6241

1 (a) (i) Weighted average (mass) of 1 atom **(1)**
on a scale in which 1 atom of ^{12}C = 12 units / compared to 1/12 atom of ^{12}C**(1)** **(2 marks)**

(ii) Number of protons plus / and neutrons or nucleons in a nucleus / an atom. **(1 mark)**

(iii) Atoms of same atomic number / same proton number **(1)**

which differ in the number of neutrons **(1)** (in the nucleus) **(2 marks)**

(b) (i) Concept of high energy electron collision:
Electron bombardment / gun / acceleration / fired **(1)**
knocks off electron / equation showing electron being knocked off **(1)** **(2 marks)**

(ii) Positive, + , S^+ **(1 mark)**

(iii) Voltage differential across plates / charged plates [plural] / electrostatic field / electric field **(1 mark)**

(c) [95.0 x 32+ 0.76 x 33 + 4.24 x 34] / 100**(1)**
= 32.0924 = 32.09 **(1)** **NOT** 32 or 32.10 **(2 marks)**

(d) $1s^2 2s^2 2p^6 3s^2 3p^4$ **(1 mark)**

(Total 12 marks)

2 (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 marks)

(b) (i) P or S or Cl / P_4, S_2, S_8, Cl_2 / names **(1 mark)**

(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 marks)

(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 marks)**

(Total 9 marks)

3 (a) % oxygen 100 –(31.84 + 28.98) = 39.18**(1)**

K	Cl	O	
31.84/39	28.98/35.5	39.18/16	Divide by A_r**(1)**
0.8164	0.8163	2.448	Divide by smallest OR state ratio 1:1:3 **(1)**
1	1	3	

Must be 2 or more significant figures

Alternative multiply by A_r + Sum **(1)** Calc % **(1)** 39.18 for O **(1)** **(3 marks)**

(b) Ratio of moles or mass **(1)**
Moles of A or relative mass of A **(1)**
× 24 or volume of O_2 **(1)** (not stand alone)

E.g.

2 moles of A gives 3 mols of oxygen **(1)**
1.0g of A 1.00/122.5 moles of A
therefore 1.00 x 3 / 122.5 x 2 moles of oxygen
volume of oxygen = 1.00 x 3 x 24 / 122.5 x 2
= 0.294 dm^3
OR
1.00 g of A gives 0.3918 g of oxygen**(1)**
0.3918 g of oxygen = 0.03918/32 moles of oxygen = 0.0122 moles**(1)**
0.0122 moles of oxygen = 0.0122 x 24 dm^3 of O_2= 0.293 dm^3**(1)**

2-4 significant figure in answer allowed **(3 marks)**

(Total 6 marks)

4 (a) (i) B **OR** $Cl_2 + 2Br^- \rightarrow Br_2 + 2Cl^-$ **(1 mark)**

(ii) Br^- or bromide [care – clearly bromide ion] **(1 mark)**

(b) A colourless solution / a greenish-yellow gas / greenish-yellow solution **(1)**
Turn to a brown/ red-brown solution/ gives a black or grey solid **(1)**
NOT red / yellow / orange
If "solution" not indicated but colourless → brown **(1)**
If neither state is indicated and colourless → black **(0)** **(2 marks)**

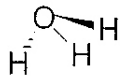
(c) (i) (Simultaneous) oxidation and reduction of same species (in the same reaction)
NOT atom, element, particle, substance, ion **(1 mark)**

(ii) Selects C **(1)** - conditional on an attempt at an explanation
3 chlorine oxidation numbers +1, +5, – 1 **(1)**
Linkage +1 to +5 identified as oxidation AND +1 to –1 identified as reduction **(1)**

(3 marks)
(Total 9 marks)

5 (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 marks)**

(b) Pyramidal **(1)**



(1) Must be 3D **(2 marks)**

(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 $\delta+$ and a $\delta-$ charge on the atoms**(1)** **(3 marks)**

(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 marks)**

(Total 11 marks)

6 (a) (i) $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$
1 mark equation – ionic equation must include spectator ions
1 mark state symbols
(2 marks)

(ii) In Ca valence electrons further away from nucleus / less attraction of nucleus on valence electrons / more shielding **(1)**
Lower IE / loses outer electrons more easily (therefore faster reaction) **(1)**
(2 marks)

(iii) Calcium sulphate **(1)**
Forms an insoluble / protective **layer (1)** – **NOT** free standing if incorrect compound
(2 marks)

(b) (i) $2KNO_3 \rightarrow 2KNO_2 + O_2$ **(1)**
(1 mark)

$2Ca(NO_3)_2 \rightarrow 2CaO + 4NO_2 + O_2$
1 for species
1 for balance
(2 marks)

(ii)
- Calcium nitrate less (thermally) stable / decomposes more easily than potassium nitrate **(1)** dependent on attempt at explanation
- Calcium **ion** smaller **(1)**
- Calcium **ion** has **double** charge **(1)**

} **(1)** for greater charge density

- Therefore greater polarising power / greater polarisation of nitrate **(1)**
- Bonds in nitrate more easily broken / oxide ion / oxygen atom more attracted **(1)**

(5 marks)

(Total 14 marks)

END

1. (a) (i) Al_2O_3 / $Al_2O_3.xH_2O$ **(1 mark)**

(ii) Iron(III) oxide / Fe_2O_3 **(1) NOT** iron(II) oxide
silica / silicon (di)oxide / SiO_2 **(1) NOT** sand **(2 marks)**

(iii)
- Al_2O_3 **reacts** because it is **amphoteric (1)**
- Dissolves / forms a solution **(1)**
  IF silica dissolves then 2nd mark is lost.
- Impurities don't react / dissolve **because Fe_2O_3 basic / silica too unreactive (1)** **(3 marks)**

(b) (i) Graphite / carbon
NOT C **(1 mark)**

(ii) $Al^{3+} + 3e^{(-)} \rightarrow Al$
IGNORE state symbols *UNLESS* (aq) given, in which case 0. **(1 mark)**

(iii) Carbon anode reacts with oxygen **(1)**
Gas / CO_2 given off / CO_2 (g) **(1) NOT** "CO_2 formed" **(2 marks)**

(Total 10 marks

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2. (a) (i) $C_2H_6 + Br_2 \rightarrow C_2H_5Br + HBr$ **(1)**

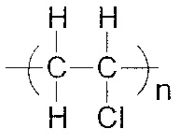
$C_2H_4 + Br_2 \rightarrow CH_2BrCH_2Br$ *ALLOW* $C_2H_4Br_2$ **(1)**

IGNORE STATE SYMBOLS **(2 marks)**

(ii) (Free) radical / homolytic **(1)** substitution **(1)**

Electrophilic **(1)** addition **(1)** **(4 marks)**

(b) (i)



(1 mark)

(ii) Water pipes
window or door frames
clothing
bottles
coating on electrical cables
flooring
NOT plastic / PVC / carrier bags

Any one

(1 mark)

(iii) Persists in the environment / persisting as litter

OR non-biodegradable / not broken down by bacteria **(1)**

because of strong C-Cl bond **(1)**

OR

combustion / burning **(1)**

produces toxic gases /acidic gases/HCl **(1)**

NOT chlorine **(2 marks)**

(Total 11 marks

3. (a) (i)
- It is the enthalpy / heat (energy) change / evolved for the formation of **1 mol of urea (1)**
- from its **elements (1)**
- in their standard states / at 1 atm and stated temperature {298K} **(1)** **(3 marks)**

(b) **AMENDED** (Ignore units)

{(- 333.0) + (- 285.8)} – {(**2** x – 46.2) + (- 393.5)}

= - 618.8 + 485.9

= - 132.9 kJ **(3)**

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

Correct answer alone **(1)**

+ 132.9 kJ **(2)**

Omitting the ×2 gives –179.1 kJ **(2)**

+ 179.1 kJ **(1)**

Incorrect application of Hess's Law gives – 1104.7 kJ **(2)**

+ 1104.7 kJ **(1)**

Incorrect Hess's Law and omit ×2 gives – 1058.5 kJ **(1)**

+ 1058.5 kJ **(0)**

NOT AMENDED (Ignore units)

{(- 632.2) + (- 285.8)} – {(**2** x – 46.2) + (- 393.5)} **(1)**

= - 918.0 + 485.9

= - 432.1 kJ **(3)**

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

Correct answer alone **(1)**

+ 432.1 kJ **(2)**

Omitting the ×2 gives – 478.3 kJ **(2)**

+ 478.3 kJ **(1)**

Incorrect application of Hess's Law gives – 1403.9 kJ **(2)**

+ 1403.9 kJ **(1)**

Incorrect Hess's Law and omit ×2 gives – 1357.1 kJ **(1)**

+ 1357.1 kJ **(0)**

(Total 6 marks

4. (a)

- A species with a lone pair / pair of electrons **(1)**

  NOT "negative ion" alone or as an alternative
- which it uses / donates to form a (dative) covalent bond **(1)** **(2 marks**

(b) (i)

- Ammonia / NH_3 (in ethanol) **(1)**
- heat **(1) NOT** heat under reflux *UNLESS* in a sealed tube

If a temperature is quoted it must be greater than 100°C

- in sealed tube / under pressure / concentrated**(1)**

If a pressure is quoted it must be greater than 1 atm

Conditions are dependent on correct reagent.

If ammonia and an additional reagent **max (1)** for two correct conditions. **(3 marks**

(ii) Carbon-bromine bond stronger / higher bond enthalpy than

carbon – iodine / Ea for C-Br is higher than C-I

IGNORE any extra explanations involving the alkyl groups **(1 mark**

(c) Identify bonds broken **and** made **(1)**

e.g. Energy in = + 464 or + 3340

AND Energy out = (-) 656 or (-) 3532 **(1)**

Energy needed to break bonds – energy released to make bonds = 36 **(1)**

e.g. C-I + 464 – 656 = + 36

or C-I + 3340 – 3532 = + 36 **(1)**

Correct evaluation dependant on use of 36 **(1)**

i.e. C-I = 228 kJ mol^{-1} **(1)**

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

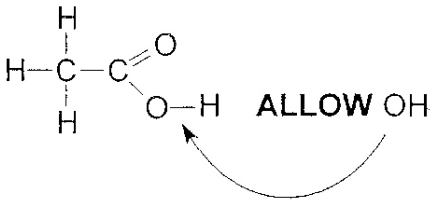
If final answer is negative max **(2)**

If 36 is on the wrong side, then 156 **max 2** (-156 **(1)**)

If miss out 36, then $^{\pm}192$ **max 1**

(3 marks)

(d)



ALLOW OH

(1 mark

(Total 10 marks

5. (a)

- A series of compounds with the same functional group / same or similar **chemical** properties **(1)**

NOT *same (physical) properties* **(0)**

NOT *same physical and chemical properties* **(0)**

- with the same general formula **(1)**
- where one member differs from the next by CH_2 **(1)** **(3 marks**

(b) (i)

- It will move to the right **(1)**
- Which is the exothermic direction **(1)**

2nd mark conditional upon first statement **(2 marks**

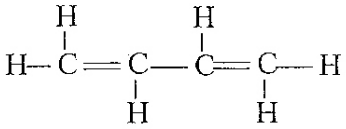
(ii)

- The rate of reaction would be too slow if cooled **(1)**
- yield too small / too little reactants converted

OR converse arguments **(1)**

NOT equilibrium yield **(2 marks**

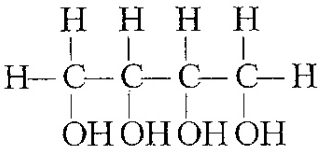
(c) (i)



(1 mark

(ii) No, as both the end carbons have two H atoms **(1 mark**

(iii)



Penalise C-HO once

Or $CH_2(OH)CH(OH)CH(OH)CH_2OH$ **(1)** for adding two OH groups across one double bond, and **(1)** for adding it across both.

Consequential on structure in (c)(i)

1 mark per double bond **max 2** **(2 marks)**

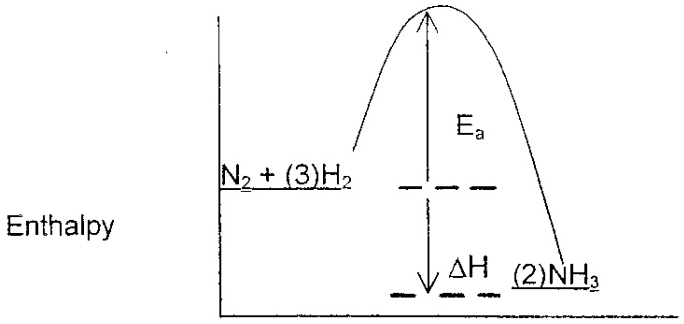
(Total 11 marks

6. (a)
- for energy level of product lower than reactant both labelled with species **(1)**
- for activation hump $\geq \Delta H$ **(1)**
- for E_a being correctly marked **(1)**

Arrow must not point downwards

- for ΔH being correctly marked **(1)**

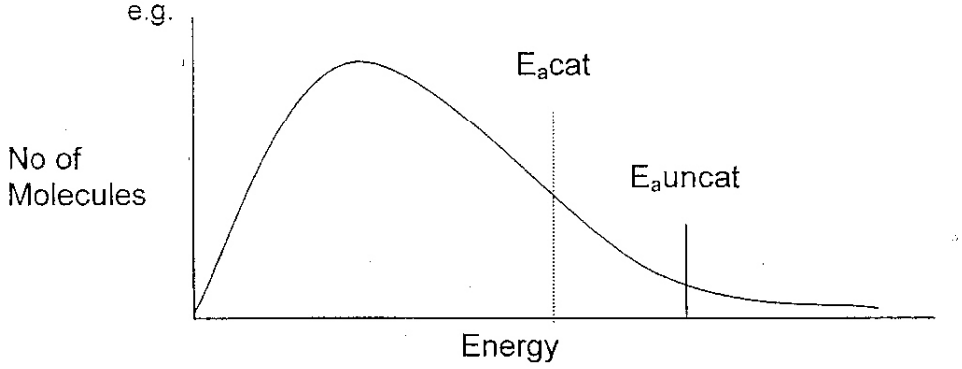
e.g.



(4 marks)

(b) (i)
- starts at or near origin (not on x or y axis) skewed distribution that is reasonably asymptotic to the x-axis **(1)**
- for E_{uncat} (must not be to the left of the peak) **(1)**
- for E_{cat} to the left of E_{uncat}**(1)** *and still not to the left of the peak* **(3 marks)**

e.g.



(ii)
- With the catalyst a greater number / proportion of the molecules **(1)**
  This point must be linked to the diagram in some way, e.g. labelled shading
- have $E \geq E_{cat}$ / sufficient energy to react **(1)**
- and so more collisions result in reaction / more successful collisions **(1)**

(3 marks)

(c)
- At 25 °C no / few molecules / collisions have $E \geq E_a$ / sufficient energy to react **(1)**
- At higher temperature the (average) energy of the molecules increases **(1)**
- At 400 °C a greater proportion of the molecules/collisions have energy greater than/equal to the activation energy **(1)** **(3 marks)**

(Total 13 marks

END

1. *Any reference to specific solids eg Na_2CO_3, $NaHCO_3$, Na_2SO_3, penalise first time only.*

Inferences are free-standing marks: award even if test/observation is wrong.

Observation marks must follow a correct test but may be given if test is a near- miss.

Formulae in inferences must be correct for mark, BUT correct name and charge error in formula eg "carbonate and CO_3^-" **(1)**

(a) ***Test:***

(pass gas through) lime water / calcium hydroxide **solution** / $Ca(OH)_2$**(aq) (1)**

NOT extinguishes lighted spill

Observation:

Cloudy / milky / white ppt **(1)**

Inference **:**

Carbonate / CO_3^{2-} **(1)** *NOT* CO_3 *NOT* CO_3^- *on its own*

Hydrogencarbonate / bicarbonate / HCO_3^- **(1)** *NOT* HCO_3

NOT carbonate and CO_3 **(0)** **(4 marks)**

(b) ***Test :***

Potassium (di)chromate((VI)) / potassium manganate((VII)) / potassium permanganate / $K_2Cr_2O_7$ / $KMnO_4$ **(1)**

HCl acid + $KMnO_4$ **(0)** *BUT IGNORE all other acidification.*

No need for test details or "solution"

May omit oxidation numbers but penalise if given incorrectly

NOT using litmus paper

Observation **:**

$K_2Cr_2O_7$: orange / yellow to green **(1)** *NOT* blue

OR

$KMnO_4$ purple to colourless/brown **(1)**

NOT observation for litmus paper test

Inference **:**

Sulphite / SO_3^{2-} / sulphate**(IV)** **(1)**

Sulphite and SO_3^- **(1)**

Sulphate / SO_4^{2-} **(0)**

N.B! Sulphite and SO_4^{2-} **(0)**

Sulphate and SO_3^{2-} **(0)**

NOT SO_3^- *on its own* **(0)** **(3 marks)**

Test :

Ignite / light / **burning** spill / burn / combust **(1)**

NOT glowing spill

Observation:

Pops **(1)**

MUST follow a correct test E.g.

Test: glowing spill **(0)**, Observation: pops **(0)**

Inference :

(Reactive) Metal / named metal e.g Mg / Zn / Fe / Ca / Li ONLY **(1)**

IF "metal and Na" **(0)**

NOT "metal ion/cation"

NOT H^+

NOT "Group I / Group II metals"

NOT Na / Al **(3 marks)**

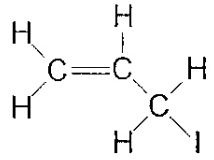
(Total 10 marks)

2. (a) 1 C=C / Is an alkene / unsaturated **(1)**
NOT "Is an alkene and propene"
NOT "propene" *on its own*
NOT "contains a double bond"
NOT –OH / alcohol

2 C–I / iodine / AgI / I^- / iodide / iodine ions **(1)**
I^- in X **(0)**
Iodine molecules / I_2 **(0)**
NOT Br references alone **(0)** but allow I **and** Br references
NOT halide

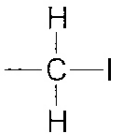
3 Confirms / proves OR selects iodine / iodide **(1)** **(3 marks)**

(b)



(2) *IGNORE* shape

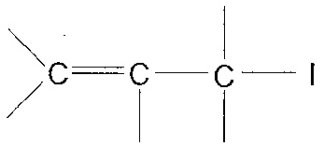
i.e. award the two marks as follows



(1) *only if more than 2 carbons in the compound*

Formula fully correct **(1)**
NOT dependent on (a)

Condensed formula / missing H's **max 1**
E.g



✓x **(1)**

$H_2C{=}CH{-}CH_2I$ ✓x **(1)**

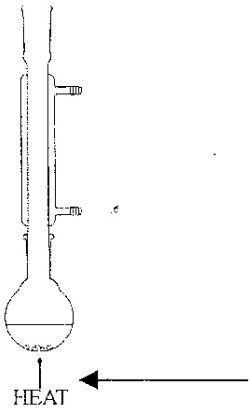
(2 marks)
(Total 5 marks)

3. (a) (Wear) gloves / add slowly / cool while adding *ONLY* **(1)**

IF multiple answers correct and incorrect **(0)** **(1 mark)**

NOT lab coats / be careful not to spill on hands / do in a fume cupboard

(b) (i)



NOT arrow on its own

Flask (round or pear shaped ONLY) + heat **(1)**

Vertical condenser (double surface and water inlet and outlet) **(1)**

NOT sealed , no gaps, joint shown between flask and condenser, safe,

NOT distillation, if water in out labelled they must be correct **(1)**

3rd mark can be awarded even if minor slip eg no heat **(3 marks)**

(ii) (Fractionally) distil **(1)**

Collect fraction that distils over at about 56 °C / stated range 55-57 or 54 –58 °C **(1)** – *a temperature value / range MUST be quoted*

Mark independently

NOT "collect fraction above 56 °C **(2 marks)**

(c)

Reagent	**Result**
PCl_5 / $SOCl_2$ **(1)**	No steamy fumes / no gas which turns blue litmus red **(1)**
OR	
$K_2Cr_2O_7 + H_2SO_4$ **(1)**	No colour change / stays orange **(1)**
OR	
$KMnO_4 + H_2SO_4$ **(1)**	No colour change / stays purple **(1)**
OR	
Na **(1)**	No bubbles / no effervescence **(1)**

Name or formula can be given.

IGNORE oxidation numbers UNLESS they are incorrect

Results may be given as negative tests Or as "if propan-2-ol was present there would be steamy fumes"

Result mark is dependent on correct reagent but may have result mark if minor error in reagent.

MUST be a chemical test eg NOT "check that boiling point is 56 °C exactly" **(2 marks)**

(Total 8 marks)

4. *Atomic numbers*

If atomic numbers used instead of molar mass penalise ONCE only.

(a) (i) Amount of iron = 1.40 ÷ 56 **(1)** (= 0.025 mol)

0.025 x 63.5 = 1.59 (g) **(1)** *Answer to 3 S.F. ONLY*

Correct answer with some working **(2)**

(ii) Amount of copper = 0.025 x 3/2 = 0.0375 (mol)

mass of copper produced = 0.0375 x 63.5 = 2.38 (g)

OR

Answer to (a)(i) × 3/2 = 2.38 / 2.39 **(1)** **(3 marks)**

(b) Fe^{2+} *consequential on (a)* **(1 mark)**

(c) (i) The copper / filter paper was still wet. **(1 mark)**

(ii) Improved drying / heat to constant mass / heat it to constant mass / wash with suitable solvent (propanone or ethanol) / suction filtration **(1 mark)**

(d) (i) So that **all** the iron reacts /dissloves / used up

NOT "the reaction is complete" **(1 mark)**

(ii) Volume = 0.025 ÷ 1.0 = 0.025 **dm^3** (25 **cm^3**) **(1)** *UNITS required*

Moles is consequential on ion in (b) *ALLOW 2 / 3 SF*

and calculation in (a)

(1 mark)

(Total 8 marks)

5. (a) (i) 1. Rinse the burette with distilled water **(1)**

2. Then with hydrochloric acid **(1)**

Wrong order **max 1** **(2 marks)**

(ii) The solution will go from yellow **(1)**

To orange / pink / peach **(1)** *NOT* red

Colours must be the correct way round **(2 marks)**

(b) (i) Titres = 24.80 and 24.70 (cm^3) **(1)**

Mean = 24.75 (cm^3)**(1)**

2nd mark consequential on selected titres. To 2 d.p including a final 0 **(3 marks)**

N.B Significant Figures in (ii) – (vi) to 3 / 4 SF

(ii) Amount of HCl = 0.105 x 0.02475 = 0.00260 (mol)

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

(iii) Amount of Na_2CO_3 in titre = ½ x 0.00260 = 0.00130 (mol).

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

(iv) Amount of pure Na_2CO_3 in 250 cm^3 = 10 x 0.00130 = 0.0130 (mol)

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

(v) M_r (Na_2CO_3) = 106 (g mol^{-1}) **(1)**

0.0130 x 106 = 1.38 (g) **(1)** **(2 marks)**

(vi) Purity = 1.38 g x 100 ÷ 1.62 g = 85.2 % (or 85.1 or 85.0)

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

6. (a) (i) Orange / yellow / stronger / longer lasting / persistent Na flame **(1)**

Obscures / hides/ covers Ba flame **(1)**

NOT "makes it difficult to distinguish between the two colours." **(2 marks)**

(ii) (conc) Sulphuric acid / H_2SO_4 / a (solution) of any specific soluble sulphate e.g $MgSO_4$, $(NH_4)_2SO_4$, Na_2SO_4/ carbonate / sulphite / chromate

NOT hydroxide

ACCEPT correct *name with minor slip in formula e.g. sodium carbonate, $NaCO_3$* **(1 mark)**

(iii) (Apple) green / yellow-green / pale green **(1)** **(1 mark)**

(b)
- Aluminium / zinc (powder) / Devarda's alloy **(1)**
- Add sodium hydroxide (solution) **(1)**
- Gas is evolved which turns damp red litmus blue / gives white smoke with hydrogen chloride fumes **(1)** *NOT* just "ammonia" *NOT* "smell"

OR

(Brown ring test)

- add **iron(II)** sulphate / $FeSO_4$ (solution) **(1)** *NOT* "iron sulphate"
- (slide in) **conc** sulphuric acid **(1)** *NOT* dilute
- Brown ring (formed at the interface) **(1)**

*If no Devarda's alloy / iron(II) sulphate **0 out of 3***

2nd mark only awarded if 1st mark given

3rd mark only awarded if 1st and 2nd given UNLESS oxidation state of iron sulphate or conc is the near miss. **(3 marks)**

(Total 7 marks)

END