Year 12
Chemistry
2006

SOLUTIONS

Part 1:

1	(b)	11	(c)	21	(a)	
2	(c)	12	(c)	22	(b)	
3	(c)	13	(c)	23	(c)	
4	(a)	14	(d)	24	(c)	
5	(b)	15	(d)	25	(d)	
6	(b)	16	(c)	26	(b)	
7	(a)	17	(b)	27	(d)	
8	(d)	18	(d)	28	(a)	
9	(a)	19	(b)	29	(b)	
10	(a)	20	(d)	30	(a)	(60)

Part 2:

1(a) $Mg^{2+}(aq) + 2OH^{-}(aq) \rightarrow Mg(OH)_2(s)$ (1)

White precipitate forms. (2)

1(b) $Cu(s) + 4H^{+}(aq) + 2NO_3^{-}(aq) \rightarrow Cu^{2+}(aq) + 2H_2O(l) + 2NO_2(g)$ (1)

Brown gas produced; green solution formed; solid dissolves . (2)

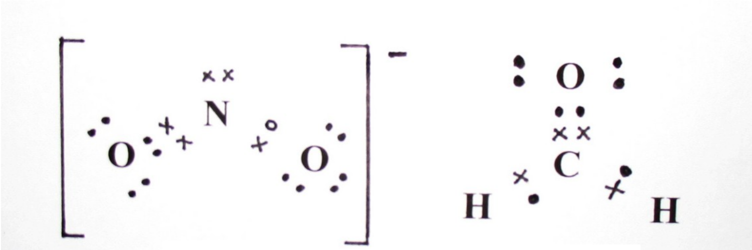
1(c) $Cr(OH)_3(s) + NaOH(s) \rightarrow Cr(OH)_4^{-}(aq) + Na^{+}(aq)$ (1)

Green solid dissolves; green solution forms. (2)

1(d) $(CH_3)_2CHCH_2CH_2OH(aq) + CH_3COOH(aq) \rightarrow CH_3COOCH_2CH_2CH(CH_3)_2(aq) + H_2O(l)$ (1)

Banana odour detected. (2)

2.



NO_2^- CH_2O

bent or V shaped triangular planar (2 + 2)

3. bent polar species: F_2O (1)
diatomic molecule exhibiting dispersion forces only: Cl_2 (1)
pyramidal: PH_3 (1)
tetrahedral and polar: CH_2F_2 (1)
triangular planar and non-polar: BCl_3 (1)

4. KCl pH = 7 salts of strong acids/bases or K^+ and Cl^- ions have no tendency to react with water. (2)

NH_4Cl pH < 7 $NH_4^+(aq) + H_2O(l) \leftrightarrow NH_3(aq) + H_3O^+(aq)$
Hydrolysis of $NH_4^+(aq)$ produces $H_3O^+(aq)$ which reduces pH below 7. (2)

Na_2CO_3 pH > 7 $CO_3^{2-}(aq) + H_2O(l) \rightarrow HCO_3^-(aq) + OH^-(aq)$
Hydrolysis of CO_3^{2-} produces $OH^-(aq)$ which increases pH above 7. (2)

5(a) $N_2(g) + 3H_2(g) \leftrightarrow 2NH_3(g) + \text{heat}$ (1)

5(b) Haber process (1)

5(c) Change the temperature (1)

5(d) **Use high pressure** (production of ammonia is accompanied by a decrease in the number of gaseous molecules so yield is increased at higher pressures; high pressure also increases reaction rate).
Use low temperature (a compromise between reaction rate and the application of LCP is needed; the catalyst allows low temperature to yield sufficient ammonia). (3)

6(a) $2H_2O_2(aq) \leftrightarrow 2H_2O(l) + O_2(g)$ (1)

6(b) (Downward) displacement of water (1)

6(c) Redox or disproportionation (1)

6(d) Provides an alternative reaction pathway with a lower activation energy. (2)

6(e) Increase temperature and use higher volume strength hydrogen peroxide. (2)

7(a) $MnO_4^-(aq) + 4H^+(aq) + 3e^- \leftrightarrow MnO_2(s) + 2H_2O(l)$ (1)

7(b) $Fe^{2+}(aq) \leftrightarrow Fe^{3+}(aq) + e^-$ (1)

7(c) $Br_2(l) + 2e^- \leftrightarrow 2Br^-(aq)$ (1)

7(d) $H_2SO_3(aq) + H_2O(l) \leftrightarrow SO_4^{2-}(aq) + 4H^+(aq) + 2e^-$ (1)

7(e) $6CO_2(g) + 18H_2O(l) + 24e^- \leftrightarrow C_6H_{12}O_6(aq) + 24OH^-(aq)$ (1)

8(a) The salt bridge allows the passage of cations to cathode and/or allows passage of anions to anode and/or prevents a buildup of charge as the redox reaction proceeds. (1)

8(b) the tin electrode (1)

8(c) $\rightarrow$ from left to right (1)

8(d) $Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$ (1)

8(e) 0.76 volts - 0.14 volts = 0.62 volts (2)

9(a) Gold has a low tendency to be oxidised (E_0 = 1.5 volts). (1)

9(b) Gold is not normally oxidised by oxygen but CN^- assists in the oxidation of gold:

$2CN^-(aq) + Au(s) \rightarrow [Au(CN)_2]^-(aq) + e^-$ (2)

9(c) Separates the dissolved $[Au(CN)_2]^-(aq)$ from the pulp (1)

9(d) $[Au(CN)_2]^-(aq) + e^- \rightarrow Au(s) + 2CN^-(aq)$ (1)

9(e) Steel wool (1)

9(f) Oxygen and water: $4OH^-(aq) \rightarrow 2H_2O(l) + O_2(g) + 4e^-$ (2)

10(a) $CH_3CH_2CH(OH)CH_3$ (1)

10(b) 4 (1)

10(c) Either of these combinations: $CH_3CH_2CH_2CH_2OH$ 1-butanol

or $CH_3CH(CH_3)CH_2OH$ 2-methyl-1-propanol

or $CH_3C(CH_3)OHCH_3$ 2-methyl-2-propanol (2)

10(d) ketone (1)

10(e) Orange solution turns green. (1)

10(f) $2CH_3CH_2CH(OH)CH_3 + 2Na(s) \rightarrow CH_3CH_2CHCH_3 + H_2(g)$ (1)

$O^- Na^+$

11(a) HOOC  COOH and CH_2OHCH_2OH (2)

11(b) (i) $n(CH_2{=}CH_2) \rightarrow -(CH_2\text{-}CH_2)_n-$ (1)

(ii) $n(CH_2{=}CHCl) \rightarrow -(CH_2\text{-}CHCl)_n-$ (1)

Part 3:

1(a) $n(C) = n(CO_2) = m/M = 8.333 / 44.01 = 0.18934$ mol C

$m(C) = n(C) \times M = 0.18934 \times 12.01 = 2.2740$ g C (could go on to work out %C)

$n(H) = 2 \times n(H_2O) = 2 \times m/M = 2 \times 3.408 / 18.016 = 0.37833$ mol H

$m(H) = n(H) \times M = 0.37833 \times 1.008 = 0.38136$ g H (could go on to work out %H)

$m(O) = m(sample) - m(C) - m(H) = 5.682 - 2.274 - 0.3814 = 3.0266$ g O

$n(O) = m(O)/ M = 3.0265 / 16.0 = 0.18917$ mol O (could go on to work out %O) (5)

n(C)	:	n(H)	:	n(O)
0.18934	:	0.37833	:	0.18917

Dividing each mole amount by the smallest number gives a ratio of

1 : 2 : 1 (2)

Hence the empirical formula is CH_2O. (1)

1(b) PV = nRT Hence n = PV / RT = [103 x 0.775] / [8.3145 x 443] = 0.021672 mol (1)

M = m / n = 3.250 g / 0.21672 mol = 149.96 (1)

ratio = [molecular formula mass] / [empirical formula mass] = 149.963 / 30.026 = 4.99 = 5.0

Hence, The molecular formula is $C_5H_{10}O_5$ (1)

2(a) anode: $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$

cathode: $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$

overall: $2Cl^-(aq) + 2H_2O(l) \rightarrow 2OH^-(aq) + H_2(g) + Cl_2(g)$ (2)

PV = nRT Hence $n(Cl_2)$ = PV / RT = [600 x 100 000] / [8.315 x 303.1] = 23 807 mol Cl_2 (1)

from equation, $n(e^-)$ = 2 x $n(Cl_2)$ = 2 x 23 807 = 47 614 mol e^- (1)

Q = $n(e^-)$ x 9.649 x 10^4 = 47 614 x 9.649 x 10^4 = 4.594 x 10^2 C (1)

Q = It Hence, I = Q / t = [4.594 x 10^2] / [1 x 24 x 60 x 60] = 53 174 = 5.32 x 10^4 A (1)

2(b) from the equation, n(NaOH) = 2 x $n(Cl_2)$ = 47 614 moles of NaOH (1)

m(NaOH) = n x M = 47614 x 39.998 = 1904458 = 1.90 x 10^6 g NaOH. (1)

2(c) from the equation, $n(H_2)$ = $n(Cl_2)$ = 23807 mol $H_2(g)$ (1)

Hence, V_{STP} = n x 22.41 = 533 275 = 5.33 x 10^5 L $H_2(g)$ at STP (1)

3. $5Fe^{2+} + MnO_4^- + 8H^+ \rightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$ (1)

$n(MnO_4^-)$ = $n(KMnO_4)$ = c x V = 0.05 x 0.025 = 0.00125 mol MnO_4^- (1)

from the equation, $n(Fe^{2+})$ = 5 x $n(MnO_4^-)$ = 5 x).00125 = 0.00625 mol Fe^{2+} (1)

n(Fe) = $n(Fe^{2+})$ = 0.00625 mol Fe

$n(Fe_2O_3)$ = ½ n(Fe) = 0.003125 mol Fe_2O_3 (1)

$m(Fe_2O_3)$ = n x M = 0.003125 x 159.7 = 0.4990625 g Fe_2O_3 (1)

$m(H_2O)$ = m(sample) - $m(Fe_2O_3)$ = 0.6680 - 0.4990625 = 0.1689 g H_2O (1)

$n(H_2O)$ = m/M = 0.1689 / 18.016 = 0.009377 mol H_2O (1)

Hence, $n(H_2O)$ / $n(Fe_2O_3)$ = 0.009377 / 0.003125 = 3 : 1 (1)

Hence, x = 3 (1)

4(a) $H_2S(g) + 2NaOH(aq) \rightarrow Na_2S(aq) + 2H_2O(l)$ (1)

$n(H_2S)$ = m / M = 6 / 34.086 = 0.1760253

n(NaOH) = c x V = 1.5 x 0.25 = 0.375 (1)

SR n(NaOH) / n (H_2S) = 2 / 1 = 2

AMR n(NaOH) / $n(H_2S)$ = 0.375 / 0.17603 = 2.13

AMR > SR Hence, H_2S is the limiting reagent (1)

from the equation, $n(H_2O)$ = 2 x $n(H_2S)$ = 2 x 0.17603 = 0.35205 mol H_2O

$m(H_2O)$ = n x M = 6.3425 g

$V(H_2O)$ = $V(H_2O)$ initial + $V(H_2O)$ produced = 250 + 6.3425 = 256.3425 mL (1)

$c(Na^+)$ = $n(Na^+)$ / V = n(NaOH) / V = 0.375 / 0.25634 = 1.463 mol L^{-1} Na^+ (1)

$c(S^{2-})$ = $n(S^{2-})$ / V = $n(H_2S)$ / V = 0.176025 / 0.25634 = 0. 687 mol L^{-1} S^{2-} (1)

$n(OH^-)$ reacting = 2 x $n(H_2S)$ = 2 x 0.176025 = 0.35205 mol

Hence, $n(OH^-)$ remaining = $n(OH^-)$ initial - $n(OH^-)$ reacting = 0.375 - 0.35205 = 0.02295 (1)

$c(OH^-)$ = $n(OH^-)$ / V = 0.02295 / 0.25634 = 0.0895 = <u>8.95×10^{-2} mol L^{-1} OH^-</u> (1)

5. The reaction is : $2H^+(aq) + CO_3^{2-}(aq) \rightarrow H_2O(l) + CO_2(g)$

$n(CO_3^{2-})$ = $n(Na_2CO_3)$ = m/M = 9.7 / 105.99 = 0.091518 mol CO_3^{2-}

$c(CO_3^{2-})$ = $c(Na_2CO_3)$ = n / V = 0.091518 / 0.5 = 0.183036 mol L^{-1}

$n(CO_3^{2-})$ in 20.0 mL = c x V = 0.183036 x 0.02 = 0.003661 mol CO_3^{2-} (2)

from the equation, n(HCl) = 2 x $n(CO_3^{2-})$ = 2 x 0.0036601 = 0.007321 mol HCl

c(HCl) = n / V = 0.0073214 / 0.01985 = 0.36884 mol L^{-1} HCl (2)

$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

$n(H^+)$ = n(HCl) = c x V = 0.36884 x 0.025 = 0.009221 mol H^+

from the equation, $n(OH^-)$ = $n(H^+)$ = 0.009221 mol OH^-

c(NaOH) = $c(OH^-)$ = n / V = 0.009221 / 0.0175 = 0.5269 mol L^{-1} NaOH (2)

$CH_3COOH(aq) + OH^-(aq) \rightarrow CH_3COO^-(aq) + H_2O(l)$

$n(OH^-)$ = n(NaOH) = c x V = 0.5269 x 0.003 = 0.0015807 mol OH^-

from the equation : $n(CH_3COOH)$ = $n(OH^-)$ = 0.0015807 mol CH_3COOH (2)

$c(CH_3COOH)$ in 20.0 mL = n / V = 0.0015807 / 0.02 = 0.079037 mol L^{-1} CH_3COOH

$n(CH_3COOH)$ in 250 mL vol. flask = c x V = 0.079038 x 0.25 = 0.019759 mol CH_3COOH (1)

$n(CH_3COOH)$ in 25 mL pure vinegar = $n(CH_3COOH)$ in 250 mL flask = 0.019759 mol CH_3COOH

$m(CH_3COOH)$ = n x M = 0.019759 x 60.052 = 1.18658 g CH_3COOH (1)

$m(CH_3COOH$ soln.) = r x V = 1.02 x 25 = 25.5 g. (1)

% (CH_3COOH) = m(pure) / m(impure) x 100 = [1.18658 / 25.5] x 100 = 4.65325

<u>Hence the solution is 4.65 % CH_3COOH by mass</u> (1)

<u>Part 4:</u> Note: You do not need to have every point to get full marks.

Trends across rows in the periodic table

atomic radius decreases	increasing positive charge in nucleus pulls electrons closer to nucleus
electronegativity increases	increase in nuclear charge increases electron attracting ability
general increase in first I.E.	increasing nuclear charge while electrons are added to same energy level
mp / bp increase to Gp IV then decrease	metallic bonding → covalent network bonding → covalent molecular

(NB: listing trends **only** is not discussing - especially since some of the data has been given to you)

(Maximum 5 marks)

Acid - base properties

Bases produce OH^- in solution - are proton acceptors - eg reactive metal hydroxides

NaOH exists as Na^+ and OH^- in solution (Maximum 2 marks)

Acids produce H^+ in solution - are proton donors

$PO(OH)_3$ can be written as H_3PO_4. It exists mainly as molecules

$H_3PO_4 \leftrightarrow H^+ + H_2PO_4^-$ Hence, moderately acidic

$SO_2(OH)_2$ can be written as H_2SO_4 and $H_2SO_4 \rightarrow H^+ + HSO_4^-$

$ClO_3(OH)$ can be written as $HClO_4$ and $HClO_4 \rightarrow H^+ + ClO_4^-$ (Maximum 3 marks)

Amphoteric - will dissolve in solutions of both strong acids and strong bases

$Al(OH)_3 + 3H^+ \rightarrow Al^{3+} + 3H_2O$ (acting as a base)

$Al(OH)_3 + OH^- \rightarrow [Al(OH)_4]^-$ (acting as an acid) (Maximum 2 marks)

Organic reactions

Na reacts with carboxylic acids to produce hydrogen gas

$2Na(s) + 2CH_3COOH(aq) \rightarrow 2Na^+ + H_2(g) + 2CH_3COO^-(aq)$

reacts with alcohols to form alkoxide anion and hydrogen gas

$2ROH + 2Na \rightarrow 2RO^-Na^+ + H_2(g)$ (Maximum 2 marks)

NaOH saponification (production of soap)

triglyceride + sodium hydroxide $\rightarrow$ soap + glycerol

neutralisation of alkylbenzene sulfonate to produce sodium alkylbenzene sulfonate detergent

neutralise acids

$CH_3COOH(aq) + OH^- \rightarrow CH_3COO^-(aq) + H_2O$ (Maximum 2 marks)

Cl_2 substitution reactions in alkanes / aromatics

$Cl_2(g) + CH_4(g) \rightarrow CH_3Cl(g) + HCl(g)$

$Cl_2(g) + CH_3Cl(g) \rightarrow CH_2Cl_2(l) + HCl(g)$

$Cl_2(g) + CH_2Cl_2 \rightarrow CHCl_3(l) + HCl(g)$

$Cl_2(g) + CHCl_3(l) \rightarrow CCl_4(l) + HCl(g)$

addition reactions in alkenes (halogenation)

$CH_3\text{-}CH{=}CH_2(g) + Cl_2(g) \rightarrow CH_3CHCl\text{-}CH_2Cl$ (Maximum 2 marks)

$SO_2(OH)_2$ (H_2SO_4)

catalyse many reactions including:

hydration of alkenes / production of alcohols

$CH_2{=}CH_2(g) + H_2O(l) \rightarrow CH_3\text{-}CH_2OH$

nitration: benzene + nitric acid $\rightarrow$ nitrobenzene + water

production of esters : carboxylic acid + alcohol $\rightarrow$ ester + water

needed to acidify / oxidise reactions eg alcohol $\rightarrow$ aldehyde $\rightarrow$ acid

hydrolysis of esters (Maximum 2 marks)

Total: 20 marks

END OF SOLUTIONS