

Atoms, Bonds and Groups

Structure & Bonding – Mark Scheme

1. (i) (Electrostatic) **attraction** between oppositely charged **ions**. ✓

IGNORE force

IGNORE references to transfer of electrons

MUST be ions, not particles

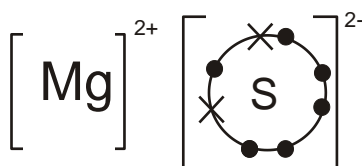
1

- (ii) Mg shown with either 8 or 0 electrons

AND

S shown with 8 electrons **with** 2 crosses and 6 dots (or vice versa) ✓

Correct charges on both ions ✓



Mark charges on ions and electrons independently

For first mark, if 8 electrons are shown around the Mg then 'extra electrons' around S must match the symbol chosen for electrons around Mg

Shell circles not required

IGNORE inner shell electrons

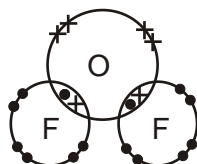
Brackets are not required

2

[3]

2. (i) Electron pairs in covalent bonds shown correctly using dots and crosses in a molecule of the F_2O ✓

Lone pairs correct on O and both F atoms ✓



Must be 'dot-and-cross'

circles for outer shells NOT needed

IGNORE inner shells

Non-bonding electrons of O do not need to be shown as pairs

Non-bonding electrons of F do not need to be shown as pairs

2

(ii) Predicted bond angle $104 - 105^\circ$. ✓

ALLOW $103 - 105^\circ$ (103° is the actual bond angle)

There are 2 bonded pairs and 2 lone pairs ✓

Lone pairs repel more than bonded pairs ✓

ALLOW responses equivalent to second marking point. e.g.

There are 4 pairs of electrons and 2 of these are lone pairs

ALLOW 'bonds' for 'bonded pairs'

DO NOT ALLOW 'atoms repel'

DO NOT ALLOW electrons repel

ALLOW LP for 'lone pair'

ALLOW BP for bonded pair

ALLOW LP repel more if bonded pairs have already been mentioned

3

[5]

3. (i) (At least) two NH_3 molecules with correct dipole shown with at least one H with δ^+ and one N with δ^- ✓

DO NOT ALLOW first mark for ammonia molecules with incorrect lone pairs

DO NOT ALLOW first mark if H_2O , NH_2 or NH is shown

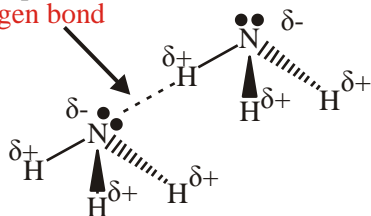
(Only) one hydrogen bond from N atom on one molecule to a H atom on another molecule ✓

ALLOW hydrogen bond need not be labelled as long as it clear the bond type is different from the covalent N-H bond

ALLOW a line (i.e. looks like a covalent bond) as long as it is labelled 'hydrogen bond'

Lone pair shown on the N atom and hydrogen bond must hit the lone pair ✓

Hydrogen bond



ALLOW 2-D diagrams

ALLOW two marks if water molecules are used. One awarded for a correct hydrogen bond and one for the involvement of lone pair

3

- (ii) Liquid H₂O is denser than solid ✓
 In solid state H₂O molecules are held apart by hydrogen bonds
OR ice has an open lattice ✓

ORA

ALLOW ice floats for first mark

OR

H₂O has a relatively high boiling point **OR** melting point ✓

ALLOW higher melting OR boiling point than expected

DO NOT ALLOW H₂O has a high melting / boiling point

(relatively strong) hydrogen bonds need to be broken

OR a lot of energy is needed to overcome hydrogen bonds

OR hydrogen bonds are strong ✓

ALLOW other properties caused by hydrogen bonding not mentioned within the specification

E.g. high surface tension – strong hydrogen bonds on the surface

2

[5]

4. Mg has a **giant** structure ✓

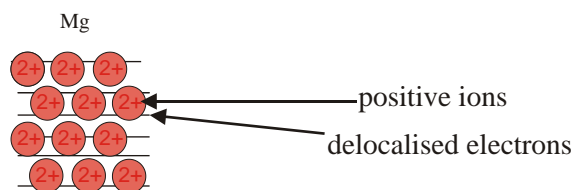
Metallic OR delocalised seen spelt correctly at least ONCE

Mg has **metallic** bonding **OR** description of metallic bonding as positive ions and **delocalised** electrons ✓

(There is electrostatic attraction between) positive ions and electrons ✓

DO NOT ALLOW as label nuclei OR protons for positive ions

ALLOW labelled diagram of metallic bonding for second and third marks



Lattice must have at least two rows of positive ions. If a Mg ion is shown it must correct charge

ALLOW for labels: + ions, positive ions, cations

DO NOT ALLOW as label nuclei OR protons for positive ions

ALLOW e⁻ or e as label for electron

DO NOT ALLOW ‘-’ without label for electron

Cl has a simple molecular **OR** simple covalent (lattice) ✓

Covalent OR molecule OR molecular seen spelt correctly at least ONCE

ALLOW Cl is a (covalent) molecule

Cl has van der Waals' forces (between molecules)

OR

Cl has instantaneous dipole–induced dipoles

OR

temporary dipole–temporary dipole ✓

***IGNORE** Cl has intermolecular bonding*

van der Waals' forces are weak **and** metallic bonds are strong

OR

van der Waals' forces are weaker than metallic bonds

OR

Less energy is needed to overcome van der Waals' than metallic bonds ✓

***ALLOW** ECF from incorrect descriptions of giant structure with strong bonds; e.g. Mg has giant ionic structure*

***ALLOW** ECF from any incorrect intermolecular forces e.g. permanent dipole–dipole from marking point 5*

***ALLOW** vdW easier to break*

ORA

[6]

5. giant covalent (lattice) ✓

layers ✓

Each of the three properties below must be linked to explanation

good conductor – because it has mobile electrons **OR**
delocalised electrons **OR** electrons can move ✓

high melting / boiling point – because strong **OR**
covalent bonds have to be broken ✓

soft – because there are van der Waals' forces **OR**
intermolecular forces **OR** weak bonds **OR** weak forces
between the layers

OR

soft – because layers can slide ✓

Use annotations with ticks, crosses etc. for this part.

All five marking points are independent

***ALLOW** giant atomic **OR** giant molecular **OR**
macromolecular*

***ALLOW** planes **OR** sheets*

Allow diagram showing at least two layers

Electron(s) must be spelt correctly ONCE

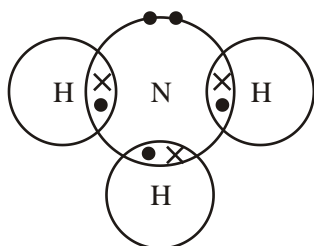
***DO NOT ALLOW** 'strong ionic bonds' **OR** strong metallic
bonds.*

[5]

6. (i) a shared pair of electrons ✓
ALLOW any response that communicates electron pair
ALLOW shared pairs

1

(ii)



✓
Must be 'dot-and-cross'
circles for outer shells NOT needed
IGNORE inner shells
Non-bonding electrons of N do not need to be shown as a pair

1

- (iii) Shape: pyramidal **OR** (trigonal) pyramid ✓

Explanation:

There are 3 bonded pairs and 1 lone pair ✓

Lone pairs repel more than bonded pairs ✓

ALLOW 'bonds' for 'bonded pairs'

DO NOT ALLOW 'atoms repel'

DO NOT ALLOW electrons repel

ALLOW LP for 'lone pair'

ALLOW BP for bonded pair

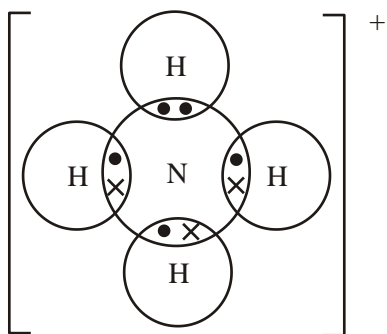
3

[5]

7. (i) $1s^2 2s^2 2p^6 3s^2 3p^6$ ✓
ALLOW subscripts

1

(ii)



'Dot-and-cross' diagram to show four shared pairs of electrons one of which is a dative covalent bond (which must consist of the same symbols) ✓

IGNORE inner shells

IGNORE '+' sign **BUT DO NOT ALLOW** a '-' sign.

Brackets and circles not required

1

(iii) tetrahedral ✓

109.5° ✓

ALLOW 109 – 110°

2

(iv) ions **OR** electrons cannot move in a solid ✓

ions can move **OR** are mobile in solution ✓

ALLOW ions can move in liquid

DO NOT ALLOW ions can move when molten

ALLOW 1 mark for:

'Ions can only move in solution'

2

[6]

8.



regular arrangement of **labelled** + ions with some attempt to show electrons ✓

scattering of labelled electrons **between** other species

OR

a statement anywhere of **delocalised** electrons (can be in text below) ✓

metallic bond as (electrostatic) **attraction** between the electrons and the positive ions ✓

Lattice must have at least 2 rows of positive ions

If a metal ion is shown (e.g. Na^+), it must have the correct charge

***ALLOW** for labels: + ions, positive ions, cations*

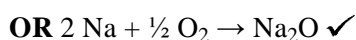
If '+' is unlabelled in diagram, award the label for '+' from a statement of 'positive ions' in text below

***DO NOT ALLOW** as label or text positive atom **OR** protons **OR** nuclei*

***ALLOW** e^- **OR** e as label for electron*

***DO NOT ALLOW** '-' as label for electron*

[3]



***ALLOW** correct multiples including fractions*

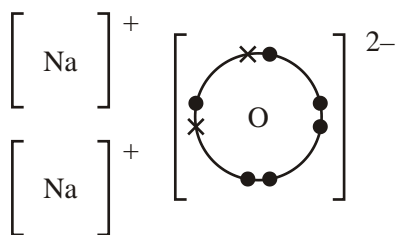
***IGNORE** state symbols*

1

(ii) (electrostatic) attraction between oppositely charged ions ✓

1

(iii)



Na shown with either 8 or 0 electrons

AND

O shown with 8 electrons **with** 6 crosses and 2 dots (or vice versa) ✓

Correct charges on both ions ✓

For 1st mark, if 8 electrons shown around cation then 'extra' electron(s) around anion must match symbol chosen for electrons in cation

Shell circles not required

IGNORE inner shell electrons

ALLOW: $2[Na^+]$ $2[Na]^+$ $[Na^+]_2$ (brackets not required)

DO NOT ALLOW $[Na_2]^{2+}$ / $[Na_2]^+$ / $[2Na]^{2+}$

DO NOT ALLOW: $[Na_2]^{2+}$ $[Na_2]^+$ $[2Na]^{2+}$ $[Na]_2^+$

2

[4]

10. sodium is a (good) conductor because it has mobile electrons **OR** delocalised electrons

OR electrons can move ✓

sodium oxide does not conduct as a solid ✓

sodium oxide conducts when it is a liquid ✓

ions cannot move in a solid ✓

ions can move **OR** are mobile when liquid ✓

Throughout this question, 'conducts' and 'carries charge' are treated as equivalent terms.

DO NOT ALLOW 'free electrons' for mobile electrons

ALLOW poor conductor **OR** bad conductor

'Sodium oxide only conducts when liquid' is insufficient to award 'solid conductivity' mark

ALLOW ions are fixed in place

IGNORE electrons

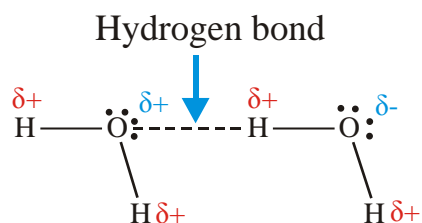
IGNORE charge carriers

IGNORE 'delocalised ions' or 'free ions' for mobile ions

Any mention of electrons moving is a CON

[5]

11. (i)



Shape of water with at least one H with $\delta+$ and at least one O with $\delta-$ ✓

H-bond between H in one water molecule and a lone pair of an O in another water molecule ✓

hydrogen bond labelled

OR H₂O has hydrogen bonding ✓

all marks can be awarded from a labelled diagram

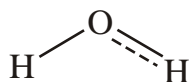
*If HO₂ shown then **DO NOT ALLOW** 1st mark*

*Dipole could be described in words so it does **not** need to be part of diagram.*

*At least one hydrogen bond **must** clearly hit a lone pair*

*Lone pair interaction could be described in words so it does **not** need to be part of diagram.*

***DO NOT ALLOW** hydrogen bonding if described in context of intramolecular bonding, ie*



3

(ii) no hydrogen bonding

OR

weaker intermolecular forces ✓

***DO NOT ALLOW** 'weaker'/'weak' hydrogen bonding*

***ALLOW** weaker van der Waals' forces*

***ALLOW** weaker dipole-dipole interactions*

***DO NOT ALLOW** 'weak intermolecular forces'*

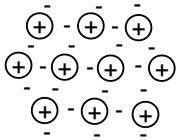
(ie comparison essential here)

***DO NOT ALLOW** 'no intermolecular forces'*

1

[4]

12. (i)



positive ions (1) electrons (1) (must be labelled)

2

(ii) the electrons move (1)

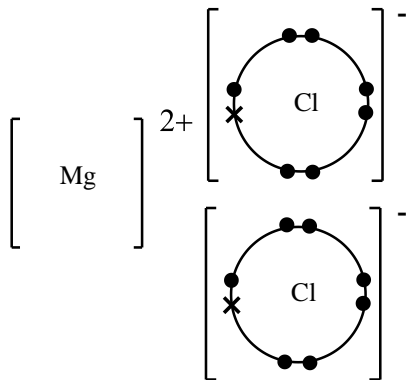
1

[3]

13. (i) attraction between oppositely charged ions

1

(ii)



Mg and Cl both with 8 electrons in outer shell, (accept 0 electrons for Mg)

Cl must have one dot to seven crosses or vice versa (1)

correct charges on each ion (1)

2

(iii) $MgCl_2$ does not conduct when solid because ions are fixed in lattice (1)

H_2O does not conduct as there are no free charge carriers/water molecules are uncharged (1)

$MgCl_2$ conducts when aqueous because ions are free to move (1)

3

[6]

14. 

To boil Cl_2 , van der Waals' forces/intermolecular forces are broken

(with van der Waals/intermolecular spelt correctly) (1)

To boil C, covalent bonds are broken (1)

covalent bonds are stronger than van der Waals' forces (1)

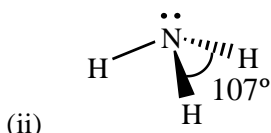
[3]

15. (i) H_2O NH_3

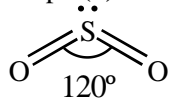
2 3 (1)

2 1 (1)

2



shape (1) bond angle labelled on diagram as 107° (1)



shape (1) bond angle labelled on diagram as $110\text{--}120^\circ$ (1)

4

[6]

16. H bonding from lone pair on O of 1 H_2O molecule to H of another (1)
dipoles shown (1)

Two properties:

Ice is lighter than water/ max density at 4°C (1)

explanation: H bonds hold H_2O molecules apart

/ open lattice in ice

/ H-bonds are longer (1)

Higher melting/boiling point than expected (1)

explanation: strength of H bonds that need to be broken (1)

must imply that intermolecular bonds are broken

High surface tension/viscosity (1)

explanation: strength of H bonds across surface (1)

[6]

17. (i) $1s^2 2s^2 2p^6 3s^2 3p^6$ ✓ 1
- (ii) 3 ✓ 1
- (iii) 10 ✓ 1
- (iv) 'dot-and-cross' of Ca^{2+} with either 8 electrons or no electrons. ✓
- 'dot-and-cross' of 2OH^- correct ✓ 2
- N.B. H electron and Ca electrons can look the same.

[5]

Lattice must have at least two rows of positive ions. If a Mg ion is shown it must correct charge

ALLOW for labels: + ions, positive ions, cations

DO NOT ALLOW as label nuclei **OR** protons for positive ions

ALLOW e^- or e as label for electron

DO NOT ALLOW '-' without label for electron

Cl has a simple molecular **OR** simple covalent (lattice) ✓✓✓18. (i)

attraction between oppositely charges ions ✓ 1

- (ii) shared pair of electrons ✓✓ 2
'shared electrons' scores 1 mark only

[3]

19. (i) attraction of an **atom/element** for electrons ✓
 in a (covalent) bond/bonded pair ✓ 2
- (ii) one element attracts bonded pair more
 /is more electronegative than other ✓
 → δ- on more electronegative atom and δ+ on less
 electronegative element in example ✓ 2

May need to look for these marks below if not given here.

[4]

20. H-bond shown between H of one molecule and O, N or F of
 another ✓
 H-bond shown going to a lone pair ✓

[2]

21. (a) 3

element	structure	bonding	
Mg	giant	metallic	✓
Si	giant	covalent	✓
S	simple	covalent	✓

1 mark for each correct row

- (b) Si has strong forces between atoms/
 covalent bonds are broken ✓
 P has weak forces between molecules/
 intermolecular forces/van der Waals' forces are broken ✓ 2

- (c) From Na \rightarrow Al, no of **delocalised** electrons increases ✓
 charge on positive ion increases/
 ionic size decreases/
 charge density increases ✓
 attraction between + ions and electrons increases/
 metallic bonding gets stronger ✓

2

[7]

22. (i) $2\text{Na(s)} + \text{Cl}_2\text{(g)} \rightarrow 2\text{NaCl(s)}$ ✓✓
 1st mark for equation
 2nd mark for state symbols

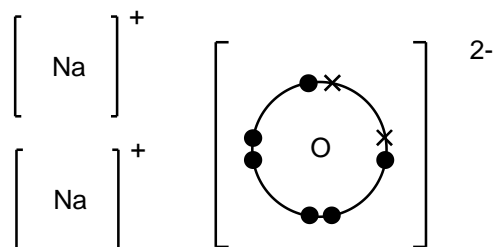
2

- (ii) Giant ionic (lattice) or 3D ✓
 with alternating Na^+ and Cl^- ✓

2

[4]

23.



Also accept Na with full shell as long as it contains 'x's
 (as in example above)

Ignore any inner shells

correct dot and cross ✓

correct charges ✓

[2]

24. (i) $2\text{Na} + \text{O}_2 \rightarrow \text{Na}_2\text{O}_2$ ✓

1

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

1

- (iii) correct covalent bonds shown ✓
 electron count (14) for rest of molecule correct ✓

2

[4]

25. (i) (trigonal) pyramidal ✓ 1
- (ii) electron pairs repel/bonds repel
/electron pairs get as far apart as possible ✓
lone pairs repel more/forces 'them' closer ✓
4 electron pairs surround central atom or N 3
/diagram with 3 bonds and a lone pair ✓
- [4]
26. Original solution contains ions/there are mobile ions ✓
Charge carriers removed as reaction takes place
/as solid forms/ as BaSO₄ forms/as water forms ✓ 2
- [2]
27. **general**
NaCl: ionic/has ionic bonds ✓
**Beware of contradictions for this mark, especially
reference to intermolecular forces.
Ignore 'atoms'.** 2
- graphite: covalent/giant molecular/macromolecular ✓
Ignore van der Waals', intermolecular, molecules
-

conductivity

NaCl: ions cannot move/
no free ions (or electrons) /
mobile ions only in solution or when molten ✓

graphite: 2
delocalised electrons/
free electrons (between layers)/
electrons conduct ✓

Ignore lone pair

melting point

both graphite and NaCl:
bonds are strong/
bonds difficult to break / 1
large amount of energy is needed to break bonds

✓

solubility

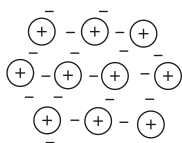
NaCl: Water is polar/water has a dipole/
ions interacts with water molecules ✓

Graphite: no interaction with water/
no intermolecular forces with water/ 2
graphite is non-polar ✓

QWC: At least 2 complete sentences in which
the meaning is clear. ✓ 1

[8]

28. (i)



positive ions ✓ electrons ✓ (must be labelled)

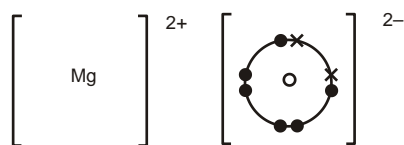
If Mg^{2+} shown then must be correct: Mg^+ not worthy 2

(ii) electrons move ✓ 1

[3]

29. (i) Oxidation state goes from 0 in O₂ ✓
 → -2 in MgO ✓ 2

(ii)



or with Mg full shell.
 correct dot and cross ✓; correct charges ✓ 2

[4]

30. (i) mark vertically:

H ₂ O	NH ₃
2	3
2	1
✓	✓

2

3D Diagram required or diagram with name

(ii) labelled bond angle required

NH ₃	pyramidal molecule shown ✓	107 ° ✓ (106-108°)
SO ₂	non-linear molecule shown ✓	110 – 130 ° ✓

4

[6]

31. (i) oxygen/ nitrogen is more electronegative/
 molecule has atoms with different electronegativities
 /oxygen/more electronegative atom ... attracts bonded
 electron pair more ✓ 1

(ii) H bonding from N of 1 NH₃ molecule to H of another NH₃
 molecule with a H^{δ+} shown and a N^{δ-} shown ✓
 with lone pair involved in bond ✓
 2nd mark is available from water molecule(s) 2

[3]

32. ice is less dense than water ✓

hydrogen bonds hold H₂O molecules apart in ice /
 hydrogen bonds cause an open lattice structure ✓ 2

[2]

