Mock Exam 2

CHEMISTRY 9701

Paper 4 A Level Structured Questions **2 hours 15 minutes**

MARK SCHEME

Maximum Mark: **114**

Published

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1 **(a)** **(i)** the enthalpy change/released when **1 mole is formed** [1]

of ionic lattice **from** the **gas** phase **ions** [1]

(ii) Mg^{2+} + O^{2-} $\longrightarrow$ MgO [1]

[3]

(b) measurements needed:
volume/mass/weight of water (in calorimeter) [1]
initial + final temperature/temperature change/temperature rise (of the water) [1]
mass of Mg (used)/mass MgO [1]
Not *volume/moles/mass of oxygen used*

[3]

(c) $\Delta H = 148 + 736 + 1450 + 496/2 - 141 + 798 - 3791$
= <u>–552</u> kJ mol^{-1} [3]

[3]

(d) $Na_2O(s) + H_2O(aq/l) \longrightarrow 2NaOH(aq)$ [1]
$MgO(s) + H_2O(aq/l) \longrightarrow Mg(OH)_2(s)$ *or* $Mg(OH)_2(aq)$ [1]
pH 12.5-14 [NaOH] **AND** 8-10.5 [$Mg(OH)_2$] respectively [1]

[3]

[Total: 12]

2 **(a)** **(i)** One that can go in either direction. [1]

(ii) both forward & reverse reactions are going on at the same time, but the concentrations of all species do not change (owtte)
or rate of forward = rate of backward reaction [1]

(b) **(i)** $K_c = [H^+][OH^-]/[H_2O]$ [1]

(ii) $K_w = [H^+][OH^-]$ [1]
rearrangement of equation in **(i)** gives $K_c[H_2O] = [H^+][OH^-]$ & $K_w = K_c[H_2O]$ (owtte)
or the $[H_2O]$ is contained within K_w [1]

(iii) K_w will be higher in hot water **because** reaction is endothermic [1]

(c) **(i)** $[OH^-] = 5 \times 10^{-2}$; $[H^+] = (1 \times 10^{-14})/ 5 \times 10^{-2} = \mathbf{2 \times 10^{-13}}$ [1]
pH $= -\log_{10}[H^+] = \mathbf{12.7}$ (correct ans = [2]) ecf [1]

(ii) $[NH_4^+] = [OH^-]$ (= x) [1]
$x^2 = 1.8 \times 10^{-5} \times 0.05 \Rightarrow x\ (= [OH^-]) = \mathbf{9.49 \times 10^{-4}}$ (mol dm^{-3}) (correct ans = [2]) [1]

(iii) $[H^+] = K_w/[OH^-] = (1 \times 10^{-14})/ 9.49 \times 10^{-4} = \mathbf{1.05 \times 10^{-11}}$(mol dm^{-3}) ecf [1]

(iv) pH = **11.0** ecf [1]

[Total: 12 max 11]

3

(a) (i)

Expt 2 3.2×10^{-4} Expt 3 3.2×10^{-4}	Both needed	1

(ii)

P order = 1 **Q** order = 2	These answers only, not consequential on 4.1 Allow if 4.1 blank.	1 1

(iii)

(Rate = $k[R]^2[S]^2$) k = Rate/$[R]^2[S]^2$ **OR** $1.20 \times 10^{-3}/(1.00 \times 10^{-2})^2(2.45 \times 10^{-2})^2$	M1 for rearrangement	M1
k = 19992 = 2.00×10^4	M2 for answer (Allow 1.99×10^4)	M2
Units $mol^{-3}\ dm^9\ s^{-1}$	Allow conseq units for their expression in M1	M3

(b)

(b) (i) (from 1 and 2:) as p(NO) halves, rate decreases to ¼ , **so order = 2** [1]
(from 1 and 3:) as $p(H_2)$ halves, so does rate, **so order = 1** [1]

(ii) rate = $k\ p_{NO}^2.p_{H2}$ [1]
units (of k) are $atm^{-2}\ s^{-1}$ [1]

(iii) add all three equations:

$NO + NO + H_2 + O + H_2 + N_2O \rightarrow N_2O + O + H_2O + N_2 + H_2O$ [1]

cross out all species common to both sides:

$NO + NO + H_2 +$ ~~O~~ $+ H_2 +$ ~~N_2O~~ $\rightarrow$ ~~N_2O~~ $+$ ~~O~~ $+ H_2O + N_2 + H_2O$ [1]

($\Rightarrow$ $2NO + 2H_2 \rightarrow N_2 + 2H_2O$)

(iv) *either*: **step 2** since it involves H_2 [1]

O formed from NO [1]

or: ***step 3*** *since it involves* H_2 *[1]*

N_2O formed from NO *[1]*

[8]

(c)

(c) (i) NO [1]

(ii) $3Fe^{2+} + 4H^+ + NO_3^- \longrightarrow 3Fe^{3+} + NO + 2H_2O$ [1]

(allow $Fe^{2+} + H^+ + HNO_2 \longrightarrow Fe^{3+} + NO + H_2O$)

(iii) dative/coordinate bonding [1]

(iv) $[Fe(H_2O)_{6-n}(NO)_n]^{2+}$ (n = 1-6) [1]

[4]

4 **(a)** **(i)** $E^o = 0.40 - (-0.83) = 1.23V$ (1)

(ii) $2H_2 + O_2 \longrightarrow 2H_2O$ (1)

(iii) LH electrode will become more negative (1)
RH electrode will also become more negative / less positive (1)

(iv) no change ecf from **(iii)** (1)

(v) increased conductance *or* lower cell resistance *or* increased rate of reaction (1) [6]

(b) **(i)** $E^o = 1.47 - (-0.13) = 1.60V$ (1)

(ii) $PbO_2 + Pb + 4H^+ \longrightarrow 2Pb^{2+} + 2H_2O$ (1)

(iii) $PbO_2 + Pb + 4H^+ + 2SO_4^{2-} \longrightarrow 2PbSO_4(s) + 2H_2O$ (1)

(iv) E^o_{cell} will increase (1)

as $[Pb^{2+}]$ decreases, $E_{electrode}(PbO_2)$ will become more positive, but $E_{electrode}(Pb)$ will become more negative (1) [5]

[Total: 11]

5 **(a)** **(i)** a solution that resists/minimises a change in its pH *or* **helps** maintain its pH..... **[2]**
(NOT any of: "maintains pH"; "keeps pH constant"; "no change in pH")
.....when small amounts of acid/H^+ or base/OH^- are added (**both** acid and base are needed)

(ii) HCO_3^- reacts with H^+ ions as follows: **[2]**

$$HCO3^- + H^+ \longrightarrow H_2CO_3 \ (\textit{or}\ H_2O + CO_2)$$

and with OH^- ions thus:

$$HCO_3^- + OH^- \longrightarrow CO_3^{2-} + H_2O$$

(the equation arrows can be equilibrium arrows, as long as HCO_3^- is on the left)

(iii) ($pK_a = -\log(K_a) = 7.21$) **[2]**

$pH = pK_a + \log([base]/[acid]) = 7.21 + \log(0.5/0.3)$
$= \mathbf{7.43\ (7.4)}$

(b) **(i)** $K_{sp} = [Ag^+]^3[PO_4^{3-}]$ **and** units: mol^4dm^{-12} **[1]**

(ii) call $[PO_4^{3-}] = x$, then $[Ag^+] = 3x$, and $K_{sp} = 27x^4$ **[3]**

$x = (K_{sp}/27)^{1/4} = (1.25 \times 10^{-20}/27)^{1/4} = 4.64 \times 10^{-6}$ mol dm^{-3}

$[Ag^+] = 3x = \mathbf{1.39 \times 10^{-5}}$ (mol dm^{-3}) (allow $\mathbf{1.4} \times 10^{-5}$)

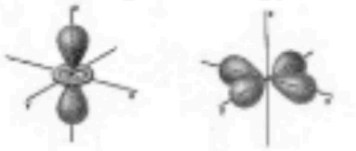
(c) $H_3PO_3 + 2Fe^{3+} + H_2O \longrightarrow H_3PO_4 + 2Fe^{2+} + 2H^+$ **[2]**

$E^\ominus_{cell} = 0.77 - (-0.28) = (+)\mathbf{1.05}$ V

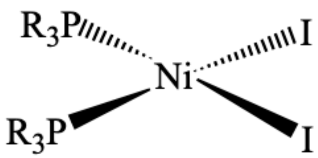
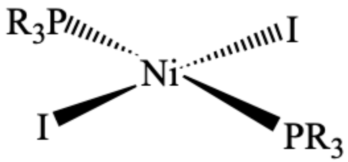
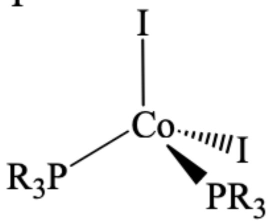
or $3H_3PO_3 + 3H_2O + 2Fe^{3+} \longrightarrow 3H_3PO_4 + 6H^+ + 2Fe$

$E^\ominus_{cell} = -0.04 - (-0.28) = (+)\mathbf{0.24}$ V

[Total: 12]

6	**(a) (i)**	chromium and copper	**1**	
	(ii)	(all orbitals have the) same energy	**1**	
	(iii)	correct id of one higher energy d orbital the other higher energy d orbital 	 **1** **1**	 **[4]**

(b)	**(i)**	Co: ...$3s^2 3p^6 3d^7 4s^2$ Co^{2+}: ...$3s^2 3p^6 3d^7$	 [1]
	(ii)	solution starts pink turns blue pink is $[Co(H_2O)_6]^{2+}$ blue is $[CoCl_4]^{2-}$ this complex is tetrahedral	[1] [1] [1] [1] [1]

(c)	  	[1] [1] [1]

(d)

reaction	acid-base	ligand exchange	precipitation	redox
$[Cu(H_2O)_6]^{2+} + 4NH_3 \rightarrow [Cu(NH_3)_4]^{2+} + 6H_2O$		✓		
$[Cu(H_2O)_6]^{2+} + 4HCl \rightarrow [CuCl_4]^{2-} + 4H^+ + 6H_2O$		✓		
$2FeCl_2 + Cl_2 \rightarrow 2FeCl_3$				✓
$[Fe(H_2O)_6]^{2+} + 2OH^- \rightarrow Fe(OH)_2 + 6H_2O$	✓		✓	
$2Fe(OH)_2 + \frac{1}{2}O_2 + H_2O \rightarrow 2Fe(OH)_3$				✓
$CrO_3 + 2HCl \rightarrow CrO_2Cl_2 + H_2O$	✓	✓		
$Cr(H_2O)_3(OH)_3 + OH^- \rightarrow [Cr(H_2O)_2(OH)_4]^- + H_2O$	✓	✓		
$[Cr(OH)_4]^- + 1\frac{1}{2}H_2O_2 + OH^- \rightarrow CrO_4^{2-} + 4H_2O$		✓		✓

(Where more than one tick appears on a line in the table above – these are alternatives – but allow the mark if both are given).

[8]

(e) $n(H_2) = 8/24 = 0.33$ mol [1]

from equation, this is produced from 0.22 mol of A*l* ecf (× 2/3) [1]

$A_r(Al) = 27$ thus mass of A*l* = 27 × 0.22 = 5.9 – 6 g hence 5.9–6.0% ecf (× 27) [1]

[3]

7
(a)

polymer	addition/condensation?	formulae of monomers
1	condensation	$HO_2C\text{-}CO_2H$ *or* $C\mathit{l}CO\text{-}COC\mathit{l}$ $NH_2\text{-}CH_2\text{-}CH_2\text{-}NH_2$
2	condensation	$HO\text{-}CH_2\text{-}CH(C_2H_5)\text{-}CO_2H$ $HO\text{-}CH_2\text{-}CH(CH_3)\text{-}CO_2H$
3	addition	$CH_2{=}CH\text{-}CH_3$ $CH_2{=}CH\text{-}CONH_2$ $CH_2{=}CH\text{-}C_6H_5$
	⇑ [2] (2 correct: [1])	⇑ [6] (6 correct: [5]) etc

(2 correct: [1])
(C=C bonds not needed, but penalise –[1] if C-C drawn instead of C=C)
(if more than 7 formulae drawn, then penalise –[1] for each formula in excess of 7) **[8]**

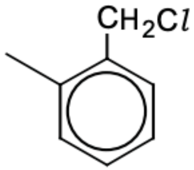
(b) **(i)** **C** is C*l*COCOC*l* (1)
D is C*l*COCOCOC*l* (1)

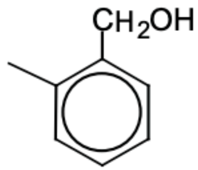
(ii) hydrogen bonding (1)

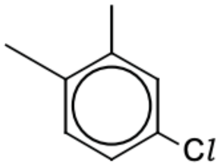
(iii) because it's an amide *or* not an amine *or* its lone pair is delocalised (over C=O) or less
available due to electronegative oxygen [NOT: **E** is neutral, but the diamine is basic] (1)

(iv) condensation (polymer) *or* polyester (1) [5]

(c)







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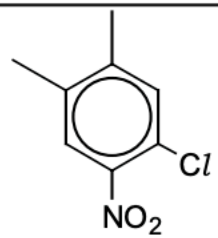

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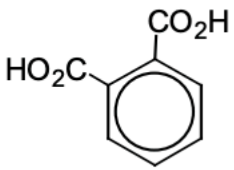
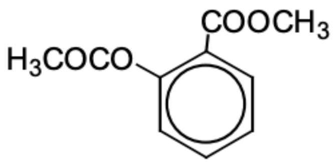
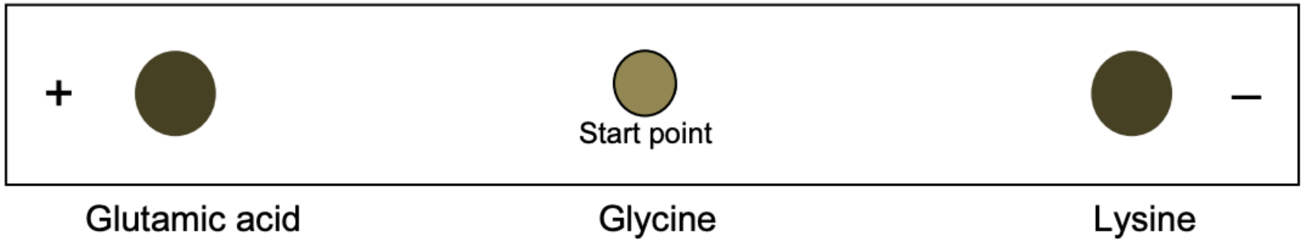




[6]

8 (a)



Glutamic acid between + and start point [1]
Lysine between – and start point [1]
Glycine at, or *very* close to, start point [1]
[3]

(b) (i)

M1 $\frac{27}{80} = 0.34$ **M2** glycine	**M1** some relevant working is needed to arrive at 0.325 - 0.35 no ECF based on **M1**	1 1

(ii)

developing / locating agent / iodine	1

(iii)

each amino acid has different (relative) affinity/attraction to/solubility in stationary and mobile phases	**allow** reference to different solubility in solvent OR different affinity for stationary phase	1