

**M1.(a)**

Method 1

Mass of H<sub>2</sub>O = 4.38–2.46  
(= 1.92 g)

Method 2

Percentage of H<sub>2</sub>O = 44%

*If there is an AE in M1 then can score M2 and M3  
If M<sub>1</sub> incorrect can only score M1*

ZnSO<sub>4</sub>

H<sub>2</sub>O

ZnSO<sub>4</sub>

H<sub>2</sub>O

2.46

1.92

56

44

161.5

18

161.5

18

(0.0152

0.107)

(0.347

2.444)

( 1 : 7 )

( 1 : 7 )

x = 7

x = 7

*If x = 7 with working then award 3 marks.*

*Allow alternative methods.*

*If M1 incorrect due to AE, M3 must be an integer.*

(b) Moles HCl = 0.12(0)

mol ZnCl<sub>2</sub> = 0.06(0) **OR** 0.12 / 2

*If M2 incorrect then CE and cannot score M2, M3 and M4.*

mass ZnCl<sub>2</sub> = 0.06 × 136.4

*Allow 65.4 + (2 × 35.5) for 136.4*

= 8.18(4) (g) **OR** 8.2 (g)  
*Must be to 2 significant figures or more.*  
*Ignore units.*

1

(c) Moles  $\text{ZnCl}_2 = \frac{10.7}{136.4}$  (= 0.0784)

1

**OR** moles Zn = 0.0784

Mass Zn reacting = 0.0784 × 65.4 = (5.13 g)  
*M2 is for their M1 × 65.4*

1

$$\% \text{purity of Zn} = \frac{5.13}{5.68} \times 100$$

M3 is  $M2 \times 100 / 5.68$  provided M2 is < 5.68

1

= 90.2% **OR** 90.3%

*Allow alternative methods.*

$$M1 = \text{Moles ZnCl}_2 = \frac{10.7}{136.4} (= 0.0784)$$

$$M2 = \text{Theoretical moles Zn} = \frac{5.68}{65.4} (= 0.0869)$$

$$M3 = M1 \times 100 / M2 = (0.0784 \times 100 / 0.0869)$$

$$M4 = \underline{90.2\%} \text{ **OR** } \underline{90.3\%}$$

1

(d) Ionic

*If not ionic CE = 0/3*

1

Strong (electrostatic) attraction (between ions)

1

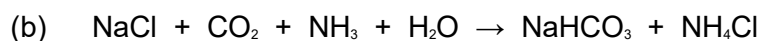
between oppositely charged ions / + and – ions /  $F^-$  and  $Zn^{2+}$  ions  
If IMF, molecules, metallic bonding implied CE = 0/3

1

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**M2.(a)** ( $CO_2$  from) burning (fossil) fuels

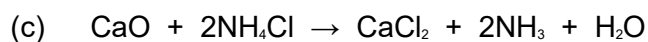
1



*Allow multiples, including fractions.*

*Ignore state symbols.*

1



*Allow multiples, including fractions.*

*Allow ionic equations.*

*Do not allow equations involving  $NH_4OH$  or  $NH_4^+$  on the right hand side.*

*Ignore state symbols.*

1

(d) (i)  $= (106) \times 100 / (117 + 100(.1))$

*Do not penalise precision but must be to minimum of two significant figures.*

1

$= 48.8$

*This answer without working scores 1 mark only.*

1

(ii) The percentage atom economy cannot be improved

**OR**

Sell the by-product /  $CaCl_2$  (solution)

*Do not accept answers which refer to improving the efficiency of the process.*

1

- (e) It is used up but then regenerated later in the cycle / No overall consumption of  $\text{NH}_3$

*Allow 'can act as a catalyst'.*

1

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**M3.(a)** Cobalt has variable oxidation states

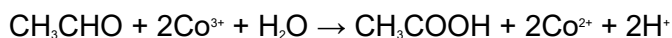
*Allow exists as Co(II) and Co(III)*

1

(It can act as an intermediate that) lowers the activation energy

*Allow (alternative route with) lower  $E_a$*

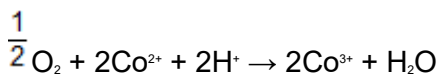
1



*Allow multiples; allow molecular formulae*

*Allow equations with  $\text{H}_3\text{O}^+$*

1



1

- (b) (i)  $[\text{Co}(\text{H}_2\text{O})_6]^{2+} + 3\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2 \rightarrow [\text{Co}(\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2)_3]^{2+} + 6\text{H}_2\text{O}$

*Do not allow en in equation, allow  $\text{C}_2\text{H}_8\text{N}_2$*

1

The number of particles increases / changes from 4 to 7

*Can score M2 and M3 even if equation incorrect or missing provided number of particles increases*

1

So the entropy change is positive / disorder increases / entropy increases

1

- (ii) Minimum for **M1** is 3 bidentate ligands bonded to Co

*Ignore all charges for M1 and M3 but penalise charges on*

any ligand in M2

1

Ligands need not have any atoms shown but diagram must show 6 bonds from ligands to Co, 2 from each ligand

Minimum for **M2** is one ligand identified as H<sub>2</sub>N-----NH<sub>2</sub>

Allow linkage as -C-C- or just a line.

1

Minimum for **M3** is one bidentate ligand showing two arrows from separate nitrogens to cobalt

1

(c) Moles of cobalt =  $(50 \times 0.203) / 1000 = \underline{0.01015}$  mol

Allow 0.0101 to 0.0102

1

Moles of AgCl =  $4.22/143.4 = 0.0294$

Allow 0.029

If not AgCl (eg AgCl<sub>2</sub> or AgNO<sub>3</sub>), lose this mark and can only score **M1, M4 and M5**

1

Ratio = Cl<sup>-</sup> to Co = 2.9 : 1

Do not allow 3 : 1 if this is the only answer but if 2.9:1 seen somewhere in answer credit this as **M3**

1

[Co(NH<sub>3</sub>)<sub>6</sub>]Cl<sub>3</sub> (square brackets not essential)

1

Difference due to incomplete oxidation in the preparation

Allow incomplete reaction.

Allow formation [Co(NH<sub>3</sub>)<sub>5</sub>Cl]Cl<sub>2</sub> etc.

Some chloride ions act as ligands / replace NH<sub>3</sub> in complex.

Do not allow 'impure sample' or reference to practical deficiencies

**M4.(a)** (i) Two rings only around nitrogen or sulfur  
*Lose this mark if more than 2 atoms are ringed.  
Do not allow two atoms at the same end of the ion.* 1

(ii) 275.8  
*Accept this answer only. Do not allow 276* 1

(iii) Carboxylate / COO<sup>-</sup>  
*Allow salt of carboxylic acid or just carboxylic acid.* 1

(b)  $(32.1 / 102.1) = 31.4\%$   
*Do not penalise precision but do not allow 1 significant figure.* 1

(c) Zineb is mixed with a solvent / water  
*Max=2 if M1 missed* 1

Use of column / paper / TLC  
*Lose M1 and M2 for GLC* 1

Appropriate collection of the ETU fraction  
**OR** Appropriate method of detecting ETU  
*Allow ETU is an early fraction in a column or collecting a range of samples over time, lowest retention time / travels furthest on paper or TLC (allow 1 mark for having the longest retention time in GLC).* 1

Method of identification of ETU (by comparison with standard using chromatography)

*If method completely inappropriate, only M1 is accessible*

1

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