

Year 12 Chemistry Semester 2 Exam 2007 Solutions**Part 1**

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

[60]

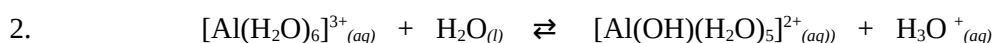
Part 2

1. Equation: [1 mark for correct species, 1 mark for balanced equation]
Do not penalise for missing or incorrect state symbols
Maximum 1 mark if molecular equation used

Observations: Need to give 'bulk' of answer for 1 mark (at least two observations)

- (a) Equation $6\text{H}^+ + \text{Cr}_2(\text{CO}_3)_3 \rightarrow 2\text{Cr}^{3+} + 3\text{CO}_2 + 3\text{H}_2\text{O}$ [2]
Observation solid dissolves to form (deep) green solution. colourless gas given off [1]
- (b) Equation $2\text{OH}^- + \text{Ni}^{2+} \rightarrow \text{Ni}(\text{OH})_2$ [2]
Observation green precipitate formed [1]
- (c) Equation $2\text{NO}_3^- + 4\text{H}^+ + \text{Cu} \rightarrow \text{Cu}^{2+} + 2\text{NO}_2 + 2\text{H}_2\text{O}$ [2]
Observation solid dissolves to give green/blue solution and brown pungent gas [1]
- (d) Equation $\text{Mg} + \text{Cu}^{2+} \rightarrow \text{Mg}^{2+} + \text{Cu}$ [2]
Observation (silver coloured) solid dissolves. blue solution decolourises and pink/brown solid produced [1]

[12 marks]

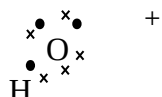


(a) $K = \frac{[\text{Al}(\text{OH})(\text{H}_2\text{O})_5]^{2+}][\text{H}_3\text{O}^+]}{[\text{Al}(\text{H}_2\text{O})_6]^{3+}}$ [1]

- (b) (i) The addition of more aluminium nitrate increases the concentration of $[\text{Al}(\text{H}_2\text{O})_6]^{3+}$ and therefore the equilibrium shifts to the right [1] to counteract this increase. Hence the $[\text{H}^+]$ increases and the pH is reduced. [1]
- (ii) The concentration of H_3O^+ is initially reduced due to the addition of the distilled water [1]. The equilibrium then moves to the right [1] to partially oppose this reduction in $[\text{H}_3\text{O}^+]$.
- (c) As the temperature increased, the $[\text{H}^+]$ increased, so the forward reaction was favoured. [1]
Therefore the forward reaction is endothermic [1] as it is opposing the temperature increase[1].

$\begin{bmatrix} \text{H} & \text{H} \\ & \end{bmatrix}$

(d)



[2]

- (e) (i) 3+ [1]
 (ii) 6 [1]

3.

Description	Name or Formula
Will form a precipitate when mixed with a solution containing Lead(IV) ions, but not with Tin(IV) ions	Sulfate
Hydrolyses in water to form an acidic solution.	Hydrogensulfate
Forms green solutions that will turn brown in the presence of oxygen.	Fe ²⁺
The conjugate base of water.	Hydroxide
Has the ability to oxidise bromide ions to bromine.	Permanganate
Is formed from oxygen in the first stage of the corrosion of iron.	Hydroxide
Contains chlorine with an oxidation number of +3.	ClO ₂ ⁻

[7 marks]

4.

Molecules	Structural formula	Shape
Carbon Monoxide CO		Linear [1]
Carbonate ion, CO ₃ ²⁻		Triangular planar[1]

[4 marks]

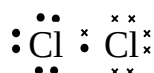
5. (a) P 1s² 2s² 2p⁶ 3s² 3p³ [1]
 (b) S²⁻ 1s² 2s² 2p⁶ 3s² 3p⁶ [1]

[2 marks]

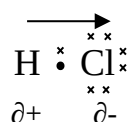
6. When atoms bond with each other they normally complete their outer (valence) electron shell. Atoms also have an ability to attract electrons which is defined as the electronegativity of the atom. When two atoms that have very different electronegativities combine, the atom with the higher electronegativity will gain electrons to form a negative ion, and the other atom will form a positive ion.

e.g. Sodium Chloride comprises of sodium ions (Na^+) and chloride ions (Cl^-) which are separate species held together by electrostatic force.

If the electronegativities of the two atoms are very similar or identical, as is the case in the element chlorine, the atoms share electrons to complete the outer shells, thus forming a covalent bond where the pair of electrons is shared equally between the two atoms.



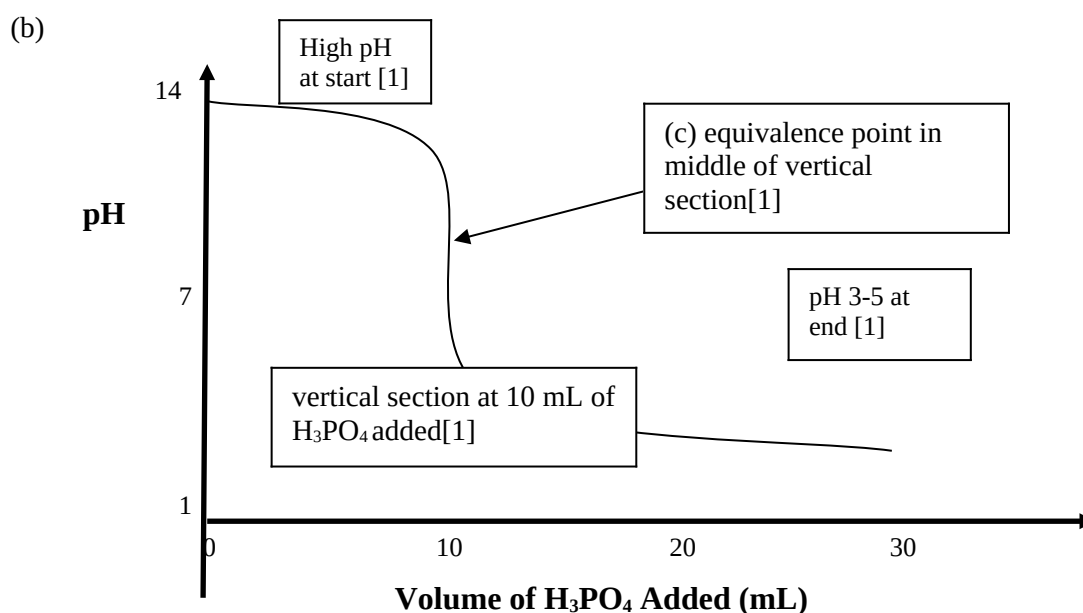
If the electronegativities of the two atoms are slightly different, as is the case in the compound hydrogen and chlorine, covalent bonding is formed but the electrons are not equally shared:



This results in a polar covalent bond, which is intermediate between a pure ionic bond as in NaCl and a non polar covalent bond as in Cl_2 .

7. (a) $\text{H}_3\text{PO}_{4(aq)} + 3\text{OH}^-_{(aq)} \rightarrow \text{PO}_4^{3-}_{(aq)} + 3\text{H}_2\text{O}_{(l)}$

[2 marks]



- (d) Sodium hydroxide solution [1]
 (e) Phenolphthalein [1]

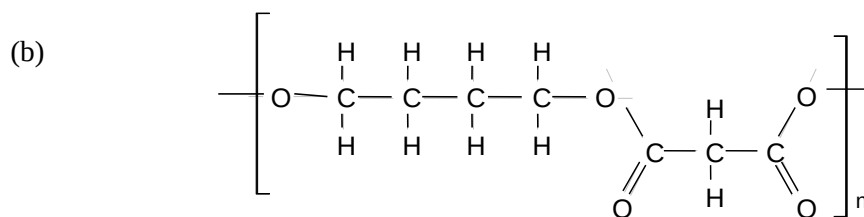
8.

Compounds	Description of Test	Expected Observations
Zinc Hydroxide and Magnesium Hydroxide	Add both substances to (concentrated) NaOH [1]	Zinc Hydroxide dissolves Magnesium Hydroxide does not. [1]
Equation(s):	$\text{Zn(OH)}_2 + 2\text{OH}^- \rightarrow [\text{Zn(OH)}_4]^{2-}$ [1]	

Compounds	Description of Test	Expected Observations
1-pentene and pentane	Add both substances to aqueous bromine. [1]	1-pentene will decolourise the bromine water (orange to colourless). No reaction with pentane [1]
Equation(s)	$\text{C}_5\text{H}_{10} + \text{Br}_2 \rightarrow \text{C}_5\text{H}_{10}\text{Br}_2$ [1]	

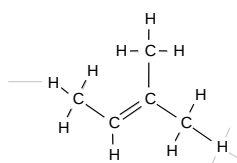
[6 marks]

9. (a) Condensation reaction. [1]



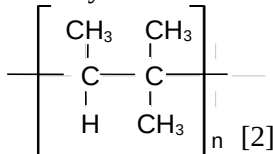
[2 marks]

(c) Monomer:



[1]

Polymer:



[2]

11. (a)

Anode half-equation: $\text{H}_2 \rightarrow 2\text{H}^+ + 2\text{e}^-$ [1]
Cathode half-equation: $\text{Cl}_2 + 2\text{e}^- \rightarrow 2\text{Cl}^-$ [1]
Overall equation: $\text{H}_2 + \text{Cl}_2 \rightarrow 2\text{H}^+ + 2\text{Cl}^-$ [1]

[3 marks]

(b) + 1.36 V [1]

(c) From right to left [1]

(d) it is unreactive/inert [1]

1. (a) $\text{CaCO}_3 + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{CO}_2 + \text{H}_2\text{O}$
 or: $\text{CaCO}_3 + 2\text{H}^+ \rightarrow \text{Ca}^{2+} + \text{CO}_2 + \text{H}_2\text{O}$ [1] [1 mark]
- (b) $n(\text{CaCO}_3) = m/M = 3.125 / 100.09 = 0.031225 \text{ mol}$ [1]
 $n(\text{HCl}) = cV = 0.0200 \times 2.00 = 0.0400 \text{ mol}$ [1]
 0.040 mol of HCl requires $(1/2) \times 0.040$ moles of $\text{CaCO}_3 = 0.0200 \text{ mol}$, [1]
 hence CaCO_3 is in excess and the **HCl is the Limiting Reagent**. [1]
need to show reasoning
 $n(\text{CaCO}_3)_{\text{remaining}} = 0.031225 - 0.0200 = 0.01123 \text{ mol}$ [1] [5 marks]
- (c) $n(\text{CO}_2) = \frac{1}{2} \times n(\text{HCl}) = \frac{1}{2} \times 0.040 = 0.0200 \text{ mol}$ [1]
 $v(\text{CO}_2) = 0.0200 \times 24.47 = \underline{\underline{0.489 \text{ L}}}$ [1] [2 marks]
2. (a) $2\text{Cr}_2\text{O}_7^{2-} + 3\text{CH}_3\text{CH}_2\text{OH} + 16\text{H}^+ \rightarrow 4\text{Cr}^{3+} + 3\text{CH}_3\text{COOH} + 11\text{H}_2\text{O}$
- $n = cV$
 $n(\text{Cr}_2\text{O}_7^{2-})_{\text{titration}} = 0.450 \times 0.01785 = 8.03 \times 10^{-3} \text{ mol}$ [1]
 [1]
 $n(\text{CH}_3\text{CH}_2\text{OH}) = (3/2) \times n(\text{Cr}_2\text{O}_7^{2-})_{\text{titration}}$ [1]
 $= 1.20 \times 10^{-2} \text{ mol}$ [1]
 $c(\text{CH}_3\text{CH}_2\text{OH}) = n/V = 1.20 \times 10^{-2} / 0.005 = \underline{\underline{2.41 \text{ mol L}^{-1}}}$ [1] [5 marks]
- (b) $m = n \times M$ $M(\text{CH}_3\text{CH}_2\text{OH}) = 46.068$ [1]
 $m(\text{CH}_3\text{CH}_2\text{OH})_{\text{in 1 litre}} = 2.41 \times 46.068 = 111 \text{ g}$ [1]
 mass of 1 litre = $1.06 \times 1000 = 1060 \text{ g}$ [1]
 $\%(\text{CH}_3\text{CH}_2\text{OH}) = (111/1060) \times 100 = \underline{\underline{10.5\%}}$ [1] [4 marks]
- (c) orange to green [1] [1 mark]

3. (a) $m(\text{H}_2\text{O}) = 10.00 - 7.21 = 2.79 \text{ g}$ [1]
 $\%(\text{H}_2\text{O}) = (2.79 / 10.00) \times 100 = 27.9\%$ [1]
 $m(\text{Si}) = (28.09 / 60.09) \times 3.10 = 1.449 \text{ g}$ [1]
 $\%(\text{Si}) = (1.449 / 10.00) \times 100 = 14.49\%$ [1]
 $\%(\text{Cu}) = 32.8\%$
 $\%(\text{O}) = 100\% - (27.9\% + 14.49\% + 32.8\%) = 24.81\%$ [1]

M	(63.55)	(28.09)	(16.00)	(18.016)	
	<u>Cu</u>	<u>Si</u>	<u>O</u>	<u>H₂O</u>	
	32.8 %	14.49 %	24.81 %	27.9 %	
$n = m/M$	$32.8 / 63.55$	$14.49 / 28.09$	$24.81 / 16.00$	$27.9 / 18.016$	[1]
n	0.516	0.516	1.55	1.55	
mole ratio	$0.516/0.516$	$0.516/0.516$	$1.55/0.516$	$1.55/0.516$	[1]
	1	1	3	3	[1]
	w	x	y	Z	

Empirical Formula is CuSiO₃·3H₂O [1]

[9 marks]

- (b) Copper = +2 Silicon = +4

[1 mark]

4. (a) $m(\text{Al}) = 1.00 \times 10^6 \text{ g}$
 $n = m/M$
 $n(\text{Al}) = 1.00 \times 10^6 / 26.98 = 3.706 \times 10^4 \text{ mol}$ [1]
Using: $\text{Al}^{3+} + 3\text{e}^- \rightarrow \text{Al}$
 $n(\text{e}^-) = 3 \times n(\text{Al}) = 3 \times 3.706 \times 10^4 = 1.11 \times 10^5 \text{ mol}$ * [1]
 $Q = n(\text{e}^-) \times 9.649 \times 10^4$ [1]
 $= 1.11 \times 10^5 \times 9.649 \times 10^4 = 1.07 \times 10^{10} \text{ C}$ [1]
 $Q = It \therefore t = Q / I$
 $= 1.07 \times 10^{10} / 40\,000 = 2.68 \times 10^5 \text{ seconds} = 74.5 \text{ hours}$ [1]

[5 marks]

- (b) $n(\text{Al}) = 3.706 \times 10^4 \text{ mol}$ $M(\text{Al}(\text{OH})_3) = 78.004$
 $n(\text{Al}(\text{OH})_3) = 3.706 \times 10^4 \text{ mol}$ [1]
 $m(\text{Al}(\text{OH})_3)_{\text{pure}} = n \times M = 3.706 \times 10^4 \times 78.004 = 2.89 \times 10^6 \text{ g}$ [1]
 $m(\text{Al}(\text{OH})_3)_{\text{impure}} = (100/87) \times 2.89 \times 10^6 \text{ g}$
 $= 3.32 \times 10^6 \text{ g}$ [1]

[3 marks]

- (c) Anode Reaction: $\text{C}_{(s)} + 2\text{O}_{(aq)}^{2-} \rightarrow \text{CO}_{2(g)} + 4\text{e}^-$
Cathode Reaction: $\text{Al}_{(aq)}^{3+} + 3\text{e}^- \rightarrow \text{Al}_{(s)}$

$$n(\text{e}^-) = 1.11 \times 10^5 \text{ mol} \text{ (*from above equation(s))}$$

$$n(\text{CO}_2) = (1/4) \times 1.11 \times 10^5 = 2.775 \times 10^5 \text{ mol}$$
 [1]
$$V(\text{CO}_2) = 2.775 \times 10^5 \times 22.41 = 6.21 \times 10^5 \text{ L}$$
 [1]

[2 marks]

- (d) $\text{Al}(\text{OH})_{3(s)} + \text{OH}^-_{(aq)} \rightarrow [\text{Al}(\text{OH})_4]^-_{(aq)}$

$$n(\text{Al}(\text{OH})_3) = 3.706 \times 10^4 \text{ mol}$$

$$n(\text{NaOH}) = 3.706 \times 10^4 \text{ mol}$$
 [1]
$$V(\text{NaOH})_{\text{required}} = n / c = 3.706 \times 10^4 / 8.00 = 4630 \text{ L}$$
 [1]

[2 marks]

5.

(a)

Burette readings (mL)	Titrations		
	1	2	3
Final volume	32.50	37.25	43.15
Initial volume	0.00	5.50	11.30
Titre	32.50	31.75	31.85 [1]

(a) Average Titre = 31.80 mL = 0.03180 L [1]

[2 marks]

(b)

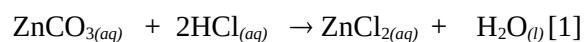
$$\begin{aligned} n &= cV \\ n(\text{NaOH}) &= 0.105 \times 0.0318 = 0.00334 \text{ mol [1]} \\ n(\text{HCl})_{\text{unreacted}} &= n(\text{NaOH}) = 0.00334 \text{ mol [1]} \end{aligned}$$

[2 marks]

(c) $n(\text{HCl})_{\text{total unreacted}} = 0.003339 \times (250/25) = \underline{\underline{0.03334 \text{ mol}}}$ [1]

$$n(\text{HCl})_{\text{original}} = 2.00 \times 0.050 = 0.10 \text{ moles}$$

$$\begin{aligned} n(\text{HCl})_{\text{reacted with CaCO}_3} &= n(\text{HCl})_{\text{original}} - n(\text{HCl})_{\text{unreacted}} \text{ [1]} \\ &= 0.10 - 0.03339 \\ &= 6.66 \times 10^{-2} \text{ mol [1]} \end{aligned}$$



$$\therefore n(\text{ZnCO}_3) = (1/2) \times n(\text{HCl})_{\text{reacted}} = (1/2) \times 6.66 \times 10^{-2} = 3.33 \times 10^{-2} \text{ mol [1]}$$

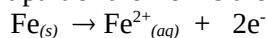
$$\begin{aligned} m &= n \times M \quad M(\text{ZnCO}_3) = 125.39 \\ m(\text{ZnCO}_3) &= 3.33 \times 10^{-2} \times 125.39 = 4.175 \text{ g [1]} \end{aligned}$$

$$\therefore \% \text{ by mass} = (4.175/4.54) \times 100 = \underline{\underline{92.0\%}} \text{ [1]}$$

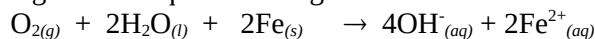
[7 marks]

Part 4 (20 Marks) Model Answer:**A. Corrosion of Iron** $\text{O}_{2(g)} + 2\text{H}_2\text{O}_{(l)} + 4\text{e}^- \rightarrow 4\text{OH}^-_{(aq)}$

- (a) The reaction above is the reduction reaction occurring in the initial stages of the rusting of iron. The oxygen is absorbed into moisture in contact with the iron. This can be considered the cathodic reaction which occurs at certain points on the surface of the iron. Occurring simultaneously, but on a different part of the iron is the anodic reaction, which involves the oxidation of iron to Fe^{2+} ions:



Combining the two equations we get:



The OH^- and Fe^{2+} ions then combine to form iron(II) hydroxide which is in time oxidised by atmospheric oxygen to hydrated iron(III) oxide (rust).

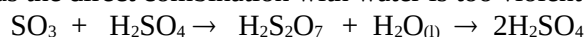
- (b) The reducing agent in the process is iron metal. In the process of the reaction this converts from metallic bonding, with positive ions being surrounded by a sea of delocalized electrons, to iron(II) ions, which initially exist in aqueous solution.
- (c) The reaction could be increased by a temperature increase, which increases the average kinetic energy of the particles. This will increase the frequency and force of the collisions and hence increases the reaction rate. (note that an increase in temperature will also reduce the solubility of oxygen in the water, so this may have a slight slowing effect)

B. Production of Sulfuric Acid $2\text{SO}_{2(g)} + \text{O}_{2(g)} \rightleftharpoons 2\text{SO}_{3(g)}$

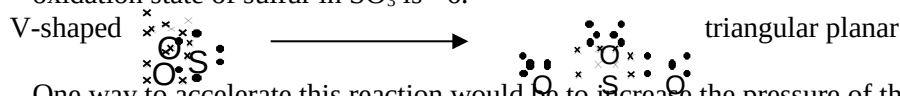
- (a) The production of sulfuric acid relies on the combination of sulfur trioxide with water:



The reaction above produces the SO_3 in a reaction called the contact process. The SO_2 is sourced from burning sulfur in oxygen. The SO_3 produced is in fact added to 98% sulfuric acid, and then water, as the direct combination with water is too violent a reaction:



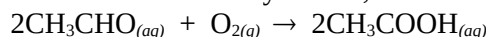
- (b) The reducing agent in the above reaction is sulfur dioxide. In this compound sulfur has an oxidation state of +4. The bonding in the sulfur containing species changes as shown below. The final oxidation state of sulfur in SO_3 is +6.



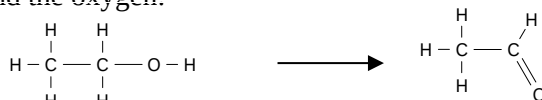
- (c) One way to accelerate this reaction would be to increase the pressure of the gases as this would increase the rate of collisions. This would also increase the yield of the reaction as there are less gaseous molecules on the right hand side of the equilibrium.

C. Oxidation of ethanol to ethanoic acid $2\text{CH}_3\text{CH}_2\text{OH}_{(aq)} + \text{O}_{2(g)} \rightarrow 2\text{CH}_3\text{CHO}_{(aq)} + 2\text{H}_2\text{O}_{(l)}$

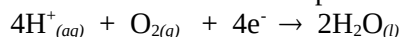
- (a) The oxygen initially oxidizes the (primary) alcohol to ethanal. As this is an aldehyde, it can be further oxidized to the carboxylic acid, ethanoic acid:



- (b) The reducing agent in the reaction above is the ethanol, which converts to ethanal. In the process it loses two hydrogen atoms, hence becomes unsaturated as a double bond forms between the carbon and the oxygen:



- (c) This reaction can be catalysed by the addition of acid. This is because in the reduction of the oxygen, hydrogen ions are involved in the process:



But in the oxidation process H^+ ions are produced:



So the acid is acting as a catalyst.

Note: Many possible responses to part (c) of these questions, but valid explanations are required.