

Mark schemes

1

- (a) (i) reduction **OR** reduced **OR** redox **OR** reduction–oxidation
Not “oxidation” alone

1



Ignore state symbols

Do not penalise absence of charge on electron

Credit $\text{Fe}^{3+} \longrightarrow \text{Fe} - 3\text{e}^-$

Credit multiples

1

- (b) (i) **Because (one of the following)**

CO is not the only product **OR**

Reference to “incomplete combustion to form CO” does not answer the question

(Some) complete combustion (also) occurs **OR**

CO₂ is (also) formed

Further oxidation occurs

1

- (ii) The enthalpy change / heat (energy) change at constant pressure in a reaction is independent of the route / path taken (and depends only on the initial and final states)

1

- (iii) **M1** The enthalpy change / heat change at constant pressure when 1 mol of a compound / substance / element

For M1, credit correct reference to molecule/s or atom/s

M2 is burned completely / undergoes complete combustion in (excess) oxygen

M3 with all reactants and products / all substances in standard states

For M3

Ignore reference to 1 atmosphere

OR all reactants and products / all substances in normal / specified states under standard conditions / 100 kPa / 1 bar and specified T / 298 K

3

- (c) **M1 (could be scored by a correct mathematical expression which must have all ΔH symbols and the Σ)**

Correct answer gains full marks

Credit 1 mark ONLY for -1 (kJ mol^{-1})

M1 $\Delta H_r = \Sigma \Delta H_f$ (products) $- \Sigma \Delta H_f$ (reactants)

Credit 1 mark ONLY for -27 (kJ mol^{-1}) i.e. assuming value for $\text{Fe}(l)$ = 0

OR correct cycle of balanced equations with 2Fe, 3C and 3O₂

M2 $\Delta H_r = 2(+14) + 3(-394) - (-822) - 3(-111)$

$$= 28 - 1182 + 822 + 333$$

(This also scores M1)

M3 = (+) 1 (kJ mol^{-1})

(Award 1 mark ONLY for -1)

(Award 1 mark ONLY for -27)

For other incorrect or incomplete answers, proceed as follows

- *check for an arithmetic error (AE), which is either a transposition error or an incorrect multiplication; this would score 2 marks (M1 and M2)*
- *If no AE, check for a correct method; this requires either a correct cycle with 2Fe, 3C and 3O₂ OR a clear statement of M1 which could be in words and scores only M1*

3



State symbols essential

Possible to include C(s, graphite)

1

- (ii) These two enthalpy changes are for the same reaction / same equation / same reactants and products

Penalise reference to CO₂ being produced by a different route

OR

They both make one mole of carbon dioxide only from carbon and oxygen
(or this idea clearly implied)

“both form CO₂” is not sufficient (since other products might occur e.g.CO)

OR

The same number and same type of bonds are broken and formed

1

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2

- (a) (i) **M1 0**

M2 (+) 5

Accept Roman V for M2

2



Accept multiples

1



For M1, ignore state symbols

Credit multiples

Accept $2\frac{1}{2}I_2 + \frac{1}{2}I_2$ as alternative to $3I_2$

Electrons must be cancelled

M2 $NaIO_3$ **OR** IO_3^- **OR** iodate ions **OR** iodate(V) ions etc.

For M2 Do not penalise an incorrect name for the correct oxidising agent that is written in addition to the formula.

Accept “the iodine in iodate ions” but NOT “iodine” alone

Accept “the iodine / I in iodate ions” but NOT “iodine” alone

2

- (c) (i) Iodine **OR** I_2

Insist on correct name or formula

1



Ignore state symbols



Credit multiples

Do not penalise absence of charge on the electron

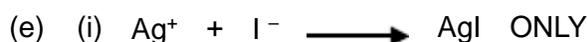
1

(d) hydrogen sulfide

OR H_2S

OR hydrogen sulphide

1



Ignore state symbols

No multiples

1

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

ignore "nothing (happens)"

OR turns to a white solid

ignore "no observation"

OR stays the same

OR no (visible/ observable) change

OR no effect / no reaction

1

(iii) The silver nitrate is acidified to

- react with / remove (an)ions that would interfere with the test

Ignore reference to "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

- react with / remove carbonate / hydroxide / sulfite (ions)

If only the formula of the ion is given, it must be correct

1

(f) (i) An electron donor

Penalise "electron pair donor"

OR (readily) donates / loses / releases / gives (away) electron(s)

Penalise "loss of electrons" alone

Accept "electron donator"

1

(ii) $\text{Cl}_2 + 2\text{e}^- \longrightarrow 2\text{Cl}^-$

Ignore state symbols

Do not penalise absence of charge on electron

Credit $\text{Cl}_2 \longrightarrow 2\text{Cl}^- - 2\text{e}^-$

Credit multiples

1

(iii) For M1 and M2, iodide ions are stronger reducing agents than chloride ions, because

Ignore general statements about Group VII trends or about halogen molecules or atoms. Answers must be specific

M1 Relative size of ions

*CE=0 for the clip if "iodine ions / chlorine ions" **QoL***

Iodide ions / they are larger / have more electron levels(shells) (than chloride ions) / larger atomic / ionic radius

*CE=0 for the clip if "iodide ions are bigger molecules / atoms" **QoL***

OR electron to be lost/outer shell/level (of the iodide ion) is further the nucleus

OR iodide ion(s) / they have greater / more shielding

Insist on iodide ions in M1 and M2 or the use of it / they / them, in the correct context (or chloride ions in the converse argument)

OR converse for chloride ion

M2 Strength of attraction for electron(s)

Must be comparative in both M1 and M2

The electron(s) lost /outer shell/level electron from (an) iodide ion(s) less strongly held by the nucleus compared with that lost from a chloride ion

OR converse for a chloride ion

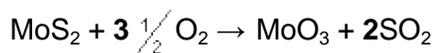
2

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3



OR



Allow multiples

Ignore state symbols

1

(ii) **M1 Environmental problem**

Acid rain

OR

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

M2 Use

SO_2 could be used to make / to form / to produce
(or wtte) H_2SO_4 / sulfuric acid

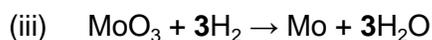
OR

To make / to form / to produce (or wtte) gypsum / CaSO_4
or plaster of Paris / plaster board

Ignore references to the greenhouse effect

Penalise reference to the ozone layer using the list principle

2



Allow multiples

Ignore state symbols

1

(iv) One from

H_2 is

- Explosive
 - (in)flammable
 - easily ignited
- Ignore "burns"*

1

(b) (i) To allow ions to move (when molten)

OR

Ions cannot move in the solid

1

(ii) $\text{Ca}^{2+} + 2\text{e}^{-} \longrightarrow \text{Ca}$

Or multiples

Ignore state symbols

Ignore charge on the electron unless incorrect and accept loss of two electrons on the RHS

1

(iii) (High) electricity / electrical energy (cost)

Ignore "energy" and ignore "current"

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(a) (i) $\text{Cu} + 4\text{HNO}_3 \longrightarrow \text{Cu}(\text{NO}_3)_2 + 2\text{NO}_2 + 2\text{H}_2\text{O}$

Or multiples

Ignore state symbols

1

(ii) **M1** HNO_3 (+) 5

M2 NO_2 (+) 4

Ignore working out

M1 Credit (V)

M2 Credit (IV)

2

(iii) $\text{HNO}_3 + \text{H}^+ + \text{e}^{-} \longrightarrow \text{NO}_2 + \text{H}_2\text{O}$

OR

$\text{NO}_3^{-} + 2\text{H}^+ + \text{e}^{-} \longrightarrow \text{NO}_2 + \text{H}_2\text{O}$

Or multiples

Ignore state symbols

Ignore charge on the electron unless incorrect and accept loss of electron on the RHS

1

(b) (i) **In either order**

M1 Concentration(s) (of reactants and products)
remain(s) constant / stay(s) the same / remain(s)
the same / do(es) not change

M2 Forward rate = Reverse / backward rate

For M1 accept [] for concentration

NOT “equal concentrations” and NOT “concentration(s) is/are the same”

NOT “amount”

Ignore “dynamic” and ignore “speed”

Ignore “closed system”

It is possible to score both marks under the heading of a single feature

2

(ii) **M1**

The (forward) reaction / to the right is endothermic
or takes in / absorbs heat

OR

The reverse reaction / to the left is exothermic or gives
out / releases heat

M2 depends on correct M1 and must refer to temperature/heat

The equilibrium shifts / moves left to right to oppose the increase in temperature

M2 depends on a correct statement for M1

For M2, the equilibrium shifts/moves

to absorb the heat OR

to lower the temperature OR

to cool the reaction

2

(iii) **M1 refers to number of moles**

There are fewer moles (of gas) on the left OR more moles (of gas) on the right.

OR there is one mole (of gas) on the left and 2 moles on the right.

M2 depends on correct M1 and must refer to pressure

The equilibrium shifts / moves right to left to oppose the increase in pressure

M2 depends on a correct statement for M1

For M2, the equilibrium shifts/moves to lower the pressure.

2

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5

(a) **M1** The yield of zinc oxide increases/greater

If M1 is given as “decrease” OR “no effect” then CE= 0

M2 Removal of the carbon dioxide results in the equilibrium

Either

Shifting/moving/goes to the right

shifting/moving/goes L to R

favours the forward reaction/towards the products

M3 (By Le Chatelier's principle) the reaction/equilibrium will respond so as to replace the CO₂/lost product

OR to make more CO₂

OR to increase concentration of CO₂

For M3, not simply “to oppose the change/to oppose the loss of CO₂/to oppose the removal of carbon dioxide.”

3

(b) **M1** Process 2 produces/releases SO₂

OR Process 2 produces/releases CO

M2 It/Process 3 avoids the release of SO₂ OR CO

OR It/Process 3 (captures and) converts SO₂ to H₂SO₄

M3 SO₂ causes acid rain OR is toxic/poisonous

OR CO is toxic/poisonous

3

Ignore “global warming” and “greenhouse gases” and “the ozone layer”

If both CO and SO₂ claimed to form acid rain, treat as contradiction

(c) **M1** Process 3 (is expensive because it) uses electrolysis
OR due to high electricity/electrical consumption

M2 this is justified because the product/zinc is pure

Ignore "energy"

Penalise "pure"

2

(d) **M1** $\text{Zn}^{2+} + 2\text{e}^{-} \longrightarrow \text{Zn}$

Ignore state symbols

M2 the negative electrode OR the cathode

Ignore absence of negative charge on electron

Accept electrons subtracted from RHS

2

(e) **M1** The reaction of ZnO with sulfuric acid
OR the second reaction in Extraction process 3

M2 neutralisation or acid-base

OR alternatively

M1 The reaction of zinc carbonate in Extraction process 1

M1 could be the equation written out in both cases

M2 (thermal) decomposition

M2 depends on correct M1

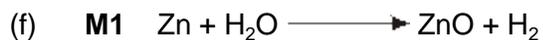
M3 It/carbon is oxidised/gains oxygen/changes oxidation state/number
from 0 to +2/increase in oxidation state/number in Process 2

Do not forget to award this mark

Ignore reference to electron loss but penalise electron gain

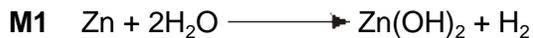
Ignore "carbon is a reducing agent"

3



M2 Zinc oxide and hydrogen

OR as an alternative



M2 Zinc hydroxide and hydrogen

Mark independently

If ZnO_2 is given for zinc oxide in the equation, penalise M1 and mark on

If ZnOH is given for zinc hydroxide in the equation, penalise M1 and mark on

Ignore state symbols

Credit multiples of the equation

If M1 is blank, either of the M2 answers could score

To gain both marks, the names must match the correct equation given.

2

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(a) (i) Reducing agent

OR

Reduce(s) (WO_3 /tungsten oxide)

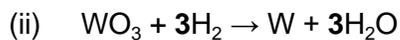
OR

electron donor

OR

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

1



Or multiples

1

(iii) One from

H₂ 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**)

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

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

$B(\text{H-H}) = (+)436$ (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

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7

(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 NO₂ is greater
- more NO₂ is formed
- equilibrium shifts (left) to right
- (equilibrium) favours the forward reaction

(**OR** converse for higher temperatures)

2

- (c) NO₂ (+) 4

NO₃⁻ (+) 5

HNO₂ (+) 3

3

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8

- (a) (i) $2\text{CuFeS}_2 + 2\text{SiO}_2 + 4\text{O}_2 \rightarrow \text{Cu}_2\text{S} + 2\text{FeSiO}_3 + 3\text{SO}_2$

1

- (ii) Acid rain

OR

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

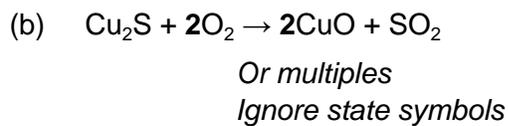
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- (iii) SO₂ could be used to make H₂SO₄

OR

to make gypsum/plaster or CaSO₄ (xH₂O)

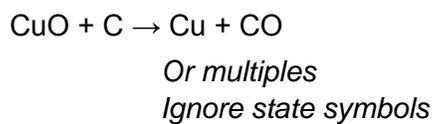
1



1



OR

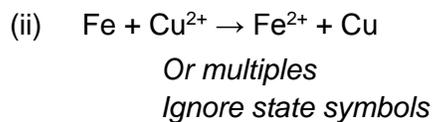


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(d) (i) *Any one from the following two ONLY*
Apply the list principle

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

1



1

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