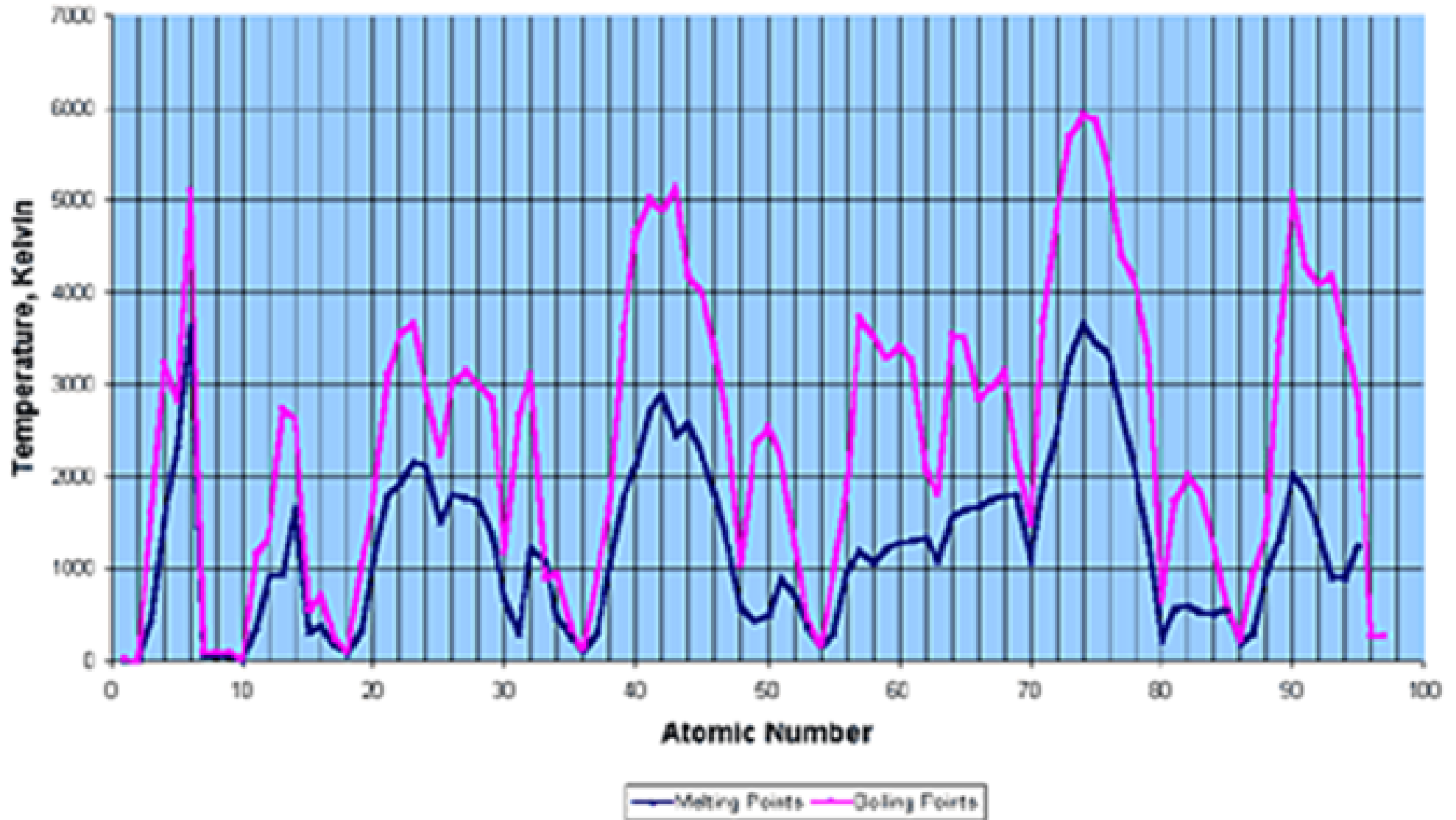


As protons are added across the period they exert an increased pull on the electrons since the electrons are in the same quantum shell they maintain a constant shielding effect. The pull from the protons cause the atomic radius to decrease.

Periodic Trends: Melting and Boiling Points for Elements 1-95



Cations decrease in size

Anions increase in size

KCl

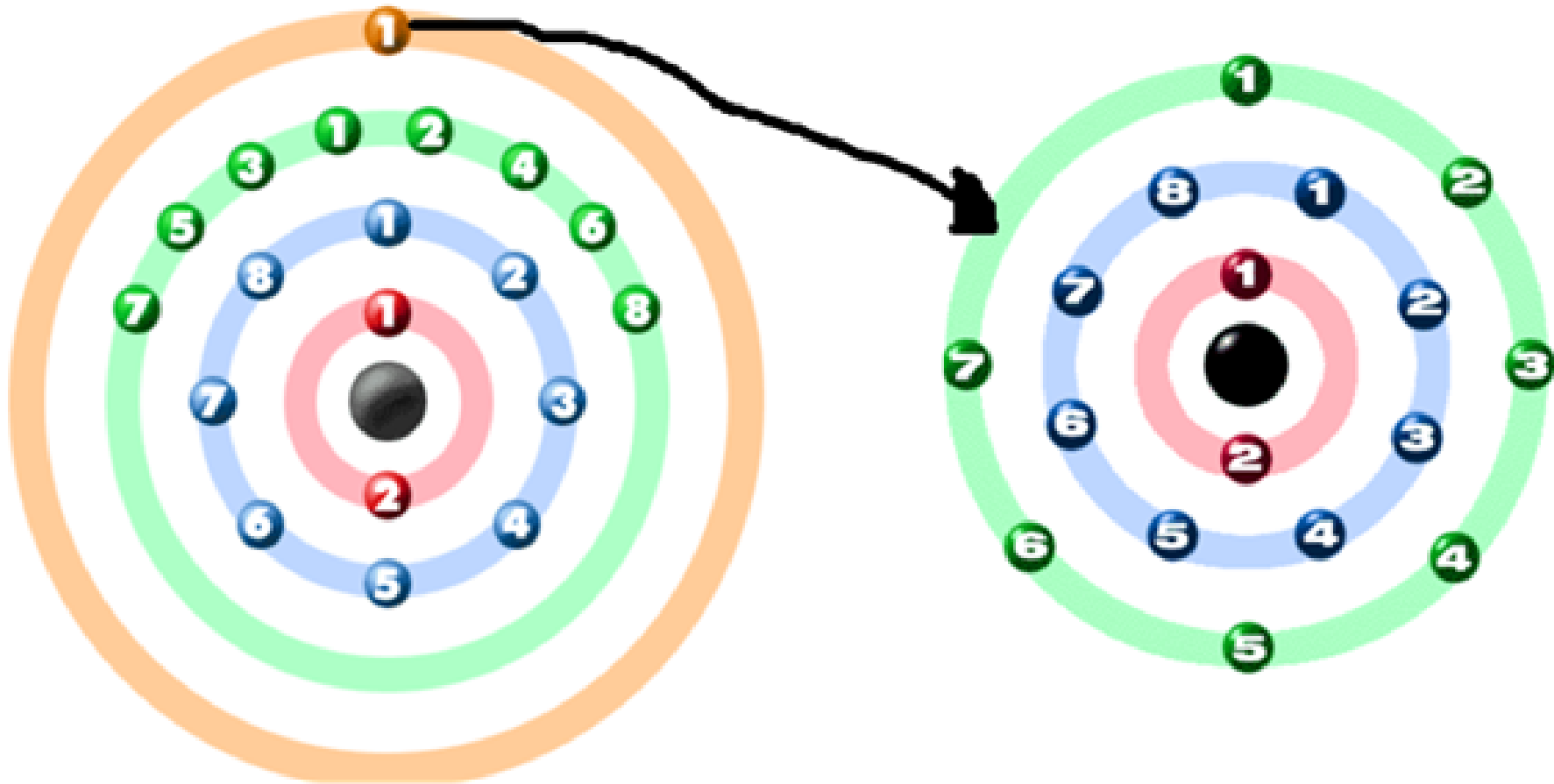
Ionic bonds (aka electrovalent)

K = 19

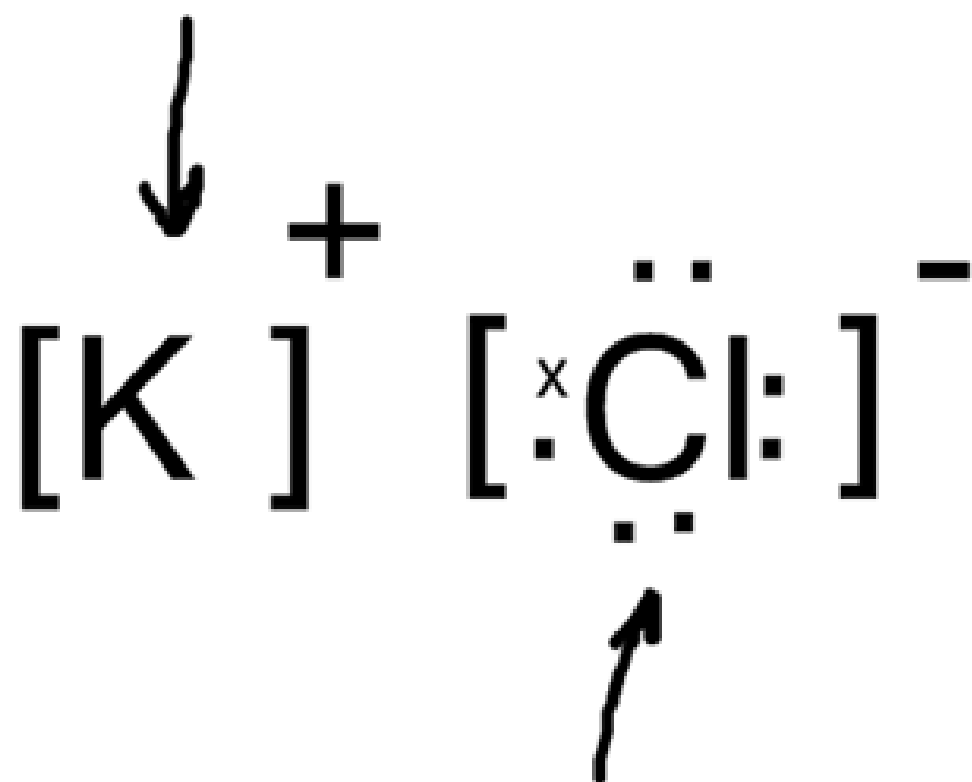
Cl = 17

$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$

$1s^2 2s^2 2p^6 3s^2 3p^5$

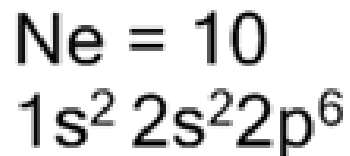
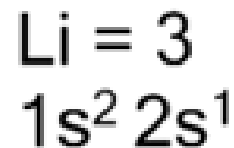
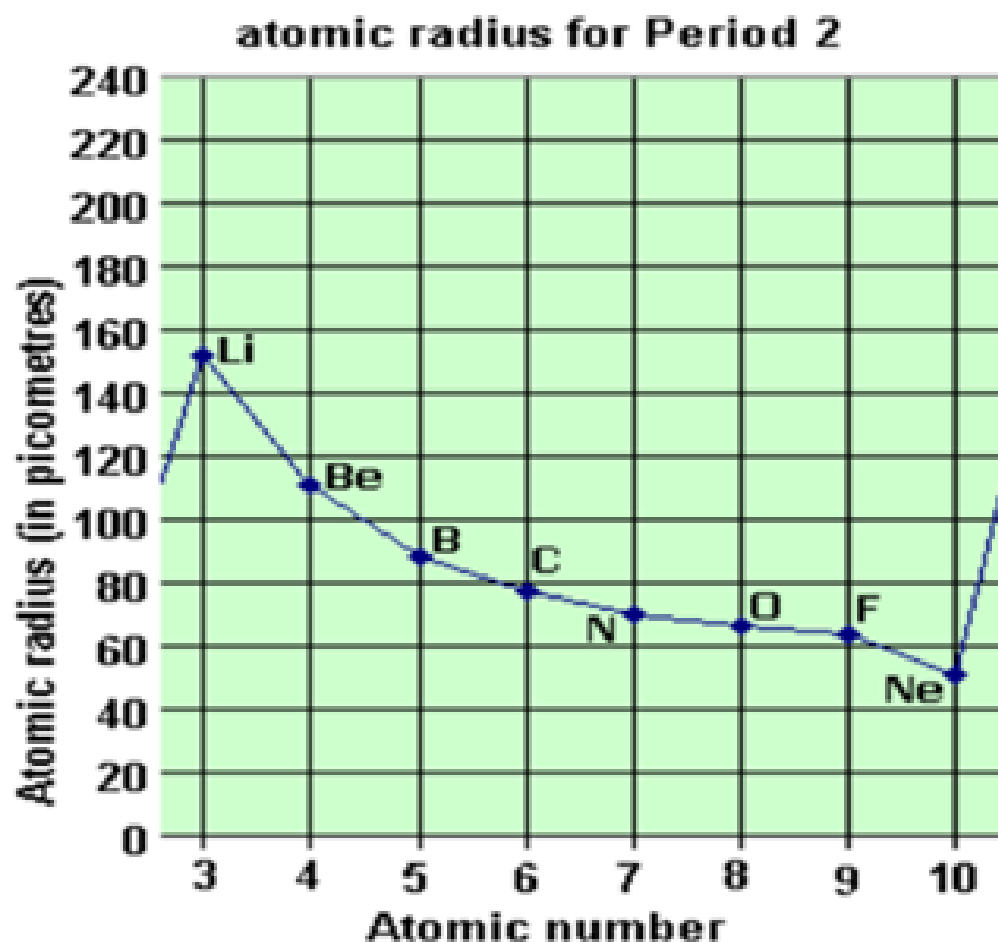


The lost electron stops shielding the other electrons from the nucleus so there is a greater pull from the nucleus and the atom becomes tightly bond decreasing the size.



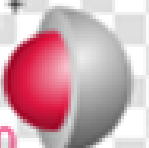





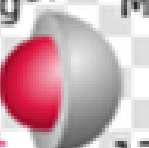


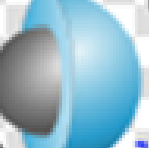
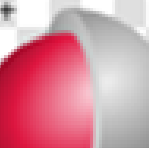



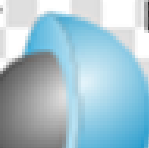
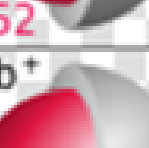
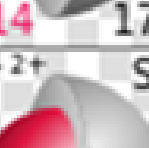
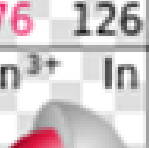


The gained electron increases the shielding of the other electrons from the nucleus and the atom increases in size.

Atomic radius decreases going from left to right. This corresponds to the increase in the number of protons and electrons. The electrons added occupy the same principal quantum shell (energy level). This increases the overall nuclear charge so now the protons are pulling on the outer shell electrons making the element more tightly bound.



Ionic radius increases going from left to right. Metals lose their electrons to become cations so their shell size decreases. Nonmetals gain electrons to become anions and their shell size increases

Sizes of atoms and their ions in pm

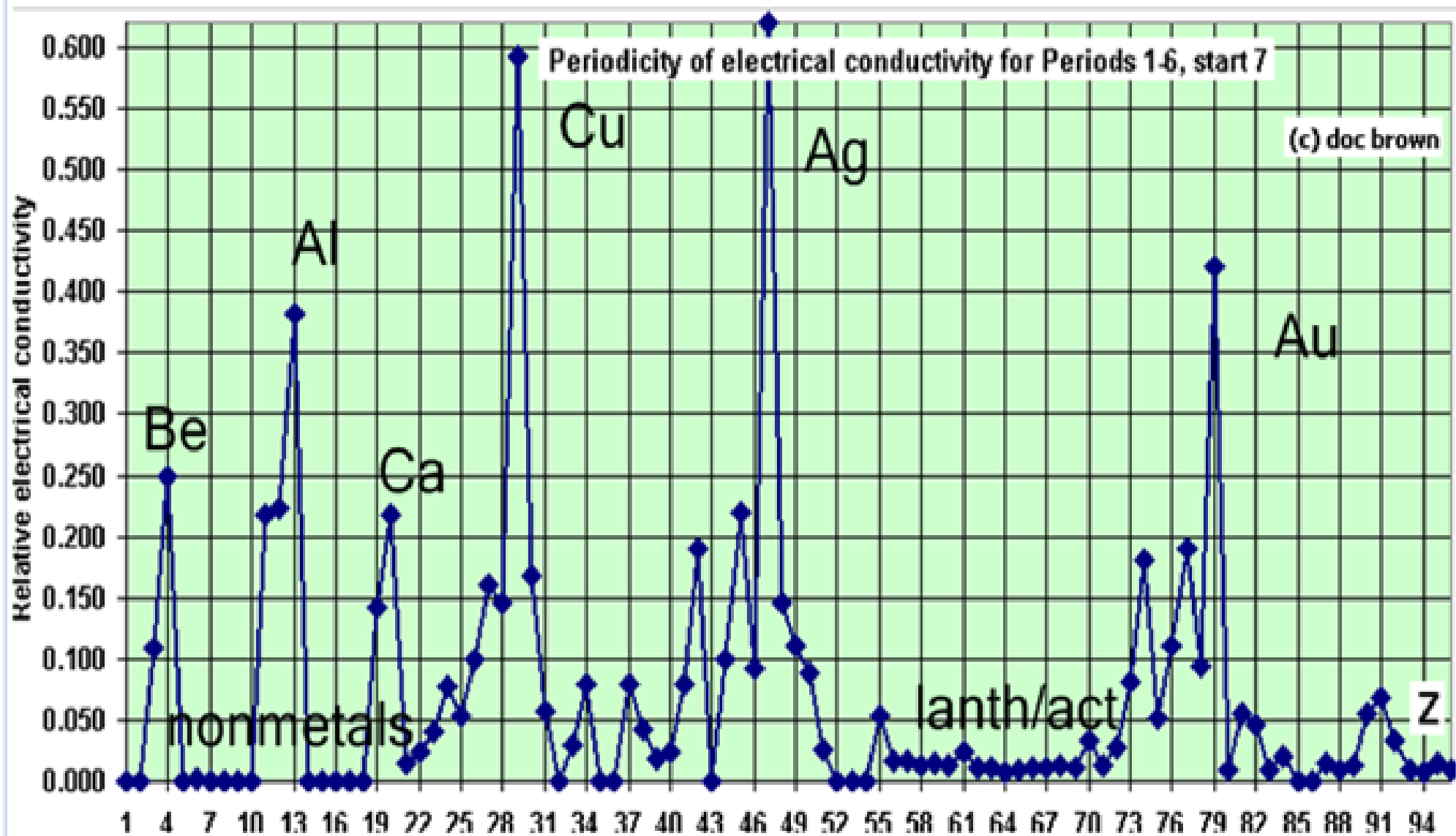
Group 1	Group 2	Group 13	Group 16	Group 17					
Li^+  90	Li 134	Be^{2+}  59	Be 90	B^{3+}  41	B 82	O 73	O^{2-}  126	F 71	F^-  119
Na^+  116	Na 154	Mg^{2+}  86	Mg 130	Al^{3+}  68	Al 118	S 102	S^{2-}  170	Cl 99	Cl^-  167
K^+  152	K 196	Ca^{2+}  114	Ca 174	Ga^{3+}  76	Ga 126	Se 116	Se^{2-}  184	Br 114	Br^-  182
Rb^+  166	Rb 211	Sr^{2+}  132	Sr 192	In^{3+}  94	In 144	Te 135	Te^{2-}  207	I 133	I^-  206

Conductivity increases from Na to Mg to Al

because they are giant metallic structures and the number of delocalized electrons contributing to the sea increases.

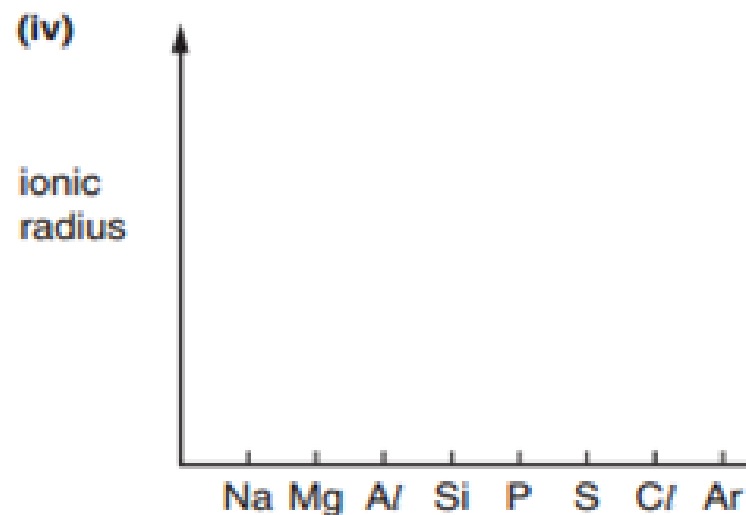
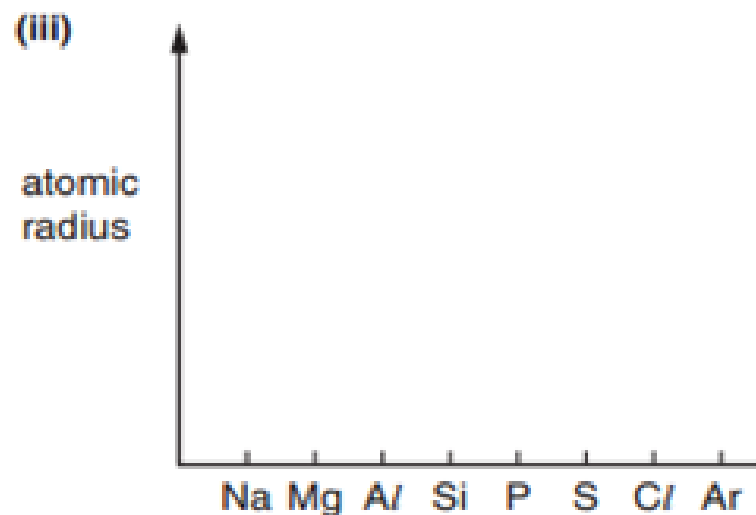
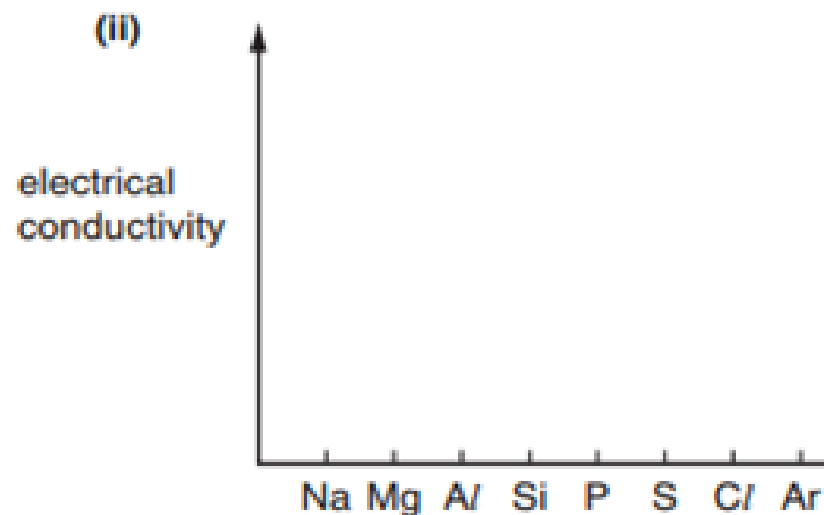
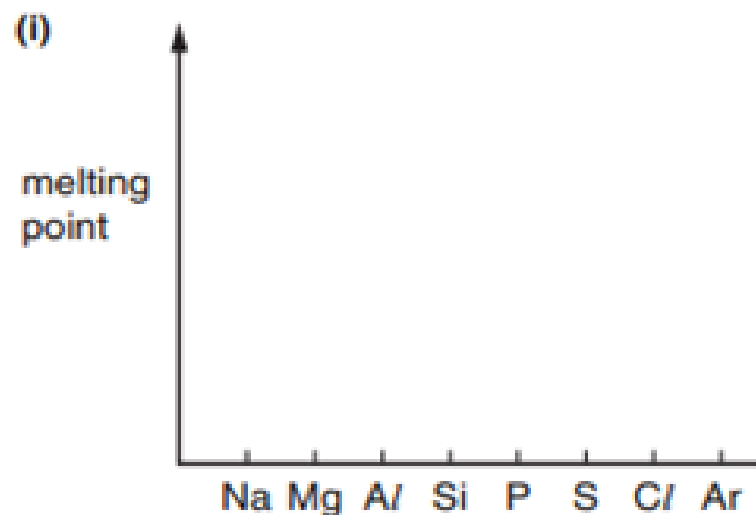
Conductivity decreases and melting point increases at Silicon because it is a giant covalent structure.

S, Cl & Ar are nonmetallic and have low BP due weak VDW forces

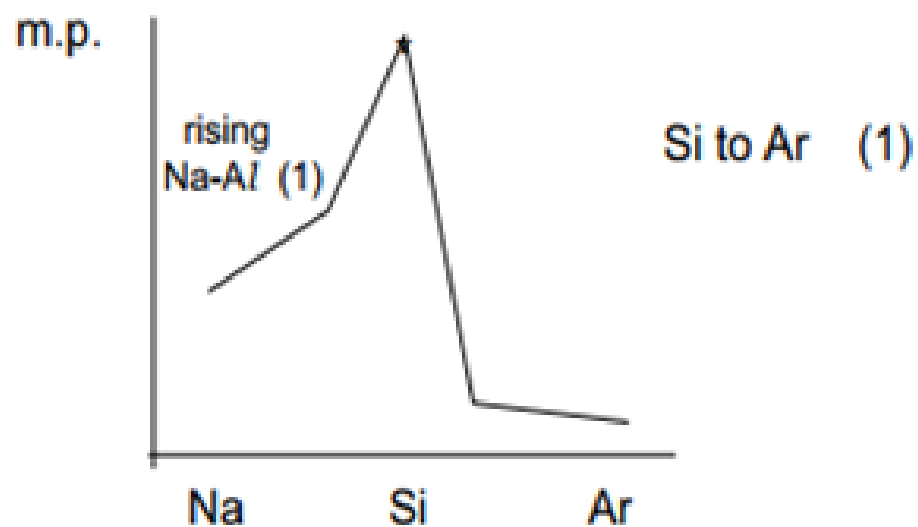


	Patterns	Nuclear Charge	Distance	Shielding	Overall effect
1	Increase across period	Increase	Constant	Constant	Increase across period
2	Last element in period To first element in next period Decrease	Increase	Increase	Increase	Shielding and distance outweigh increased nuclear charge
3	Be \rightarrow B Decrease	Increase	Increase	Increase	Shielding and distance outweigh increased nuclear charge
4	Down a group Decrease	Increase	Increase	Increase	Shielding and distance outweigh increased nuclear charge
5	N \rightarrow O Decrease				Spin pair repulsion

- 4 (a) The use of the *Data Booklet* is relevant to this question. Complete these sketches for elements of the third period (sodium to argon) to show how each property changes along the period.

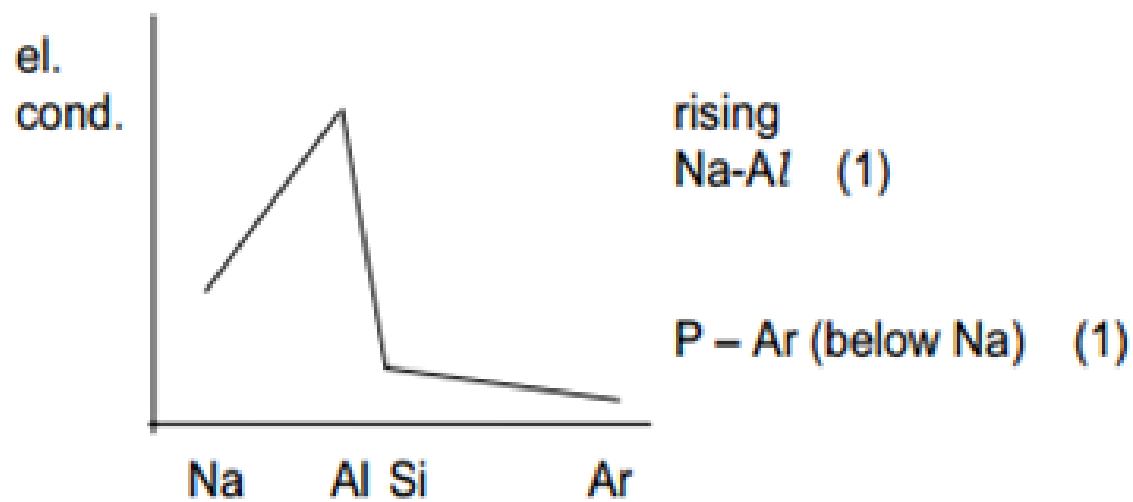


4 (a) (i)



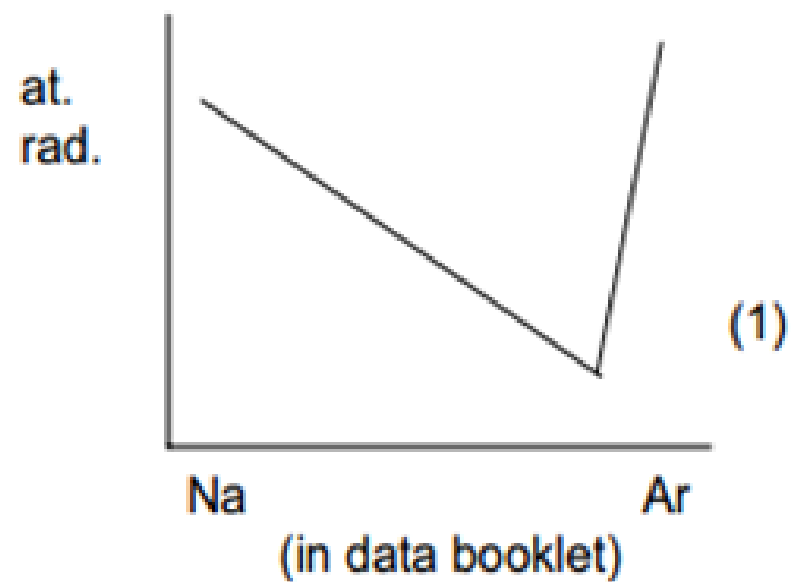
[2]

(ii)



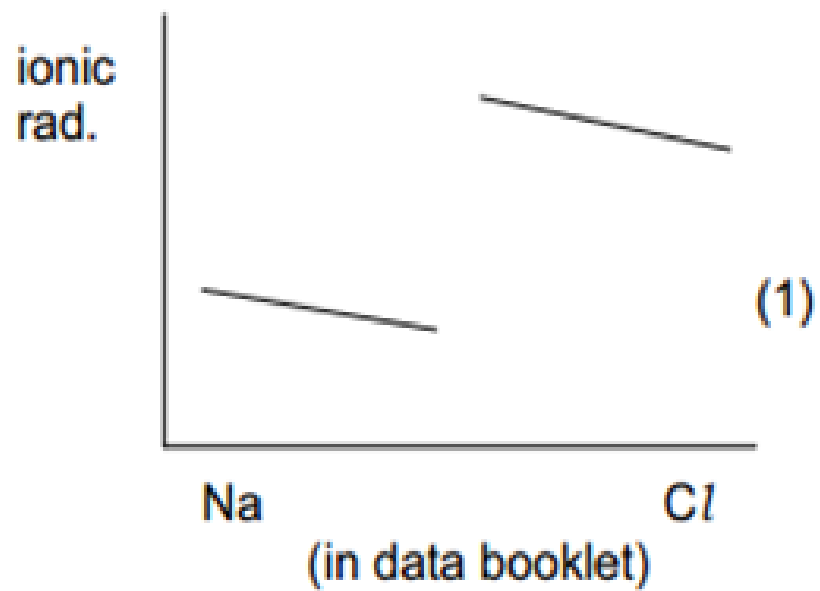
[2]

(iii)



[1]

(iv)



[1]

[6]

(b) (i) In the boxes below, write the formulae of **one** of the oxides of each of these five elements.

sodium	magnesium	aluminium	phosphorus	sulphur

(ii) Write an equation for sodium oxide reacting with water.

.....

(iii) Write an equation for your chosen oxide of sulphur reacting with an alkali.

.....[3]

[Total : 9]

(c) (i) Na_2O MgO Al_2O_3 P_2O_5 (or P_4O_{10} or P_2O_3) SO_2 or SO_3 (1)

(ii) $\text{Na}_2\text{O} + \text{H}_2\text{O} \rightarrow 2\text{NaOH}$ (1)

(iii) $2\text{NaOH} + \text{SO}_2 \rightarrow \text{Na}_2\text{SO}_3 + \text{H}_2\text{O}$ (1) or NaHSO_3

OR $2\text{NaOH} + \text{SO}_3 \rightarrow \text{Na}_2\text{SO}_4 + \text{H}_2\text{O}$ (1) NaHSO_4 [3]

[Total: 9]

4 What is the order of increasing energy of the listed orbitals in the atom of titanium?

A 3s 3p 3d 4s

B 3s 3p 4s 3d

C 3s 4s 3p 3d

D 4s 3s 3p 3d

5 Which of the following particles would, on losing an electron, have a half-filled set of p orbitals?

A C^-

B N

C N^-

D O^+

6 Magnesium oxide is used to line industrial furnaces because it has a very high melting point.

Which type of bond needs to be broken for magnesium oxide to melt?

A co-ordinate

B covalent

C ionic

D metallic

7 Which solid exhibits more than one kind of chemical bonding?

A brass

B copper

C diamond

D ice

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

No other combination of statements is used as a correct response.

34 Which pairs of compounds contain one that is giant ionic and one that is simple molecular?

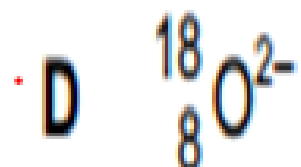
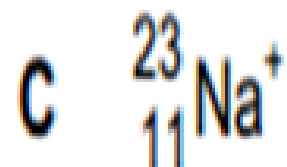
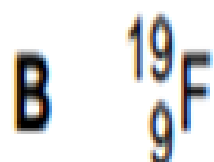
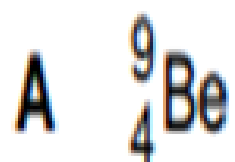
- 1 Al_2O_3 and Al_2Cl_6
- 2 SiO_2 and $SiCl_4$
- 3 P_4O_{10} and PCl_3

3 The first six ionisation energies of four elements, **A** to **D**, are given.

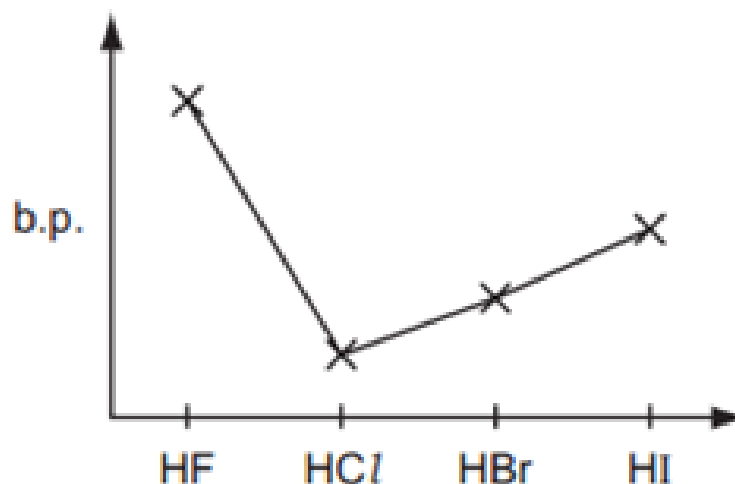
Which element is most likely to be in Group IV of the Periodic Table?

ionisation energy / kJ mol^{-1}	1st	2nd	3rd	4th	5th	6th
A	494	4560	6940	9540	13400	16600
B	736	1450	7740	10500	13600	18000
C	1090	2350	4610	6220	37800	47000
D	1400	2860	4590	7480	9400	53200

4 In which species are the numbers of electrons and neutrons equal?



5 The diagram shows the variation of the boiling points of the hydrogen halides.



What explains the higher boiling point of hydrogen fluoride?

- A The bond energy of HF molecules is greater than in other hydrogen halides.
- B The effect of nuclear shielding is much reduced in fluorine which polarises the HF molecule.
- C The electronegativity of fluorine is much higher than for other elements in the group.
- D There is hydrogen bonding between HF molecules.

6 Three substances, *R*, *S*, *T*, have physical properties as shown.

substance	mp / °C	bp / °C	electrical conductivity	
			of solid	of liquid
<i>R</i>	801	1413	poor	good
<i>S</i>	2852	3600	poor	good
<i>T</i>	3550	4827	good	not known

What could be the identities of *R*, *S* and *T* ?

	<i>R</i>	<i>S</i>	<i>T</i>
A	NaF	KCl	Cu
B	NaBr	BaO	SiO ₂
C	NaCl	MgO	C [graphite]
D	NaBr	CaO	C [diamond]

12 The following species contain the same number of electrons.

In which order do their radii increase?

	smallest radius	—————→	largest radius
A	Ar		Ca ²⁺
B	Ca ²⁺		K ⁺
C	Ca ²⁺		Ar
D	K ⁺		Ca ²⁺

13 *Use of the Data Booklet is relevant to this question.*

Which element is likely to have an electronegativity similar to that of aluminium?

- A** barium
- B** beryllium
- C** magnesium
- D** strontium

14 Use of the Data Booklet is relevant to this question.

Which is true for calcium or its compounds compared with the corresponding statements for magnesium?

- A Calcium has a smaller atomic radius.
- B Calcium oxide reacts less vigorously with water.
- C Calcium reacts more vigorously with water.
- D The sum of the first two ionisation energies of calcium is greater.

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

No other combination of statements is used as a correct response.

36 The number of moles of chlorine that react with 1 mol of *X* is twice the number of moles of chlorine that react with 1 mol of *Y*.

Which of these pairs could be *X* and *Y*?

	<i>X</i>	<i>Y</i>
1	Mg(s)	Na(s)
2	H ₂	KBr(aq)
3	cold NaOH(aq)	hot NaOH(aq)

- 3 Gallium nitride, GaN, could revolutionise the design of electric light bulbs because only a small length used as a filament gives excellent light at low cost.

Gallium nitride is an ionic compound containing the Ga^{3+} ion.

What is the electron arrangement of the nitrogen ion in gallium nitride?

- A $1s^2 2s^2$
- B $1s^2 2s^2 2p^3$
- C $1s^2 2s^2 2p^4$
- D $1s^2 2s^2 2p^6$

5 In which process are hydrogen bonds broken?



13 In which pair is the radius of the second atom greater than that of the first atom?

A Na, Mg

B Sr, Ca

C P, N

D Cl, Br

14 The oxide and chloride of an element **X** are separately mixed with water. The two resulting solutions have the same effect on litmus.

What is element **X**?

A sodium

B magnesium

C aluminium

D phosphorus

17 What happens when chlorine is bubbled through aqueous potassium iodide?

- A** Chlorine is oxidised to chloride ions.
- B** Hydrochloric acid is formed.
- C** Iodide ions are oxidised to iodine.
- D** Potassium iodide is reduced to iodine.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

No other combination of statements is used as a correct response.

- 31 The Group IV elements carbon, silicon and germanium all exist in a diamond structure. The bond lengths in these structures are given below.

element <i>X</i>	C	Si	Ge
bond length <i>X</i> – <i>X</i> /nm	0.154	0.234	0.244

Why does the bond length increase down the group?

- 1 Orbital overlap decreases down the group.
- 2 Atomic radius increases down the group.
- 3 Nuclear charge increases down the group.

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

32 Sodium ions can be formed from sodium atoms.



Which quantities are required to calculate the enthalpy change of formation of gaseous sodium ions?

- 1 enthalpy change of atomisation of sodium
- 2 first ionisation energy of sodium
- 3 enthalpy change of formation of sodium

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

34 Compound X

- does not conduct electricity when in a liquid state,
- when added to water produces a solution that readily conducts electricity.

What could X be?

- 1 MgCl_2
- 2 SiCl_4
- 3 PCl_3

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

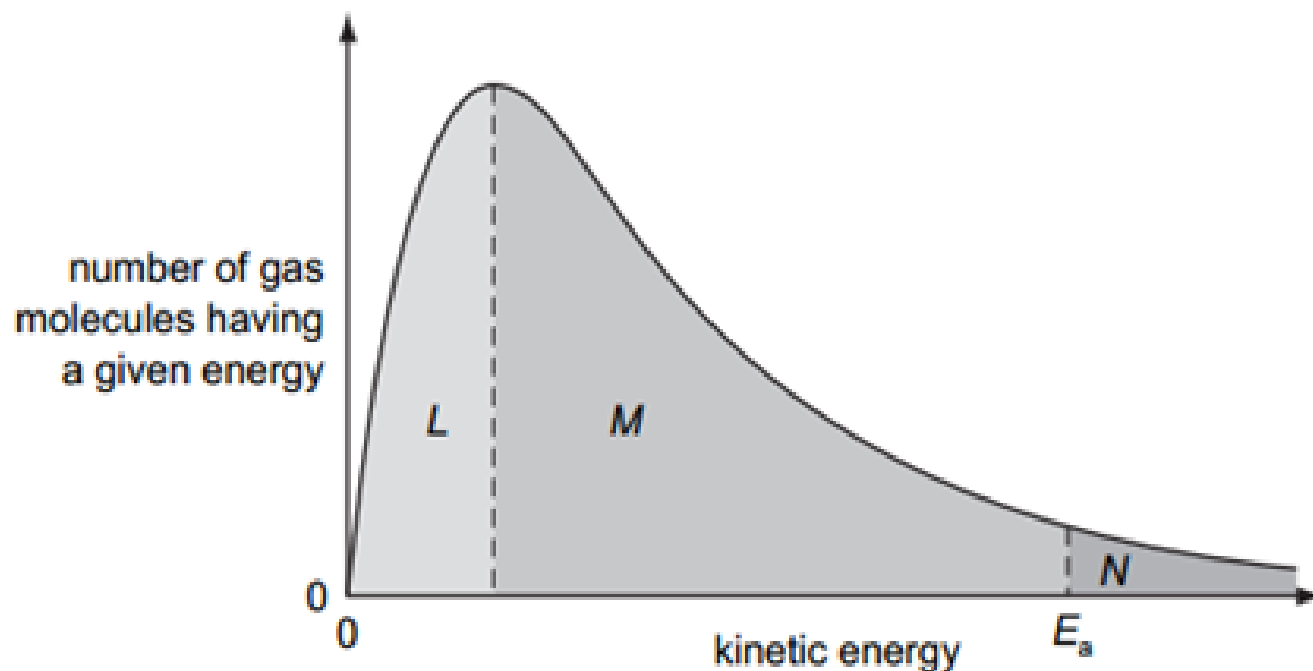
35 Hydroxyapatite, a basic calcium phosphate, $\text{Ca}(\text{OH})_2 \cdot 3\text{Ca}_3(\text{PO}_4)_2$, is the mineral found in bone.

In older people, calcium ions can be lost from the hydroxyapatite, weakening the bone structure. In such cases, strontium salts are administered to strengthen the bone. The strontium ions replace the lost calcium ions in the hydroxyapatite.

Which statements are correct?

- 1 Strontium ions are nearly the same size as calcium ions and so may easily replace them in the hydroxyapatite.
- 2 Strontium hydroxide is less soluble than calcium hydroxide and so will precipitate better in the bone structure.
- 3 There is ionic, covalent and metallic bonding in hydroxyapatite which gives it strength.

- 10 The Boltzmann distribution shows the number of molecules having a particular kinetic energy at constant temperature.



If the temperature is decreased by 10°C , what happens to the size of the areas labelled *L*, *M* and *N*?

	<i>L</i>	<i>M</i>	<i>N</i>
A	decreases	decreases	decreases
B	decreases	increases	decreases
C	increases	decreases	decreases
D	increases	decreases	increases

12 Which chlorine compound has bonding that can be described as ionic with some covalent character?

A NaCl

B MgCl₂

C AlCl₃

D SiCl₄

14 Slaked lime, Ca(OH)_2 , may be made from limestone, CaCO_3 .

On heating in a lime kiln at 1000°C , limestone decomposes as follows.



Water is then reacted with calcium oxide, CaO , as follows.



What are the enthalpy changes of these reactions?

	reaction 1	reaction 2
A	endothermic	endothermic
B	endothermic	exothermic
C	exothermic	endothermic
D	exothermic	exothermic

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

32 Which of the following solids contain more than one type of chemical bond?

- 1 brass (an alloy of copper and zinc)
- 2 graphite
- 3 ice

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

35 Which statements concerning the third period elements (sodium to argon) and their compounds are correct?

- 1 The elements become more electronegative from sodium to chlorine.
- 2 Aluminium oxide is the only oxide which is insoluble in water.
- 3 The maximum oxidation state is shown by silicon.

3 This question is about the elements in Group II of the Periodic Table, magnesium to barium.

(a) Complete the table below to show the electronic configuration of calcium atoms and of strontium ions, Sr^{2+} .

	1s	2s	2p	3s	3p	3d	4s	4p	4d
Ca	2	2	6						
Sr^{2+}	2	2	6						

[2]

(b) Explain the following observations.

(i) The atomic radii of Group II elements increase down the Group.

.....
.....

(ii) The strontium ion is smaller than the strontium atom.

.....
.....

(iii) The first ionisation energies of the elements of Group II decrease with increasing proton number.

.....

.....

.....

.....

[4]

3 (a)

	1s	2s	2p	3s	3p	3d	4s	4p	4d
Ca	2	2	6	2	6	0	2	0	0
Sr ²⁺	2	2	6	2	6	10	2	6	

[1]

[1]

[2]

(b) (i) more shells of electrons

[1]

(ii) outermost shell has been removed

[1]

(iii) outermost electrons are further from nucleus/there are more shells
increased shielding

[1]

[1] [4]

(c) Samples of magnesium and calcium are placed separately in cold water and left for some time. In **each case**, describe what you would see and write a balanced equation for each reaction.

(i) magnesium

observation

.....

equation

(ii) calcium

observation

.....

equation

[6]

- (c) (i) very slow reaction [1]
formation of bubbles of gas [1]



- (ii) faster reaction than with Mg [1]

white suspension formed

or evolution of gas

or calcium dissolves/disappears [1]



allow 1 mark in (i) or (ii) if gas is described as colourless [1] [7]

(d) Strontium nitrate, $\text{Sr}(\text{NO}_3)_2$ undergoes thermal decomposition.

(i) State one observation you would make during this reaction.

.....
.....

(ii) Write a balanced equation for this reaction.

.....
[4]

[Total: 16]

- (d) (i) gas evolved [1]
gas is brown [1]
- (ii) $2\text{Sr}(\text{NO}_3)_2 \rightarrow 2\text{SrO} + 4\text{NO}_2 + \text{O}_2$
correct products [1]
balanced equation [1] [4]

[Total: 17 max. 16]

