Q13.

For many years, swimming pool water has been treated with chlorine gas. The chlorine is added to kill any harmful bacteria unintentionally introduced by swimmers. Pool managers are required to check that the chlorine concentration is high enough to kill the bacteria without being a health hazard to the swimmers.

When chlorine reacts with water in the absence of sunlight, the chlorine is both oxidised and reduced and an equilibrium is established.

(a) Write an equation for this equilibrium.

For each chlorine-containing species in the equation, write the oxidation state of chlorine below the species.

(2)

(b) The pool manager maintains the water at a pH slightly greater than 7.0

Explain how this affects the equilibrium established when chlorine is added to water.

(2)

(c) Explain why chlorine is used to kill bacteria in swimming pools, even though chlorine is toxic.

(2)

(Total 6 marks)

Q14.

This question is about Group 7 chemistry.

(a) Sea water is a major source of iodine.
The iodine extracted from sea water is impure. It is purified in a two-stage process.

Stage **1** $I_2 + 2H_2O + SO_2 \longrightarrow 2HI + H_2SO_4$

Stage **2** $2HI + Cl_2 \longrightarrow I_2 + 2HCl$

(i) State the initial oxidation state and the final oxidation state of sulfur in Stage **1**.

Oxidation state of S in SO_2 _____

Oxidation state of S in H_2SO_4 _____

(2)

(ii) State, in terms of electrons, what has happened to chlorine in Stage **2**.

_____

_____

(1)

(b) When concentrated sulfuric acid is added to potassium iodide, iodine is formed in the following redox equations.

$$.....KI + ...H_2SO_4 \longrightarrow .....KHSO_4 + ...I_2 + S + ...H_2O$$

$$8KI + 9H_2SO_4 \longrightarrow 8KHSO_4 + 4I_2 + H_2S + 4H_2O$$

(i) Balance the equation for the reaction that forms sulfur.

(1)

(ii) Deduce the half-equation for the formation of iodine from iodide ions.

_____

(1)

(iii) Deduce the half-equation for the formation of hydrogen sulfide from concentrated sulfuric acid.

_____

(1)

(c) A yellow precipitate is formed when silver nitrate solution, acidified with dilute nitric acid, is added to an aqueous solution containing iodide ions.

(i) Write the **simplest ionic** equation for the formation of the yellow precipitate.

_____

(1)

(ii) State what is observed when concentrated ammonia solution is added to this yellow precipitate.

_____

_____

(1)

(iii) State why the silver nitrate solution is acidified when testing for iodide ions.

_____

_____

_____

(1)

(iv) Explain why dilute hydrochloric acid is **not** used to acidify the silver nitrate solution in this test for iodide ions.

_____

_____

_____

(1)

(d) Chlorine is toxic to humans. This toxicity does not prevent the large-scale use of chlorine in water treatment.

(i) Give **one** reason why water is treated with chlorine.

_____

_____

(1)

(ii) Explain why the toxicity of chlorine does **not** prevent this use.

_____

_____

_____

(1)

(iii) Write an equation for the reaction of chlorine with cold water.

_____

(1)

(e) Give the formulas of the **two** different chlorine-containing compounds that are formed when chlorine reacts with cold, dilute, aqueous sodium hydroxide.

Formula 1 _____

Formula 2 _____

(1)

(Total 14 marks)

Q15.

The price of copper is increasing as supplies of high-grade ores start to run out.
The mineral covellite (CuS), found in low-grade ores, is a possible future source of copper.

(a) When copper is extracted from covellite, a reaction occurs between copper(II) sulfide and nitric acid to form a dilute solution of copper(II) sulfate.

(i) Balance the equation for this reaction.

$3CuS(s) + ...HNO_3(aq) \longrightarrow .....CuSO_4(aq) + ...NO(g) + ...H_2O(l)$

(1)

(ii) Give the oxidation state of nitrogen in each of the following.

HNO_3 _____

NO _____

(2)

(iii) Deduce the redox half-equation for the reduction of the nitrate ion in acidified solution to form nitrogen monoxide and water.

_____

(1)

(iv) Deduce the redox half-equation for the oxidation of the sulfide ion in aqueous solution to form the sulfate ion and $H^+(aq)$ ions.

_____

(1)

(b) Use your knowledge of metal reactivity to state and explain a low-cost method for the extraction of copper from a dilute aqueous solution of copper(II) sulfate.
Write the **simplest ionic** equation for the reaction that occurs during this extraction process.

Simplest ionic equation

(4)
(Total 9 marks)

Q16.

Metals can be extracted by different methods.

(a) Give **one** reason why titanium cannot be extracted directly from titanium(IV) oxide using carbon.

(1)

(b) Titanium steel is an alloy of titanium and iron. Titanium steel is extracted from the mineral ilmenite ($FeTiO_3$) in a two-stage process.
Purified $FeTiO_3$ is first converted into a mixture of two metal chlorides. These two metal chlorides are then reduced simultaneously using sodium.

(i) Write an equation for the reaction of $FeTiO_3$ with chlorine and carbon to produce iron(III) chloride ($FeCl_3$), titanium(IV) chloride and carbon monoxide.

(1)

(ii) Write an equation for the simultaneous reduction of the mixture of iron(III) chloride and titanium(IV) chloride to iron and titanium using sodium.

(1)

(c) Scrap iron is used to extract copper from dilute aqueous solutions containing copper(II) ions.
Explain, in terms of redox, what happens to the copper(II) ions in this extractio.

_____

_____

_____

_____

(2)

(d) Aluminium is an expensive metal because it is extracted from molten aluminium oxide using electrolysis.
Write the half-equation for the reaction that occurs at the positive electrode during this extraction.

_____

(1)

(Total 6 marks)

Q17.

The silicon chip industry requires the production of pure silicon. Silicon is extracted from its ore, silicon dioxide (SiO_2), by a process similar to that used in the extraction of titanium.

(a) (i) Write an equation for the formation of $SiCl_4$ from SiO_2 using chlorine and carbon.

_____

(1)

(ii) Suggest how the liquid $SiCl_4$ is purified.

_____

_____

(1)

(b) The final stage in the extraction of silicon involves the use of hydrogen gas to convert the $SiCl_4$ into silicon and hydrogen chloride.

(i) Write an equation for this reaction.

_____

(1)

(ii) State the role of hydrogen in this reaction.

_____

(1)

(iii) Give **one** risk associated with the use of hydrogen gas.

_____

(1)

(c) The magnesium used to make magnesium ferrosilicon alloys is extracted from magnesium oxide using silicon.
Write an equation for this reaction to produce magnesium and silicon dioxide.

_____

(1)

(Total 6 marks)

Q18.

Hydrogen gas is used in the chemical industry.

(a) Tungsten is extracted by passing hydrogen over heated tungsten oxide (WO_3).

(i) State the role of the hydrogen in this reaction.

_____

(1)

(ii) Write an equation for this reaction.

_____

(1)

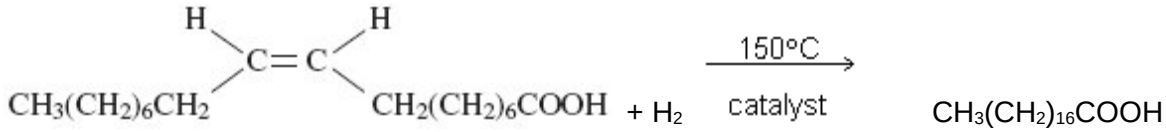
(iii) State **one** risk of using hydrogen gas in metal extractions.

_____

_____

(1)

(b) Hydrogen is used to convert oleic acid into stearic acid as shown by the following equation.



oleic acid stearic acid

(i) Use your knowledge of the chemistry of alkenes to deduce the type of reaction that has occurred in this conversion.

_____

(1)

(ii) State the type of stereoisomerism shown by oleic acid.

_____

(1)

(c) Hydrogen reacts with nitrogen in the Haber Process. The equation for the equilibrium that is established is shown below.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

(i) State Le Chatelier's principle.

_____

_____

(1)

(ii) Use Le Chatelier's principle to explain why an increase in the total pressure of this equilibrium results in an increase in the equilibrium yield of ammonia.

_____

_____

_____

_____

(2)

(d) Hydrogen reacts with oxygen in an exothermic reaction as shown by the following equation.

$$H_2(g) + \frac{1}{2} O_2(g) \rightarrow H_2O(g) \qquad \Delta H = -242 \text{ kJ mol}^{-1}$$

Use the information in the equation and the data in the following table to calculate a value for the bond enthalpy of the H–H bond.

	O–H	O=O
Mean bond enthalpy / kJ mol^{-1}	+ 463	+ 496

(3)

(Total 11 marks)

Q19.

Nitric acid is manufactured from ammonia in a process that involves several stages.

(a) In the first stage, ammonia is converted into nitrogen monoxide and the following equilibrium is established.

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g) \qquad \Delta H = -905 \text{ kJ mol}^{-1}$$

The catalyst for this equilibrium reaction is a platinum–rhodium alloy in the form of a gauze. This catalyst gauze is heated initially but then remains hot during the reaction.

(i) In terms of redox, state what happens to the ammonia in the forward reaction.

(1)

(ii) Suggest a reason why the catalyst must be hot.

(1)

(iii) Suggest a reason why the catalyst remains hot during the reaction.

(1)

(iv) State how a catalyst increases the rate of a reaction.

_____

_____

_____

_____

(2)

(b) In the second stage, nitrogen monoxide is converted into nitrogen dioxide. The equation for the equilibrium that is established is shown below.

$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$ $\Delta H = -113$ kJ mol^{-1}

Explain why the equilibrium mixture is cooled during this stage of the process.

_____

_____

_____

_____

(2)

(c) In the final stage, nitrogen dioxide reacts with water as shown by the following equation.

$$2NO_2(g) + H_2O(l) \rightarrow H^+(aq) + NO_3^-(aq) + HNO_2(aq)$$

Give the oxidation state of nitrogen in each of the following.

NO_2 _____

NO_3^- _____

HNO_2 _____

(3)

(Total 10 marks)

Q20.

Copper is extracted from the ore chalcopyrite ($CuFeS_2$) in a three-stage process.

(a) In the first stage of this extraction, the chalcopyrite is heated with silicon dioxide and oxygen.

(i) Balance the following equation for this first stage in which copper(I) sulfide is formed.

.....$CuFeS_2$ + ...SiO_2 + ...O_2 → Cu_2S + ...$FeSiO_3$ + ...SO_2

(1)

(ii) Give **one** environmental reason why the SO_2 gas formed in this reaction is not allowed to escape into the atmosphere.

_____

_____

(1)

(iii) State **one** use for the sulfur dioxide formed in this reaction.

_____

_____

(1)

(b) In the second stage of this extraction, the copper(I) sulfide is converted into copper(II) oxide. This occurs by roasting the sulfide with oxygen at high temperature.
Write an equation for this reaction.

_____

(1)

(c) In the third stage of this extraction, copper(II) oxide is reduced to copper by its reaction with carbon. Write an equation for this reaction.

_____

(1)

(d) Scrap iron can be used to extract copper from dilute aqueous solutions containing copper(II) ions.

(i) Explain why this is a low-cost method of extracting copper.

_____

_____

(1)

(ii) Write the **simplest ionic** equation for the reaction of iron with copper(II) ions in aqueous solution.

_____

(1)

(Total 7 marks)

Q21.

This question is about the extraction of metals.

(a) Coke is mainly carbon and is a raw material used in the extraction of iron from iron(III) oxide.

(i) Write an equation for the formation of carbon monoxide from carbon.

_____

(1)

(ii) Write an equation for the reduction of iron(III) oxide to iron by carbon monoxide.

_____

(1)

(iii) The Earth's resources of iron(III) oxide are very large and commercial ores have a high iron content. Give **one** economic and **one** environmental reason for recycling scrap iron and steel.

Economic reason _____

_____

Environmental reason _____

_____

(2)

(b) Pure titanium is extracted by the reduction of titanium(IV) chloride, but not by the direct reduction of titanium(IV) oxide using carbon.

(i) Write an equation for the conversion of titanium(IV) oxide into titanium(IV) chloride.

_____

(2)

(ii) Write an equation for the extraction of titanium from titanium(IV) chloride.

_____

(2)

(iii) State why titanium is not extracted directly from titanium(IV) oxide using carbon.

_____

(1)

(c) Aluminium is extracted by the electrolysis of a molten mixture containing aluminium oxide.

(i) State why the electrolysis needs to be of a *molten* mixture.

_____

(1)

(ii) Write an equation for the reaction of oxide ions at the positive electrode during the electrolysis.

_____

(1)

(iii) State why the positive electrodes need frequent replacement.

_____

(1)

(iv) Give the major reason why it is less expensive to recycle aluminium than to extract it from aluminium oxide by electrolysis.

_____

(1)

(Total 13 marks)

Q13.

(a) $Cl_2 + H_2O \rightleftharpoons HOCl + HCl$

Allow the products shown as ions.

1

Cl_2 = 0, HOCl = +1 and HCl = −1

1 mark for all three oxidation states correct. Allow a reaction arrow in this equation.

Oxidation states must match the species

1

(b) Hydroxide / alkali ions react with the acids

Mark independently

1

Equilibrium moves to the right

1

(c) Only used in small amounts

1

The health benefits outweigh the risks

1

[6]

Q14.

(a) (i) **M1** (+) 4 **OR** IV

M2 (+) 6 **OR** VI

2

(ii) It / Chlorine has gained / accepted electron(s)

OR

Correctly balanced half-equation eg $Cl_2 + \mathbf{2}e^- \longrightarrow \mathbf{2}Cl^-$

Credit 1 or 2 electrons but not lone pair.

The idea of 'reduction' alone is not enough.

1

(b) (i) $\mathbf{6}KI + \mathbf{7}H_2SO_4 \longrightarrow \mathbf{6}KHSO_4 + \mathbf{3}I_2 + S + \mathbf{4}H_2O$

1

(ii) $\mathbf{2}I^- \longrightarrow I_2 + \mathbf{2}e^-$

OR

$8I^- \longrightarrow 4\mathbf{I}_2 + 8e^-$

Ignore charge on the electron unless incorrect.

Or multiples.

Credit the electrons being subtracted on the LHS.

Ignore state symbols.

1

(iii) $H_2SO_4 + \mathbf{8}H^+ + \mathbf{8}e^- \longrightarrow H_2S + \mathbf{4}H_2O$

OR

$SO_4^{2-} + \mathbf{10}H^+ + \mathbf{8}e^- \longrightarrow H_2S + \mathbf{4}H_2O$

Ignore charge on the electron unless incorrect.
Or multiples.
Credit the electrons being subtracted on the RHS.
Ignore state symbols.

1

(c) (i) $Ag^+ + I^- \longrightarrow AgI$ ONLY

Ignore state symbols.
Not multiples.

1

(ii) The precipitate / solid / it does not dissolve / is insoluble / remains

OR a white / cream / yellow solid / precipitate

OR stays the same

OR no (visible / observable) change

OR no effect / no reaction

Ignore 'nothing (happens)'.
Ignore 'no observation'.

1

(iii) The silver nitrate is acidified to

- react with / remove (an)ions that would interfere with the test
  Credit a correct reference to ions that give a 'false positive'.
- prevent the formation of other silver precipitates / insoluble silver compounds that would interfere with the test
  Do not penalise an incorrect formula for an ion that is written in addition to the name.
- remove (other) ions that react with the silver nitrate
  If only the formula of the ion is given, it must be correct.
- react with / remove carbonate / hydroxide / sulfite (ions)
  Ignore 'sulfate'.

1

(iv) HCl would form a (white) precipitate / (white) solid (with silver nitrate and this would interfere with the test)

*It is not sufficient simply to state either that it will interfere **or** simply that the ions / compounds react to form AgCl*

1

(d) (i) Any **one** from

Ignore 'to clean water'.

- to sterilise / disinfect water
  Ignore 'water purification' and 'germs'.
- to destroy / kill microorganisms / bacteria / microbes / pathogens
  Credit 'remove bacteria etc' / prevent algae.

1

(ii) The (health) benefit outweighs the risk

OR

a clear statement that once it has done its job, little of it remains

OR

used in (very) dilute concentrations / small amounts / low doses

1

(iii) $Cl_2 + H_2O \longrightarrow HClO + HCl$

OR

$Cl_2 + H_2O \longrightarrow \mathbf{2}H^+ + ClO^- + Cl^-$

OR

$\mathbf{2}Cl_2 + \mathbf{2}H_2O \longrightarrow \mathbf{4}HCl + O_2$

Credit HOCl or ClOH
Or multiples.
Credit other ionic or mixed representations.
Ignore state symbols.

1

(e) **In either order - Both required for one mark only**
Credit correct ionic formulae.

NaClO (OR NaOCl) **and** NaCl
Give credit for answers in equations unless contradicted.

1

[14]

Q15.

(a) (i) $3CuS(s) + \mathbf{8}HNO_3(aq) \longrightarrow \mathbf{3}CuSO_4(aq) + \mathbf{8}NO(g) + \mathbf{4}H_2O(l)$

1

(ii) **(+) 5**
(+) 2

2

(iii) $\mathbf{4}H^+ + NO_3^- + \mathbf{3}e^- \longrightarrow \mathbf{2}H_2O + NO$
Ignore state symbols.
*Credit multiples of **this equation only**.*
Ignore absence of charge on the electron.

1

(iv) $S^{2-} + \mathbf{4}H_2O \longrightarrow SO_4^{2-} + \mathbf{8}e^- + \mathbf{8}H^+$

Ignore state symbols.

*Credit multiples of **this equation only**.*

Ignore absence of charge on the electron.

1

(b) M1 add <u>scrap / recycled / waste iron (or steel)</u> to the aqueous solution

*If **M1** refers to iron / steel, but does not make it clear in the text that it is "scrap" / "waste" / "recycled", penalise **M1** but mark on.*

M2 the iron is a <u>more reactive</u> metal ***OR*** <u>Fe is a better reducing agent</u>

*Credit zinc or magnesium as an alternative to iron for **M2**, **M3** and **M4** only, penalising **M1***

M3 <u>Cu^{2+} / copper ions</u> are <u>reduced</u> / <u>gain electrons</u>
OR $Cu^{2+} + 2e^- \longrightarrow Cu$
OR <u>copper / Cu is displaced by Fe</u>

Ignore absence of charge on the electron.

M4 $Fe + Cu^{2+} \longrightarrow Fe^{2+} + Cu$ ONLY

*For **M4**, ignore state symbols*

4

[9]

Q16.

(a) Ti is not produced

OR

TiC / <u>carbide</u> is produced OR titanium reacts with carbon

OR

Product is brittle

OR

Product is a poor engineering material

Penalise "titanium carbonate"

Ignore "impure titanium"

Credit "it / titanium is brittle"

1

(b) (i) $FeTiO_3 + \mathbf{3}½Cl_2 + \mathbf{3}C \longrightarrow FeCl_3 + TiCl_4 + \mathbf{3}CO$

Ignore state symbols

Credit multiples

1

(ii) $FeCl_3 + TiCl_4 + \mathbf{7}Na \longrightarrow \mathbf{7}NaCl + Fe + Ti$

OR (for example)

$2FeCl_3 + TiCl_4 + \mathbf{10}Na \longrightarrow \mathbf{10}NaCl + 2Fe + Ti$

Ignore state symbols
Credit multiples including ratios other than 1:1
Ignore working

1

(c) Either order

*Penalise reference to incorrect number of electrons in **M1***

M1 The Cu^{2+} / copper(II) ions / they have gained (two) electrons

OR $Cu^{2+} + 2e^- \longrightarrow Cu$

*For **M1**, accept "copper" if supported by correct half-equation or simplest ionic equation*

OR oxidation state / number decreases (or specified from 2 to 0)

Ignore charge on the electron

M2 The <u>Cu^{2+} / copper(II) ions / they</u> have been <u>reduced</u>

*For **M2** do **not** accept "copper" alone*

2

(d) $2O^{2-} \longrightarrow O_2 + \mathbf{4}e^-$

Or multiples including
$\mathbf{3}O^{2-} \longrightarrow \mathbf{1.5}\ O_2 + \mathbf{6}e^-$
Ignore state symbols
Ignore charge on the electron
Credit the electrons being subtracted on the LHS

1

[6]

Q17.

(a) (i) $SiO_2 + \mathbf{2}Cl_2 + \mathbf{2}C \longrightarrow SiCl_4 + \mathbf{2}CO$

Ignore state symbols
Credit multiples of either equation

OR

$SiO_2 + \mathbf{2}Cl_2 + C \longrightarrow SiCl_4 + CO_2$

1

(ii) (fractional) distillation

OR

G(L)C or gas (–liquid–) chromatography

1

(b) (i) $SiCl_4 + \mathbf{2}H_2 \longrightarrow Si + \mathbf{4}HCl$

Ignore state symbols
Credit multiples
Penalise ionic HCl

1

(ii) Reducing agent / reductant / reduces $SiCl_4$ / reduces (silicon) / electron donor

1

(iii) Explosion / explosive

OR

(highly) flammable / inflammable

OR

readily / easily ignites / burns / combusts

1

(c)

$$\mathbf{2}MgO + Si \longrightarrow \mathbf{2}Mg + SiO_2$$

Ignore state symbols
Credit multiples

1

[6]

Q18.

(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) $WO_3 + \mathbf{3}H_2 \rightarrow W + \mathbf{3}H_2O$
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) ΣB(reactants) – ΣB(products) = Δ*H* (**M1**)

OR

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

B(H–H) + ½B(O=O) – 2B(O–H) = – 242 (**M1**)

B(H–H) = – 242 – ½(+496) + 2(+463) (this scores **M1** and **M2**)

B(H–H) = (+)436 (kJ mol^{-1}) (**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]

Q19.

(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]

Q20.

(a) (i) $\mathbf{2}CuFeS_2 + \mathbf{2}SiO_2 + \mathbf{4}O_2 \rightarrow Cu_2S + \mathbf{2}FeSiO_3 + \mathbf{3}SO_2$

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) $Cu_2S + \mathbf{2}O_2 \rightarrow \mathbf{2}CuO + SO_2$

Or multiples
Ignore state symbols

1

(c) $\mathbf{2}CuO + C \rightarrow \mathbf{2}Cu + CO_2$

OR

$CuO + C \rightarrow Cu + CO$

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]

Q21.

(a) (i) $\mathbf{2}C + O_2 \rightarrow \mathbf{2}CO$
OR
$C + CO_2 \rightarrow 2CO$

Or multiples.
Ignore state symbols.

1

(ii) $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

Or multiples
Penalise FE and Fe_2
Ignore state symbols

1

(iii) **Economic:**

- Scrap iron/steel has higher iron content.
- Recycling involves <u>lower energy</u> 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

$TiO_2 + \mathbf{2}Cl_2 + \mathbf{2}C \rightarrow TiCl_4 + \mathbf{2}CO$

OR

$TiO_2 + \mathbf{2}Cl_2 + C \rightarrow TiCl_4 + CO_2$

Or multiples
Ignore state symbols

2

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

M2 Balanced equation consequential on correct reactants

EITHER

$TiCl_4 + \mathbf{4}Na \rightarrow Ti + \mathbf{4}NaCl$

OR

$TiCl_4 + \mathbf{2}Mg \rightarrow Ti + \mathbf{2}MgCl_2$

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

- ions to move

- current to flow
- it to conduct electricity

1

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

Or multiples including
3$O^{2-} \rightarrow$ ***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 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

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