M1.(a)

Method 1		Method 2	
Mass of H_2O = 4.38−2.46		Percentage of H_2O = 44%	
(= 1.92 g)			

If there is an AE in M1 then can score M2 and M3
If M_r incorrect can only score M1

1

$ZnSO_4$	H_2O	ZnSO4	H2O
$\frac{2.46}{161.5}$	$\frac{1.92}{18}$	$\frac{56}{161.5}$	$\frac{44}{18}$

1

(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.

1

(b) Moles HCl = 0.12(0)

1

mol $ZnCl_2$ = 0.06(0) ***OR*** 0.12 / 2

1

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

mass $ZnCl_2$ = 0.06 × 136.4
Allow 65.4 + (2 × 35.5) for 136.4

1

= <u>8.18(4)</u> (g) ***OR*** <u>8.2</u> (g)

Must be to 2 significant figures or more.
Ignore units.

1

(c) Moles $ZnCl_2 = \frac{10.7}{136.4}$ (= 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 × 100 / 5.68 provided M2 is < 5.68

1

= <u>90.2</u>% ***OR*** <u>90.3</u>%

Allow alternative methods.

M1 = Moles $ZnCl_2$ = <u>10.7</u> (= 0.0784)
136.4

M2 = Theoretical moles Zn = <u>5.68</u> (= 0.0869)
65.4

M3 = M1 × 100 / M2 = (0.0784 × 100 / 0.0869)

M4 = <u>90.2%</u> ***OR*** *<u>90.3%</u>*

1

(d) Ionic

If not ionic CE = 0/3

1

<u>Strong</u> (electrostatic) <u>attraction</u> (between ions)

1

between oppositely charged ions / + and − ions / F^- and Zn^{2+} ions

If IMF, molecules, metallic bonding implied CE = 0/3

1

[14]

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

1

(b) $NaCl + CO_2 + NH_3 + H_2O \rightarrow NaHCO_3 + NH_4Cl$

Allow multiples, including fractions.

Ignore state symbols.

1

(c) $CaO + 2NH_4Cl \rightarrow CaCl_2 + 2NH_3 + H_2O$

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) × 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 NH_3

Allow 'can act as a catalyst'.

1

[7]

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

$CH_3CHO + 2Co^{3+} + H_2O \rightarrow CH_3COOH + 2Co^{2+} + 2H^+$

Allow multiples; allow molecular formulae

Allow equations with H_3O^+

1

$\frac{1}{2}O_2 + 2Co^{2+} + 2H^+ \rightarrow 2Co^{3+} + H_2O$

1

(b) (i) $[Co(H_2O)_6]^{2+} + 3H_2NCH_2CH_2NH_2 \rightarrow [Co(H_2NCH_2CH_2NH_2)_3]^{2+} + 6H_2O$

Do not allow en in equation, allow $C_2H_8N_2$

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_2N-----NH_2

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 × 0.203) / 1000 = <u>0.01015</u> mol

Allow 0.0101 to 0.0102

1

Moles of AgCl = 4.22/143.4 = 0.0294

Allow 0.029

*If not AgCl (eg $AgCl_2$ or $AgNO_3$), lose this mark and can only score **M1, M4** and **M5***

1

Ratio = Cl^- 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

$[Co(NH_3)_6]Cl_3$ (square brackets not essential)

1

Difference due to incomplete oxidation in the preparation

Allow incomplete reaction.

Allow formation $[Co(NH_3)_5Cl]Cl_2$ etc.

Some chloride ions act as ligands / replace NH_3 in complex.

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

1

[15]

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^-

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 <u>solvent / water</u>

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

[8]