## Section 1 Multiple Choice

1. **A**
2. **B**
3. **D**
4. **B**
5. **C**
6. **B**
7. **D**
8. **B**
9. **C**
10. **B**
11. **A**
12. **C**
13. **B**
14. **B**
15. **D**
16. **A**
17. **D**
18. **A**
19. **D**
20. **B**
21. **C**
22. **B**
23. **A**
24. **B**
25. **D**

**Section2: Short Answer 35% (70 marks)**

This section has **12** questions. Answer all questions. Write your answers in the space provided. Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page
- Continuing an answer. If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued. i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Suggested working time for this section is 60 minutes.

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**Question 26 (6 marks)**

Write the equation for the reaction that occurs in each of the following procedures. If no reaction occurs, write 'no reaction'. For full marks, chemical equations should refer only to those species consumed in the reaction and the new species produced. These species may be ions [for example $Ag^+(aq)$], molecules [for example $NH_3(g)$, $NH_3(aq)$, $CH_3COOH(l)$] or solids [for example $BaSO_4(s)$, $Cu(s)$, $Na_2CO_3(s)$].

(a) Pieces of chromium are warmed with concentrated nitric acid.

Equation $\boldsymbol{3NO_3^- + 6H^+ + Cr \rightarrow Cr^{3+} + 3NO_2 + 3H_2O}$

Observation ***Silver coloured solid dissolves producing a green solution and a brown gas***

(3 marks)

(b) Bromine solution is added to cis 2-butene.

Equation $\boldsymbol{Br_2 + CH_3CH_2CH_2CH_3 \rightarrow CH_3CH_2BrCH_2BrCH_3}$

Observation ***Orange solution decolourises***

(3 marks)

**Question 27** **(4 marks)**

Write observations for any reactions that occur in the following procedures. In each case describe what you would observe, including any:

- colours
- odours
- precipitates (give the colour)
- gases evolved (give the colour or describe as colourless).

If no change is observed, you should state this.

(a) Copper carbonate dissolves in dilute sulfuric acid.

***Green solid dissolves to give a blue solution and a colourless gas***

(2 marks)

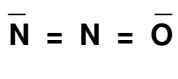
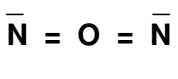
(b) Excess lead (II) nitrate solution is mixed with cobalt (II) iodide solution.

***A colourless solution is added to a pink solution to produce a yellow precipitate and a pink solution***

(2 marks)

**Question 28** **(4 marks)**

The $N_2O$ molecule is both linear and polar. On the basis of this experimental information, determine whether the arrangement NNO or NON is correct. Draw at least one electron dot diagram for each of these forms to illustrate and help explain your answer.

| **NNO** | **NON** |
|---|---|
|  |  |

(2 marks)

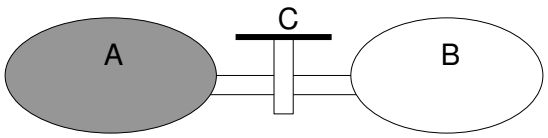
Explanation ***NNO, since NNO is symmetrical and linear the sum of the bond polarities is not equal to zero and the molecule is therefore polar***

***NON is linear and symmetrical and the sum of its bond polarities is equal to zero and the molecule is therefore non-polar***

(2 marks)

**Question 29** **(12 marks)**

Vessel A contains an equilibrium mixture of CO, $Cl_2$ and $COCl_2$ at 28°C.
Vessel B is empty; A and B are connected by a tube with a stopcock C.




The equilibrium reaction is

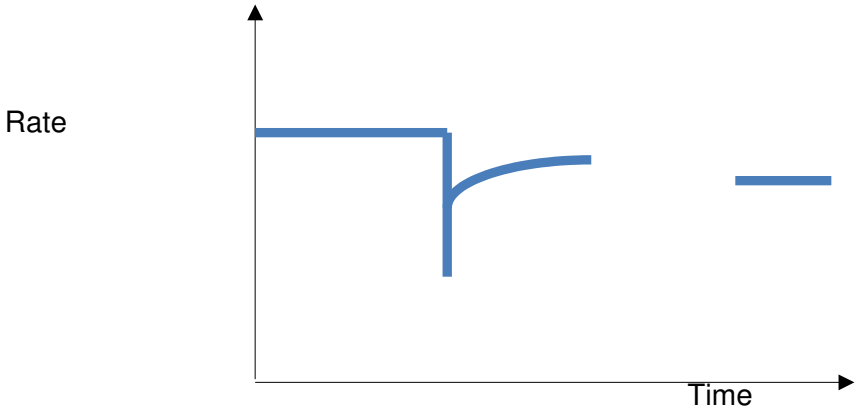
$$CO(g) + Cl_2(g) \Leftrightarrow COCl_2(g) \qquad \Delta H < 0$$

Using the words ***increases, decreases, or no change*** determine what happens to the value of K [equilibrium constant] , the value of the $[Cl_2]$ and the mass of $Cl_2$ when the following two changes (a,b) are made to the initial equilibrium.

| Change made | K value | $[Cl_2]$ | Mass of $Cl_2$ |
|---|---|---|---|
| (a) stopcock C is opened at 28°C; A and B are now connected. | ***No change*** | ***Decrease*** | ***Increase*** |
| (b) container A has been immersed in a water bath at 67°C [at constant pressure] | ***Decrease*** | ***Increase*** | ***Increase*** |

(6 marks)

(c) (i) Sketch a graph of what happens to the rate of the **forward** reaction for the **change (a) above**, from when the reaction was initially at equilibrium until equilibrium is re-established after the change is made.




(3 marks)

(ii) Explain why the rate changes in the way shown in your sketch.

***Initially the rate is constant. Increased volume leads to a rate decrease because of reduced number of collisions.Equilibrium shifts towards the reactants. More reactants mean more collisions and a higher rate of reaction but not as high as it was initially***

(3 marks)

**Question 30** **(6 marks)**

When an acidified solution of potassium permanganate ($KMnO_4$) is added to a solution of potassium chlorate ($KClO_3$), the main products formed are manganese (IV) dioxide ($MnO_2$) and potassium perchlorate ($KClO_4$).

Write a balanced equation for this reaction by first balancing the half equations for both the oxidation and reduction processes.

oxidation process

***3X*** $ClO_3^- + H_2O \rightarrow ClO_4^- + 2H^+ + 2e^-$

(2 marks)

reduction process

***2X*** $MnO_4^- + 4H^+ + 3e^- \rightarrow MnO_2 + 2H_2O$

(2 marks)

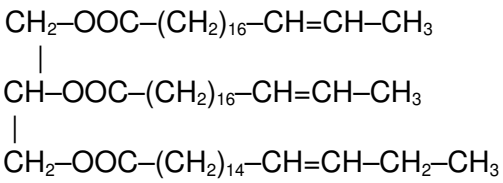
Full balanced equation

$3ClO_3^- + 2MnO_4^- + 2H^+ \rightarrow H_2O + 2MnO_2 + 3ClO_4^-$

(2 marks)

**Question 31** **(3 marks)**

The following trigylceride was boiled (hydrolysed) with sodium hydroxide solution to produce soap. Draw the **structures** of three likely products formed. The trigylceride is :



| **Product 1** | **Product 2** | **Product 3** |
|---|---|---|
| ***$CH_3CH{=}CH(CH_2)_{16}COO^-$*** | ***$CH_3CH_2CH{=}CH(CH_2)_{14}COO^-$*** | ***$CH_2OHCHOHCH_2OH$*** |

**Question 32** **(4 marks)**

A student titrates a solution of oxalic acid against 20.0 mL of a standardised 0.052 mol $L^{-1}$ solution of sodium carbonate in a conical flask using a suitable indicator.

How would the following experimental errors affect the value of the concentration of the oxalic acid calculated from the titration compared to its actual concentration? **(use higher, lower or no change)**

| experimental error | Effect on calculated concentration of oxalic acid |
|---|---|
| (a) He washed the pipette with water | ***higher*** |
| (b) He washed the burette with water | ***lower*** |
| (c) He washed the conical flask with sodium carbonate solution | ***lower*** |
| (d) He added too much water to the conical flask | ***No change*** |

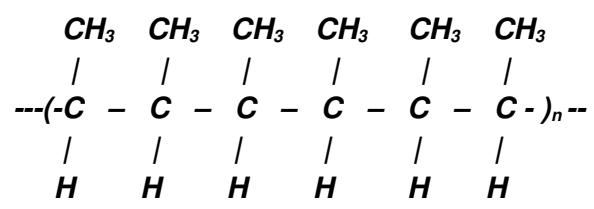
**Question 33** **(4 marks)**

In column one you are given a clue to an unknown chemical, write the formula, structural where appropriate, for this unknown in column two.

| Clue | **Formula** of unknown chemical |
|---|---|
| (a) It is the conjugate acid of $CH_3COOH$ | ***$CH_3COOH_2^+$*** |
| (b) It is a saturated isomer of $C_4H_8$ |   Or |
| (c) It is the alcohol used to produce 1-propylbutanoate | ***$CH_3CH_2OH$*** |
| (d) It is an amine with seven H atoms | ***$CH_3CH_2NH_2$*** |

**Question 34** **(6 marks)**

Give the name and structural formula of the **main organic product(s)** for the following reactions:

| Reaction | Structural Formula of the **main organic product(s)** | Name of the **main organic product(s)** |
|---|---|---|
| (a) excess acidified potassium permanganate is added to ethanal | ***$CH_3COOH$*** (1 mark) | ***Ethanoic acid*** (1 mark) |
| (b) 2–propanol is warmed with methanoic acid in the presence of conc. sulfuric acid | ***$HCOOCH(CH_3)CH_3$*** (1 mark) | ***2-propyl methanoate*** (1 mark) |
| (c) cis -2-butene forms an addition polymer. Draw a 3 monomer polymer. |  | ***LEAVE THIS SPACE BLANK*** |

**Question 35** **(8 marks)**

Give the compound with the lowest melting point of the following trios of solids; give an explanation for your choice.

(a) $P_4O_{10}$, $SiO_2$, $SO_2$ Compound with highest MP is ***$SiO_2$***

(1 mark)

Explanation

***SiO2 is a covalent network compound. Strong continuous covalent bonding. High MP***

***$P_4O_{10}$ and $SO_2$ are both covalent molecular; Low MP***

(3 marks)

(b) $PH_3$, $NH_3$, $AsH_3$ Compound with lowest MP is ***$PH_3$***

(1 mark)

Explanation

***All covalent molecular***

***Predominant IM forces in $NH_3$ are H – bonding. Therefore highest MP***

***Predominant IM forces in $PH_3$, and $AsH_3$ are dipole – dipole forces but $AsH_3$ has more electrons therefore greater dispersion forces and higher MP than $PH_3$***

(3 marks)

**Question 36** **(6 marks)**

An operational electrochemical cell consists of the following half cells:

**$Ag^+(aq)/Ag(s)$ and $Cr^{3+}(aq)/Cr(s)$**

(a). Write equations for reactions occurring at the anode and cathode.

Cathode ***$Ag^+(aq) + e^- \rightarrow Ag(s)$***
Anode ***$Cr(s) \rightarrow Cr^{3+}(aq) + e^-$***

(2 marks)

(b). If the anode weighs 10.4 g before the cell is operational and the cathode gained 0.340g after 10 minutes. What is the mass of the anode after 10 minutes?

***$3Ag^+(aq) + Cr(s) \rightarrow Cr^{3+}(aq) + 3\,Ag(s)$***

***n(Ag) deposited = 0.34/107.9 = 0.0032 mol***

***n(Cr) dissolved = 0.0032/3 = 0.0011 mol***

***m(Cr) dissolved = 0.0011 x 52 = 0.055g***

***m(anode) = 10.4 - .055 = 10.345g***

(4 marks)

**Question 37** **(7 marks)**

**G**lycine $(NH_2)CH_2COOH$ is an amino acid.

(a) Name the two functional groups that make up this amino acid.

***AMINE*** and ***CARBOXYLIC ACID***

(2 marks)

(b) Draw a three monomer polymer formed by using glycine as the monomer.

***- ( NH - $CH_2$ – CO – NH – $CH_2$ – CO – NH – $CH_2$ – CO ) -***

(2 marks)

(c) What would be the mass of a piece of polymer that has been made from **50** glycine molecules?

***m(polymer) = 50 x M(glycine) - 49 x M(water)***

***= 50 x 75.07 - 49 x 18.016***

***= 2870.7 g***

(3 marks)

**Section 3: Extended answer** **40% (80 Marks)**

This section contains **six (6)** questions. You must answer **all** questions. Write your answers in the spaces provided. Spare pages are included at the end of the booklet. They can be used for planning your responses and/ or as additional space if required to continue an answer.

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- Continuing an answer: If you need the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Suggested working time for this section is 70 minutes.

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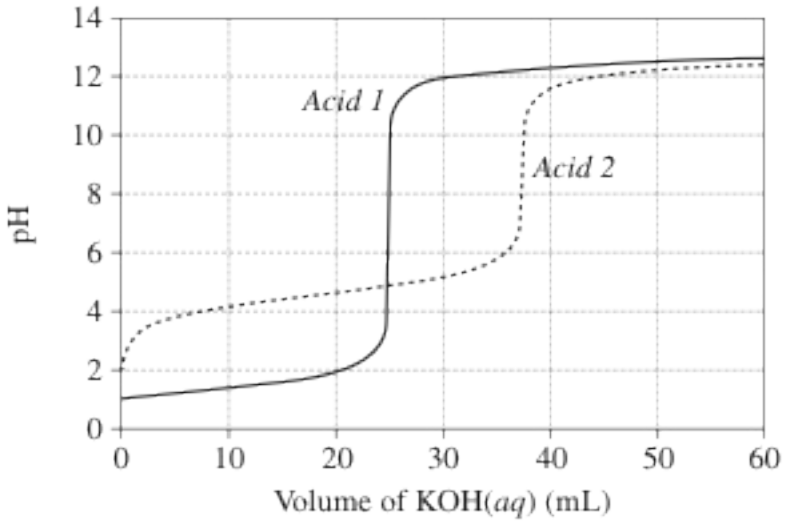
**Question 38** **(19 marks)**

The graph shows changes in pH for the titrations of equal volumes of solutions of two monoprotic acids, *Acid 1* and *Acid 2*.




(a) Explain the differences between *Acid 1* and *Acid 2* in terms of their relative strengths and concentrations.

***Acid 2 is more concentrated because it requires a greater volume of KOH for neutralisation. Acid 1 is stronger because it has a lower initial pH, pH is 7 at equivalence and equivalence occurs over a greater pH range***

(4 marks)

(b) Is the salt produced by the reaction of an acid of the same type as *Acid 2* with KOH*(aq)* acidic, basic or neutral*?* Explain your choice using relevant chemical equations.

***The salt is basic.***

- ***pH at equivalence is in the basic range***
- ***the anion of the weak acid (Acid 2) hydrolyses to produce hydroxide ions***

$A^- + H_2O \leftrightarrows HA + OH^-$

(3 marks)

(c) Use the graph to determine the concentration of hydrogen ions when 20 mL of KOH(*aq*) has been added to *Acid 1*.

***When V(KOH) = 20 mL, pH = 2***

$[H^+] = 10^{-2}$

(2 marks)

(d) Why would phenolphthalein be a suitable indicator for both titrations?

***pH of the colour change forphenolphthalein is in the basic range (8.3 – 10) which corresponds to equivalence for both titrations***

(1 mark)

(e) *Acid 1* would be the best acid to use in an investigation to determine the % of ammonia in household cleaner. Explain why.

***A titration between Acid 1 and NH3 (SA + WB) will have an acidic equivalence point. A titration between Acid 2 and NH3 (WA + WB) has an unpredictable pH at equivalence. The end point may not correspond to the equivalence point***

(2 marks)

(f) *Acid 2* is the only acid of the two that could be used to make a buffer solution. Explain why.

***A buffer must be made using a weak acid and its conjugate base***

(2 marks)

Consider the following buffer solutions **A** to **C**

**A** 1.0 L of solution containing 1.0 mol $L^{-1}$ $CH_3COOH$ and 1.0 mol $L^{-1}$ $NaCH_3COO$
**B** 1.0 L of solution containing 0.1 mol $L^{-1}$ $CH_3COOH$ and 0.1 mol $L^{-1}$ $NaCH_3COO$
**C** 1.0 L of solution containing 0.1 mol $L^{-1}$ $NH_3$ and 0.1 mol $L^{-1}$ $NH_4Cl$

(g) Write the formula of the weak acid and its conjugate base for buffers A and C.

Buffer A *Weak Acid:* ***$CH_3COOH$*** *Conjugate base*: ***$CH_3COO^-$***
Buffer C *Weak Acid:* ***$NH_4^+$*** *Conjugate base*: ***$NH_3$***

(2 marks)

(h) Write an equation to show what happens when a small amount of the strong acid HCl is added to buffer A.

$$CH_3COO^- + H^+ \leftrightarrows CH_3COOH$$

(1 mark)

(i) Use buffers A and B to illustrate the meaning of buffer capacity.

***Buffer capacity is the extent to which a buffer solution can absorb $H^+$ or $OH^-$ without a significant change in pH. Buffer A has a higher concentration of acid and conjugate base . Therefore it has a higher capacity to react with $H^+$ or $OH^-$***

(2 marks)

**Question 39** **(16 marks)**

An unknown organic compound, A, consisting of only C, H and O was analysed to determine its structure. During analysis compound A was easily oxidised by a potassium permanganate solution to form another compound, B, which reacted with $Na_2CO_3(s)$ to produce a colourless gas.

3.53 g of compound B was completely burnt in excess oxygen to produce carbon dioxide and water which were then completely absorbed into a solution of sodium hydroxide. The mass of the sodium hydroxide solution increased by 7.278 g. In this process the carbon dioxide is completely converted to sodium carbonate. Adding calcium nitrate to this solution results in a precipitate of calcium carbonate. The mass of calcium carbonate when washed and dried was 11.74 g.

(a) Write a balanced ionic equation for the reaction of carbon dioxide with sodium hydroxide solution.

$$CO_2(g) + 2OH^-(aq) \rightarrow CO_3^{2-}(aq) + H_2O(l)$$

(1 mark)

(b) Write a balanced ionic equation for the reaction between the sodium carbonate and calcium nitrate solutions.

$$Ca^{2+}(aq) + CO_3^{2-}(aq) \rightarrow CaCO_3(s)$$

(1 mark)

(c) Calculate the mass of carbon dioxide produced during the combustion of compound B.

***$m(CaCO_3) = 11.74g$***
***$n(CaCO_3) = 11.74/100.1 = 0.1173$ mol***

***$n(CO_2) = n(CaCO_3) = 0.1173$ mol***
***$m(CO_2) = 0.1173 \times 44$***
***5.162g***

(3 marks)

(d) Calculate the mass of water produced during the combustion of compound B.

***m(H2O) = 7.278 – 5.162 g***
***2.116g***

(1 mark)

(e) Determine the empirical formula of compound B

***n(H2O) = 2.127/18.016 = 0.0175 mol***

***n(H) = 2 x 0.1175 = 0.2349mol***

***m(H) = 0.2349 x 1.008 = 0.2367g***

***n(C) = n(CO2) = 0.1173 mol***

***m(C) = 0.1173 x 12.01 = 1.4088g***

***m(O) = m(compound) – m(C) – m(H)***

***= 3.53 – 1.4088 - 0.2367 g***
***= 1.885 mol***

***n(O) = 1.885/16 = 0.1178 mol***

***n(C) : n(H) : n(O)***
***= 0.1173 : 0.2367 : 0.1178***
***= 1: 2 : 1***

***EF = $CH_2O$***

(5 marks)

Another 7.320 g of compound B was vapourised in 2.00L container and produced a pressure of 200 kPa at 120°C.

(f) Determine the molecular formula of compound B.

***PV = nRT = mRT/M***

***M = 7.32 x 8.31 x 393/ 200 x 2 = 59.7 $gmol^{-1}$***
***M(EF) = 30$gmol^{-1}$***
***MF = 2 x EF = $C_2H_4O_2$***

(3 marks)

(g) Draw the structural formulae of A and B in the boxes below.

| Compound A | Compound B |
|---|---|
| ***$CH_3CH_2OH$*** ***or*** ***$CH_3CHO$*** | ***$CH_3COOH$*** |

(2 marks)

**Question 40** **(13 marks)**

Hydrogen, which is used for the synthesis of ammonia, is sometimes made from the reaction:

$$CH_4(g) + H_2O(g) \overset{\text{Ni catalyst, 1030 K}}{\Leftrightarrow} CO(g) + 3H_2(g); \quad \Delta H = +206 \text{ kJ mol}^{-1}$$

In a research laboratory, at t = 0 minutes, 3 moles of methane and water are added to a 1000 mL reaction vessel and equilibrium is established at 2 minutes.

(a) At time = 3 minutes the concentration of CO(g) at 1030 K is doubled by the addition of CO(g). As a result, the temperature in the reaction vessel should

***rise*** **fall** **remain constant**

Circle the correct response above **and** explain your answer in the space below.

***Increase in [CO] causes equilibrium to shift left favouring the exothermic process and increasing the temperature.***

(3 marks)

(b) The mixture is allowed to re-establish equilibrium and then at time = 6 minutes the temperature of the reaction vessel is halved. As a result the yield of hydrogen would

**increase** ***decrease*** **remain constant**

Circle the correct response **and** explain your answer in the space below.

***A decrease in temperature favours the exothermic process (reverse reaction) shifting the equilibrium left, consuming $H_2$***

(3 marks)

(c) The mixture is allowed to re-establish equilibrium and then at t = 9 minutes the total pressure on the reacting system is increased by adding argon (an inert gas) to the reaction vessel without changing its volume. As a result the yield of hydrogen would

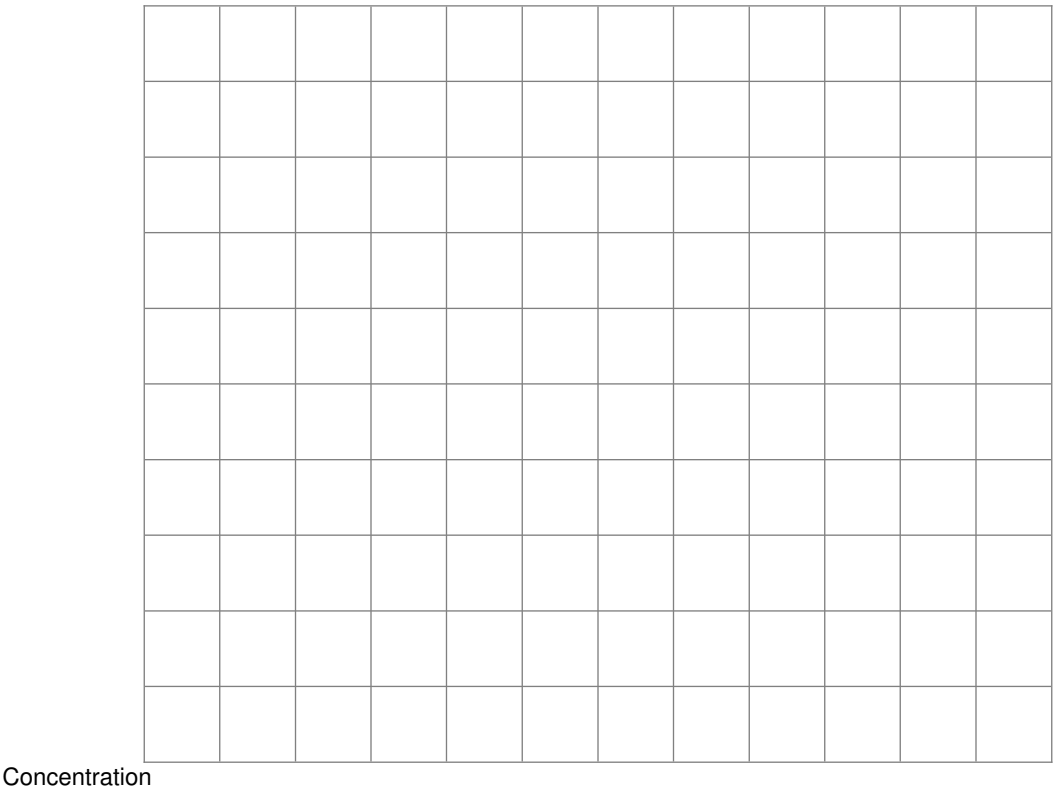
**increase** **decrease** ***remain constant***

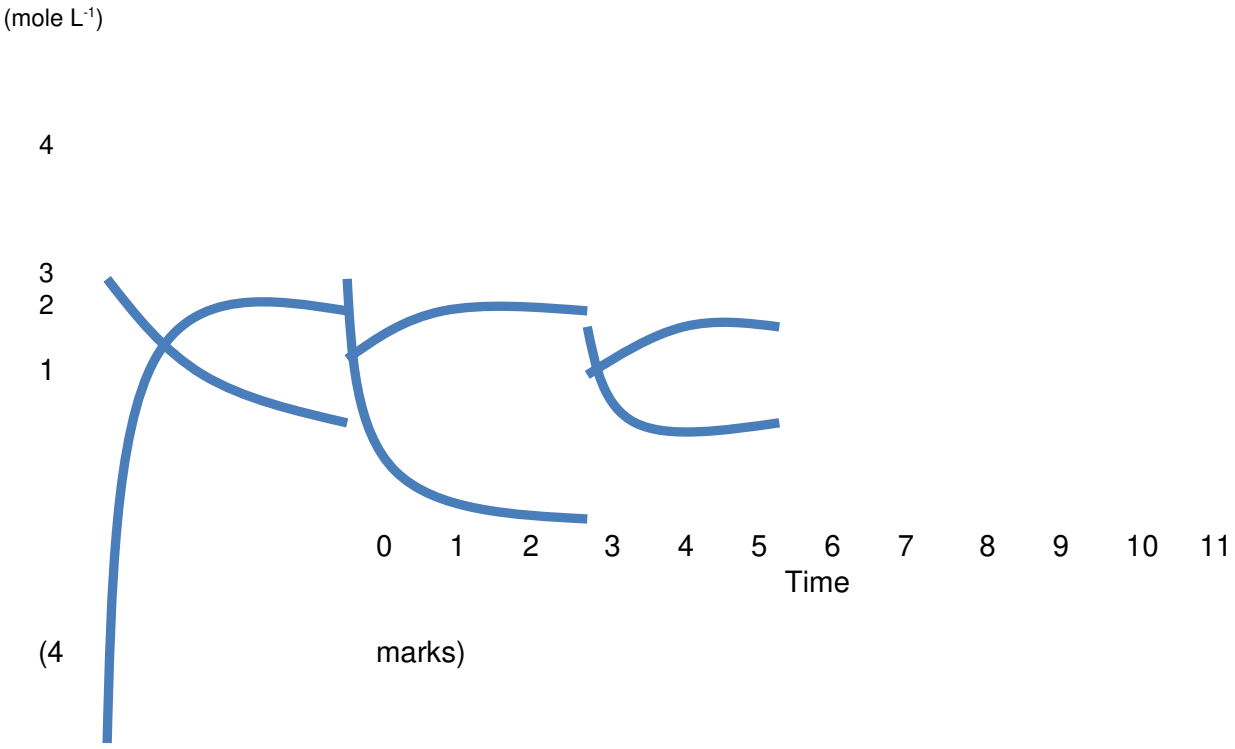
Circle the correct response **and** explain your answer in the space below.

***Partial pressures (concentrations) of the reactants and products do not change. There is no change in the equilibrium position***

(2 marks)

(d) On the set of axes below sketch a graph of the concentration of **methane and hydrogen only,** from t = 0 minutes to t = 12 minutes.






(4 marks)

(e) Equal numbers of mole of methane and water are added to an empty reaction vessel at 1030K in the presence of the nickel catalyst. The system reaches equilibrium. At equilibrium, the concentrations of methane and water are each 0.012 M and the concentration of carbon monoxide is 0.0083 M. What is the concentration of hydrogen?

***n(H2) = 3 x n(CO) = 3 x 0.0083 mol = 0.0249 mol***

(1 mark)

**Question 41** **(15 marks)**

Copper is an extremely useful metal due to its excellent conductivity properties and low reactivity with air and water. Most of Australia's copper deposits are in the form of the mineral chalcopyrite ($CuFeS_2$). Copper is extracted from this ore by roasting the powdered mineral in air. The chemical reactions for the roasting process are shown below.

**Reaction 1** **$2CuFeS_2(s) + 4O_2(g) \rightarrow Cu_2S(s) + 2FeO(s) + 3SO_2(g)$**

**Reaction 2** **$Cu_2S(s) + O_2(g) \rightarrow 2Cu(l) + SO_2(g)$**

A particular **ore** body contains 13.6% chalcopyrite by mass. In order to extract the copper it is first crushed and the mineral component, chalcopyrite, concentrated in a process called 'froth floatation'. The **concentrate** is then roasted according to the chemical reactions above.

(a) What mass of copper can be obtained from 1 tonne ($10^6$ g) of the **<u>concentrate</u>** if it contains 95.7% chalcopyrite by mass?

***m(chalcop) = 0.957 t = 9.57 x $10^5$ g***

***n(chalcop) = 9.57 x $10^5$/ 183.5 = 5.215 x $10^3$ mol***

***n(Cu) = n(chalcop) = 5.215 x $10^3$ mol***

***m(Cu) = 5.215 x $10^3$ x 63.5 = 3.31 x $10^4$ g***

(4 marks)

The by product of the copper extraction ($SO_2$) is a dangerous pollutant and combines with environmental oxygen and water in similar chemical processes to those used in the Contact Process to produce sulphuric acid.

(b) Write balanced chemical equations for the reactions of sulphur dioxide with oxygen and subsequently the reaction of the product with water.

***$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$***

***$SO_3(g) + H_2O(l) \rightarrow H_2SO_4(aq)$***

(2 marks)

(c) Determine the volume of sulphur dioxide produced during **reactions 1 and 2** that would result from the treatment of **one tonne of <u>chalcopyrite ore</u>**. The gas is released at atmospheric conditions of 101kPa and 27°C and the process has a 100% yield.

***Reaction 1: 1mol Chalcopyrite $\rightarrow$ 0.5 mol $Cu_2S$ + 3/2 mol $SO_2$***

***Reaction 2: 0.5 mol $Cu_2S$ $\rightarrow$ 0.5 mol $SO_2$***

***1 mol chalcopyrite $\rightarrow$ 2 mol $SO_2$***

***m(chalcopyrite) = 0.136 x $10^6$g***

***n(chalcopyrite) = 0.136 x $10^6$/183.5 = 741.14 mol***

***n($SO_2$) = 1482.3 mol***

***PV = nRT***

***V = 1482.3 x 8.31 x 300/101 = 3.66 x $10^4$ L***

(6 marks)

(d) Determine the mass of sulphuric acid produced **per tonne of <u>chalcopyrite ore</u>** if the reaction of sulphur dioxide with oxygen is 93% efficient. Assume the reaction of the product with water gives a 100% yield.

***n($SO_2$) = n($H_2SO_4$)***

***n($SO_2$) converted = 0.93 x 1482.3 = 1378.5 mol***

***m($H_2SO_4$) = 1378.5 x 98.16 = 1.35 x $10^5$g***

(3 marks)

**Question 42** **(9 marks)**

On the label of a 750 mL bottle of white wine is the statement:

**13.5% Alc/Vol**
**CONTAINS APPROX 8 STANDARD DRINKS**

**Note:** 13.5% Alc/Vol means that every 100 mL of the wine contains 13.5 mL of pure ethanol, $C_2H_5OH$. The density of pure ethanol is 0.790 g $mL^{-1}$ at room temperature.

(a) Calculate the mass of ethanol in one 750 mL bottle of the wine at room temperature.

***V(ethanol) = 13.5 x 750/100 = 101.25 mL***

***mass = density x volume = 0.79 x 101.25 = 80 g***

(3 marks)

Quality control demands that the alcohol content falls within 1% of the quoted value on the bottle. One way to determine the alcohol content in wine involves the oxidation of ethanol to ethanoic acid ($CH_3COOH$) using acidified dichromate as the oxidant. The equation for the oxidation of ethanol with dichromate in acid solution is:

$$\mathbf{2Cr_2O_7^{2-}(aq) + 16H^+(aq) + 3C_2H_5OH(aq) \rightarrow 3CH_3COOH(aq) + 4Cr^{3+}(aq) + 11H_2O(l)}$$

The half equation for dichromate as an oxidant is:

$$\mathbf{Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^- \rightarrow 2Cr^{3+}(aq) + 7H_2O(l)}$$

(b) Write the half equation for the oxidation of ethanol to ethanoic acid in acid solution.

$$\boldsymbol{CH_3CH_2OH + H_2O \rightarrow CH_3COOH + 4H^+ + 4e^-}$$

(1 mark)

A10.0 mL sample of white wine was diluted to 250 mL in a volumetric flask. Then 25.0 mL aliquots of the diluted wine were titrated against 0.0750 mole $L^{-1}$ acidified potassium dichromate solution ($K_2Cr_2O_7$). The average titre was 20.61 mL.

(c) Calculate the number of mole of ethanol in the 10.0 mL sample of white wine.

***$n(Cr_2O_7^{2-}) = 0.075 \times 20.61 \times 10^{-3} = 1.546 \text{ xx } 10^{-3}$ mol***

***n(ethanol in 25 mL aliquot) = 3/2 x 1.546 xx $10^{-3}$ = 2.319 x $10^{-3}$ mol***

***n(ethanol in 250mL and 10mL wine sample) = 2.319 x $10^{-3}$ x 250/25 = 2.319 x $10^{-2}$ mol***

(3 marks)

(d) Determine whether the alcohol content of this wine falls within the 1% tolerance limit.

***m(ethanol) = 2.319 x $10^{-2}$ x 46.07 = 1.068g***

***m(ethanol) in 750 mL = 1.068 x 750/10 = 80.1g***

***Within the 1% limit (0.8g)***

(2 marks)

**Question 43** **(8 marks)**

Many alcohols are industrially important. They can be used as solvents, disinfectants, preservatives and as reactants in organic syntheses.

Up to $C_{10}$, the straight chain alcohols are colourless liquids with characteristic odours at room temperature. The longer chain alcohols are waxy solids. The boiling points of alcohols are considerably higher than for corresponding hydrocarbons. This is particularly true for the shorter chain alcohols. The table below gives the boiling points for some of the shorter chain alcohols.

| Alcohol | Boiling point (°C) |
|---|---|
| Methanol | 64.7 |
| Ethanol | 78.3 |
| 1-propanol | 97.2 |
| 2-propanol | 82.4 |
| 1-butanol | 117.7 |

| | |
|---|---|
| 2-butanol | 99.5 |

With reference to the table above discuss the nature and relative strengths of the intermolecular forces in alcohols.

***BP of alcohols is dependent on the intermolecular (IM) forces acting between the alcohol molecules, the larger the IM forces the higher the BP***

- ***H bonding between the positive end (H) of the alcohol group on some molecules and the negative (O) on the alcohol group of others.***
- ***Dispersion forces which increase with the number of electrons in the molecules***

***(2 marks)***

***The BP of the alcohols is considerably higher than the corresponding hydrocarbons because the predominant IM forces between hydrocarbon molecules are dispersion forces. The predominant forces between alcohol molecules are hydrogen bonds. Hydrogen bonds are stronger than dispersion forces for similar sized molecules***

***(1 mark)***

***The difference in the BP of the alcohols is due to the dispersion forces as each alcohol has only one –OH group.***

***(1 mark)***

***BP increases from methanol → ethanol → propan-1-ol → butan-1-ol because the length of the carbon chain is increasing and so are the dispersion forces between molecules.***

***(2 marks)***

***The secondary alcohols have a lower BP than the corresponding primary alcohols because the primary alcohol molecules are in closer proximity and have a greater surface area in contact***
***(2 marks)***