Year 12 Semester 1 Exam 2013

Section One: Multi choice **25% (50 Marks)**

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

Section Two: Short answer **35% (70 Marks)**

Question 26 **(2 marks)**

Write the equilibrium constant expression for each of the following.

$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$	$CO_2(g) + H_2O(l) \rightleftharpoons H^+(aq) + HCO_3^-(aq)$
$\underline{\mathbf{[CO]\,[H_2]^3}}$ $\mathbf{[CH_4]\,[H_2O]}$ (1 mark)	$\underline{\mathbf{[H+]\,[HCO_3^-]}}$ $\mathbf{[CO_2]}$ (1 mark)

Question 27 **(4 marks)**

(a) Ammonia gas is bubbled through ethanoic acid solution. (2 marks)

Equation: $NH_3 + CH_3COOH \rightarrow NH_4^+ + CH_3COO^-$

(b) Ammonium carbonate solution is added to potassium sulfate solution. (2 marks)

Equation: NR

Question 28 **(8 marks)**

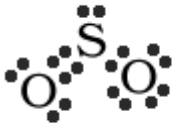
Oxides of sulfur and nitrogen are major pollutants that contribute to the formation of acid rain in industrialised countries.

½

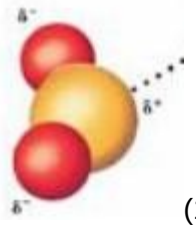
(a) State whether sulfur has a high, an intermediate, or a low electronegativity. **High**

1 mark)

(b) Draw an electron dot diagram to show the bonding and shape of a molecule of SO_2.



[2 marks)



(1 mark)

(c) On the diagram that you have drawn above, show the polarity of one bond, using the appropriate convention.

(d) State why the bond between S and O is polar. **O is more electronegative than S therefore the electrons spend more time closer to O than S. the bond is polar therefore polar, S is more positive and O is more negative.** (2 marks)

(e) State why the molecule is polar. **The molecule is bent due to the lone pair of electrons therefore there is a net diploe and the molecules is polar**. (2 marks)

Question 29 **(10 marks)**

(a) Ancient coins often contain copper and silver, however, modern coins are made of many different metals including nickel and magnesium.

Write the electron configuration of magnesium. **2, 8, 2**

(1 mark)

Why would it be unlikely to find magnesium in ancient coins? **Magnesium is very reactive therefore it is unlikely to be found in its elemental state. It will always be found as a compound and therefore won't be found in ancient coins as there were no techniques for separating compounds.** (2 marks)

(b) Green spots on ancient coins contain the corrosion product copper(II) ethanoate.

Write the formula of copper(II) ethanoate. **$Cu(CH_3COO)_2$** (1 mark)

(c) The ancient Romans discovered that copper coins dipped in molten silver chloride became coated with silver.

Write an equation for this reaction**.** **$Cu + 2Ag^+ \rightarrow 2Ag + Cu^{2+}$** (2 marks)

(d) The only cleaning agents recommended for use on ancient coins are soapy water or CF_3CCl_3 (1,1,1-Trichlorotrifluoroethane), which is a non-polar solvent.

Explain why CF_3CCl_3 would be used to remove grease from coins rather than plain water.

Grease is non-polar only containing weak dispersion forces and would not dissolve in polar water which has the stronger intermolecular forces of hydrogen bonding. (also likes dissolve likes) The grease would dissolve in a non-polar solvent with similar intermolecular forces. Bonds need to break and new ones need to form. (4 marks)

Question 30 **(10 marks)**

State the name used to describe any reaction that causes an increase in temperature.
Exothermic (1 mark)

(a) Write an equation for the reaction of CaO and water.

$CaO + H_2O \rightarrow Ca(OH)_2$ (2 marks)

Calcium oxide or quicklime as it is known has many other uses, for example making cement or plaster. It is made by the decomposition of calcium carbonate.

(b) Write a reaction for the production of quicklime from calcium carbonate.

$CaCO_3 \rightarrow CaO + CO_2$ (2 marks)

Calcium oxide is also an important material in the manufacture of chemicals, for example calcium carbide, CaC_2.

$2\ CaO(s) + 5\ C(s)$	⟶	$2\ CaC_2(s) + CO_2(g)$

Calcium carbide reacts with water, releasing acetylene, C_2H_2.

$CaC_2(s) + 2\ H_2O(l)$	⟶	$C_2H_2(g) + Ca(OH)_2(aq)$

(c) If 500 g of calcium oxide is used to make acetylene via the two equations shown above, what mass of acetylene will be produced if the process is only 85% efficient?

m(CaO) = 500 g **n(CaO) = 500÷56.08 = 8.916 moles (1)**

$n(C_2H_2)$ = 8.916 mol (1) **$m(C_2H_2) = n \times M = 8.916 \times 26.036 = 232.132$ g (1)**

85% efficiency = 0.85 x 232.132 = <u>197 g</u> (1) M (1) (5 marks)

Question 31 **(4 marks)**

Sub-stance	Electrical conductivity			Solubility in water	Colour of solid	Name of substance
	Solid	Liquid	aq			
A	nil	nil	nil	insoluble	white	**Wax**
B	conducts	conducts	-	insoluble	silver	**Aluminium**
C	nil	conducts	-	insoluble	black	**Copper(II) oxide**
D	nil	conducts	conducts	soluble	white	**Potassium nitrate**

Question 32 **(4 marks)**

(a) a piece of zinc is added to a solution of copper(II) sulfate. (2 marks)

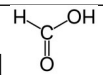
Observation: A Silver coloured solid is added to a clear blue solution. It becomes coated with a black solid. Over time the solution becomes colourless and the silver solid disappears.

(b) a piece of magnesium is burned in air. (2 marks)

Observation: A Silver coloured solid burns producing a lot of heat and light. A crumbly white solid remains.

Question 33 **(8 marks)**

Complete the following table.

Molecule	**Major type of intermolecular attraction**	**Boiling point ranking (1 = highest, 4 = lowest)**
methanoic acid 	**H-bonding**	**1**
methanol 	**H-bonding**	**2**
methane	**Dispersion**	**4**
fluoro-methane 	**Dipole-dipole**	**3**

Question 34 **(4 marks)**

Equation 1: $CO_2(g) + aq \leftrightarrow CO_2(aq)$

(i) State the effect that an increase in the concentration of $CO_2(g)$ has on the concentration of $CO_2(aq)$. Explain your answer with reference to Le Châtelier's principle.

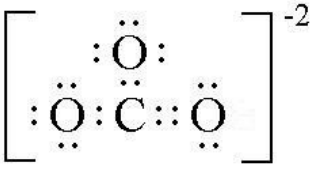
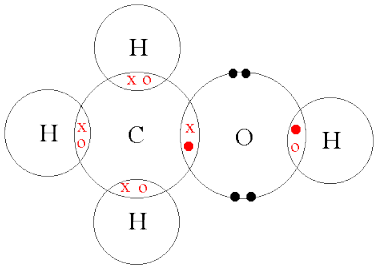
Increasing the $CO_2(g)$, the system wants to decrease the $CO_2(g)$ therefore more dissolves and $CO_2(aq)$ will increase as the system wants to get back to equilibrium and Le Chatelliers states it will counteract the imposed change. (2 marks)

(ii) The effect of temperature on the concentration of $CO_2(aq)$ in sea water is shown in the graph below:

Using the graph above, state and explain whether the dissolving of carbon dioxide in water, as shown in Equation 1, is an exothermic reaction or an endothermic reaction.

As Temp increases $CO_{2(aq)}$ decreases, the system wants to decrease temperature and therefore would favour the endothermic reaction. This means the forward reaction must be exothermic. $CO_2(g) + aq \leftrightarrow CO_2(aq) + heat$ (2 marks)

Question 35 **(6 marks)**

Species	Structural formula (showing all valence shell electrons)	Shape (sketch or name)	Polarity
Carbonate ion		**Triangular planar**	**Non-polar**
Methanol (CH_3OH)		**tetrahedral**	**polar**

Question 36 **(4 marks)**

Use the Bronsted-Lowry theory to write equations to illustrate the following reactions in water:

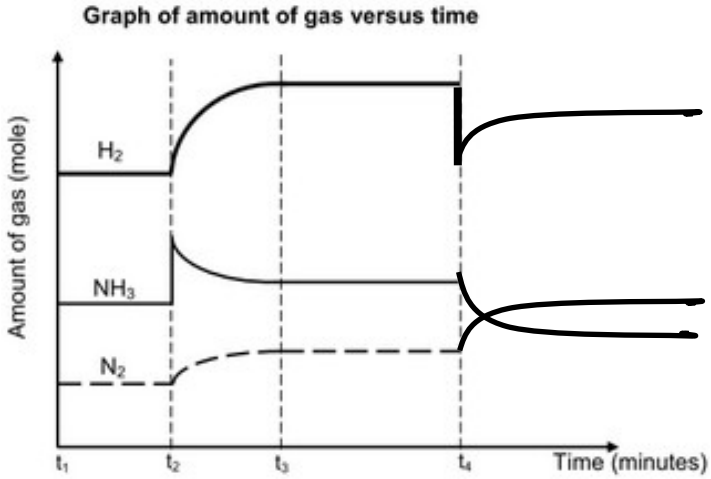
a) **HCO_3^- acting as a base** $HCO_3^-(aq) + H_2O \leftrightarrow H_2CO_3(aq) + OH^-$

b) **HSO_4^- acting as an acid** $HSO_4^-(aq) + H_2O \leftrightarrow SO_4^{-2}(aq) + H_3O^+$

Question 37 **(6 marks)**

Below is a graph showing the progress of the production of ammonia by the following reaction:

$3\ H_2(g) + N_2(g) \longrightarrow 2\ NH_3(g) + Heat$



(a) Describe the change that occurred at time t_2 on the graph and explain why you have come to this conclusion. **[NH_3] suddenly increase which causes system to favour reverse and this causes [NH_3] to decrease and N_2 and H_2 both go up, which proves reverse is favoured.** (2 marks)

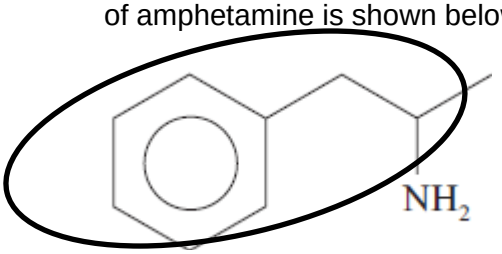
(b) What has happened at time t_3? **Equilibrium is re-established.** (1 mark)

End of Section Two

Section Three: Extended answer **40% (80 Marks)**

Question 38 **(9 marks)**

Amphetamine is a chemical that stimulates the human nervous system. The structural formula of amphetamine is shown below:



(a) Amphetamine has a low solubility in water and is usually taken in the form of a salt.

(i) Using the structural formula above, explain why amphetamine has a low solubility in water. **Although it has NH_2 which would form H-bonds, it also has a large section of CH (circled) which is non-polar, this would decrease solubility**. (2 marks)

Amphetamine is converted into a salt by reaction with an acid solution. With reference to the structural formula above, explain how amphetamine reacts with an acid solution **$X\text{-}NH_2 + H^+ + Cl^- \rightarrow X\text{-}NH_3^+ + Cl^-$**

(i) **The NH_2 react with the Acid forming a salt** (2 marks)

(b) Lithium carbonate, Li_2CO_3, is commonly used in tablet form as a mood stabiliser. The tablets release Li^+ into the aqueous body fluid. One commonly prescribed tablet contains 0.25 g of Li_2CO_3.

(i) Calculate the number of moles of Li+ in one tablet.

$m(Li_2CO_3) = 0.25$ g $n(Li_2CO_3) = m \div M = 0.25 \div 73.892 = 0.00338$ mol

$n(Li^+) = 2 \times 0.00338$ mol $= 0.00667$ mol $= 6.77$mmol (2 marks)

(ii) The volume of aqueous body fluid in an average adult is approximately 42 L. Calculate the average concentration of Li+, in mmol L-1, in the aqueous body fluid of an adult who has taken four tablets.

$n(Li^+) = 6.77\text{mmol} \times 4 = 27.0$ mmol **(1)** $c = $ **$n \div V = 27.0 \div 42 = 0.644$ mmol** **(1)** **(1)** (3 marks)

Question 39 **(15 marks)**

The production of zinc occurs in the steps listed below:

Step 1 Roasting of the mineral zinc sulfide in air.

Step 2 Production of sulfuric acid.

Step 3 Conversion of zinc oxide into zinc sulfate solution.

Step 4 Purification of zinc sulfate solution.

Step 5 Reduction of zinc sulfate solution.

(a) In Step 1 the roasting of the mineral zinc sulfide in air produces zinc oxide and sulfur dioxide gas, SO_2.

Write an equation for this reaction. **$2\ ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$** (2 marks)

(b) If 2 tons (2000 kg) of zinc sulfide ore is roasted, what volume of sulfur dioxide gas is produced if the reaction occurs at 320 ^oC and 150 kPa.

m(ZnO) = 2000000 g n(ZnO) = 20525 mol

PV = nRT V(SO2) = 20525 x 8.314 x 593 / 150 = 6.75 x 10^{-5} L (4 marks)

(c) In Step 2 the SO_2 produced is used to make sulfuric acid. The first stage in the production of sulfuric acid is shown by the equation below:

$$2SO_2(g) + O_2(g) \leftrightarrow 2SO_3(g) \quad \Delta H = -198 \text{ kJ}$$

Write a *K* expression for this reaction. $\mathbf{K = \frac{[SO_3]^2}{[SO_2]^2[O_2]}}$ (1 mark)

(ii) State whether the reaction is exothermic or endothermic. **Exothermic** (1 mark)

(iii) State and explain the effect on the value of *K* of increasing the temperature. Increasing Temp the system wants to decrease temp and therefore favours the reverse reaction therefore there is led products and the K will decrease in value. (3 marks)

(d) In Step 3 zinc oxide reacts with sulfuric acid to produce zinc sulfate solution.

Write an equation for this reaction. **$ZnO + H_2SO_4 \rightarrow ZnSO_4 + H_2O$** (2 marks)

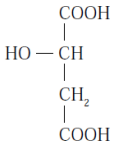
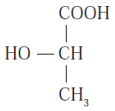
Ionic **$ZnO + 2H^+ \rightarrow Zn^{2+} + H_2O$**

(e) In Step 4 metal ions that contaminate the zinc sulfate solution are removed by the addition of zinc powder. Circle one ion, of those shown below, that will be removed by the addition of zinc powder. **Hg^+ Pb^{2+}** (1 mark)

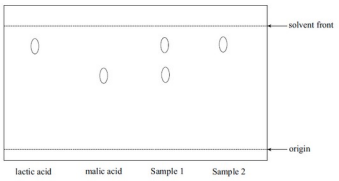
(f) In Step 5 zinc sulfate solution is reduced to zinc using electrolysis.

State how the use of electrolysis suggests that the production of zinc from zinc sulfate is a non-spontaneous reaction. **Spontaneous would occur on its own electricity would not be required and is only used when a reaction will not occur on its own.** (1 mark)

Question 40 **(15 marks)**

Malic acid	Lactic acid
	

The following two samples of the wine were spotted onto the chromatography paper:
Sample 1 — no malo-lactic fermentation had occurred in the wine.
Sample 2 — malo-lactic fermentation had occurred.
Reference samples of lactic acid and malic acid were also spotted onto the paper.
The chromatography obtained is shown below:



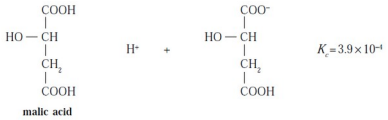
(a) Suggest a reason why malic acid moved a shorter distance than lactic acid. **It is heavier** (1 mark)

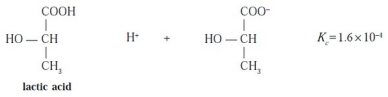
(b) Explain how the chromatogram indicates that malo-lactic fermentation has occurred in Sample 2. **Both are present in sample 1 but in sample 2 any malic acid has converted to lactic acid therefore there is none.** (2 marks)

(c)What type of intermolecular forces is the solvent likely to have? Explain your answer fully.

Both have H-bonding due to the –OH groups. (1)Therefore the solvent must be polar (1) and would preferably have H-bonds(1) eg water. (3 marks)

(d) Malic acid and lactic acid ionise in water, as shown in the equations below:





State which is the stronger acid and use the information above, explain why malo-lactic fermentation causes wine to become less acidic. **Both are weak acids, lactic acid is marginally weaker therefore there are less H^+ ions in solution and the wine would be less acidic when is contains only lactic acid.** (2 marks)

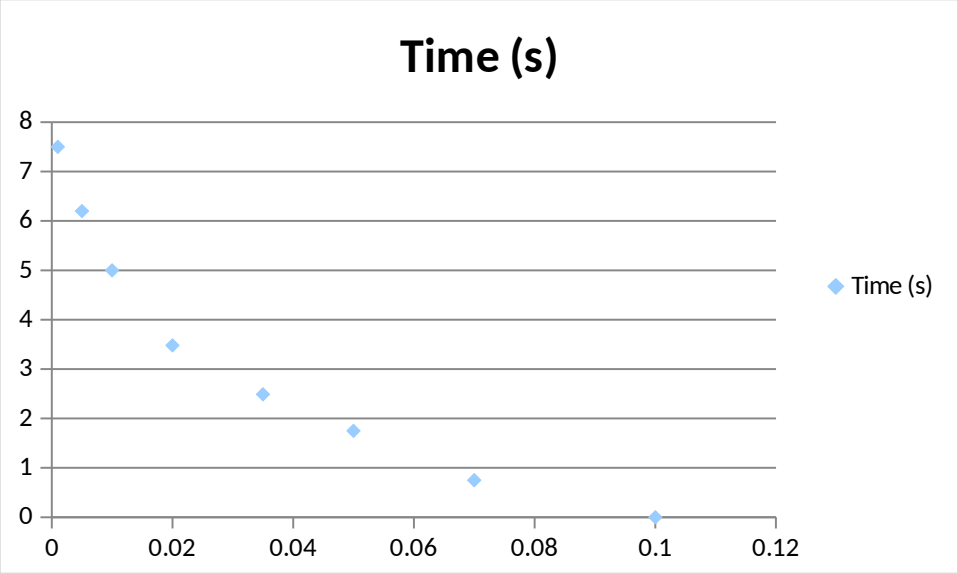
(d) Lactic acid is neutralised by addition of sodium hydroxide. Jaimie is trying to determine the amount of lactic acid in a sample of wine. If she has a solution of 500.0 mL containing an unknown amount of lactic acid and adds 20.0 mL of 0.01 mol L^{-1} NaOH which is an excess, she then has to add 3.78 mL of 0.01 mol L^{-1} HCl to neutralise the excess NaOH. What is the concentration of lactic acid present in the wine sample? (7 marks)

$C_3H_6O_3$ + NaOH → $C_3H_5O_3^-$ + Na^+ + H_2O (1)
V = 0.5 L V = 0.02 L
c= n/V c = 0.01 mol L^{-1}
= 0.000162/0.5 (1) n = 0.0002mol (1)
= 0.0003244 n reacted = 0.0002 – 0.0000378 = 0.000162 (1)
= 3.24 x 10^{-4} mol L^{-1} (1)

NaOH + HCl → NaCl + H_2O (1)
V = 0.00378, c =0.01 mol L^{-1}, n = 0.0000378 (1)

Question 41 **(16 marks)**

a) Plot a graph of the concentration of bromine against time. (4 marks)



(b) Name the independent and dependent variables in this experiment. (2 marks)

Independent **Bromine conc**

Dependent **Time taken**

(c) Name **two** variables that must be kept constant during this experiment. (2 marks)
Volume, Temperature

(d) What is the relationship between the concentration of bromine and the reaction rate? (1 mark)
As Bromine concentration increases reaction rate increase

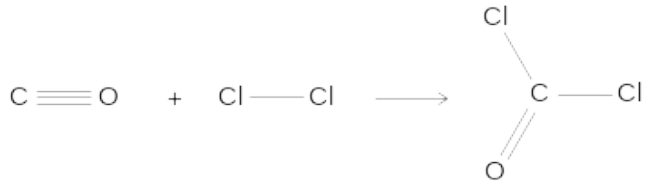
(e) Provide an explanation for your answer to question (d) (2 marks)
As concentration increases more collisions take place which means more successful collisions occur which increases rate.

(f) "Hydrobromic acid is a strong acid." Explain what this statement means. (2 marks)

Hydrobromic acid fully ionises in solution (1)
$HBr \rightarrow H^+ + Br^-$ (1)

(g) Name another factor that could cause an increase in the reaction rate. Explain your answer. (3 marks)
Temperaturen or catalyst with explanation. Sub-division not acceptable.

Question 42 **(12 marks)**



Phosgene

(a) If 500 kg of phosgene is being produced, what volume of chlorine and carbon monoxide would be required if the temperature is 150°C and the pressure is 108.6 kPa?

$n(COCl_2) = m/M = 500000/98.91 = 5055$ mol
$n(CO) = n(Cl_2) = 5055$ mol
PV = nRT
$V = 5055 \times 8.314 \times 423/108.6 = 1.64 \times 10^5$ L (4 marks)

The poison phosgene ($COCl_2$) can be neutralized with sodium hydroxide (NaOH) to produce salt (NaCl), water and carbon dioxide by the reaction:

$COCl_2 + 2\ NaOH \rightarrow 2\ NaCl + H_2O + CO_2$

If 9.5 grams of phosgene and 9.5 grams of sodium hydroxide are reacted:

(i) will all of the phosgene be neutralized?
(ii) If so, how much sodium hydroxide remains? If not, how much phosgene remains?

$n(COCl_2) = m/M = 9.5/98.91 = 0.0960$ mol (1) $n(NaOH) = m/M = 9.5/39.998 = 0.2375$ mol (1)

$(COCl_2)$: 2(NaOH)
0.0960 : 0.2375/2
<u>0.096</u> : 0.1187 (1)
Limiting reagent (1)
Therefore all phosgene is neutralised. (1)
$n(NaOH)_{remaining} = n_{originally} - n_{reacted}$ (1)
$= 0.2375 - 0.192$
$= 0.0454$ mol (1)
$m(NaOH) = 0.0454 \times 39.998 = 1.817$ g (1)

(8 marks)

Question 43 **(13 marks)**

Explain the following data:

Boiling points (°C)

Group IV Hydrides		**Group VII Hydrides**	
CH_4	-162	HF	20
SiH_4	-111	HCℓ	-85
GeH_4	-88	HBr	-67
SnH_4	-52	HI	-35
PbH_4	-13		

3 types of forces:

- **Dipole dipole- occur in polar only**
- **Dispersion- occur in polar and non-polar**
- **H-bonding-occur only in polar when H is bonded to N, O, or F**

(3) must include relative strengths

Group IV- all are non-polar therefore only have dispersion forces. As they increase in size going down the group, they have more electrons and the dispersion forces increase also. This causes increase in BP. (4)

Group VII –all of the molecules are polar. Going down the group the electronegativity goes down and therefore the dipoles get smaller and you would expect the BP to get smaller also. However the molecules going down also get larger and have more electrons therefore they experience greater dispersion forces also. This causes the BP going down to increase due to the dispersion force increase despite the decrease in electronegativity. (3)

The exception to this is the HF which has H-bonding which is much stronger than dipole forces or dispersion forces and consequently its BP is larger than all the others. (2)

Group IV <Group VII as dispersion versus dipole and dispersion (1)