

**Q19.**

Silicon dioxide ( $\text{SiO}_2$ ) has a crystal structure similar to diamond.

- (a) Give the name of the type of crystal structure shown by silicon dioxide.

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(1)

- (b) Suggest why silicon dioxide does **not** conduct electricity when molten.

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(1)

- (c) Silicon dioxide reacts with hydrofluoric acid (HF) to produce hexafluorosilicic acid ( $\text{H}_2\text{SiF}_6$ ) and one other substance.

Write an equation for this reaction.

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(1)

(Total 3 marks)

**Q20.**

Some airbags in cars contain sodium azide ( $\text{NaN}_3$ ).

- (a) Sodium azide is made by reacting dinitrogen monoxide gas with sodium amide ( $\text{NaNH}_2$ ) as shown by the equation.



Calculate the mass of sodium amide needed to obtain 550 g of sodium azide, assuming there is a 95.0% yield of sodium azide.

Give your answer to 3 significant figures.

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(5)





- (ii) Nitrous acid decomposes on heating.

Balance the following equation for this reaction.



(1)

- (d) Sodium azide has a high melting point.

Predict the type of bonding in a crystal of sodium azide.  
Suggest why its melting point is high.

Type of bonding \_\_\_\_\_

Reason for high melting point \_\_\_\_\_

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(3)

- (e) The azide ion has the formula  $\text{N}_3^-$

- (i) The azide ion can be represented as  $\text{N} \equiv \text{N} - \text{N}^-$   
One of these bonds is a co-ordinate bond.

On the following diagram, draw an arrowhead on one of the bonds to represent the direction of donation of the lone pair in the co-ordinate bond.



(1)

- (ii) Give the formula of a molecule that has the same number of electrons as the azide ion.

\_\_\_\_\_

(1)



(iii) Which is the correct formula of magnesium azide?

Tick (✓) **one** box.

Mg<sub>3</sub>N

MgN

MgN<sub>6</sub>

Mg<sub>3</sub>N<sub>2</sub>

(1)

(Total 21 marks)

**Q21.**

(a) Nickel is a metal with a high melting point.

(i) State the block in the Periodic Table that contains nickel.

\_\_\_\_\_

(1)

(ii) Explain, in terms of its structure and bonding, why nickel has a high melting point.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

(2)

(iii) Draw a labelled diagram to show the arrangement of particles in a crystal of nickel. In your answer, include at least six particles of each type.

(2)



- (iv) Explain why nickel is ductile (can be stretched into wires).

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(1)

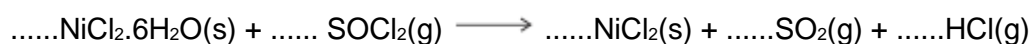
- (b) Nickel forms the compound nickel(II) chloride ( $\text{NiCl}_2$ ).

- (i) Give the full electron configuration of the  $\text{Ni}^{2+}$  ion.

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(1)

- (ii) Balance the following equation to show how anhydrous nickel(II) chloride can be obtained from the hydrated salt using  $\text{SOCl}_2$ . Identify **one** substance that could react with both gaseous products.



Substance \_\_\_\_\_

(2)

(Total 9 marks)

### Q22.

Thallium is in Group 3 of the Periodic Table.

Thallium reacts with halogens to form many compounds and ions.

- (a) Draw the shape of the  $\text{TlBr}_3^{2-}$  ion and the shape of the  $\text{TlCl}_4^{3-}$  ion. Include any lone pairs of electrons that influence the shapes.

Name the shape made by the atoms in  $\text{TlBr}_3^{2-}$  and suggest a value for the bond angle.

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(4)



- (b) Thallium(I) bromide (TlBr) is a crystalline solid with a melting point of 480 °C.

Suggest the type of bonding present in thallium(I) bromide and state why the melting point is high.

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(3)

- (c) Write an equation to show the formation of thallium(I) bromide from its elements.

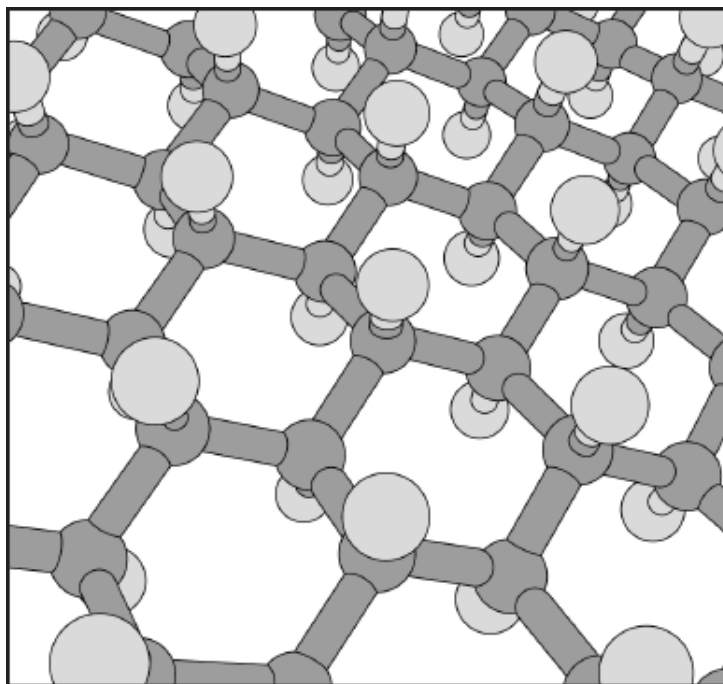
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(1)

(Total 8 marks)

### Q23.

In 2009 a new material called graphane was discovered. The diagram shows part of a model of the structure of graphane. Each carbon atom is bonded to three other carbon atoms and to one hydrogen atom.



- (a) Deduce the type of crystal structure shown by graphane.

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(1)



- (b) State how two carbon atoms form a carbon–carbon bond in graphane.

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(1)

- (c) Suggest why graphane does **not** conduct electricity.

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(1)

- (d) Deduce the empirical formula of graphane.

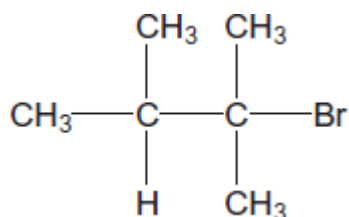
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(1)

(Total 4 marks)

**Q24.**

- (a) The structure of the bromoalkane **Z** is



Give the IUPAC name for **Z**.

Give the general formula of the homologous series of straight-chain bromoalkanes that contains one bromine atom per molecule.

Suggest **one** reason why 1-bromohexane has a higher boiling point than **Z**.

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(3)



- (b) Draw the displayed formula of 1,2-dichloro-2-methylpropane.

State its empirical formula.

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(2)  
(Total 5 marks)

### Q25.

The following table shows the electronegativity values of the elements from lithium to fluorine.

	Li	Be	B	C	N	O	F
Electronegativity	1.0	1.5	2.0	2.5	3.0	3.5	4.0

- (a) (i) State the meaning of the term *electronegativity*.

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(2)

- (ii) Suggest why the electronegativity of the elements increases from lithium to fluorine.

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(2)

- (b) State the type of bonding in lithium fluoride.  
Explain why a lot of energy is needed to melt a sample of solid lithium fluoride.

Bonding \_\_\_\_\_

Explanation \_\_\_\_\_

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(3)



- (c) Deduce why the bonding in nitrogen oxide is covalent rather than ionic.

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(1)

- (d) Oxygen forms several different compounds with fluorine.

- (i) Suggest the type of crystal shown by  $\text{OF}_2$

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(1)

- (ii) Write an equation to show how  $\text{OF}_2$  reacts with steam to form oxygen and hydrogen fluoride.

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(1)

- (iii) One of these compounds of oxygen and fluorine has a relative molecular mass of 70.0 and contains 54.3% by mass of fluorine.

Calculate the empirical formula and the molecular formula of this compound.  
Show your working.

Empirical formula \_\_\_\_\_

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Molecular formula \_\_\_\_\_

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(4)

(Total 14 marks)



## Mark Scheme

### Q19.

(a) Macromolecular / giant covalent / giant molecule  
*Not giant atomic* 1

(b) No delocalised electrons / no free ions / no free charged particles 1

(c)  $\text{SiO}_2 + 6\text{HF} \longrightarrow \text{H}_2\text{SiF}_6 + 2\text{H}_2\text{O}$   
*Accept multiples* 1

[3]

### Q20.

(a) M1  $550 \times \frac{100}{95} = 579$  g would be 100% mass  
*Allow alternative methods.*  
*There are 4 process marks:* 1

M2 So  $\frac{579}{65} = 8.91$  moles  $\text{NaN}_3$

or

M1  $\frac{550}{65} = 8.46$  moles  $\text{NaN}_3$  (this is 95%)

M2 So 100% would be  $8.46 \times \frac{100}{95} = 8.91$  moles  $\text{NaN}_3$

1:  $\text{mass} \div 65$

2:  $\text{mass or moles} \times 100 / 95$  or  $\times 1.05$

3:  $\text{moles } \text{NaN}_3 \times 2$

4:  $\text{moles } \text{NaNH}_2 \times 39$  1

Then M3 Moles  $\text{NaNH}_2 = 8.91 \times 2 = (17.8(2))$  moles 1

M4  $\text{mass } \text{NaNH}_2 = 17.8(2) \times 39$  1

M5 693 or 694 or 695 (g)  
*If 693, 694 or 695 seen to 3 sig figs award 5 marks* 1

(b) M1 308 K and 150 000 Pa 1



$$M2 \quad n = \frac{PV}{RT} \quad \text{or} \quad \frac{150\,000 \times 7.5 \times 10^{-2}}{8.31 \times 308}$$

1

$$M3 = 4.4(0) \text{ or } 4.395 \text{ moles } N_2$$

*Allow only this answer but allow to more than 3 sig figs*

1

$$M4 \text{ Moles } NaN_3 = 4.395 \times \frac{2}{3} (= 2.93)$$

*M4 is for M3  $\times \frac{2}{3}$*

1

$$M5 \text{ Mass } NaN_3 = (2.93) \times 65$$

*M5 is for moles M4  $\times 65$*

1

$$M6 = 191 \text{ g}$$

*Allow 190 to 191 g allow answers to 2 sig figs or more*

1

(c) (i)  $150 / 65 = 2.31$  moles  $NaN_3$  or 2.31 moles nitrous acid

1

$$\text{Conc} = 2.31 \times \frac{1000}{500}$$

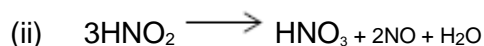
*M2 is for M1  $\times 1000 / 500$*

1

$$4.6(1) \text{ or } 4.6(2) \text{ (mol dm}^{-3}\text{)}$$

*Only this answer*

1



*Can allow multiples*

1

(d) Ionic

*If not ionic then CE = 0 / 3*

1

Oppositely charged ions /  $Na^+$  and  $N_3^-$  ions

*Penalise incorrect ions here but can allow M3*

1

Strong attraction between (oppositely charged) ions / lots of energy needed to overcome (strong) attractions (between ions)

*M3 dependent on M2*

1



*Only*

1



- (ii)  $\text{CO}_2 / \text{N}_2\text{O} / \text{BeF}_2 / \text{HN}_3$   
*Allow other correct molecules* 1
- (iii)  $\text{MgN}_6$   
*Only* 1
- [21]**

**Q21.**

- (a) (i) d (block) **OR** D (block)  
*Ignore transition metals / series.*  
*Do not allow any numbers in the answer.* 1

- (ii) Contains positive (metal) ions or protons or nuclei and delocalised / mobile / free / sea of electrons  
*Ignore atoms.* 1

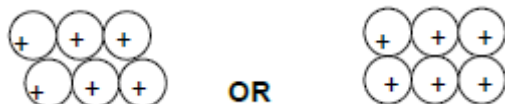
Strong attraction between them or strong metallic bonds

*Allow 'needs a lot of energy to break / overcome' instead of 'strong'.*

*If strong attraction between incorrect particles, then CE = 0 / 2.*

*If molecules / intermolecular forces / covalent bonding / ionic bonding mentioned then CE=0.* 1

(iii)



*M1 is for regular arrangement of atoms / ions (min 6 metal particles).*

*M2 for + sign in each metal atom / ion.*

*Allow 2+ sign.* 2

- (iv) Layers / planes / sheets of atoms or ions can slide over one another  
*QoL.* 1

- (b) (i)  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^8 (4s^0)$   
*Only.* 1

- (ii)  $\text{NiCl}_2 \cdot 6\text{H}_2\text{O} + 6 \text{SOCl}_2 \longrightarrow \text{NiCl}_2 + 6 \text{SO}_2 + 12 \text{HCl}$   
*Allow multiples.* 1

$\text{NaOH} / \text{NH}_3 / \text{CaCO}_3 / \text{CaO}$

*Allow any name or formula of alkali or base.*



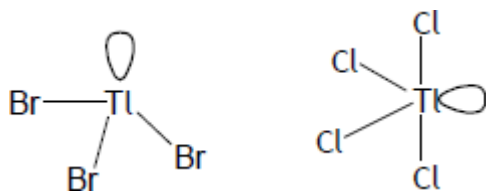
Allow water.

1

[9]

**Q22.**

(a)



Mark is for correct number of bonds and lone pair in each case.  
Ignore charges if shown.

2

Pyramidal / trigonal pyramid

Allow tetrahedral.

1

107°

Allow 107 to 107.5°.

1

(b) M1 Ionic

CE = 0 / 3 if not ionic.

1

M2 Oppositely charged ions / Tl<sup>+</sup> and Br<sup>-</sup> ions

If molecules / intermolecular forces / metallic bonding, CE=0.

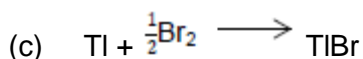
1

M3 Strong attraction between ions

M3 dependent on M2.

Allow 'needs a lot of energy to break / overcome' instead of 'strong'.

1



Allow multiples.

Ignore state symbols even if incorrect.

1

[8]

**Q23.**

(a) Giant covalent / giant molecular / macromolecular

Not giant alone.

Not covalent alone.

1

(b) Shared pair of electrons / one electron from each C atom



1

- (c) No delocalised / free / mobile electrons

*Allow all (outer) electrons involved in (covalent) bonds.**Ignore ions.*

1

- (d) CH

*Allow HC**C and H must be capital letters.*

1

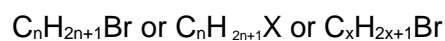
[4]

**Q24.**

- (a) 2-bromo-2,3-dimethylbutane

*Ignore punctuation.*

1

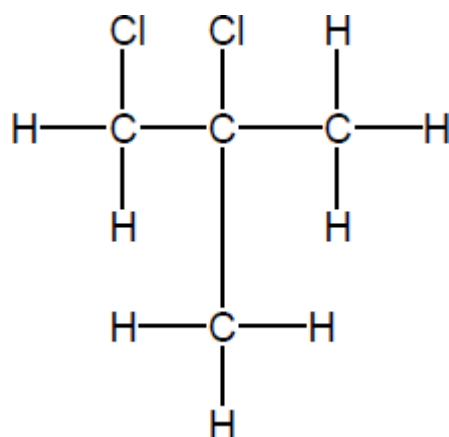
*Any order.*

1

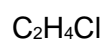
Stronger / more vdw (forces) between molecules (of 1-bromohexane)*QoL**Allow converse arguments for Z**Not just more IMF.**Ignore size of molecule.*

1

- (b)



1

*Any order*

1

[5]

**Q25.**

- (a) (i) The power of an
- atom
- or
- nucleus
- to withdraw or attract electrons
- OR**
- electron*



- density **OR** a pair of electrons (towards itself)  
Ignore retain 1
- In a covalent bond 1
- (ii) More protons / bigger nuclear charge 1
- Same or similar shielding / electrons in the same shell or principal energy level / atoms get smaller  
Not same sub-shell  
Ignore more electrons 1
- (b) Ionic  
If not ionic then CE = 0 / 3  
If blank lose M1 and mark on 1
- Strong or many or lots of (electrostatic) attractions (between ions)  
If molecules / IMF / metallic / atoms lose M2 + M3, penalise incorrect ions by 1 mark 1
- Between + and - ions / between Li<sup>+</sup> and F<sup>-</sup> ions / oppositely charged ions  
Allow strong (ionic) bonds for max 1 out of M2 and M3 1
- (c) Small electronegativity difference / difference = 0.5  
Must be comparative  
Allow 2 non-metals 1
- (d) (i) (simple) molecular  
Ignore simple covalent 1
- (ii)  $\text{OF}_2 + \text{H}_2\text{O} \longrightarrow \text{O}_2 + 2\text{HF}$   
Ignore state symbols  
Allow multiples  
Allow OF<sub>2</sub> written as F<sub>2</sub>O 1
- (iii) 45.7% O 1
- ( O    F )  
( 45.7   54.3 )  
( 16    19 )  
If students get M2 upside down lose M2 + M3  
Check that students who get correct answer divide by 16 and 19 (not 8 and 9). If dividing by 8 and 9 lose M2 and M3 but could allocate M4 ie max 2 1



(2.85 2.85)  
(1 1)

EF = OF or FO

*Calculation of OF by other correct method = 3 marks*

*Penalise FI by 1 mark*

1

MF (= 70.0 / 35) = O<sub>2</sub>F<sub>2</sub> or F<sub>2</sub>O<sub>2</sub>

1

[14]