

Periodicity Past Papers

1. The difference between the atomic size of sodium and chlorine is mainly due to the difference in the

- A number of electrons
- B number of protons
- C number of neutrons
- D mass of each atom.

2.

Which entry in the table shows the trends in the electronegativity values of the elements in the Periodic Table?

	Across a period	Down a group
A	decrease	decrease
B	decrease	increase
C	increase	decrease
D	increase	increase

3. Which of the following elements has the greatest electronegativity?

- A Caesium
- B Oxygen
- C Fluorine
- D Iodine

4. Which of the following equations represents the first ionisation energy of chlorine?

- A $\text{Cl(g)} + \text{e}^- \rightarrow \text{Cl}^-(\text{g})$
- B $\text{Cl}^+(\text{g}) + \text{e}^- \rightarrow \text{Cl(g)}$
- C $\text{Cl(g)} \rightarrow \text{Cl}^+(\text{g}) + \text{e}^-$
- D $\text{Cl}^-(\text{g}) \rightarrow \text{Cl(g)} + \text{e}^-$

5. The difference between the covalent radius of sodium and silicon is mainly due to the difference in the

- A number of electrons
- B number of protons
- C number of neutrons
- D mass of each atom.

6. Which of the processes represents the second ionisation energy of magnesium?

- A $\text{Mg}^+(\text{g}) \rightarrow \text{Mg}^{2+}(\text{g}) + \text{e}$
- B $\text{Mg(g)} \rightarrow \text{Mg}^{2+}(\text{g}) + 2\text{e}$
- C $\text{Mg(s)} \rightarrow \text{Mg}^{2+}(\text{g}) + 2\text{e}$
- D $\text{Mg}^+(\text{s}) \rightarrow \text{Mg}^{2+}(\text{s}) + \text{e}$

7. Which of the following elements has the smallest electronegativity?

- A Lithium
- B Caesium
- C Fluorine
- D Iodine

8. Which of the following statements is true?

- A The potassium ion is larger than the potassium atom.
- B The chloride ion is smaller than the chlorine atom.
- C The sodium atom is larger than the sodium ion.
- D The oxygen atom is larger than the oxide ion.

9. Which of the following equations represents the first ionisation energy of fluorine?

- A $\text{F}^-(\text{g}) \rightarrow \text{F(g)} + \text{e}^-$
- B $\text{F}^-(\text{g}) \rightarrow \frac{1}{2}\text{F}_2(\text{g}) + \text{e}^-$
- C $\text{F(g)} \rightarrow \text{F}^+(\text{g}) + \text{e}^-$
- D $\frac{1}{2}\text{F}_2(\text{g}) \rightarrow \text{F}^+(\text{g}) + \text{e}^-$

10. A potassium atom is larger than a sodium atom because potassium has

- A a larger nuclear charge
- B a larger nucleus
- C more occupied energy levels
- D a smaller ionisation energy.

Periodicity Past Papers

11. As the atomic number of the alkali metals increases

- A the first ionisation energy decreases
- B the atomic size decreases
- C the density decreases
- D the melting point increases.

12. Which of the following atoms has the least attraction for bonding electrons?

- A Carbon
- B Nitrogen
- C Phosphorus
- D Silicon

13. Which of the following reactions refers to the third ionisation energy of aluminium?

- A $\text{Al(s)} \rightarrow \text{Al}^{3+}(\text{g}) + 3\text{e}^-$
- B $\text{Al(g)} \rightarrow \text{Al}^{3+}(\text{g}) + 3\text{e}^-$
- C $\text{Al}^{2+}(\text{g}) \rightarrow \text{Al}^{3+}(\text{g}) + \text{e}^-$
- D $\text{Al}^{3+}(\text{g}) \rightarrow \text{Al}^{4+}(\text{g}) + \text{e}^-$

14. Which of the following elements has the greatest attraction for bonding electrons?

- A Lithium
- B Chlorine
- C Sodium
- D Bromine

15.

	State at 30 °C	Covalent radii (pm)
A	solid	less than 238
B	liquid	less than 238
C	solid	greater than 238
D	liquid	greater than 238

16.

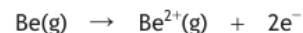
Particles with the same electron arrangement are said to be isoelectronic. Which of the following compounds contains ions which are isoelectronic?

- A Na_2S
- B MgCl_2
- C KBr
- D CaCl_2

17. Which of the following atoms has the greatest attraction for bonding electrons?

- A Sulfur
- B Silicon
- C Nitrogen
- D Hydrogen

18. What is the enthalpy change, in kJ mol^{-1} , for the following reaction?



- A 900
- B 1757
- C 2657
- D 3514

19. The electron affinity of an element is the energy change when one mole of gaseous atoms combines with one mole of electrons to form one mole of gaseous ions.

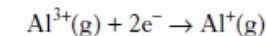
Which of the following equations represents the electron affinity of chlorine?

- A $\text{Cl(g)} + \text{e}^- \rightarrow \text{Cl}^-(\text{g})$
- B $\frac{1}{2}\text{Cl}_2(\text{g}) + \text{e}^- \rightarrow \text{Cl}^-(\text{g})$
- C $\frac{1}{2}\text{Cl}_2(\text{g}) \rightarrow \text{Cl}^+(\text{g}) + \text{e}^-$
- D $\text{Cl(g)} \rightarrow \text{Cl}^+(\text{g}) + \text{e}^-$

20. The table shows the first three ionisation energies of aluminium.

Ionisation energy/ kJ mol^{-1}		
1st	2nd	3rd
584	1830	2760

Using this information, what is the enthalpy change, in kJ mol^{-1} , for the following reaction?



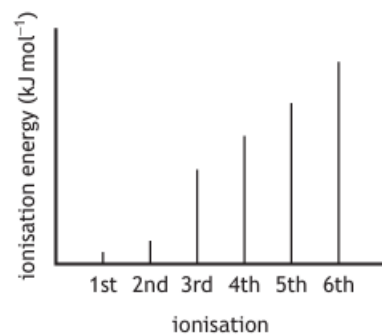
- A +2176
- B -2176
- C +4590
- D -4590

21.

Which of the following statements is true?

- A The sodium atom is larger than the sodium ion.
- B The chloride ion is smaller than the chlorine atom.
- C The magnesium ion is larger than the magnesium atom.
- D The oxygen atom is larger than the oxide ion.

- 22 The graph below shows the relative quantities of energy equivalent to successive ionisation energies for an element.

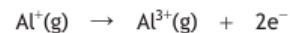


The most stable ion formed from an atom of this element has a charge of:

- A 2+
 - B 3+
 - C 2-
 - D 3-
- 23 The table shows the first three ionisation energies of aluminium.

<i>Ionisation energy (kJ mol⁻¹)</i>		
<i>First</i>	<i>Second</i>	<i>Third</i>
578	1817	2745

Using this information, what is the enthalpy change, in kJ mol⁻¹, for the following reaction?



- A 1817
- B 2395
- C 4562
- D 5140

Periodicity Past Papers

1. Some metal ions are required for a healthy diet.

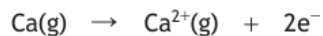
(a) Sodium, magnesium and calcium form positively charged ions.

The table shows the values for ionisation energies for these elements.

Element	Ionisation energies (kJ mol ⁻¹)			
	First	Second	Third	Fourth
Sodium	496	4562	6910	9543
Magnesium	738	1451	7733	10 543
Calcium	590	1145	4912	6491

(i) Write the equation for the first ionisation of sodium. 1

(ii) Using the ionisation energies from the table, calculate the energy required, in kJ mol⁻¹, for the following reaction. 1



(iii) Explain **fully** why the second ionisation energy of sodium is much higher than the second ionisation energy of magnesium. 2

(iv) The Mg²⁺ ion and the Na⁺ ion have the same number of occupied energy levels.
Explain why the Mg²⁺ ion is smaller than the Na⁺ ion. 1

2. Covalent radius is half the distance between the nuclei of two covalently bonded atoms of an element.

(i) State the trend in covalent radius going from sodium to chlorine. 1

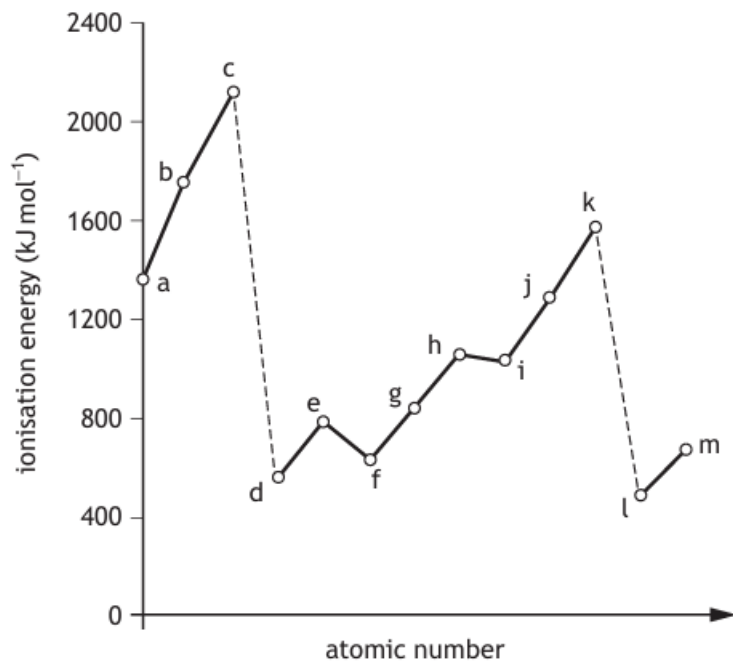
(ii) Suggest why no covalent radius is listed in the data booklet for argon. 1

Periodicity Past Papers

3. Elements are arranged in the periodic table in order of increasing atomic number. Many physical and chemical properties of the elements show periodic trends.

(a) First ionisation energy is a property that has a periodic trend.

The diagram shows part of a graph of first ionisation energy against atomic number for some elements in the periodic table.



(i) Explain why there is an increase in first ionisation energy from elements d to k in the diagram.

(ii) State an element from a to m in the diagram that represents an element from group 7.

(iii) The table shows four ionisation energies of sodium.

Ionisation energy (kJ mol ⁻¹)			
First	Second	Third	Fourth
496	4562	6910	9543

(A) Explain **fully** the large increase between the first and second ionisation energies of sodium. 2

(B) Use the information in the table to determine the enthalpy change, in kJ mol⁻¹, for the following reaction. 1



(b) Electronegativity is another property that has a periodic trend.

(i) State what is meant by the term electronegativity.

(ii) Explain **fully** why electronegativity decreases going down a group. 2

Periodicity Past Papers

4. Elements and compounds can exist as diatomic molecules.

(a) The seven elements that exist as diatomic molecules are shown in the periodic table below.

1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba		72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra		104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og

(i) Nitrogen, oxygen and fluorine are found in the second period of the periodic table. 1

Explain the decrease in covalent radius going from nitrogen to fluorine. 1

(ii) First ionisation energies decrease going down a group. 1

State what is meant by the term *first ionisation energy*. 1

(b) Explain why the first ionisation energy of the group 7 elements decreases going down the group. 1

5. The elements of group 7 in the periodic table are known as the halogens.

(a) Going down group 7 the electronegativity of the halogens decreases.

(i) State what is meant by the term *electronegativity*. 1

(ii) Explain why electronegativity values decrease going down group 7. 1

(b) The elements sodium to argon form the third period of the periodic table.

Explain the decrease in atom size going across the third period from sodium to argon. 1

6. Ionisation energy changes across the period.

(i) Explain why the first ionisation energy increases across the period. 1

(ii) Write an equation, including state symbols, for the **second** ionisation energy of magnesium. 1

(iii) The table shows the values for the first four ionisation energies of aluminium.

<i>Ionisation energies (kJ mol⁻¹)</i>			
First	Second	Third	Fourth
578	1817	2745	11 577

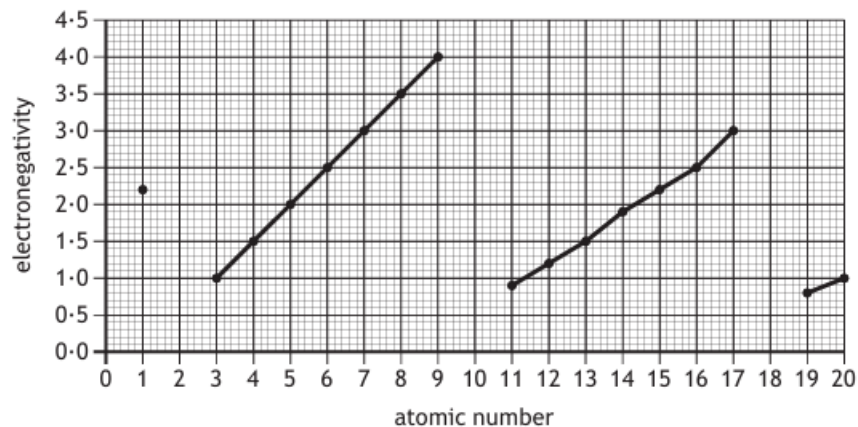
Explain why there is a large difference between the third and fourth ionisation energies. 1

Periodicity Past Papers

7

Electronegativity is a measure of the attraction an atom involved in a bond has for the electrons of the bond.

The graph shows the trend in electronegativity for the first 20 elements.



(a) (i) State the trend in electronegativity as you go across period 2 from lithium to fluorine.

1

(ii) No electronegativity values are shown for the elements with atomic numbers 2, 10 and 18.

Suggest why no values are provided for these elements.

1

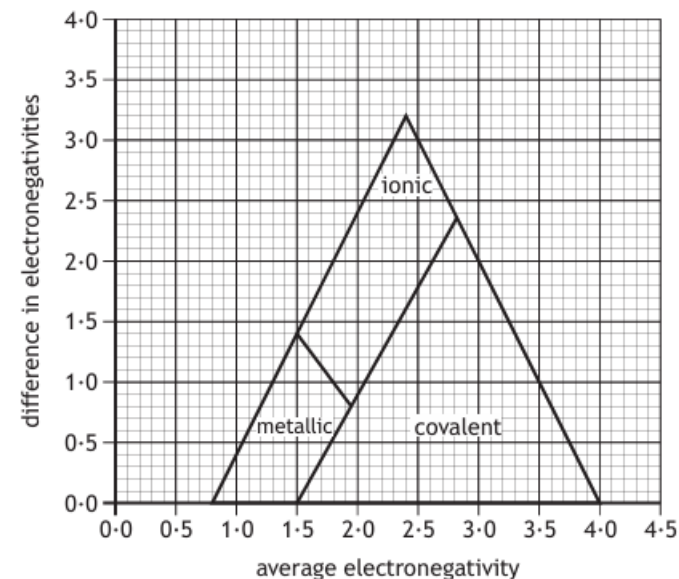
(iii) On descending Group 7 from fluorine to iodine, the electronegativity of the elements decreases.

Explain why the electronegativity of the elements decreases as you go down the group.

1

(b) Electronegativity values can be used to predict the type of bonding present in substances.

The type of bonding between two elements can be predicted using the diagram below.



(i) Using the information in the diagram, state the highest average electronegativity found in ionic compounds.

1

(ii) The electronegativity values of magnesium and nitrogen are shown.

Electronegativity of magnesium = 1.2

Electronegativity of nitrogen = 3.0

Draw an X on the diagram on page 04 to show the position of magnesium nitride.

Show your calculations clearly.

2

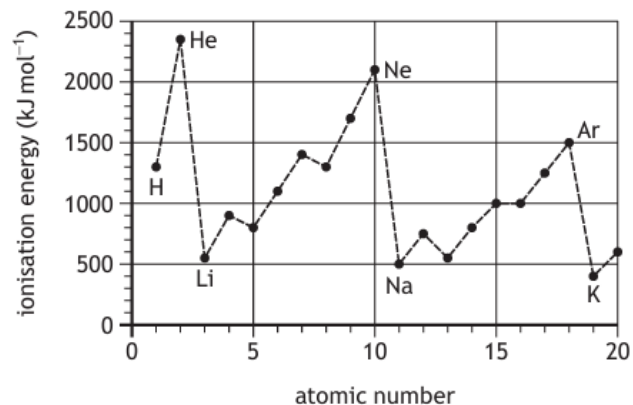
(An additional diagram, if required, can be found on page 38.)

Periodicity Past Papers

8.

2019 is the 150th anniversary of the periodic table's creation by Dmitri Mendeleev. The patterns identified by Mendeleev form the basis of the modern periodic table. The major periodic trends include ionisation energy and covalent radius.

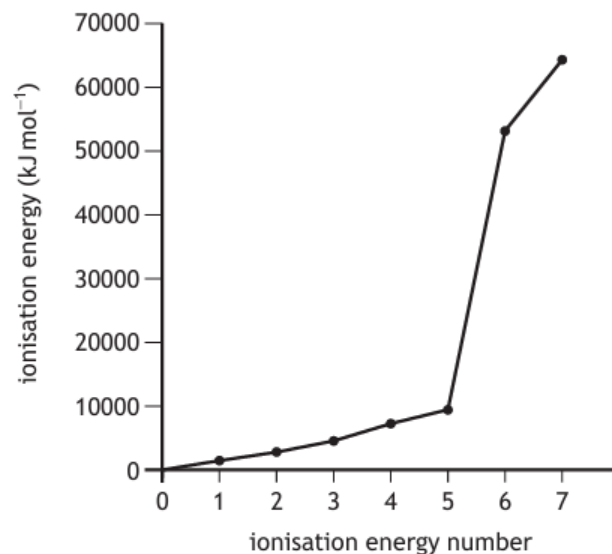
(a) The first ionisation energies of elements with atomic number 1 to 20 are shown in the graph.



(i) Explain why the first ionisation energy shows an increase going from lithium to neon. 1

(ii) Explain why the first ionisation energy of potassium is less than the first ionisation energy of lithium. 1

(b) A graph showing the ionisation energies for nitrogen is shown.



(i) Write the equation for the second ionisation energy of nitrogen. 1

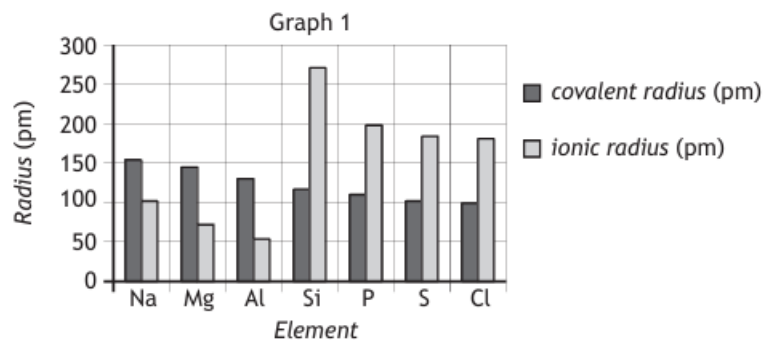
(ii) Explain **fully** the increase between the 5th and 6th ionisation energies of nitrogen. 2

(c) Ionic radius is a measure of the size of an ion.

Explain **fully** why the ionic radius of phosphorus is greater than the ionic radius of aluminium. 2

Periodicity Past Papers

9. (a) Graph 1 shows the sizes of atoms and ions for elements in the third period of the Periodic Table.



The covalent radius is a measure of the size of an atom.

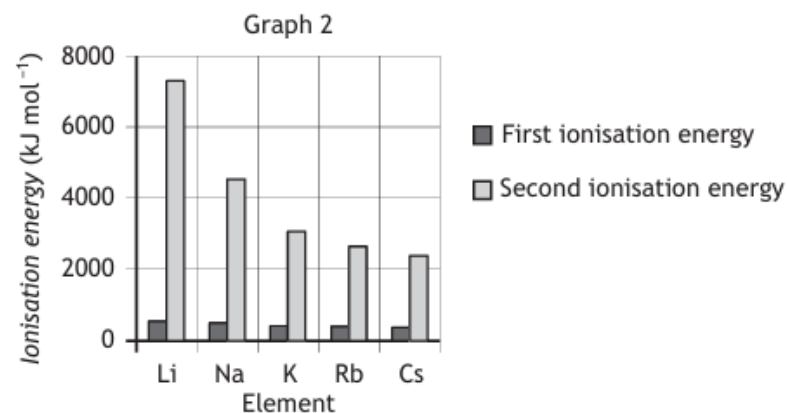
- (i) Explain why covalent radius decreases across the period from sodium to chlorine.

1

- (ii) Explain **fully** why the covalent radius of sodium is larger than the ionic radius of sodium.

2

- (b) Graph 2 shows the first and second ionisation energies of elements in Group 1 of the Periodic Table.



- (i) Explain why the first ionisation energy decreases going down Group 1.

1

- (ii) Explain **fully** why the second ionisation energy is much greater than the first ionisation energy for Group 1 elements.

2

Periodicity Past Papers

9. (c) The lattice enthalpy is the energy needed to completely separate the ions in one mole of an ionic solid.

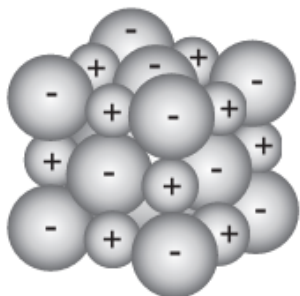


Table 1 shows the size of selected ions.

Table 1

Ion	Li ⁺	Na ⁺	K ⁺	Rb ⁺	F ⁻	Cl ⁻
Ionic radius (pm)	76	102	138	152	133	181

Table 2 shows the lattice enthalpies, in kJ mol^{-1} , for some Group 1 halides.

Table 2

Ions	F ⁻	Cl ⁻
Li ⁺	1030	834
Na ⁺	910	769
K ⁺	808	701
Rb ⁺		658

- (i) Predict the lattice enthalpy, in kJ mol^{-1} , for rubidium fluoride. 1
- (ii) Write a general statement linking lattice enthalpy to ionic radii. 1

- 10 Explain why the covalent radius of sulfur is smaller than that of phosphorus. 1

- 11 (a) Atoms of different elements have different attractions for bonded electrons. What term is used as a measure of the attraction an atom involved in a bond has for the electrons of the bond?
- (b) Atoms of different elements are different sizes. What is the trend in atomic size across the period from sodium to argon?
- (c) Atoms of different elements have different ionisation energies. **Explain clearly** why the first ionisation energy of potassium is less than the first ionisation energy of sodium.

- 12 The elements lithium to neon make up the second period of the Periodic Table.

Li	Be	B	C	N	O	F	Ne
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- (Why do the atoms decrease in size from lithium to neon? 1

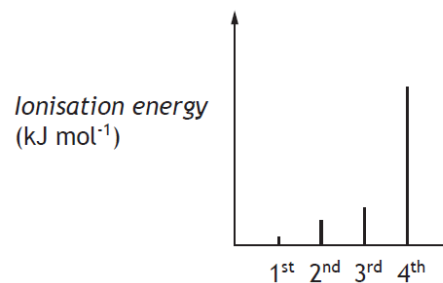
Periodicity Past Papers

13. Sodium is the first element in the third period of the periodic table.

Na	Mg	Al	Si	P	S	Cl	Ar
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(a) Describe the trend in electronegativity values across this period from Na to Cl. 1

(b) The spike graph shows the first four ionisation energies for aluminium.



Explain why the fourth ionisation energy of aluminium is much higher than the third ionisation energy. 1

14. Common salt, NaCl, is widely used in the food industry as a preservative and flavour enhancer.

(i) Write the ion-electron equation for the first ionisation energy of sodium. 1

(ii) **Explain clearly** why the first ionisation energy of sodium is much lower than its second ionisation energy. 3

15. The elements from sodium to argon make up the third period of the Periodic Table.

(a) On crossing the third period from left to right there is a general increase in the first ionisation energy of the elements.

(i) Why does the first ionisation energy increase across the period? 1

(ii) Write an equation corresponding to the first ionisation energy of chlorine. 1

(b) The electronegativities of elements in the third period are listed on page 10 of the databook.

Why is no value provided for the noble gas, argon? 1

16. Why is there a decrease in the size of atoms across the period from aluminium to sulfur? 1

17.

The three statements below are taken from a note made by a student who is studying trends in the Periodic Table.

1 First Ionisation Energy
The energy required to remove one mole of electrons from one mole of atoms in the gaseous state.

2 Second Ionisation Energy
The energy required to remove a second mole of electrons.

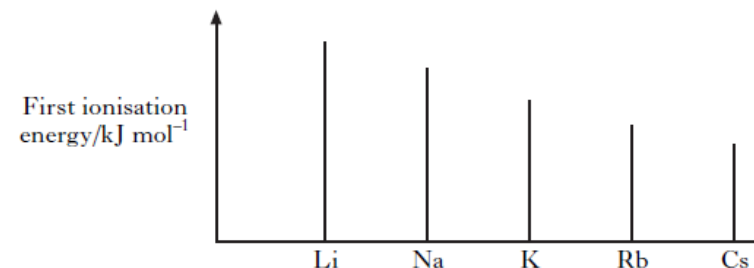
3 _____
The measure of the attraction an atom has for the shared electrons in a bond.

- (a) Complete the note above to give the heading for the third statement.
- (b) What is the trend in the first ionisation energy across a period from left to right?
- (c) Why is the second ionisation energy of sodium so much greater than its first ionisation energy?

18

- (a) The first ionisation energy of an element is defined as the energy required to remove one mole of electrons from one mole of atoms in the gaseous state.

The graph shows the first ionisation energies of the Group 1 elements.



Clearly explain why the first ionisation energy decreases down this group.

- (b) The ability of an atom to form a negative ion is measured by its Electron Affinity.

The Electron Affinity is defined as the energy change when one mole of gaseous atoms of an element combines with one mole of electrons to form gaseous negative ions.

Write the equation, showing state symbols, that represents the Electron Affinity of chlorine.

19.

Attempts have been made to make foods healthier by using alternatives to traditional cooking ingredients.

- (a) An alternative to common salt contains potassium ions and chloride ions.
- (i) Write an ion-electron equation for the first ionisation energy of potassium.
- (ii) **Explain clearly** why the first ionisation energy of potassium is smaller than that of chlorine.

20. Ionisation energies provide information about the structure of atoms.
- (a) Write the equation, showing state symbols, for the first ionisation energy of sodium.
- b) Calculate the energy required to convert one mole of boron atoms into one mole of boron ions with a charge of $3+$.

21. On crossing the Periodic Table, there are trends in the sizes of atoms and ions.
- (a) Why is the atomic size of chlorine less than that of sodium?

(b)

Ion	Ionic radius/pm
Si^{4+}	42
P^{3-}	198

Why is there a large increase in ionic radius on going from Si^{4+} to P^{3-} ?

34. The following answer was taken from a student's examination paper. The answer is incorrect.

Give the correct explanation

Question Explain the difference in atomic size between potassium and chlorine atoms.

Student answer A potassium nucleus has 19 protons but a chlorine nucleus has only 17 protons. The greater pull on the outer electron in the potassium atom means the atomic size of potassium is less than that of chlorine.

Correct explanation

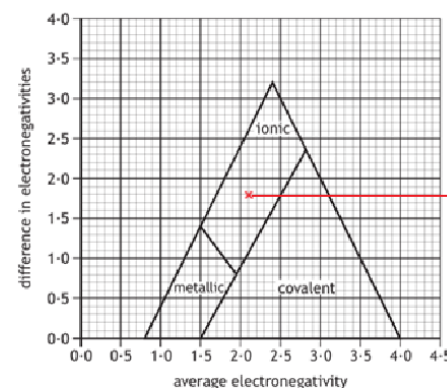
Periodicity Past Papers—Multi choice Answers

1. B	2. C	3. C	4. C	5. B	6. A	7. B
8. C	9. C	10. C	11. A	12. D	13. C	14. B
15. D	16. D	17. C	18. C	19. A	20. D	21. A
22. A	23. C					

Periodicity Written section Marking Scheme

1. a (i) $\text{Na(g)} \rightarrow \text{Na}^{\text{+}}(\text{g}) + \text{e}^{-}$
 (ii) 1735 (590 + 1145)
 (iii) 2nd ionisation energy involves removal of an electron from an inner/full shell
 (iv) more protons/increased nuclear charge of Mg^{2+} ion.
2. (i) decreases
 (ii) doesn't form covalent bonds
- 3 A (i) increasing nuclear charge OR increasing number of protons
 (ii) b or j
 (iii) A Second ionisation energy involves removal of an electron from an inner/full shell.
 B 11, 472
- B (i) Electronegativity is the attraction an atom has for the shared electrons.
 (ii) increased screening/shielding (1 mark)
 Attraction of the nucleus/protons for the outer electrons decreases (1 mark)
- 4 A (i) Increasing nuclear charge/numbers of protons
 (ii) The energy required to remove 1 mole of electrons from 1 mole of gaseous atoms.
 B Increasing screening/shielding (1 mark) OR
 More shells so attraction of nucleus/protons for outer electrons decrease
5. (i) Electronegativity is the measure of attraction an atom/nucleus has for its shared electrons
 (ii) Increasing screening/shielding (1 mark) OR
 More shells so attraction of nucleus/protons for outer electrons decrease
 B) increasing nuclear charge OR increasing number of protons
6. (i) $\text{Mg}^{\text{+}}(\text{g}) \rightarrow \text{Mg}^{2+}(\text{g}) + \text{e}^{-}$ Increasing nuclear charge/number of protons
 (ii)
 (iii) 4th ionisation energy involves removal of an electron from an inner/full shell

7. a (i) increased
 (ii) The nobles gases do not form covalent bonds.
 (iii) Increasing screening/shielding (1 mark) OR
 More shells so attraction of nucleus/protons for outer electrons decrease
- B (i) 2.8 ± 0.05
 (ii) 1 mark correct numbers 2.1/1.8 & 1 mark for graph plotting



2.1 across average electronegativity

1.8 up difference in electronegativity

- 8 a (i) increasing nuclear charge OR number of protons
 (ii) increased shielding/screening (1) OR
 More shells so attraction of nucleus/protons for outer electrons decrease
- B (i) $\text{N}^{\text{+}}(\text{g}) \rightarrow \text{N}^{2+}(\text{g}) + \text{e}^{-}$
 (ii) 6th ionisation energy involves removal of an electron from an inner/full shell
1 mark
- (c) Aluminium atom loses 3 electrons to form an ion (2,8,3 \rightarrow 2,8)
 AND
 Phosphorus atom gains 3 electrons to form an ion (2,8,5 \rightarrow 2,8,8)
1 mark
 Aluminium has one less energy level than phosphorus

Periodicity Marking Scheme

9. a) (i) increasing nuclear charge/number of protons
(ii) covalent radius has electron arrangement 2,8,1 whereas ion loses an electron to form 2,8
Sodium atom has Less energy shells than the ion OR
Sodium atom has 3 electron shells whereas sodium ion only has 2 shells
- B (i) increasing shielding/screening OR
More shells so attraction of nucleus/protons for outer electrons decrease
(ii) 2nd ionisation energy involves removal of an electron from an inner/full shell
- C (i) Any value 720-770
(ii) As ionic radii increases, the lattice enthalpy decreases
- 10 increased nuclear charge/ number of protons
- 11 a) electronegativity
b) decreases
c) increased shielding/screening (1) OR
More shells so attraction of nucleus/protons for outer electrons decrease
12. Increasing nuclear charge/number of protons
13. a) increases
b) 4th ionisation energy involves removal of an electron from an inner/full shell
14. (i) $\text{Na(g)} \longrightarrow \text{Na}^+(\text{g}) + \text{e}^-$
(ii) 2nd ionisation energy involves removal of an electron from an inner/full shell
- 15 A (i) increasing nuclear charge/number of protons
(ii) $\text{Cl(g)} \longrightarrow \text{Cl}^+(\text{g}) + \text{e}$
B) Can't form covalent bonds
16. increasing nuclear charge/number of protons.
17. a) Electronegativity
b) increasing
c) 2nd ionisation energy involves removal of an electron from an inner/full shell
18. a) Increasing screening/shielding (1 mark) OR
More shells so attraction of nucleus/protons for outer electrons decrease
b) $\text{Cl (g)} + \text{e} \longrightarrow \text{Cl}^- (\text{g})$
- 19 a) $\text{K (g)} \longrightarrow \text{K}^+ (\text{g}) + \text{e}$
b) Increasing screening/shielding (1 mark) OR
More shells so attraction of nucleus/protons for outer electrons Decrease.
- 20 a) $\text{Na (g)} \longrightarrow \text{Na}^+ (\text{g}) + \text{e}$
b) 6907 (801 + 2427 + 3660 from databook)
- 21 a) increasing nuclear charge/number of protons
b) Silicon atom has electron arrangement 2,8,4 & silicon ion Loses 4 electrons to become 2,8
AND
Phosphorus atom has electron arrangement 2,8,5 & phosphorus ion gains 3 electrons to become 2, 8, 8
(1 mark)
Silicon ion has less energy shells than phosphorus
OR
Silicon has 2 energy shells whereas phosphorus has 3 (1 mark)
22. Potassium has one more energy level than chlorine.