**1.** (a)

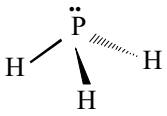
| H | C |
|---|---|
| 11.1 / 1 | 88.9 / 12 **(1)** |
| = 11.1 | = 7.4 |
| 1.5 | 1 **(1)** |

Empirical formula $C_2H_3$ **(1)** 3

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

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

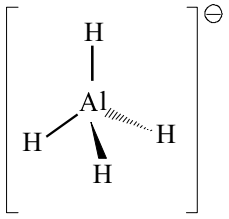
(c) (i) *pyramidal*




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

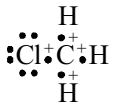
NB the relationship between the strength of the intermolecular forces and boiling/melting missed in (b)(ii) could be awarded in (c)(i)

(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

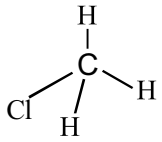
**[15]**

**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

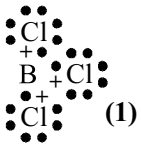
- Octahedral diagram
- Angle = 90°
- Repulsion between 6 bonding pairs / bonding pairs as far apart as possible 3

(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]**

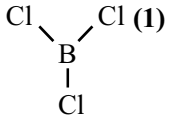
**7.** (a)




**(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

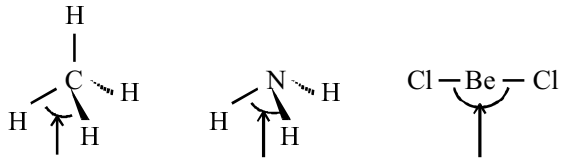
(ii) Size /radius /ionic radius **(1)** charge **(1)** 2

(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)




109 – 110° 106 – 108° 180°

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*

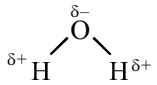
(b) (i) Temporary and/ or induced dipole forces **(1)** allow 'instantaneous' in place of 'temporary' 1
*Allow London/dispersion/van der Waal's forces*

(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

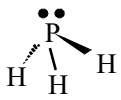
$= \frac{(6.02 \times 7.39) + (7.02 \times 92.61)}{100}$ **(1)**

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

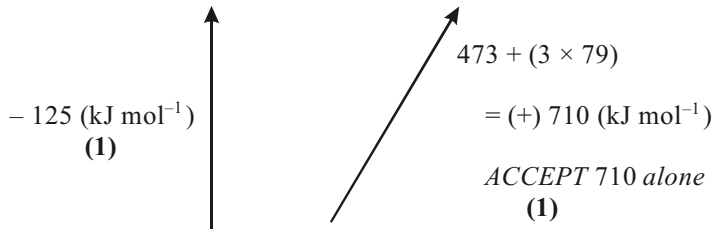
(ii) $NCl_3$ / chlorine because more electrons 1

(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

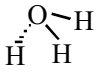
(iii)
- 1. Magnesium ion has larger charge (density) than sodium / magnesium contributes two electrons per atom to the 'sea' of electrons. **(1)**
- 2. Hence magnesium (ions) have greater attraction for (sea of) electrons than sodium. **(1)**
- 3. Melting requires energy to overcome this attraction,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

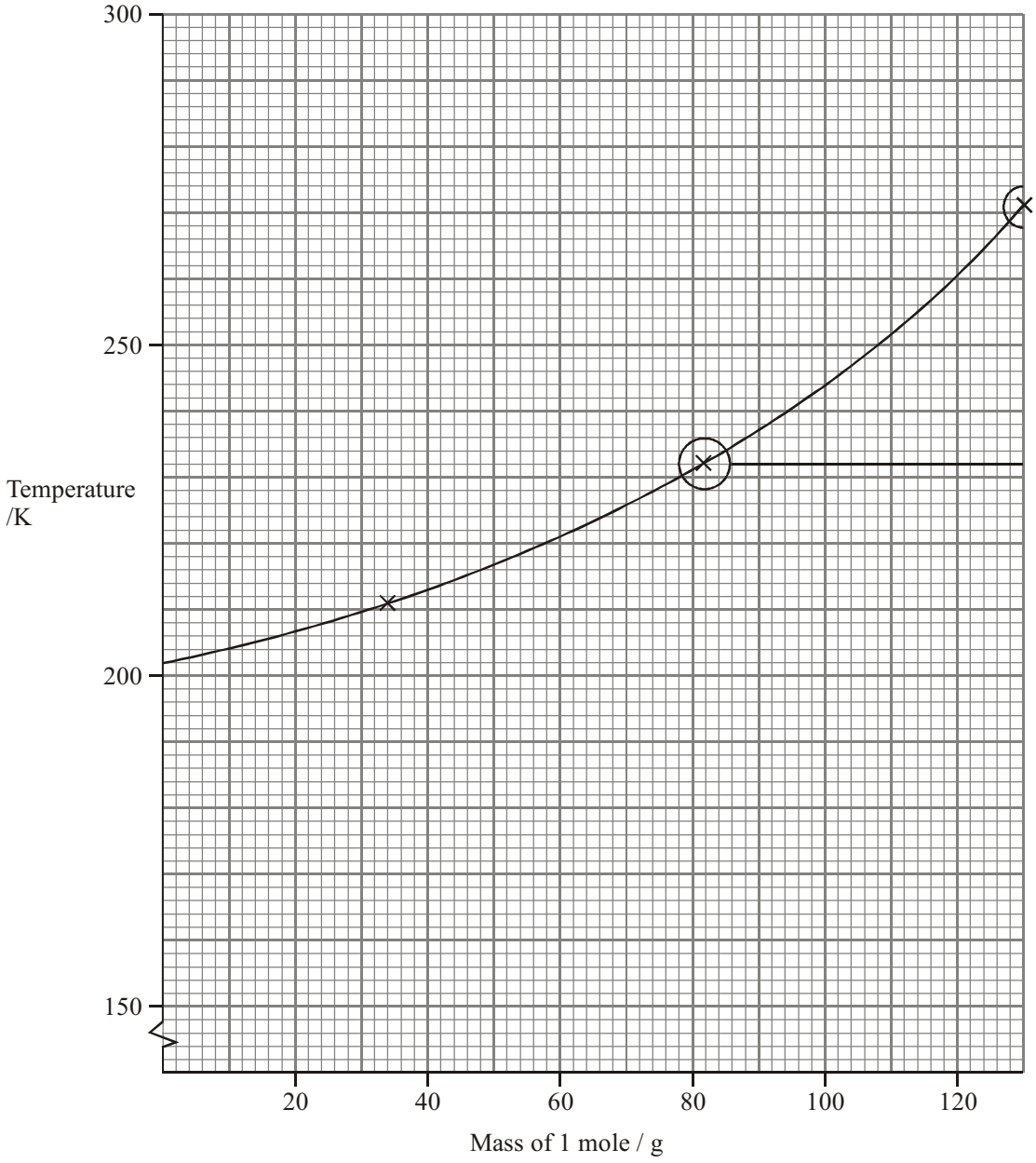
**[9]**

**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

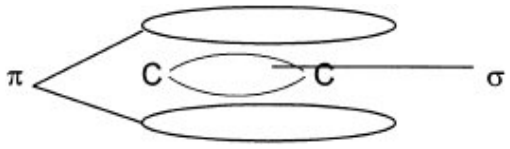
(b) **ions** mobile(in molten) / can move **(1)** *NOT* "free" *on its own*
fixed positions in solid / cannot move **(1)**
**Max 1** if only one ion mentioned eg $Na^+$ 2

**[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*

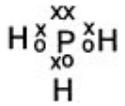
Shapes **(1)** ACCEPT crescents for π bonds NOT lines for σ bond 2
Labels **(1)**

(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]**

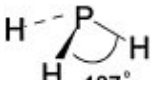
**26.** (a) (i)



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

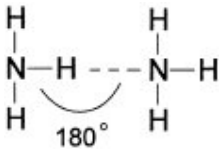
(iii) Answer to (ii) divided by 3
+ 321(.1)/320 **kJ mol$^{-1}$** 1

**[10]**

**27.** (a) Phosphine has more electrons 1

(b) (i) Hydrogen/H bonds 1

(ii)



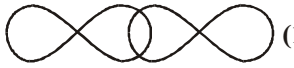

Correct atoms **(1)**
Angle 180° /N-H ··· N in straight line **(1)** 2

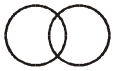
**[4]**

**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)**,

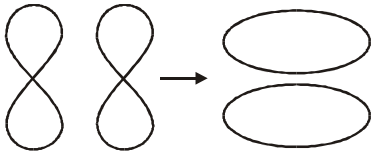

**(1)**


**(1)**

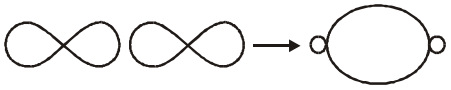

**(1)**


**(1)** NOT  on its own

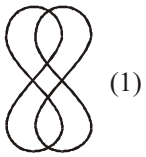
π bond:
diagram showing the side by side overlap of two (p) orbitals **(1)**

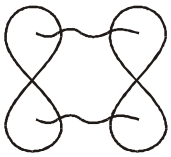

(1)

(but not alone)


(1)

(but not alone)


(1)


(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

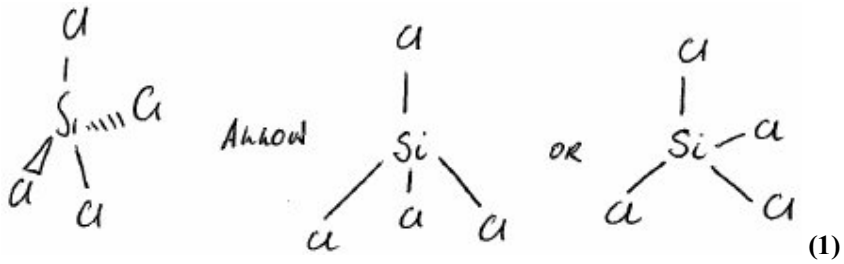
(ii) moles chlorine = 2 × 0.357 moles Si × 2 **(1)** **(1)**

∴ 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

*$4^{th}$ 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

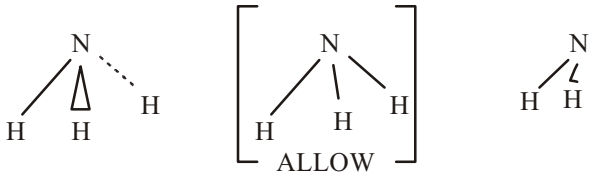
(ii) C-l bond is weaker than C-Cl
*Must say which bond is weaker* — 1

(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/ $\delta^-$ $\delta^+$ 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)**

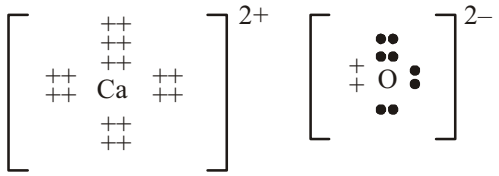
Use of atomic number **max 1** 2

**[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** (kJ$mol^{-1}$)
*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)**

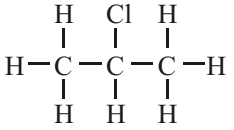
as lone / non-bonding pairs take up **more** space/
repel **more strongly** than bonded pairs **(1)**
*NOT* bonds being repelled/H and Cl being repelled 2

(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]**

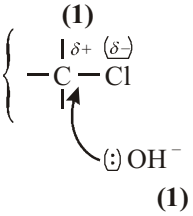
**43.** (a) (i) 2(-)chloropropane



*No internal TE from name to structure*

*MUST be fully displayed* 2

(ii)

*IGNORE* rest of molecule 


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

*ACCEPT*  *NOT* 

*NOT* $C^+$

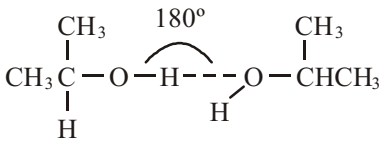
(b) (i) Elimination
*NOT in conjunction with additional incorrect information*
eg "nucleophile" 1

(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

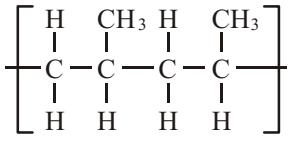
(c) (i) Hydrogen/H bonding 1

(ii)



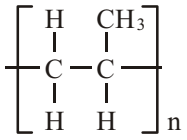

*H-bond and rest of molecule* ***(1)***
*angle must be between 3 atoms for a correct H bond* ***(1)***
*ALLOW HOH 106-108°* 2

(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 **and** $Cl^-$ or chlor**ide** ion 1

*Reject Na and Cl*
*(ie no charge)*

*Reject sodium / chlor**ine***

(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)**

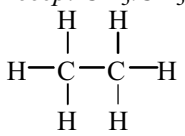
with increase in number of electrons **(1)** 3

*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*

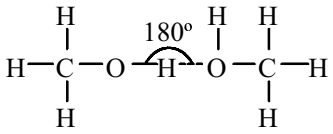
(iii) methanol because there are hydrogen bonds between the methanol molecules 1

*Allow ethanol*

*Accept dipole-dipole interaction*

*Reject stronger*
*Reject intermolecular forces*

(iv)

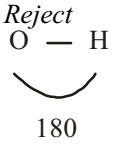



*Allow ethanol*

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]**

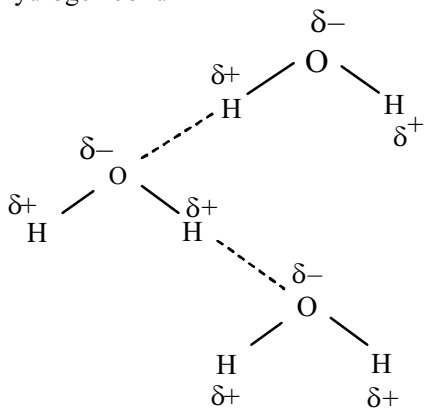
**48.** (a)

- 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)**
- $\delta^+$ H and $\delta^-$ O **(1)** must be shown across at least one hydrogen bond




3

*Reject blobs for O and H provided correct $\delta^+/\delta^-$ 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*

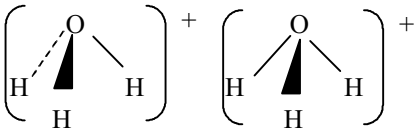
So more energy is needed to break the hydrogen bonds in water/ separate molecules (hence higher boiling temperature) **(1)**

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)**

∴ 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 $44 \times 16$ g $CO_2$ **(1)**

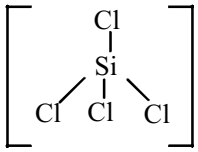
$\therefore$ 700g of TMP give $\frac{44 \times 16 \times 700}{228}$ g of $CO_2$

= 2161 g **(1)**

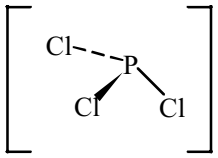
Could be consequential on (i) 2

**[10]**

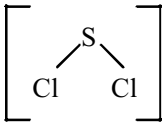
**50.**




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*

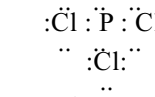
*Reject mention of covalency between metal and carbonate/electronegativity/vdW or other intermolecular forces / polarising power of the carbonate ion scores zero for last 2 marks*

**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)



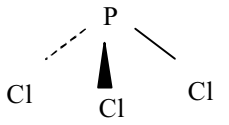
8 electrons around each Cl **(1)**

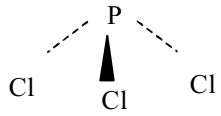
three shared pairs and one lone pair around P **(1)**

*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*

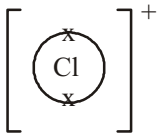
(ii) attraction between ions and delocalised electrons is stronger in lithium **(1)**

*With reference to atoms 1 max*

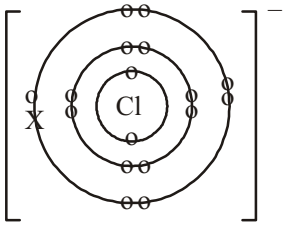
as lithium ion is smaller / lithium ion has greater charge density/ electrons closer to nucleus **(1)** 2

*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*

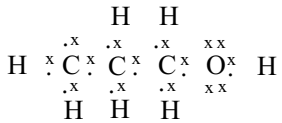
(ii) Same/similar/about the same number of electrons
IGNORE numbers of electrons even if incorrect

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*

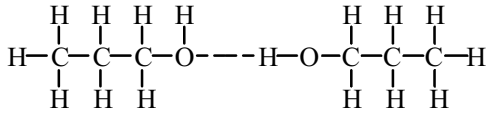
*Reject four carbon chain*

(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]**