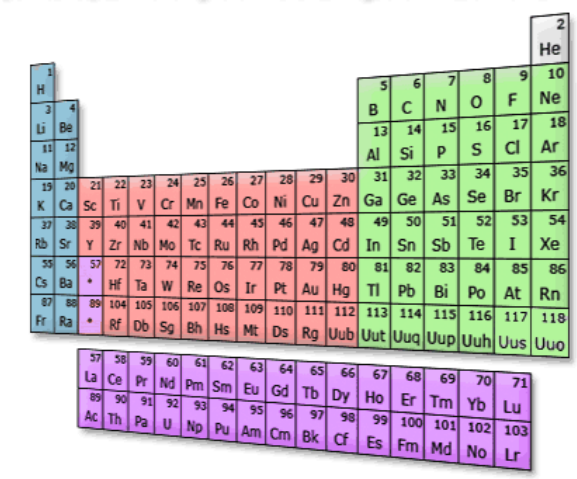
Higher Chemistry

Unit 1 Past Paper Questions



Unit 1 – Chemical Changes and Structure

SECTION 1

1. Which type of bonding is **never** found in elements?

   A Metallic
   B London dispersion forces
   C Polar covalent
   D Non-polar covalent

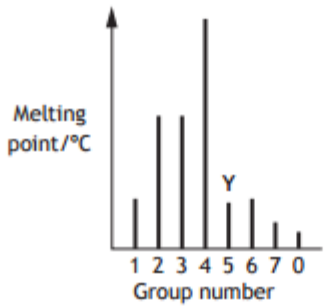
2. In which of the following molecules will the chlorine atom carry a partial positive charge ($\delta+$)?

   A Cl—Br
   B Cl—Cl
   C Cl—F
   D Cl—I

3. Which of the following is **not** an example of a Van der Waals' force?

   A Covalent bonding
   B Hydrogen bonding
   C London dispersion forces
   D Permanent dipole-permanent dipole interactions

4. The diagram shows the melting points of successive elements across a period in the Periodic Table.



Which of the following is a correct reason for the low melting point of element Y?

A It has weak ionic bonds
B It has weak covalent bonds
C It has weakly-held outer electrons
D It has weak forces between molecules

5.

The elements nitrogen, oxygen, fluorine and neon

A can form negative ions
B are made up of diatomic molecules
C have single bonds between the atoms
D are gases at room temperature.

6.

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

A $F^-(g) \rightarrow F(g) + e^-$

B $F^-(g) \rightarrow \frac{1}{2}F_2(g) + e^-$

C $F(g) \rightarrow F^+(g) + e^-$

D $\frac{1}{2}F_2(g) \rightarrow F^+(g) + e^-$

7.

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

A Carbon
B Nitrogen
C Phosphorus
D Silicon

8.

Which of the following is **not** an example of a van der Waals' force?

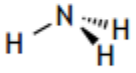
A Covalent bond
B Hydrogen bond
C London dispersion force
D Permanent dipole - permanent dipole attraction

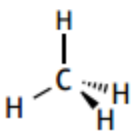
9.

Which of the following has more than one type of van der Waals' force operating between its molecules in the liquid state?

. A Br—Br

B O=C=O

C 

D 

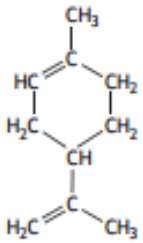
10.

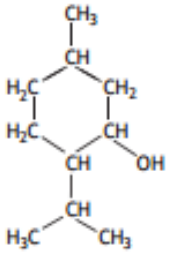
Which of the following bonds is the **least** polar?

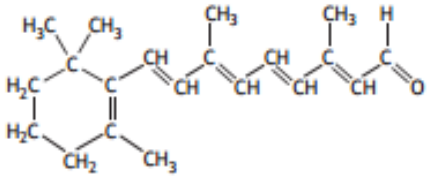
A C — I
B C — F
C C — Cl
D C — Br

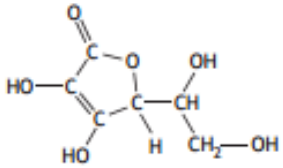
11.

Which of the following compounds would be the **most water** soluble?

A 

B 

C 

D 

12.

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

A Sulfur
B Silicon
C Nitrogen
D Hydrogen

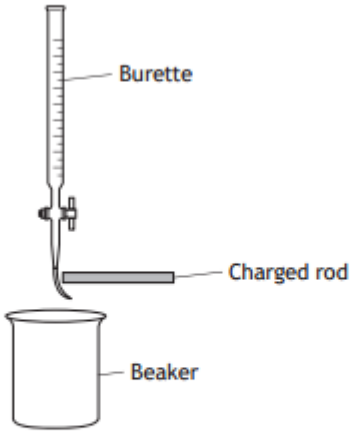
13.

Which type of structure is found in phosphorus?

A Covalent network
B Covalent molecular
C Monatomic
D Metallic lattice

14.

The polarity of molecules can be investigated using a charged rod. The charged rod will attract a stream of polar liquid flowing from a burette.



Which of the following liquids would **not** be attracted?

A Water
B Propanone
C Propanol
D Hexane

15.

$xP_2H_4 + yO_2 \rightarrow P_4O_{10} + zH_2O$

The equation is balanced when

A $x = 1, y = 5, z = 4$
B $x = 4, y = 6, z = 2$
C $x = 2, y = 7, z = 4$
D $x = 2, y = 5, z = 2$

16.

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

Ionisation energy (kJ mol^{-1})		
First	*Second*	*Third*
578	1817	2745

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

$$Al^{+}(g) \rightarrow Al^{3+}(g) + 2e^{-}$$

A 1817
B 2395
C 4562
D 5140

17.

An element contains covalent bonding and London dispersion forces.
The element could be

A boron
B neon
C sodium
D sulfur.

18.

In which of the following molecules will the chlorine atom carry a partial positive charge ($\delta+$)?

A Cl–Br
B Cl–Cl
C Cl–F
D Cl–I

19. Which of the following does **not** contain covalent bonds?

A Hydrogen gas
B Helium gas
C Nitrogen gas
D Solid sulphur

20. Which of the following structures is **never** found in compounds?

A Ionic
B Monatomic
C Covalent network
D Covalent molecular

21

Atoms of nitrogen and element **X** form a bond in which the electrons are shared equally.

Element **X** could be

A carbon

B oxygen

C chlorine

D phosphorus.

22

A positively charged particle with electron arrangement 2, 8 could be

A a neon atom

B a fluoride ion

C a sodium atom

D an aluminium ion.

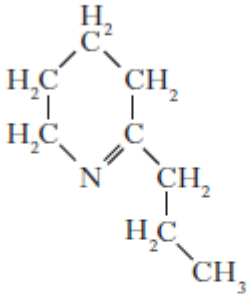
23

Which line in the table represents the solid in which only London dispersion forces are overcome when the substance melts?

	Melting point/°C	**Electrical conduction of solid**
A	714	non-conductor
B	98	conductor
C	660	conductor
D	44	non-conductor

24.

Coniceine is a deadly poison extracted from the plant hemlock.



coniceine

Which of the following would be the best solvent for coniceine?

A Propanoic acid

B Propan-1-ol

C Heptane

D Water

25.

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

A Lithium

B Chlorine

C Sodium

D Bromine

26. Which of the following elements exists as discrete molecules?

A Boron

B Carbon (diamond)

C Silicon

D Sulfur

27 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.

28.

Which type of bonding is **never** found in elements?

A Metallic

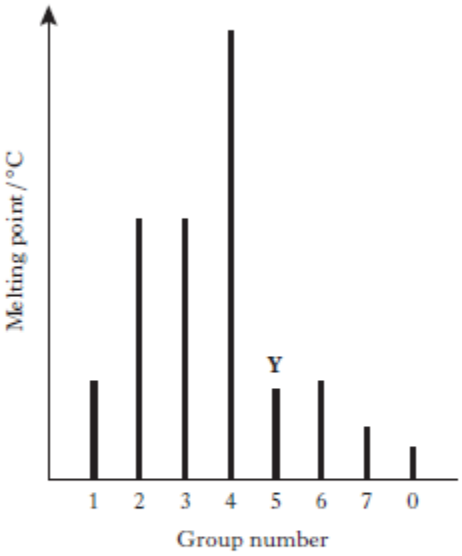
B London dispersion forces

C Polar covalent

D Non-polar covalent

29.

The diagram shows the melting points of successive elements across a period in the Periodic Table.



Which of the following is a correct reason for the low melting point of element **Y**?

A It has weak ionic bonds.

B It has weak covalent bonds.

C It has weakly-held outer electrons.

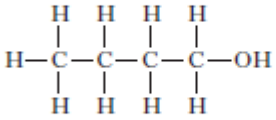
D It has weak forces between molecules.

30.

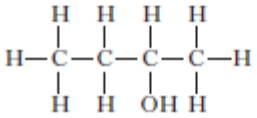
The structures for molecules of four liquids are shown below.

Which liquid will be the most viscous?

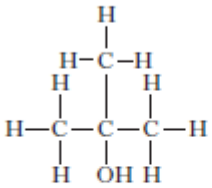
A



B



C



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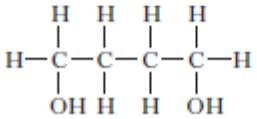
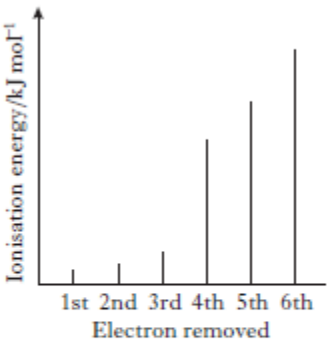


31.

The spike graph shows the variation in successive ionisation energies of an element, **Z**.



In which group of the Periodic Table is element **Z**?

A 1

B 3

C 4

D 6

32.

For elements in Group 7 of the Periodic Table, which of the following statements is true as the group is descended?

A The boiling point decreases.

B The covalent radius decreases.

C The electronegativity decreases.

D The strength of London dispersion forces decreases.

33.

Which of the following chlorides is likely to have **least** ionic character?

A $BeCl_2$

B $CaCl_2$

C LiCl

D CsCl

34.

Which of the following elements would have the strongest London dispersion forces?

A Argon

B Chlorine

C Nitrogen

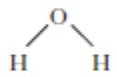
D Oxygen

35.

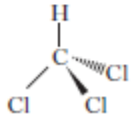
The shapes of some common molecules are shown below and each contains at least one polar bond.

Which molecule is non-polar?

A O=C=O

B 

C H—Cl

D 

36.

Diamond has

A an ionic lattice structure

B a covalent network structure

C covalent molecules linked by London dispersion forces

D covalent sheets with only London dispersion forces acting between sheets.

37. Which of the following elements would require the most energy to convert one mole of gaseous atoms into gaseous ions each carrying two positive charges?
(You may wish to use the data booklet.)

A Scandium

B Titanium

C Vanadium

D Chromium

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

A Caesium

B Oxygen

C Fluorine

D Iodine

39.

Which of the following chlorides is likely to have the most ionic character?

A LiCl

B CsCl

C $BeCl_2$

D $CaCl_2$

40. Which of the following is **not** an example of a Van der Waals' force?

A Covalent bonding

B Hydrogen bonding

C London dispersion forces

D Permanent dipole-permanent dipole interactions

41.

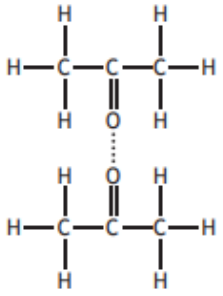
Hydrogen will form a non-polar covalent bond with an element that has an electronegativity value of

A 0·9
B 1·5
C 2·2
D 2·5.

42. Which of the following is a polar molecule?

A CCl_4
B NH_3
C CO_2
D CH_4

43. In which of the following diagrams does the dotted line represent a permanent dipole-permanent dipole interaction between propanone molecules?

A


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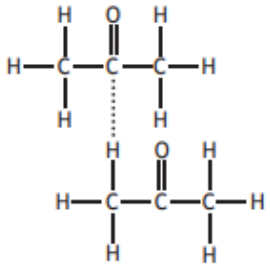

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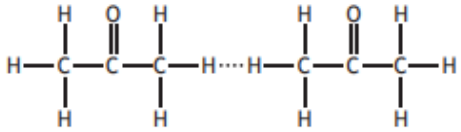

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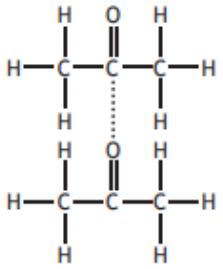
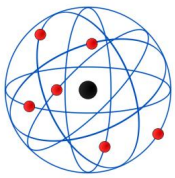


Unit 1 – Chemical Changes and Structure



Section 2

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

   (a) (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**

2. If the viscosity of a fuel is not within a certain range then it can result in damage to the fuel pump and engine.

   A student was asked to design an experiment to compare the viscosity of some fuels. Suggest an experiment that could be done to compare viscosities.

   (You may wish to use a diagram to help with your description.) **2**

3. Volcanoes produce a variety of molten substances, including sulfur and silicon dioxide.

   (a) Complete the table to show the strongest type of attraction that is broken when each substance melts.

Substance	*Melting point* (°C)	*Strongest type of attraction broken when substance melts*
sulfur	113	
silicon dioxide	1610	

2

   (b) Volcanic sulfur can be put to a variety of uses. One such use involves reacting sulfur with phosphorus to make a compound with formula P_4S_3.

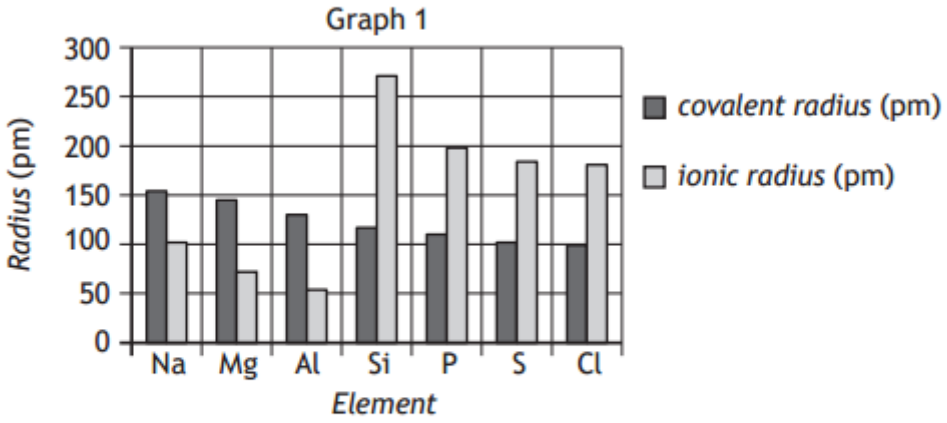
   (i) Draw a possible structure for P_4S_3. **1**

   (ii) Explain why the covalent radius of sulfur is smaller than that of phosphorus. **1**

(iii) The melting point of sulfur is much higher than that of phosphorus.

Explain fully, in terms of the structures of sulfur and phosphorus molecules and the intermolecular forces between molecules of each element, why the melting point of sulfur is much higher than that of phosphorus. **3**

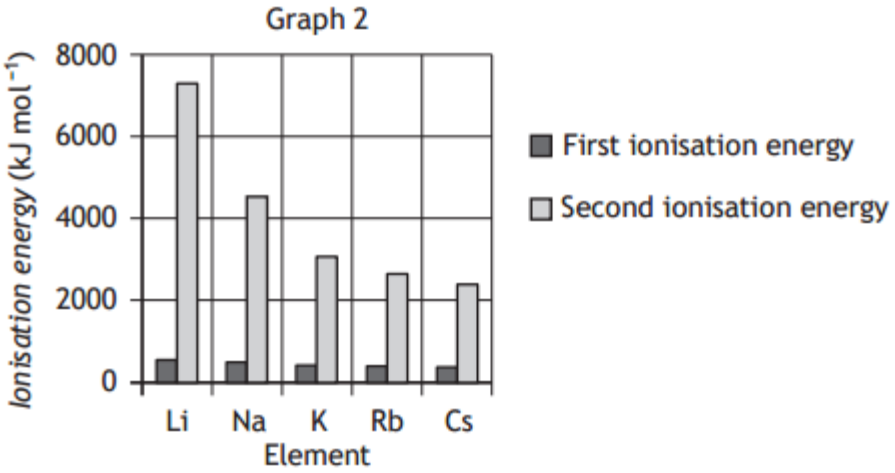
4. (a) Graph 1 shows the sizes of atoms and ions for elements in the third period of the Periodic Table.



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**

(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**

5. (ii) Explain **fully** why the second ionisation energy is much greater

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

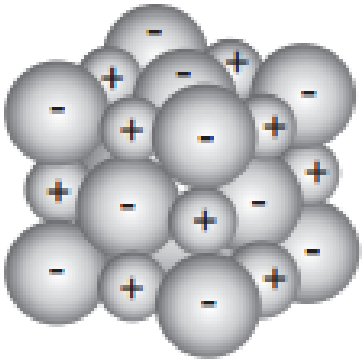


Table 1 shows the size of selected ions.

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**

6. Phosphine (PH_3) is used as an insecticide in the storage of grain.

Phosphine can be produced by the reaction of water with aluminium phosphide

$$AlP(s) + 3H_2O(\ell) \longrightarrow PH_3(g) + Al(OH)_3(aq)$$

(a) State the type of bonding and structure in phosphine. **1**

(b) Carbon dioxide is fed into the phosphine generator to keep the phosphine concentration less than 2·6%. Above this level phosphine can ignite due to the presence of diphosphane, $P_2H_4(g)$, as an impurity.

Draw a structural formula for diphosphane. **1**

7.

The viscosity of alcohols depends on a number of factors:

- the strength of intermolecular forces
- the size of the molecule
- temperature

These factors can be investigated using alcohols and apparatus from the lists below.

Alcohols	***Apparatus***
methanol	beakers
ethanol	funnels
propan-1-ol	burettes
ethan-1,2-diol	measuring cylinders
butan-1-ol	plastic syringes
propan-1,3-diol	glass tubing
pentan-1-ol	stoppers
propan-1,2,3-triol	timer
	metre stick
	ball bearing
	clamp stands
	kettle
	thermometer

Using your knowledge of chemistry, identify the alcohols and apparatus that you would select and describe how these could be used to investigate one, or more, of the factors affecting the viscosity of alcohols.

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

Na	Mg	Al	Si	P	S	Cl	Ar

(a) Name the element from the third period that exists as a covalent network. **1**

(b) 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.

Ionisation energies (kJ mol^{-1})			
First	Second	Third	Fourth
578	1817	2745	11 577

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

(c) The boiling point of chlorine is much higher than that of argon.

Explain **fully**, in terms of structure and the type of van der Waals forces present, why the boiling point of chlorine is higher than that of argon. **3**

9.

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**

p the
ıe can

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

1

(b) Explain **fully** why the boiling points of the halogens increase going down group 7.

In your answer you should name the intermolecular forces involved. **3**

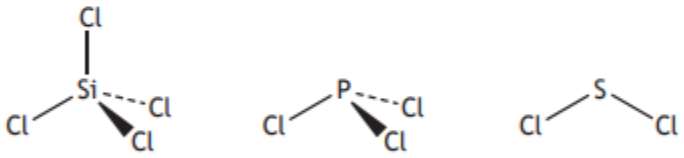
10

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

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

(b) Elements in the third period of the periodic table form chlorides.

The structures of three of these chlorides are shown.



(i) Circle the structure of the molecule above that contains **bonds** with the lowest polarity. **1**

(An additional diagram, if required, can be found on *page 37*).

(ii) Explain **fully** why, of these three chlorides, silicon tetrachloride is the most soluble in hexane. **2**

(c) Silicon tetrachloride can be used to make silicon nitride (Si_3N_4), a compound found in many cutting tools.

(i) Silicon nitride has a melting point of 1900 °C and does not conduct electricity when molten.

Explain **fully**, in terms of structure and bonding, why silicon nitride has a high melting point. **2**

11

The Periodic Table allows chemists to make predictions about the properties of elements.

(*a*) The elements lithium to neon make up the second period of the Periodic Table.

Li	Be	B	C	N	O	F	Ne

(i) Name an element from the second period that exists as a covalent network.

1

(ii) Why do the atoms decrease in size from lithium to neon?

1

(iii) Which element in the second period is the strongest reducing agent?

1

(*b*) On descending Group 1 from lithium to caesium, the electronegativity of the elements decreases.

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

12.

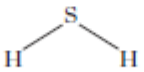
Compounds containing sulfur occur widely in nature.

(*a*) The compound dimethyldisulfide, $CH_3S_2CH_3$, is present in garlic and onions.

Draw a full structural formula for this compound.

1

(*b*) Liquid hydrogen sulfide has a boiling point of −60 °C.



Name the strongest type of intermolecular force present in liquid hydrogen sulfide and state how this force arises.

13.

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.

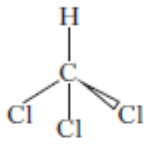
1

(ii) **Explain clearly** why the first ionisation energy of potassium is smaller than that of chlorine.

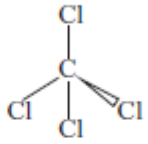
3

14.

The structures below show molecules that contain chlorine atoms.



trichloromethane



tetrachloromethane

(*a*) The compounds shown above are not very soluble in water. Trichloromethane is around ten times more soluble in water than tetrachloromethane.

Explain clearly why trichloromethane is more soluble in water than tetrachloromethane.

Your answer should include the names of the intermolecular forces involved.

3

15.

Information about four elements from the third period of the Periodic Table is shown in the table.

Element	aluminium	silicon	phosphorus	sulfur
Bonding		covalent		covalent
Structure	lattice		molecular	

(*a*) Complete the table to show the bonding and structure for each element. **2**

(*b*) Why is there a decrease in the size of atoms across the period from aluminium to sulfur?

1

(*c*) Argon is also in the third period. Argon is a very useful gas and each year 750 000 tonnes of argon are extracted from liquid air.

(i) Suggest how argon could be extracted from liquid air.

1

16.

(*b*) The boiling point of hydrogen fluoride, HF, is much higher than the boiling point of F_2.

H — F	F — F
boiling point: 19·5 °C	boiling point: −188 °C

Explain fully why the boiling point of hydrogen fluoride is much higher than the boiling point of fluorine.

In your answer you should mention the intermolecular forces involved and how they arise.

3

17

(*a*) Complete the table below by adding the name of an element for each of the types of bonding and structure described.

Bonding and structure at room temperature and pressure	**Name of element**
metallic solid	sodium
monatomic gas	
covalent network solid	
discrete covalent molecular gas	
discrete covalent molecular solid	

2

(*b*) Many patterns in the physical and chemical properties of elements are observed.

Why does the electronegativity of elements increase across the second row of the Periodic Table from lithium to fluorine?

1

18.

The table below contains information about some diatomic molecules.

	H–H	H–Cl	Cl–Cl	I–Cl	Br–Br
Boiling point / °C	–253	–85	–35	97	59
Bond enthalpy / kJ mol^{-1}	432	428	243	211	194

(*a*) Boiling points can be used to show the effect of intermolecular forces.

Explain why a comparison of the boiling points of ICl and Br_2 provides good evidence about the strength of permanent dipole-permanent dipole interactions.

3

(*b*) In the table above, which of the diatomic molecules listed has the strongest covalent bond?

1

19

The melting and boiling points and electrical conductivities of four substances are given in the table.

Substance	Melting point / °C	Boiling point / °C	Solid conducts electricity?	Melt conducts electricity?
A	92	190	no	no
B	1050	2500	yes	yes
C	773	1407	no	yes
D	1883	2503	no	no

Complete the table below by adding the appropriate letter for each type of bonding and structure.

Substance	Bonding and structure at room temperature
	covalent molecular
	covalent network
	ionic
	metallic

(3)

20.

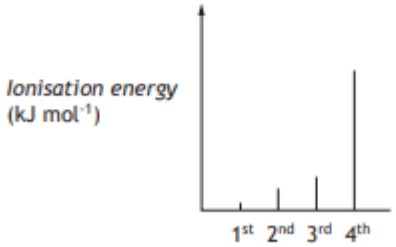
Sodium is the first element in the third period of the periodic table.

Na	Mg	Al	Si	P	S	Cl	Ar

(a) Describe the trend in electronegativity values across this period from Na to Cl. **1**

(b) Name the element in the third period that has a covalent network structure. **1**

(c) 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**

21.

Hydrogen cyanide is highly toxic. Molecules of hydrogen cyanide and molecules of nitrogen gas both have 14 electrons.

(a)

	Structure	*Boiling point* (°C)
Hydrogen cyanide	H—C≡N	27
Nitrogen	N≡N	−196

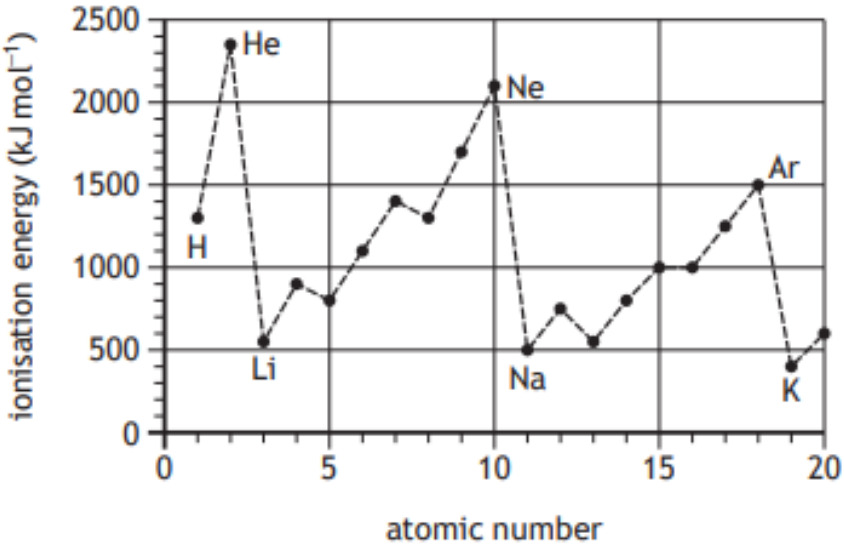
Explain why the boiling point of hydrogen cyanide is much higher than the boiling point of nitrogen.

In your answer you should mention the intermolecular forces involved and how they arise. **3**

22.

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.

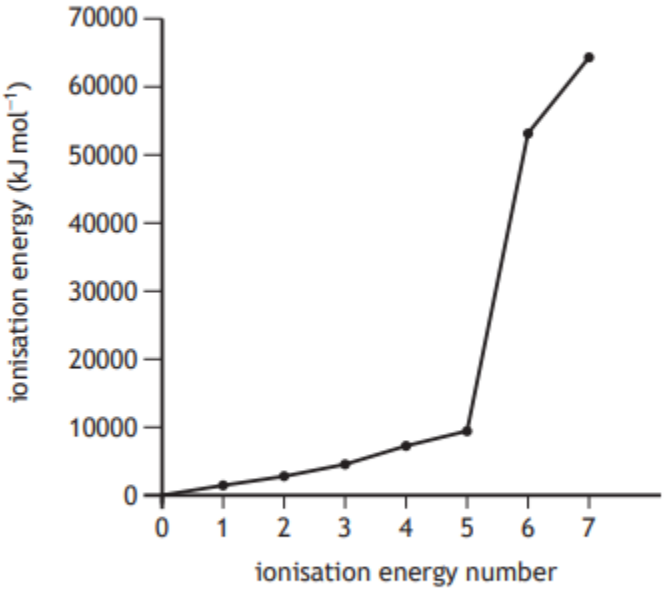


(i) Explain why the first ionisation energy shows an increase going from lithium to neon. **1**

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

(continued)

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



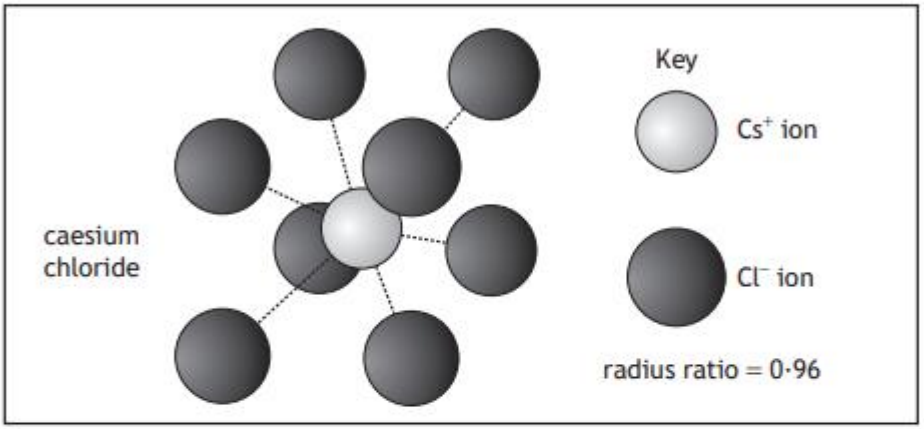
(i) Write the equation for the second ionisation energy of nitrogen. **1**

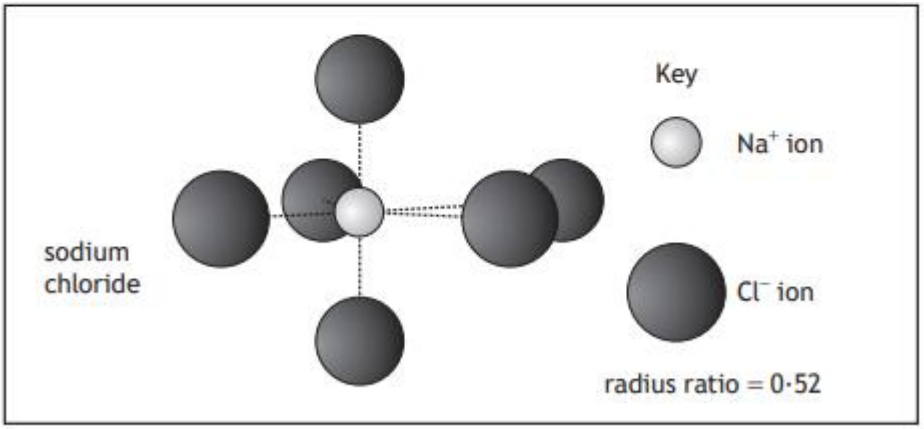
(ii) Explain **fully** the increase between the 5th and 6th ionisation energies of nitrogen. **2**

(continued)

(d) The structure of an ionic compound consists of a giant lattice of oppositely charged ions. The arrangement of ions is determined by the 'radius ratio' of the ions involved.

$$\text{radius ratio} = \frac{\text{radius of positive ion}}{\text{radius of negative ion}}$$





By using the table of ionic radii on *page 17* of the data booklet, predict whether the structure of barium oxide, BaO, is similar to caesium chloride or sodium chloride.

Your answer **must** include a calculated radius ratio. **1**

23.

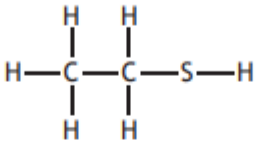
The melting point of **non-metal elements** depends on structure and bonding.

Using your knowledge of chemistry, comment on this statement. **3**

24.

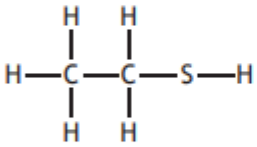
Thiols are compounds that contain an –SH functional group. They often have very strong, unpleasant odours.

(a) Ethanethiol is used to add a smell to gaseous fuels in order to give warnings of gas leaks.

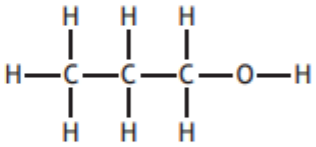


ethanethiol

(i) A student used the boiling points of ethanethiol and propan-1-ol to compare the strength of intermolecular forces.



ethanethiol
boiling point = 35 °C



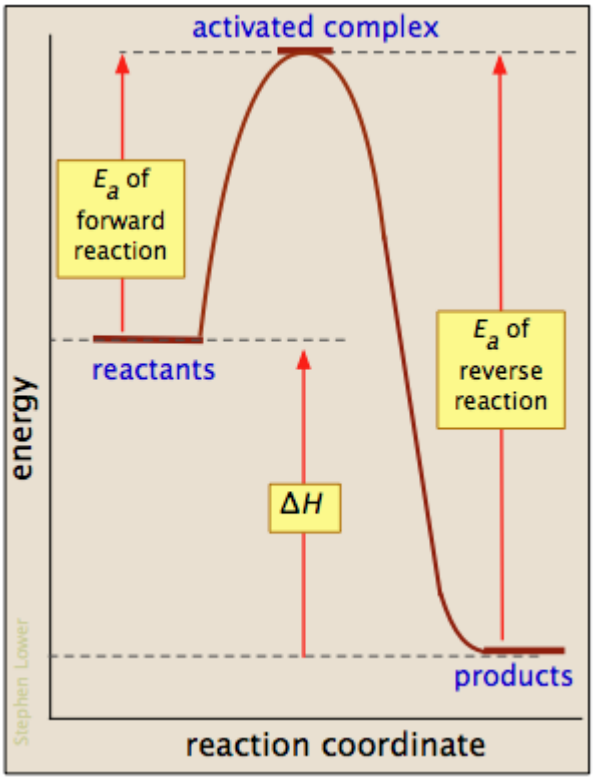
propan-1-ol
boiling point = 97 °C

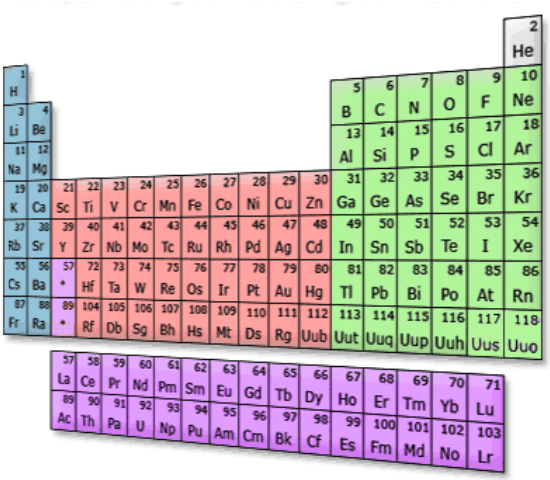
(A) State the reason why propan-1-ol was a suitable alcohol to compare with ethanethiol. **1**

(B) Explain why propan-1-ol has a higher boiling point than ethanethiol. Your answer should include the names of the intermolecular forces broken when each liquid boils. **2**

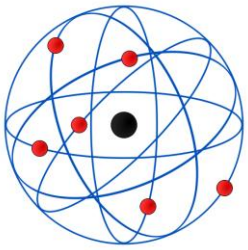
Higher Chemistry

Unit 1 Past Paper Answers



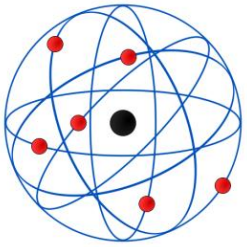


Section 1 Answers



1	C	11	D	21	C	31	B	41	C
2	C	12	C	22	D	32	C	42	B
3	A	13	B	23	D	33	A	43	D
4	D	14	D	24	C	34	B		
5	D	15	C	25	B	35	A		
6	C	16	C	26	D	36	B		
7	D	17	D	27	C	37	D		
8	A	18	C	28	C	38	C		
9	C	19	B	29	D	39	B		
10	A	20	B	30	D	40	A		

Section 2 Answers

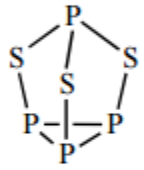


Question			Expected response	Max mark	Additional Guidance
1	a	i	$Na(g) \rightarrow Na^+(g) + e^-$	1	No necessity to show negative charge on e
1	a	ii	Idea that ionisation energy is removal of an electron (1 mark) Idea that 1st ionisation energy is removal of electron from 3rd (outermost) shell and second is removal of electron from an inner shell. (1 mark) Idea of shielding effect of inner electrons ie that second electron is less well shielded from nuclear pull and therefore more energy is needed to remove electron. or The removal from a full shell requires more energy than removal from an incomplete shell. (1 mark)	3	
1	b		0·178 g (0·18 g)	1	

2.

	d		1 mark for design of experiment. Eg inverting sealed tubes and measuring time taken for an air bubble to rise through the tube or dropping a ballbearing into the fuels and timing how long they take to drop or any other reasonable experiment. 1 mark for stating how experiment allows viscosities to be compared.	2	

3.

(a)		Sulfur - London dispersion forces / van der Waals / intermolecular forces **(1)** Silicon dioxide - (polar)covalent (network) bonds **(1)**	**2**	Accept LDF for London dispersion forces If candidate answers pure covalent, ignore pure.
(b)	**(i)**	Any structure for P_4S_3 that obeys valency rules 	**1**	Only trivalent phosphorus structures accepted
	(ii)	Increased nuclear attraction for electrons / increased nuclear charge / sulfur has more protons in nucleus	**1**	0 marks awarded for increased attraction of electrons for nucleus
	(iii)	**1 mark** Correctly identify that the forces are stronger between sulfur (molecules) than between the phosphorus molecules	**3**	
		1 mark Correctly identifying that there are London dispersion forces between the molecules of both these elements **1 mark** These forces are stronger due to sulfur structure being S_8 whereas phosphorus is P_4		This mark should only be awarded if no other forces are mentioned Must mention S_8 and P_4 (A-mark)

4.

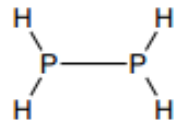
(a)	(i)	(The electron shells are pulled closer because) nuclear charge increases/the number of protons in the nucleus increases.	**1**	Mention must be made of nuclear charge or number of protons in candidate's answer giving the idea of pull by the nucleus. Increased nuclear pull is not accepted.
	(ii)	Two points are required Understanding that the atom loses an electron (when the ion is formed), **(1 mark)** **AND** the Sodium ion will only have two electron shells whereas the sodium atom has three electron shells **OR** the sodium ion will have fewer electron shells (than the sodium atom). **(1 mark)**	**2**	A diagram of the atom and ion or stating the electron arrangement of both would be sufficient to gain 1 mark but the second mark can only be awarded if this diagram or electron arrangement is accompanied with an explanatory statement.
(b)	(i)	As you go down the group the outer electron is more shielded from the nuclear pull **OR** less strongly attracted by the nucleus.	**1**	
	(ii)	2nd ionisation energy involves removal from an electron shell which is inner/full (whole)/(more) stable/closer to the nucleus **OR** second electron is removed from an electron shell which is inner/full (whole)/(more) stable/closer to the nucleus. **(1 mark)** The electron is less shielded from, or, more strongly attracted to the nucleus. **(1 mark)**	**2**	Stating that more energy is required to remove the second electron would be seen as restating the information from the stem.

5.

(c)	(i)	Any value in range 720–770 ($kJ\ mol^{-1}$).	1	Data value 760 $kJ\ mol^{-1}$ No units required but no mark is awarded if wrong unit is given. (wrong units would only be penalised once in any paper).
	(ii)	As the ionic radii (of the positive and/or the negative ion) increase, the lattice enthalpy decreases.	1	A general statement stating the greater the difference in ionic radii the greater the lattice enthalpy must be related to either chlorides or fluorides. The mark cannot be awarded for a statement such as, "As the lattice enthalpy decreases the ionic radii increases" which implies that ionic radius is a dependent variable.

6.

(a)		Covalent molecular.	1	

(c)			1	

7. open ended

8.

(a)		Silicon	1	Accept symbol
(b)	(i)	Increasing/greater/stronger/higher nuclear charge (holds electron more tightly) **OR** Increasing number of protons	1	Increased nuclear pull is not accepted on its own. Mention must be made of nuclear charge **or** number of protons.
	(ii)	$Mg^{+}(g) \longrightarrow Mg^{2+}(g) + e^{-}$	1	State symbols required.
	(iii)	Fourth ionisation energy involves removal of an electron from an electron shell which is inner/full (whole)/(more) stable/closer to the nucleus **OR** fourth electron is removed from an electron shell which is inner/full (whole)/(more) stable/closer to the nucleus. **OR** removing third electron is taking from an outer/a part full shell **OR** taking an electron from a full shell requires more energy (than removing from a part full shell) **OR** taking an electron from a part full shell requires less energy (than removing from a full shell) **OR** fourth electron is less shielded than the third electron **OR** third electron is more shielded than the fourth electron	1	

.

(c)		1 mark - Correctly identify that there are stronger/more (Van der Waals) forces between chlorine (molecules) than between the argon (atoms) 1 mark - Correctly identifying that the van der Waals forces present in both these elements are London dispersion forces 1 mark Chlorine molecules (Cl_2) have more electrons than argon atoms (Ar).	3	This mark can only be awarded if no other forces are mentioned as being broken.

9.

(a)	(i)	Electronegativity is the measure of attraction an atom/nucleus has for the electrons in a bond/shared electrons.	**1**	
	(ii)	(More shells) so increased shielding/more shielding. **OR** Covalent radius increases/atom size increases/more shells so attraction of the nucleus/protons for the (outer/shared) electrons decreases.	**1**	
(b)		(Intermolecular) forces/bonds increase (going down the group). **(1)** LDFs are the forces (broken) between the molecules. **(1)** The more electrons the stronger the LDFs. **(1)**	**3**	Use of VdW is acceptable for first mark. Mention of **increasing/stronger** intramolecular/covalent/ionic/ metallic bonds - cancels the first mark. This mark can only be awarded if no other forces are mentioned (as being broken). Use of VdW does not cancel but is not sufficient for the second mark.

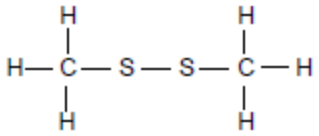
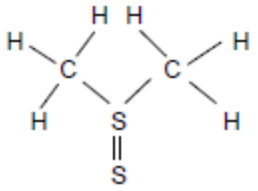
10

(a)		Increasing number of protons (in the nucleus). **OR** Increasing/greater/stronger/higher nuclear charge.	**1**	Mention must be made of **nuclear charge or number of protons.** Increased nuclear pull is not accepted on its own. Increased attraction of the electron for the nucleus is not an acceptable answer.
(b)	(i)	Sulfur chloride should be circled.	**1**	Accept other indications of correct structure, eg tick, arrow. Do not accept circling of single atoms or bond in SCl_2 molecule on its own.
	(ii)	Silicon tetrachloride and hexane are non-polar. **(1)** Silicon tetrachloride is non-polar due to its shape/dipoles/polarities cancelling out. **(1)**	**2**	Like dissolves like on its own - zero marks - answer must mention polarity.
(c)	(i)	Silicon nitride is a (covalent) network. **(1)** (Strong) covalent bonds are broken. **(1)**	**2**	'Covalent lattice' is acceptable, but 'lattice' on its own is not. Mention of silicon is cancelling for the first mark. Covalent network molecule is cancelling.

11.

(a)	(i)	Boron or Carbon or B or C or graphite or diamond	1	Silicon
	(ii)	Number of protons <u>increases</u> or <u>increased</u> atomic number or <u>greater</u> nuclear/positive charge (pull) or <u>greater</u> pull on (outer) electrons	1	Increased number of electrons or larger nucleus or stronger nucleus or any answer which does not indicate an <u>increase</u> in pull/charge
	(iii)	Lithium or Li	1	Li^+
(b)		Electrons are further from the nucleus or atomic size increases or extra energy level **(1)** Screening or shielding or explanation thereof **(1)**	2	Answers <u>only</u> stating that there are more electrons

12.

(a)	  Or any structure for an expansion of the shortened structural formula $CH_3S_2CH_3$ containing • 6 hydrogen atoms, valency 1 • 2 carbon atoms, valency 4 • 2 sulphur atoms, valency 2 or 4 or 6 All Bonds must be shown	1		Shortened structural formulae

(b)		First mark for naming the strongest type of intermolecular forces in H_2S Permanent dipole - permanent dipole attractions (accept dipole/dipole) **(1)** Second Mark for explaining how the intermolecular forces they have named arise. If permanent dipole-permanent dipole named, award mark for mention of electronegativities of S and H or diagram showing correct partial changes **(1)** If London dispersion forces named, award mark for mention of instantaneous/induced/temporary dipoles/electron cloud wobbles or similar **(1)**	2	Mention of Hydrogen bonding results in mark of 0 for whole question Polar bonding If van der Waals' named as the strongest intermolecular force, do not award any mark for explanation as this could be any one of several different types of intermolecular force.

13.

a	i	$K(g) \rightarrow K^+(g) + e^-$ **(1)** $K(g) \rightarrow K^+(g) + e$ **(1)**	**1**	Missing or incorrect state symbols
a	ii	Answers can be given either in terms of potassium or of chlorine Answers starting with "it" are assumed to refer to Potassium **Either** K has more shells/levels or electron further from nucleus or diagram showing this **(1)** Correct and clear use of <u>greater</u> shielding/screening (or clear explanation thereof) **(1)** So less energy required to remove electron/ weaker attraction for the electron **(1)** **or** Cl has fewer shells or electron closer to nucleus **(1)** Correct and clear use of <u>less</u> shielding/screening (or clear explanation thereof) **(1)** So more energy required <u>to remove electron</u>/stronger attraction for the electron **(1)**	3	

14.

a		Stating that one ($CHCl_3$) is polar **and/or** the other (CCl_4) is non-polar **(1)** Identifying that $CHCl_3$ has permanent dipole/permanent dipole attractions **and** identifying that CCl_4 has London dispersion forces **(1)** Other mark is for a statement linking intermolecular forces/polarity to the solubility in water. Statements such as the following would be acceptable • Water is polar **(1)** • Water has permanent dipole/ permanent dipole attractions **(1)** • Water is a good solvent for polar molecules **(1)** • Like dissolves like **(1)**	3	

15.

a		**Completed table in order:** Metallic (metal) Network (lattice) Covalent Molecular (discrete) 2/3 pieces of info **(1 mark)** 4 pieces of info **(2 marks)**	**2**	
b		Increasing nuclear charge / increasing number of protons / stronger pull from the nucleus (pulls electrons closer)	**1**	Increasing atomic number Increasing no. of electrons therefore bigger pull
c	**i**	(Fractional) distillation	**1**	

16.

b		For 1 mark Stronger intermolecular forces between H-F molecules than between F-F molecules (No need to name forces) OR for 1 mark – More energy is required to break intermolecular forces in HF than in F_2 For 1 mark Strong intermolecular forces (H bonds) caused by: (large) difference in electronegativity OR indication of polar bonds OR indication of permanent dipole For 1 mark Weak intermolecular forces (LDF) caused by: temporary dipoles OR uneven distribution of electrons OR electron cloud wobble	3	

17.

(*a*) If 4 correct elements chosen – 2 marks If 2 or 3 correct elements chosen – 1 mark	Only one element correctly chosen
(*b*) Increasing nuclear charge – 1 mark Increasing number of protons – 1 mark Decreasing atomic size – 1 mark	Electrons more tightly held Ionisation energy is increasing

18.

(*a*) Looking for three ideas Br_2 non-polar/ICl polar – 1 mark Br_2 and ICl have same number of electrons – 1 mark BPt ICl higher than BPt Br_2 – 1 mark ICl has permanent dipole/permanent dipole – 1 mark (*b*) H_2 – 1 mark	

19.

		A – covalent molecular solid ½ **D** – covalent network solid ½ **C** – ionic ½ **B** – metallic ½	**2**	

20.

a		Electronegativity values increase across the period.	**1**	
b		silicon	**1**	
c		• fourth electron being removed is from an inner electron shell **OR** • shell closer to the nucleus (and therefore requires more energy to remove)	**1**	

21.

a		• naming of intermolecular forces (**1 mark**) • description of how they arise (**1 mark**) • comparison of strength and effect on boiling point (**1 mark**) Hydrogen cyanide molecules are polar with permanent dipole – permanent dipole attractions between molecules. Nitrogen molecules are non-polar. The intermolecular forces between nitrogen molecules are London dispersion forces. Hydrogen cyanide molecules are polar due to electronegativity difference between nitrogen and hydrogen. London dispersion forces are temporary dipole-temporary dipole attractions due to due to temporary. More energy is required to break permanent dipole – permanent dipole attractions.	**3**	

22.

(a)	(i)	Increasing/greater/stronger/larger nuclear charge (holds electrons more tightly) **OR** Increasing number of protons	**1**	Increased nuclear pull is not accepted on its own. Mention must be made of nuclear charge **or** number of protons. Increased attraction of the electron **for** the nucleus would be considered cancelling.
	(ii)	(More shells) so increased/more screening/shielding. **OR** Covalent radius increases/atom size increases/more shells so attraction of the nucleus/protons for the **outer electron** decreases.	**1**	'Shielding effect' by itself is not acceptable. If candidate says 'it' assume the candidate is talking about potassium.
(b)	(i)	$N^{+}(g) \rightarrow N^{2+}(g) + e^{-}$	**1**	State symbols must be shown. Negative charge on the electron is not required.

	(ii)	The 6th ionisation energy involves removing an electron from the shell which is inner/full (whole)/(more) stable/closer to the nucleus **OR** the 6th electron is removed from the electron shell which is inner/full (whole)/(more) stable/closer to the nucleus. **(1)** The 6th electron is less shielded **OR** the 6th electron is more strongly attracted to/pulled towards the nucleus. **(1)**	**2**	Correct statements made about the 5th ionisation energy/electron can also be credited. Stating that the 6th electron requires more energy than the 5th electron is not sufficient on its own.
(c)		Al forms Al^{3+}/loses electrons to form an ion **and** P forms P^{3-}/gains electrons to form an ion. **(1)** Aluminium ion has one less energy level than phosphide/phosphorus ion. **OR** Phosphide/phosphorus ion has one more energy level than aluminium ion. **(1)**	**2**	A diagram or electron arrangement of **both** ions would be sufficient to gain this first mark.

(d)		(Radius ratio =) 0·96, (hence) caesium chloride (or correct formula).	**1**	Calculated value (of 0·96) or 135/140 must be written for radius ratio required for mark.

23. Open ended

24.

(a)	(i) A	Same number of electrons (34) **(1)** **OR** same strength of London dispersion forces/LDFs **(1)**	**1**	
	(i) B	Propan-1-ol has stronger intermolecular/Van der Waal's forces than ethanethiol or vice versa. **OR** The intermolecular forces in propan-1-ol take more energy to break than those in ethanethiol or vice versa.**(1)** **1 mark** for identifying that the intermolecular forces in propan-1-ol are hydrogen bonds AND those in ethanethiol are permanent dipole - permanent dipole interactions/ attractions. **(1)**	**2**	If candidate says 'it/its' assume the candidate is talking about propan-1-ol. Any mention of breaking covalent/ ionic/metallic bonds is cancelling. Accept London Dispersion Forces/ LDFs in place of permanent dipole-permanent dipole interactions.