



MARKSCHEME

May 2001

CHEMISTRY

Higher Level

Paper 2

14 pages

SECTION A

1. (a) (i) Tl [1]
- (ii) Mn^{2+} (accept Mn) [1]
- (iii) Any two of N, P, As, Sb, Bi [1]

- (b) Lines (may be shown on diagram) [1]
 Convergence at high frequency / energy / short wavelength (may be shown on a diagram) [1]
 Electron transfer between energy levels / each transition / line depends on energy differences / $\Delta E = h\nu$ [1] [3 max]
- (c) remaining electrons in one shell / Li^+ has one less shell or converse [1]
 effective nuclear charge (Li^+) greater than that of the atom [1] [2 max]
- (d) Any two of the following, [1] each
- Do not form bonds
 - Full outer shells
 - No attraction for electrons
 - Stable / inert / do not react
- [2 max]

2. (a)

	Pt	Cl	N	H	
Divide by A_r values					[1]
No. of moles	0.3332	0.6666	0.667	2	[1]

Empirical formula $\text{PtCl}_2\text{N}_2\text{H}_6$ [1] [3 max]

- (b) Accept any diagram that shows two Cl atoms attached to Pt **and** two NH_3 groups attached to Pt. (Allow ECF from (a)). [1]
- (c) Moles of $\text{AgNO}_3 = 0.0162 \times 0.102 = 0.00165$ [1]
 Moles of $\text{NaCl} = 0.0148 \times 0.125 = 0.00185$ [1]
 Therefore limiting reactant is AgNO_3 / 0.00165 moles AgCl produced [1]
 Mass of AgCl produced = $0.00165 \times 143.32 = 0.236$ g (accept values in range 0.236 - 0.237 g) [1] [4 max]

*If the wrong limiting reagent is used (NaCl), 0.265 g scores [3].
 (N.B. Error carried forward; other routes are possible for the deduction that AgNO_3 is limiting / moles $\text{AgCl} = \text{moles } \text{AgNO}_3$)*

3. (a) (i) Energy / enthalpy change for the formation of 1 mol of a compound [1]
from its elements in their standard states / 101 kPa, 298K [1] [2 max]
- (ii) $3\text{C(s)} + 4\text{H}_2\text{(g)} \rightarrow \text{C}_3\text{H}_8\text{(g)}$ [1]
- (b) (i) Reference to (particular) bonds in a range of compounds / average values [1]
Break or make 1 mole of bonds in gaseous state
 $= [2(\text{C—C}) + 8(\text{C—H}) + 5(\text{O}=\text{O})] - [6(\text{C}=\text{O}) + 8(\text{O—H})]$ [1]
 $= [2(348) + 8(412) + 5(496)] - [6(743) + 8(463)]$ [1] *
 $= -1690$ [1] (units not required) [5 max]
- (N.B. correct extraction of **five** bond enthalpy values (even with wrong coefficients) would score [1])
- (ii) Positive [1]
Increase in disorder / less order / more gas (on RHS) [1] [2 max]
4. (a) (i) Any two of the following, [1] each
Some mention of a **reversible** reaction \rightleftharpoons etc.
Indication that rate of left to right = rate right to left
At equilibrium no net change in concentration of reactants and products
Closed system [2 max]
- (ii) $K_c = \frac{[\text{CH}_3\text{CO}_2\text{C}_2\text{H}_5][\text{H}_2\text{O}]}{[\text{CH}_3\text{CO}_2\text{H}][\text{C}_2\text{H}_5\text{OH}]}$ [1] [1]
- (iii) $[\text{C}_2\text{H}_5\text{OH}] = [\text{CH}_3\text{CO}_2\text{H}] = 0.33$ [1]
- $K_c = 4.1$ (accept 4.0) [1] [2 max]
- (Allow for ECF from (ii))
- (b) K_w increases with temperature rise / $[\text{H}^+]$ or $[\text{OH}^-]$ rises as temperature rises [1]
Equilibrium shifts to right (as temperature increases) [1] [3 max]
Endothermic reaction [1]
- (c) (i) No effect [1]
Some description of role of catalyst e.g. increases rate of forward **and** reverse reaction (equally) / increases rate of attainment of equilibrium [1] [2 max]
- (ii) No effect [1]
Concentration of reactants the same [1] [2 max]

SECTION B

5. (a) Volume of gas method: **or** Mass loss method:
 Chemicals in flask / beaker [1] Chemicals in flask / beaker [1]
 Method of collection [1] Top pan balance [1]
 Airtight [1] Not airtight [1]
- Measurement and processing:
 Volume / mass monitoring [1]
 Timing [1]
 Appropriate processing of data [1]
 e.g. convert time to rate / $\text{rate} = \frac{1}{\text{time}}$ / plot volume–time graph and measure slope [6 max]
- (b) Slope decreases / slope becomes less steep / rate decreases [1]
 Acid / reactant concentration falls / surface area of magnesium / reactant decreases [1] [2 max]
- (c) (i) For line B:
 Curve shown less steep than A [1]
 Curve becomes horizontal at half the height of A / explain why curve goes to half height [1]
 Acid particles more widely spaced / less frequent collisions between reactant particles [1] [3 max]
- (ii) For line C:
 Curve shown steeper than A [1]
 Curve becomes horizontal at same height as A [1]
 Magnesium surface area increased / more frequent collisions between reactant particles [1] [3 max]
- (d) Order = 1 / first order [1]
 Rate proportional to concentration / graph is straight line [1] [2 max]
- (e) $\text{Rate} = k[\text{H}_2\text{SO}_4]$ [1]
 e.g. $k = \frac{0.008}{0.9} \bigg/ \frac{0.006}{0.675} \approx 8.9 \times 10^{-3}$ [1] (accept answer $\pm 2 \times 10^{-3}$)
- s^{-1} [1]
 The value of k would be greater at a higher temperature [1] [4 max]

(f) Diagram:

Line for products below line for reactants **[1]**

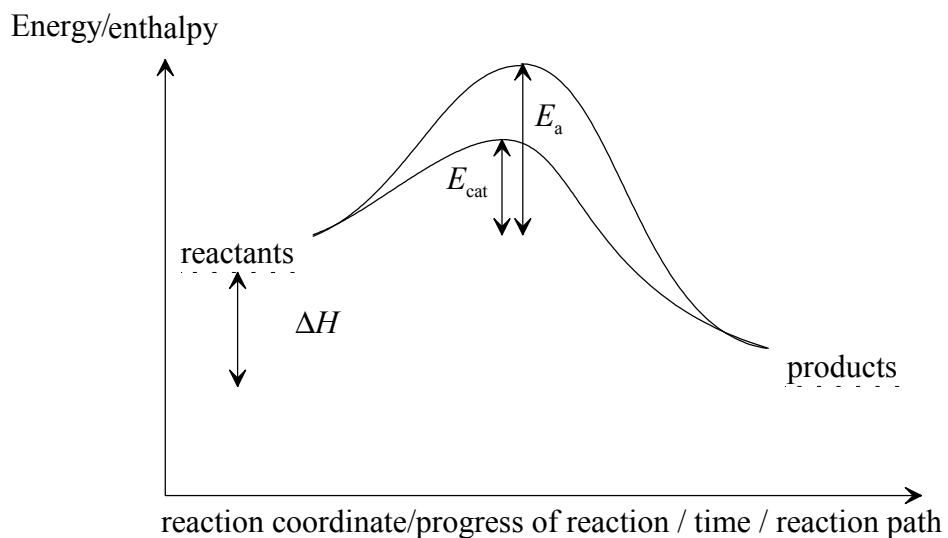
ΔH marked on vertical distance between reactants line and products line **[1]**

y axis label and x axis label or reactant and product labels **[1]**

E_a marked on vertical distance between reactants line and intermediate / transition state **[1]**

E_{cat} marked on vertical distance between reactants line and catalyst intermediate / transition state **[1]**

[5 max]



(If reaction is shown as endothermic, award **[4 max]**)

6. (a) **Brønsted–Lowry**: acid is proton (H^+) donor and base is proton acceptor **[1]**

For example, $\text{HNO}_3 + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+ + \text{NO}_3^-$ **[1]** (*accept other valid example*)

Identification of the acid **and** the base on the left hand side **[1]**

Lewis: acid is electron pair acceptor (electrophile) and base is electron pair donor (nucleophile) **[1]**

For example, $\text{BF}_3 + \text{NH}_3 \rightarrow \text{BF}_3\text{NH}_3$ / $\text{Cu}^{2+} + 4\text{NH}_3 \rightarrow \text{Cu}(\text{NH}_3)_4^{2+}$ **[1]**
(*accept other valid example*)

Identification of **both** the acid and the base on the left hand side **[1]**

Bond formed is (dative) covalent / co-ordinate / indication that one species gives bonding electron pair **[1]**

[7 max]

- (b) Strong acid completely dissociated, weak acid weakly / partially dissociated **[1]**
example of strong **and** weak acid (names or formulas) **[1]**

[2 max]

- (c) Molecule and anion equilibrium / $\text{HIn} \rightleftharpoons \text{H}^+ + \text{In}^-$ / indicator is a weak acid or weak base **[1]**

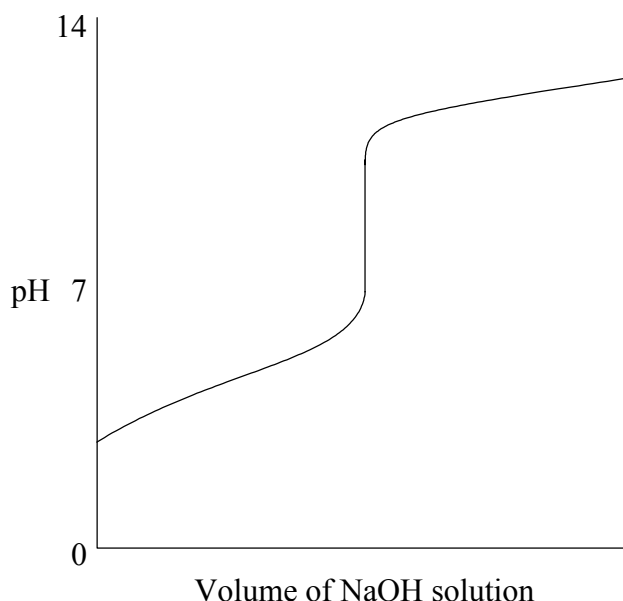
Different colours **[1]**

Addition of H^+ or OH^- / acid or alkali causes shift in equilibrium **[1]**

$\text{H}^+ \rightarrow$ colour A / OH^- causes colour B **[1]**

[4 max]

- (d) (i)



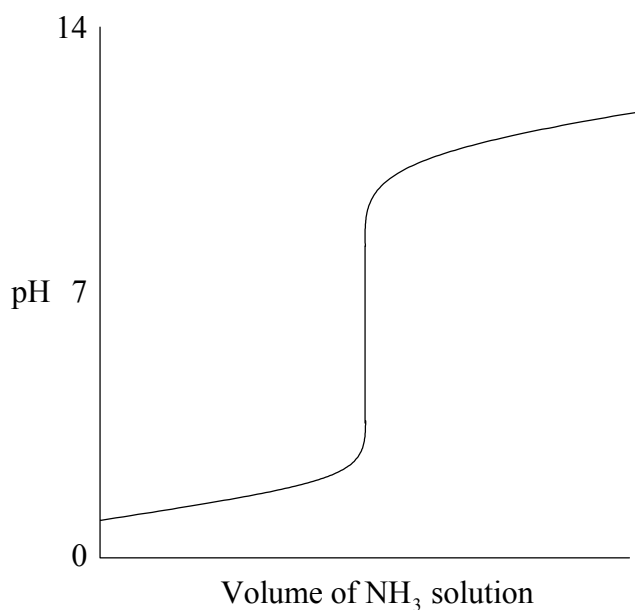
Line starts clearly above $\text{pH} = 1$ **[1]**

More of vertical line in alkaline than acidic region **[1]**

Phenolphthalein **[1]**

[3 max]

(ii)

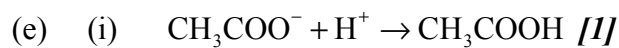


Line starts at pH = 1 / same as printed graph *[1]*

More of vertical line in acidic than alkaline region *[1]*

Methyl orange / methyl red / bromophenol blue / bromothymol blue /
bromocresol green *[1]*

[3 max]



Added H^+ ions react with conjugate base / CH_3COO^- *[1]*

[2 max]

(ii) $[\text{H}^+] = \frac{K_a [\text{CH}_3\text{COOH}]}{[\text{CH}_3\text{COO}^-]}$ / $\text{pH} = \text{p}K_a + \log \frac{[\text{base}]}{[\text{acid}]}$ *[1]*

Correct values of CH_3COOH and CH_3COO^- mol or mol dm^{-3} *[1]*

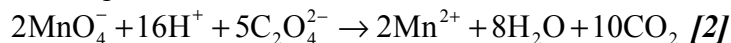
Correct value of $[\text{H}^+] = 3.48 \times 10^{-5} (\text{mol dm}^{-3})$ *[1]*

pH = 4.4–4.5 (consequential on $[\text{H}^+]$ value) *[1]*

[4 max]

7. (a) Oxidation number of Mn on left-hand side 7 **[1]**
 Oxidation number of C on left-hand side 3 **[1]**
 Oxidation number of Mn **and** C on right-hand side 2 and 4 respectively **[1]**

Final equation:



(If ratio $\text{MnO}_4^- : \text{C}_2\text{O}_4^{2-}$ is 2 : 5 but equation wrong give [1]. Do not penalise absence of state symbols)

[5 max]

- (b) (i) Diagram must show:
 Voltmeter and metals **[1]**
 Salt bridge correctly labelled **[1]**
 $[\text{Ni}^{2+}]$ **and** $[\text{Cd}^{2+}]$ as 1 mol dm⁻³ **[1]**

[3 max]

- (i) • H₂ gas
 • At 1 atm / 101.3 kPa
 • 298 K
 • 1 mol dm⁻³ H⁺

(Four correct [2], 2/3 correct [1])

Pt electrode **[1]**

[3 max]

- (c) (i) $\text{Ni}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Ni}(\text{s})$ **[1]**
 $\text{Cd}(\text{s}) - 2\text{e}^- \rightarrow \text{Cd}^{2+}(\text{aq})$ / $\text{Cd}(\text{s}) \rightarrow \text{Cd}^{2+}(\text{aq}) + 2\text{e}^-$ **[1]**
 Allow $\text{Cd} + \text{Ni}^{2+} \rightarrow \text{Cd}^{2+} + \text{Ni}$ for **[2]**

Cd is oxidised **[1]**

Oxidising agent is Ni^{2+} (do not accept Ni) **[1]**

[4 max]

- (ii) Cd is A **[1]**
 External electron flow from Cd to Ni **[1]**.

[2 max]

- (iii) Overall voltage is 0.2 volts (accept + or – 0.2 V) **[1]**
 ΔG is negative (consequential on the sign of the potential) **[1]**

[2 max]

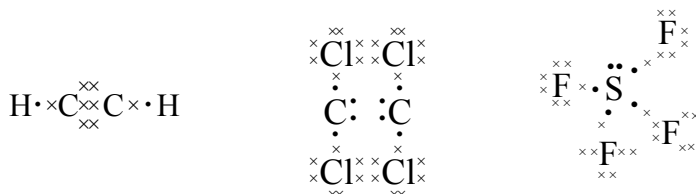
- (d) Silver at cathode / - ve **[1]**
 Oxygen at anode / + ve **[1]**

[2 max]

- (e) Number of coulombs = $20 \times 5 \times 60^2$ / 360 000 **[1]**
 Number of Faradays = 3.73 **[1]**
 Moles of OH⁻ = 3.73 **[1]**
 Mass of NaOH = $3.73 \times 40 = 149.2$ g **[1]**

[4 max]

8. (a) Each structure (**with** non-bonding e^- pairs where relevant) [1]
(lines are acceptable instead of pairs of dots/crosses)



Shapes:

C_2H_2 linear / straight [1]
angle 180° [1]

C_2Cl_4 (trigonal) planar [1]
angle 120° [1]

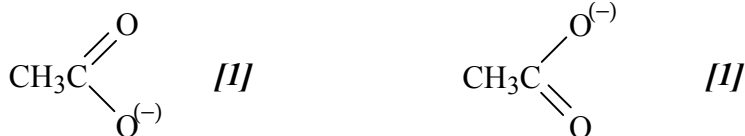
SF_4 K-shaped / based on trigonal bipyramid / see saw [1]
angle 90° [1]
angle 120° [1]

[10 max]

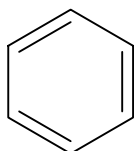
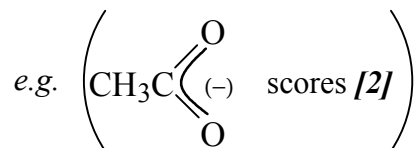
- (b) sp (C_2H_2) [1]
 sp^2 (C_2Cl_4) [1]

[2 max]

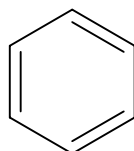
- (c) Acceptable resonance structures



(accept delocalized ethanoate ion for [2])



[1]



[1]

[4 max]

(accept delocalized benzene for [2])

- (d) (i) C to O in the ion equal **[1]**
 Different bond length in acid **[1]**
 $C=O < C-O$ (or converse) **[1]**
 C to O in ethanoate ion intermediate bond length / 1.5 bonds **[1]** **[4 max]**
- (ii) Benzene is stable because of delocalization **[1]**
 Addition destroys delocalization **[1]** **[2 max]**
- (iii) (pK_a values show) ethanoic stronger acid than ethanol **[1]**
(Some correct statement about difference in acidity)
- Reference to relative stability of (both) anions *(they do not have to be shown)* **[1]**
- Anion of acid more stable C = O group e^- withdrawing / delocalisation of charge (or resonance) in ethanoate ion / explain instability of ethoxide **[1]** **[3 max]**
-