic equations by removing spectator ions.

 (i) Give the electronic configuration of the nickel ion present in nickel(II) compounds.

(1)

....

 (ii) Write the **ionic** equation for the formation of basic nickel(II) carbonate from nickel(II) sulfate.
State symbols are not required.

$3NiSO_4(aq) + Na_2CO_3(aq) + 4NaOH(aq) + 4H_2O(l) \rightarrow Ni_3CO_3(OH)_4 \cdot 4H_2O(s) + 3Na_2SO_4(aq)$

(1)
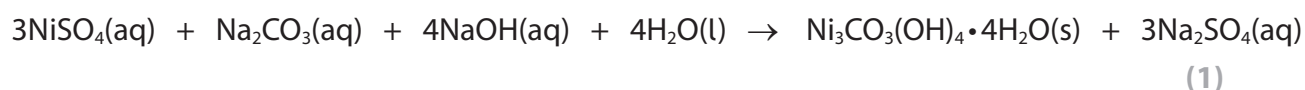
(c) Another basic carbonate found in minerals contains the metal element **X** and is formed by the reaction shown.

$$2\mathbf{X}SO_4 \;+\; 2Na_2CO_3 \;+\; H_2O \;\rightarrow\; \mathbf{X}_2CO_3(OH)_2 \;+\; 2Na_2SO_4 \;+\; CO_2$$

1.995 g of **X**SO_4 is reacted with excess Na_2CO_3 forming 150.0 cm³ of carbon dioxide gas, CO_2, at room temperature and pressure, r.t.p.

[Molar volume of a gas at r.t.p. = 24.0 dm³ mol⁻¹]

 (i) Calculate the relative formula mass of **X**SO_4, using these data.

(4)

 (ii) Deduce the identity of **X**, using your answer to (c)(i).

(1)

(Total for Question 21 = 11 marks)

TOTAL FOR SECTION B = 60 MARKS
TOTAL FOR PAPER = 80 MARKS