1 In atoms, electrons fill up the sub-shells in order of increasing energy.

(a) Fill in the last two boxes in the table below to show the order in which the next two sub-shells are filled.

1s	2s	2p	3s	3p	4s		

energy increases →

(2)

(b) Electrons in atoms occupy orbitals.

(i) Explain the term **orbital**.

(1)

.....

.....

.....

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

(2)

s-orbital

p-orbital

(c) State the **total** number of electrons occupying **all** the p-orbitals in one atom of chlorine.

(1)

.....

(d) State the number of electrons present in an ion of calcium, Ca^{2+}.

(1)

.....

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

(3)

(f) The ionization energies of sodium, Na, are shown in the table below.

Show with a tick (✓), in the third row of the table below, **all** the ionization numbers that involve the removal of an electron from an s-orbital.

(2)

Ionization energy / kJ mol^{-1}	496	4563	6913	9544	13352	16611	20115	25491	28934	141367	159079
Ionization number	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th

(Total for Question = 12 marks)

2 (a) Define the term **first ionization energy**.

(2)

.....

.....

.....

*(b) Explain why the first ionization energy of the elements down Group 1 decreases even though the atomic number increases.

(2)

.....

.....

.....

.....

.....

.....

(c) The eleven successive ionization energies for sodium are given below.

Electron removed	1	2	3	4	5	6	7	8	9	10	11
Ionization energy / kJ mol^{-1}	496	4563	6913	9544	13352	16611	20115	24491	28934	141367	159079

(i) Explain why the successive ionization energies increase.

(1)

.....

.....

.....

*(ii) Explain how these ionization energies give evidence for the electronic structure of sodium. You may use a sketch graph if you wish.

(2)

.....

.....

.....

.....

.....

(d) The first ionization energy of aluminium (element 13) is lower than that of magnesium (element 12).

(i) Give the electronic structures of magnesium and of aluminium in *s*, *p* and *d* notation.

(1)

Magnesium .....

Aluminium .....

*(ii) Explain the difference in the first ionization energies of the two metals.

(1)

.....

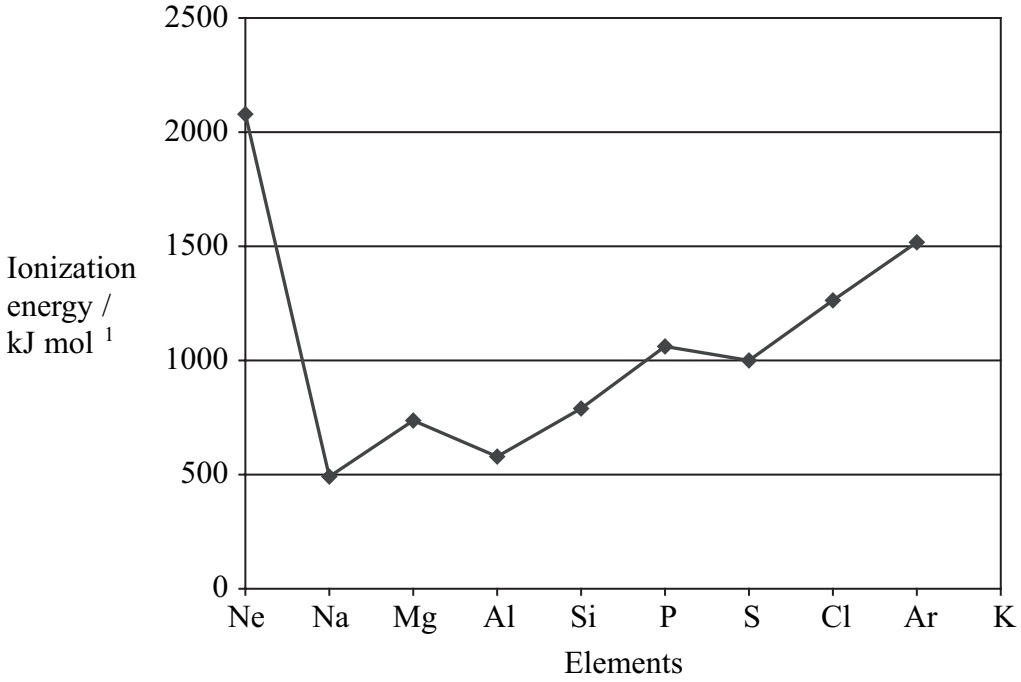
.....

.....

.....

(Total for Question 9 marks)

3 The first ionization energy of each of the elements from neon to argon is shown on the graph below. The first ionization energy of potassium has been omitted.



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

(3)

(b) Explain why, in moving from Na to Ar, the general trend is for the first ionization energy to increase.

(3)

.....

.....

.....

.....

.....

.....

(c) Explain why the first ionization energy decreases from P to S.

(2)

.....

.....

.....

.....

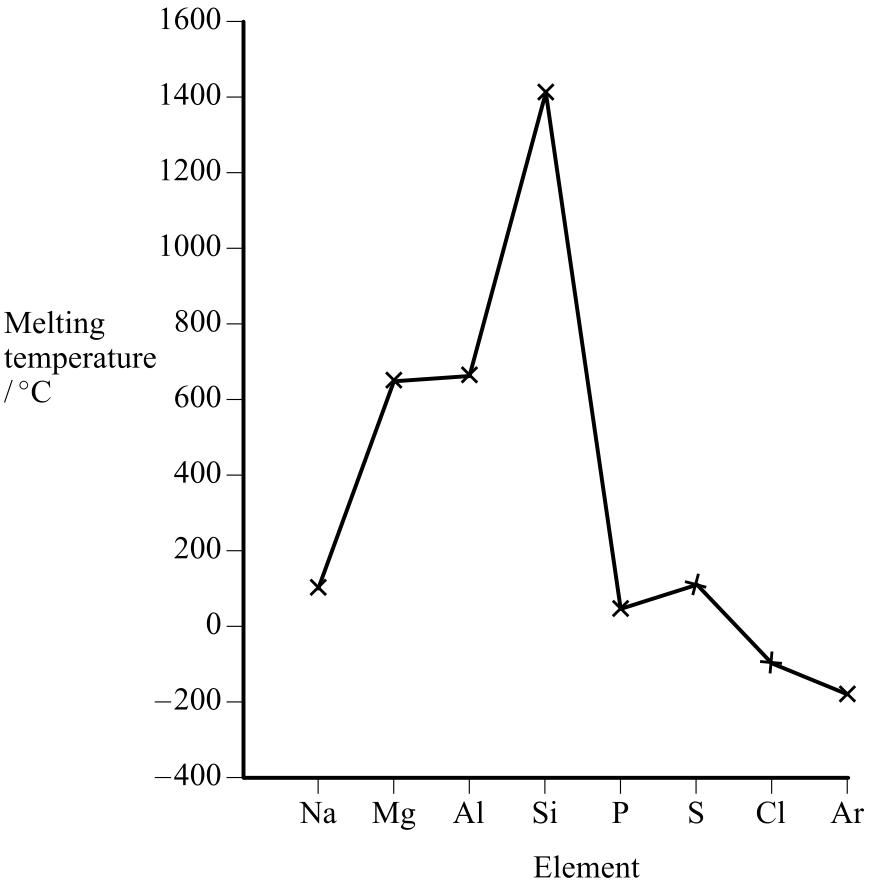
(d) Estimate the value of the first ionization energy of potassium, K, and write your answer below.

(1)

..... kJ mol ^{1}

(Total for Question 9 marks)

4 The graph shows the variation in melting temperatures of the elements across Period 3 (Na to Ar) of the Periodic Table.



(a) Complete the table below to show the type of structure and bonding for the elements shown.

(3)

Element	Structure	Bonding
sodium		
silicon		
sulfur		

(b) Explain why silicon has a much higher melting temperature than sulfur.

(2)

*(c) Explain why the melting temperature increases from sodium to aluminium.

(2)

(d) Magnesium forms the basic oxide magnesium oxide, MgO. This oxide is almost insoluble in water. On gentle warming with dilute sulfuric acid, magnesium oxide reacts to form aqueous magnesium sulfate solution.

*(i) Describe how you would use the above reaction to prepare a pure sample of magnesium sulfate.

(5)

(ii) Suggest what action should be taken if a pupil spilt a small quantity of dilute sulfuric acid on a laboratory bench.

(1)

(e) The data in the table below will be useful when answering this question.

Soluble in water	Insoluble in water
$MgSO_4$	$MgCO_3$ $SrCO_3$ $SrSO_4$

Magnesium carbonate reacts with dilute sulfuric acid.

$$MgCO_3(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + CO_2(g) + H_2O(l)$$

(i) Explain why the reaction between strontium carbonate and dilute sulfuric acid stops after a few seconds.

(1)

(ii) Strontium sulfate is produced when aqueous sodium sulfate is added to aqueous strontium chloride.

Give the **ionic** equation for the reaction, including state symbols.

(2)

(Total for Question = 16 marks)