

M1.D

[1]

M2.D

[1]

M3. (a) (i) Reducing agent

OR

Reduce(s) (WO_3 /tungsten oxide)

OR

electron donor

OR

to remove oxygen (from WO_3 /tungsten oxide or to form water);

1

(ii) $\text{WO}_3 + 3\text{H}_2 \rightarrow \text{W} + 3\text{H}_2\text{O}$

Or multiples

1

(iii) *One from*

H_2 is

- explosive
- flammable or inflammable
- easily ignited

Ignore reference to pressure or temperature

1

(b) (i) Addition

*Ignore "electrophilic"
Penalise "nucleophilic addition"*

OR

(catalytic) hydrogenation

OR

Reduction

1

(ii) Geometric(al)

OR

cis/trans OR E Z OR E/Z

1

(c) (i) (If any factor is changed which affects an equilibrium), the position of equilibrium will shift/move/change/respond/act so as to oppose the change.

OR

(When a system/reaction in equilibrium is disturbed), the equilibrium shifts/moves in a direction which tends to reduce the disturbance

A variety of wording will be seen here and the key part is the last phrase and must refer to movement of the equilibrium.

QoL

1

(ii) **M1 – Statement of number of moles/molecules**

There are more moles/molecules (of gas) on the left/of reactants

OR

fewer moles/molecules (of gas) on the right./products

OR

there are 4 moles/molecules (of gas) on the left and 2 moles/molecules on the right.

Ignore "volumes" for M1

Mark independently

M2 – Explanation of response/movement in terms of pressure

Increase in pressure is opposed (or words to that effect)

OR

pressure is lowered by a shift in the equilibrium (from left) to right/favours forward reaction.

2

(d) $\Sigma B(\text{reactants}) - \Sigma B(\text{products}) = \Delta H$ (**M1**)

OR

Sum of bonds broken – Sum of bonds formed = ΔH (**M1**)

$$B(\text{H-H}) + \frac{1}{2}B(\text{O=O}) - 2B(\text{O-H}) = -242 \text{ (M1)}$$

$$B(\text{H-H}) = -242 - \frac{1}{2}(+496) + 2(+463) \text{ (this scores M1 and M2)}$$

$$B(\text{H-H}) = (+)436 \text{ (kJ mol}^{-1}\text{) (M3)}$$

Award 1 mark for – 436

Candidates may use a cycle and gain full marks.

M1 could stand alone

Award full marks for correct answer.

Ignore units.

Two marks can score with an arithmetic error in the working.

3

[11]



1

(ii) Acid rain

OR

an effect either from acid rain or from an acidic gas in the atmosphere

1

(iii) SO_2 could be used to make H_2SO_4

OR

to make gypsum/plaster or $\text{CaSO}_4 \cdot (\text{xH}_2\text{O})$

1

(b) $\text{Cu}_2\text{S} + 2\text{O}_2 \rightarrow 2\text{CuO} + \text{SO}_2$

*Or multiples
Ignore state symbols*

1

(c) $2\text{CuO} + \text{C} \rightarrow 2\text{Cu} + \text{CO}_2$

OR

$\text{CuO} + \text{C} \rightarrow \text{Cu} + \text{CO}$

*Or multiples
Ignore state symbols*

1

(d) (i) *Any one from the following two ONLY
Apply the list principle*

- (Scrap) iron is cheap
- Low energy requirement
Not "less energy"

1

(ii) $\text{Fe} + \text{Cu}^{2+} \rightarrow \text{Fe}^{2+} + \text{Cu}$

*Or multiples
Ignore state symbols*

1

[7]

M5. (a) Gain of electrons

- (b) (i) (+)5 or V or N⁵⁺ 1
- (+)4 or IV or N⁴⁺ 1
- (+)2 or II or N²⁺ 1
- (ii) Reduction 1
- $4\text{H}^+ + \text{NO}_3^- + 3\text{e}^{(-)} \rightarrow \text{NO} + 2\text{H}_2\text{O}$ 1
- (iii) $2\text{H}^+ + \text{NO}_3^- + \text{e}^{(-)} \rightarrow \text{NO}_2 + \text{H}_2\text{O}$ 1
- (iv) $\text{Cu} + 4\text{H}^+ + 2\text{NO}_3^- \rightarrow \text{Cu}^{2+} + 2\text{H}_2\text{O} + 2\text{NO}_2$
- species 1
- balanced
- If electrons included, **mark CE if these are not balanced** 1

[9]

- M6.** (a) (i) $2\text{C} + \text{O}_2 \rightarrow 2\text{CO}$
- OR**
- $\text{C} + \text{CO}_2 \rightarrow 2\text{CO}$
- Or multiples.*
- Ignore state symbols.* 1
- (ii) $\text{Fe}_2\text{O}_3 + 3\text{CO} \rightarrow 2\text{Fe} + 3\text{CO}_2$
- Or multiples*
- Penalise FE and Fe₂*
- Ignore state symbols* 1

(iii) **Economic:**

- Scrap iron/steel has higher iron content.
 - Recycling involves lower energy consumption
 - Blast furnace not required
- Ignore cost*
Assume that "it" means recycling for both reasons

1

Environmental:

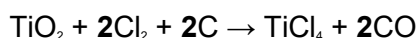
- Reduces greenhouse gas / CO₂ / SO₂ emission.
- Reduces acid rain
- Reduces mining
- Reduces landfill
- Removes an eyesore

1

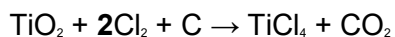
(b) (i) **M1** Use of Cl₂ and C

M2 Balanced equation consequential on correct reactants

EITHER



OR



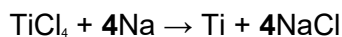
Or multiples
Ignore state symbols

2

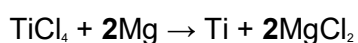
(ii) **M1** Use of Na OR Mg

M2 Balanced equation consequential on correct reactants

EITHER



OR



*Or multiples
Ignore state symbols*

2

(iii) One from

- TiC / carbide is produced
- Product is brittle
- Product is a poor engineering material

1

(c) (i) One from

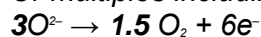
To allow

- ions to move
- current to flow
- it to conduct electricity

1

(ii) $2\text{O}^{2-} \rightarrow \text{O}_2 + 4\text{e}^-$

Or multiples including



Ignore state symbols

Ignore charge on the electron

Credit the electron being subtracted on the LHS

1

(iii) Carbon / graphite / the electrodes oxidise

OR

Carbon / graphite / the electrodes burn in / react with the oxygen
formed

OR

carbon dioxide / CO_2 is formed

1

(iv) Recycling involves lower electricity OR less energy
consumption

OR

The converse for electrolysis

*Ignore references to raw materials
Assume that "it" means recycling
The answer MUST show some evidence of comparison e.g.
lower or less*

1

[13]

- M7.** (a) **M1** $\text{MnO}_2 + 4\text{H}^+ + 2\text{e}^- \rightarrow \text{Mn}^{2+} + 2\text{H}_2\text{O}$ 1
- OR multiples*
- M2** An oxidising agent is an electron acceptor OR receives / accepts / gains electrons
*Ignore state symbols
M2 NOT an "electron pair acceptor"* 1
- M3** MnO_2 is the oxidising agent
Ignore "takes electrons" or "takes away electrons" 1
- (b) **M1** Formation of SO_2 and Br_2 (could be in an equation) 1
- M2** Balanced equation
Several possible equations
 $2\text{KBr} + 3\text{H}_2\text{SO}_4 \rightarrow 2\text{KHSO}_4 + \text{Br}_2 + \text{SO}_2 + 2\text{H}_2\text{O}$
OR
 $2\text{KBr} + 2\text{H}_2\text{SO}_4 \rightarrow \text{K}_2\text{SO}_4 + \text{Br}_2 + \text{SO}_2 + 2\text{H}_2\text{O}$ 1
- M3** $2\text{KBr} + \text{Cl}_2 \rightarrow 2\text{KCl} + \text{Br}_2$
*M2 Could be ionic equation with or without K^+
 $2\text{Br}^- + 6\text{H}^+ + 3\text{SO}_4^{2-} \rightarrow \text{Br}_2 + 2\text{HSO}_4^- + \text{SO}_2 + 2\text{H}_2\text{O}$
($3\text{H}_2\text{SO}_4$)
 $2\text{Br}^- + 4\text{H}^+ + \text{SO}_4^{2-} \rightarrow \text{Br}_2 + \text{SO}_2 + 2\text{H}_2\text{O}$
($2\text{HBr} + \text{H}_2\text{SO}_4$)
Accept HBr and H_2SO_4 in these equations as shown or mixed variants that balance.
Ignore equations for KBr reacting to produce HBr
M3 Could be ionic equation with or without K^+
 $2\text{Br}^- + \text{Cl}_2 \rightarrow 2\text{Cl}^- + \text{Br}_2$* 1

M4 % atom economy of bromine

$$= \frac{\text{Br}_2}{2\text{KBr} + \text{Cl}_2} \times 100 = \frac{(2 \times 79.9)}{238 + 71} \times 100 = \frac{159.8}{309} \times 100$$

= **51.7% OR 52%**

M4 Ignore greater number of significant figures

1

M5 One from:

- High atom economy
- Less waste products
- Cl₂ is available on a large-scale
- No SO₂ produced
- Does not use concentrated H₂SO₄
- (Aqueous) KBr or bromide (ion) in seawater.
- Process 3 is simple(st) or easiest to carry out

M5 Ignore reference to cost

Ignore reference to yield

1

(c) **M1** HBr **-1**

1

M2 HBrO **(+)**1

1

M3 Equilibrium will shift to the right

OR

L to R

OR

Favours forward reaction

OR

Produces more HBrO

1

M4 Consequential on correct M3

OR

to oppose the loss of HBrO

OR

replaces (or implied) the HBrO (that has been used up)

1

[12]

