1

(a) (i) **2**$CuFeS_2$ + **2**SiO_2 + **4**O_2 → Cu_2S + **2**$FeSiO_3$ + **3**SO_2

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 $CaSO_4$ (xH_2O)

1

(b) Cu_2S + **2**O_2 → **2**CuO + SO_2

Or multiples
Ignore state symbols

1

(c) **2**CuO + C → **2**Cu + CO_2

OR

CuO + C → Cu + CO

Or multiples
Ignore state symbols

1

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

Apply the list principle

- <u>(Scrap) iron is cheap</u>
- <u>Low energy requirement</u>

Not "less energy"

1

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

Or multiples
Ignore state symbols

1

[7]

2

(a) (i) **2**C + O_2 → **2**CO

OR

C + CO_2 → 2CO

Or multiples.
Ignore state symbols.

1

(ii) Fe_2O_3 + 3CO → 2Fe + $3CO_2$

Or multiples
Penalise FE and Fe_2
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 / CO_2 / SO_2 emission.
- Reduces acid rain
- Reduces mining
- Reduces landfill
- Removes an eyesore

1

(b) (i) **M1** Use of Cl_2 and C

M2 Balanced equation consequential on correct reactants

EITHER

TiO_2 + **2**Cl_2 + **2**C → $TiCl_4$ + **2**CO

OR

TiO_2 + **2**Cl_2 + C → $TiCl_4$ + CO_2

Or multiples
Ignore state symbols

2

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

M2 Balanced equation consequential on correct reactants

EITHER

$TiCl_4$ + **4**Na → Ti + **4**NaCl

OR

$TiCl_4$ + **2**Mg → Ti + **2**$MgCl_2$

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

- <u>ions</u> to <u>move</u>
- <u>current</u> to <u>flow</u>
- it to <u>conduct electricity</u>

1

(ii) $2O^{2-} \rightarrow O_2 + 4e^-$

Or multiples including
***3**O^{2-} → **1.5** O_2 + 6e^-*
Ignore state symbols
Ignore charge on the electron
Credit the electron being subtracted on the LHS

1

(iii) Carbon / graphite / the electrodes <u>oxidise</u>
OR
Carbon / graphite / the electrodes <u>burn in</u> / <u>react with</u> the <u>oxygen</u> formed
OR
carbon dioxide / CO_2 is formed

1

(iv) Recycling involves <u>lower electricity</u> OR <u>less energy</u> 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** $MnO_2 + 4H^+ + 2e^- \rightarrow Mn^{2+} + 2H_2O$

1

OR multiples

M2 An oxidising agent is an <u>electron acceptor</u> OR <u>receives / accepts / gains electrons</u>

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

2KBr + **3**$H_2SO_4 \rightarrow$ **2**$KHSO_4 + Br_2 + SO_2$ + **2**H_2O

OR

2KBr + $2H_2SO_4 \rightarrow K_2SO_4 + Br_2 + SO_2$ + **2**H_2O

1

M3 **2**KBr + $Cl_2 \rightarrow$ **2**KCl + Br_2

M2 Could be ionic equation with or without K^+

2Br^- + ***6***H^+ + ***3***$SO_4^{2-} \rightarrow Br_2$ + ***2***HSO_4^- + SO_2 + ***2***H_2O

*(**3**H_2SO_4)*

2Br^- + ***4***H^+ + $SO_4^{2-} \rightarrow Br_2 + SO_2$ + ***2***H_2O

*(**2**HBr + H_2SO_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$Br^- + Cl_2 \rightarrow$ ***2***$Cl^- + Br_2$

1

M4 % atom economy of bromine

$$= \frac{Br_2}{2KBr + Cl_2} \times 100 = \frac{(2 \times 79.9)}{238 + 71} \times 100 = \frac{159.8}{309} \times 100$$

= **51.7%** OR **52%**

M4 Ignore greater number of significant figures

1

M5 One from:

- High atom economy
- Less waste products
- Cl_2 is available on a large-scale
- No SO_2 produced
- Does not use concentrated H_2SO_4
- (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 <u>to the right</u>
OR
<u>L to R</u>
OR
Favours forward reaction
OR
Produces more HBrO

1

M4 **<u>Consequential on correct M3</u>**
OR
to <u>oppose the loss</u> of HBrO
OR
<u>replaces</u> (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

$4H^+ + NO_3^- + 3e^{(-)} \rightarrow NO + 2H_2O$

1

(iii) $2H^+ + NO_3^- + e^{(-)} \rightarrow NO_2 + H_2O$

1

(iv) $Cu + 4H^+ + 2\ NO_3^- \rightarrow Cu^{2+} + 2H_2O + 2NO_2$

species

1

balanced
If electrons included, **mark CE if these are not balanced**

1

[9]

5 D

[1]

6 D

[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) $NO_3^- + 4H^+ + 3e^- \rightarrow NO + 2H_2O$ **1**

(iii) $Ag \rightarrow Ag^+ + e^-$ **1**

(iv) $NO_3^- + 4H^+ + 3Ag \rightarrow NO + 2H_2O + 3Ag^+$ **1**

[12]

8 B **[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) $Cu^{-} \rightarrow Cu^{2+} + 2e^{-}$

1

(ii) $NO_3^- + 4H^+ \; 3e^- \rightarrow NO_2 \; H_2O$

1

(iii) $3Cu + 2NO_3^- + 8H^+ \rightarrow 3Cu^{2+} + 2NO + 4H_2O$

1

[8]

10 (a) Gains electrons (or removes electrons)

1

(b) (i) +4

1

+6

1

(ii) $Br_2 + 2e^- \rightarrow 2Br^-$

1

(iii) $SO_2 + 2H_2O \rightarrow 4H^+ + SO_4^{2-} + 2e^-$

1

(iv) $Br_2 + SO_2 + 2H_2O \rightarrow 2Br^- + 4H^+ + SO_4^{2-}$

1

(c) $Cl_2 + H_2O \rightarrow H^+ + Cl^- + HOCl$

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) $KCl + H_2SO_4 \rightarrow HCl + KHSO_4$

(Allow $2KCl + H_2SO_4 \rightarrow 2HCl + K_2SO_4$)

1

(f) (i) Bromine

1

(ii) Sulphur dioxide

1

[13]

11 A

[1]

12 B

[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) $SO_2 + 2H_2O \rightarrow SO_4^{2-} + 4H^+ + 2e^-$ **(1)** (*or* $H_2SO_4 + 2H^+ + 2e^-$)

allow e i.e. no charge
penalise E^- *once only*
allow $-e^-$ *on LHS*

3

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

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

(iii) $ClO_3^- + 6H^+ + 6e^- \rightarrow Cl^- + 3H_2O$ **(1)**

(iv) $ClO_3^- + 6H^+ + 6Fe^{2+} \rightarrow Cl^- + 3H_2O + 6Fe^{3+}$ **(1)**
Mark parts (i) to (iv) independently

4

(d) *Equation*: Mg + S → MgS **(1)**

allow FeS + Mg → MgS + Fe
allow Ca

Oxidising agent: S **(1)**

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

2

[10]

14 C **[1]**

15 C **[1]**

16 B **[1]**

17 B **[1]**

18 (a) (i) –2 OR 2–

(ii) NaI or NaAt or I^- or iodide or At^-or Astatide **(1)**

<u>Not</u> atoms or molecules

(iii) Smell of bad eggs **(1)**

Allow $PbAc_2$ goes black and $K_2Cr_2O_7/H^+$ goes cloudy green

(iv) $8\ e^- + 8\ H^+ + H_2SO_4 \rightarrow H_2S + 4H_2O$ **(1)**

OR $10\ H^+ + SO_4^{2-}$

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) $H^+ + F^- \rightarrow HF$

OR $H_2SO_4 + NaF \rightarrow NaHSO_4 + HF$

OR $H_2SO_4 + 2\ NaF \rightarrow Na_2SO_4 + 2\ HF$

OR for chloride

4

[8]

19

(a) A reducing agent gives electrons **(1)**

Not electron pairs

1

(b) Zero **(1)**

1

(c) (i) (+)3 **(1)**

(ii) –3 **(1)**

(iii) –1 **(1)**

Allow answers in roman

3

(d) (i) $PbO_2 + 4H^+ + 2e^- \rightarrow Pb_2^+ + 2H_2O$ **(1)**

(ii) $2Cl^- \rightarrow Cl_2 + 2e^{(-)}$ **(1)**

(iii) $PbO_2 + 4H^+ + 2Cl^- \rightarrow Pb^{2+} + Cl_2 + 2H_2O$ **(1)**

Or molecular

3

[8]

20 D

[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) $Cl_2 + 2e^- \rightarrow 2Cl^-$ **(1)**

(ii) $SO_2 + 2H_2O \rightarrow SO_4^{2-} + 4H^+ + 2e^-$ **(1)**

(iii) $SO_2 + 2H_2O + Cl_2 \rightarrow SO_4^{2-} + 2Cl^- + 4H^+$ **(1)**
or $H_2SO_4 + 2HCl$ etc

Ignore state symbols in equation

Allow multiples of all equations

3

[7]

22

(a) (i) Halides:- Fluoride
Chloride **(1)**

Equation:- $H^+ + F^- \rightarrow HF$ *(or molecular / for a correct halide)* **(1)**

(ii) Halides:- Bromide and iodide **(1)**

Equation:- H_2SO_4 *(or $2H^+ + SO_4^{2-}$)* $+ 2H^+ + 2e^- \rightarrow SO_2 + 2H_2O$ **(1)**

$2Br^- \rightarrow Br_2 + 2e^-$ **(1)**

$H_2SO_4 + 2H^+ + 2Br^-$ (or 2HBr) $\rightarrow Br_2 + SO_2 + 2H_2O$ **(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 $2H^+ + SO_4^{2-}$)* $+ 6H^+ + 6e^- \rightarrow S + 4H_2O$ **(1)**

OR

H_2SO_4 *(or $2H^+ + SO_4^{2-}$)* $+ 8H^+ + 8e^- \rightarrow H_2S + 4H_2O$

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 D

[1]