1. (a) Use the Aufbau principle to write the electron configuration of an atom of germanium.

....

(1)

(b) The successive ionization energies of germanium are shown in the following table:

	1st	2nd	3rd	4th	5th
Ionization energy / kJ mol^{-1}	760	1540	3300	4390	8950

(i) Identify the sub-level from which the electron is removed when the first ionization energy of germanium is measured.

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(1)

(ii) Write an equation, including state symbols, for the process occurring when measuring the second ionization energy of germanium.

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(1)

(iii) Explain why the difference between the 4th and 5th ionization energies is much greater than the difference between any two other successive values.

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(2)
(Total 5 marks)

2. (i) Explain why successive ionization energies of an element increase.

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(1)

(ii) Explain how successive ionization energies account for the existence of three main energy levels in the sodium atom.

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(3)
(Total 4 marks)

3. Explain the following statements.

(a) The first ionization energy of sodium is

(i) less than that of magnesium.

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(2)

(ii) greater than that of potassium.

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(1)

(b)   The electronegativity of chlorine is higher than that of sulfur.

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        …………………………………………………………………………………………….

(2)
(Total 5 marks)

4.   The following table shows values that appear in the Data Booklet.

Table 1 Covalent (atomic) radii /10^{-12} m

				N	0	F
				70	66	58
Na	Mg	Al	Si	P	S	Cl
186	160	143	117	110	104	99

Table 2 Ionic radii/10^{-12} m

				N^{3-}	O^{2-}	F^{-}
				171	146	133
Na^{+}	Mg^{2+}	Al^{3+}	Si^{4+}	P^{3-}	S^{2-}	Cl^{-}
98	65	45	42	212	190	181

Explain why

(i)   the magnesium ion is much smaller than the magnesium atom.

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(2)

(ii)   there is a large increase in ionic radius from silicon to phosphorus.

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(2)

(iii)   the ionic radius of Na^+ is less than that of F^-.

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(2)
(Total 6 marks)

5.   (a)   (i)   Define the term *ionization energy*.

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(2)

(ii)   Write an equation, including state symbols, for the process occurring when measuring the first ionization energy of aluminium.

....

(1)

(b) The first ionization energies of the elements are shown in Table 8 of the Data Booklet. Explain why the first ionization energy of magnesium is greater than that of sodium.

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(2)

(c) Lithium reacts with water. Write an equation for the reaction and state **two** observations that could be made during the reaction.

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(3)
(Total 8 marks)

6. (a) State the meaning of the term *electronegativity*.

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(1)

(b) State and explain the trend in electronegativity across period 3 from Na to Cl.

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(2)

(c)   Explain why Cl_2 rather than Br_2 would react more vigorously with a solution of I^-.

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(2)
(Total 5 marks)

7.   Describe the acid-base character of the oxides of the period 3 elements Na to Ar. For sodium oxide and sulfur trioxide, write balanced equations to illustrate their acid-base character.

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(Total 4 marks)

8. Table 7 of the Data Booklet lists melting points of the elements. Explain the trend in the melting points of the alkali metals, halogens and period 3 elements.

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(Total 8 marks)

9. (i) Explain how the first ionization energy of K compares with that of Na and Ar.

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(3)

(ii)   Explain the difference between the first ionization energies of Na and Mg.

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(4)

(iii)   Suggest why much more energy is needed to remove an electron from Na^+ than from Mg^+.

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(1)
(Total 8 marks)

10. Nitrogen is found in period 2 and group 15 of the periodic table.

(i)   Distinguish between the terms *period* and *group*.

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…………………………………………………………………………………………

(1)

(ii)   State the electron arrangement of nitrogen and explain why it is found in period 2 and group 15 of the periodic table.

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(3)
(Total 4 marks)

11.   Table 9 of the Data Booklet gives the atomic and ionic radii of elements. State and explain the difference between

(i)   the atomic radius of nitrogen and oxygen.

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(2)

(ii)   the atomic radius of nitrogen and phosphorus.

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………………………………………………………………………………………………

(1)

(iii)   the atomic and ionic radius of nitrogen.

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(2)
(Total 5 marks)

12.   State and explain the trends in the atomic radius and the ionization energy

(i)   for the alkali metals Li to Cs.

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(4)

(ii)   for the period 3 elements Na to Cl.

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(4)
(Total 8 marks)

13. (i) Describe **three** similarities and **one** difference in the reactions of lithium and potassium with water.

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(4)

(ii) Give an equation for **one** of these reactions. Suggest a pH value for the resulting solution, and give a reason for your answer.

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(3)
(Total 7 marks)

14. (a) Classify each of the following oxides as acidic, basic or amphoteric.

(i) aluminium oxide

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(1)

(ii) sodium oxide

……………………………………………………………………………………

(1)

       (iii)   sulfur dioxide

        …………………………………………………………………………………………

(1)

    (b)   Write an equation for each reaction between water and

       (i)   sodium oxide

        …………………………………………………………………………………

        …………………………………………………………………………………

(1)

       (ii)   sulfur dioxide.

        …………………………………………………………………………………

        …………………………………………………………………………………

(1)
(Total 5 marks)

15.   This question is about Period 3 elements and their compounds. (type of bonding Topic 4)

    (a)   Explain, in terms of their structure and bonding, why the element sulfur is a non-conductor of electricity and aluminium is a good conductor of electricity.

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        ....

(4)

(b)   Explain, in terms of its structure and bonding, why silicon dioxide, SiO_2, has a high melting point.

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(2)
(Total 6 marks)

16.   Explain why

(i)   the first ionization energy of magnesium is lower than that of fluorine.

(2)

(ii)   magnesium has a higher melting point than sodium.

(3)

(Total 5 marks)

17.   Discuss the acid-base nature of the period 3 oxides. Write an equation to illustrate the reaction of one of these oxides to produce an acid, and another equation of another of these oxides to produce a hydroxide.

(Total 5 marks)

18. Information about the halogens appears in the Data Booklet.

(i) Explain why the ionic radius of chlorine is less than that of sulfur.

(2)

(ii) Explain what is meant by the term *electronegativity* and explain why the electronegativity of chlorine is greater than that of bromine.

(3)

(Total 5 marks)

19. (a) (i) State the meaning of the term *electronegativity* and explain why the noble gases are not assigned electronegativity values.

(2)

(ii) State and explain the trend in electronegativity across period 3 from Na to Cl.

(2)

(iii) Explain why Cl_2 rather than Br_2 would react more vigorously with a solution of I^-.

(2)

(b) State the acid-base properties of the following period 3 oxides.

$$MgO \quad Al_2O_3 \quad P_4O_6$$

Write equations to demonstrate the acid-base properties of each compound.

(7)

(Total 13 marks)

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

(1)

(ii) Write an equation for the reaction of lithium with water.

(1)

(iii) State and explain the trend in the ionization energy of alkali metals down the group.

(3)

(iv)   Explain why the electronegativity of phosphorus is greater than that of aluminium.

(2)

(v)   Table 9 in the Data Booklet contains two values for the ionic radius of silicon. Explain, by reference to atomic structure and electron arrangements, why the two values are very different.

(4)

(Total 11 marks)

21.   Explain why sulfur has a lower first ionization energy than oxygen, and also a lower first ionization energy than phosphorus.

(Total 4 marks)

22. With reference to the types of bonding present in period 3 elements:

    (i)   explain why Mg has a higher melting point than Na.

                                                     (2)

    (ii)   explain why Si has a very high melting point.

                                                     (2)

    (iii)   explain why the other non-metal elements of period 3 have low melting points.

                                                   (2)
                                              (Total 6 marks)

23. Describe the acid-base character of the oxides of the period 3 elements Na to Ar. For sodium oxide and sulfur trioxide, write balanced equations to illustrate their acid-base character.
                                                   (Total 3 marks)