

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:

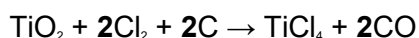
- Reduces greenhouse gas / CO₂ / SO₂ emission.
- Reduces acid rain
- Reduces mining
- Reduces landfill
- Removes an eyesore

1

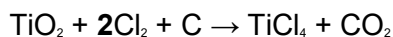
(b) (i) **M1** Use of Cl₂ and C

M2 Balanced equation consequential on correct reactants

EITHER



OR



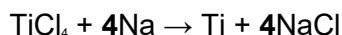
Or multiples
Ignore state symbols

2

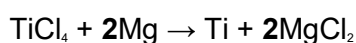
(ii) **M1** Use of Na OR Mg

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

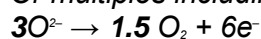
To allow

- 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

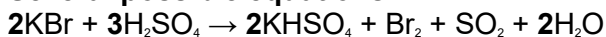
Ignore "takes electrons" or "takes away electrons"

1

(b) **M1** Formation of SO_2 and Br_2 (could be in an equation) 1

M2 Balanced equation

Several possible equations



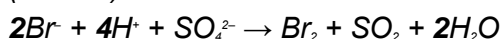
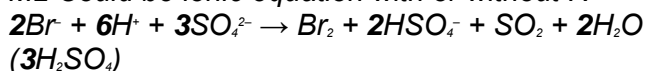
OR



1

M3 $2\text{KBr} + \text{Cl}_2 \rightarrow 2\text{KCl} + \text{Br}_2$

M2 Could be ionic equation with or without K^+

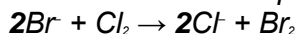


($2\text{HBr} + \text{H}_2\text{SO}_4$)

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^+



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]

