Periodicity & Trends

Question Paper 2

Level	International A Level
Subject	Chemistry
Exam Board	Edexcel
Topic	The Core Principles of Chemistry
Sub Topic	Periodicity & Trends
Booklet	Question Paper 2

Time Allowed: **72 minutes**

Score: **/60**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 Ionization energies provide evidence for the arrangement of electrons in atoms.

(a) (i) Write an equation, including state symbols, to show the **second** ionization energy of magnesium.

(2)

*(ii) Give **two** reasons why the second ionization energy of magnesium is greater than the first ionization energy of magnesium.

(2)

1 .....

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2 .....

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(iii) Complete the table by suggesting a value for the **third** ionization energy of magnesium.

(1)

Ionization number	First	Second	Third	Fourth	Fifth
Ionization energy / kJ mol^{-1}	738	1450		10 500	13 600

(b) (i) Give the electronic configurations of phosphorus and of sulfur in s, p and d notation.

(2)

Phosphorus (atomic number 15) .....

Sulfur (atomic number 16) .....

(ii) By reference to your answer in (b)(i), explain why the first ionization energy of sulfur is lower than that of phosphorus.

(2)

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(Total for Question 1 = 9 marks)

2 This question is about some of the elements in Period 3 of the Periodic Table.

(a) (i) An atom of silicon has mass number 29. Complete the table below showing the numbers of sub-atomic particles in this atom of silicon. Use the Periodic Table as a source of data.

(1)

Sub-atomic particles present in one atom of ^{29}Si	Number
protons	
electrons	
neutrons	

(ii) Complete the electronic configuration of silicon.

(1)

$1s^2$.....

*(b) Explain the following, referring to differences in structure and bonding.

(i) Silicon has a higher melting temperature than phosphorus.

(3)

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(ii) Magnesium has a higher melting temperature than sodium.

(2)

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(c) Suggest why the atomic radius decreases going across the Periodic Table from sodium to silicon.

(2)

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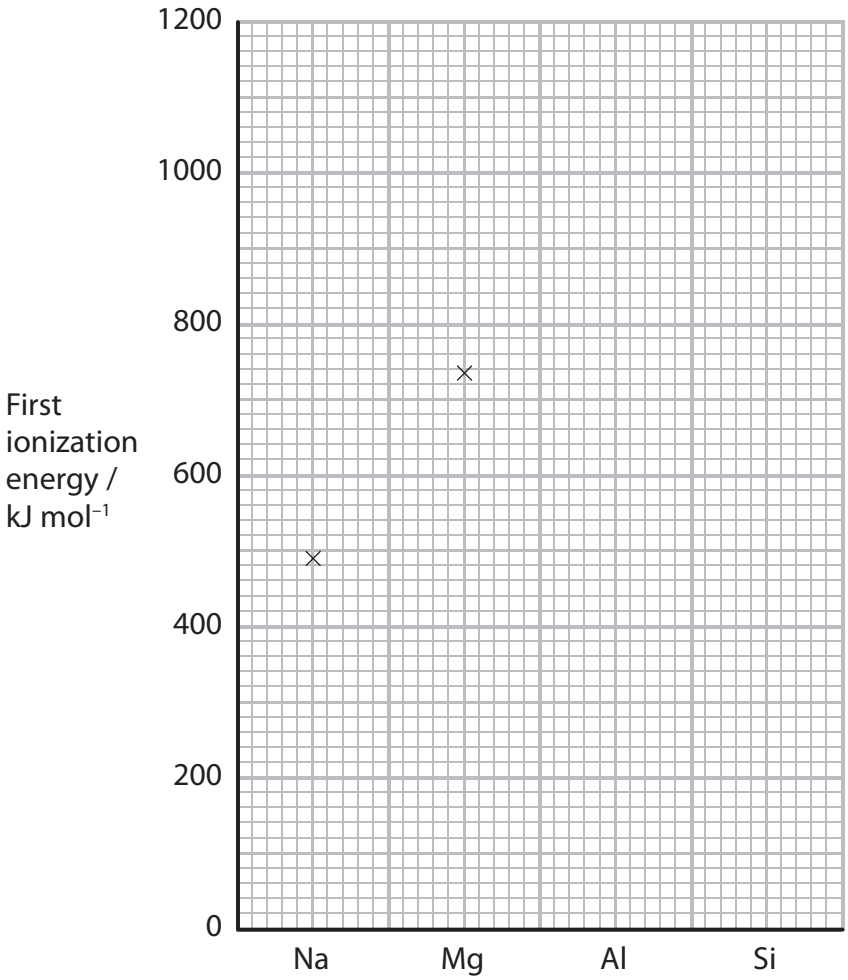
(d) At room temperature, silicon tetrachloride, $SiCl_4$, is a liquid that does not conduct electricity.

Draw a dot and cross diagram illustrating the bonding in silicon chloride. Show only the outer electron shells of the atoms. Use crosses to represent the electrons from silicon and dots to represent the electrons from chlorine.

(2)

(e) The diagram below shows the values of the first ionization energies of sodium and magnesium.



(i) On the diagram, add crosses to mark the approximate positions for the values of the first ionization energies of the elements Al and Si.

(1)

*(ii) Justify your suggested values in terms of the atomic structure and electronic configuration of the elements.

(2)

Aluminium .....

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Silicon .....

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(Total for Question 2 = 14 marks)

3 Bromine, Br_2, can react with both alkanes and alkenes. The type of reaction that occurs depends on whether the Br—Br bond breaks by homolytic or heterolytic fission.

(a) (i) Write an equation to show the **homolytic** fission of the Br—Br bond. Do **not** include curly arrows or state symbols.

(1)

(ii) Write an equation to show the **heterolytic** fission of the Br—Br bond. Do **not** include curly arrows or state symbols.

(1)

(iii) Choosing from the products you have given in (a)(i) and (a)(ii), write the formula of a free radical and an electrophile.

(2)

Free radical .....

Electrophile .....

(b) The compound hexane, C_6H_{14}, can react with bromine, in the presence of UV light, according to the equation

$$C_6H_{14} + Br_2 \rightarrow C_6H_{13}Br + HBr$$

(i) Give the displayed formulae of the three structural isomers of $C_6H_{13}Br$ that could be formed in the above reaction.

(3)

First isomer

Second isomer

Third isomer

(ii) The bromoalkanes and the hydrogen bromide formed in this reaction are hazardous.

The bromoalkanes would be labelled as 'flammable'. Suggest a suitable hazard warning for the hydrogen bromide.

(1)

(iii) Calculate the percentage atom economy by mass for the formation of $C_6H_{13}Br$.

Give your answer to **three** significant figures.

Use the expression

$$\text{atom economy} = \frac{\text{molar mass of the desired product}}{\text{sum of the molar masses of all products}} \times 100\%$$

(2)

(c) Fluorine, F_2, and chlorine, Cl_2, react with **methane**, CH_4, by a similar mechanism, although the rates of reaction are very different.

(i) Write an equation for the reaction between **methane** and fluorine, assuming they react in a 1:1 mole ratio. State symbols are not required.

(1)

*(ii) On the basis of comparing the relative sizes of the fluorine and chlorine atoms, it might be predicted that the F—F bond energy would be greater than the Cl—Cl bond energy.
Suggest an explanation for this prediction.

(2)

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(iii) Draw a dot and cross diagram to show the arrangement of the outermost electrons in a fluorine molecule, F_2.

(2)

(iv) The actual bond energies are shown below.

Bond	Bond energy / kJ mol^{-1}
F—F	158
Cl—Cl	243

By referring to your dot and cross diagram in your answer to (c)(iii), suggest an explanation for the fact that the F—F bond energy is **less** than that of the Cl—Cl bond energy.

(2)

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(v) Suggest why a mixture of methane and chlorine requires exposure to UV light, or heat, before a reaction occurs, whereas methane reacts rapidly with fluorine at room temperature in the absence of UV light or heat.

(1)

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(d) The alkene hex-3-ene reacts with bromine to produce 3,4-dibromohexane. Complete the mechanism below by adding curly arrows to show the movement of electron pairs in both steps and by giving the structural formula of the intermediate carbocation.

(3)

3,4-dibromohexane

(e) The mechanism shown in (d) shows *Z*-hex-3-ene reacting with bromine. *E*-hex-3-ene also reacts with bromine to form 3,4-dibromohexane.

(i) Draw the structure of *E*-hex-3-ene.

(1)

(ii) Explain why both *Z*-hex-3-ene and *E*-hex-3-ene react with bromine to produce the **same** structural isomer.

(1)

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(Total for Question 3 = 23 marks)

4 This question is about atomic structure.

(a) Draw diagrams to show the shape of an s-orbital and of a p-orbital.

(2)

s-orbital	p-orbital

(b) Complete the table to show the number of electrons that **completely** fill the following regions.

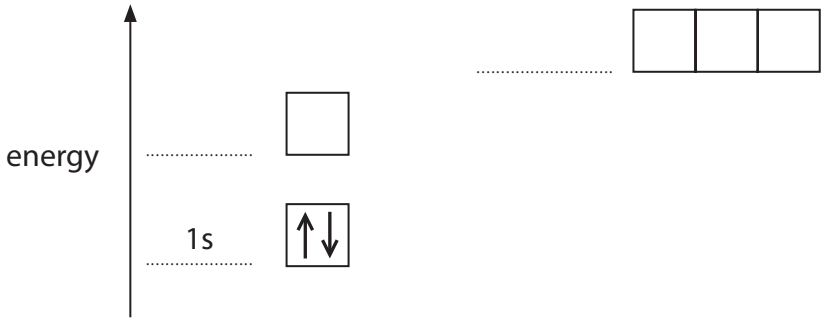
(3)

Region	Number of electrons present when completely filled
a d-orbital	
a p sub-shell	
the third shell (n = 3)	

(c) The energy diagram below is for the eight electrons present in an oxygen atom. Complete the diagram for an oxygen atom by adding

- labels to identify the other occupied sub-shells
- arrows to show how the remaining six electrons are arranged in the orbitals.

(2)



(d) Successive ionization energies provide evidence for the arrangement of electrons in atoms. The eight successive ionization energies of oxygen are shown in the table below.

Ionization number	1st	2nd	3rd	4th	5th	6th	7th	8th
Ionization energy / kJ mol^{-1}	1314	3388	5301	7469	10989	13327	71337	84080

(i) Define the term **first ionization energy**.

(3)

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(ii) Write an equation, with state symbols, to show the **third** ionization energy of oxygen.

(2)

*(iii) Explain how the data in the table provide evidence that there are two occupied electron shells in an oxygen atom.

(2)

(Total for Question 4 = 14 marks)