M1. (a) (i) Ammonia

If reagent is missing or incorrect cannot score M3

1

Starts as a pink (solution)

1

Changes to a yellow/straw (solution)

Allow pale brown

Do not allow reference to a precipitate

1

(ii) (dark) brown

Do not allow pale/straw/yellow-brown (i.e. these and other shades except for dark brown)

1

(b) (i) Ruby/red-blue/purple/violet/green

Do not allow red or blue

If ppt mentioned contradiction/CE =0

1

Green

If ppt mentioned contradiction/CE =0

1

$[Cr(H_2O)_6]^{3+} + 6OH^- \rightarrow [Cr(OH)_6]^{3-} + 6H_2O$

1

Formula of product

Can score this mark in (b) (ii)

1

(ii) $H_2O_2 + 2e^- \rightarrow 2OH^-$

1

$2[Cr(OH)_6]^{3-} + 3H_2O_2 \rightarrow 2CrO_4^{2-} + 8H_2O + 2OH^-$

Allow 1 mark out of 2 for a balanced half-equation such as $Cr(III) \rightarrow Cr(VI) + 3e^-$

or $Cr^{3+} + 4H_2O \rightarrow CrO_4^{2-} + 8H^+ + 3e^-$ *etc*

also for $2Cr(III) + 3H_2O_2 \rightarrow 2CrO_4^{2-}$ *(unbalanced)*

2

Yellow

Do not allow orange

1

(c) $2MnO_4^- + 6H^+ + 5H_2O_2 \rightarrow 2Mn^{2+} + 8H_2O + 5O_2$

if no equation and uses given ratio can score M2, M3, M4 & M5

1

Moles MnO_4^- = (24.35/1000) × 0.0187 = $\underline{4.55 \times 10^{-4}}$

Note value must be quoted to at least 3 sig. figs.

M2 is for 4.55×10^{-4}

1

Moles H_2O_2 = (4.55×10^{-4}) $\underline{\times 5/2}$ = 1.138×10^{-3}

M3 is for × 5/2 (or 7/3)

Mark consequential on molar ratio from candidate's equation

1

Moles H_2O_2 in 5 cm^3 original

M4 is for × 10

1

= (1.138×10^{-3}) $\underline{\times 10}$ = 0.01138

Original $[H_2O_2]$ = 0.01138 $\underline{\times (1000/5)}$ = 2.28 mol dm^{-3}

(allow 2.25-2.30)

M5 is for consequentially correct answer from (answer to mark 4) × (1000/5)

Note an answer of between 2.25 and 2.30 is worth 4 marks)

If candidate uses given ratio 3/7 max 4 marks:

***M1**: Moles of* MnO_4^- = $\underline{4.55 \times 10^{-4}}$

***M2**: Moles* H_2O_2 = (4.55×10^{-4}) $\underline{\times 7/3}$ = 1.0617×10^{-3}

***M3**: Moles* H_2O_2 *in 5* cm^3 *original*

= (1.0617×10^{-3}) × 10 = 0.01062

M4: Original $[H_2O_2]$ = 0.01062 × (1000/5) = 2.12 mol dm^{-3}

(allow 2.10 to 2.15)

1

[17]

M2. (a) $CaF_2(s) \rightarrow Ca^{2+}(g) + 2F^-(g)$

1

(b) (i) Enthalpy change for formation of 1 mol of substance

Allow heat energy change, NOT energy

1

From its elements

1

Reactants and products/all substances in their standard states

Or normal states at 298 K, 1 bar (100 kPa)

1

(ii) $Ca(s) + F_2(g) \rightarrow CaF_2(s)$

1

(iii) $\Delta H_f(CaF_2) = \Delta H_a(Ca) + 1st\ IE(Ca) + 2^{nd}\ IE(Ca) + BE(F_2) + 2 \times EA(F) - \Delta H_L(CaF_2)$

Or labelled diagram

1

$= 193 + 590 + 1150 + 158 + (2 \times -348) - 2602$

1

$= -1207\ kJ\ mol^{-1}$

Correct answer scores 3
–842 scores 2 (transfer error)
–859 scores 1 only (using one E.A.)
Units not required, wrong units lose 1 mark

1

(c) Electrostatic attraction stronger/ionic bonding stronger/attraction between ions stronger/more energy to separate ions

Molecular attraction/atoms/intermolecular forces CE=0

1

Because fluoride (ion) smaller than chloride

Do not allow F or fluorine

1

(d) (i) $\Delta H = \Delta H_L + \Sigma\Delta H_{hyd} = 2237 - 1650 + (2 \times -364)$

Can be on cycle/diagram

1

$= -141\ kJ\ mol^{-1}$

Correct answer scores 2
Units not required, wrong units lose 1 mark

1

(ii) Decreases

If ans to (d)(i) positive allow increases

1

Reaction exothermic/ΔH –ve

If (d)(i) +ve allow endothermic/ΔH + ve

1

(Equilibrium) shifts to left/backwards
(as temperature rises)/equilibrium
opposes the change

If (d) (i) +ve allow shifts to right/forwards/equilibrium opposes the change

If no answer to (d) (i) assume –ve ΔH used
If effect deduced incorrectly from any ΔH CE = 0 for these 3 marks

1

(e) u.v. absorbed: electrons/they move to higher energy (levels)/electrons excited

1

visible light given out: electrons/they fall back down/move to lower energy (levels)

Must refer to absorbing u.v. NOT visible light or this must be implied.

1

[17]

M3. (a) Partially filled/incomplete d sub-shell/orbital/shell

Ignore reference to f orbitals

*Do **not** allow d block*

*Do **not** allow half-filled d orbitals*

1

(b) Has ligand(s)

Allow molecules/ions with lone pairs

1

linked by co-ordinate bonds

Allow dative/donation of lone pair

1

(c) (Blue) light is absorbed (from incident white light)

1

Due to electrons moving to higher levels/electrons excited

Allow d → d transitions

1

Red light (that) remains (is transmitted)/light that remains (transmitted light) is the colour observed

Allow red light reflected

1

(d) (i) Circle round any O^-

List principle

1

Circle round either N

1

(ii) $EDTA^{4-} + [Co(H_2O)_6]^{2+} \rightarrow [CoEDTA]^{2-} + 6H_2O$

Allow missing square brackets
Ignore state symbols

1

(iii) Increase in entropy/ΔS positive

Or increase in disorder

1

Because 2 mol (of particles/molecules/species/entities) form 7 mol

Allow 'increase in number' as stated in words or as shown by any numbers deduced correctly from an incorrect equation

Do not allow increase in ions/atoms

1

(e) (i) Co-ordinate/dative/dative covalent bond

Allow pair of electrons donated by nitrogen/ligand
Do not allow pair of electrons donated from Iron/Fe

1

Covalent bond

Shared electron pair

1

(ii) Transport of oxygen/O_2

Allow any statement that implies oxygen carried (around the body)

Do not allow transport of carbon dioxide (CO_2). This also contradicts the mark (list principle)

1

(iii) Because it bonds to the iron/haemoglobin

Allow blocks site
/CO has greater affinity for haemoglobin
/carboxyhaemoglobin more stable than oxyhaemoglobin

1

Displaces oxygen

Or prevents transport of oxygen
QoL

1

[16]