

Write your name here

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Centre Number

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# Chemistry

**Advanced Subsidiary**

**Unit 1: The Core Principles of Chemistry**

Friday 26 May 2017 – Morning

**Time: 1 hour 30 minutes**

Paper Reference

**6CH01/01**

**Candidates may use a calculator.**

Total Marks

## Instructions

- Use **black** ink or **black** 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.*
- Questions labelled with an **asterisk** (\*) are ones where the quality of your written communication will be assessed  
– *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

## Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ►

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Pearson

## 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 The concentration of carbon monoxide in the exhaust gases of a car without a catalytic converter is 0.7 % by volume.

In units of parts per million, this concentration is

- A 7  
 B 70  
 C 700  
 D 7000

(Total for Question 1 = 1 mark)

- 2 Ionization occurs in a mass spectrometer when an atom or a molecule

- A is accelerated to high kinetic energy and loses an electron.  
 B is accelerated to high kinetic energy and gains an electron.  
 C collides with a high energy electron and loses an electron.  
 D collides with a high energy electron and gains an electron.

(Total for Question 2 = 1 mark)

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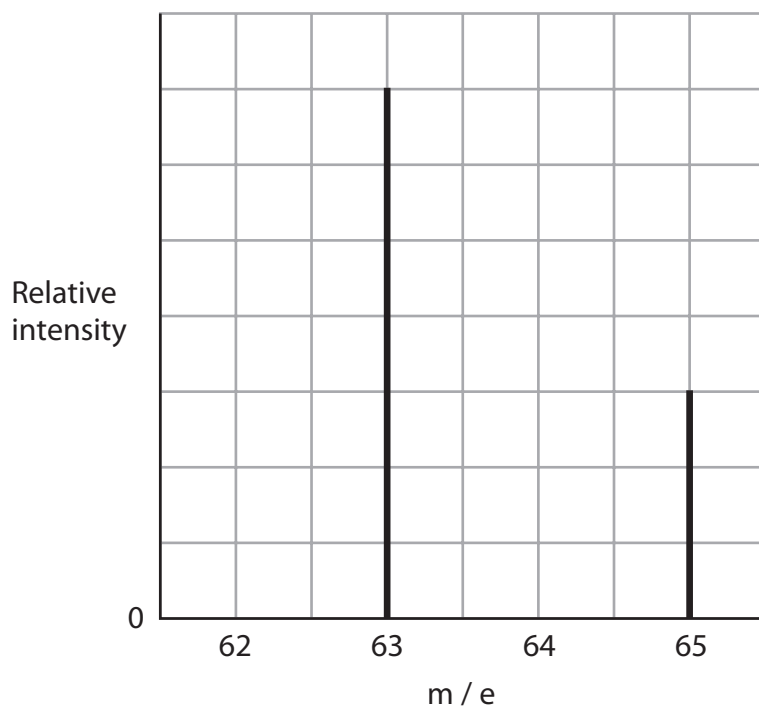


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3 The mass spectrum of a metal has only the peaks shown in the diagram.



The relative atomic mass of the metal is

- A 63.0
- B 63.6
- C 64.0
- D 65.0

(Total for Question 3 = 1 mark)

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



4 An atom and an ion with a single positive charge are isoelectronic. Therefore the

- A atom and the ion have the same mass number.
- B atom and the ion have the same atomic number.
- C atomic number of the atom is one more than that of the ion.
- D atomic number of the atom is one less than that of the ion.

(Total for Question 4 = 1 mark)

5 The electronic configuration of a species which has only one unpaired electron is

- A  $1s^2 2s^2 2p^2$
- B  $1s^2 2s^2 2p^3$
- C  $1s^2 2s^2 2p^4$
- D  $1s^2 2s^2 2p^5$

(Total for Question 5 = 1 mark)

6 The CFC dichlorodifluoromethane has the molecular formula  $CCl_2F_2$  and its molar mass is  $121 \text{ g mol}^{-1}$ . What is the total number of **atoms** in 2.42 g of dichlorodifluoromethane?

[Avogadro constant =  $6.0 \times 10^{23} \text{ mol}^{-1}$ ]

- A  $6.0 \times 10^{22}$
- B  $4.8 \times 10^{22}$
- C  $3.6 \times 10^{22}$
- D  $1.2 \times 10^{22}$

(Total for Question 6 = 1 mark)

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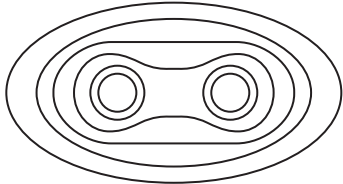
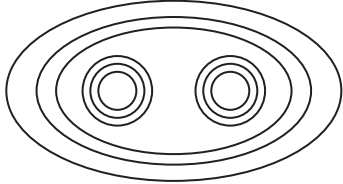
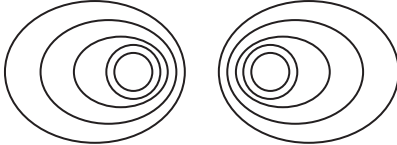
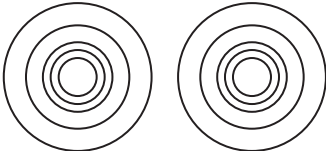
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7 A chemical compound has a high melting temperature and a high boiling temperature. From this it can be deduced that its bonding could be

- A ionic but not covalent.
- B covalent but not ionic.
- C either ionic or covalent.
- D metallic.

(Total for Question 7 = 1 mark)

8 Which diagram best represents the electron density map of a chlorine molecule?

- A 
- B 
- C 
- D 

(Total for Question 8 = 1 mark)



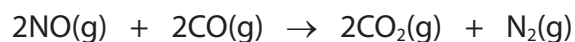
- 9 When gold(III) oxide is heated, it decomposes to form gold and oxygen. Calculate the mass of gold formed when 2.21 g of gold(III) oxide is heated to constant mass.

[Molar masses: O = 16.0 g mol<sup>-1</sup> Au = 197 g mol<sup>-1</sup>]

- A 1.97 g  
 B 2.04 g  
 C 2.10 g  
 D 2.15 g

(Total for Question 9 = 1 mark)

- 10 One of the reactions in the catalytic converter of a car exhaust is



400 cm<sup>3</sup> of NO is mixed with 500 cm<sup>3</sup> of CO. What is the **total** volume of gas when the reaction is complete? All gas volumes are measured at the same temperature and pressure.

- A 600 cm<sup>3</sup>  
 B 700 cm<sup>3</sup>  
 C 1300 cm<sup>3</sup>  
 D The volume cannot be calculated without the molar volume of gas at the appropriate temperature and pressure.

(Total for Question 10 = 1 mark)

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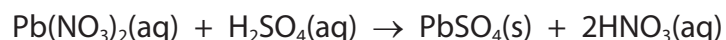


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11 When dilute sulfuric acid is added to a solution of lead(II) nitrate, the reaction is



(a) This reaction is

(1)

- A displacement.
- B neutralization.
- C precipitation.
- D redox.

(b) When excess sulfuric acid was added to a solution containing 6.62 g of lead(II) nitrate, 4.80 g of lead(II) sulfate was obtained.

What is the percentage yield by mass of lead(II) sulfate in this reaction?

(1)

[Molar masses:  $\text{Pb}(\text{NO}_3)_2 = 331 \text{ g mol}^{-1}$ ;  $\text{PbSO}_4 = 303 \text{ g mol}^{-1}$ ]

- A 91.5 %
- B 79.2 %
- C 72.5 %
- D 66.4 %

(Total for Question 11 = 2 marks)

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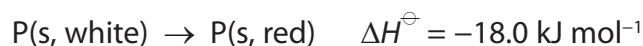


12 Which is correct for chlorine?

|                            | First ionization energy | First electron affinity |
|----------------------------|-------------------------|-------------------------|
| <input type="checkbox"/> A | exothermic              | endothermic             |
| <input type="checkbox"/> B | exothermic              | exothermic              |
| <input type="checkbox"/> C | endothermic             | exothermic              |
| <input type="checkbox"/> D | endothermic             | endothermic             |

(Total for Question 12 = 1 mark)

13 In the solid state, phosphorus exists in three forms: black, red and white. These forms may be interconverted:



From these data, it may be calculated that the standard enthalpy change for the conversion of black phosphorus into red phosphorus is

- A +61.1 kJ mol<sup>-1</sup>
- B +25.1 kJ mol<sup>-1</sup>
- C -25.1 kJ mol<sup>-1</sup>
- D -61.1 kJ mol<sup>-1</sup>

(Total for Question 13 = 1 mark)

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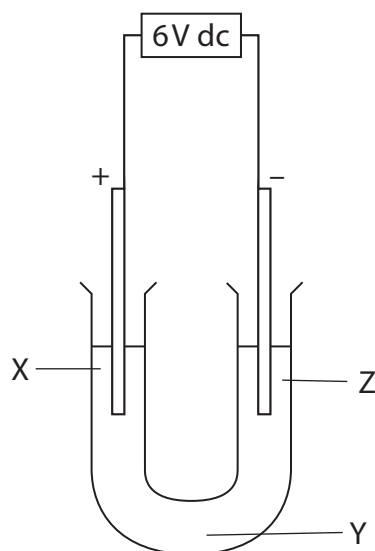


14 The reaction between hydrogen and fluorine is highly exothermic. This is mainly because the

- A F—F bond is weak and the H—F bond is strong.
- B F—F bond is strong and the H—F bond is weak.
- C F—F bond is weak and the H—F and H—H bonds are strong.
- D F—F bond is strong and the H—F and H—H bonds are weak.

(Total for Question 14 = 1 mark)

15 An aqueous solution of copper(II) chromate(VI) was electrolysed in the apparatus shown in the diagram using platinum electrodes.



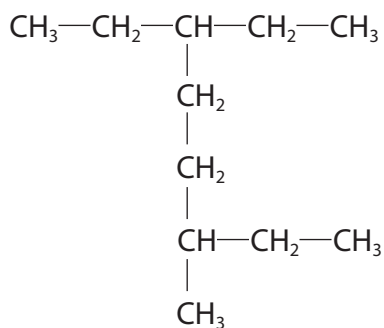
After five minutes, the colours observed in the different parts of the solution in the U-tube were

|                            | X      | Y      | Z      |
|----------------------------|--------|--------|--------|
| <input type="checkbox"/> A | green  | yellow | blue   |
| <input type="checkbox"/> B | yellow | blue   | green  |
| <input type="checkbox"/> C | blue   | green  | yellow |
| <input type="checkbox"/> D | yellow | green  | blue   |

(Total for Question 15 = 1 mark)



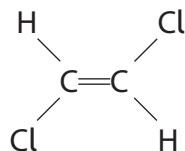
16 Give the systematic name for this hydrocarbon.



- A 1,1,4-triethylpentane
- B 2,5,5-triethylpentane
- C 2,5-diethylheptane
- D 3-ethyl-6-methyloctane

(Total for Question 16 = 1 mark)

17 A compound has the structure



Depending on the naming system used, this compound is

- A *cis*-1,2-dichloroethene or *E*-1,2-dichloroethene.
- B *cis*-1,2-dichloroethene or *Z*-1,2-dichloroethene.
- C *trans*-1,2-dichloroethene or *E*-1,2-dichloroethene.
- D *trans*-1,2-dichloroethene or *Z*-1,2-dichloroethene.

(Total for Question 17 = 1 mark)

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18 The carbon-carbon bond in ethene consists of

- A two  $\sigma$  bonds.
- B one  $\pi$  bond.
- C one  $\sigma$  bond and one  $\pi$  bond.
- D two  $\pi$  bonds.

(Total for Question 18 = 1 mark)

19 The terms hazard and risk are used when considering the use of chemical compounds. For a particular characteristic of a pure compound,

- A hazard is fixed but risk varies.
- B hazard varies but risk is fixed.
- C hazard and risk are fixed.
- D hazard and risk vary.

(Total for Question 19 = 1 mark)

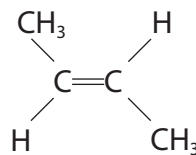
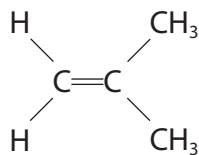
**TOTAL FOR SECTION A = 20 MARKS**



## SECTION B

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

20 Compounds **A** and **B** are isomeric alkenes.



(a) (i) Name compound **A**.

(1)

(ii) Give the molecular formula of compound **B**.

(1)

(iii) Explain why **A** and **B** are isomers.

(2)

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(iv) Draw the **geometric** isomer of compound **B**.

(1)

(v) Explain why compound **B** has a geometric isomer but compound **A** does not.

(1)

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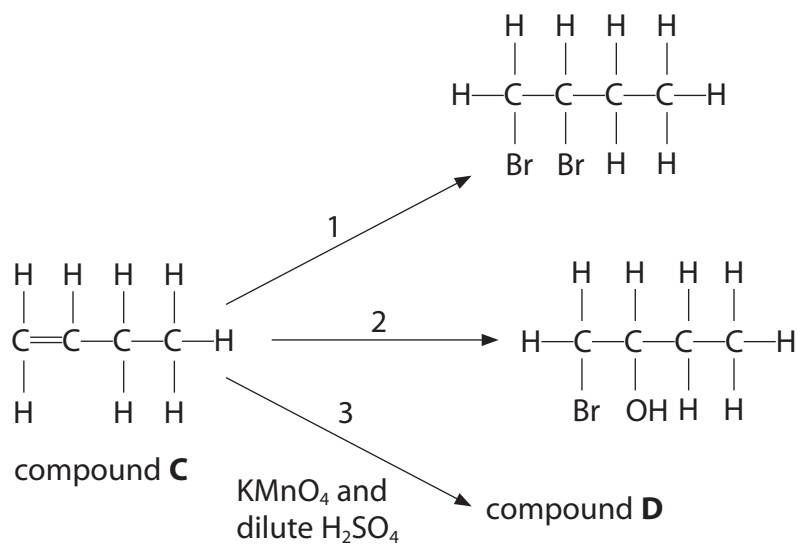
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(b) Compound **C** is an isomer of compounds **A** and **B**. Some reactions of compound **C** are shown below.



(i) **Name** the reagent(s) required for reaction 1.

(1)

(ii) **Name** the reagent(s) required for reaction 2.

(1)

(iii) Draw the **displayed** formula of compound **D**.

(1)



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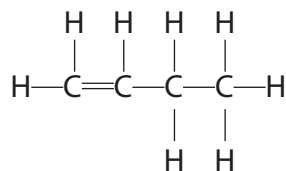
(c) Compound **C** also reacts with hydrogen chloride.

(i) Classify the type and mechanism of this reaction.

(2)

(ii) Complete the diagram below by adding any dipoles and curly arrows relevant to the **first** step of the mechanism of this reaction.

(2)



(iii) Draw the intermediate for the reaction which produces the major product. Hence show the final step of the mechanism and the product.

Include relevant curly arrows, lone pairs and charges.

(4)



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(d) Compound **C** forms a polymer which, because of its temperature resistance, is used in hot water piping.

Draw a section of this polymer, showing **two** repeat units.

(1)

(Total for Question 20 = 18 marks)





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21 Magnesium is in Group 2 of the Periodic Table. It has a number of naturally occurring isotopes, including  $^{24}\text{Mg}$  and  $^{26}\text{Mg}$ .

- (a) (i) Explain, in terms of the subatomic particles in the atoms, why  $^{24}\text{Mg}$  and  $^{26}\text{Mg}$  are isotopes.

(2)

.....

.....

.....

.....

- (ii) A sample of magnesium, which contains only the isotopes  $^{24}\text{Mg}$  and  $^{26}\text{Mg}$ , has a relative atomic mass of 24.433.

Calculate the percentage abundance of each isotope in this sample of magnesium.

(2)



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(b) (i) Give the electronic structure of a magnesium atom, using the s, p, d notation. (1)

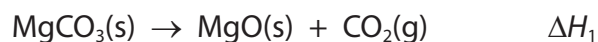
(ii) Write the equation for the first ionization energy of magnesium. Include state symbols. (1)

\*(iii) Explain why the first ionization energy of magnesium is higher than the first ionization energy of sodium. (2)

(iv) Explain why the first ionization energy of magnesium is higher than the first ionization energy of aluminium. (2)



(c) Magnesium carbonate decomposes on heating:

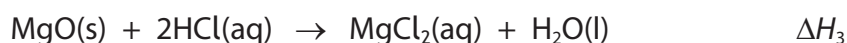


The enthalpy change can only be determined indirectly, by applying Hess's Law.

(i) Explain why the enthalpy change of this reaction cannot be determined directly. (1)

(ii) State Hess's Law. (1)

(d) A class of students carried out an experiment to measure  $\Delta H_1$  indirectly by determining the enthalpy changes of two reactions:



One group used the following method to measure  $\Delta H_2$ .

- Pipette 50.0 cm<sup>3</sup> of 2 mol dm<sup>-3</sup> hydrochloric acid (a large excess) into a polystyrene cup and note the temperature of the acid.
- Weigh accurately 2.50 g of magnesium carbonate powder.
- Add the magnesium carbonate to the acid, stir continuously and note the highest temperature.



(i) Why is excess hydrochloric acid used?

(1)

(ii) The students were told that using a polystyrene cup gives better results than using a glass beaker because of its good thermal insulation and its low heat capacity. Explain why these properties improve experimental results.

(2)

Good thermal insulation.....

Low heat capacity.....

(iii) One student using this method measured a temperature increase of 18.5°C. Calculate the energy change, in joules, for this reaction. Assume the specific heat capacity of the solution is 4.18 J g<sup>-1</sup> °C<sup>-1</sup> and use the expression

energy change (J) = 50.0 × specific heat capacity × temperature change

(1)

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- \*(iv) Use your answer to (d)(iii) to calculate the molar enthalpy change for the reaction between magnesium carbonate and hydrochloric acid.  
Give your answer to **three** significant figures and include a sign and units.

(3)

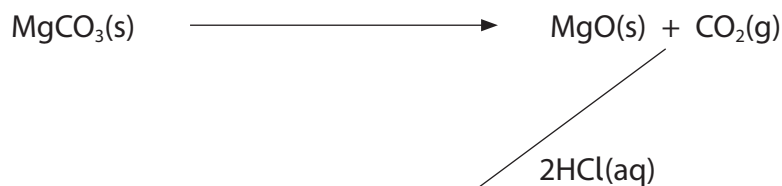
- (e) The class collected all their results and, after eliminating anomalous results, calculated the mean values of  $\Delta H_2$  and  $\Delta H_3$ :

$$\Delta H_2 = -126 \text{ kJ mol}^{-1}$$

$$\Delta H_3 = -231 \text{ kJ mol}^{-1}$$

- (i) Complete the Hess cycle below by adding the missing arrow and species.

(1)



..... ( ) + ..... ( ) + ..... ( )



- (ii) Use your completed Hess cycle and the students' mean values for  $\Delta H_2$  and  $\Delta H_3$  to calculate the enthalpy change for the thermal decomposition of magnesium carbonate. Include a sign and units.

(2)

- \*(f) Data book values for  $\Delta H_2$  and  $\Delta H_3$  are

$$\Delta H_2 = -179.4 \text{ kJ mol}^{-1}$$

$$\Delta H_3 = -296.4 \text{ kJ mol}^{-1}$$

Most of the values obtained by the students were close to their mean values, and they suggested that the difference between their values and those from the data book was due to the measurement uncertainties in their experiments.

Evaluate this suggestion.

(2)

(Total for Question 21 = 24 marks)



- 22 (a) The table below shows the experimental and calculated values for the lattice energy of sodium chloride and silver chloride.

| Compound        | Lattice Energy / $\text{kJ mol}^{-1}$ |            |
|-----------------|---------------------------------------|------------|
|                 | Experimental                          | Calculated |
| sodium chloride | -780                                  | -770       |
| silver chloride | -905                                  | -833       |

- (i) Write the equation for the lattice energy of sodium chloride. Include state symbols.

(1)

- (ii) Name the energy cycle used to calculate lattice energies from experimental data.

(1)

- \* (iii) Explain fully why the experimental and calculated values for the lattice energy of sodium chloride are similar, whereas those for silver chloride differ significantly.

(3)





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- (b) The percentage composition by mass of a sodium compound is  
Na = 29.1%; S = 40.6%; O = 30.3%.

Calculate the empirical formula of the compound.

(3)

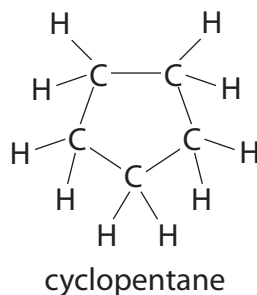
- (c) Draw the dot and cross diagram for sodium oxide.  
Show the outer electrons only.

(2)

(Total for Question 22 = 10 marks)



**23** Cycloalkanes are hydrocarbons which contain a ring of carbon atoms. Cycloalkanes have essentially the same chemical reactions as alkanes such as butane and pentane. Cyclopentane, which has a five-carbon ring, is a foam-blowing agent used to propel insulation into the doors and cases of refrigerators. The use of cyclopentane, rather than CFCs, reduces greenhouse gas emissions from this process by 99%.



(a) (i) Write the **empirical** formula of cyclopentane.

(1)

(ii) Suggest the general formula of the cycloalkanes.

(1)

(b) Cyclopentane may be manufactured by reforming pentane, which is obtained from crude oil.

(i) Name the first stage in the process used to obtain compounds such as pentane from crude oil.

(1)

(ii) Write an equation for the reforming of pentane into cyclopentane. State symbols are not required.

(1)



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(c) Cyclopentane and methane react with chlorine by the same mechanism.

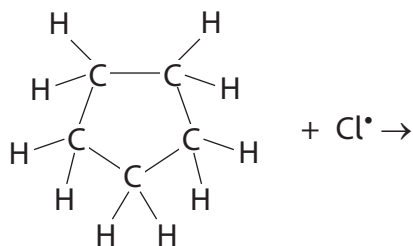
(i) State the essential condition for the reaction between cyclopentane and chlorine. (1)

(ii) Give the **propagation** stage for the reaction between cyclopentane and chlorine by completing the first equation of this stage and then writing the second equation.

Curly half-arrows are **not** required.

(2)

Equation 1



Equation 2



(iii) The termination stage of the reaction between cyclopentane and chlorine produces only one hydrocarbon. Draw the displayed formula of this hydrocarbon.

(1)

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(Total for Question 23 = 8 marks)

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**TOTAL FOR SECTION B = 60 MARKS**

**TOTAL FOR PAPER = 80 MARKS**

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# The Periodic Table of Elements

|  | 1                                    | 2                                    | 3 | 4  | (5)  | (6)                                   | (7)                                     | (8)                                   | (9)                                     | (10)                                      | (11)                                     | (12)                                 | (13)                                     | (14)                                  | (15)                                    | (16)                                  | (17)                                | 0 (8)                              |
|--|--------------------------------------|--------------------------------------|---|--|--|---------------------------------------|---|---------------------------------------|---|---|--|--------------------------------------|--|---------------------------------------|---|---------------------------------------|-------------------------------------|------------------------------------|
|  | 6.9<br><b>Li</b><br>lithium<br>3     | 9.0<br><b>Be</b><br>beryllium<br>4   |   | 45.0<br><b>Sc</b><br>scandium<br>21      | 47.9<br><b>Ti</b><br>titanium<br>22        | 50.9<br><b>V</b><br>vanadium<br>23    | 54.9<br><b>Mn</b><br>manganese<br>25    | 55.8<br><b>Fe</b><br>iron<br>26       | 58.9<br><b>Co</b><br>cobalt<br>27       | 58.7<br><b>Ni</b><br>nickel<br>28         | 63.5<br><b>Cu</b><br>copper<br>29        | 65.4<br><b>Zn</b><br>zinc<br>30      | 10.8<br><b>B</b><br>boron<br>5           | 12.0<br><b>C</b><br>carbon<br>6       | 14.0<br><b>N</b><br>nitrogen<br>7       | 16.0<br><b>O</b><br>oxygen<br>8       | 19.0<br><b>F</b><br>fluorine<br>9   | 20.2<br><b>Ne</b><br>neon<br>10    |
|  | 23.0<br><b>Na</b><br>sodium<br>11    | 24.3<br><b>Mg</b><br>magnesium<br>12 |   | 88.9<br><b>Y</b><br>yttrium<br>39        | 91.2<br><b>Zr</b><br>zirconium<br>40       | 92.9<br><b>Nb</b><br>niobium<br>41    | 95.9<br><b>Mo</b><br>molybdenum<br>42   | [98]<br><b>Tc</b><br>technetium<br>43 | 101.1<br><b>Ru</b><br>ruthenium<br>44   | 102.9<br><b>Rh</b><br>rhodium<br>45       | 106.4<br><b>Pd</b><br>palladium<br>46    | 107.9<br><b>Ag</b><br>silver<br>47   | 27.0<br><b>Al</b><br>aluminium<br>13     | 28.1<br><b>Si</b><br>silicon<br>14    | 31.0<br><b>P</b><br>phosphorus<br>15    | 32.1<br><b>S</b><br>sulfur<br>16      | 35.5<br><b>Cl</b><br>chlorine<br>17 | 39.9<br><b>Ar</b><br>argon<br>18   |
|  | 39.1<br><b>K</b><br>potassium<br>19  | 40.1<br><b>Ca</b><br>calcium<br>20   |   | 138.9<br><b>La*</b><br>lanthanum<br>57   | 178.5<br><b>Hf</b><br>hafnium<br>72        | 180.9<br><b>Ta</b><br>tantalum<br>73  | 183.8<br><b>W</b><br>tungsten<br>74     | 190.2<br><b>Os</b><br>osmium<br>76    | 192.2<br><b>Ir</b><br>iridium<br>77     | 195.1<br><b>Pt</b><br>platinum<br>78      | 197.0<br><b>Au</b><br>gold<br>79         | 200.6<br><b>Hg</b><br>mercury<br>80  | 69.7<br><b>Ga</b><br>gallium<br>31       | 72.6<br><b>Ge</b><br>germanium<br>32  | 74.9<br><b>As</b><br>arsenic<br>33      | 79.0<br><b>Se</b><br>selenium<br>34   | 79.9<br><b>Br</b><br>bromine<br>35  | 83.8<br><b>Kr</b><br>krypton<br>36 |
|  | 85.5<br><b>Rb</b><br>rubidium<br>37  | 87.6<br><b>Sr</b><br>strontium<br>38 |   | 173.1<br><b>Lu*</b><br>lutetium<br>71    | 186.2<br><b>Re</b><br>rhenium<br>75        | 186.2<br><b>Os</b><br>osmium<br>76    | 186.2<br><b>Re</b><br>rhenium<br>75     | 190.2<br><b>Os</b><br>osmium<br>76    | 192.2<br><b>Ir</b><br>iridium<br>77     | 195.1<br><b>Pt</b><br>platinum<br>78      | 197.0<br><b>Au</b><br>gold<br>79         | 200.6<br><b>Hg</b><br>mercury<br>80  | 114.8<br><b>In</b><br>indium<br>49       | 118.7<br><b>Sn</b><br>tin<br>50       | 121.8<br><b>Sb</b><br>antimony<br>51    | 127.6<br><b>Te</b><br>tellurium<br>52 | 126.9<br><b>I</b><br>iodine<br>53   | 131.3<br><b>Xe</b><br>xenon<br>54  |
|  | 132.9<br><b>Cs</b><br>caesium<br>55  | 137.3<br><b>Ba</b><br>barium<br>56   |   | [227]<br><b>Ac*</b><br>actinium<br>89    | [261]<br><b>Rf</b><br>rutherfordium<br>104 | [262]<br><b>Db</b><br>dubnium<br>105  | [266]<br><b>Sg</b><br>seaborgium<br>106 | [277]<br><b>Hs</b><br>hassium<br>108  | [268]<br><b>Mt</b><br>meitnerium<br>109 | [271]<br><b>Ds</b><br>darmstadtium<br>110 | [272]<br><b>Rg</b><br>roentgenium<br>111 | 204.4<br><b>Pb</b><br>lead<br>82     | 207.2<br><b>Pb</b><br>lead<br>82         | 209.0<br><b>Bi</b><br>bismuth<br>83   | 209.0<br><b>Po</b><br>polonium<br>84    | [210]<br><b>At</b><br>astatine<br>85  | [222]<br><b>Rn</b><br>radon<br>86   |                                    |
|  | [223]<br><b>Fr</b><br>francium<br>87 | [226]<br><b>Ra</b><br>radium<br>88   |   | 140<br><b>Ce</b><br>cerium<br>58         | 144<br><b>Nd</b><br>neodymium<br>60        | 147<br><b>Pm</b><br>promethium<br>61  | 150<br><b>Sm</b><br>samarium<br>62      | 152<br><b>Eu</b><br>europium<br>63    | 157<br><b>Gd</b><br>gadolinium<br>64    | 159<br><b>Tb</b><br>terbium<br>65         | 163<br><b>Dy</b><br>dysprosium<br>66     | 165<br><b>Ho</b><br>holmium<br>67    | 167<br><b>Er</b><br>erbium<br>68         | 169<br><b>Tm</b><br>thulium<br>69     | 173<br><b>Yb</b><br>ytterbium<br>70     | 175<br><b>Lu</b><br>lutetium<br>71    |                                     |                                    |
|  | 232<br><b>Th</b><br>thorium<br>90    | 238<br><b>U</b><br>uranium<br>92     |   | [231]<br><b>Pa</b><br>protactinium<br>91 | [237]<br><b>Np</b><br>neptunium<br>93      | [242]<br><b>Pu</b><br>plutonium<br>94 | [243]<br><b>Am</b><br>americium<br>95   | [247]<br><b>Cm</b><br>curium<br>96    | [245]<br><b>Bk</b><br>berkelium<br>97   | [251]<br><b>Cf</b><br>californium<br>98   | [254]<br><b>Es</b><br>einsteinium<br>99  | [253]<br><b>Fm</b><br>fermium<br>100 | [256]<br><b>Md</b><br>mendelevium<br>101 | [255]<br><b>No</b><br>nobelium<br>102 | [254]<br><b>Lr</b><br>lawrencium<br>103 |                                       |                                     |                                    |

|                                  |
|----------------------------------|
| 1.0<br><b>H</b><br>hydrogen<br>1 |
|----------------------------------|

|                        |
|------------------------|
| relative atomic mass   |
| atomic symbol          |
| name                   |
| atomic (proton) number |

- \* Lanthanide series
- \* Actinide series

Elements with atomic numbers 112-116 have been reported but not fully authenticated



DO NOT WRITE IN THIS AREA