Section A

1   The isotopes of magnesium, $^{24}_{12}Mg$ and $^{25}_{12}Mg$, both form ions with charge 2+. Which of the following statements about these ions is true?

☐   A   Both ions have electronic configuration $1s^2\ 2s^2\ 2p^6\ 3s^2$.

☐   B $^{25}_{12}Mg^{2+}$ has more protons than $^{24}_{12}Mg^{2+}$.

☐   C   The ions have the same number of electrons but different numbers of neutrons.

☐   D   The ions have the same number of neutrons but different numbers of protons.

1 mark)

2   Chlorine has two isotopes with relative isotopic mass 35 and 37. Four m/z values are given below. Which will occur in a mass spectrum of chlorine gas, Cl_2, from an ion with a single positive charge?

☐   A   35.5

☐   B   36

☐   C   71

☐   D   72

1 mark)

3)

The first ionization energies, in kJ mol^{-1}, of four elements with consecutive atomic numbers are shown below.

A   1680

B   2080

C   496

D   738

(a) Which element could be an inert gas?

(1)

☐   A

☐   B

☐   C

☐   D

(b) Which element could be X in a covalent compound with formula HX?
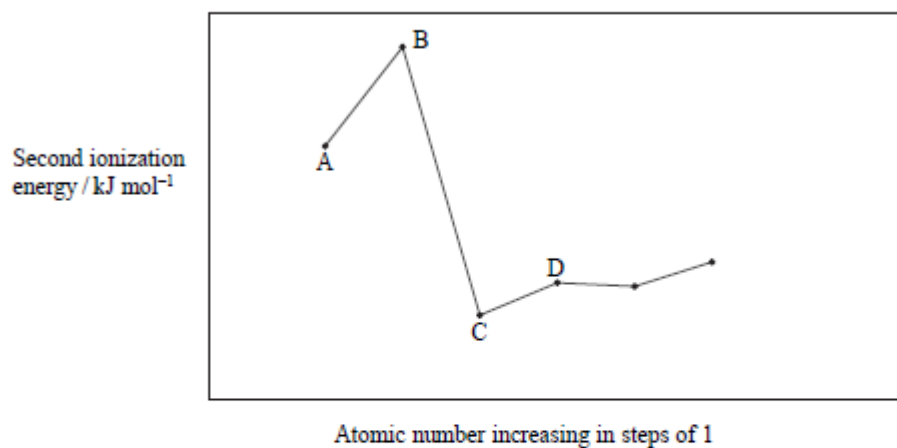
(1)

☐   A

☐   B

☐   C

☐   D

(c) Which element could be Y in an ionic compound with formula YH_2?

(1)

4)   ☐   A

☐   B

☐   C

☐   D

The graph below shows the **second** ionization energy of a series of elements with consecutive atomic numbers.

Atomic number increasing in steps of 1

Which element could be lithium?

☒ A

☐ B

☒ C

☐ D

1 mark)

5)

The first five ionization energies, in kJ mol^{-1}, of aluminium are

578   1817   2745   11 578   14 831

The orbitals from which the first five electrons are removed during ionization, starting with the first electron, are

☐ A 1s 2s 2p 3s 3p

☐ B 1s 1s 2s 2s 2p

☐ C 3p 3s 2p 2s 1s

☐ D 3p 3s 3s 2p 2p

6 Going across the Periodic Table from sodium to aluminium,

    ☐ A   the melting temperature increases.

    ☐ B   the radius of the atom increases.

    ☐ C   the radius of the metal ion increases.

    ☐ D   the bonding in the element changes from metallic to covalent.

(Total for Question   = 1 mark)

7 Going down Group 1 from lithium to rubidium

    ☐ A   the radius of the atom decreases.

    ☐ B   the radius of the ion decreases.

    ☐ C   the first ionization energy decreases.

    ☐ D   the polarizing power of the ion increases.

(Total for Question   = 1 mark)

8 A drop of concentrated nickel(II) sulfate solution, which is green, is placed on moist filter paper on a microscope slide and the ends of the slide are connected to a 24 V DC power supply. After ten minutes,

    ☐ A   a blue colour has moved towards the negative terminal and a yellow colour towards the positive terminal.

    ☐ B   a blue colour has moved towards the positive terminal and a yellow colour towards the negative terminal.

    ☐ C   a green colour has moved towards the negative terminal but there is no other visible change.

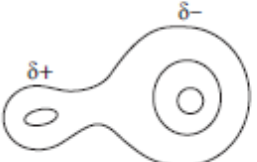   ☐ D   a green colour has moved towards the positive terminal but there is no other visible change.

(Total for Question   = 1 mark)

9 Which of the following quantities, used in the calculation of the lattice energy of lithium oxide, Li_2O, has a negative value?

☒ **A** The enthalpy change of atomization of lithium.

☒ **B** The first ionization energy of lithium.

☐ **C** The first electron affinity of oxygen.

☒ **D** The second electron affinity of oxygen.

(Total for Question = 1 mark)

10 Which of the diagrams below best represents the shapes of the electron contours in sodium fluoride?

☒ **A**

☒ **B**

☐ **C**

☒ **D**

11 Which of the equations below represents the first electron affinity for oxygen?

☐ **A** $O_2(g) + 2e^- \rightarrow 2O^-(g)$

☐ **B** $O_2(g) - 2e^- \rightarrow 2O^-(g)$

☐ **C** $\frac{1}{2}O_2(g) + e^- \rightarrow O^-(g)$

☐ **D** $O(g) + e^- \rightarrow O^-(g)$

(Total for Question = 1 mark)

- 4 -

4

·12 Which pair of ions is isoelectronic?

☐ A Ca^{2+} and O^{2-}

☐ B Na^+ and O^{2-}

☐ C Li^+ and Cl^-

☐ D Mg^{2+} and Cl^-

(Total for Question = 1 mark)

13 A drop of sodium manganate(VII) solution is placed at the centre of a piece of moist filter paper on a microscope slide. The ends of the paper are clipped to a 30 V DC power supply. After a few minutes,

☐ A a purple colour has moved towards the positive terminal.

☐ B a purple colour has moved towards the negative terminal.

☐ C an orange colour has moved towards the positive terminal.

☐ D an orange colour has moved towards the negative terminal.

(Total for Question = 1 mark)

Section B

14 This question is about the elements arsenic to rubidium which have atomic numbers 33 to 37.

The first ionization energies, E_{m1}, of these elements are given in the table.

Element	As	Se	Br	Kr	Rb
E_{m1} / kJ mol^{-1}	947	941	1140	1351	403

(a) Write the equation, with state symbols, which represents the first ionization energy of arsenic.

(2)

(b) Suggest the formulae of the hydrides of arsenic and selenium.

(2)

(c) (i) Complete the electronic configuration for an arsenic and a selenium atom using the electrons-in-boxes notation.

(2)

		4s	4p		
As	[Ar] 3d^{10}	↑↓			
Se	[Ar] 3d^{10}	↑↓			

*(ii) Explain why the first ionization energy of selenium is lower than that of arsenic.

(2)

*(d) Explain why the first ionization energy of krypton is higher than that of selenium.

(2)

*(e) Explain why the first ionization energy of rubidium is lower than that of krypton.

(2)

(f) Which of the elements, arsenic to rubidium, is likely to have atoms with the smallest atomic radius?

(1)

15 Hydrogen has three isotopes, ^{1}H, known as protium, ^{2}H, deuterium, and ^{3}H, tritium.

(a) In terms of sub-atomic particles, give the similarities and differences between atoms of these three isotopes of hydrogen.

(3)

(b) When a nitrogen atom collides with a high energy neutron, one atom of tritium and one atom of another element are formed. Complete the equation below.

(1)

$$^{14}_{7}N + \, ^1_0n \rightarrow \, ^3_1H + \, \text{―――――}$$
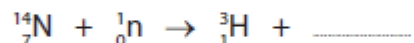
(c) Tritium-deuterium gas, consisting of molecules each containing one deuterium atom and one tritium atom, is used in some nuclear warheads. Typically, each warhead has about 4.0 g of the gas added.

(i) Calculate the number of moles of tritium-deuterium in 4.0 g.

(2)

(ii) Calculate the volume, in cm^3, of 4.0 g of tritium-deuterium gas.

[Molar volume of a gas under these conditions = 24 000 cm^3 mol^{-1}]

(1)

(d) Tritium is not usually included in calculations of the relative atomic mass of hydrogen, because it is radioactive and has a relatively short half-life.

Calculate the relative atomic mass of hydrogen with the following isotopic composition. Give your answer to four decimal places.

(2)

Isotope	Mass number	Relative abundance
^{1}H	1.0078	99.9850
^{2}H	2.0141	0.0150

(e) The electronic energy levels in hydrogen are shown below.

n = ∞ ――――――
―――――――
―――――――
n = 4 ―――――――
n = 3 ―――――――

n = 2 ―――――――

n = 1 ―――――――
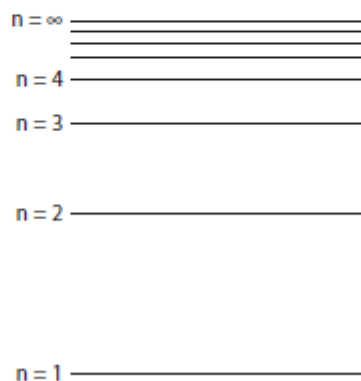
(i) Mark on the energy level diagram, with an arrow, the transition that represents the ionization energy of hydrogen.

(ii) In some versions of the Periodic Table, hydrogen is placed in the same group as sodium. Give the electronic configurations for both a hydrogen atom and a sodium atom, using the *s* and *p* notation.

Use these electronic configurations to suggest why this is a reasonable grouping.

(2)

H...

Na...

....

....

*(f) Which element in the Periodic Table has the highest first ionization energy? Justify your answer.

(3)

16 Metals are good conductors of heat and electricity and usually have high melting temperatures and boiling temperatures.

(a) (i) Describe the **structure** of a metal.

(2)

(ii) Describe the **bonding** in a metal.

(2)

(b) Explain why the melting temperature of magnesium (650 °C) is much higher than that of sodium (98 °C).

(3)

(c) Explain how metals conduct electricity.

(2)

17 This question is about lithium iodide, an ionic salt.

(a) Draw dot and cross diagrams for the lithium and iodide ions. Show all the electrons in the lithium ion but only outer shell electrons in the iodide ion.

(2)

*(iii) Suggest why the melting temperature of magnesium oxide is higher than that of magnesium chloride, even though both are almost 100% ionic.

(3)

....

(c) Magnesium chloride may be prepared from magnesium by reaction with chlorine or with hydrochloric acid. Compare these two preparations in terms of the atom economies of the reactions. No calculation is required.

(2)

....