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2002

**XVIII**

1583

Time allowed  
**276 Minutes**

**Score**

**/230**

**Percentage**

**%**

**CHEMISTRY**

**OCR  
AS & A LEVEL**

**Mark Scheme**

**Module 2: Foundations in chemistry**

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# F321: 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*

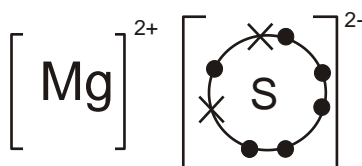
1

- (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*

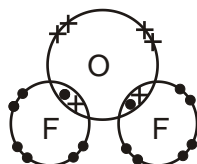
*Brackets are not required*

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**  $103 - 105^\circ$  ( $103^\circ$  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  $\text{NH}_3$  molecules with correct dipole shown with at least one H with  $\delta^+$  and one N with  $\delta^-$  ✓

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

**DO NOT ALLOW** first mark if  $\text{H}_2\text{O}$ ,  $\text{NH}_2$  or  $\text{NH}$  is shown

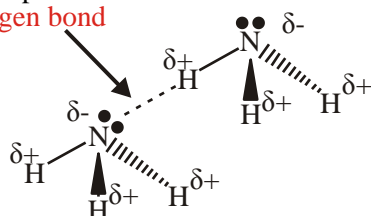
(Only) one hydrogen bond from N atom on one molecule to a H atom on another molecule ✓

**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  $\text{H}_2\text{O}$  is denser than solid ✓  
 In solid state  $\text{H}_2\text{O}$  molecules are held apart by hydrogen bonds  
**OR** ice has an open lattice ✓

*ORA*

*ALLOW ice floats for first mark*

**OR**

$\text{H}_2\text{O}$  has a relatively high boiling point **OR** melting point ✓

*ALLOW higher melting **OR** boiling point than expected*

***DO NOT ALLOW**  $\text{H}_2\text{O}$  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 ✓

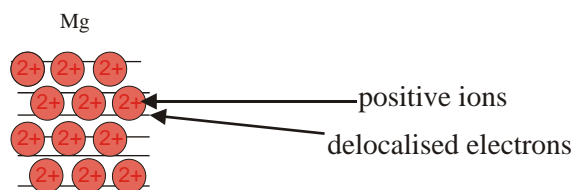
***Metallic **OR** delocalised** seen spelt correctly at least **ONCE***

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.*

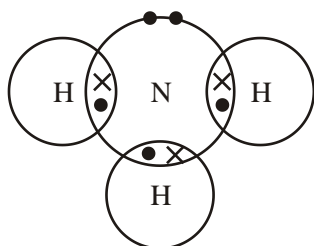
[5]

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

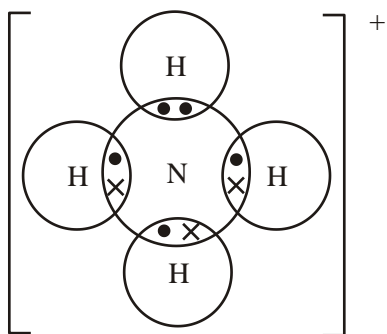
[5]

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

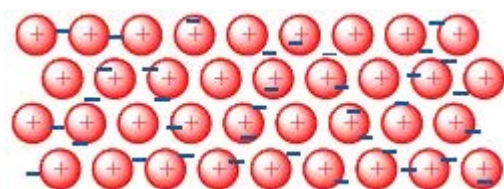
**ALLOW 1 mark for:**

'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.  $\text{Na}^+$ ), it must have the correct charge*

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

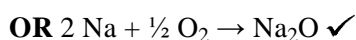
*If '+' is unlabelled in diagram, award the label for '+' from a statement of 'positive ions' in text below*

**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

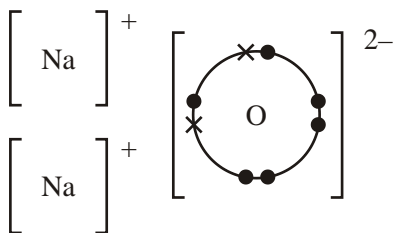
1

(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:**  $2[\text{Na}^+]$   $2[\text{Na}]^+$   $[\text{Na}^+]_2$  (brackets not required)

**DO NOT ALLOW**  $[\text{Na}_2]^{2+}$  /  $[\text{Na}_2]^+$  /  $[2\text{Na}]^{2+}$

**DO NOT ALLOW:**  $[\text{Na}_2]^{2+}$   $[\text{Na}_2]^+$   $[2\text{Na}]^{2+}$   $[\text{Na}]_2^+$

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

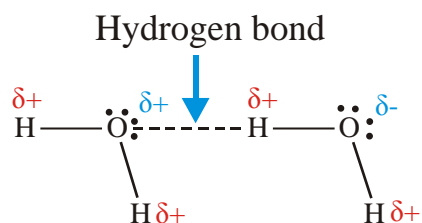
**IGNORE** charge carriers

**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  $\text{H}_2\text{O}$  has hydrogen bonding ✓

*all marks can be awarded from a labelled diagram*

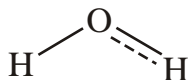
*If  $\text{HO}_2$  shown then **DO NOT ALLOW** 1st mark*

*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'

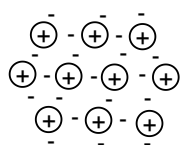
(ie comparison essential here)

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

1

[4]

12. (i)



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

2

(ii) the electrons move (1)

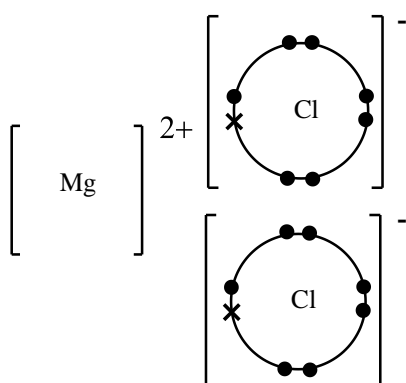
1

[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)  $\text{MgCl}_2$  does not conduct when solid because ions are fixed in lattice (1)

$\text{H}_2\text{O}$  does not conduct as there are no free charge carriers/water molecules are uncharged (1)

$\text{MgCl}_2$  conducts when aqueous because ions are free to move (1)

3

[6]

14. 

To boil  $\text{Cl}_2$ , 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)

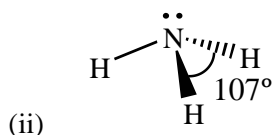
[3]

15. (i)  $\text{H}_2\text{O}$   $\text{NH}_3$

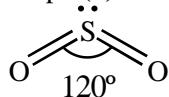
2 3 (1)

2 1 (1)

2



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



shape (1) bond angle labelled on diagram as 110–120° (1)

4

[6]

16. H bonding from lone pair on O of 1 H<sub>2</sub>O 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<sub>2</sub>O 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<sup>2+</sup> with either 8 electrons or no electrons. ✓
- 'dot-and-cross' of 2OH<sup>-</sup> 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<sup>-</sup> 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 ✓  
 →  $\delta^-$  on more electronegative atom and  $\delta^+$  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 → 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]

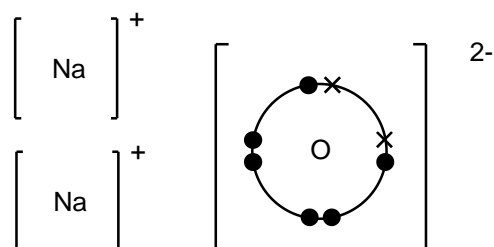
22. (i)  $2\text{Na(s)} + \text{Cl}_2\text{(g)} \rightarrow 2\text{NaCl(s)}$  ✓✓  
 1st mark for equation  
 2nd mark for state symbols
- (ii) Giant ionic (lattice) or 3D ✓  
 with alternating  $\text{Na}^+$  and  $\text{Cl}^-$  ✓

2

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)  $2\text{Na} + \text{O}_2 \rightarrow \text{Na}_2\text{O}_2$  ✓
- (ii)  $\text{Na}_2\text{O}_2 + 2\text{H}_2\text{O} \rightarrow \text{H}_2\text{O}_2 + 2\text{NaOH}$  ✓  
 correct covalent bonds shown ✓
- (iii) electron count (14) for rest of molecule correct ✓

1

1

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  $\text{BaSO}_4$  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**

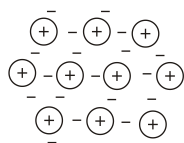
NaCl: Water is polar/water has a dipole/  
ions interacts with water molecules ✓

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

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

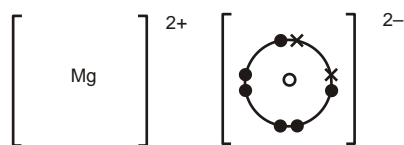
**[3]**



29. (i) Oxidation state goes from 0 in  $O_2$  ✓  
 → -2 in  $MgO$  ✓

2

(ii)



or with Mg full shell.

correct dot and cross ✓; correct charges ✓

2

[4]

30. (i) mark vertically:

$H_2O$	$NH_3$
2	3
2	1
✓	✓

2

3D Diagram required or diagram with name

- (ii) labelled bond angle required

$NH_3$	pyramidal molecule shown ✓	$107^\circ$ ✓ ( $106-108^\circ$ )
$SO_2$	non-linear molecule shown ✓	$110 - 130^\circ$ ✓

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  $NH_3$  molecule to H of another  $NH_3$   
 molecule with a  $H^{\delta+}$  shown and a  $N^{\delta-}$  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  $H_2O$  molecules apart in ice /  
 hydrogen bonds cause an open lattice structure ✓

2

[2]

33. (i)  $107^\circ$  ✓ (accept any angle in the range  $108^\circ \rightarrow 91^\circ$ ) 1  
 (ii) electron pairs repel electron pairs/bonds go as far apart as possible ✓  
 lone pairs repel more ✓ 2  
**[3]**
34. attraction between oppositely charged ions/  
 oppositely charged atoms ✓ 1  
 For CaO: correct dot and cross ✓; correct charges ✓  
 For CO<sub>2</sub>: correct dot and cross ✓ 3  
 $1s^2 2s^2 2p^6 3s^2 3p^6$  ✓ 1  
**[5]**
35. (i) dative covalent, bonded pair comes from same atom/  
 electron pair is donated from one atom/  
 both electrons are from the same atom ✓ 1  
 (ii)  $\text{Ca}(\text{NO}_3)_2 \rightarrow \text{CaO} + 2\text{NO}_2 + \frac{1}{2}\text{O}_2$  ✓  
 or double equation with 2/2/4/1 1  
**[2]**
36. High boiling point **or** difficult to break linked to strong bonds in the right  
 context within Li **or** C ✓ 1  
 Li conducts by delocalised/free/mobile electrons ✓ structure: giant ✓ metallic ✓ 3  
 or '+ ions with a sea of electrons' for giant mark  
 C conducts by delocalised/free/mobile electrons ✓ structure: giant ✓ covalent  
 with layers ✓ 4  
 N No mobile charge carriers/electrons/ions to conduct electricity ✓  
 simple molecular structure/made of N<sub>2</sub> molecules ✓  
 low boiling point **or** easily broken due to 3  
 intermolecular forces/  
 van der Waals' forces ✓  
 QWC: At least 2 complete sentences in which the meaning is clear. ✓ 1  
**[12]**
37. CO<sub>2</sub>: correct covalent bonds around carbon ✓

outer shell electrons correct ✓  
 (must be 'dot AND cross' or electron source clearly shown  
 (different coloured for source?))

[2]

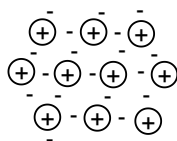
38. correct dot and crosses ✓  
 correct charges ✓

[2]

39. uneven distribution of electrons ✓  
 instantaneous /oscillating/changing/temporary/transient/  
 dipole on one atom ✓  
 causes an induced/resultant dipole on another  
 molecule/atom ✓  
 chlorine gas; bromine liquid; iodine solid/  
 volatility decreases from  $Cl_2 \rightarrow Br_2 \rightarrow I_2$ /  
 boiling point increases from  $Cl_2 \rightarrow Br_2 \rightarrow I_2$ /  
 stronger forces are broken from  $Cl_2 \rightarrow Br_2 \rightarrow I_2$  ✓  
 number of electrons increases down group ✓  
 greater/more van der Waals' forces / induced dipole-  
 dipole interactions / forces between the molecules ✓

[6]

40. (i)



positive ions ✓      electrons ✓      (must be labelled)

2

- (ii) electrons move ✓

1

[3]

41. simple molecular ✓

2

[2]



42. (i)  $\text{Cl}_2 + 2\text{I}^- \rightarrow \text{I}_2 + 2\text{Cl}^-$  ✓✓ 2  
1 mark for species.  
1 mark for balancing

(ii) *Cl* atom is smaller/has less shells ✓  
electron to be captured will be attracted more ✓ 2

[4]

43. (i) H bonding from O of 1  $\text{H}_2\text{O}$  molecule to H of another ✓  
dipoles shown ✓ with lone pair involved in bond ✓ 3

(ii) Two properties from:  
Ice is lighter than water/ max density at  $4^\circ\text{C}$  ✓  
*explanation:* H bonds hold  $\text{H}_2\text{O}$  molecules apart  
/ open lattice in ice  
/ H-bonds are longer ✓

Higher melting/boiling point than expected ✓  
*explanation:*

strength of H bonds that need to be broken ✓  
*must imply that intermolecular bonds are broken*

High surface tension/viscosity ✓  
*explanation* strength of H bonds across surface ✓ 4

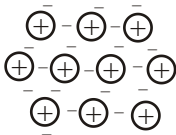
[7]

44.  $\text{NH}_3$ :  $107^\circ$  ✓ (range  $106 - 108^\circ$ )  
electron pairs repel other electron pairs ✓  
lone pair has more repulsion ✓  
electron pairs get as far apart as possible ✓

[4]

45. shared pair ✓ of electrons ✓  
*i.e. 'shared electrons' is worth 1 mark. pair of electrons for second mark*

[2]

46. H<sub>2</sub>O: all correct including lone pairs around O ✓  
 CO<sub>2</sub>: correct covalent bonds around carbon ✓  
       lone pairs added around oxygen atoms ✓  
 (must be 'dot AND cross' or electron source clearly shown  
 (different coloured for source is OK) [3]
47. (i) molecule shown as non-linear ✓  
       angle: 104 - 105° ✓  
       molecule shown as linear ✓ 4  
 (ii) angle: 180° ✓  
       shape of H<sub>2</sub>O  
       shape of CO<sub>2</sub>  
       Electron pairs repel/groups (or regions) of electrons 2  
       repel/electron pairs get as far apart as possible ✓  
       Oxygen in water surrounded by 4 areas of electron  
       density/2 bonds and 2 lone pairs  
       **AND**  
       Carbon in CO<sub>2</sub> surrounded by 2 regions of electron  
       density/2 double bonds ✓ [6]
48. (i) Attraction of electrons ✓ in a bond ✓ towards an atom 2  
 (ii) CO<sub>2</sub> is symmetrical/H<sub>2</sub>O is not symmetrical ✓  
       In CO<sub>2</sub>, dipoles cancel/in H<sub>2</sub>O, the dipoles don't cancel ✓ 2 [4]
49. (i)   
       positive ions/cations ✓ and negative electrons ✓  
       Can be described in words only for both marks 2  
 (ii) contain free/mobile/delocalised electrons ✓ 1 [3]
50. (i) shared pair of ✓ electrons ✓ 2



*i.e. 'shared electrons' is worth 1 mark. Pair of electrons for second mark*

- (ii) correct dot-and cross diagram ✓ 1 [3]

51. (i) electrostatic attraction ✓  
between oppositely charged ions ✓  
(charged or electrostatic for 1st mark) 2
- (ii) correct dot-and cross diagram ✓  
correct charges ✓ 2
- (iii)  $\text{Mg} \rightarrow \text{Mg}^{2+} + 2\text{e}^-$  ✓  
 $\text{F}_2 + 2\text{e}^- \rightarrow 2\text{F}^-$  ✓ 2  
*–sign not required with electron*
- (iv) solid: ions cannot move /in fixed positions in lattice ✓  
solution: ions are free to move ✓ 2
- [8]

52.  $\text{H}_2\text{O}$   
H bonding from O of 1 molecule to H of another ✓  
dipoles shown or described ✓ 3  
with lone pair of O involved in the bond ✓
- $\text{CH}_4$   
van der Waals' forces from oscillating dipoles/ temporary  
dipoles/ transient dipoles/ instantaneous dipoles ✓  
leading to induced dipoles ✓  
caused by uneven distribution of electrons ✓ 3
- [6]



53. Two properties from:  
Ice is less dense/lighter than water/floats on water/ max density at 4°C ✓
- explanation:* H bonds hold H<sub>2</sub>O molecules apart  
/ open lattice in ice  
/ H-bonds are longer ✓ 2
- Higher melting/boiling point than expected ✓  
*Not just high*  
*Accept: 'unusually high/strangely high/relatively high'*
- explanation:* H bonds need to be broken ✓ 2  
*must imply that intermolecular bonds are broken*
- High surface tension ✓  
*explanation* strength of H bonds across surface ✓  
*mark 2 properties only → 4 max*
- QoWC over whole question 1  
– legible text with accurate spelling, punctuation and grammar ✓

[5]