1. (a)

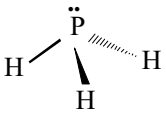
H	C
11.1 / 1	88.9 / 12 **(1)**
= 11.1	= 7.4
1.5	1 **(1)**

Empirical formula C_2H_3 **(1)** 3

(b) HI has more electrons **(1)**

has greater induced–dipole–induced dipole / vdW forces **(1)** 2

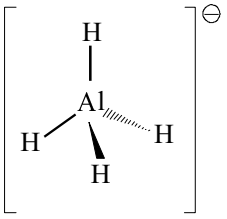
(c) (i) *pyramidal*



Need to show evidence of three dimensional or state it is pyramidal with two dimensional diagram **(1)**

3 bond pairs and 1 lone pair to get as far apart as possible **(1)** 2

(ii) *tetrahedral*



Need to show evidence of three dimensional or state it is tetrahedral with two dimensional diagram **(1)**

4 bond pairs around aluminium as far apart as possible **(1)** 2

(d) Amount of phosphine = 8.0/24000 **(1)**

$= 3.33 \times 10^{-4}$ mol

Number of molecules of phosphine $= 6.0 \times 10^{23} \times 3.33 \times 10^{-4}$ **(1)** 2

$= 2.0 \times 10^{20}$

[11]

2. (i) C 1

(ii) A 1

(iii) D 1

(iv) B 1

[4]

3. (a) Chlorine: yellow/green **(1)** gas **(1)**

brown solution or grey solid or black particles **(1)** 3

Bromine: red/brown **(1)** liquid **(1)** not orange or yellow brown or darker brown solution or grey solid or black particles **(1)** 3

last boxes must be observations

(b) (i) sharing **(1)** a pair of electrons **(1)** 2

(ii) weak intermolecular forces 1

require little energy to break 1

Non–polar/ temporary dipoles/ v.d.w. or some valid comment on weak interaction 1

Breaking covalent bonds scores 0

(c) (i) Intermolecular forces depend upon the number of protons / electrons or the size of the molecule

NOT mass 1

This number or size increases HCl < HBr < HI so (more energy needed) to separate molecules 1

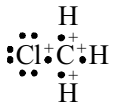
NB the relationship between the strength of the intermolecular forces and boiling/melting missed in (b)(ii) could be awarded in (c)(i)

(ii) HF has hydrogen bonding OR HF is more polar OR HF has bigger electronegativity difference OR F is more electronegative than Cl 1

Stronger intermolecular forces in HF than in HCl 1

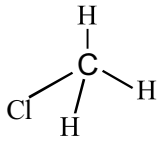
[15]

4. (a) 4 bond pairs around 1 carbon **(1)**



all electrons shown around chlorine **(1)** 2

(b) Correct tetrahedral diagram



Or poor diagram + 'tetrahedral' **(1)**

4 pairs (in words or diagram) of electrons around C arranged to minimise repulsion or as far apart as possible / four electron pairs repel each other equally **(1)** 2

(c) chloromethane has a (permanent) dipole / is polar **(1)**
methane does not / **only** has temporary dipoles or van der Waals forces **(1)**
attraction (forces) between dipoles **(1)**
stronger than van der Waals in CH_4 **(1)**

Increase in number of electrons in molecule ***(1)*** *causes increase in vdW forces of attraction between molecules* ***(1)*** *Scores maximum of 2 marks* 4

(d) hydrogen bonding in methanol **(1)**
between molecules **(1)**
even stronger than dipole-dipole / vdW / hydrogen strongest of all intermolecular forces **(1)** 3

[11]

5. (a) $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$ *ignore state symbols* 1

(b) Increases as group is descended
(or the reverse – decrease as the group is ascended) 1

(c) (i)
- Energy/heat/enthalpy change/needed/required per mole
- of gaseous atoms
- for the removal of 1 electron
  $Ca_{(g)} \rightarrow \rightarrow Ca_{(g)}^{+} + e^{-}$
  1 mark for formulae and charges
  1 mark for state symbols (unless already stated 'gaseous') 4

(ii)
- Decreases as group is descended, direction must be stated. (If wrong trend is stated, then no further marks are awarded for this question)
- Because outer electron further from nucleus
- More shielded 3

[9]

6. (a) For diagrams there must be some attempt at 3D

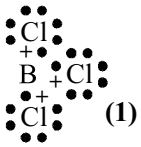
- Octahedral diagram
- Angle = 90°
- Repulsion between 6 bonding pairs / bonding pairs as far apart as possible 3

(b)
- Trigonal pyramidal diagram
- Angle = 106^o – 108^o
- 3 bp and 1 lp (or shown by dot and cross diagram) / lp repels more than bp 3

(c)
- Tetrahedral diagram
- Angle = 109^o – 110^o
- Repulsion between 4bp / 4 bonding pairs as far apart as possible 3

[9]

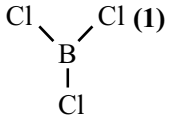
7. (a)



(1)

Must show all the outer electrons around the chlorine
Do not have to be • and + 1

(b) (i)



(1) 1

(ii) The (three) bonding (electron) pairs **(1)**
repel as far apart as possible / position of minimum repulsion
(1) *not stand alone*
not just equal repulsion 2

(c) (i) Power (of an atom) to attract (the pair of) electrons **(1)**
in a covalent bond / bonding pair **(1)** 2

(ii) Bonds arranged symmetrically /molecule symmetrical /bond polarities directional/ are vectors **(1)**
Bond polarities cancel **(1)**
Could be shown as a diagram

Note:
The answer to (b) is consequential on the answer to (a) in the following situation
If the candidate puts a lone pair of electrons on the boron

- *the shape mark can be given for a clear, 3-D diagram of a molecule with the same shape as ammonia*
- *the explanation will need to refer to both bond and lone pairs of electrons* 2

[8]

8. (a) (i) Ca brick red or orange red, Ba (apple) green **(1)** each 2

(ii) electrons excited / promoted **(1)**
fall to lower energy level / orbital **(1)**
give out energy in the visible region / in form of light **(1)** 3

(b) $2Ba(NO_3)_2 \rightarrow 2BaO + 4NO_2 + O_2$ **(2)**
species **(1)** balance **(1)** 2

(c) (i) ability (of a cation) to distort / change shape of **(1)**
the electron cloud around an anion **(1)** 2

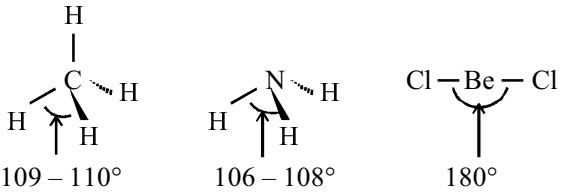
(ii) Size /radius /ionic radius **(1)** charge **(1)** 2

(iii) Mg^{2+} / magnesium **ion** smaller than Ba^{2+}/ barium **ion**
or
Mg^{2+} has higher change density **(1)**
Polarising power increases/ Mg^{2+} able to polarise the nitrate ion more effectively than Ba^{2+} **(1)**
this weakens the bonds in the nitrate / bonds in nitrate more easily broken **(1)** 3

[14]

9. (a)

(i) (ii) (iii)



Shape: **1 mark × 3**
Angle marked on diagram in correct place: **1 mark × 3** 6
Must be some attempt to show 3-D.
Poor diagram can be salvaged by correct name or correct bond angle.
Ignore lone pair on ammonia if shown.
If angle just written alongside diagram, penalise once

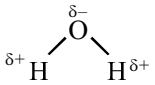
(b) (i) Temporary and/ or induced dipole forces **(1)** allow 'instantaneous' in place of 'temporary' 1
Allow London/dispersion/van der Waal's forces

(ii) Hydrogen bonding **(1)** 1

(c) HF **(1)** *consequential on some attempt at explanation..*
hydrogen bonding stronger / requires more energy to overcome (than vdW forces) / HF has stronger intermolecular force **(1)** 2

[10]

10. (i)



Correct partial charges on oxygen and at least one hydrogen **(1)** 1

(ii) Oxygen has higher electronegativity (than hydrogen) **(1)**
Oxygen attracts more or has greater share of covalent / bonding / shared…electrons / pair **(1)** 2

(iii) Polar / yes because / bond polarities don't cancel / dipoles don't cancel / vectors don't cancel / centres of positive and negative charge don't cancel (or don't overlap) **(1)** 1

[4]

11. (a) Protons 3 **(1)**
Neutrons 4 **(1)**
Electrons 2 **(1)** 3

(b) Relative atomic mass

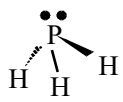
$= \frac{(6.02 \times 7.39) + (7.02 \times 92.61)}{100}$ **(1)**

6.95 (must be three s.f.) **(1)** 2

(c) • Dip Pt / nichrome wire in solid and place in hot/blue flame **(1)**
• Na salt gives yellow colour **(1)**
Li salt give deep / magenta red / crimson colour **(1)** 3

[8]

12. (a) (i) • Bond pairs 3 **(1)**
• lone pairs / **(1)** 2

(ii)  **(1)**

Angle (actual figure is 93) any value between 108 and 93 is acceptable **(1)** 2

(b) (i) • Hydrogen bonds **(1)**
• Induced dipole-dipole interactions / van der Waals / London / dispersion **(1)** 2

(ii) • Phosphine does not have hydrogen bonds **(1)**
• Lack of hydrogen bond not compensated by / increased induced dipole-dipole **(1)** 2

(c) (i) • When the pair of electrons shared by two atoms (in covalent bond) **(1)**
• both come from the same atom **(1)** 2

(ii) The lone pair on the nitrogen **(1)** 1

(iii) • Tetrahedral **(1)**
• has four pairs of bonding electrons **(1)**
repel as far away from each other as, possible / minimum repulsion **(1)** 3

[14]

13. (a) (i) Description of asymmetry of electron/charge cloud hence attractive forces between neighbouring induced dipoles 1

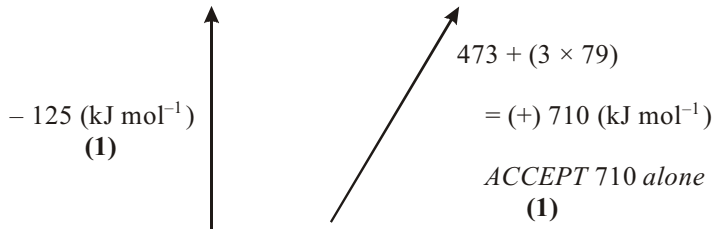
(ii) NCl_3 / chlorine because more electrons 1

(iii) NF_3 because F more electronegative (than Cl) 1

(iv) Van der Waals forces more significant/greater than permanent dipole-dipole interactions 1

(b) (i) N(g) + 3F(g) in top right-hand box
½ N_2(g) + 1 ½ F_2(g) in lower box. 1

(ii)



Arrows in correct directions and labelled with correct data 2

(iii) $\Delta H^{\ominus}_{at}$ for $[NF_3(g)] \rightarrow N(g) + 3F(g) = 710 - (-125) = (+) 835$ (kJ mol $^{-1}$) **(1)**

$E(N - F) = \frac{835}{3} = (+) 278$ kJ mol^{-1} **(1)**

Penalise 4 or more SF
Penalise incorrect units 2

[9]

14. (a) *Trend* - boiling point increases down the group / from He to Xe or Rn **(1)**
Reason – number of electrons (and protons) increases **(1)**
Increased strength of van der Waals'/ dispersion / London forces / temporary dipoles / induced dipoles / attraction between nucleus and electrons on other atom **(1)** 3

(b) (i) P or S or Cl / P_4, S_2, S_8, Cl_{12} / names 1

(ii)
- The atoms of silicon are held together by covalent bonds across the whole structure (1)
- High energy required (to break bonds) (1) consequential on indication of covalent. Mention of ionic or metallic or van der Waals' forces loses both marks. 2

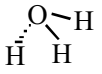
(iii)
- 1. Magnesium ion has larger charge (density) than sodium / magnesium contributes two electrons per atom to the 'sea' of electrons. **(1)**
- 2. Hence magnesium (ions) have greater attraction for (sea of) electrons than sodium. **(1)**
- 3. Melting requires energy to overcome this attraction, hence greater attraction means higher melting temperature **(1)**

This mark is consequential upon the concept of metallic bonding. 3

[9]

15. (a) Bent / v- shaped **(1)** non-linear (0) unless clarified by diagram
- Oxygen has two lone pairs and two bonding pairs **(1)**
- Basic shape of electron pairs is tetrahedral / shape based on 2 bonds or 3 atoms / electron pairs repel to positions of maximum separation / minimum repulsion **(1)** 3

(b) Pyramidal **(1)**



(1) 2

(c) (i)
- Hydrogen bond is force of attraction between the hydrogen of one and the oxygen in a second molecule **(1)**
- It arises because of the electronegativity difference between the oxygen and the hydrogen in the molecule **(1)**
- which sets up a δ+ and a δ– charge on the atoms **(1)** 3

(ii)
- Water is more dense than solid ice **(1)**
- The hydrogen bonds in solid ice which hold the molecules together are in fixed positions and lead to an open structure **(1)**

In water the hydrogen bonds are (constantly) being broken and made **(1)** 3

[11]

16. (a) (i) White / colourless 1

(ii) Yellow / orange 1

(iii) $2Br^- + Cl_2 \rightarrow Br_2 + 2Cl^-$ *ACCEPT multiples* 1

(iv) Separate layers – *stated or implied* **(1)**
Organic /Hydrocarbon / upper layer coloured orange **(1)** 2

(b) (i) Sulphur / S)
Bromine / Br) ✓ **(1)**

S, initially –2, finally +1 *sign needed* **(1)**
Br,initially 0, finally –1 **(1)** 3

(ii) $2 \times +3 = +6$, $6 \times -1 = -6$
OR total change in ON of S = +6, total change in ON of Br = –6
OR Up 6, down 6
OR 6 electrons lost, 6 electrons gained 1

(c) (i) Greater **van der Waals** attractions in HI / iodine **(1)**
because it has more **electrons (1)**
Can be from a HBr perspective 2

(ii) Hydrogen / H bonding in HF (but not in HBr or HI) 1

(iii) Within range 174 to 195 (actually 188) (K) **(1)**
Fewer electrons than in HBr (but no hydrogen bonding)
weaker van der Waals forces than in HBr **(1)** 2

[14]

17. (a) (i) $(1s^2)2s^2 2p^6$
OR $2s^2 2p_x{}^2 2p_y{}^2 2p_z{}^2$ 1

(ii) $2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$ / $2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6$ 1

(b) Krypton because **greater/ stronger** (*NOT* **more**) van der Waals'/
London/ dispersion/ temporary or induced dipole forces / attractions **(1)**

Because of larger number of **electrons**/ extra shell(s) of electrons **(1)** 2

(c) (i) Sample bombarded/ fired at by electrons/ electron gun **(1)**

Knocks out/ loses/ removes electrons from the sample
Or equation **(1)** 2

(ii) Electric/electrostatic field/ (negatively) charged plates/ potential difference 1

(iii) Magnetic field/ (electro)magnet 1

[8]

18. (a) (i) +7/7+ /VII 1

(ii) +7/7+ /VII 1

(b) (i) $Sn^{2+} \rightarrow Sn^{4+} + 2e^{(-)}$ *OR* $Sn^{2+} - 2e^{(-)} \rightarrow Sn^{4+}$ **(1)**

$I_2 + 2e^{(-)} \rightarrow 2I^-$ **(1)** 2

(ii) $Sn^{2+} + I_2 \rightarrow Sn^{4+} + 2I^-$
IGNORE state symbols 1

[5]

19. (a) Substance that accepts / removes/ takes electrons or gains electrons from ... **(1)**
fluorine/F/F2 **(1)** 2

(b) (i) $Cl_2 + 2OH^- \rightarrow Cl^- + ClO^- + H_2O$

Formulae **(1)**

Balancing **(1)** – *dependent on 1st mark*

Balanced molecular equation **(1)** only 2

(ii) Disproportionation 1

(c) (i) $NaCl + H_2SO_4 \rightarrow NaHSO_4 + HCl$
Or $2NaCl + H_2SO_4 \rightarrow Na_2SO_4 + 2HCl$
IGNORE state symbols 1

(ii) Misty/ steamy fumes/ gas/ vapour
OR bubbles/ effervescence/ fizzing
OR gets / feels hot / heat comes out 1

(d) (i) Trigonal planar diagram **(1)**
120° marked on diagram **(1)** 2

(ii) Trigonal bipyramidal diagram including an attempt at 3–D **(1)**
120° marked on diagram **(1)**
90° / mathematical right angle sign marked on diagram **(1)**
in (i) and (ii) correct name can rescue a poor but not an incorrect diagram 3

[12]

20. (a) (i) Electron pair/ lone pair acceptor
Or accepts electrons to form a (dative) covalent bond 1

(ii) Particle with an unpaired electron 1

(iii) Electron pair/ lone pair donor
Or donates electrons to form a (dative) covalent bond 1

(b) (i) Nucleophilic **(1)**
Substitution **(1)** 2

(ii) (Free) radical **(1)**
Substitution **(1)** 2

(iii) Electrophilic **(1)**
Addition **(1)** 2

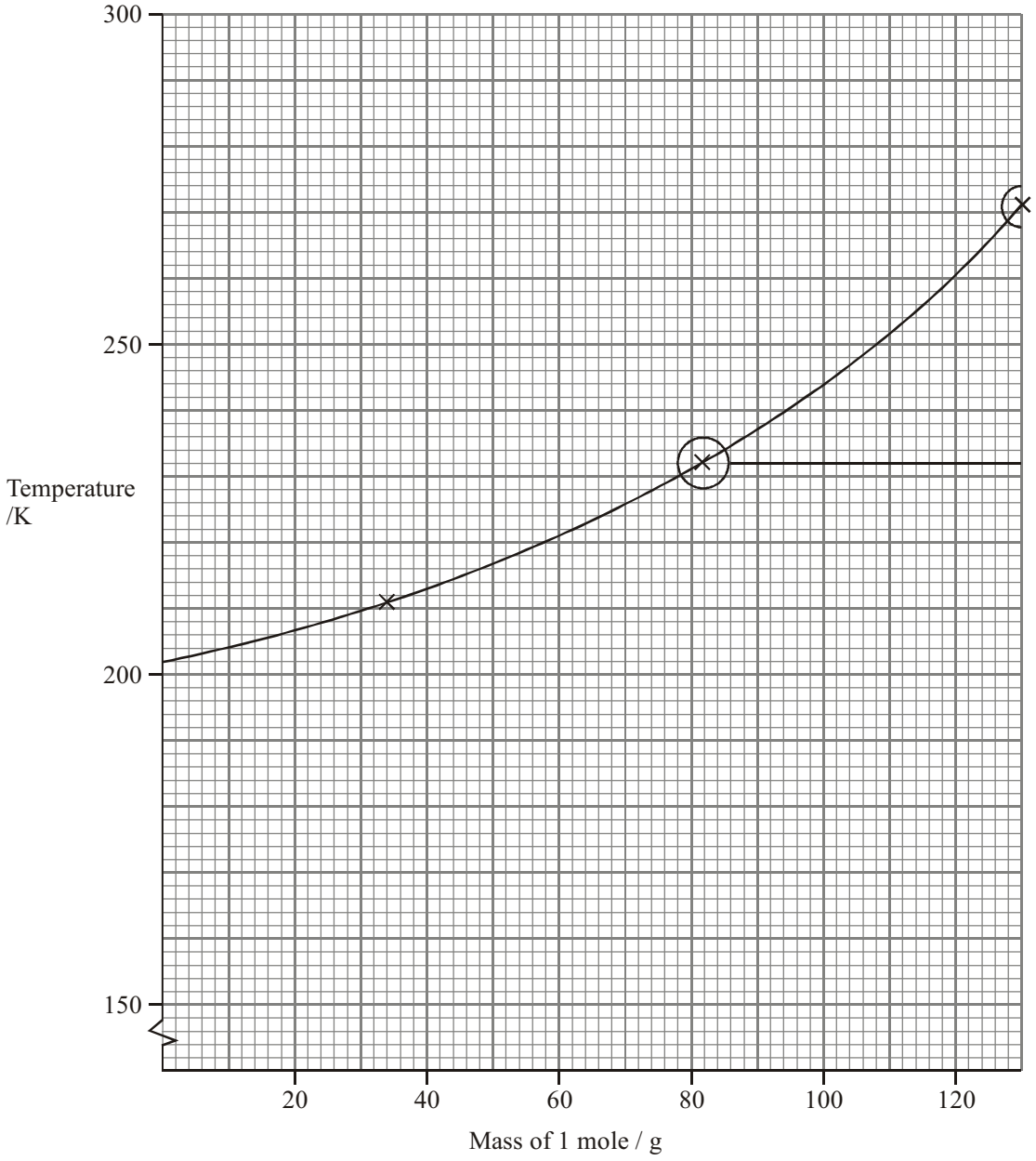
[9]

21. (a) Diagram showing
Electrons 2,8 **(1)**
Charge 2+ **(1)** 2

(b) Energy/light/radiation
is emitted outside the visible spectrum/ in UV region
or frequency/wavelength/emission outside visible region. 1

22. (a) 81 g mol^{-1} 1

(b) (i)



correctly plotted points **(1)**
smooth curve **(1)** 2

(ii) As you go down the group the number of electrons increases. **(1)**
so the strength of the van der Waals forces increase. **(1)** 2

(c) (i) 204 – 210 K 1

(ii) *Hydrogen/H- bonds* 1

(iii) *Oxygen is more **electronegative** than the others (because the outer electrons are closer to the nucleus)* 1

(iv) ammonia **(1)**
hydrogen fluoride **(1)** 2

(d) Higher surface tension)
Comparison of density of water and ice ie ice is lighter than water)
It expands on freezing)
Higher enthalpy change of vaporization) *Any two*
Shape of snow flakes/ice crystals)
Higher viscosity)
Higher heat capacity) 2

[12]

23. (a) (i) *ALLOW 3 or 4 sig figs – penalise once only*
MUST be some working

moles P = 93/31 = 3.0 **(1)**
moles PCl_3 also = 3.0 **(1)**
mass PCl_3 = 137.5 × 3.0 = 412.5 / 413 (g) **(1)**
OR alternative route
Max 2 *if wrong units* 3

(ii) moles Cl_2 = 3/2 × 3 = 4.5 **(1)**
volume of Cl_2 = 4.5 × 24 = 108 (dm^3) **(1)** - *consequential on 1st mark* 2

(iii) Cl_2 *with **attempt** at reason* **(1)**
because gains electrons / ox. no. becomes more negative / oxidation number decreases / 0 → –1
OR
P loses electrons / oxidation number increases / 0 → +3 **(1)** 2

(b) (i) Outer shell of P in a molecule **(1)**
Cl lone pairs / six more electrons around each Cl **(1)**
Lone *pair must be in the same space.* 2

(ii) Trigonal pyramidal diag. **(1)**

Must be some attempt to show 3-D. A poor diagram can be rescued by a correct name.

100 – 108° **(1)** NOT consequential 2

(c) Tetrahedral 1

[12]

24. (a) bonding: (giant) **covalent (1)**
Diag. shows at least 5 carbon atoms correctly joined **(1)**

plus a hexagonal ring **(1)**
Must NOT be graphite 3

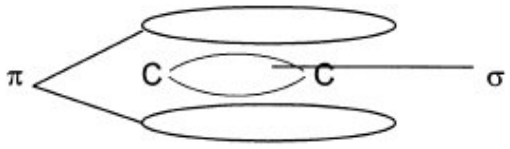
(b) **ions** mobile(in molten) / can move **(1)** *NOT* "free" *on its own*
fixed positions in solid / cannot move **(1)**
Max 1 if only one ion mentioned eg Na^+ 2

[5]

25. (a) (i) $C_2H_6(g)/(l) \rightarrow C_2H_4(g) + H_2(g)$
If a state symbol is missing **(0)**
If (aq) **(0)** 1

(ii) At high pressure reaction goes in direction to reduce pressure/to oppose change by Le Chatelier's principle **(1)**
towards side with fewer molecules/moles **(1)** 2

(b) Shapes of orbitals between and above carbon



If p orbitals drawn msut show overlapping

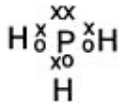
Shapes **(1)** ACCEPT crescents for π bonds NOT lines for σ bond 2
Labels **(1)**

(c) Addition of bromine **water/solution (1)**
from yellow/brown/orange to **colourless (1)**
OR
acidified potassium manganate(VII) **(1)**
from pink/purple to **colourless (1)** 2

(d) Addition **(1)**
Elecrophilic/electrophile *OR* appropriate *explanation* **(1)** 2

[9]

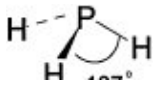
26. (a) (i)



1

ACCEPT all dots/crosses

(ii)



Trigonal pyramid/Tetrahedral/'Three leg stool' shape **(1)** –
must be some attempt at 3D or correct name
107° *ALLOW* 92-108 **(1)** 2

(iii) repulsion between four pairs of electrons gives
tetrahedral shape **(1)**)
Greater repulsion of non-bonding electrons/lone pair
closes down tetrahedral bond angle **(1)** 2

(b) (i) $PH_3(g) \rightarrow P(g) + 3H(g)$ 1

(ii) Hess applied **(1)**
Multiples **(1)**
Correct answer + 963(.2)/960 **kJ mol^{-1} (1)** 3

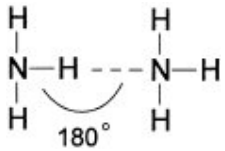
(iii) Answer to (ii) divided by 3
+ 321(.1)/320 **kJ mol^{-1}** 1

[10]

27. (a) Phosphine has more electrons 1

(b) (i) Hydrogen/H bonds 1

(ii)



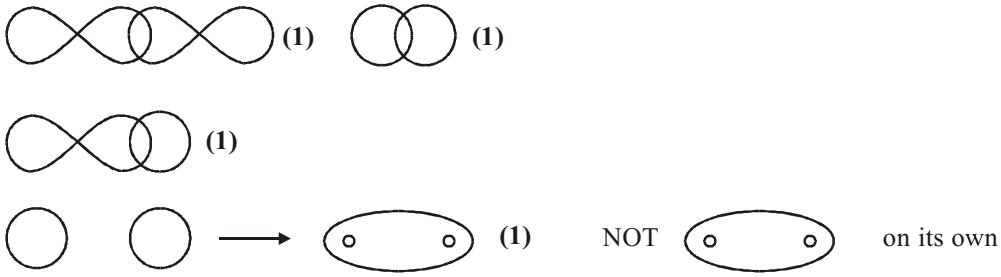
Correct atoms **(1)**
Angle 180° /N-H ··· N in straight line **(1)** 2

[4]

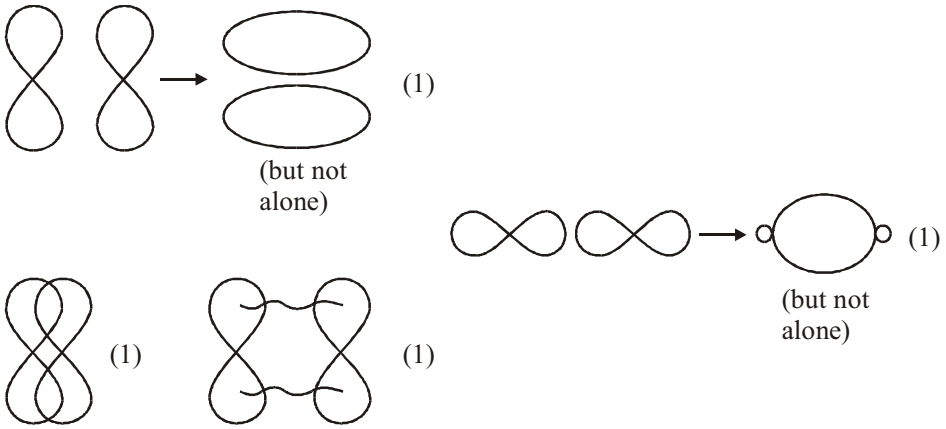
28. Diagram showing correct covalent and hydrogen bonds **(1)**
Linear around H and water shown "V" shaped **(1)**
δ+ H and δ– O **(1)**
due to difference in electronegativities / because both atoms small /
description of involvement of lone pair **(1)** 4

[4]

29. (a) σ bond:
diagram showing the head on overlap between two (s or p or s & p) orbitals **(1)**,



π bond:
diagram showing the side by side overlap of two (p) orbitals **(1)**



2

(b) (i) Methane is tetrahedral **(1)** – *stated or drawn 3D*
It has **4 pairs** of electrons **(1)**
Which repel to a position of maximum separation / minimum repulsion could be awarded from (ii) **(1)** – *can score even if first two are wrong*
Do not allow atoms or bonds repelling 3

(ii) Shape of CO_2 is linear **(1)** – *can be a diagram*
1st mark is stand alone

because there are 2 pairs of σ electrons / 2 sets of bonding electrons / 2 areas of negative charge/2 double bonds **(1)** 2

[7]

30. (a) Van der Waals/induced dipole-dipole 1

(b) (i) Hydrogen/dipole-dipole in **propan-1-ol**,(but no hydrogen/ dipole-dipole in butane) 1

(ii) Van der Waals forces in propan-1-ol are stronger
OR reverse argument **(1)**
because chain is not branched/so more surface contact between molecules)
OR reverse argument **(1)** 2

[4]

31. (a) (i) $(1s^2)2s^2 2p^6 3s^2 3p^6 4s^2$
OR
$(1s^2)2s^2 2p^6 3s^2 3p^6 3d^0 4s^2$
OR
$(1s^2)2s^2 2p^6 3s^2 3p^6 4s^2 3d^0$
ALLOW subscript numbers in place of superscripts

$2p^6 \equiv 2p_x^2 2p_y^2 2p_z^2$ numbers must be superscript
$3p^6 \equiv 3p_x^2 3p_y^2 3p_z^2$ *numbers must be superscript*
IGNORE caps 1

(b) (i) Energy/ enthalpy / heat energy change / required per **mole (1)**
NOT evolved
for the **removal of 1 electron (1)**
from **gaseous atoms** *NOT* molecules **(1)**
OR
$X(g) \rightarrow X^+(g) + e^-$ *states required for 2nd and 3rd marks* **(2)**
Can be actual symbol of an element
ACCEPT - $e^{(-)}$ 3

(ii) (Even though) there is a greater nuclear charge / number of protons
OR nuclear charge increases down the group **(1)**
outer / **valency** electron(s) further from nucleus *NOT* "shell" *on its own* **(1)**
and **more** shielded *OR* **more** (filled) inner shells/electrons **(1)** 3

(c) (i) Similarity: number of protons (proton number) **(1)**
IGNORE electrons
NOT atomic number

Difference: number of neutrons
[correct numbers can be given]
NOT atomic mass or number of nucleons **(1)** 2

(ii) $\frac{(24\times 78.6)+(25\times 10.1)+(26\times 11.3)}{100} = 24.3$

Method **(1)**

Answer must be to 3 SF **(1)**

Correct answer to 3 SF with some working **(2)**

IGNORE g or g mol^{-1} *other wrong units lose a mark* 2

[11]

32. (i) $Na \rightarrow Na^+ + e^{(-)}$ *OR* $Na - e^{(-)} \rightarrow Na^+$ **(1)**

$\frac{1}{2} Cl_2 + e^{(-)} \rightarrow Cl^-$ **(1)**

IGNORE state symbols

ALLOW multiples 2

NOT Cl + $e^{(-)} \rightarrow Cl^-$

NOT $Cl \rightarrow Cl^- - e^{(-)}$

NOT $\frac{1}{2} Cl_2 \rightarrow Cl^- - e^{(-)}$

(ii) $Na + \frac{1}{2} Cl_2 \rightarrow NaCl / Na^+Cl^-$ NOT $Na^+ + Cl^-$

Stand alone but not consequential on incorrect half equations

ALLOW multiples

IGNORE state symbols 1

[3]

33. (a) (i) moles silicon = 10/28 = 0.357 **(1)**

moles $SiCl_4$ = 0.357 **(1)**

mass = 0.357 × 170 = 60.7 / 60.69 (g) *ALLOW 2- 4 SF* **(1)**

OR by mass ratio

Units not required but if given must be correct.

Correct answer with some recognisable working **(3)**

Correct answer with no working **(1)** 3

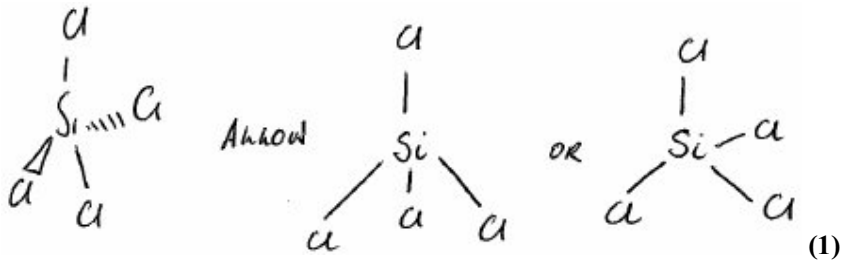
(ii) moles chlorine = 2 × 0.357 moles Si × 2 **(1)** **(1)**

$\therefore$ vol = 0.714 × 24.0 = 17.1 (dm^3) moles Cl_2 × 24 **(1)** **(1)**

ALLOW TE from (i)
ALLOW 2 – 4 SF
Units not required, but if given must be correct
Correct answer with some recognisable working **(2)**
Correct answer with no working **(1)**
Penalise SF once only across (i) and (ii) 2
Penalise units once across (i) and (ii)

ratio	10/28	10/28 = 0.357	10/28 = 0.36	10/28 = 0.4 loses SF mark
mass	60.69	60.71	61.2	68
vol	17.14	17.14	17.3	19.2

(b)



(1)

Wedges ***not*** *required e.g.*
Atoms can be represented by circles etc provided there are 4 of one type and 1 of another

tetrahedral **(1)**

Any angle in range 109 – 109.5 ° **(1)**
degree symbol can be shown on diagram **(1)**

4 (bond) pairs of electrons / 4 bonding pairs **(1)**
NOT bonds
NOT atoms
NOT groups of electrons

Repel to position of **minimum** repulsion / **potential energy** *NOT* "Equal repulsion" **(1)**
OR Repel to position of **maximum** separation 5

4th mark cannot be awarded if atoms referred to

(c) (i) Si and Cl have different electronegativities / Cl attracts the **bonding electrons** very / more strongly / Si less electronegative than Cl / Cl **very** electronegative — 1

(ii) symmetrical molecule / chlorines equally spaced **(1)**
bond polarities / dipoles / vectors cancel
OR
Centres of positive and negative charge coincide / vectors cancel. **(1)** — 2

[13]

34. (a) (i) 1-chloropropane has more electrons than chloroethane **(1)**

So van der Waals' forces (between molecules) stronger/greater
OR
More/greater van der Waals' forces **(1)**

OR reverse argument

If dipoles are mentioned they must be temporary /induced / transient / fluctuating / flickering — 2

(ii) Molecules in 2-chloropropane make less contact / pack less well / can get closer together OWTTE

ACCEPT annotated diagram

If the explanation about van der Waals' forces is given here allow it in (i) UNLESS incorrect intermolecular force mentioned in (i) — 1

(b) (i) Reagent with a lone pair of electrons
OR
Pair of electrons which it can use to make a bond
OR
Reagent which attacks species with a (δ) + charge

NOT "attacks nucleus" *on its own*
NOT "species with a negative charge" — 1

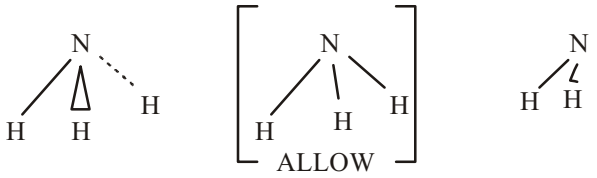
(ii) C-l bond is weaker than C-Cl
Must say which bond is weaker — 1

(c) (i) Use ethanolic KOH/KOH in alcohol/KOH in ethanol/ ethanol as solvent (and raise temperature) — 1

(ii) Elimination **(1)**
IGNORE comment on what is eliminated
IGNORE qualification eg electrophilic — 1

[7]

35. (a) Trigonal pyramidal diagram



IGNORE lone pair
*If trigonal planar/octahedral stated (**–1**)*
Allow tetrahedral stated,
must be some attempt at 3D i.e. must NOT look planar

$106 – 108^0$ marked on diagram *OR* stated

4 pairs (of electrons) / 3 bond pairs and 1 lone pair repel to maximum separation / minimum repulsion

lone pair (–bond pair) repulsion > bond pair (–bond pair) repulsion 4

(b) N more electronegative than H / N and H different electronegativity / (N-H) bonds polar/ δ^- δ^+ N – H

Dipoles do not cancel/dipoles not symmetrical (*ALLOW* molecule not symmetrical) / centres of positive and negative charge do not coincide **so polar molecule**

ALLOW vector diagram **(1)**
explanation **(1)** 2

(c) ammonia has H bonding (but PH_3 does not)
phosphine has induced dipole (–induced dipole) / dispersion / London / van der Waals
IGNORE dipole–dipole

Hydrogen bonding **stronger** so more **energy / heat** needed (to separate ammonia molecules)

Comparison mark only if two forces correctly identified. 3

(d) (i) **lone pair** on **N**
forms **dative** / **co-ordinate** bond with $\mathbf{H^+}$ 2

(ii) p = 11
e=10 2

[13]

36. (a) N_2O 1

(b) Refrigerants/heat transfer agents and anaesthetics / they share similar properties
OR properties exemplified

eg non flammable/non toxic/volatile - a*ny **two** of these*

OR

Refrigeration technology resulted in the production of CFCs which were then found to have properties of anaesthetics

OR

Refrigerants/heat transfer agents were found to be anaesthetics 1

(c) Inertness of **fluorine in the C-F bond**
Inertness of fluorine in the CF_2 / CF_3 groups
$CF/CF_2/CF_3$ group conferred stability on **adjacent/neighbouring** C—Hal bonds
NOT inertness of C-F bond/fluorine alone 1

(d) (i) There is a greater difference between the electronegativities of fluorine and hydrogen than between fluorine and chlorine / chlorine is more electronegative than hydrogen

Answer in terms of relevant relative shifts in electron densities are acceptable.
ACCEPT answers based on relative symmetries, e.g. electron cloud in CF_3CCl_3 is more symmetric than with CF_3CH_2Cl
ACCEPT argument in terms of electropositivities 1

(ii) CF_3CH_2Cl
because it possesses C–H bonds
OR enables (electrostatic) interactions with "brain molecules"
OR because a lower dose can be used 1

(e) (2) - bromo - (2) - chloro - 1,1,1 - trifluoroethane
OR
(1) - bromo - (1) - chloro - 2,2,2 - trifluoroethane
IGNORE punctuation

ACCEPT non alphabetic versions
NOT bromochlorotrifluoroethane 1

(f) 100-106.5 °
Any value or range of values within this range 1

Marking for key points
One mark should be awarded for **every** key point clearly identified in an answer.

Key points minus word penalty = maximum 6 marks

To gain the mark for a key point the wording used by the candidate must make clear the essential chemistry of the point.

Key points

<u>Advantages of using halothane</u>: Any 5 (max) of these key points

1 Halothane is non/less flammable/ non explosive/toxic.
ALLOW inverse argument with reference to $CHCl_3$, ether or 'earlier anaesthetics' **(1)**

2 It does not cause gastric irritation / post operative vomiting.
ALLOW inverse argument with reference to $CHCl_3$, ether or 'earlier anaesthetics' **(1)**

3 It is not thought to cause **irreversible** liver damage **with repeated dosage.**
ALLOW inverse argument **(1)**

4 Halothane contains a C–Br /bromine **/ C–H** bond**,** so is **safer** (to use than other CFCs).
ALLOW inverse argument **(1)**

5 Halothane produces narcosis /anaesthesia/deep sleep at low(er) doses/concentrations (than other CFCs)
OR halothane does not need high dose which lead to breathing paralysis. **(1)**

6 Halothane (was a potent inhalation agent) with a **smooth, pleasant induction** (period for the patient). **(1)**

<u>Why halothane's use declined:</u>

7 Halothane is associated with **post-operative liver dysfunction**. **(1)**

8 **Safer** and **cheaper** anaesthetics/agents (such as enflurane and isoflurane) were discovered. **(1)** 6

Quality of Written Communication

These should *be impression* marked on a scale 2-1-0, and the mark out of 2 should be recorded in the body of the script at the end of the answer.
This mark can not be lost as a result of a word penalty.

Candidates are expected to:
- show clarity of expression;
- construct and present coherent argument;
- demonstrate effective use of grammar punctuation and spelling.

The aspects to be considered are:

- use of technical terms; the answer should convey a correct understanding by the writer of the technical terms used in the passage which are involved in the key points.
- articulate expression; the answer should be well–organised in clear, concise English, without ambiguity. It should read fluently, with the links between key points in the original maintained.
- legible handwriting; the reader should be able to read the answer without difficulty at normal reading pace, with only the occasional difficulty with a word.
- points must be in a logical order.

Good style and use of English, with only infrequent minor faults, no use of formulae **(2)**

Frequent minor or a few major faults in style and use of English **(1)**

Very poor style and use of English **(0)**

NB: The quality of written communication mark cannot be lost through word penalties. 2

[7]

37. (a) (i) Covalent 1

(ii) Induced-dipole(-induced dipole)/dispersion/London/v der Waals/vdw
Temporary or instantaneous can be used instead of induced

NOT "dipole" forces
NOT permanent dipole
NOT dipole-dipole 1

(iii) polymer has stronger/more vdw/intermolecular forces **(1)**
ALLOW dipole forces
because it has more electrons/larger electron cloud/more contact area **(1)**
NOT larger molecules/surface area

so more energy/heat needed to overcome/break these forces
OR so more energy/heat needed to separate these molecules **(1)**
NOT breaking **bonds** 3
3rd mark is NOT stand alone

(b) **strong** attraction between Mg **ions**/Mg^{2+}/cations/metal ions **(1)**
NOT electrostatic forces/metallic bonds

and **delocalised/sea** of electrons **(1)**
Mark independently 2

[7]

38. (a) (i) –1/–l, 0 –1/–l, 0
minus can be either side, sub or superscript

iodine no's correct **(1)**
chlorine no's correct **(1)** 2

(ii) chlorine oxidation number goes down/goes from 0 to –1, so reduced **(1)**

iodine oxidation number goes up/goes from –1 to 0, so oxidised **(1)** 2
Mark consequentially on (a)(i)

(iii) moles NaI = $\frac{30.0}{150} = 0.2$ **(1)**

moles $I_2 = 0.1$ **(1)**

mass of $I_2 = 0.1 \times 254 = 25.4$ (g) **(1)**

OR
300g NaI **(1)** → 254g I_2 **(1)**

$30.0 \times \frac{254}{300} = 25.4$(g) **(1)**

Correct answer with some working **(3)**
Use of atomic numbers **2 max**
Penalise wrong units 3

(iv) vol = $0.1 \times 24 = 2.4$ (dm^3) 1
If not 2.4, check for consequential on (a)(iii)

(b) (i) black/grey/grey-black **(1)**
NOT blue-black
NOT purple
IGNORE shiny/silvery
Solid **(1)** 2

(ii) $I(g) \rightarrow I^{+}(g) + e^{(-)}$ *OR* $I(g) - e^{(-)} \rightarrow I^{+}(g)$

species **(1)**
state symbols **(1) -** *award state symbols mark only if species correct and in correct place, or if wrong halogen used*
If I_2 *OR* $\frac{1}{2}I_2$ **(0)** 2

[12]

39. (a) (i) 4 pairs of electrons /2 lone pairs and 2 bond pairs **(1)**

so electron pairs arranged tetrahedrally
OR
Arranged to give maximum separation/minimum repulsion **(1)** 2

(ii) 103 – 105 $^{(\circ)}$ **(1)**

lone pair repulsion> bond pair repulsion **(1)** 2

(b) (i) trigonal planar diagram **(1)**
e.g two opposite wedges gets **(1)**
three wedges of two types gets **(1)**
one wedge only gets **(0)**
IGNORE name

120 $^{(\circ)}$ marked on diagram **(1)** - *stand alone* 2

(ii) B and Cl have different electronegativities / Cl more electronegative than B 1
OR different electronegativities explained

(iii) Dipoles (or vectors) cancel/symmetrical molecule/centres of positive and negative charges coincide
IGNORE polarity cancels 1

(iv) Induced-dipole(-induced dipole)/dispersion/London/v der Waals/vdw
Temporary or instantaneous can be used instead of induced

NOT "dipole" forces
NOT permanent dipole
NOT dipole-dipole 1

(c) $\frac{14.9}{31} = (0.481)$ $\frac{85.1}{35.5} = (2.40)$ **(1)**

$\frac{0.481}{0.481} = 1$ $\frac{2.40}{0.481} = 5$, so $\mathbf{PCl_5}$ **(1)**

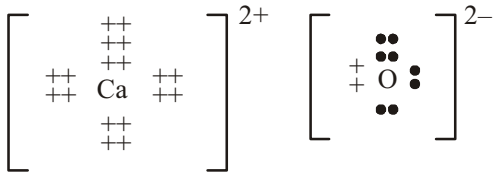
Use of atomic number **max 1** 2

[11]

40. (a) $Ca + ½ O_2 \rightarrow CaO$ 1

IGNORE state symbols
ALLOW multiples

(b)



(1) **(1)**

ALLOW all dots or all crosses for oxide ion
Max 1 if no/wrong charges
1 mark for two correct charges
*Covalent bonding **(0)*** 2

(c) (i) Calcium hydroxide 1
NOT limewater

(ii) 10 – 14 1

[5]

41. (a) Oxidised as electrons lost / forms positive ion / oxidation number has increased.
If oxidation numbers are quoted, must be correct ie 0 to +1 1

(b) (i) **<u>Na</u>** yellow
ALLOW orange/yellow-orange/orange-yellow **(1)**
NOT shades of red

Mg no colour / does not change flame colour **(1)**
NOT references to white light in combination with a flame colour
NOT ultraviolet 2

(ii) Electrons are excited / raised to a higher energy level / shell with different energy **(1)**

Then return / fall back emitting light/ a colour / a certain wavelength / frequency **(1)** 2

(iii)

Streetlights
OR (colour for) fireworks
OR measuring Na^+ concentration/testing for sodium
OR lamp with standard wavelength
NOT distress flares
NOT light bulbs

} *Anyone* 1

(c) $1s^2 2s^2 2p^6$ 1

(d) (i) $Mg(g) \rightarrow Mg^+(g) + e^{(-)}((g))$
OR
$Mg(g) - e^{(-)}((g)) \rightarrow Mg^+(g)$

Equation **(1)**
state symbols **(1)** 2

2nd mark can be given if:

- *electron is on wrong side eg* $Mg(g) + e^- \rightarrow Mg^+(g)$
- *2nd ionisation energy given eg* $Mg^+(g) \rightarrow Mg^{2+}(g) + e^-$
- *If cumulative first and second ionisation energy given*

eg $Mg(g) \rightarrow Mg^{2+}(g) + 2e^-$

Multiples of the equation are not allowed
If equation is given correctly for wrong element eg sodium, Na, ***max 1***
If equation is given using a letter like M or X, ***max 1***

(ii) Mg has more protons / greater atomic number / greater nuclear charge **(1)**

Shielding unchanged / electrons removed from same sub-shell / orbital **(1)**

IGNORE comments on Na "wanting" to lose electron 2

(iii) Value between 900 to 3000 inclusive (actual is 1451) (kJ mol^{-1}) **(1)**

(>738 because) e^- removed from a +ve ion / is higher than 1st ionisation energy **(1)**
ALLOW ratio of protons:electrons is higher than in atom/electron in Mg^+ closer to nucleus/ radius of Mg^+ smaller

(< 4563 because) e^- in Mg is from same shell / lower the Na as second e^- in Na is taken from shell closer to the nucleus / removing second e^- from Mg is not breaking into a new energy level **(1)** 3

(e) Na larger as fewer protons/ smaller nuclear force on electrons. 1

[15]

42. (a) (i) H(g) + O(g) + Cl(g) *in top RH box*

½ H_2(g) + ½ O_2(g) + ½ Cl_2(g) in lower box
Brackets around the state symbols are not required 1

(ii) 589 – 667 = –**78** (kJ mol^{-1})
ALLOW final answer on its own 1

(iii) 667 – 464 = (+)**203** (kJmol^{-1})
ALLOW final answer on its own 1

(b) (i)

ALLOW all dots/crosses
*ALLOW **1 max** if electrons are correct but atoms are not identified*
*If ionic dot and cross diagram **(0)*** 2

(ii) 100 – 106° **(1)**

as lone / non-bonding pairs take up **more** space/
repel **more strongly** than bonded pairs **(1)**
NOT bonds being repelled/H and Cl being repelled 2

(c) No change **(1)**

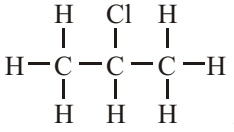
as number of **gaseous** reactant molecules = number of **gaseous** product molecules **(1)**

*ALLOW **1 max** if candidates state or imply a very small change with correct justification*

eg "hardly changes"
"doesn't change much"
"very little effect/change" 2

[9]

43. (a) (i) 2(-)chloropropane

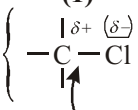


No internal TE from name to structure

MUST be fully displayed 2

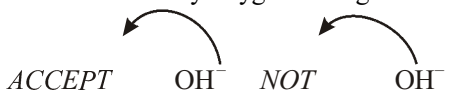
(ii)

(1)

IGNORE rest of molecule 

(1)

Mark independently
Must attack the carbon
ALLOW attack by oxygen or negative charge or lone pair 2



NOT C^+

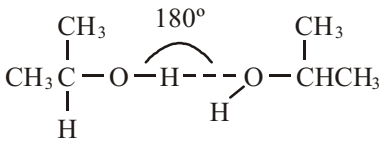
(b) (i) Elimination
NOT in conjunction with additional incorrect information
eg "nucleophile" 1

(ii) Sodium hydroxide / NaOH/potassium hydroxide / KOH **(1)**
*Any additional incorrect reagent **(0)***
NOT alkali on its own for 1st mark

Alcoholic solution / ethanolic solution **and** heat / warm / reflux **(1)**
2nd mark is dependent on mention of correct reagent or "alkali"
"aqueous" negates 2nd mark eg KOH(aq) + heat **(1)** *– ie reagent mark*
NaOH(alc) + heat **(2)** 2

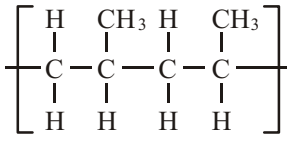
(c) (i) Hydrogen/H bonding 1

(ii)



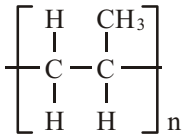
H-bond and rest of molecule ***(1)***
angle must be between 3 atoms for a correct H bond ***(1)***
ALLOW HOH 106-108° 2

(d) (i)



IGNORE any "n" in this diagram

Brackets optional but continuation must be shown
4 carbon chain with 6Cs overall in structure **(1)**
methyl groups can be on C_1 and C_3, C_1 and C_4, C_2 and C_4, C_2 and C_3 **(1)**



1 max 2

(ii) (big molecule) so large number of electrons **(1)**

Hence **large/strong van der Waals'** forces
(to be overcome to change state)**(1)** 2

[14]

44. (a) (i) Minimum of one shaded blob **and** one clear blob labelled **(1)**
Labels are:
Na^+ or sodium ion **<u>and</u>** Cl^- or chlor**ide** ion 1

Reject Na and Cl
(ie no charge)

*Reject sodium / chlor**<u>ine</u>***

(ii) Strong (force of) **attraction** between (oppositely charged) ions **(1)**

Accept held together by strong ionic forces/bonds

Accept "attraction" may be implied by "breaking bonds"

a lot of energy needed to separate ions **(1)** 2

Accept a lot of energy implies "strong"

Accept break ionic bonds

Accept break lattice

Reject any reference to atoms or molecules
Or covalent bonds
Or intermolecular forces
Or metallic bonds
(scores zero)

Reject all the bonds need to be broken

(b) Covalent between carbon atoms in plane **(1)**

Van der Waals' between planes of carbon atoms **(1)** 2

Accept induced dipole/ dispersion/ London forces/temporary dipoles

Names not linked to bonds **(max 1)**

Reject giant covalent delocalised e–

(c) Covalent

Label not needed 1

*Reject giant covalent BUT do **not** penalise twice*

(d) Covalent bonds in diamond are shorter than the distance between layers in graphite **(1)**

The atoms in diamond are packed closer together **(1)** 2

*Accept layers in graphite are far apart **(1)***

[8]

45. (a) HF hydrogen bonding /H bonding **(1)**

Reject just "hydrogen"

HCl }
HBr van der Waals' } **(1)** – all three needed 2
HI }

Accept induced dipole/ dispersion/ London/temporary dipole forces

Accept any combination

Reject dipole-dipole

(b) (The boiling temperature of HF is higher) because the hydrogen bonding between HF molecules is stronger than the intermolecular forces in HCl **(1)**

Accept H bonding strongest/strong

Reject any mention of ions, ionic bonds or covalent bonds ***(scores 0)***

The rise from HCl to HI is because the strength of the van der Waals' forces (etc) increases **(1)**

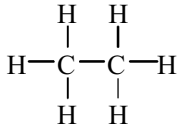
with increase in number of electrons **(1)** 3

Reject bigger mass/size for 3rd mark

[5]

46. (i) ethane C_2H_6 1

Accept $CH_3.CH_3$ $CH_3–CH_3$



Reject ethene, methane

(ii) van de(r) Waals/Walls Van Der Waals
London forces/temporary dipole-dipole/induced dipole-dipole 1

Reject VDW vdw
Reject dipoles
Reject permanent dipoles
Reject fluctuating/flickering dipoles

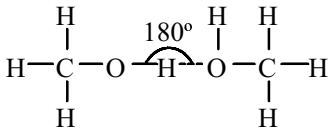
(iii) methanol because there are hydrogen bonds between the methanol molecules 1

Allow ethanol

Accept dipole-dipole interaction

Reject stronger
Reject intermolecular forces

(iv)

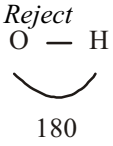


Allow ethanol

correct atoms involved in hydrogen bonds **(1)**
bond angle 180° and correctly indicated **(1)**
second mark dependant on first 2

Drawing does NOT have to be at 180°

Reject



Reject NO TE from (e) (iii) if alkane selected

[5]

47. (i) The beryllium ion would be (very) small **(1)**

Allow Be^{2+} has a large charge to size ratio/large charge density

Accept answers that refer to polarisation of atoms score zero

and would polarise chloride **ions** (producing sharing of electrons / covalency) **(1)**

Accept distort for polarise

Accept anion for chloride ion

OR
Difference in electronegativity small /similar **(1)**
Therefore **share** (pair of) electrons / no electron transfer **(1)**

Reject answers that refer to electronegativity of ions score zero

If both routes given. Mark both out of 2 and then score higher hark 2

(ii) $: \ddot{Cl} : Be : \ddot{Cl} :$

Ignore shape and inner electrons if correct 1

Accept all dots or all crosses or mixture of both

Accept polymer with continuation bonds

Reject dimmer
Reject Ionic formula

[3]

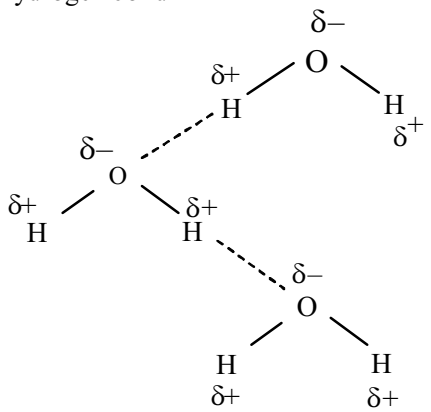
48. (a)

- Diagram showing correct covalent and hydrogen bonds **(1)**

  If only two water molecules shown max 2 marks

  If use O_2H allow third mark only

- Linear around at least two H and water shown as 'v' shaped **(1)**
- δ^+ H and δ^- O **(1)** must be shown across at least one hydrogen bond



3

Reject blobs for O and H provided correct δ^+/δ^- shown

Ignore a slip in partial charges provided not part of hydrogen bond

Reject if any H bond shown between two oxygens or two hydrogens

(b) Each water can form **more** hydrogen bonds (than each hydrogen fluoride molecule) **(1)**

Accept each water molecule can form two hydrogen bonds, HF can only form one

Accept each water molecule can form four hydrogen bonds HF can only form two

Just 'H bonds in water are stronger'
Is not good enough to score the mark

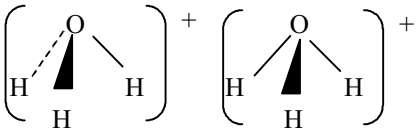
So more energy is needed to break the hydrogen bonds in water/ separate molecules (hence higher boiling temperature) **(1)**

2nd mark is stand alone unless wrong intermolecular force identified in first part e.g. vdw 2

Accept "Intermolecular force" for "hydrogen bond"

Any reference to breaking covalent bonds/bonds in the molecule scores zero.

(c) (i)



Must attempt to draw as a pyramid – wedge or dash or both.
If three lines drawn must not look planar

Ignore name unless "planar" 1

Ignore omission of + sign in diagram

(ii) Any number from 105 to 108 inclusive.
Mark independently of (c)(i) 1

(iii) Repulsion between the H_3O^+ and the H^+ 1

Accept they are both cations so repulsion
OR
They are both positive so repulsion

[8]

49. (a) (i) The ability of an atom/element/ species to attract the electrons **(1)**

Accept "Power/extent" instead of "ability"

Accept "pulls toward/draws" instead of "attract"

Reject molecule

in a covalent bond/bond pair/shared electrons **(1)** 2

(ii) The molecule is symmetrical / tetrahedral **(1)**

Reject too small a difference in electronegativity

So bond polarity/dipoles cancels
OR
centres of positive and negative charge coincide **(1) – stand alone** 2

Accept diagrams showing vectors

Reject charge cancels

(iii) Dispersion/Induced dipole /London
OR
temporary/instantaneous dipole 1

Accept van der Waals/vdw

Reject dipole-dipole

Reject hydrogen bond

(b) (i) Ignore sig. figs UNLESS rounded to 1SF

700 g TMP = $\frac{700}{114}$ **(1)** = 6.14 mol

Reject moles $2C_8H_{18} = \frac{700}{228} = 3.07$

Moles of oxygen = 12.5 × 6.14 **(1)** = 76.75

Volume of oxygen = 12.5 × 6.14 × 24 = 1842 dm^3 **(1)**
Units essential
Working must be checked i.e.
3.07 × 25 × 24 = 1842 dm^3 **(2)**
3.07 × 12.5 × 24 = 921 dm^3 **(1)**

Accept 1840/1800 dm^3
Accept 1830 if 6.14 rounded to 6.1

OR 228 g of TMP need 25 × 24 dm^3 of oxygen **(1)**

$\therefore$ 700 g of TMP need $\frac{25\times 24\times 700}{228}$ of oxygen **(1)**

= 1842 dm^3 **(1)**

Units essential
[Working must be checked] 3

(ii) Ignore sig. figs UNLESS rounded to 1SF

Moles of $CO_2 = 8 \times 6.14$ **(1)** = 49.12

Mass of $CO_2 = 8 \times 6.14 \times 44 = 2161$ g **(1)**
Units essential but don't penalise if already penalised in (i)

Accept 2160/2200 or 2147 / 2150 / 2100 if 6.14 rounded to 6.1

OR
228 g of TMP give 44×16 g CO_2 **(1)**

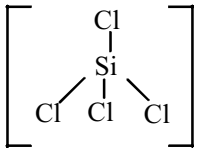
$\therefore$ 700g of TMP give $\frac{44 \times 16 \times 700}{228}$ g of CO_2

= 2161 g **(1)**

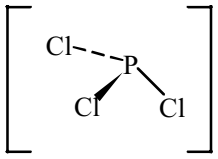
Could be consequential on (i) 2

[10]

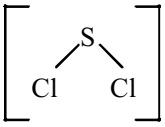
50.



ClSiCl = 109(.5)°



ClPCl = 107° (accept 95 – 108)



ClSCl = 104.5° (accept 95 – 105)

First mark is for a 3dimensional diagram for the shape of $SiCl_4$ **or** PCl_3
All three bond angles correct (2)
Two bond angles correct (2 max)
One bond angle correct (1 max)

[3]

51. *Please read complete answer first*

Accept reverse argument based on Ba^{2+}

*Reject mention of molecules and atoms throughout answer scores **(0)***

1st mark Stand alone

The Mg^{2+}/cation/Mg ion has (the same charge but) smaller size
OR
Mg^{2+}/cation has larger charge density **(1)**

2nd Mark
Mg^{2+}/cation /Mg ion is more polarising
OR
Carbonate anion more polarised **(1)**

Penalise omission of ions only once

Accept Mg^{2+}/cation /Mg ion has greater polarising power

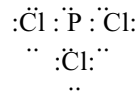
Reject mention of covalency between metal and carbonate/electronegativity/vdW or other intermolecular forces / polarising power of the carbonate ion scores zero for last 2 marks

3rd mark We are looking for some effect on the carbonate ion of the above
Carbon to oxygen bond weakened
OR
Weakens (covalent) bonds **in** the carbonate
OR
electrons in anion pulled towards the cation
OR
Distorts the electron cloud (around the carbonate) 3

Reject weakens IONIC BONDS

[3]

52. (i)



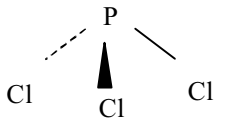
8 electrons around each Cl **(1)**

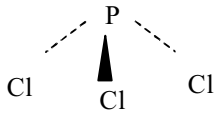
three shared pairs and one lone pair around P **(1)**

If symbols omitted max 1 2

Accept all dots or all crosses

(ii)





1

Must be an attempt to draw as a pyramid.
Wedge, dashes, both. If draw 3 lines must not look planar

Ignore name unless they say planar

Ignore indicated bond angles unless it is written as 120°

Reject planar triangular even if no lone pair shown in part (i)

(iii) **Mark consequentially on part (a)(ii)**

1st mark
PCl_3 has 4 pairs of electrons/3 bond and 1 lone pair **(1)**

2nd mark
The electron pairs repel to a position of maximum separation / minimum repulsion
OR
lp–bp repulsion > bp–bp **(1)**

3rd mark
CH_4 has 4 bonding pairs of electrons so angle **less** in PCl_3 or more in CH_4
OR
CH_4 has no lone pairs so angle **less** in PCl_3 or more in CH_4 **(1)**

If in part (ii) they give a structure which <u>is planar triangular</u> they can score full for a correct description of why it is planar triangular i.e.

PCl_3 has 3 pairs of electrons **(1)**

The electron pairs repel to a position of maximum separation /minimum repulsion **(1)**

So the angles are 120° for PCl_3 and CH_4 has 4 bonding pairs of electrons, so 109(.5)° for CH_4 **(1)** 3

Accept phosphorus in PCl_3 has a lone pair but carbon in CH_4 has no lone pairs scores first mark

Reject repulsion of atoms or bonds

[6]

53. (a) (i) metallic 1

Reject metal

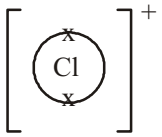
(ii) attraction between ions and delocalised electrons is stronger in lithium **(1)**

With reference to atoms 1 max

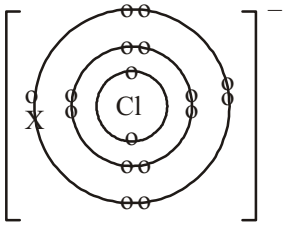
as lithium ion is smaller / lithium ion has greater charge density/ electrons closer to nucleus **(1)** 2

Accept reverse argument

(b) (i)



(1)



(1) 2

Accept all dots and crosses

Accept charges next to element symbols

Reject correct electronic structure but wrong or no charges max 1

Reject covalent structures = 0

(ii) **Electrons** are promoted (to higher energy level). **(1)**

Then they fall back to lower levels (they emit light of particular wavelength). **(1)** 2

(iii) strontium / calcium 1

Accept rubidium

[8]

54. (a) (i) van der Waal(s) 1

Accept reasonable phonetic spelling

Accept London/dispersion forces

Reject vdw

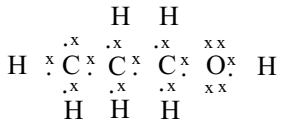
(ii) Same/similar/about the same number of electrons
IGNORE numbers of electrons even if incorrect

BUT allow
"Both have 34 electrons" without any other comment 1

Allow additional comments like 'both are straight chain'

Reject "Similar molar mass" on its own

(b) (i)



Check non bonding electrons on oxygen (which can be ".x") 1

Accept all dots and crosses

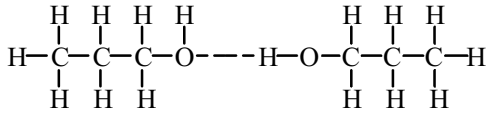
Reject four carbon chain

(ii) Hydrogen bond(ing) 1

Accept H bonding

Reject 'Hydrogen' on its own

(iii)



(1)

The hydrogen bond can be represented by any number of dots/dashes but not a continuous straight line

Bond angles
COH **103–106.5° (1)**
Between molecules **180° (1)**

Mark independently throughout 3

O-----H–O do not have to be in straight line but…

…reject two hydrogen bonds between two molecules

Reject chain not fully displayed

(c) (i) (Permanent) dipole – (permanent) dipole (forces/ interactions/ attractions) 1

Accept permanent dipole (alone)

Reject 'Dipole' alone

(ii) Propan-1-ol can form hydrogen bonds to propanone… **(1)**

Can be shown by a diagram labelling "hydrogen bond"

Reject answers based on dipoles

…using the oxygen of the carbonyl group/propanone
(and the hydrogen of the OH group)
Or
Interactions/bonds made are of a similar strength to those broken **(1)** 2

Can be shown as a diagram

[10]

55. A

[1]

56. A

[1]

57. D

[1]

58. D

[1]

59. C

[1]

60. D

[1]

61. A

[1]