1. (a) (i) The mass of an atom (of the isotope) **(1)** - NOT average mass....

relative to $1/12^{th}$ the mass of a ^{12}C atom
OR
relative to $^{12}C = 12$ **(1)** - *stand alone mark*
An answer all in moles can get 2 marks
Atom need only be mentioned once. If not mentioned **1 (out of 2)** **(2 marks)**

(ii) Both have 35 protons **(1)**
^{79}Br has 44 neutrons **(1)**
^{81}Br has 46 neutrons **(1)** **(3 marks)**

(b) $(^{79}Br\text{-}^{79}Br)^+$ **(1)**
$(^{79}Br\text{-}^{81}Br)^+$ **(1)**
$(^{81}Br\text{-}^{81}Br)^+$ **(1)**
-1 for no charge then check the rest
If give $^{79}Br + ^{79}Br$ etc with or without charge **1 (out of 3)**
79 + 79...all three must be given **1 (out of 3)** **(3 marks)**

TOTAL 8 MARKS

2. (a) Al atom is $(1s^2)\ 2s^2\ 2p^6\ 3s^2\ 3p^1$ **(1)**
Al^{3+} ion is $(1s^2)\ 2s^2\ 2p^6$ **(1)** **(2 marks)**

(b) The structure is a regular array / lattice of positive ions **(1)** *NOT* nuclei surrounded by delocalised/'a sea of' electrons **(1)**
1st two marks can be on a diagram

(It conducts electricity) because the electrons are mobile. **(1)** **(3 marks)**

(c) (i) Energy/enthalpy change per mole **(1)**
For $E(g) \rightarrow E^+(g) + e^{(-)}$ **(2)**
OR equivalent in words **(3 marks)**

(ii) In aluminium the outer electron is in the (3)p orbital whereas in magnesium it is in the (3)s orbital **(1)** - *comparison between p and s required*

so aluminium's outer electron is in a higher energy (level)
OR
the (3)p electron is **more** shielded (and so less energy is needed to remove it.) **(1)** **(2 marks)**

TOTAL 10 MARKS

3. (a) Diagram showing correct covalent and hydrogen bonds **(1)**
Linear around H and water shown "V" shaped **(1)**
$\delta+$ H and $\delta-$ O **(1)**
due to difference in electronegativities / because both atoms small / description of involvement of lone pair **(1)** **(4 marks)**

(b) (i) A covalent bond **(1 mark)**

(ii) A dative (covalent)/co-ordinate bond **(1 mark)**

(c) (i) $2Na + 2H_2O \rightarrow 2NaOH + H_2$ **(1 mark)**

(ii) $CaO + H_2O \rightarrow Ca(OH)_2$ **(1 mark)**

(iii) $Cl_2 + H_2O \rightarrow HCl + HOCl$ *OR* $\rightleftharpoons$

OR
$Cl_2 + H_2O \rightarrow 2HCl + \frac{1}{2} O_2$ *OR doubled*

NaOH, $Ca(OH)_2$ and HCl can be shown as separate ions **(1 mark)**

TOTAL 9 MARKS

4. (a) (i)

OR all dots/crosses

shared pair **(1)**
correct outer shell **(1)** - *consequential on 1st mark* **(2 marks)**

(ii) Because HI has more electrons **(1)** *NOT* iodine/iodide
NOT because atoms are bigger/heavier

it has stronger/larger **induced** dipole / vdW / London / dispersion forces **(1)**

more energy is required to separate the molecules/break/overcome vdW forces **(1)** **(3 marks)**

(b) (i) $HI + H_2O \rightarrow H_3O^+ + I^-$
IGNORE state symbols
NOT $HI \rightarrow H^+(aq) + I^-(aq)$ **(1 mark)**

(ii) It forms (hydrated) hydrogen/hydroxonium ions
Any reference to H^+ will suffice
NOT proton donor **(1 mark)**

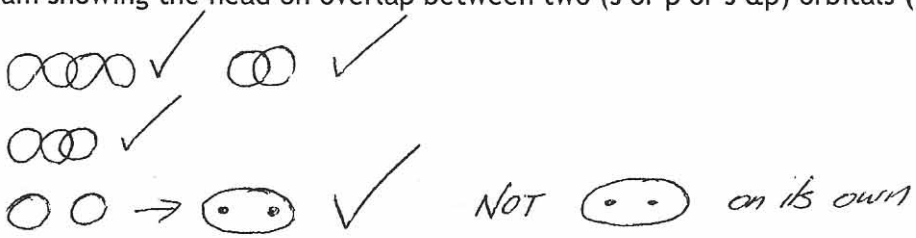
(c) (i) $CaO(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l)$
equation **(1)**
state symbols *consequential on correct equation* **(1)** **(2 marks)**

(ii) Because the surface of the calcium oxide gets coated with **insoluble**/sparingly soluble / impermeable calcium sulphate
"A protective layer of .... ≡ impermeable and coated **(1 mark)**

TOTAL 9 MARKS

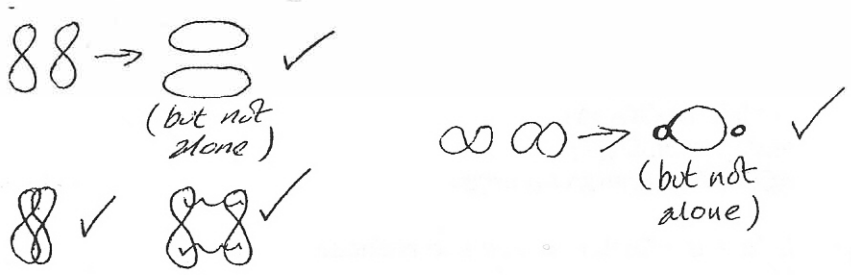
5. (a) **σ bond:**

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 marks)

(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 marks)**

(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 marks)**

(c) CO_2 is molecular **(1)**

with weak inter-molecular / vdW / dispersion forces/dipole dipole **(1)**

SiO_2 is giant covalent **(1)** *ACCEPT* giant molecular *OR* macromolecular
NOT giant lattice

SiO_2 melting needs intramolecular bonds/covalent bonds to be broken **(1)**
OR
C=O stronger than two C-O **(1)**
Si=O weaker than two Si-O **(1)**
In CO_2 double bonding so molecular covalent favoured **(1)** **(4 marks)**
But giant covalent in SiO_2 **(1)**

TOTAL 11 MARKS

6. (a) Reduction is electron gain **(1)** *IGNORE any reference to oxygen and hydrogen*
ALLOW decrease in oxidation number/state **(1 mark)**

(b) *In (i) and (ii) allow multiples*

(i) $Fe^{3+} + e^- \rightarrow Fe^{2+}$

(1 mark)

(ii) $2I^- \rightarrow I_2 + 2e^-$ *Do NOT allow I for ½I_2*

(1 mark)

(iii) $2Fe^{3+} + 2I^- \rightarrow 2Fe^{2+} + I_2$
Stand alone
This equation must be correct for the mark and not just a combination of (i) and (ii) **(1 mark)**

(c) (i) Cl is (+) 1 in NaClO **(1)**,
(+) 5 in $NaClO_3$ **(1)**,
and -1 in NaCl **(1)**
ACCEPT as Roman numerals **(3 marks)**

(ii) Chlorine is both oxidised and reduced
OR
The chlorine's oxidation number goes from +1 to +5 and -1.
consequential on oxidation numbers in (i) provided that chlorine has gone both up and down **(1 mark)**

(d) (i) Amount of N_2 = 54 dm^3/20 dm^3 mol^{-1} = 2.7 (mol) **(1 mark)**

(ii) Amount of NaN_3 = 2.7 x 2/3 = 1.8 mol **(1 mark)**

(iii) 117 g **(2)**

Salvage marks:

M_r of NaN_3 = 65 g mol^{-1} **(1)**

Mark consequentially (i-iii)
2-4 SF
117 with no unit **(1)**
117 with wrong unit **(1)**

(2 marks)

TOTAL 12 MARKS

1. (a) (i) aluminium oxide/Al_2O_3/alumina **(1)** *NOT* bauxite
dissolved in molten cryolite/ cryolite T › 800°C **(1)**

brine/(concentrated) aqueous sodium chloride/NaCl **(aq)** **(1)**

(3 marks)

(ii) The oxygen **produced** **(1)**

Reacts with /oxidizes the carbon/ anode (forming carbon dioxide thus eating it away)**(1)** **(2 marks)**

(b) (i) resistant to corrosion/doesn't rust/**protective** oxide layer **(1)**

its low density/lower density than iron **(1)**

high strength to weight ratio forms strong alloys **(1)**

Any two

NOT "it is light/ strong" **(2 marks)**

(ii) water treatment/bleach/disinfectant **(1)**

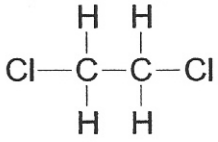
manufacture of PVC **(1)**
herbicides/insecticides **(1)**
HCl **(1)**
solvents **(1)**
aerosol propellants **(1)**
bromine **(1)**
titanium **(1)**

Any one

(1 mark)

NOT water purification/ swimming pools/ cleaning ,

(c) (i) CH_2ClCH_2Cl *OR*



NOT $C_2H_4Cl_2$

(1 mark)

(ii) Nucleophilic substitution **(1 mark)**

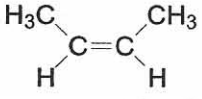
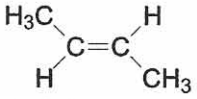
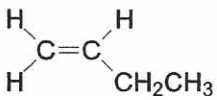
TOTAL 10 MARKS

2. (a) (i) $CH_3CHICH_2CH_3$ / $CH_3CHIC_2H_5$ (1) **(1 mark)**
(allow full structural formula)

(ii) Reagent: sodium hydroxide/potassium hydroxide (1)

Condition: aqueous (ethanolic) solution (1)
dependent on correct reagent **(2 marks)**

(iii) (Heat) in ethanolic solution /ethanol/ alcohol (1) **(1 mark)**

(iv)   

(1) (1) (1)

(3 marks)

$CH_3CH{=}CH\ CH_3$ and $CH_2{=}CH\ CH_2CH_3$ max 2

(b) Rate bromo would be slower (1) (or reverse argument)

as C-Br bond is stronger (than C- I) (1)
consequential on correct 1st point

and so activation energy would be greater (1) **(3 marks)**
consequential on their answer to 1st point

TOTAL 10 MARKS

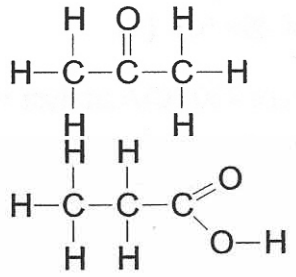
3. (a) (i)

C	60.0 ÷ 12 = 5.00	÷ 1.67 = 3	(1)
H	13.3 ÷ 1 = 13.3	÷ 1.67 = 8	
O	26.7 ÷ 16 = 1.67	÷ 1.67 = 1	

Empirical formula is C_3H_8O **(1)** **(2 marks)**

(ii) propan-2-ol has the empirical formula of C_3H_8O and is consistent with the data / or calculate % C, H and O from formula and show it is the same as the data/same formula mass **(1)** **(1 mark)**

(b)



(1)

(1) allow OH

Max 1 if both given as correct structural but not full structural formulae **(2 marks)**

(c) Reagent: conc sulphuric /(conc) phosphoric acid / aluminium oxide (1)
OR formulae

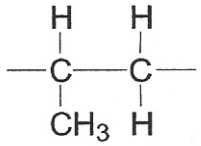
Condition: heat (1) **(2 marks)**
consequential on correct reagents

(If temperature stated: H_2SO_4 between 150 & 200°C; H_3PO_4 50-100°C)

(d) (i) $CH_3CHBrCH_3$ **(1)** **(1 mark)**

(ii) Electrophilic addition **(1)** **(1 mark)**

(e)



(1) *OR with more repeat units* **(1 mark)**

TOTAL 10 MARKS

4. **(a)** **(i)** rate forward = rate back **(1)**

no change in concentration/partial pressure/amount **(1)** **(2 marks)**

(ii) (%) increases **(1)** **(1 mark)**

(iii) None **(1)** **(1 mark)**

(b) If temperature too low, rate too slow/high temperature gives fast rate(1),

but if too high, yield too small/high yield needs low temperature **(1)**

therefore a compromise temperature (of 450 °C) **(1)**

and catalyst for quick rate (at temperature 450 °C)/catalyst not effective if temperature below 400°C **(1)** **(4 marks)**

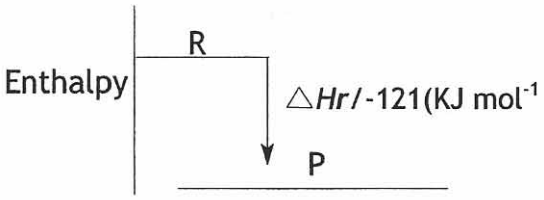
(c) In car batteries **(1)**
manufacture of:
- fertilisers / ammonium sulphate/phosphates **(1)**
- paints **(1)**
- detergents **(1)**
- car batteries **(1)**
- man-made fibres **(1)**
- dyes **(1)**
- explosives **(1)**

Any one

(1 mark)

TOTAL 9 MARKS

5. (a) (i)



ΔH marked **(1)**
NOT double headed arrow

Reactants (R) and products(P) marked with R above P **(1)** **(2 marks)**

(ii) the reactants are at a higher enthalpy/energy level than the products **(1)**

products (more) thermodynamically stable/reactants(more)thermodynamically unstable **(1)** **(2 marks)**

(iii) The E_a (of this slower) reaction is **larger** (than that of the reaction which is rapid at RT) **(1)** **(1 mark)**

(b) (i) Graph with modal point lower than for T_C **(1)**
and more to the right **(1)**

(2 marks)

bad shape eg crosses x axis **max 1**

(ii) E_a drawn to the right of both modal points **(1)**

Area under graph to the right of E_a is greater for T_H (than for T_C) stated or clearly shaded and labelled on diagram or explain before **(1)**,

so a greater fraction of / more molecules have $E \geq E_a$ **(1)**

which will therefore react on **collision** / thus there will be more effective **collisions** (and hence a faster rate) **(1)** **(4 marks)**

If no mention of increased rate, max 3

TOTAL 11 MARKS

6. (a) Enthalpy / heat/energy change when **1 mol** of a substance **(1)**
NOT "heat needed"

is burnt in excess / burnt completely in **air/oxygen (1)**

under standard conditions of 1 atm pressure & stated temperature / at 298 K **(1)** **(3 marks)**

(b) Bonds broken 4 x C-H = + 1740
2 x O=O = + 996
= + 2736 **(1)**

Bonds made 2 x C=O = - 1610
4 x H-O = - 1856
= - 3466 **(1)**

ΔH = + 2736 + (-3466) = - 730 **(1)** (kJ mol^{-1}) **(3 marks)**

(c) $CH_4(g) + 2H_2O(g) \longrightarrow CO_2(g) + 4H_2(g)$

$4H_2(g) + C(s) + O_2(g)$

Cycle **(1)**
do not allow the word "elements"

Arrows labelled $\triangle H_f$ etc or numbers**(1)**

ΔH_r = - 394 - (- 75) - 2x (-242) **(1)**
= + 165 **(1)** (kJ mol^{-1}) **(4 marks)**

TOTAL 10 MARKS

1 (a) A Sodium sulphate/Na_2SO_4 (1)

B Barium sulphate/$BaSO_4$ (1)

If name and formula given, **both** must be correct **(2 marks)**

(b) (i) C Ammonium bromide/NH_4Br (1)

D Ammonia/NH_3 (1) **(2 marks)**

(ii) Cream / off-white / ivory / pale-yellow **(1 mark)**

(c) (i) F Ethanol/C_2H_5OH (1)

G Hydrogen chloride / HCl (NOT hydrochloric acid) (1) **(2 marks)**

(ii) Orange to green / turquoise / blue / green-blue **(1 mark)**

(d) (i) Propene/C_3H_6 **(1 mark)**

(ii) Red / orange / yellow to colourless (NOT "clear") **(1 mark)**

Total 10 marks

2 (a) (i) ✓W for weighing bottle full and then empty (1)

ALLOW weigh empty and then full BUT must wash out weighing bottle subsequently.

✓T transfer solid to beaker / funnel in volumetric flask (1)

✓V mention volumetric flask / graduated flask anywhere (1)

✓D dissolve solid (in water)/wash solid through funnel to dissolve (1)

✓R rinse beaker and transfer washings to flask/ rinse funnel (1)

✓M make up to mark (1) **(6 marks)**

*QWC**

(ii) $M_r(Na_2CO_3) = 106$ **(1)**

$\frac{1.28}{106}$ **(1)** $\times \frac{1000}{250} = 0.0483$ / 0.04830 (mol dm^{-3}) **(1)**

Correct answer plus working **(3)**
Correct answer no working scores **(1)**
ALLOW 3 or 4 SF **(3 marks)**
Answer cq on M_r

(b) (i) Yellow to peach / orange **(1 mark)**

(ii) Titres not concordant/not within 0.05 to 0.2 (cm^3) **(1 mark)**
Ignore sig figs. Ignore references to 'accuracy' or 'reliable'

(c) • Correct answer plus working (0.0989/0.09885 mol dm^{-3}) scores **(2)** (1)
3 or 4 SF

• Correct calculation of moles of Na_2CO_3 **and** correct use of 2:1 ratio (0.002415 mol HCl (aq))
CQ on (a) (ii) (1)
Check SF

• Correct concentration of HCl, CQ on moles of HCl $\frac{(0.002415)}{(0.02443)}$

(The concentration to be checked. Wrong volume for titre penalised once)

If formulae such as $c_1 V_1/n_1$ etc used and answer correct **(2)** scored. **(2 marks)**
If incorrect by this method **(0)** scored

(d) $\frac{0.5}{25} \times 100 = 2.0$ % must have both working **and** correct answer
ALLOW 1-3 SF **(1 mark)**

Total 14 marks

3 (a) Step II Wait before reading temperature/ take a series of (temperature) readings **(1)**

NOTE Ignore any references to time or more accurate thermometer

Step III Stir after each addition / leave thermometer in solution throughout/do not rinse **(1)** **(2 marks)**

(b) Drawing two best fit lines (second line can be through first three points) **(1)**

Extending to a maximum **(1)**

(2 marks)

Curve between 20 and 25 cm^3 scores first mark only

Note if use wrong last point for first line, no marks can be scored.
Hand sketched (without ruler) scores one mark only.

(c) Reading ΔT consequentially **(1)** expected $\Delta T = 7.0 \pm 0.1$ ($^\circ C$) 2sf for ΔT

Reading V_N consequentially **(1)** expected V_N = 22.5 to 23.0 (cm^3) 3sf for V_N

(2 marks)

ΔT = 6.9 ($^\circ C$) V_N = 25.0 (cm^3) scores **(1)** only

(d) (i) Heat calculated using candidate's values in (c) ignore 3 or more SF at this stage **(1 mark)**

(ii) (-) $\frac{\text{Answer to (d)(i)}}{0.025}$

Method consequentially **(1)**
Answer, sign and 2-4 SF **(1)** **(2 marks)**

ΔT	Vol	Heat/kJ	ΔH/kJ mol^{-1}
7.0	22.5	1.39	-55.6
7.0	23.0	1.40	-56.0 / - 56.2
6.9	25.0	1.44	-57.7/ - 57.6

Total 9 marks

4 (a) (i) $\frac{137}{74} \times 4.0 = 7.4 / 7.41$ g 7.40 g is an s.f. error
2 or 3 SF **(1 mark)**

(ii) $\frac{5.9}{7.4} \times 100 = 80\ \%$

ALLOW 79.7 / 79.6
conseq on (a) (i)
2 or 3 SF **(1 mark)**

(b) (i) (Turns hot) vapour into liquid / condenses **(1)**
NOT just 'cooled'
NOT just 'product vapour'

Which returns to reaction mixture / allows reaction to go to completion / minimises loss of reactants or products **(1)** **(2 marks)**

(ii) Two layers shown and upper layer is water **(1 mark)**

(iii) To dry (1-bromobutane) / as a drying agent
NOT 'to prevent reaction with 1-bromobutane' **(1 mark)**

(iv) • Heated flask (round or pear shaped ONLY) **(1)**

• Condenser **(1)**

• Thermometer in correct position **(1)**

• Quality - workable and safe ✓ Q **(1)**

(NOT scored if:
wrong direction of water flow in condenser
gaps in apparatus
sealed apparatus
delivery tube in product
no joints whatsoever
condenser not sloping downwards
water bath used for heating **(4 marks)**

(c) Wear gloves, 1-bromobutane harmful (by skin absorption)
NOT 'corrosive' *NOT* 'irritant'
H_2SO_4 is corrosive *NOT* 'irritant'

Electrical heater / heating mantle, 1-bromobutane flammable

Fume cupboard, 1-bromobutane harmful (vapour) *NOT* 'irritant' **(1 mark)**

Total 11 marks

5 Ignore flame tests and other chemical tests. Penalise wrong formulae once only.

Idea that <u>all four</u> compounds are heated **(1)**
(Mark not awarded if heating compounds where identity is presupposed)

Brown gas - calcium nitrate **(1)**

Glowing splint relights - sodium nitrate **(1)**

Limewater cloudy - sodium hydrogencarbonate **(1)**

(5 marks)

No positive tests/ remaining compound - sodium carbonate **(1)**
NOT 'no gas evolved'

Sixth mark scored from any of:

Overall **FULLY** correct and logical sequence ✓^{0}
OR
No brown gas - sodium nitrate
OR
(brown gas and) relights glowing splint - calcium nitrate
OR
(damp) blue litmus paper red / turns starch-iodide paper blue-black - calcium nitrate
OR
Condensation / chemical test for water - sodium hydrogencarbonate

(1 mark)

QWC*

Total 6 marks