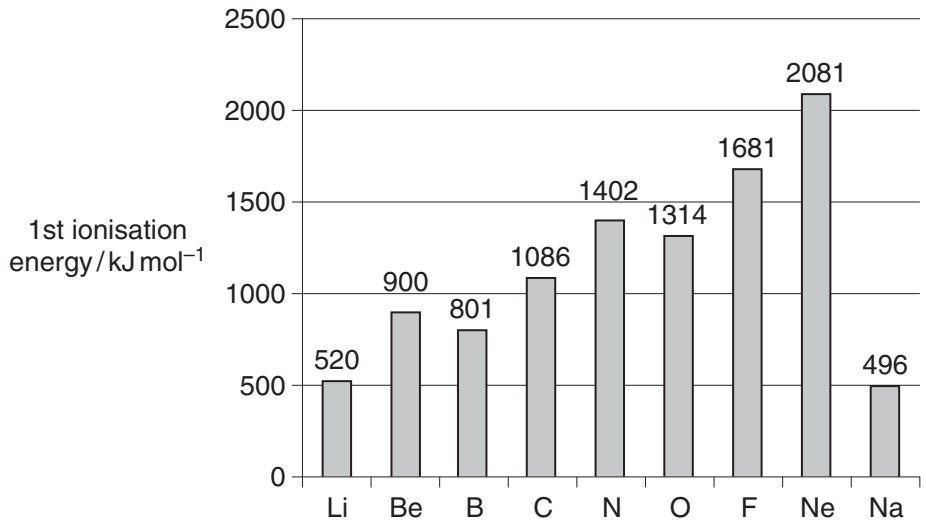
1 Ionisation energies have been used to develop the model of the atom.

The first ionisation energies of the elements Li to Na are shown in the figure below.



(a) Define the term *first ionisation energy*.

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..... **[3]**

(b) **(** Explain why the first ionisation energies show a general increase from Li to Ne.

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..... **[3]**

(ii) Explain the difference between the first ionisation energies of Li and Na.

In your answer, you should use appropriate technical terms, spelt correctly.

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..... **[3]**

(c) The first ionisation energy of oxygen is 1314 kJ mol^{-1} and the second ionisation energy of oxygen is 3388 kJ mol^{-1}.

(i) Write an equation to represent the **second** ionisation energy of oxygen.

Include state symbols.

..... **[1]**

(ii) Suggest why the second ionisation energy of oxygen has a greater value than the first ionisation energy of oxygen.

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..... **[1]**

[Total: 11]

2 The Periodic Table is a table of elements arranged in order of atomic number. The elements are classified into blocks.

(a) (State what is meant by the term *atomic number*.

..... **[1]**

(ii) Complete the full electron configuration for a titanium atom.

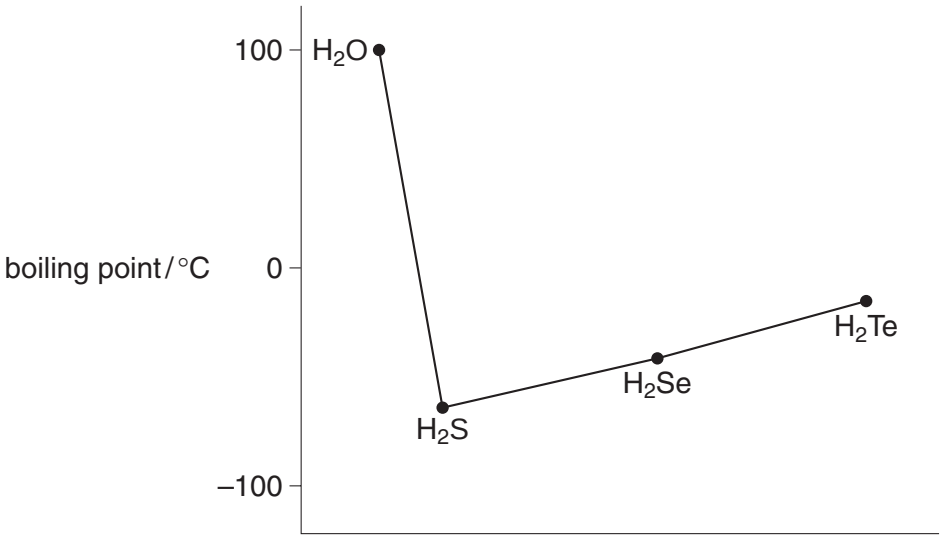
$1s^2$ ..... **[1]**

(iii) Identify the **seventh** element in the **fourth** period.

State which block this element is in.

element ..... block ..... **[1]**

(b) The figure below shows the boiling points of four hydrides of Group 6 elements.



(i) Explain, with the aid of a diagram, the intermolecular forces in H_2O that lead to the relatively high boiling point of H_2O.

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..... **[3]**

(ii) Suggest why H_2S has a much lower boiling point than H_2O.

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..... **[1]**

(c) The boiling points of some Group 7 elements are shown below.

Group 7 element	boiling point / °C
chlorine	–35
bromine	59
iodine	184

Explain why the halogens show this trend in boiling points.

In your answer, you should use appropriate technical terms, spelt correctly.

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..... **[3]**

(d) During the extraction of bromine industrially, chlorine is bubbled through a solution of bromide ions. A student thought this principle would also work for extracting iodine and carried out the experiment below.

Stage 1 The student bubbled some chlorine through an aqueous solution of potassium iodide.

Stage 2 The student added an organic solvent and shook the mixture.

(i) What would the student see at **stage 1**?

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..... **[1]**

(ii) Name the products and write an ionic equation for the reaction in **stage 1**.

names of products: .....

ionic equation: ..... **[2]**

(iii) Why does the reaction in **stage 1** occur?

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..... **[1]**

(iv) What would the student see at **stage 2**?

..... **[1]**

[Total: 15]

3 The modern Periodic Table is arranged into blocks of elements based on their electron configuration.

(a) We now know that electrons are in shells; shells have sub-shells and sub-shells have orbitals.

(i) Explain what is meant by the term *orbital*.

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..... **[1]**

(ii) Complete the electron configuration below, in terms of sub-shells, for an atom of sulfur.

$1s^2$ ..... **[1]**

(iii) How many full orbitals are in an atom of sulfur?

..... **[1]**

(b) One mole of sulfur atoms has a mass of 32.1 g.

What is meant by *one mole of substance*?

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..... **[1]**

(c) Ionisation energies provide evidence for the order of elements in the modern Periodic Table.

Define the term *first ionisation energy*.

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..... **[3]**

(d) The first ionisation energies and atomic radii of F, Ne and Na are shown below.

element	first ionisation energy / kJ mol^{-1}	atomic radius / nm
F	1681	0.071
Ne	2081	0.065
Na	496	0.191

(i) Explain why there is an increase in first ionisation energy between F and Ne.

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(ii) Explain why there is a decrease in first ionisation energy between Ne and Na.

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..... **[3]**

[Total: 13]

4 Chlorine, bromine and iodine are halogens commonly used in school and college experiments.

(a) Halogens have van der Waals' forces between their molecules.

(i) Describe how van der Waals' forces arise.

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..... **[3]**

(ii) State **and** explain the trend in the boiling points of chlorine, bromine and iodine.

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..... **[3]**

(b) The halogen astatine does **not** exist in large enough quantities to observe any of its reactions.

Why would astatine be expected to react similarly to other halogens?

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..... **[1]**

(c) A student investigated the reactivity of halogens by attempting some redox reactions.

(i) The student added bromine water to aqueous solutions of sodium chloride and sodium iodide in separate test-tubes. The student then added an organic solvent, cyclohexane, to each test-tube and these were shaken.

- State what colour you would see in the cyclohexane in each test-tube after shaking.
- Write **ionic** equations for any chemical reactions that take place.
- State and explain the trend in reactivity shown by these observations.

In your answer you should use appropriate technical terms spelled correctly.

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(ii) Suggest why the student carried out the reactions in a well ventilated area.

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..... **[1]**

(d) The halogen fluorine is too reactive to use in a school or college laboratory. Fluorine is a powerful oxidising agent. It will react with water as shown below.

(i) Complete and balance the equation for the reaction of fluorine with water.

$F_2(g)$ + $_2O(l)$ $\rightarrow$ ..... + $_2(g)$ **[1]**

(ii) Using oxidation numbers, show what has been oxidised and what has been reduced in this reaction.

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..... **[2]**

(e) Fluorine will react violently with gallium to produce gallium fluoride.

Mendeleev originally called gallium 'eka-aluminium' as he predicted that gallium would have similar properties to aluminium.

(i) Complete the electron structure of the gallium atom.

$1s^2$ ..... **[1]**

(ii) Use Mendeleev's prediction to suggest the empirical formula of gallium fluoride.

..... **[1]**

[Total: 19]