



Ignore state symbols

Credit loss of electrons from LHS

Credit multiples

Do not penalise absence of charge on electron

1



Allow Mn^{+7} and 7+

1



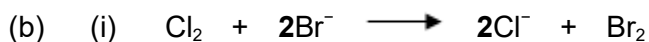
Ignore state symbols

Credit loss of electrons from RHS

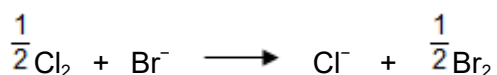
Credit multiples

Do not penalise absence of charge on electron

1



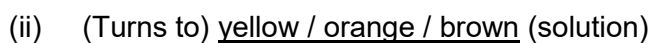
OR



One of these two equations only

Ignore state symbols

1



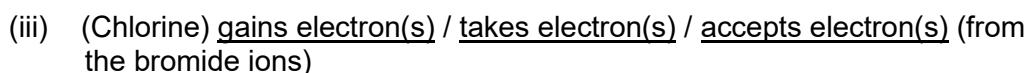
Penalise "red / reddish" as the only colour

Accept "red-brown" and "red-orange"

Ignore "liquid"

Penalise reference to a product that is a gas or a precipitate

1



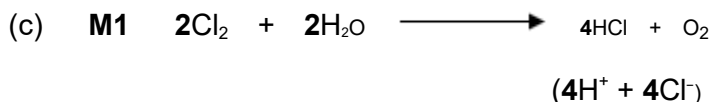
OR



Penalise "electron pair acceptor"

Not simply "causes loss of electrons"

1



M2 Oxidation state -1

Ignore state symbols

Credit multiples

M2 consequential on HCl or Cl^- which **must** be the only chlorine-containing product in the (un)balanced equation.

For **M2** allow Cl^- or Cl^- but **not** Cl^-

2

(d) **M1 The relative size (of the molecules / atoms)**

Chlorine is smaller than bromine **OR** has fewer electrons / electron shells

For M1 ignore whether it refers to molecules or atoms.

OR It is smaller / It has a smaller atomic radius / it is a smaller molecule / atom (or converse)

CE=0 for the clip for reference to (halide) ions or incorrect statements about relative size

Ignore molecular mass and M_r

M2 How size of the intermolecular force affects energy needed

Ignore shielding

The forces between chlorine / Cl_2 molecules are weaker (than the forces between bromine / Br_2 molecules)

(or converse for bromine)

OR chlorine / Cl_2 has weaker / fewer / less (VdW) intermolecular forces / forces between molecules

(or converse for bromine)

QoL in M2 for clear reference to the difference in size of the force between molecules. Reference to Van der Waals forces alone is not enough.

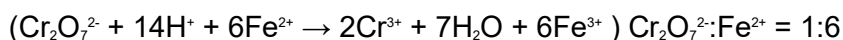
Penalise M2 if (covalent) bonds are broken

2

[10]

M2.(a) moles of $\text{Cr}_2\text{O}_7^{2-}$ per titration = $21.3 \times 0.0150 / 1000 = \underline{3.195 \times 10^{-4}}$

1



If 1:6 ratio incorrect cannot score M2 or M3

1

$$\text{moles of Fe}^{2+} = 6 \times 3.195 \times 10^{-4} = 1.917 \times 10^{-3}$$

Process mark for M1 × 6 (also score M2)

1

$$\text{original moles in } 250 \text{ cm}^3 = 1.917 \times 10^{-3} \times 10 = 1.917 \times 10^{-2}$$

Process mark for M3 × 10

1

$$\text{mass of FeSO}_4 \cdot 7\text{H}_2\text{O} = 1.917 \times 10^{-2} \times 277.9 = 5.33 \text{ (g)}$$

Mark for answer to M4 × 277.9

(allow 5.30 to 5.40)

*Answer **must** be to at least 3 sig figs*

Note that an answer of 0.888 scores M1, M4 and M5 (ratio 1:1 used)

1

- (b) (Impurity is a) reducing agent / reacts with dichromate / impurity is a version of FeSO₄ with fewer than 7 waters (not fully hydrated)

Allow a reducing agent or compound that that converts Fe³⁺ into Fe²⁺

1

Such that for a given mass, the impurity would react with more dichromate than a similar mass of FeSO₄·7H₂O

OR for equal masses of the impurity and FeSO₄·7H₂O, the impurity would react with more dichromate.

Must compare mass of impurity with mass of FeSO₄·7H₂O

1

[7]

M3.(a) M1 (could be scored by a correct mathematical expression)

M1 $\Delta H = \sum \Delta H_f (\text{products}) - \sum \Delta H_f (\text{reactants})$

OR a correct cycle of balanced equations

$$\mathbf{M2} \quad = 5(-635) - (-1560)$$

$$= -3175 + 1560$$

(This also scores M1)

M3 = **-1615** (kJ mol⁻¹)
Award 1 mark **ONLY** for (+) 1615

Correct answer to the calculation gains all of M1, M2 and M3

Credit 1 mark for (+) 1615 (kJ mol⁻¹)

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 V₂O₅ and 5CaO OR a clear statement of M1 which could be in words and scores **only M1***

M4 Type of reaction is

- reduction
- redox
- (or accept) V₂O₅ / it / V(V) has been reduced
In M4 not "vanadium / V is reduced"

M5 Major reason for expense of extraction – the answer must be about calcium

Calcium is produced / extracted by electrolysis

OR calcium is expensive to extract

OR calcium extraction uses electricity

OR calcium extraction uses large amount of energy

OR calcium is a (very) reactive metal / reacts with water or air

OR calcium needs to be extracted / does not occur native

QoL

Accept calcium is expensive "to produce" but not "to source, to get, to obtain, to buy" etc.

In M5 it is neither enough to say that calcium is "expensive" nor that calcium "must be purified"

5

(b) **M1**



Ignore state symbols

Credit multiples of the equation

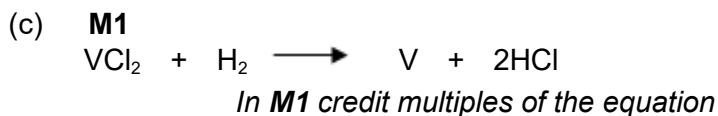
M2

(Change in oxidation state) **0 to (+)3**

OR

(changed by) **+3**

In M2 if an explanation is given it must be correct and unambiguous

**M2 and M3**

Two hazards in either order

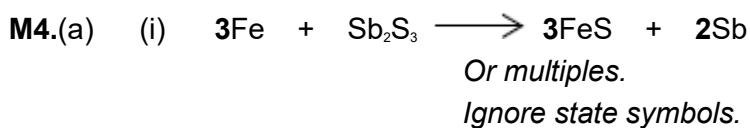
- HCl / hydrogen chloride / hydrochloric acid is acidic / corrosive / toxic / poisonous
- Explosion risk with hydrogen (gas) OR H₂ is flammable
For M2 / M3 there must be reference to hydrogen; it is not enough to refer simply to an explosion risk
For M2 / M3 with HCl hazard, require reference to acid(ic) / corrosive / toxic only

M4

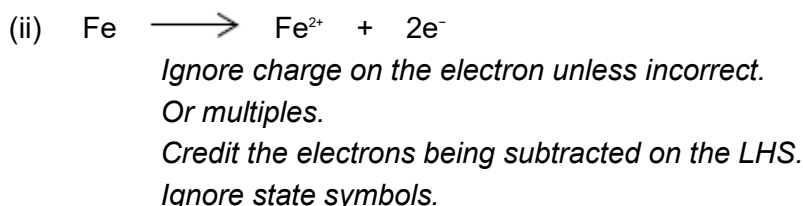
The only other product / the HCl is easily / readily removed / lost / separated because it is a gas OR will escape (or this idea strongly implied) as a gas
OR vanadium / it is the only solid product (and is easily separated)
OR vanadium / it is a solid and the other product / HCl is a gas
In M4 it is not enough to state simply that HCl is a gas, since this is in the question.

4

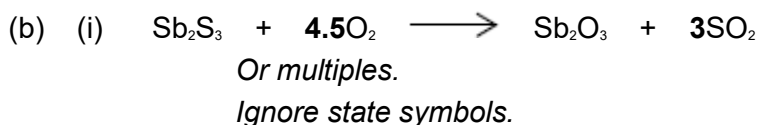
[11]



1



1



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- (ii) SO_3 or sulfur trioxide / sulfur (VI) oxide
Credit also the following ONLY.
 H_2SO_4 or sulfuric acid.
OR
 Gypsum / CaSO_4 or plaster of Paris.

1

- (c) (i) **M1 (could be scored by a correct mathematical expression)**
Correct answer gains full marks.

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

OR a correct cycle of balanced equations / correct numbers of moles
Credit 1 mark for +104 (kJ mol⁻¹).

M2
$$= 2(+20) + 3(-394) - (-705) - 3(-111)$$

$$= 40 - 1182 + 705 + 333$$

$$= -1142 - (-1038)$$

(This also scores M1)

M3 $= \underline{-104}$ (kJ mol⁻¹)

(Award 1 mark ONLY for + 104)

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.
- If no AE, check for a correct method; this requires either a correct cycle with 3CO, 2Sb and 3CO₂ OR a clear statement of **M1** which could be in words and scores **only M1**.

3

- (ii) It / Sb is not in its standard state

OR

Standard state (for Sb) is solid / (s)

OR

(Sb) liquid is not its standard state

Credit a correct definition of standard state as an alternative to the words 'standard state'.

QoL

1

(iii) Reduction **OR** reduced **OR** redox

1

(d) Low-grade ore extraction / it

- uses (cheap) scrap / waste iron / steel
- is a single-step process

uses / requires less / low(er) energy

Ignore references to temperature / heat or labour or technology.

1

[10]

M5.D

[1]

M6.D

[1]

M7.B

[1]

M8.(a) $\text{Cl}_2 + \text{H}_2\text{O} = \text{HOCl} + \text{HCl}$

Allow the products shown as ions.

1

$\text{Cl}_2 = 0$, $\text{HOCl} = +1$ and $\text{HCl} = -1$

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]

M9.C

[1]

M10.D

[1]