Mark Schemes

Practice Paper 1A

Section A

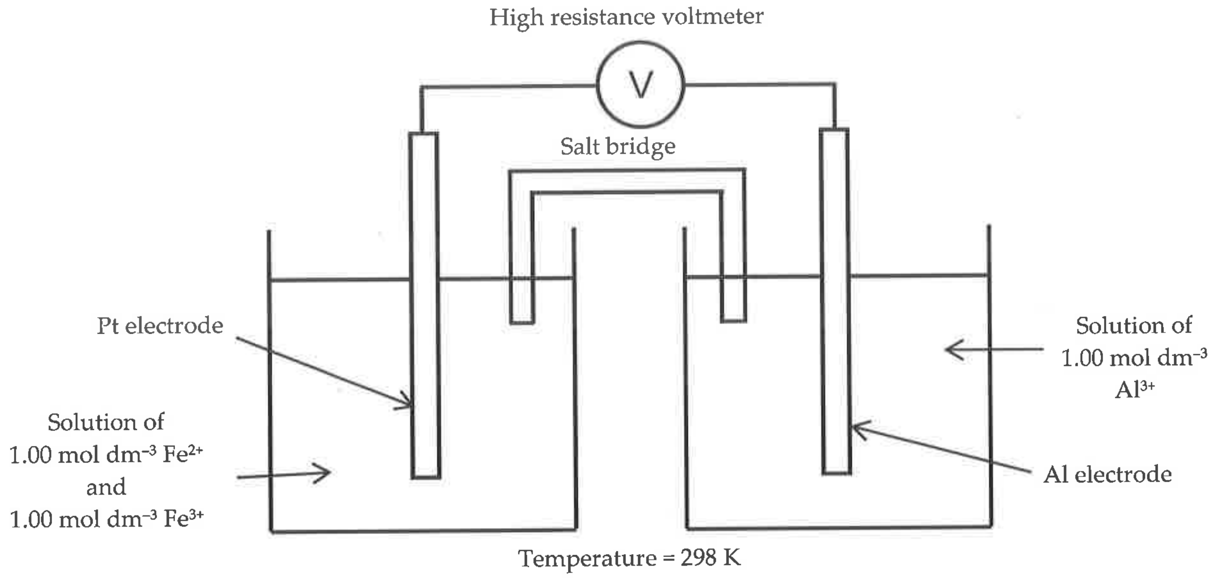
1	A	6	C	11	A
2	D	7	C	12	C
3	D	8	B	13	A
4	A	9	B	14	D
5	C	10	A	15	D

Section B

16 a) The best reducing agent is the best at losing electrons / has the most negative electrode potential ✓
Al ✓

b) 0.80 – (-1.66) = 2.46 V ✓

c) Aluminium electrode in a solution of Al^{3+} ions ✓
Platinum electrode in a solution of Fe^{2+} and Fe^{3+} ions ✓
1.00 mol dm^{-3} solutions AND temperature = 298 K AND 100 kPa/1 bar pressure ✓
Salt bridge AND voltmeter ✓



d) Kinetic barrier / activation energy barrier is too high to be overcome by a very small cell potential ✓

e)

LEVEL OF RESPONSE QUESTION	
Level 3: (5–6 marks)	Answer is structured in an entirely ordered manner. Equations, equipment and details of the method are correct.
Level 2: (3–4 marks)	Answer is mostly well structured. Details from two of the method, equipment and reactions are included.
Level 1: (1–2 marks)	Answer has limited structure. Either equipment or method is included, but an equation is not.
0 marks	No creditworthy response.

Indicative Content

- $Fe^{2+} \rightleftharpoons Fe^{3+} + e^-$
- Iron(II) is oxidised
- $MnO_4^- + 8H^+ + 5e^- \rightleftharpoons Mn^{2+} + 4H_2O$
- Potassium permanganate is an oxidising agent
- $5Fe^{2+} + 8H^+ + MnO_4^- \rightleftharpoons Mn^{2+} + 4H_2O + 5\,Fe^{3+}$
- Sample placed into a conical flask / beaker / other suitable container
- On a white tile (to see colour)
- Burette washed with oxidising agent first
- Oxidising agent added to burette
- Open tap to add potassium permanganate to the factory sample
- Swirl
- Slow down addition of potassium permanganate when colour starts to fade
- Endpoint is when colour just changes from purple to colourless

17 a) $Ba + 2\,H_2O \rightarrow Ba(OH)_2 + H_2$

Correct species ✓ Balancing ✓ IGNORE state symbols

b) i) ANY THREE FROM:

Dissolve the metals in the same volume of water ✓

Stir ✓

Measure the pH of the solution formed using a pH meter ✓

Record the pH once a constant value has been reached (indicating no more will dissolve on swirling) ✓

ii) Barium hydroxide will have a higher pH / be more alkaline AND because barium hydroxide is more soluble ✓

c) i) $[H^+] = 10^{-pH} = 10^{-10.94} = 1.15 \times 10^{-11}$✓

$[OH^-] = \frac{K_W}{[H^+]} = \frac{1.00\times10^{-14}}{1.15\times10^{-11}}$ (ALLOW ECF)

8.71×10^{-4} (mol dm^{-3}) ✓ (For correct final answer)

ii) Moles $OH^- = 8.71 \times 10^{-4} \times 0.0500 = 4.355 \times 10^{-5}$ ✓ (ALLOW ECF from c i))

Moles H^+ = Moles $OH^- = 4.355 \times 10^{-5}$

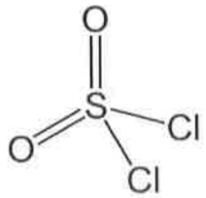
$[H^+] = \frac{\text{Moles}}{\text{Volume}} = \frac{4.355\times10^{-5}}{0.025} = 1.74 \times 10^{-3}$ ✓ (ALLOW ECF)

$[HNO_3] = \frac{[H^+]^2}{K_a}\ \frac{(1.74\times10^{-3})^2}{4.51\times10^{-4}}$ ✓(ALLOW ECF)

$[HNO_3] = 6.73 \times 10^{-3}$ mol dm^{-3} ✓ (For correct final answer)

18 a) Atom economy is 100 % ✓
No waste products ✓

b) Correct connectivity ✓
Correct shape ✓
Name of shape is tetrahedral AND bond angle is 109.5° (ALLOW 109°) ✓



c) i) Bonds broken = 2 × S=O + Cl–Cl = (2 × 523) + 242 = 1288 (kJ mol^{-1}) (ALLOW just 242) ✓
Bonds formed = 2 × S=O + 2 × S–Cl = (2 × 523) + (2 × 253) = 1552 (kJ mol^{-1}) (ALLOW just 506) ✓
Enthalpy change = bonds broken – bonds formed = 1288 – 1552 = -264 kJ mol^{-1} ✓

ii) Values used are average values across a range of molecules, and exact values depend on the particular molecule / environment AW ✓ (IGNORE references to calculated in gaseous state, as all reactants and products are gases in the equation)

d) i)

	SO_2	Cl_2	SO_2Cl_2	
Moles (initial)	0.400	0.400	0.00	
Moles (eqm)	0.0240	0.0240	0.376	✓
Mole Fraction	$\frac{0.0240}{0.024 + 0.024 + 0.376}$ 0.05660	$\frac{0.0240}{0.024 + 0.024 + 0.376}$ 0.05660	$\frac{0.376}{0.024 + 0.024 + 0.376}$ 0.8868	
Partial Pressure	0.05660 × 2	0.05660 × 2	0.8868 × 2	
	0.1132	0.1132	1.774	✓

$$K_p = \frac{p\,(SO_2Cl_2)}{p(Cl_2) \times p\,(SO_2)}$$ ✓

$$K_p = \frac{1.774}{0.1132 \times 0.1132} = 138(.4)$$ ✓ Units = $\frac{kPa}{kPa \times kPa}$ = kPa^{-1} ✓

ii) $p(SO_2Cl_2)$ is left out OR the equation becomes $\frac{1}{p(Cl_2) \times p(SO_2)}$ ✓

e) i) In case any SO_2 or Cl_2 leaks out AND they are toxic gases ✓

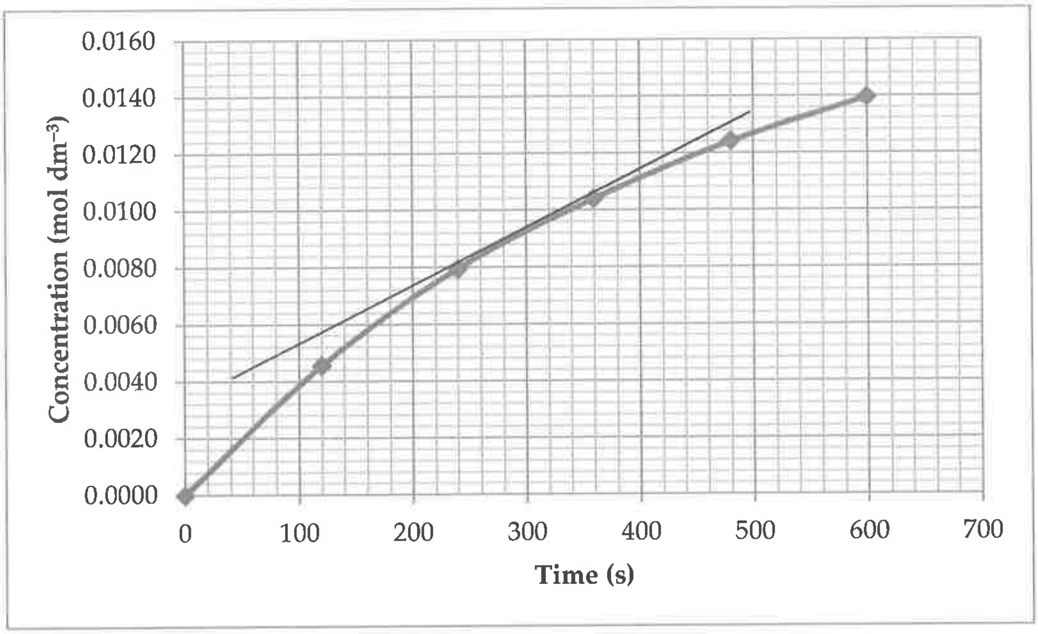
ii) <u>**Reflux**</u> condenser ✓
To ensure reactant vapours condense and are returned to the reaction ✓

iii) To purify the SO_2Cl_2 ✓
Other liquids / impurities with different boiling points will not be collected at the same time ✓

19 a) i) (Speeds up a reaction by) providing an alternative route for the reaction ✓
Which has a lower activation energy ✓

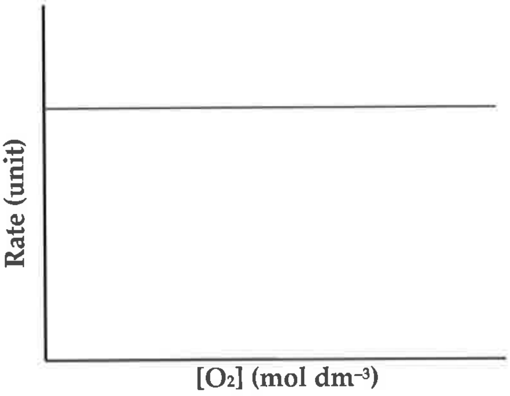
ii) Catalyst may be toxic OR cost of removing the catalyst OR catalysts are expensive (ANY TWO) ✓✓

b) Even scale AND plot take up more than half the paper in both directions AND axis titles AND units ✓
All points in correct place ✓
Smooth line of best fit ✓
Tangent taken at 300 s ✓
Rate calculated using gradient $\left(\frac{\Delta y}{\Delta x}\right)$ to be between 2.0×10^{-5} and 2.6×10^{-5} ✓ (DO NOT AWARD if no evidence of measuring gradient) ✓
Unit is mol dm^{-3} s^{-1} ✓



c) i) Plot $[Fe(H_2O)_6]^{2+}$ against time and measure several half-lives ✓
Half-lives will be constant if it is first order ✓

ii) ✓ Horizontal line



d) Calibration is needed to give reference values ✓
Record the values given by the colorimeter for known concentrations of $[Fe(H_2O)_6]^{3+}$ (in $[Fe(H_2O)_6]^{2+}$) ✓
Plot a graph / calibration curve so concentrations can be worked out for a given reading from the colorimeter ✓

20

LEVEL OF RESPONSE QUESTION	
Level 3: (5–6 marks)	Answer is structured in an entirely ordered manner. All three types of reaction described and exemplified. An explanation of the importance of transition metals is given in each context.
Level 2: (3–4 marks)	Answer is mostly well structured. Two out of three reactions are described and exemplified, and one example of how the reactions of these metals is important is given.
Level 1: (1–2 marks)	Answer has limited structure. No examples are given, nor is importance explained. Descriptions of reactions are vague or only partially correct.
0 marks	No creditworthy response.

Indicative Content

Explanation and examples:

- Ligand substitution involves the replacement of one ligand surrounding a metal ion with another.
- e.g. $[Cu(H_2O)_6]^{2+} + 4Cl^- \rightleftharpoons [CuCl_4]^{2-} + 6H_2O$
- Redox reactions involve a change in oxidation state of the transition metal ion.
- e.g. $[Fe(H_2O)_6]^{2+} + [O] \rightleftharpoons [Fe(H_2O)_6]^{3+}$
- Precipitation reactions involve the formation of a solid from a solution.
- e.g. $Fe^{2+}_{(aq)} + 2OH^-_{(aq)} \rightleftharpoons [Fe(OH)_2]_{(s)}$ (State symbols should be given)

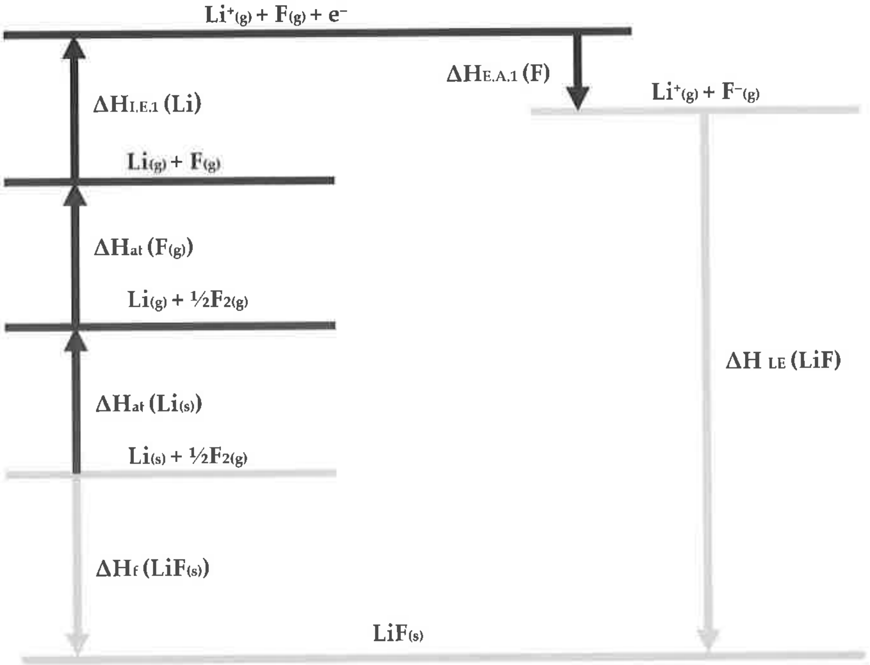
Importance (accept any valid example):

- Ligand substitution reactions are important in, for example, the replacement of oxygen by carbon monoxide in haemoglobin.
- Redox reactions are important in, for example, catalytic behaviour such as Cu^{2+} catalysing the reaction of zinc with acids.
- Precipitation reactions are important in analysis, e.g. Cu^{2+} forms a blue precipitate with sodium hydroxide.

21 a) **<u>Giant ionic</u>** lattice of many oppositely charged ions ✓
Held together by electrostatic attraction (between the oppositely charged ions) ✓

b) (The enthalpy change when) one mole of a compound is formed ✓
From its gaseous ions ✓

c)

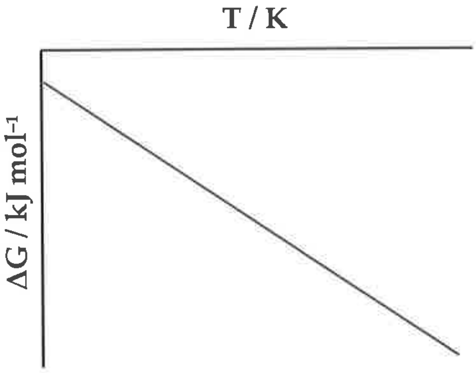


Correct species on lines with correct state symbols (✓for two correct, ✓✓for four correct) ALLOW different order
All arrows correct direction ✓
All labels correct ✓(IGNORE state symbols)
$\Delta H_{LE} = \Delta H_f(LiF_{(s)}) - \Delta H_{at}(Li_{(s)}) - \Delta H_{at}(F_{(g)}) - \Delta H_{I.E.1}(Li) - \Delta H_{E.A.1}(F)$ ✓
$\Delta H_{LE} = -616 - 158 - 79 - 520 - -326 = -1047$ (kJ mol^{-1}) ✓

d) The ions are approximately the same size AND but the ions in beryllium oxide have twice the charge ✓
Electrostatic attraction is greater, meaning more energy is released when the lattice forms ✓

e) Dissolution involves breaking apart the lattice / lattice energy (as well as enthalpy of hydration) ✓
Additional energy needed to break apart LiF lattice outweighs more exothermic enthalpies of hydration AW ✓

f)



Negative ΔG on graph, starting at origin or below on y-axis
AND because reaction is feasible at all temperatures in range ✓
Negative gradient ✓
Because ΔS is positive for dissolution, so -ΔS, the gradient, is negative ✓