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**Pearson Edexcel International Advanced Level**

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.
- **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 ►

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## SECTION A

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 Which mixture results in a displacement reaction?

- A iron and copper(II) sulfate solution
- B lead(II) nitrate solution and sodium iodide solution
- C dilute hydrochloric acid and sodium hydroxide solution
- D zinc and magnesium sulfate solution

(Total for Question 1 = 1 mark)

2 Which mixture results in a precipitation reaction?

- A dilute sulfuric acid and potassium hydroxide solution
- B iron and calcium chloride solution
- C chlorine water and potassium bromide solution
- D silver nitrate solution and potassium bromide solution

(Total for Question 2 = 1 mark)

3 An atom of  $^{15}_7\text{N}$  forms a nitride ion,  $\text{N}^{3-}$ .

What are the numbers of protons, neutrons and electrons in this ion?

	Protons	Neutrons	Electrons
<input type="checkbox"/> A	7	8	7
<input type="checkbox"/> B	7	8	4
<input type="checkbox"/> C	7	8	10
<input type="checkbox"/> D	8	7	10

(Total for Question 3 = 1 mark)

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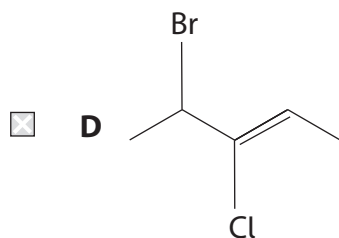
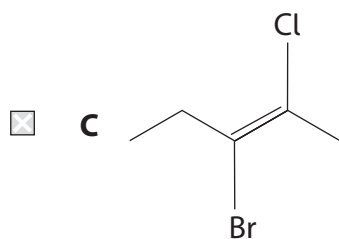
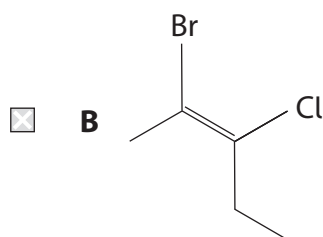
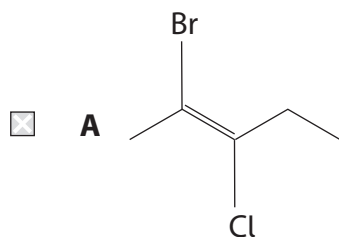
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4 What is the total number of orbitals in a sulfur atom which contain at least one electron?

- A 3
- B 5
- C 8
- D 9

(Total for Question 4 = 1 mark)

5 Which structure has the name *E*-2-bromo-3-chloropent-2-ene?

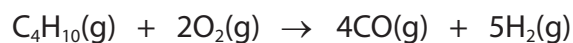


(Total for Question 5 = 1 mark)

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- 6 The partial oxidation of butane in the presence of a catalyst has been investigated as a possible source of hydrogen.



- (a) What is the most significant hazard associated with the pollutant CO(g)?

(1)

- A it is a major contributor to the formation of acid rain
- B it strongly absorbs infrared radiation
- C it is toxic at low concentrations
- D it is the main cause of ozone layer depletion

- (b) A mixture of 40 cm<sup>3</sup> of butane and 20 cm<sup>3</sup> of oxygen reacts in a sealed system to form carbon monoxide and hydrogen.

What is the total volume of gas in the system at the end of the reaction, in cm<sup>3</sup>?

(1)

- A 30
- B 60
- C 90
- D 120

(Total for Question 6 = 2 marks)

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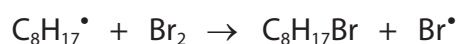
7 Octane,  $C_8H_{18}$ , reacts with bromine in the presence of ultraviolet radiation.

(a) What is the role of ultraviolet radiation in the reaction?

(1)

- A** to break the Br—Br bond only
- B** to break a C—H bond only
- C** to break a C—C bond only
- D** to break both the Br—Br and a C—H bond

(b) One of the steps of the reaction is shown.



What is the name of this step and the type of bond breaking that takes place in the bromine molecule?

(1)

	Name of step	Type of bond breaking
<input type="checkbox"/> <b>A</b>	initiation	heterolytic
<input type="checkbox"/> <b>B</b>	initiation	homolytic
<input type="checkbox"/> <b>C</b>	propagation	heterolytic
<input type="checkbox"/> <b>D</b>	propagation	homolytic

(c) What is the overall equation for the reaction of octane with bromine?

(1)

- A**  $C_8H_{18} + Br_2 \rightarrow C_8H_{16}Br_2 + H_2$
- B**  $C_8H_{18} + Br_2 \rightarrow C_8H_{17}Br + HBr$
- C**  $C_8H_{18} + Br_2 \rightarrow 2C_4H_9Br$
- D**  $C_8H_{18} + 3Br_2 \rightarrow 2C_4H_7Br + 4HBr$

(Total for Question 7 = 3 marks)

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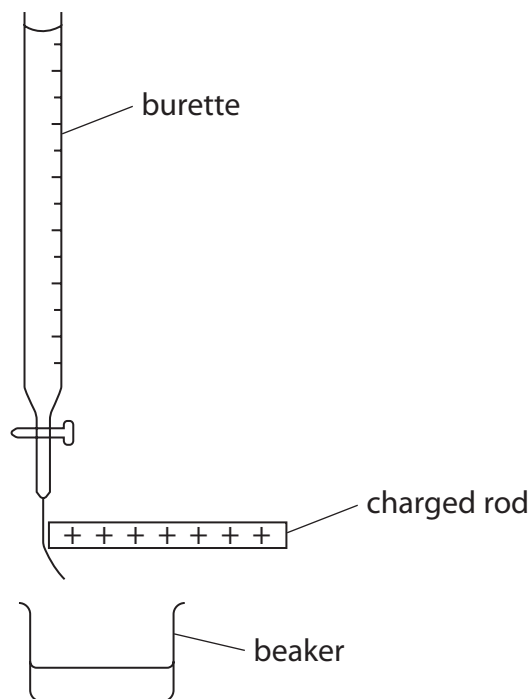
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8 A stream of liquid from a burette is deflected by a charged rod.



Which substance, in its liquid state, will be deflected the most?

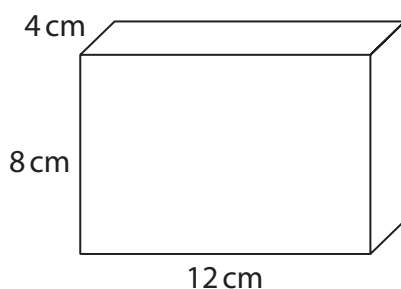
- A  $C_5H_{12}$
- B  $CCl_4$
- C  $BCl_3$
- D  $CH_2Cl_2$

(Total for Question 8 = 1 mark)

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9 A piece of copper is shown.



How many moles of copper atoms are there in this piece of copper?

[Density of copper =  $8.96 \text{ g cm}^{-3}$ ]

- A 0.675
- B 1.48
- C 6.05
- D 54.2

(Total for Question 9 = 1 mark)

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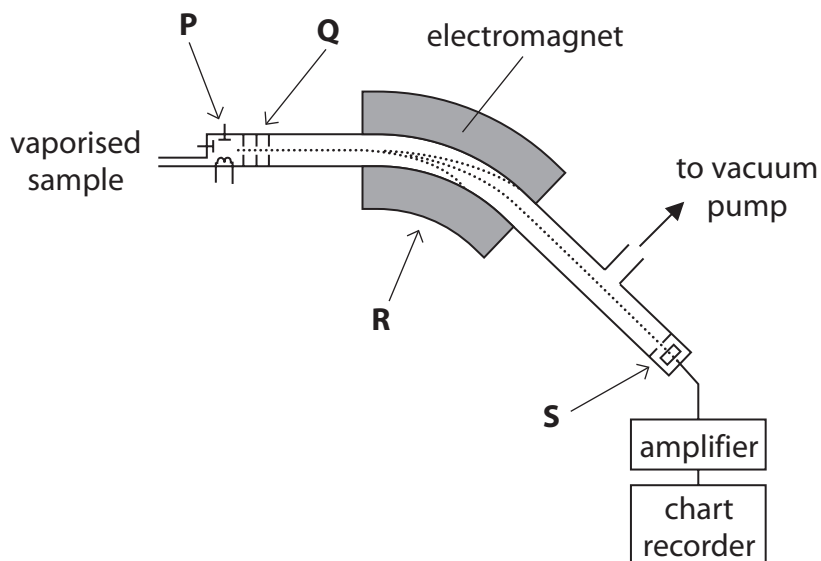
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10 Mass spectrometers are used in chemical analysis.

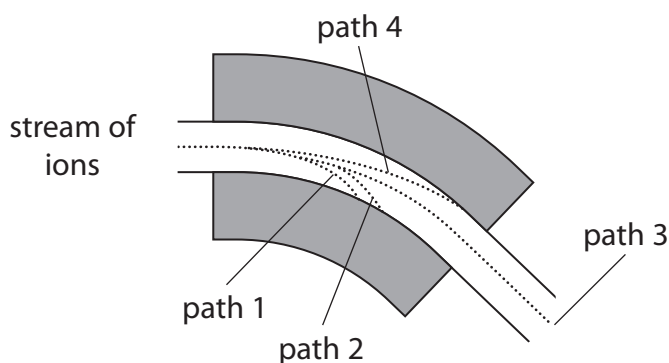
(a) In which region of this mass spectrometer are the ions accelerated?

(1)



- A region P
- B region Q
- C region R
- D region S

(b) Four iron ions are present in a stream of ions in a mass spectrometer. The paths of these ions are shown.



Which of these ions will follow path 1 through the mass spectrometer?

(1)

- A  $^{54}\text{Fe}^+$
- B  $^{54}\text{Fe}^{2+}$
- C  $^{56}\text{Fe}^+$
- D  $^{56}\text{Fe}^{2+}$



(c) Naturally-occurring chlorine has two isotopes,  $^{35}\text{Cl}$  and  $^{37}\text{Cl}$ .

How many peaks due to the singly-charged **molecular** ions are seen in the mass spectrum of chlorine,  $\text{Cl}_2$ ?

(1)

- A 1
- B 2
- C 3
- D 4

(Total for Question 10 = 3 marks)

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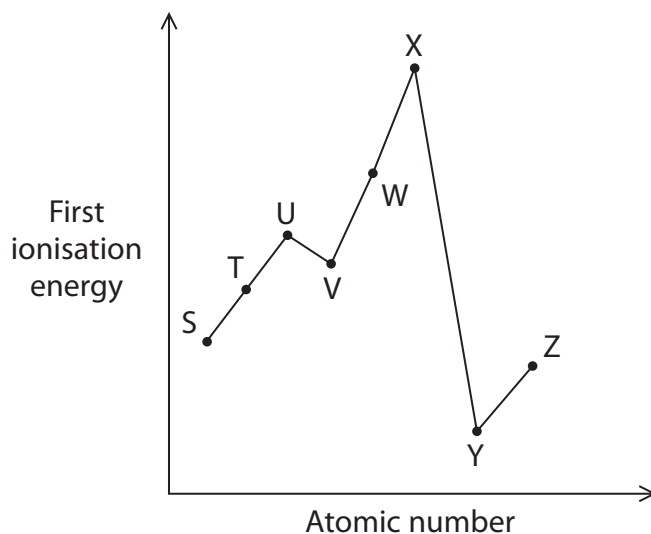
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- 11 The graph shows the first ionisation energies of some consecutive elements from Periods 2 and 3 of the Periodic Table.

The letters used to label the elements are **not** their chemical symbols.



- (a) Which element has only **one** p orbital containing a pair of electrons?

(1)

- A element U  
 B element V  
 C element W  
 D element X

- (b) Which element is the least reactive?

(1)

- A element S  
 B element X  
 C element Y  
 D element Z

- (c) Which element has the greatest **second** ionisation energy?

(1)

- A element S  
 B element T  
 C element X  
 D element Y

(Total for Question 11 = 3 marks)



**12** A mass of 4.08 g of hydrated copper(II) sulfate,  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ , was dissolved in deionised water to form  $250 \text{ cm}^3$  of solution.

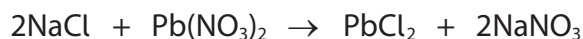
What is the concentration of the copper(II) sulfate solution formed, in  $\text{mol dm}^{-3}$ ?

- A** 0.0163
- B** 0.0256
- C** 0.0654
- D** 0.102

**(Total for Question 12 = 1 mark)**

**13** A mass of 2.50 g of sodium chloride reacts with excess lead(II) nitrate solution forming lead(II) chloride with a yield of 95 %.

What is the mass of lead(II) chloride,  $\text{PbCl}_2$ , formed?



[ $M_r$  values:  $\text{NaCl} = 58.5$   $\text{PbCl}_2 = 278.2$ ]

- A** 5.65 g
- B** 5.94 g
- C** 11.3 g
- D** 11.9 g

**(Total for Question 13 = 1 mark)**

**TOTAL FOR SECTION A = 20 MARKS**

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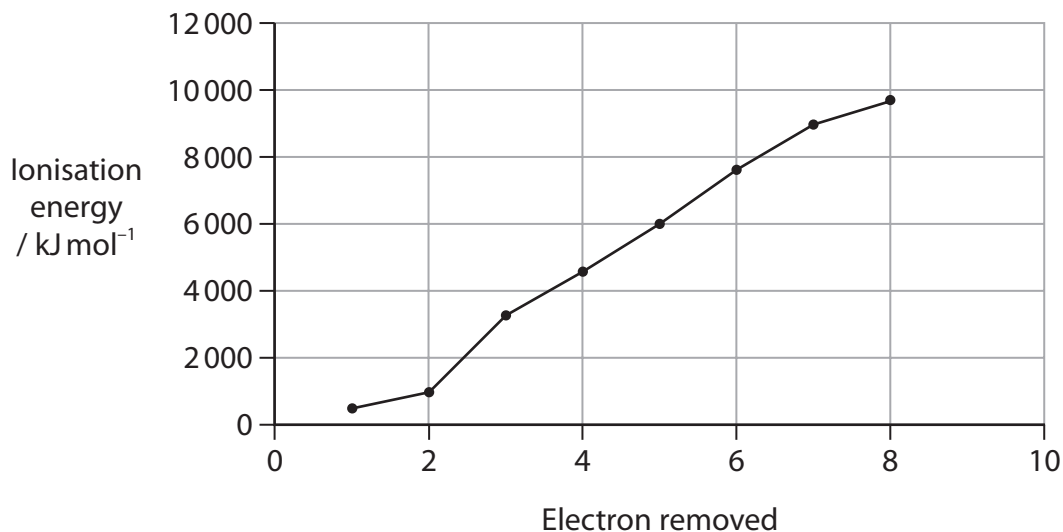
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## SECTION B

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

14 This question is about barium and barium compounds.

(a) The graph shows the first eight ionisation energies of barium.



(i) Write an equation, including state symbols, for the **third** ionisation energy of barium.

(1)

(ii) State how the graph confirms that barium is in Group 2 in the Periodic Table.

(1)

.....

.....

.....

.....



(b) An acidified aqueous solution of barium chloride,  $\text{BaCl}_2$ , is used to test for sulfate ions.

- (i) Draw a dot-and-cross diagram for barium chloride.  
Show the outer electrons only.

(2)

- (ii) Calculate the mass of barium chloride needed to form  $150 \text{ cm}^3$  of  $\text{BaCl}_2(\text{aq})$  with a concentration of  $0.200 \text{ mol dm}^{-3}$ .

Give your answer to an appropriate number of significant figures.

(2)

- (iii) The barium chloride solution is acidified to prevent carbonate ions giving a false positive result.

Write the **ionic** equation for the reaction of hydrochloric acid with carbonate ions. State symbols are not required.

(1)

- (c) Give a reason why solid barium chloride does not conduct electricity.

(1)

(Total for Question 14 = 8 marks)

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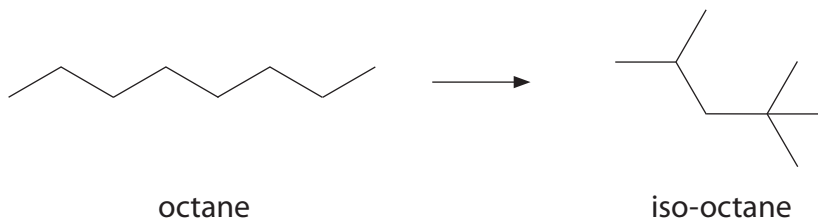
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15 This question is about hydrocarbons obtained from crude oil.

- (a) Petrol used in cars has a high proportion of the alkane iso-octane. Iso-octane can be formed by heating octane to 400 °C in the presence of a catalyst.



- (i) Give the IUPAC name for iso-octane. (1)

- (ii) Name the industrial process used to convert octane into iso-octane. (1)

- (iii) Give a reason why petrol needs a high proportion of iso-octane. (1)

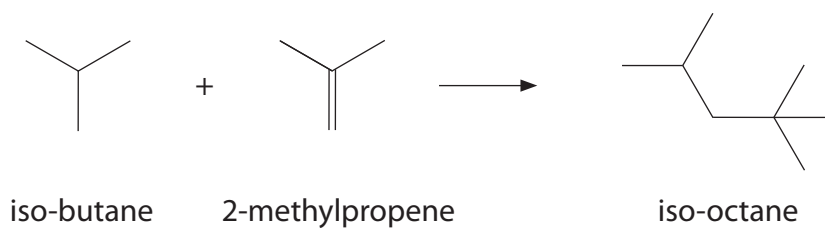
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(b) Another way to produce iso-octane is by reacting iso-butane with 2-methylpropene.



Draw the **skeletal** formulae of four isomers of 2-methylpropene.  
Include only **one** isomer that does not decolorise bromine water.

(4)


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(c) 2-methylpropene reacts with hydrogen bromide to form two possible products.

- (i) Draw the mechanism for the formation of the **major** product of the reaction between 2-methylpropene and hydrogen bromide, HBr.

Include curly arrows, and relevant lone pairs and dipoles.

(4)

- (ii) Give the reason why your product in (c)(i) is the major product.

(1)

(d) Another component of petrol, compound **X**, contains 92.3 % carbon and 7.7 % hydrogen by mass.

- (i) Calculate the empirical formula of compound **X**.  
You must show all your working.

(2)



- (ii) A sample of compound **X** has a mass of 0.267 g and vaporises at 85.0 °C and 104 kPa to produce a gaseous sample with a volume of 98.0 cm<sup>3</sup>.

Calculate the molar mass of compound **X**.  
You must show all your working.

$$[pV = nRT \quad R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}]$$

(4)

- (iii) Deduce the molecular formula of compound **X**, using your answers to (d)(i) and (d)(ii).

(1)

(Total for Question 15 = 19 marks)



**16** This question is about the Group 4 element germanium and some of its compounds.

(a) Naturally-occurring germanium consists of five stable isotopes.

Explain what is meant by the term isotopes.

(2)

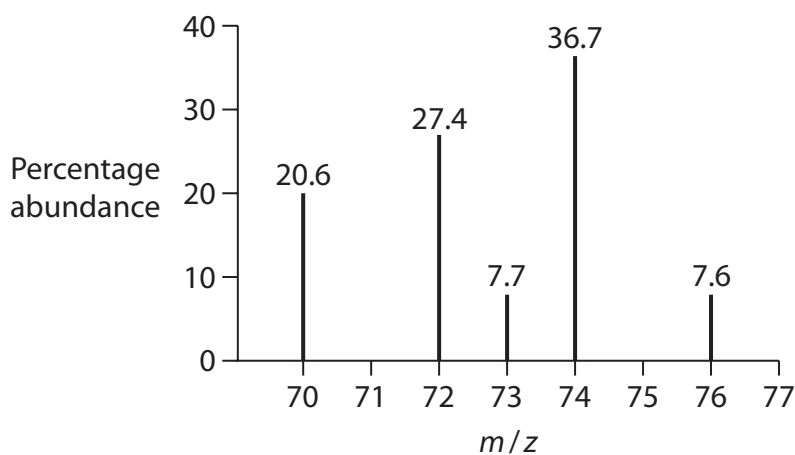
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(b) The mass spectrum of a sample of germanium is shown.



Calculate the relative atomic mass of this sample of germanium.

(2)

(c) Give the electronic configuration of a germanium atom.

(1)

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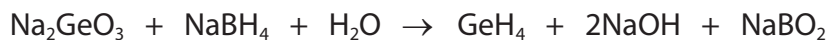
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(d) Germane is a compound with the formula  $\text{GeH}_4$ .

It can be formed by the reaction shown.



(i) Calculate the atom economy, by mass, for the formation of germane.  
Use  $A_r$  of Ge = 72.6

(2)

(ii) Germane can donate a proton to ammonia, forming the ion  $\text{GeH}_3^-$ .



Draw a dot-and-cross diagram of the ion  $\text{GeH}_3^-$ . Show the outer electrons only.

(2)

(iii) Use your answer to (d)(ii) and electron-pair repulsion theory to predict the name of the shape and bond angle of the ion  $\text{GeH}_3^-$ .

(2)

Name of the shape

.....

Bond angle

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(iv) Germane is toxic and the maximum permitted concentration is  $0.640 \text{ mg m}^{-3}$  in air.

Calculate the maximum number of germane molecules permitted in a laboratory with a volume of  $231 \text{ m}^3$ .

[Avogadro constant ( $L$ ) =  $6.02 \times 10^{23} \text{ mol}^{-1}$ ]

(4)

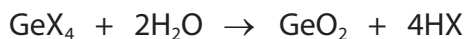
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(e) A halide of germanium,  $\text{GeX}_4$ , reacts with water as shown.



1.50 g of  $\text{GeX}_4$  was added to excess water.

The insoluble  $\text{GeO}_2$  was removed by filtration.

The solution of hydrogen halide formed was then added to excess magnesium carbonate, forming  $335.5 \text{ cm}^3$  of carbon dioxide at room temperature and pressure (r.t.p.).



[Molar volume of a gas at r.t.p. =  $24\,000 \text{ cm}^3 \text{ mol}^{-1}$ ]

(i) Calculate the number of moles of carbon dioxide formed. (1)

(ii) Deduce the number of moles of HX formed when  $\text{GeX}_4$  reacted with the excess water. (1)

(iii) Deduce the number of moles of  $\text{GeX}_4$  that reacted with the excess water. (1)

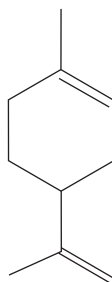
(iv) Calculate the molar mass of  $\text{GeX}_4$  and hence identify X. (2)

(Total for Question 16 = 20 marks)



- 17 Limonene is an oil extracted from the skin of citrus fruits such as oranges or lemons. It is found in some cleaning products such as those used to remove chewing gum.

Limonene has the structure shown.



- (a) Deduce the molecular formula of limonene. (2)

- (b) (i) A few drops of acidified potassium manganate(VII) solution are mixed with a sample of limonene.

State the colour change.

(1)

From ..... to .....

- (ii) Draw the skeletal formula of the structure of the **organic** product formed when the reaction in (b)(i) is carried out with **excess** acidified potassium manganate(VII).

(1)

- (iii) Name the type of reaction that limonene undergoes in (b)(i).

(1)

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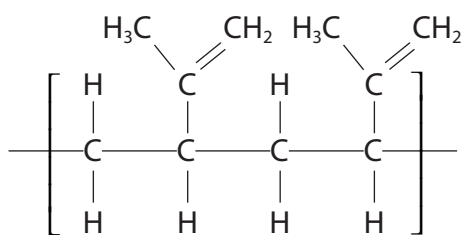
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(c) On heating, limonene reacts to form two molecules of a smaller hydrocarbon, **Q**.

**Q** can be polymerised to form **R**, a polymer used to improve the grip of car tyres.

A section of **R** is shown.



Section of polymer **R**

Draw the structure of **Q**.

(1)

(d) Give **two** ways in which chemists can help minimise problems caused by the disposal of polymers.

(2)

.....

.....

.....

.....



- (e) Limonene is extracted from orange peel using a solvent.  
Possible solvents are hexane and liquid carbon dioxide.

Liquid carbon dioxide can be obtained by allowing solid carbon dioxide to melt under high pressure.

- (i) Suggest one advantage and one disadvantage of using liquid carbon dioxide rather than hexane to dissolve the limonene. Assume that the carbon dioxide does not escape into the atmosphere.

(2)

Advantage

.....

.....

Disadvantage

.....

.....

- (ii) Orange peel contains 1.63 % of limonene by mass.

A chewing gum remover contains  $30 \text{ cm}^3$  of limonene per bottle.

Calculate the mass of orange peel, in kg, needed to obtain  $30 \text{ cm}^3$  of limonene.

[Density of limonene =  $0.841 \text{ g cm}^{-3}$ ]

(3)

(Total for Question 17 = 13 marks)

TOTAL FOR SECTION B = 60 MARKS

TOTAL FOR PAPER = 80 MARKS



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