INTERNATIONAL BACCALAUREATE
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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 / $\Delta E = h\upsilon$ ***[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 $PtCl_2N_2H_6$ ***[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 $AgNO_3 = 0.0162 \times 0.102 = 0.00165$ ***[1]***
Moles of $NaCl = 0.0148 \times 0.125 = 0.00185$ ***[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 AgCl = moles $AgNO_3$)

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) $3C(s) + 4H_2(g) \rightarrow C_3H_8(g)$ ***[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
$= [2(C—C) + 8(C—H) + 5(O=O)] - [6(C=O) + 8(O—H)]$ ***[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 /⇌ *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) $K_c = \dfrac{[CH_3CO_2C_2H_5][H_2O]}{[CH_3CO_2H][C_2H_5OH]}$ ***[1]*** ***[1]***

(iii) $[C_2H_5OH] = [CH_3CO_2H] = 0.33$ ***[1]***

$K_c = 4.1$ (accept 4.0) ***[1]*** ***[2 max]***

(Allow for ECF from (ii))

(b) K_w increases with temperature rise / $[H^+]$ or $[OH^-]$ 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]***
Method of collection ***[1]***
Airtight ***[1]***

Chemicals in flask / beaker ***[1]***
Top pan balance ***[1]***
Not airtight ***[1]***

Measurement and processing:
Volume / mass monitoring ***[1]***
Timing ***[1]***
Appropriate processing of data ***[1]***
e.g. convert time to rate / 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]***

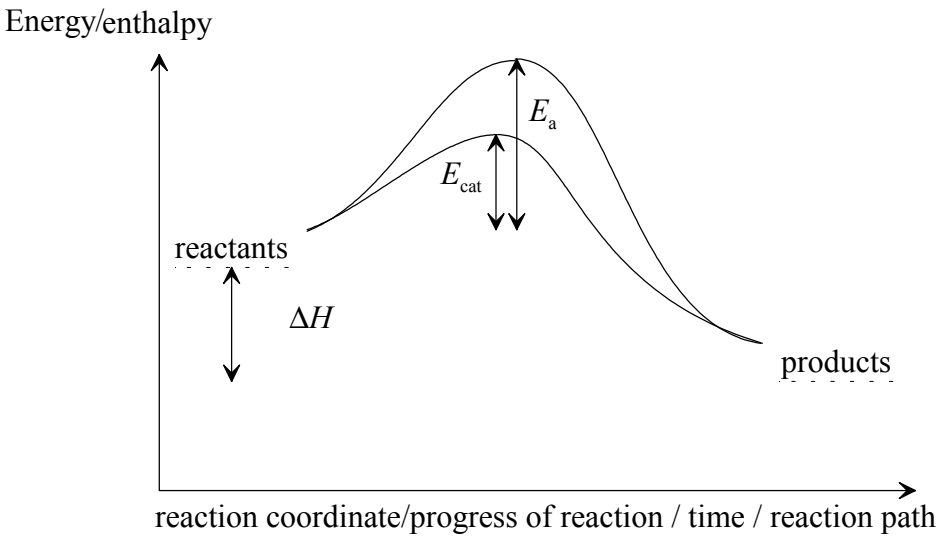
(d) Order = 1 / first order ***[1]***
Rate proportional to concentration / graph is straight line ***[1]*** ***[2 max]***

(e) Rate $= k[H_2SO_4]$ ***[1]***

e.g. $k = \frac{0.008}{0.9} \Big/ \frac{0.006}{0.675} \Big/ \approx 8.9\times10^{-3}$ ***[1]*** (*accept answer* $\pm 2\times10^{-3}$)

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, $HNO_3 + H_2O \rightarrow H_3O^+ + NO_3^-$ ***[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, $BF_3 + NH_3 \rightarrow BF_3NH_3 / Cu^{2+} + 4NH_3 \rightarrow Cu(NH_3)_4^{2+}$ ***[1]***
(*accept other valid example*)

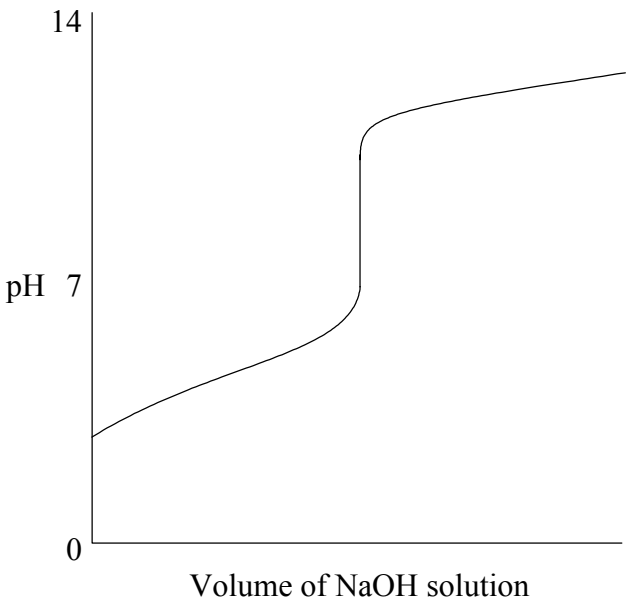
Identification of **both** the acid and the base on the left hand side ***[1]***

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]***

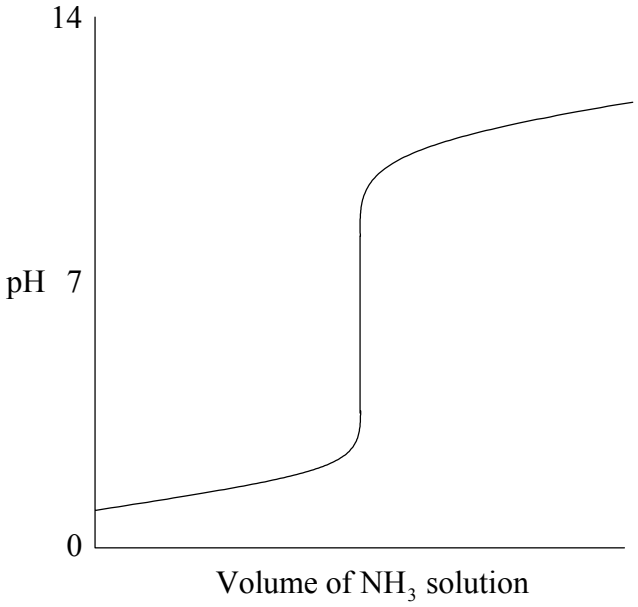
(c) Molecule and anion equilibrium / $HIn \rightleftharpoons H^+ + In^-$ / indicator is a weak acid or weak base ***[1]***
Different colours ***[1]***
Addition of H^+ or OH^- / acid or alkali causes shift in equilibrium ***[1]***
$H^+ \rightarrow$ colour A / OH^- causes colour B ***[1]*** ***[4 max]***

(d) (i)



Line starts clearly above 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]***

(e) (i) $CH_3COO^- + H^+ \rightarrow CH_3COOH$ ***[1]***
Added H^+ ions react with conjugate base / CH_3COO^- ***[1]*** ***[2 max]***

(ii) $[H^+] = \frac{K_a[CH_3COOH]}{[CH_3COO^-]}$ / $pH = pK_a + \log\frac{[base]}{[acid]}$ ***[1]***
Correct values of CH_3COOH and CH_3COO^- mol or $mol\,dm^{-3}$ ***[1]***
Correct value of $[H^+] = 3.48\times10^{-5}$ ($mol\,dm^{-3}$) ***[1]***
pH = 4.4–4.5 (consequential on $[H^+]$ 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:
$2MnO_4^- + 16H^+ + 5C_2O_4^{2-} \rightarrow 2Mn^{2+} + 8H_2O + 10CO_2$ ***[2]***

*(If ratio $MnO_4^- : C_2O_4^{2-}$ 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]***
$[Ni^{2+}]$ **and** $[Cd^{2+}]$ as 1 $mol\,dm^{-3}$ ***[1]*** ***[3 max]***

(i)
- H_2 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) $Ni^{2+}(aq) + 2e^- \rightarrow Ni(s)$ ***[1]***
$Cd(s) - 2e^- \rightarrow Cd^{2+}(aq) / Cd(s) \rightarrow Cd^{2+}(aq) + 2e^-$ ***[1]***
Allow $Cd + Ni^{2+} \rightarrow Cd^2 + Ni$ for ***[2]***

Cd is oxidised ***[1]***
Oxidising agent is Ni^{2+} (*do not accept Ni*) ***[1]*** ***[4 max]***

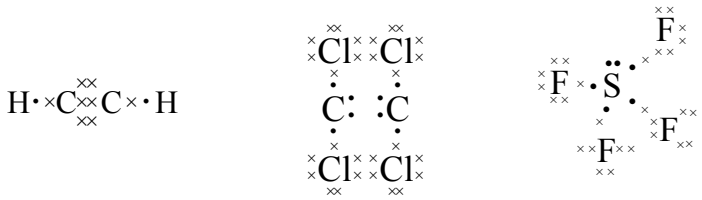
(ii) Cd is **A** ***[1]***
External electron flow from Cd to Ni ***[1]***. ***[2 max]***

(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 $= 20 \times 5 \times 60^2 / 360000$ ***[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:

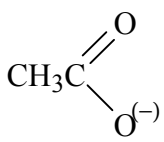
C_2H_2 linear / straight ***[1]***
angle 180° ***[1]***

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

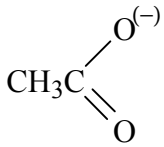
SF_4 K-shaped / based on trigonal bipyramid / see saw ***[1]***
angle 90° ***[1]***
angle 120° ***[1]*** ***[10 max]***

(b) sp (C_2H_2) ***[1]***
sp^2 (C_2Cl_4) ***[1]*** ***[2 max]***

(c) Acceptable resonance structures

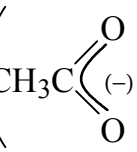


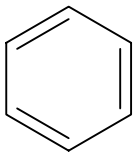
[1]



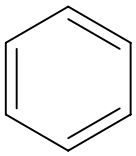
[1]

(accept delocalized ethanoate ion for ***[2]***)

e.g.  scores ***[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]***