EXAMINER'S REPORT ON MOCK CHEMISTRY EXAM 2007

Mean = 64% Standard deviation = 17.3 Range 22.5% - 95%

Part 1 Multiple Choice Section:

2 students scored 29/30

Part 2 Short Answer Section:

Q1. (c) **H_2 gas is NOT liberated in the reaction of Conc HNO_3 with Cu. This reaction has been listed in the document "common student misconceptions/misunderstandings in chemistry" located in the revision pack.**

Q2. **Explain = give reasons. Up symbol ↑ and down symbol ↓ are NOT to be used in explanations unless a clear directive in the question indicates that it is satisfactory to use such symbolism. Electron dot/Lewis diagrams for ions must have the species included in a box bracket with the charge as a right superscript e.g. $[\text{species}]^{+\text{ or }-}$**

Q3. **"hydrolyses in water" means reacts with water**
Use name if given in question and use symbol/formula if given in question.
How can Fe^{2+} be formed from oxygen???
Oxidation numbers of C*l* in ClO_2^-, ClO^-, Cl_2 were done poorly

Q4. **Electron dot diagrams were done poorly.**
Again Electron dot/Lewis diagrams for ions must have the species included in a box bracket with the charge as a right superscript e.g. $[\text{species}]^{+\text{ or }-}$
The idea is to get 8 valence electrons around the central atom (with H only having 2 valence electrons around it.
Add up the total number of valence electrons to ensure you have accounted for ALL the valence electrons

Q6. **Use 3 examples of your choice**
Many students did not quite understand the word "continuum"

Q7. **"Write an ionic equation" was ignored by many**
Titration curve/graph was very poorly done

Q8. **Observation = what would you see**

Q9. **Many students were unable to draw the polymer.**
In addition polymerization the double bond breaks (opens out) and monomers join up

Q10. **ANOde = AN Oxidation i.e. the electrode where oxidation takes place.**

Part 3 Calculations:

In general the calculations were well done with the exception of Q3.

Q2. **What colour change would you observe = from what colour to what colour does it change?**

Q3. **Poorly done requires revision**

Part 4 Extended Answer Section:

where possible the answer should include

Equations and Diagrams

Year 12 Chemistry Final 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 $6H^+ + Cr_2(CO_3)_3 \rightarrow 2Cr^{3+} + 3CO_2 + 3H_2O$ [2]
Observation solid dissolves to form (deep) green solution. colourless gas given off [1]

(b) Equation $2OH^- + Ni^{2+} \rightarrow Ni(OH)_2$ [2]
Observation green precipitate formed [1]

(c) Equation $2NO_3^- + 4H^+ + Cu \rightarrow Cu^{2+} + 2NO_2 + 2H_2O$ [2]
Observation solid dissolves to give green/blue solution and brown pungent gas [1]

(d) Equation $Mg + Cu^{2+} \rightarrow Mg^{2+} + Cu$ [2]
Observation (silver coloured) solid dissolves. blue solution decolourises and pink/brown solid produced [1]

[12 marks]

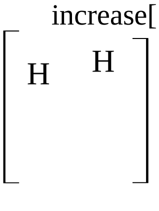
2. $[Al(H_2O)_6]^{3+}{}_{(aq)} + H_2O_{(l)} \rightleftarrows [Al(OH)(H_2O)_5]^{2+}{}_{(aq))} + H_3O^+{}_{(aq)}$

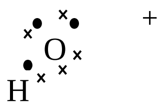
(a) $$K = \frac{[[Al(OH)(H_2O)_5]^{2+}][H_3O]^+}{[[Al(H_2O)_6]^{3+}]}$$ [1]

(b) (i) The addition of more aluminium nitrate increases the concentration of $[Al(H_2O)_6]^{3+}$ and therefore the equilibrium shifts to the right [1] to counteract this increase. Hence the $[H^+]$ 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[1] oppose this reduction in $[H_3O^+]$.

(c) A the temperature increased, the $[H^+]$ increased, so the forward reaction was favoured. [1] Therefore the forward reaction is endothermic [1] as it is opposing the temperature increase[1].



(d) 

[2]

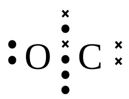
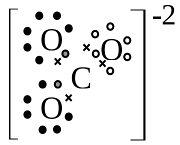
(e) (i) 3+ [1]
(ii) octahedral [1]

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 or I^-**
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 or Au^+**
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	 [1]	Linear [1]
Carbonate ion, CO_3^{2-}	 [1]	Triangular planar[1]

[4 marks]

5. (a) P $1s^2 2s^2 2p^6 3s^2 3p^3$ [1]

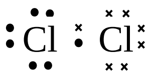
(b) S^{2-} $1s^2 2s^2 2p^6 3s^2 3p^6$ [1]

[2 marks]

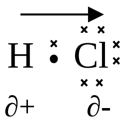
6. When atoms bond with each other they normally complete their outer (valence) electron shell. Atoms also have an ability to attract electrons which is defined as the electronegativity of the atom. When two atoms that have very different electronegativities combine, the atom with the higher electronegativity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

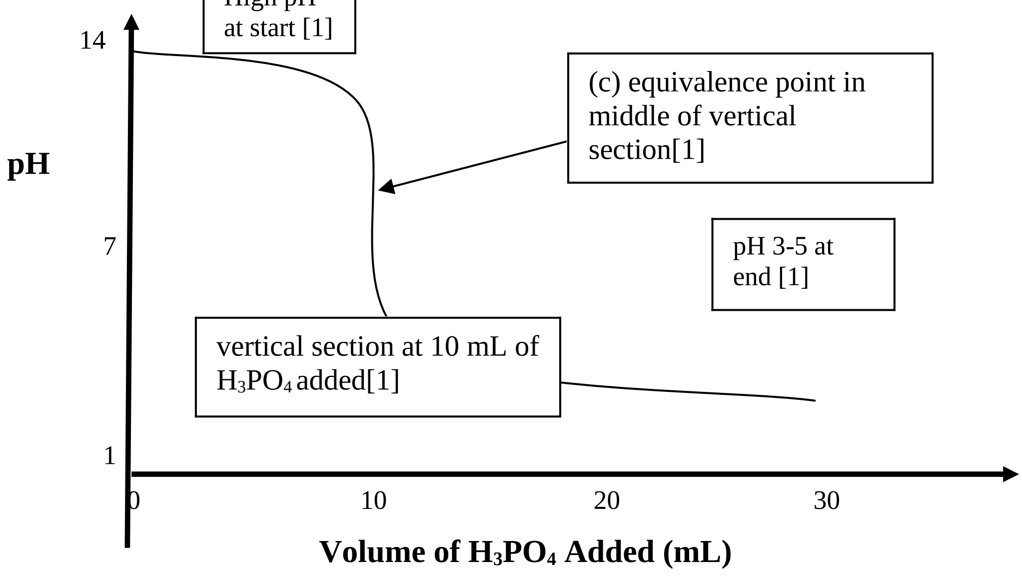


This results in a polar covalent bond, which is intermediate Between a pure ionic bond as in NC*l* and a non polar covalent bond as in Cl_2.

7. (a) $H_3PO_{4(aq)} + 3OH^-_{(aq)} \rightarrow PO_4^{3-}{}_{(aq)} + 3H_2O_{(l)}$
or $H^+_{(aq} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$

[2 marks]
[1 mark for molecular type equation]

(b)



(d) Sodium hydroxide solution [1]

(e) Phenolphthalein [1]

8.

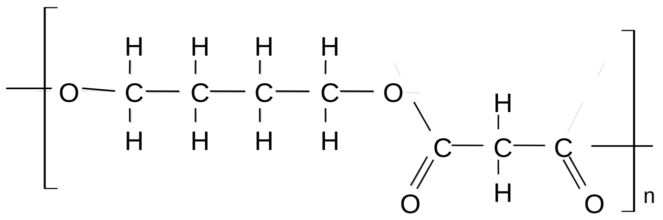
Compounds	Description of Test	Expected Observations
Zinc Hydroxide and **Magnesium Hydroxide**	Add both substances to (concentrated) NaOH [1]	Zinc Hydroxide dissolves Magnesium Hydroxide does not. [1]
Equation(s):	$Zn(OH)_2 + 2OH^- \rightarrow [Zn(OH)_4]^{2-}$ [1]	

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)	$C_5H_{10} + Br_2 \rightarrow C_5H_{10}Br_2$ [1]	

[6 marks]

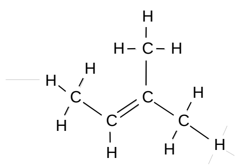
9. (a) Condensation reaction. [1]

(b)



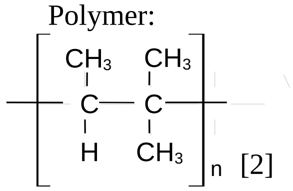
[2 marks]

(c) Monomer:



[1]

Polymer:



[2]

11. (a)

Anode half-equation:	$H_2 \rightarrow 2H^+ + 2e^-$ [1]
Cathode half-equation:	$Cl_2 + 2e^- \rightarrow 2Cl^-$ [1]
Overall equation:	$H_2 + Cl_2 \rightarrow 2Cl^- + 2H^+$ [1]

[3 marks]

(b) + 1.36 V [1]
(c) From left to right [1]
(d) it is unreactive/inert [1]

Part 3

1. (a) $CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$
or: $CaCO_3 + 2H^+ \rightarrow Ca^{2+} + CO_2 + H_2O$ [1]

[1 mark]

(b) $n(CaCO_3)$ = m/M = 3.125 / 100.09 = 0.031225 mol [1]
$n(HCl)$ = cV = 0.0200 x 2.00 = 0.0400 mol [1]

0.040 mol of HCl requires (1/2) x 0.040 moles of $CaCO_3$ = 0.0200 mol, [1]
hence $CaCO_3$ is in excess and the **<u>HCl is the Limiting Reagent</u>**. [1]
need to show reasoning
$n(CaCO_3)_{remaining}$ = 0.031225 – 0.0200 = 0.01123 mol [1]

[5 marks]

(c) $n(CO_2)$ = ½ x n(HCl) = ½ x 0.040 = 0.0200 mol [1]
$v(CO_2)$ = 0.0200 x 24.47 **<u>= 0.489 L</u>** [1]

[2 marks]

2. (a) $2Cr_2O_7^{2-} + 3CH_3CH_2OH + 16H^+ \rightarrow 4Cr^{3+} + 3CH_3COOH + 11H_2O$

n = cV
$n(Cr_2O_7^{2-})_{titration}$ = 0.450 x 0.01785 [1]
= 8.03×10^{-3} mol [1]

$n(CH_3CH_2OH)$ = (3/2) x $n(Cr_2O_7^{2-})_{titration}$ [1]
= 1.20×10^{-2} mol [1]
$c(CH_3CH_2OH)$ = n /V = 1.20×10^{-2} / 0.005 **<u>= 2.41 mol L^{-1}</u>** [1]

[4 marks]

(b)
m = n x M $M(CH_3CH_2OH)$ = 46.068 [1]
$m(CH_3CH_2OH)_{in\ 1\ litre}$ = 2.41 x 46.068 = 111 g [1]

mass of 1 litre = 1.06 x 1000 = 1060 g [1]

%(CH_3CH_2OH) = (111/1060) x 100 **= 10.5%** [1]

[3 marks]

(c) orange to green [1]

[1 mark]

3. (a)

m(H_2O) = 10.00 – 7.21 = 2.79 g [1]
%(H_2O) = (2.79 / 10.00) x 100 = 27.9% [1]
m(Si) = (28.09 / 60.09) x 3.10 = 1.449 g [1]
%(Si) = (1.449 / 10.00) x 100 = 14.49% [1]
%(Cu) = 32.8%
%(O) = 100% – (27.9% + 14.49% + 32.8%) **<u>= 24.81 %</u>** [1]

	Cu		Si		O		H_2O	
M	*(63.55)*		*(28.09)*		*(16.00)*		*(18.016)*	
	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	

<u>Empirical Formula is $CuSiO_3.3H_2O$</u> [1]
[Total = 9 marks]

(b) Copper = +2 [1 mark]
Silicon = +4 [1 mark]

4. (a)

m(Al) = 1.00×10^6 g
n = m/M
n(Al) = 1.00×10^6 / 26.98 = 3.706×10^4 mol [1]
Using: $Al^{3+} + 3e^- \rightarrow Al$
n(e^-) = 3 x n(Al) = 3 x 3.706×10^4 = 1.11×10^5 mol * [1]
Q = n(e^-) x 9.649×10^4 [1]
= 1.11×10^5 x 9.649×10^4 = 1.07×10^{10} C [1]
Q = It ∴ t = Q / I
= 1.07×10^{10} / 40 000 **<u>= 2.68×10^5 seconds = 74.5 hours</u>**[1]

[5 marks]

(b)

n(Al) = 3.706×10^4 mol M($Al(OH)_3$) = 78.004
n($Al(OH)_3$) = 3.706×10^4 mol [1]
m($Al(OH)_3$)$_{pure}$ = n x M = 3.706×10^4 x 78.004 = 2.89×10^6 g [1]
m($Al(OH)_3$)$_{impure}$= (100/87) x 2.89×10^6 g
<u>= 3.32×10^6 g</u> [1]

[3 marks]

(c)

Anode Reaction: $C_{(s)} + 2O^{2-}_{(aq)} \rightarrow CO_{2\,(g)} + 4e^-$
Cathode Reaction: $Al^{3+}_{(aq)} + 3e^- \rightarrow Al_{(s)}$

n(e^-) = 1.11×10^5 mol(*from above equation(s))
n(CO_2) = (1/4) x 1.11×10^5 = 2.775×10^5 mol [1]
v(CO_2) = 2.775×10^5 x 22.41 **<u>= 6.21×10^5 L</u>** [1]

[2 marks]

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

n($Al(OH)_3$) = 3.706×10^4 mol
n(NaOH) = 3.706×10^4 mol [1]
v(NaOH)$_{required}$ = n / c = 3.706×10^4 / 8.00 **<u>= 4630 L</u>** [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) **n = cV**

n(NaOH) = 0.105 x 0.0318 = 0.00334 mol [1]

$n(HCl)_{unreacted}$ = n(NaOH) = 0.00334 mol [1]

[2 marks]

(c) $n(HCl)_{total\ unreacted}$ = 0.003339 x (250/25) **<u>= 0.03334 mol</u>** [1]

$n(HCl)_{original}$ = 2.00 x 0.050 = 0.10 moles

$n(HCl)_{reacted\ with\ CaCO3}$ = $n(HCl)_{original}$ - $n(HCl)_{unreacted}$ [1]
= 0.10 - 0.03339
= 6.66×10^{-2} mol [1]

$ZnCO_{3(aq)} + 2HCl_{(aq)} \rightarrow ZnCl_{2(aq)} + H_2O_{(l)}$ [1]

∴ $n(ZnCO_3)$ = (1/2) x $n(HCl)_{reacted}$ = (1/2) x 6.66×10^{-2}
= 3.33×10^{-2} mol [1]

m = n x M $M(ZnCO_3)$ = 125.39

$m(ZnCO_3)$ = 3.33×10^{-2} x 125.39 = 4.175 g [1]

∴ % by mass = (4.175/4.54) x 100 **<u>= 92.0%</u>** [1]

[7 marks]

Part 4 (20 Marks) *Model Answer:*

A. Corrosion of Iron $O_{2(g)} + 2H_2O_{(l)} + 4e^- \rightarrow 4OH^-_{(aq)}$

(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:

$$Fe_{(s)} \rightarrow Fe^{2+}_{(aq)} + 2e^-$$

Combining the two equations we get:

$$O_{2(g)} + 2H_2O_{(l)} + 2Fe_{(s)} \rightarrow 4OH^-_{(aq)} + 2Fe^{2+}_{(aq)}$$

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 $2SO_{2(g)} + O_{2(g)} \rightleftarrows 2SO_{3(g)}$

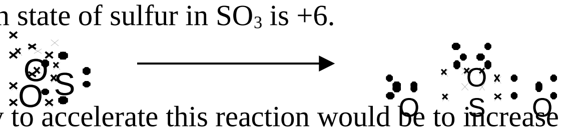
(a) The production of sulfuric acid relies on the combination of sulfur trioxide with water:

$$SO_3 + H_2O \rightarrow H_2SO_4$$

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:

$$SO_3 + H_2SO_4 \rightarrow H_2S_2O_7 + H_2O_{(l)} \rightarrow 2H_2SO_4$$

(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.

V-shaped  triangular planar

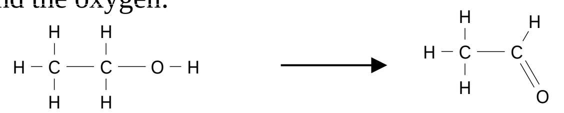
(c) One way to accelerate this reaction would be to increase the pressure of the gases as this would increase the rate of collisions. This would also increase the yield of the reaction as there are less gaseous molecules on the right hand side of the equilibrium.

C. Oxidation of ethanol to ethanoic acid $2CH_3CH_2OH_{(aq)} + O_{2(g)} \rightarrow 2CH_3CHO_{(aq)} + 2H_2O_{(l)}$

(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:

$$2CH_3CHO_{(aq)} + O_{2(g)} \rightarrow 2CH_3COOH_{(aq)}$$

(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:

$$4H^+_{(aq)} + O_{2(g)} + 4e^- \rightarrow 2H_2O_{(l)}$$

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

$$CH_3CH_2OH_{(aq)} \rightarrow CH_3CHO_{(l)} + 2H^+_{(aq)} + 2e^-$$

So the acid is acting as a catalyst.

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