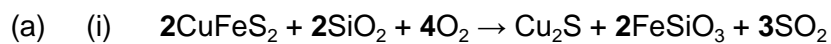


Mark schemes

1



1

(ii) Acid rain

OR

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

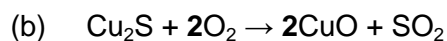
1

(iii) SO_2 could be used to make H_2SO_4

OR

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

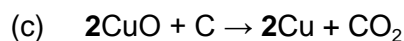
1



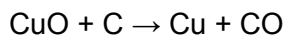
Or multiples

Ignore state symbols

1



OR



Or multiples

Ignore state symbols

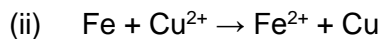
1

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

Apply the list principle

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

1



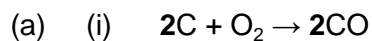
Or multiples

Ignore state symbols

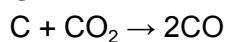
1

[7]

2



OR



Or multiples.

Ignore state symbols.

1



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

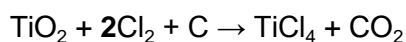
(b) (i) **M1** Use of Cl₂ and C

M2 Balanced equation consequential on correct reactants

EITHER



OR



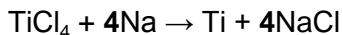
Or multiples

Ignore state symbols

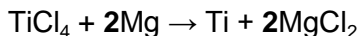
2

- (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

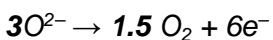
To allow

- 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]

3

- (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



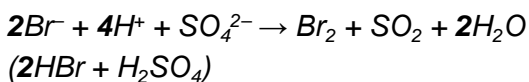
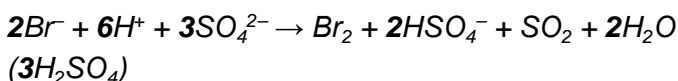
OR



1

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

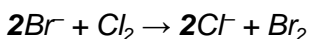
M2 Could be ionic equation with or without K^+



Accept HBr and H₂SO₄ 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]

4	(a) Gain of electrons	1	
	(b) (i) (+)5 or V or N ⁵⁺	1	
	(+)4 or IV or N ⁴⁺	1	
	(+)2 or II or N ²⁺	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]

5		[1]
---	--	-----

6		[1]
---	--	-----

7	(a) removal/loss of electrons	1	
	(b) no change	1	
	equal number of gaseous moles on either side	1	
	both sides affected equally	1	
	increases	1	
	equilibrium moves to lower the temperature/oppose the change	1	
	endothermic reaction favoured /forward reaction is endothermic	1	
	(c) (i) +2	1	
	+5	1	
	(ii) $\text{NO}_3^- + 4\text{H}^+ + 3\text{e}^- \rightarrow \text{NO} + 2\text{H}_2\text{O}$	1	
	(iii) $\text{Ag} \rightarrow \text{Ag}^+ + \text{e}^-$	1	
	(iv) $\text{NO}_3^- + 4\text{H}^+ + 3\text{Ag} \rightarrow \text{NO} + 2\text{H}_2\text{O} + 3\text{Ag}^+$	1	
			[12]

8		[1]
----------	--	------------

9	(a) Accepts electrons	1	
	(b) Charge on the ion (or element or atom)	1	
	(c) +4	1	
	+5	1	
	-3	1	

- (d) (i) $\text{Cu}^- \rightarrow \text{Cu}^{2+} + 2\text{e}^-$ 1
- (ii) $\text{NO}_3^- + 4\text{H}^+ + 3\text{e}^- \rightarrow \text{NO}_2 + \text{H}_2\text{O}$ 1
- (iii) $3\text{Cu} + 2\text{NO}_3^- + 8\text{H}^+ \rightarrow 3\text{Cu}^{2+} + 2\text{NO} + 4\text{H}_2\text{O}$ 1

[8]

10

- (a) Gains electrons (or removes electrons) 1
- (b) (i) +4 1
- +6 1
- (ii) $\text{Br}_2 + 2\text{e}^- \rightarrow 2\text{Br}^-$ 1
- (iii) $\text{SO}_2 + 2\text{H}_2\text{O} \rightarrow 4\text{H}^+ + \text{SO}_4^{2-} + 2\text{e}^-$ 1
- (iv) $\text{Br}_2 + \text{SO}_2 + 2\text{H}_2\text{O} \rightarrow 2\text{Br}^- + 4\text{H}^+ + \text{SO}_4^{2-}$ 1
- (c) $\text{Cl}_2 + \text{H}_2\text{O} \rightarrow \text{H}^+ + \text{Cl}^- + \text{HOCl}$ 1
- Chloride: -1 1
- Chlorate(I): +1 1
- (d) Chloride ions cannot reduce sulphuric acid
*(Or chloride ions are weak reducing agents
 Or sulphuric acid is not a strong enough oxidising agent
 Or sulphuric acid is a weaker oxidising agent than chlorine)* 1
- (e) $\text{KCl} + \text{H}_2\text{SO}_4 \rightarrow \text{HCl} + \text{KHSO}_4$
(Allow $2\text{KCl} + \text{H}_2\text{SO}_4 \rightarrow 2\text{HCl} + \text{K}_2\text{SO}_4$) 1

- (f) (i) Bromine 1
- (ii) Sulphur dioxide 1
- [13]**

A
11 **[1]**

B
12 **[1]**

13 (a) gains electrons **(1)**
or accepts/takes electrons
*Allow an electron
or just 'gains'
or reduction is gain of electrons, but NOT OILRIG even if stated
Do not allow mention of electron pair(s)* 1

(b) (i) Oxidising agent: Ag^+ **(1)** (or Ag I)
*Reducing agent: SO_2 **(1)** (or S^{VI} , not sulphur)*

(ii) $\text{SO}_2 + 2\text{H}_2\text{O} \rightarrow \text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^-$ **(1)** (or $\text{H}_2\text{SO}_4 + 2\text{H}^+ + 2\text{e}^-$)
*allow e i.e. no charge
penalise E^- once only
allow $-\text{e}^-$ on LHS* 3

(c) (i) $\text{Fe}^{2+} \rightarrow \text{Fe}^{3+} + \text{e}^-$ **(1)**

(ii) 5 **(1)** (or V or +5)

(iii) $\text{ClO}_3^- + 6\text{H}^+ + 6\text{e}^- \rightarrow \text{Cl}^- + 3\text{H}_2\text{O}$ **(1)**

(iv) $\text{ClO}_3^- + 6\text{H}^+ + 6\text{Fe}^{2+} \rightarrow \text{Cl}^- + 3\text{H}_2\text{O} + 6\text{Fe}^{3+}$ **(1)**
Mark parts (i) to (iv) independently 4

- (d) Equation: $\text{Mg} + \text{S} \rightarrow \text{MgS}$ (1)
 allow $\text{FeS} + \text{Mg} \rightarrow \text{MgS} + \text{Fe}$
 allow Ca

Oxidising agent: S (1)

Only award mark if first answer given unless no first answer then
 can allow

2

[10]

C
14 [1]

C
15 [1]

B
16 [1]

B
17 [1]

18 (a) (i) -2 OR 2-

(ii) NaI or NaAt or I⁻ or iodide or At⁻ or Astatide (1)
Not atoms or molecules

(iii) Smell of bad eggs (1)
 Allow PbAc_2 goes black and $\text{K}_2\text{Cr}_2\text{O}_7/\text{H}^+$ goes
 cloudy green

(iv) $8 \text{e}^- + 8 \text{H}^+ + \text{H}_2\text{SO}_4 \rightarrow \text{H}_2\text{S} + 4\text{H}_2\text{O}$ (1)
 OR $10 \text{H}^+ + \text{SO}_4^{2-}$

4

- (b) (i) HF or HCl (1)
 CE = 0 if redox answer given
 If wrong halide given allow max one in b(iii)
 If NaF or NaCl, or F⁻ or Cl⁻ given lose mark in (i)
 Mark on if X is e.g. HF_2 or H_2F

- (ii) NaF or NaCl or F⁻ or Cl⁻ **(1)**
- (iii) A proton donor or an acid **(1)**
- (iv) H⁺ + F⁻ → HF
 OR H₂SO₄ + NaF → NaHSO₄ + HF
 OR H₂SO₄ + 2 NaF → Na₂SO₄ + 2 HF
 OR for chloride

4

[8]

19

- (a) A reducing agent gives electrons **(1)**
Not electron pairs
- (b) Zero **(1)**
- (c) (i) (+)3 **(1)**
 (ii) -3 **(1)**
 (iii) -1 **(1)**
Allow answers in roman
- (d) (i) PbO₂ + 4H⁺ + 2e⁻ → Pb₂⁺ + 2H₂O **(1)**
 (ii) 2Cl⁻ → Cl₂ + 2e⁽⁻⁾ **(1)**
 (iii) PbO₂ + 4H⁺ + 2Cl⁻ → Pb²⁺ + Cl₂ + 2H₂O **(1)**
Or molecular

1

1

3

3

[8]

20

[1]

21

- (a) (i) Loss (of electrons) **(1)**
 (ii) Oxidation state of nitrogen in NO: (+) 2 **(1)**
 Oxidation state of nitrogen in NH^+ : -3 **(1)**
 (iii) I_2 **(1)**

4

- (b) (i) $\text{Cl}_2 + 2\text{e}^- \rightarrow 2\text{Cl}^-$ **(1)**
 (ii) $\text{SO}_2 + 2\text{H}_2\text{O} \rightarrow \text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^-$ **(1)**
 (iii) $\text{SO}_2 + 2\text{H}_2\text{O} + \text{Cl}_2 \rightarrow \text{SO}_4^{2-} + 2\text{Cl}^- + 4\text{H}^+$ **(1)**
 or $\text{H}_2\text{SO}_4 + 2\text{HCl}$ etc

*Ignore state symbols in equation**Allow multiples of all equations*

3

[7]**22**

- (a) (i) Halides:- Fluoride
 Chloride **(1)**
 Equation:- $\text{H}^+ + \text{F}^- \rightarrow \text{HF}$ (or molecular / for a correct halide) **(1)**
- (ii) Halides:- Bromide and iodide **(1)**
 Equation:- H_2SO_4 (or $2\text{H}^+ + \text{SO}_4^{2-}$) + $2\text{H}^+ + 2\text{e}^- \rightarrow \text{SO}_2 + 2\text{H}_2\text{O}$ **(1)**
 $2\text{Br}^- \rightarrow \text{Br}_2 + 2\text{e}^-$ **(1)**
 $\text{H}_2\text{SO}_4 + 2\text{H}^+ + 2\text{Br}^-$ (or 2HBr) $\rightarrow \text{Br}_2 + \text{SO}_2 + 2\text{H}_2\text{O}$ **(1)**

*Q of L penalise wrong symbol for fluoride or bromide once**Ignore state symbols in equations*

- (iii) Products Sulphur (or S_8 not S_4) **(1)**
 Hydrogen sulphide **(1)**
 Equation:- H_2SO_4 (or $2\text{H}^+ + \text{SO}_4^{2-}$) + $6\text{H}^+ + 6\text{e}^- \rightarrow \text{S} + 4\text{H}_2\text{O}$ **(1)**
OR
 H_2SO_4 (or $2\text{H}^+ + \text{SO}_4^{2-}$) + $8\text{H}^+ + 8\text{e}^- \rightarrow \text{H}_2\text{S} + 4\text{H}_2\text{O}$

9

*Ignore halide if given even if incorrect**Do not allow elements, molecules or atoms in part (a)*

(b) Addition of silver nitrate

Chloride gives white precipitate / solid **(1)**

Bromide gives cream precipitate / solid **(1)**

Iodide gives yellow precipitate / solid **(1)**

Addition of ammonia

Chloride precipitate soluble in dilute **(1)**

Bromide precipitate soluble in concentrated **(1)**

Iodide precipitate insoluble **(1)**

Do not allow halogen or sodium halide

6

[15]

23

[1]