

# Year 12 Chemistry Semester 2 Exam 2003 Solutions

## Part 1

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

[60]

## Part 2

- 1 (a)  $\text{Zn(OH)}_{2(s)} + 2\text{OH}^{-}_{(aq)} \longrightarrow \text{Zn(OH)}_4^{2-}_{(aq)}$   
white solid dissolves to form colourless solution [3]
- (b)  $\text{Cu}^{2+}_{(aq)} + 2\text{OH}^{-}_{(aq)} \longrightarrow \text{Cu(OH)}_{2(s)}$   
(pale)blue ppt. formed [3]
- (c)  $2\text{Na}_{(s)} + 2\text{C}_2\text{H}_5\text{OH}_{(l)} \longrightarrow 2\text{NaCH}_3\text{CH}_2\text{O} + \text{H}_{2(g)}$   
colourless, odourless gas produced [3]
- (d)  $\text{H}_2\text{O}_{2(aq)} + 2\text{Br}^{-}_{(aq)} + 2\text{H}^{+}_{(aq)} \longrightarrow \text{Br}_{2(aq)} + 2\text{H}_2\text{O}_{(l)}$   
solution turns from colourless to orange/brown [3]

2

Description	Solution
Will have a pH of 2.0	<b>G</b>
Will decolourise when added to $\text{C}_2\text{H}_2$	<b>F</b>
Can oxidise bromide ions to bromine	<b>C</b>
Will form a precipitate when added to a solution of $\text{BaCl}_2$	<b>E</b>
Will develop a red/brown colour when left in air	<b>I</b>
Can reduce $\text{Sn}^{2+}$ to tin metal but not $\text{Mg}^{2+}$ to magnesium metal	<b>D</b>
Contains a salt of a weak acid	<b>E</b>
Will go pink when a few drops of phenolphthalein are added	<b>H</b>

[8]

- 3  $n(\text{OH}^{-}) = 2.0 \times 0.025 = 0.050$  (1/2)  
 $n(\text{H}^{+}) = 1.0 \times 0.0495 = 0.0495$  (1/2)  
 $n(\text{OH}^{-})_{\text{excess}} = 0.050 - 0.0495 = 5.00 \times 10^{-4}$  (1) total volume = 74.5 mL = 0.0745 L  
 $[\text{OH}^{-}] = 5.00 \times 10^{-4} / 0.0745 = 6.71 \times 10^{-3}$  (1)  
 $[\text{H}^{+}] = 1.00 \times 10^{-14} / 6.71 \times 10^{-3} = 1.49 \times 10^{-12}$  (1/2)  
pH =  $-\log[\text{H}^{+}] = -\log 1.49 \times 10^{-12}$  **pH = 11.8** (1/2) [4]

- 4 (a) Acts as the anode/source of electrons/reducing agent/casing of the cell {any 2} [2]  
(b) provides  $\text{H}^{+}$  ions (acts as an acid) is the electrolyte {both} [2]

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Anode: $4\text{OH}^{-}_{(aq)} \longrightarrow \text{O}_{2(g)} + 2\text{H}_2\text{O}_{(l)} + 4\text{e}^{-}$
Cathode: $[\text{Au}(\text{CN})_2]^{-}_{(aq)} + \text{e}^{-} \longrightarrow \text{Au}_{(s)} + 2\text{CN}^{-}_{(aq)}$ :
Overall: $4[\text{Au}(\text{CN})_2]^{-}_{(aq)} + 4\text{OH}^{-}_{(aq)} \longrightarrow 4\text{Au}_{(s)} + 8\text{CN}^{-}_{(aq)} + \text{O}_{2(g)} + 2\text{H}_2\text{O}_{(l)}$

[3]

- (b)  $-0.40 \text{ V} + -0.6 \text{ V} = \underline{\underline{1.00 \text{ V}}}$  [1]  
(c) oxygen is produced stainless steel will resist corrosion [2]

6. (a)  $K = \frac{[\text{CrO}_4^{2-}]^2 [\text{H}^{+}]^2}{[\text{Cr}_2\text{O}_7^{2-}]}$  [2]  
(b) addition of  $\text{OH}^{-}$  shifts equilibrium towards  $\text{H}_2\text{O}$  thus removing  $\text{H}^{+}$   
system in (a) shifts to right to replace  $\text{H}^{+}$

more yellow  $\text{CrO}_4^{2-}$  ions produced

[3]

7.

Imposed change	Forward reaction	Reverse reaction	position
Reduce Temperature	slower	slower	To left
Reduce Pressure	no change	slower	To right
Increase surface area	faster	no change	no change

[9]

8.

Species	Electron dot diagram	Shape	Polarity
$\text{BF}_3$			non polar
$\text{HCO}_3^-$			polar

[6]

9. Corrosion of iron initiated by  $\text{Fe}_{(s)} \longrightarrow \text{Fe}^{2+}_{(aq)} + 2e^-$  (anodic area) (1/2)  
 (and  $2\text{H}_2\text{O}_{(l)} + \text{O}_{2(g)} + 4e^- \longrightarrow 4\text{OH}^-_{(aq)}$  (cathodic area) ) (1/2)  
 When zinc is present the following can occur (1)  $\text{Zn}_{(s)} \longrightarrow \text{Zn}^{2+}_{(aq)} + 2e^-$

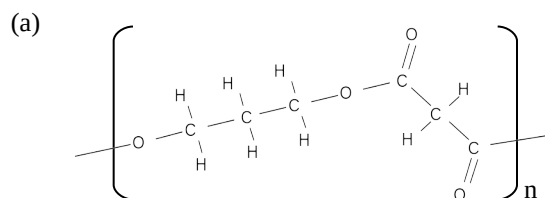
Shown on a diagram (1) (that should show flow of electrons through the iron surface)

This process has more positive reaction potential/Zn is a stronger reducing agent (1/2)

So Zn becomes the provider of electrons/the (sacrificial)anode in place of the iron so the top process will not occur so readily. (1/2)

[4]

10.



[2]

- (b) Water [1]  
 (c) as a catalyst/to remove water [1]  
 (d) sodium/potassium dichromate/potassium permanganate and dilute (sulphuric)acid [2]

11.

	Compounds	Test [1 mark each]	Observations [both required for 1 mark]
(a)	$\text{PbCl}_{2(s)}$	dissolve in water and add $\text{OH}^-/\text{SO}_4^{2-}$ to solution formed.	precipitate
	$\text{KCl}_{(s)}$		no precipitate
(b)	$\text{CH}_3\text{CO}_2\text{C}_2\text{H}_5$	Add carbonate or use indicator	no fizzing                      indicator = neutral
	$\text{C}_3\text{H}_7\text{CO}_2\text{H}$		fizzing                          indicator = acidic
(c)	1-pentanol	Add acidified dichromate or permanganate	colour change: orange to green or purple to colourless
	2-ethyl-2-propanol		no visible change

[6]

**Part 3**

1 (a)

Burette readings (mL)	Titrations			
	1	2	3	4
Final volume	6.50	11.40	17.25	23.25
Initial volume	0.00	5.50	11.30	17.25
<b>Titre</b>	<b>6.50</b>	<b>5.90</b>	<b>5.95</b>	<b>6.00</b>

Average volume =  $(5.90 + 5.95 + 6.00) / 3 = \underline{5.95 \text{ mL}}$   $= \underline{5.95 \times 10^{-3} \text{ L}}$  [2]

(b)  $n(\text{NaOH}) = cV = 0.100 \times 5.9 \times 10^{-3} = 5.95 \times 10^{-4} \text{ mol}$   
 $n(\text{H}^+) = n(\text{NaOH}) = 5.95 \times 10^{-4} \text{ mol}$   
 $V(\text{acid}) = 5.00 \text{ mL} = 5.00 \times 10^{-3} \text{ L}$   
 $c(\text{H}^+) = n/V = 5.95 \times 10^{-4} / 5.00 \times 10^{-3} = \underline{0.119 \text{ mol L}^{-1}}$  [3]

(c)  $n(\text{C}_4\text{H}_6\text{O}_6) \text{ in } 5\text{mL} = \frac{1}{2} n(\text{H}^+) = \frac{1}{2} \times 5.95 \times 10^{-4} = 2.975 \times 10^{-4} \text{ mol}$   
 $M(\text{C}_4\text{H}_6\text{O}_6) = 150.088$   
 $m(\text{C}_4\text{H}_6\text{O}_6) = nM = 2.975 \times 10^{-4} \times 150.088 = 0.04465 \text{ g in } 5\text{mL}$   
 $m(\text{C}_4\text{H}_6\text{O}_6) \text{ in } 100 \text{ mL} = 0.04465 \times 100/5 = \underline{0.893 \text{ g/100mL}}$  [3]

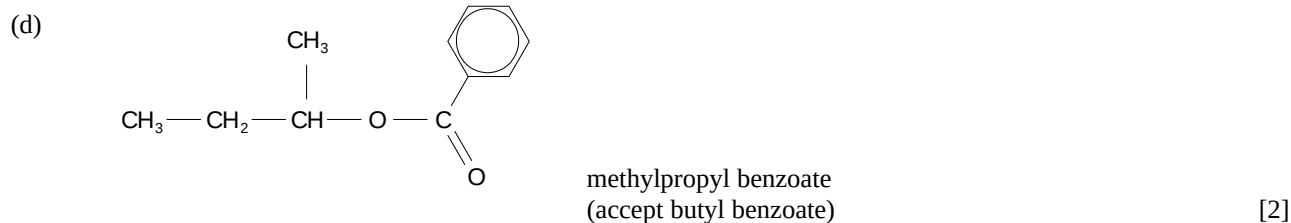
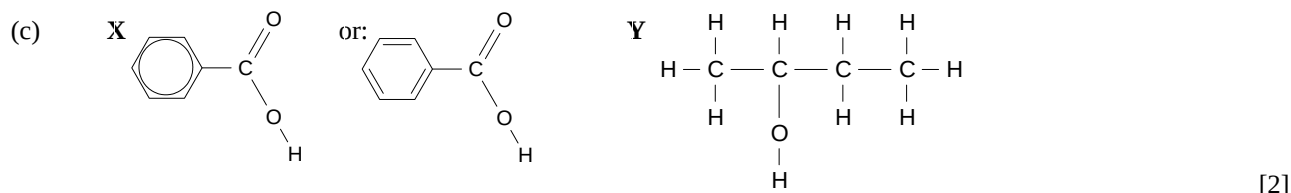
(d) Difficulty in seeing appearance of (pink) end point [1]

2. (a)  $m(\text{C}) = 12.01/44.01 \times 44.15 = 12.048 \text{ g}$   
 $m(\text{H}) = 2.016/18.016 \times 7.750 = 0.8672 \text{ g}$   
 $m(\text{O}) = 17.50 - 12.048 - 0.8672 = 4.585 \text{ g}$

	<u>C</u>	<u>H</u>	<u>O</u>
mole ratio =	12.048/12.01	0.8672 /1.008	4.585 /16.00
	1.003	0.8603	0.2866
	1.003/0.2866	0.8603/0.2866	0.2866/0.2866
	3.50	3.00	1.00
	7	6	2

**empirical formula of X =  $\text{C}_7\text{H}_6\text{O}_2$**  [4]

(b)  $n(\text{Cr}_2\text{O}_7^{2-}) = cV = 0.500 \times 0.04488 = 0.02244 \text{ mol}$   
 $n(\text{Y}) = 3 \times n(\text{Cr}_2\text{O}_7^{2-}) = 3 \times 0.02244 = 0.06732 \text{ mol}$   
 $M(\text{Y}) = m/n = 4.99/0.06732 = \underline{74.1}$  [3]



3. (a)  $n(\text{Cr}) = 2.50/52.00 = 0.0481 \text{ mol}$   
 $n(e^-) = (12/2) \times n(\text{Cr}) = 6 \times 0.0481 = 0.2885 \text{ mol}$   
 $Q = n \times 96\,500 = 27836.5 \text{ C}$   
 $t = Q/I = 27836.5/2.50 = 11134.6 \text{ s} = \underline{\underline{186 \text{ minutes}}}$  [4]

(b) original pH = 2.00      pH =  $-\log[\text{H}^+]$        $\therefore [\text{H}^+] = \text{inv log}(-\text{pH})$   
original  $[\text{H}^+]$  =  $\text{inv log}(-2.00) = 0.01 \text{ mol L}^{-1}$   
original  $n(\text{H}^+)$  =  $cV = 0.01 \times 5.00 = 0.0500 \text{ mol}$   
 $n(\text{H}^+)_{\text{used}} = n(\text{Cr}) = 0.0481 \text{ mol}$   
 $n(\text{H}^+)_{\text{remaining}} = \text{original } n(\text{H}^+) - n(\text{H}^+)_{\text{used}}$   
 $= 0.0500 - 0.0481 = 1.9 \times 10^{-3} \text{ mol}$   
final  $[\text{H}^+] = n/V = 1.9 \times 10^{-3}/5.00 = 3.8 \times 10^{-4} \text{ mol L}^{-1}$       pH =  $-\log(3.8 \times 10^{-4}) = \underline{\underline{3.42}}$  [4]

(c)  $n(\text{Na}_2\text{Cr}_2\text{O}_7) = \frac{1}{2} \times n(\text{Cr})$   
 $= \frac{1}{2} \times 0.0481 = 0.02405$   
 $m(\text{Na}_2\text{Cr}_2\text{O}_7) = nM = 0.02405 \times 261.98 = \underline{\underline{6.30 \text{ g}}}$  [3]

(d) Chromium would react with acidic electrolyte. [1]

4. (a) Standardisation:  
 $2\text{MnO}_4^-(\text{aq}) + 5\text{H}_2\text{C}_2\text{O}_4(\text{aq}) + 6\text{H}^+(\text{aq}) \longrightarrow 2\text{Mn}^{2+}(\text{aq}) + 8\text{H}_2\text{O}(\text{l}) + 5\text{CO}_2(\text{g})$   
 $n(\text{H}_2\text{C}_2\text{O}_4) = cV = 0.200 \times 0.02907 = 5.814 \times 10^{-3} \text{ mol}$   
 $n(\text{MnO}_4^-) = \frac{2}{5} \times n(\text{H}_2\text{C}_2\text{O}_4)$   
 $= \frac{2}{5} \times 5.814 \times 10^{-3} = 2.326 \times 10^{-3} \text{ mol}$   
 $c(\text{MnO}_4^-) = n/V = 2.326 \times 10^{-3}/0.02215 = \underline{\underline{0.105 \text{ mol L}^{-1}}}$  [4]

(b) Titration:  
 $\text{MnO}_4^-(\text{aq}) + 5\text{Fe}^{2+}(\text{aq}) + 8\text{H}^+(\text{aq}) \longrightarrow \text{Mn}^{2+}(\text{aq}) + 4\text{H}_2\text{O}(\text{l}) + 5\text{Fe}^{3+}(\text{aq})$   
 $n(\text{MnO}_4^-) = cV = 0.105 \times 0.00737$   
 $= 7.7385 \times 10^{-4} \text{ mol}$   
 $n(\text{Fe}^{2+}) = 5 \times n(\text{MnO}_4^-) = 5 \times 7.7385 \times 10^{-4}$   
 $= 3.869 \times 10^{-3} \text{ mol (in 20 mL sample)}$   
total  $n(\text{Fe}^{2+}) = (250/20) \times 3.869 \times 10^{-3} = \underline{\underline{0.04837 \text{ mol}}}$  [4]

(c)  $n(\text{FeSO}_4) = 0.04837 \text{ mol}$   
 $m(\text{FeSO}_4) = nM = 0.04837 \times 151.92 = 7.347 \text{ g}$   
 $m(\text{H}_2\text{O}) = 13.45 - 7.347 = 6.10 \text{ g}$

	<u>FeSO<sub>4</sub></u>	<u>H<sub>2</sub>O</u>
m	7.347g	6.10g
n	7.347/151.92	6.10/18.016
	= 0.04837	= 0.3386
ratio	0.04837/0.04837	0.3386/0.04837
	1	7

$x = 7$  [4]

5. (a)  $m(\text{C}_8\text{H}_{18}) = 45.0 \times 92/100 = \underline{\underline{41.4 \text{ g}}}$   
 $m(\text{C}_4\text{H}_{10}) = 45.0 \times 8/100 = \underline{\underline{3.6 \text{ g}}}$  [1]

(b)  $n(\text{C}_8\text{H}_{18}) = m/M = 41.4/114.224 = 0.3624 \text{ mol (1/2)}$   
 $n(\text{O}_2) = (25/2) \times 0.3624 = 4.530 \text{ mol (1/2)}$   
 $n(\text{C}_7\text{H}_{16}) = m/M = 3.6/100.198 = 0.0359 \text{ mol (1/2)}$   
 $n(\text{O}_2) = 11 \times 0.0359 = 0.3952 \text{ mol (1/2)}$   
total  $n(\text{O}_2)_{\text{used}} = 4.530 + 0.3952 = 4.925 \text{ mol (1)}$   
using PV=nRT

$$\begin{aligned}\text{original } n(\text{O}_2) &= PV/RT = (100 \times 130) / (8.315 \times 298) = 5.246 \text{ mol } \mathbf{(1/2)} \\ \text{moles remaining} &= 5.246 - 4.925 = 0.321 \text{ mol } \mathbf{(1)} \\ \text{volume remaining} &= 22.41 \times 0.321 = \mathbf{\underline{7.20 \text{ L}}}\end{aligned}$$

**(1/2)** [5]

Part 4 Guidelines for marking.

1. 5 marks for each concept: should be explained with diagrams and equations as appropriate.

	<u>Aluminium Extraction</u>	<u>Possible Other Examples</u>
(a) <u>Amphoteric nature:</u>	<p><i>Ability to react with acids or bases as shown by:</i></p> <p>ability of <math>\text{Al}(\text{OH})_3</math> to dissolve in <math>\text{NaOH}</math>  equation for above process:  <math display="block">\text{Al}(\text{OH})_{3(s)} + \text{OH}^-_{(aq)} \longrightarrow \text{Al}(\text{OH})_4^-_{(aq)}</math> required to allow filtration of impurities  also show reaction of <math>\text{Al}(\text{OH})_3</math> with acid</p>	<p>Reaction of amphoteric metals with hydroxides.  Used to distinguish between metals/metal compounds</p>
(b) <u>Complex ion:</u>	<p><i>An ion where the co-ordination number of the metal atom is greater than the oxidation number/An ion with ligands around a central atom held with dative covalent bonds. As shown by:</i></p> <p>aluminate ion <math>[\text{Al}(\text{OH})_4]^-</math>  (allows separation from impurities)  or: <math>[\text{AlF}_6]^{3-}</math> ion in cryolite  draw diagram to show bonding</p>	<p><math>[\text{Cu}(\text{NH}_3)_4]^{2+}</math> in identification  Plumbate/stannate ions  <math>[\text{Fe}(\text{CN})_6]^{3-}</math> used to test for <math>\text{Fe}^{2+}</math>  <math>[\text{Au}(\text{CN})_2]^-</math> used in extraction of gold</p>
(c) <u>Precipitation</u>	<p><i>The formation of an insoluble solid in a solution as shown by:</i></p> <p>ppt. of <math>\text{Al}_2\text{O}_3</math> by seeding with <math>\text{Al}(\text{OH})_3</math>  explain how this process works</p>	<p>tests for sulphates/chlorides  must show (ionic) equations</p>
(d) <u>Electrolytic Reduction</u>	<p><i>The reduction of positive ions to an element at the cathode of an electrolytic cell caused by electrons passing round a circuit with an external voltage applied as shown by:</i></p> $\text{Al}^{3+}_{(l)} + 3\text{e}^- \longrightarrow \text{Al}_{(s)}$ <p>explanation of process  basic diagram of set up</p>	<p>production of <math>\text{Au/Na}</math> etc.  purification of <math>\text{Cu}</math> etc.  <math display="block">\text{Cu}^{2+}_{(aq)} + 2\text{e}^- \longrightarrow \text{Cu}_{(s)}</math> explain use of the process with diagram</p>

2. 1. Ammonia Oxidation [approx. 7 marks]

1:9 ammonia/air mixture required to give 4:5  $\text{NH}_3:\text{O}_2$  ratio  
Exothermic reaction so lower temperatures favour maximum yield  
Catalyst used (high activation energy of uncatalysed reaction).  
Catalyst functions best at higher temperature for forward reaction.  
Temperature of 1380 °C to 1470°C temperature a compromise between yield and rate.  
Surface area of catalyst maximised by fine wire.

2. Nitric Oxide Oxidation [approx. 5 marks]

Low temperature used so exothermic reaction  
High pressure used as reaction:  
$$2\text{NO}_{(g)} + \text{O}_{2(g)} \rightleftharpoons 2\text{NO}_{2(g)}$$
  
Produces 2 moles of gas from 3 moles of gas  
No catalyst (not suitable catalyst or other explanation)  
Slow reaction: high activation energy?

3. Absorption [approx. 5 marks]

NO produced is re-oxidised to form  $\text{NO}_2$ .  
This reduces concentration of product and increases concentration of reactant so forward reaction is preferred  
By removing the NO from the nitric acid the reverse reaction is reduced.  
Water is still present as nitric acid is 30% to 70% (yield low).  
high temperature required, (steam) otherwise reaction is too slow.

4. High-Strength Nitric Acid Production [approx. 3 marks]

Hydrogen bonding between  $\text{H}_2\text{O}$  and  $\text{HNO}_3$  (show by diagram).  
Dehydrating agent removes water therefore allows more nitric acid to be produced.  
Possible comparison of  $\text{H}_2\text{O} - \text{HNO}_3$  and  $\text{H}_2\text{O} - \text{H}_2\text{SO}_4$  intermolecular attractions.