SOLUTIONS 2012 Chemistry 3AB Semester 2
Section One (50 marks)

Answer ALL questions in Part 1 on the separate Multiple Choice Answer Sheet provided, using a blue or black pen or a 2B or B pencil. Each question in this part is worth 2 marks.

ANSWER SHEET

NAME: _____

TOTAL MARKS : 50

SECTION 1 : MULTIPLE CHOICE

Put a cross through the letter after selecting the most appropriate answer.

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

Section Two: Short Answer **[Total=70 marks]**

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

This section has **11** questions. Answer **all** questions. Write your answers in the spaces 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: 60 minutes.

Question 26 **[8 marks]**

Write equations and observations for any reactions that occur in the following situations. In each case describe in full what you would observe, including any colours, odours, precipitates (state the colour) and gases evolved (state the colour or describe as colourless). If no change is observed, you should write "no visible change".

a) Copper(II) nitrate solution is added to excess sodium carbonate solution.

Equation **(2 marks)**

$CO_3^{2-}(aq) + Cu^{2+}(aq) \rightarrow CuCO_3(s)$ (2)

Observation **(2 marks)**

A blue liquid is added to a colourless liquid. (1) A green precipitate forms and liquid becomes colourless.(1)

b) Acidified potassium dichromate solution reacted with oxalic acid ($H_2C_2O_4$) to produce chromium (III) ions, carbon dioxide and water

Equation **(2 marks)**

$3H_2C_2O_4 + Cr_2O_7^{-2} + 8H^+ \rightarrow 2Cr^{+3} + 6CO_2 + 7H_2O$ (2)

Observation **(2 marks)**

A colourless and an orange solution are combined. (1) The mixture turns deep green. (1)

Question 27 **[4 marks]**

A solution of potassium hydrogen phosphate (K_2HPO_4) has strong buffering ability and is involved in the buffering the cytoplasm of living cells. Use the example of potassium hydrogen phosphate to explain the concept of buffering in aqueous solutions. You should include appropriate equations to support your answer.

A buffer solution has the ability to resist changes in pH when either acid or base is added to the solution. (1)

The ion HPO_4^{2-} has the ability to act as a weak acid or a weak base and itself has little effect on pH. (1)

If some acid is added to the solution then the HPO_4^{2-} ion reacts with it partially preventing the pH from falling.

$HPO_4^{2-} + H^+ \rightleftharpoons H_2PO_4^-$ *(1)*

If some base is added to the solution then the HPO_4^{2-} ion reacts with it partially preventing the pH from rising.

$HPO_4^{2-} + OH^- \rightleftharpoons PO_4^{3-} + H_2O$ *(1)*

Question 28 **[7 marks]**

The alcoholic beverage wine contains the active ingredient ethanol, CH_3CH_2OH. When left exposed to air for long periods the alcohol in wine will become oxidised. This will give the wine an unpleasant taste.

(a) Given that most wines are slightly acidic, write the reduction half equation involved in the oxidation of wine. (2 marks)

$O_2\,(aq) + 4H^+\,(aq) + 4e^- \rightleftarrows 2H_2O\,(l)$ *(2)*

(b) When the alcohol in wine becomes oxidised it may result in one of two different products. Write oxidation half equations showing the formation of each of these products. (4 marks)

If partially oxidised the alcohol will be converted to ethanal. (1)

$CH_3CH_2OH\,(aq) \rightleftarrows CH_3CHO\,(aq) + 2H^+\,(aq) + 2e^-$ *(1)*

If completely oxidised the alcohol will be converted to ethanoic acid. (1)

$CH_3CH_2OH\,(aq) + H_2O\,(l) \rightleftarrows CH_3COOH\,(aq) + 4H^+\,(aq) + 4e^-$ *(1)*

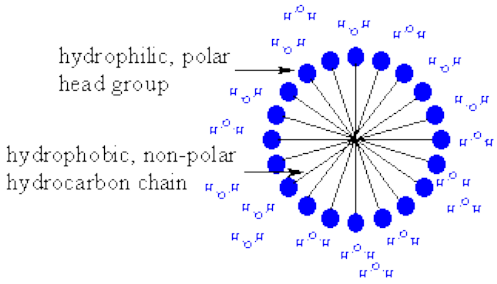
Also accept ethanal to ethanoic acid.

(c) Red wine vinegar is produced by the action of bacteria on red wine. What is the probable role of bacteria in this process? Justify your answer. (1 mark)

The bacteria provide a catalyst to speed up the oxidation of the alcohol to ethanoic acid. (1)

Question 29 **[4 marks]**

Explain with the aid of a diagram how a non-polar hydrocarbon like oil is able to be dissolved in soapy water.



(1)

The soap ion has a long hydrocarbon section which is said to be hydrophobic. This part of the soap ion is non-polar and as such not attracted to polar solutes but is attracted to non polar solutes. (1)

The head or ionic part of the soap ion (COO-) is said to be hydrophobic. This part of the soap ion is charged and as such not attracted to non polar solutes but is attracted to polar solutes. (1)

When soap is added to water,hydrophobic non-polar end of the soap molecule links to the polar impurity like oil and the hydrophylic or polar end links to the water molecule (1).

Question 30 **[9 marks]**

Complete the table below by giving a brief description of a chemical test that could be used to distinguish between the substances listed. List the observations relating to the test for each of the substances.

Substances to be distinguished	Description of chemical test	Observation with Substance 1	Observation with Substance 2
Substance 1 **cyclopentane** Substance 2 **2-methylpropene**	*Add a few drops of bromine water* *Chlorine water will also work though the colour change wont be so obvious (1)*	*The bromine water will be very slow to change from red/brown to colourless (1)*	*The bromine water changes from red/brown to colourless rather quickly (1)*
Substance 1 **potassium sulfate solution** Substance 2 **sodium hydroxide solution**	*Add a few drops of barium nitrate solution, any soluble barium compound will do.* *Alternatively any soluble Mg^{2+} ,Cr^{3+}, Mn^{2+}, Fe^{2+}, Fe^{3+}, Co^{2+}, Cu^{2+}, Ni^{2+}, Zn^{2+}, Cd^{2+}, Al^{3+}, Sn^{2+} etc (1)*	*The mixture goes cloudy white as a Ba precipitate forms.* *Other cations give different observations. (1)*	*The mixture remains colourless and clear (ie no change).* *Other cations may give different observations. (1)*
Substance 1 **propanone** Substance 2 **propan-2-ol**	*Add some acidified potassium permanganate (or dichromate). (1)*	*Upon addition of the acidified potassium permanganate the mixture turns purple and remains purple. (1)*	*Upon addition of the acidified potassium permanganate the mixture turns purple but then goes colourless. (1)*

Question 31 **[7 marks]**

a) Write the electronic configuration of a potassium atom.

2, 8, 8, 1 *(1)*

b) The first four ionisation energies of potassium are shown in the table below:

ionisation	1st	2nd	3rd	4th
ionisation energy/kJ mol	1 419	3051	4420	5877

(i) Explain what is meant by the term *first ionisation energy* of potassium. (1 marks)

Energy to remove an electron from each atom of gaseous potassium (1)

(ii) Why is there a **large** difference between the values for the first and the second ionisation energies of potassium? (2 marks)

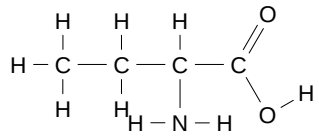
2nd electron is removed from a different shell (1)

The 1st electron is closer to nucleus/more attraction; less shielding (1)

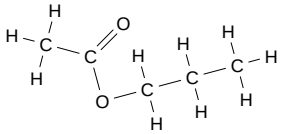
Question 32 **[4 marks]**

Draw complete structural formula for the substances being described.

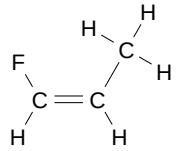
(a)an alpha amino acid with four carbon atoms (1 mark)



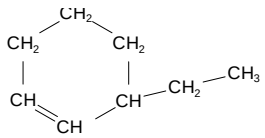
(b)the compound propyl ethanoate (1 mark)



(c)the cis isomer of C_3H_5F (1 mark)

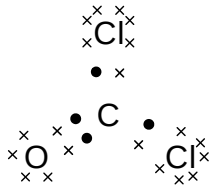
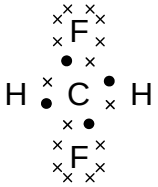
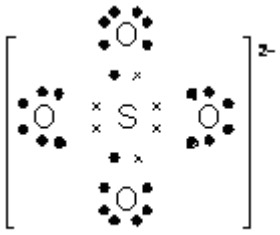


(d)the compound 3-ethylcyclohexene (1mark)



Question 33 **[11 marks]**

Complete the following table showing the electron dot diagram, shape, molecular polarity and name the shape for the three species listed.

Cl_2CO	**F_2CH_2**	**SO_4^{2-}**
Electron dot diagram (1) 	Electron dot diagram (1) 	Electron dot diagram (1) 
Sketch shape (1)	Sketch shape (1)	Sketch shape (1)
Name shape *Trianglar Planar* (1)	Name shape *Tetrahedral* (1)	Name shape *Tetrahedral* (1)
Polarity *Polar* (1)	Polarity *Polar* (1)	

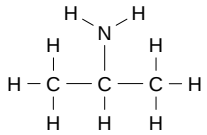
Question 34 **[7 marks]**

(a) Give the IUPAC name for the following compounds and rank them according to their boiling point. In the table write "1" for the compound with the highest boiling point, down to "4" for the compound with the lowest boiling point. (4 marks)

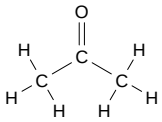
Compound	**Molar mass g mol^{-1}**	**IUPAC name** (2 marks)	**Boiling points** (1=highest, 4=lowest) (2 marks; -1 each error)
CH_3CH_2COOH	74.1	*propanoic acid (1/2)*	*1*
$CH_3CH_2CH(CH_3)_2$	72.1	*methylbutane (1/2)*	*4*
$CH_3CHOHCH_2CH_3$	74.1	*butan-2-ol (1/2)*	*2*
$CH_3COCH_2CH_3$	72.1	*butanone (1/2)*	*3*

(b) How would the boiling point of the compound propan-2-amine compare with that of CH_3COCH_3. Support your answer with reference to intermolecular forces. (3 marks)

The structure of propan-2-amine is



The structure of CH_3COCH_3 is



Both molecules are polar. (1)
The amine group is site for H bonding, (1)
therefore the propan-2-amine would have the higher bp as its intermolecular are stronger (1)

Question 35 **[6 marks]**

The atomic radii of some of the elements in groups 1-17 of the Periodic Table are shown in the table below. Some radii have been omitted.

Group	**1**	**2**	**13**	**14**	**15**	**16**	**17**
Period 2 element	**Li**	**Be**	**B**	**C**	**N**	**O**	**F**
atomic radius in nm	0.134	0.125	0.090	0.077	0.075	0.073	
Period 3 element	**Na**	**Mg**	**Al**	**Si**	**P**	**S**	**Cl**
atomic radius in nm							

(a)(i) State the trend shown in atomic radius across a period. (1 mark)

Decreases Left to Right_(1)

(ii) Explain why this trend occurs. (3 marks)

protons added to nucleus/nuclear charge increases (1)

electrons added to same shell (1)

attraction is greater (1)

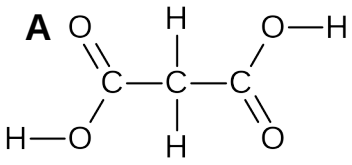
(b)Mendeleev studied periodic data to make predictions for the properties of elements which had yet to be discovered. Using your knowledge of periodic trends and the data above, estimate values for the atomic radius of: (2 marks)

(i) **F** *0.070 < radius < 0.073 nm (1)* (ii) **S** *radius > 0.073 nm (1)*

Question 36 **[6 marks]**

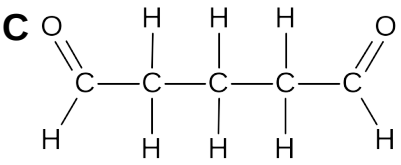
A variety of organic compounds, labeled A to F are shown here. Use these compounds to answer the following.

A

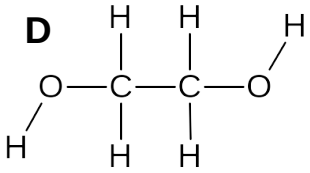


B $CH_3CH_2CHCH_2$

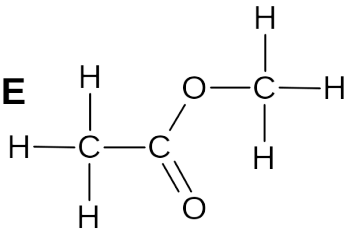
C



D



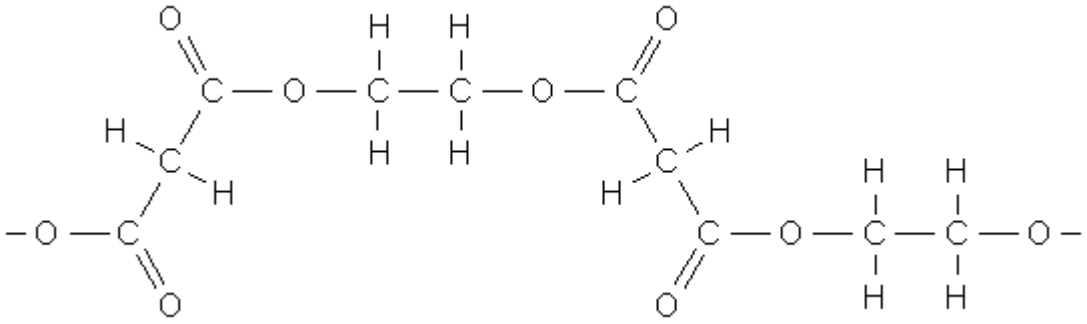
E



F CH_3CH_2Cl

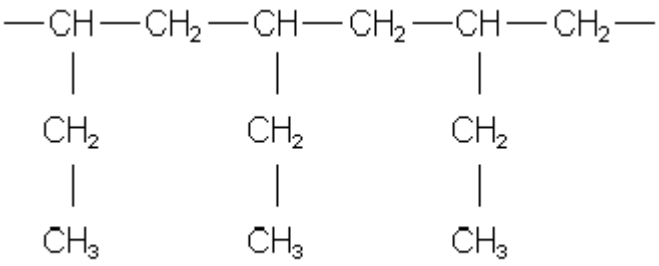
(a)Using any of the above molecules as monomer(s) draw a structural diagram for a section of a condensation polymer molecule. Your diagram should have two complete repeating units. State the molecule(s) chosen as monomer(s), ie **A, B, C, D, E or F**. (3 marks)

Use monomers A and D (1) *Correct diagram (2)*



(b)Using any of the above molecules as monomer(s) draw a structural diagram for a section of an addition polymer molecule. Your diagram should have three complete repeating units. State the molecule(s) chosen as monomer(s), ie **A, B, C, D, E or F**. (3 marks)

Use monomer B (1) *Correct diagram (2)*



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

This section contains **seven (7)** questions. You must answer **all** questions. Write your answers in the spaces provided.

Where questions require an explanation and/or description, marks are awarded for the relevant chemical content and also for coherence and clarity of expression.

Final answers to calculations should be expressed to **three (3)** significant figures and include appropriate units.

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.

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Suggested working time: 70 minutes.

SIGNIFICANT FIGURES
$-\frac{1}{2}$ mark for ERROR.

Question 37 **[11 marks]**

Esters are the basis of many naturally occurring odours and are therefore widely used in the creation of artificial flavours. The particular ester shown below is a major component that contributes to the smell of pineapple. A manufacturer wishes to produce this compound as a food additive. The reaction involved is shown:

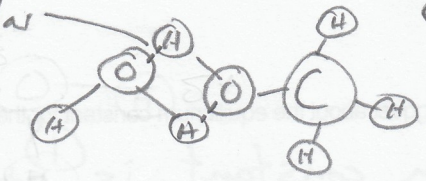
$$CH_3OH(aq) + C_3H_7COOH(aq) \rightleftarrows \underset{\text{"pineapple" ester}}{C_3H_7COOCH_3(aq)} + H_2O(l)$$

In a trial procedure to produce this ester a chemist uses 3.40 kg sample of methanol with excess butanoic acid. The methanol used is only 88.5% pure as it contains water which is extremely soluble in methanol and is difficult to remove.

(a) Name the "pineapple" ester. methyl butanoate (1 mark)

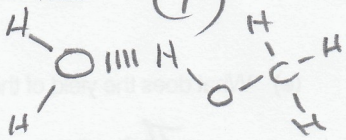
(b) Explain with the aid of a diagram why water is extremely soluble in methanol. (2 marks)

intermolecular forces



OR Similar (1)

OR



Both water and methanol molecules have sites for Hydrogen bonding which leads to very strong intermolecular attractions. (1)

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(c) What maximum mass of ester can the chemist expect? (4 marks)

$m(CH_3OH) = 3.40 \times 10^3 \times 0.885 = 3.009 \times 10^3$ g (1)

$n(CH_3OH) = \frac{3.009 \times 10^3}{32.042} = 93.91$ mol (1)

$M(CH_3OH)$
$= 12.01 + 4.032 + 16.00$
$= 32.042$

$\therefore n(ester) = 93.91$ mol

$\therefore m(ester)_{EX} = 93.91 \times 102.13 = 9591$ (1)
$= 9.59$ kg $= 9.59 \times 10^3$ g
(1)

$M(C_5H_{10}O_2)$
$60.05 + 10.08 + 32.00 = 102.13$

(d) On completion of the procedure and extraction of the ester the chemist found the process had a yield of 68.5%. What mass of ester was actually produced? (2 marks)

$m(ester)_{EX} = 9.59 \times 10^3$ g

$m(ester)_{ACTUAL} = 9.59 \times 10^3 \times \frac{68.5}{100}$ (1)

$= 6.57 \times 10^3$ g $= 6.57$ kg (1)

(e) What does the yield of this reaction suggest about the equilibrium constant for the reaction? (2 marks)

The equilibrium constant is (1) greater than 1; as the yield indicates that products are favoured over reagents (1)

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Question 38 **[14 marks]**

The Haber process for the manufacture of ammonia involves a reversible equilibrium reaction that is exothermic with a ΔH of 46 kJ per mole of NH_3 produced. The reaction is operated by passing a mixture of nitrogen gas and hydrogen gas over finely divided iron. The reaction mixture is maintained at a pressure of 300 atm and a temperature of 450 °C.

(a) (i) Use this to information to write a balanced chemical equation for the manufacture of NH_3. (2 marks)

- base eqn ½

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3 + 92kJ$ - Balanced ½ - ΔH included ½ - double arrow ½

(ii) What is the purpose of the finely divided iron? (2 marks)

- a catalyst (1)
- fine divided to increase surface area to aid its effectiveness. (1)

(b) Conducting the synthesis of ammonia at a high pressure has several advantages, state two advantages of producing ammonia this way and use your knowledge of chemical principles to support your answer. (6 marks)

Advantage 1: Reaction Rate is Increased (1)

Explanation based on chemical principles:

pressure of gases increases collision rate or concentration, therefore the rate of reaction (forward and reverse) is increased. (2)

Advantage 2: Yield of NH_3 is Increased (1)

Explanation based on chemical principles: 2 moles of gases on product side, 4 moles of gases on reagent side. High pressure moves new equilibrium to side with smallest moles of gases. ie product side. (2)

SEE NEXT PAGE

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(c) Based on chemical principles alone, pressures well above 300 atm would be even more advantageous. Suggest why such higher pressures are not used. (1 mark)

The cost of achieving higher pressures becomes too high. (1)

(d) The chosen temperature of 450°C is said to be something of a compromise. Explain what this means. (3 marks)

Raising the temperature will make the equilibrium mixture have more nitrogen and hydrogen because forming these from ammonia consumes energy. (1) If we cool the reaction down, the amount of ammonia will increase but the rate at which ammonia is formed will decrease because the temp is lower. (1) The temp of 450°c achieves a reasonable rate of reaction with a satisfactory yield. (1)

Question 39 **[11 marks]**

A student carried out an experiment with some magnesium and a hydrochloric acid solution. In this experiment, the student added a granule of magnesium with a mass of 0.152 g to a conical flask containing 85.5 mL of 0.0951 mol L^{-1} hydrochloric acid. This resulted in the formation of hydrogen gas as shown here.

$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$

(a) What was the pH of the solution in the flask prior to adding the magnesium granule? (2 marks)

$c(HCl) = 0.0951\ mol\ L^{-1}$

$\therefore c(H^+) = 0.0951\ mol\ L^{-1}$ (1)

$\therefore pH = -\log [H^+] = -\log (0.0951)$

$pH = 1.02$ (1)

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(b) Determine the number of moles of magnesium and hydrochloric acid initially present in the flask. (2 mark)

$m(Mg) = 0.152\,g$

$n(Mg) = \frac{0.152}{24.31} = 6.253 \times 10^{-3}\,mol$ (1)

and $n(HCl) = cV = 0.0951 \times 0.0855 = 8.13 \times 10^{-3}\,mol$ (1)

(c) How many moles of hydrogen gas could be expected from this experiment? (2 marks)

Limiting Reagent is HCl (1)

$\therefore n(H_2) = \frac{1}{2} \times 0.008131 = 4.07 \times 10^{-3}\,mol.$ (1)

(d) Calculate the volume of H_2 gas that would be expected if the gas were collected at 28.0 °C and 104 kPa. (2 mark)

$\therefore V(H_2) = \frac{nRT}{P} = \frac{4.07 \times 10^{-3} \times 8.314 \times 301}{104}$ (1)

$= 0.09793\,L$

$= 9.79 \times 10^{-2}\,L$ (1)

(e) The student repeated this experiment using a granule of strontium of similar dimensions to the granule of magnesium.

(i) What difference would you expect in reaction rate? (1 mark)

faster rate (1)

(ii) Explain your answer to (i). (2 marks)

- The reactivity of the elements in this group 2 increases as you go down the group. (1)
- This is due to lower Ionisation Energy as each new energy shell is added. (1)

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Question 40 **[13 marks]**

Wines often contain a small amount of sulfur dioxide that is added as a preservative. The amount of sulfur dioxide added needs to be carefully calculated; too little and the wine goes bad; too much and the wine tastes of sulphur dioxide.

The sulfur dioxide content of a wine can be tested by titration with an aqueous iodine solution, $I_2(aq)$. The reaction involved is shown here:

$$SO_2(aq) + I_2(aq) + 2H_2O(l) \rightarrow SO_4^{2-}(aq) + 2I^-(aq) + 4H^+(aq)$$

(a) What species is oxidised in this reaction? Support your answer with an explanation. (2 marks)

Species that has been oxidised SO_2 (1)

Explanation: The oxidation number of S in SO_2 is +4 and this is increased to +6 in SO_4^{2-} as the S loses $2e^-$ as it is oxidised (1)

(b) Suggest how the end point of this titration might be observed. You may assume the wine is almost colourless and that the iodine solution is added from the burette. (2 marks)

The colourless wine will be in the conical flask and the brown (1) I_2 solution in the burette. The end point will be indicated by the presence of a pale brown colour in the conical flask. (1)

(c) What problem would you encounter by having the I_2 (aq) solution in the burette? (2 marks)

as the I_2 (aq) is brown (1) it will be necessary to read the burette from the top of the meniscus (1)

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(d) The sulfur dioxide content of a white wine sample was found by titration with iodine. In this procedure a laboratory technician measured 50.0 mL of white wine and diluted this to 250.0 mL. She then titrated 20.0 mL samples of the diluted wine with 0.00215 mol L^{-1} aqueous iodine, $I_2(aq)$. On average 16.40 mL of iodine solution was needed for equivalence. Determine the concentration of sulfur dioxide in the original wine sample in mol L^{-1}. (4 marks)

$n(I_2) = cV = 0.00215 \times 16.40 \times 10^{-3}$

$= 3.526 \times 10^{-5}$ mol $(\frac{1}{2})$

$\therefore n(SO_2) = 3.526 \times 10^{-5}$ mol $(\frac{1}{2})$

$\therefore c(SO_2)_{dil} = \frac{n}{V} = \frac{3.526 \times 10^{-5}}{0.020} = 0.001763 \text{ mol } L^{-1}$ (1)

$\therefore c(SO_2)_{wine} = 0.001763 \times \frac{250}{50}$ (1)

$= 0.008815 \text{ mol } L^{-1}$

$= 8.82 \times 10^{-3} \text{ mol } L^{-1}$ (1)

(e) The generally accepted maximum concentration of sulfur dioxide in wine is 0.25 g L^{-1}. Higher concentrations will make the wine taste unpleasant and concentrations less than 0.01 g L^{-1} are insufficient to preserve the wine. Comment on the effectiveness of the sulfur dioxide in the wine analysed in (d). (3 marks)

$c(SO_2) = 0.008815 \text{ mol } L^{-1}$

$= 0.008815 \times 64.06$

$= 0.565 \text{ g } L^{-1}$ (1)

$M(SO_2)$

32.06
32
64.06

The SO_2 conc is too high (1)

$\therefore$ wine has unpleasant taste (1)

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Question 41 **[9 marks]**

Dioxin is a dangerous pollutant that needs to be closely monitored in our food and the environment. The formula of dioxin is $C_{12}H_4O_2Cl_4$. On combustion, the chlorine in dioxin is completely converted into hydrogen chloride gas. An impure sample of dioxin with a mass of 3.600g was burnt in oxygen. The hydrogen chloride produced was bubbled through 50.00 mL of 1.030 mol L^{-1} potassium hydroxide solution. The resulting solution was then titrated with a standard solution of 0.500 mol L^{-1} sulfuric acid and an average titre of 23.65 mL was required. Calculate the percentage, by mass, of dioxin in the impure sample.

$2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O$

$n(H_2SO_4) = cV = 0.500 \times 0.02365$

$= 0.011825$ mol (1)

$\therefore n(KOH)_{left} = \frac{2}{1} \times 0.011825 = 0.02365$ mol (1)

(1)

$n(KOH)_{initial} = c \times V = 1.030 \times 0.050 = 0.05150$ mol

$\therefore n(KOH)_{used} = 0.05150 - 0.02365$

$= 0.02785$ mol (1)

$HCl + KOH \rightarrow KCl + H_2O$

$\therefore n(HCl) = n(KOH) = 0.02785$ mol (1)

$\therefore n(Cl) = 0.02785$ mol (1)

(1)

$\therefore n(dioxin) = \frac{0.02785}{4} = 0.006963$ mol

$\therefore m(dioxin) = 0.006963 \times 321.95$

$= 2.242$ g (1)

$\therefore \%$ dioxin $= \frac{2.242}{3.600} \times 100$

$= 62.3\%$ (1)

M(dioxin)
144.12
4.03
32.00
141.80
321.95

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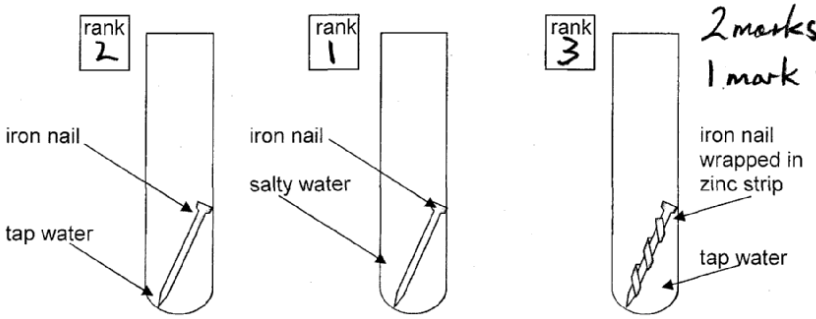
Question 42 **[13 marks]**

The corrosion of iron is a redox process that causes iron and steel structures to decay and become degraded over time. In an investigation into the corrosion process a student placed some iron nails into a variety of different environments and observed the extent of corrosion that occurred. He compared the extent of corrosion by looking for the amount of orange/brown deposit that formed in the test tubes.



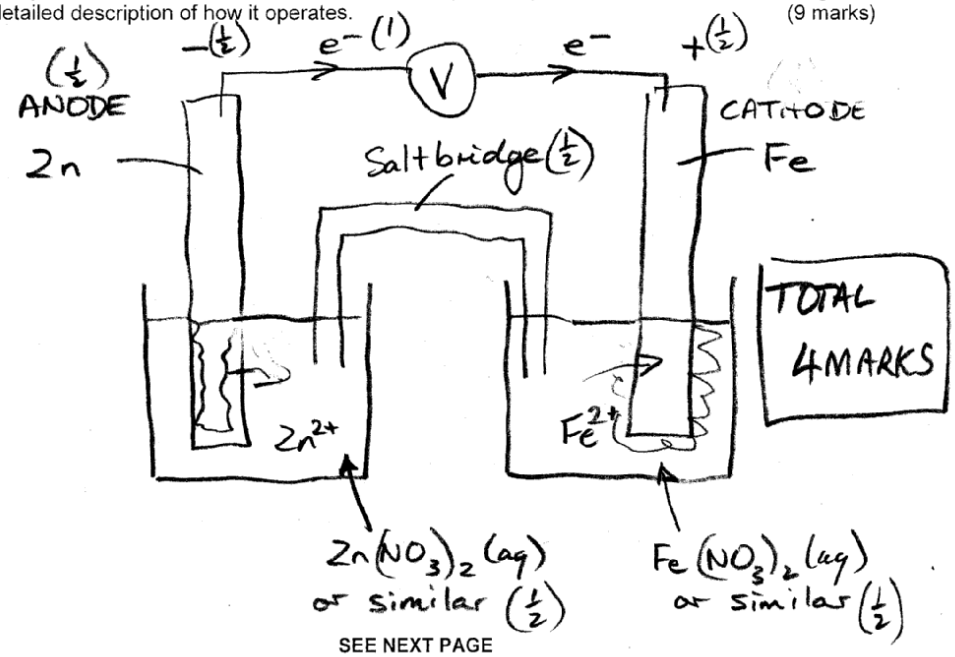
2 marks - 3 correct
1 mark - 1 correct

(a) What is the likely chemical composition or the orange/brown precipitate? (2 marks)

Iron III hydroxide OR $Fe(OH)_3$ (2) OR Hydrated Fe III Oxide [1 mark for $Fe(OH)_3$]

(b) Rank the three tubes 1 (the most corrosion) to 3 (the least corrosion). Place your ranking in the boxes above. (2 marks)

(c) Explain how the zinc strip and iron nail used above could be arranged to make an electrochemical cell that would produce an electric current. You can use any of the glassware usually available in a school laboratory. If you are using any other reagents to produce your cell you should note this. Include a labelled diagram of your electrochemical cell and give a detailed description of how it operates. (9 marks)



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$Zn(s) \rightleftharpoons Zn^{2+} + 2e$ $+0.76$

$Fe(s) \rightleftharpoons Fe^{2+} + 2e^-$ $+0.44$

OVERALL $Zn(s) + Fe^{2+}(aq) \rightleftharpoons Zn^{2+}(aq) + Fe(s)$ (1)

– Zn electrode dissolves as it oxidises (1)

– e^- released by zinc travel to iron electrode (1)

– e^- collect on surface of Fe; attract Fe^{2+} ions which are reduced to Fe solid (1)

– negative ions migrate towards zinc electrode to complete circuit. (1)

TOTAL 5 MARKS

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Question 43 **[9 marks]**

A 3.210 g sample of an organic compound containing the elements carbon, hydrogen and chlorine only is burnt in air. All of the water produced during the compounds combustion was absorbed by bubbling the gas mixture of combustion products through some pure sulfuric acid. As a result the sulfuric acid increases in mass by 0.6446 g.

(a) What is the mass of hydrogen in the sample of organic compound? (2 marks)

$m(H_2O) = 0.6446g$

$\therefore n(H_2O) = \frac{0.6446}{18.016} = 0.03578 mol$

$\therefore n(H) = 2 \times 0.03578 = 0.07156 mol$ (1)

$\therefore m(H) = 0.07156 \times 1.008 = 0.0721g$ (1)

The remaining products of combustion are then passed through a sodium hydroxide solution, thus absorbing any carbon dioxide present as sodium carbonate. Addition of excess calcium nitrate solution yields a precipitate of calcium carbonate. When washed and dried the resulting calcium carbonate was found to have a mass of 4.810 g.

(b) Determine the mass of carbon in the sample of organic compound. (3 marks)

$m(CaCO_3) = 4.810g$

$n(CaCO_3) = \frac{4.810}{100.09} = 0.04806 mol$ (1)

$\therefore n(C) = 0.04806 mol$ (1) (1)

$\therefore m(C) = 0.04806 \times 12.01 = 0.577g$

$M(CaCO_3)$: 40.08, 12.01, 48.00 → 100.09

(c) Determine the organic compound's empirical formula. (4 marks)

$m(Cl) = 3.210 - (m(C) + m(H))$

$= 3.210 - 0.5772 - 0.07213$

$= 2.561g$ (1)

	C	H	Cl
moles	$\frac{0.5772}{12.01}$	$\frac{0.07213}{1.008}$	$\frac{2.5607}{35.45}$
	0.0480	0.0716	0.0722 (1)
Ratio	$\frac{0.0480}{0.0480}$	$\frac{0.0716}{0.0480}$	$\frac{0.0722}{0.0480}$
	1	1.5	1.5 (1)
	2	3	3 (1)

$\therefore$ E.F is $C_2H_3Cl_3$

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