M1. (a) **M1** The yield of zinc oxide <u>increases/greater</u>

If M1 is given as "decrease" OR "no effect" then CE= 0

M2 Removal of the carbon dioxide results in the **<u>equilibrium</u>**

Either

Shifting/moving/goes to the right
shifting/moving/goes L to R
favours the forward reaction/towards the products

M3 (By Le Chatelier's principle) the reaction/equilibrium will respond so as <u>to replace the CO_2/lost product</u>
OR <u>to make more CO_2</u>
OR <u>to increase concentration of CO_2</u>

For M3, not simply "to oppose the change/to oppose the loss of CO_2/to oppose the removal of carbon dioxide."

3

(b) **M1** Process 2 produces/releases SO_2
OR Process 2 produces/releases CO

M2 It/Process 3 avoids the release of SO_2 OR CO
OR It/Process 3 (captures and) converts SO_2 to H_2SO_4

M3 SO_2 causes acid rain OR is toxic/poisonous
OR CO is toxic/poisonous

3

Ignore "global warming" and "greenhouse gases" and "the ozone layer"

If both CO and SO_2 claimed to form acid rain, treat as contradiction

(c) **M1** Process 3 (is expensive because it) uses <u>electrolysis</u>
OR due to high <u>electricity/electrical</u> consumption

M2 this is justified because the product/zinc is pure

Ignore "energy"

Penalise "pur<u>er</u>"

2

(d) **M1** $Zn^{2+} + 2e^- \longrightarrow Zn$

Ignore state symbols

M2 the negative electrode OR the cathode

Ignore absence of negative charge on electron

Accept electrons subtracted from RHS

2

(e) **M1** The reaction of ZnO with sulfuric acid
OR the second reaction in Extraction process 3

M2 neutralisation or acid-base

OR alternatively

M1 The reaction of zinc carbonate in Extraction process 1

M1 could be the equation written out in both cases

M2 (thermal) decomposition

M2 depends on correct M1

M3 It/carbon is <u>oxidised/gains oxygen/changes oxidation state/number from 0 to +2/increase in oxidation state/number</u> in Process 2

Do not forget to award this mark

Ignore reference to electron loss but penalise electron gain

Ignore "carbon is a reducing agent"

3

(f) **M1** $Zn + H_2O \longrightarrow ZnO + H_2$

M2 <u>Zinc oxide and hydrogen</u>

OR as an alternative

M1 $Zn + 2H_2O \longrightarrow Zn(OH)_2 + H_2$

M2 <u>Zinc hydroxide and hydrogen</u>

Mark independently

If ZnO_2 is given for zinc oxide in the equation, penalise M1 and mark on

If ZnOH is given for zinc hydroxide in the equation, penalise M1 and mark on

Ignore state symbols

Credit multiples of the equation

If M1 is blank, either of the M2 answers could score

To gain <u>both</u> marks, the names must match the correct equation given.

2

[15]

M2. (a) Hydrogen/H_2 gas/bubbles

1

1.0 mol dm^{-3} HCl/H^+

1

At 298K and 100kPa

Allow 1 bar instead of 100 kPa
Do not allow 1 atm

1

Pt (electrode)

1

(b) $Li^+ + MnO_2 + e^- \rightarrow LiMnO_2$

Ignore state symbols

1

–0.13(V)

1

(c) Fe^{3+} ions reduced to Fe^{2+}

Can score from equation/scheme

1

Because $E(Fe^{3+}/Fe^{2+}) > E(H^+/H_2)$/*E*(hydrogen)

Allow emf/E_{cell} +ve/0.77V
Allow Fe^{3+} better oxidising agent than H^+
Allow H_2 better reducing agent than Fe^{2+}
Only award this explanation mark if previous mark given

1

(d) Moles $Cr_2O_7^{2-}$ = $\underline{23.7 \times 0.01/1000}$ = 2.37×10^{-4}

1

1 mol $Cr_2O_7^{2-}$ reacts with 6 mol Fe^{2+} so moles Fe^{2+} in 25 cm^3 = $6 \times 2.37 \times 10^{-4} = 1.422 \times 10^{-3}$

1

M1 × 6

Moles Fe^{2+} in 250 cm^3 = 1.422×10^{-2}

M2 × 10 or M4/10

1

Original moles Fe^{2+} = 10.00/277.9 = 0.0360

Independent mark

1

Moles Fe^{2+} oxidised = 0.0360 – 0.0142 = 0.0218

M4 – M3

1

% oxidised = (0.0218 × 100)/0.0360 = 60.5%

(M5 × 100)/M4
Allow 60 to 61
Note Max 3 if mol ratio for M2 wrong
eg 1:5 gives 67.1%
1:1 gives 93.4%
Note also, 39.5% (39-40) scores M1, M2, M3 and M4 (4 marks)

1

[14]

M3.(a) (i) Propanone evaporates (or similar)

1

Removes water (from the precipitate)

Accept 'removes impurities / excess reagents'.
Accept 'salt insoluble in propanone'.

1

(ii) Add NaOH / NH_3 / Na_2CO_3

1

No green ppt

Accept 'no visible change'.
Must have correct reagent to score this mark.

1

(iii) Some salt dissolves (in propanone) **or** some lost in filtration **or** some Fe^{2+}

gets oxidised (to Fe^{3+} in air)

Do not accept 'reaction reversible' or 'incomplete reaction' or similar.

1

(iv) Moles $Fe^{2+} = 2.50 \times 10^{-2}$

Accept 2.5×10^{-2}

1

M_r of salt = 179.8

Allow 180

Allow if 179.8 or 180 appears in a calculation.

1

Mass of salt = $179.8 \times 2.5 \times 10^{-2} \times 0.95 = 4.27$ (g)

Correct answer with no working scores this mark only.

Allow range 4.2 to 4.3 (g)

1

(v) 1.67 mol or correct ratio of $5FeC_2O_4 : 3MnO_4^-$

1

(b) $Ca^{2+} + C_2O_4^{2-} \rightarrow CaC_2O_4$

Accept multiples.

1

(c) (Insoluble) calcium ethanedioate coats surface

Allow 'calcium ethanedioate is insoluble'.

Do not allow answers based on ethanedioic acid being a weak acid.

Do not accept 'acid used up' or 'reaction very fast'.

1

(d) Small amount of tea used **or** concentration of the acid in tea is low

Accept 'high temperature decomposes the acid'.

Accept 'calcium ions in milk form a precipitate with the acid'.

Do not accept 'do not drink tea often' or similar.

1

(e) Mass of acid = 180.0 and mass of reagents = 450.0

Accept 180 and 450.

1

(180 / 450 ×100 =) 40.0%

Do not penalise precision.

Correct answer without working scores this mark only.

1

[14]

M4. (a) (i) Oxidation

OR

Oxidised ONLY

1

(ii) Any one from

- to provide/overcome activation energy
- to provide the minimum energy to make the reaction go/start

NOT simply to increase the (initial) reaction rate.

1

(iii) The reaction is exothermic OR releases heat (energy)

1

(iv) M1
Catalysts provide an alternative route/pathway OR an alternative mechanism

OR

(in this case) surface adsorption occurs (or a description of adsorption)

Ignore reference to "surface" alone

M2
Lowers the activation energy

OR

of lower activation energy

2

(b) M1
The (forward) reaction is exothermic OR the (forward) reaction releases heat

OR

The reverse reaction is endothermic or absorbs heat

M2 – Direction of change N.B. M2 depends on correct M1
At lower temperatures,

- the equilibrium yield of NO_2 is greater
- more NO_2 is formed
- equilibrium shifts (left) to right
- (equilibrium) favours the forward reaction

(***OR*** converse for higher temperatures)

2

(c) NO_2 (+) 4

NO_3^- (+) 5

HNO_2 (+) 3

3

[10]