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Year 12 *Trial Exam Paper*

2016

CHEMISTRY

Written examination

Reading time: 15 minutes
Writing time: 2 hours 30 minutes

STUDENT NAME:

QUESTION AND ANSWER BOOK

Structure of book

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	30	30	30
B	12	12	90
			Total 120

- Students are permitted to bring the following items into the examination: pens, pencils, highlighters, erasers, sharpeners, rulers and one scientific calculator.
- Students are NOT permitted to bring sheets of paper or white out liquid/tape into the examination.

Materials provided

- The question and answer book of 35 pages.
- An answer sheet for multiple-choice questions.
- A data book

Instructions

- Remove the data book from this book during reading time.
- Write your **name** in the box provided.
- You must answer the questions in English.

At the end of the examination

- Place the multiple-choice answer sheet inside the front cover of this question and answer book.
- You may keep the data book

Students are NOT permitted to bring mobile phones or any other unauthorised electronic devices into the examination.

SECTION A – Multiple-choice questions

Instructions for Section A

Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.

Choose the response that is **correct** or that **best answers** the question.

A correct answer scores 1, an incorrect answer scores 0.

Marks will **not** be deducted for incorrect answers.

No marks will be given if more than one answer is completed for any question.

Use the following information to answer Questions 1 to 3.

The equation for the reaction between potassium permanganate and hydrochloric acid is

$$2KMnO_4(aq) + 16HCl(aq) \rightarrow 2MnCl_2(aq) + 5Cl_2(g) + 8H_2O(l) + 2KCl(aq)$$

Question 1

In a particular reaction, 10 mole of $KMnO_4$ is reacted with 72 mole of HCl. When this happens

A. $KMnO_4$ is in excess and 1 mole will remain unreacted.

B. HCl is in excess and 1 mole will remain unreacted.

C. HCl is in excess and 40 mole will remain unreacted.

D. HCl is in excess and 62 mole will remain unreacted.

Question 2

The volume of chlorine gas that can be formed at STP from the reaction of 0.562 mol of $KMnO_4$ will be, in L,

A. 12.5

B. 25.1

C. 31.5

D. 40.2

Question 3

In this reaction the oxidation number of manganese will

A. be unchanged since this is an acid/base reaction.

B. decrease from +6 to +2 as the manganese is reduced.

C. decrease from +7 to +2 as the manganese is oxidised.

D. decrease from +7 to +2 as the manganese is reduced.

Question 4

A 23 g sample of gas has a volume of 11.2 L at STP. What is the identity of the gas?

A. O_2

B. NO_2

C. O_3

D. SO_2

Question 5

A sample from a solution is poured into two separate test tubes.

A few drops of methyl red indicator are added to the first test tube and the solution turns yellow.

A few drops of phenol red indicator are added to the second test tube and the solution turns yellow.

Based on these observations, the pH of the solution

A. is lower than 6.3

B. is higher than 6.8

C. lies between 6.3 and 6.8

D. lies outside the range of 6.3 to 6.8

Question 6

The correct half-equation for the reaction of IO_4^- to IO_3^- is

A. $IO_4^-(aq) + 2H^+(aq) + 2e^- \rightarrow IO_3^-(aq) + H_2O(l)$

B. $IO_4^-(aq) + 2H^+(aq) + e^- \rightarrow IO_3^-(aq) + H_2O(l)$

C. $IO_4^- + 2H_2O(aq) + 2e^- \rightarrow IO_3^-(aq) + 4H^+(l)$

D. $IO_4^- + 2H^+(aq) \rightarrow 2e^- + IO_3^-(aq) + H_2O(l)$

Question 7

In an experiment, 80 mL of distilled water is added to 20 mL of 0.5 M HCl. The pH of the resulting solution will be

A. 0.3

B. 0.9

C. 1

D. 1.3

Question 8

A 1.40 g sample of ethene is reacted with excess steam in the presence of phosphoric acid. The mass of ethanol produced will be, in g,

A. 1.40

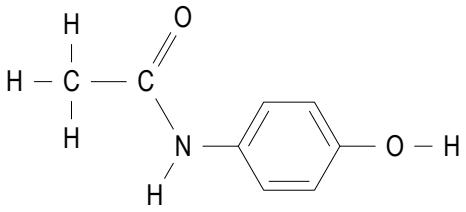
B. 1.70

C. 2.00

D. 2.30

Use the following information to answer Questions 9 and 10.

Paracetamol is a drug that is effective as a painkiller. Its chemical structure is drawn below.



Question 9

The amide functional group in this molecule

A. is present because paracetamol is a dipeptide.

B. could be made when an amine reacts with a carboxylic acid.

C. could be made when an amine reacts with an alkanol.

D. could be made when an amide reacts with a carboxylic acid.

Question 10

The molar mass of paracetamol is, in g mol^{-1},

A. 140

B. 147

C. 151

D. 153

Question 11

An organic compound has the empirical formula of CH_2O. The compound could be

A. ethanol.

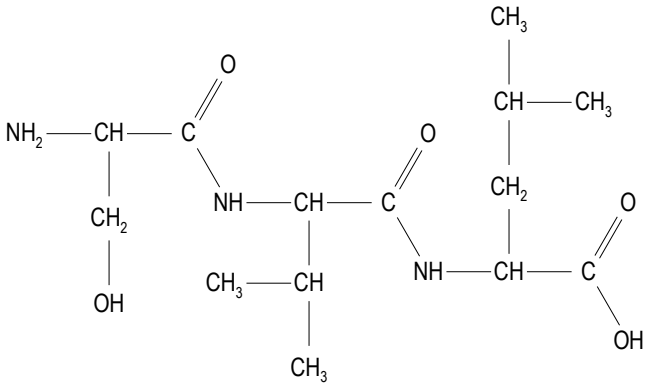
B. ethanoic acid.

C. stearic acid.

D. glycerol.

Use the following information to answer Questions 12 and 13.

A tripeptide is drawn below.



Question 12

The three amino acids used to form this tripeptide are, from left to right respectively,

A. serine, valine, leucine.

B. serine, leucine, valine.

C. serine, leucine, isoleucine.

D. threonine, valine, isoleucine.

Question 13

How many different tripeptides could be formed from these three amino acids?

A. 1

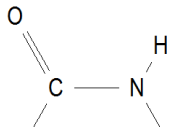
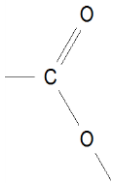
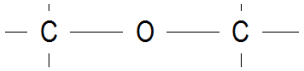
B. 2

C. 3

D. 6

Question 14

The three linkages shown below can all be found in biomolecules. Select the alternative that correctly states the biomolecule where the linkage is found.

			
A.	protein	polysaccharide	fatty acid
B.	protein	polysaccharide	ethanol
C.	amino acid	triglyceride	disaccharide
D.	protein	triglyceride	polysaccharide

Question 15

A molecule of biodiesel is formed from the reaction between ethanol and oleic acid. The molecular formula of the molecule formed will be

A. $C_{10}H_{20}O$

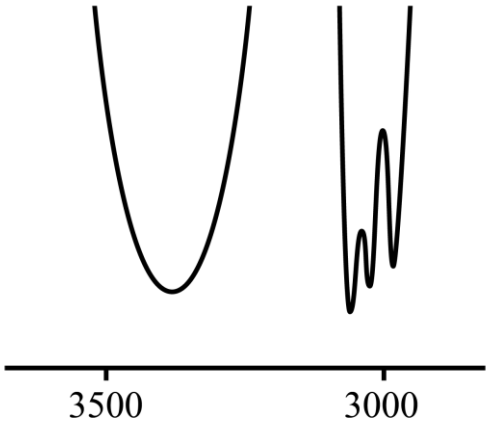
B. $C_{19}H_{38}O_2$

C. $C_{20}H_{38}O_2$

D. $C_{20}H_{40}O_2$

Question 16

A small segment of an infrared spectrum of a molecule is shown below.



Based on this segment, the molecule could be

A. propan-2-ol.

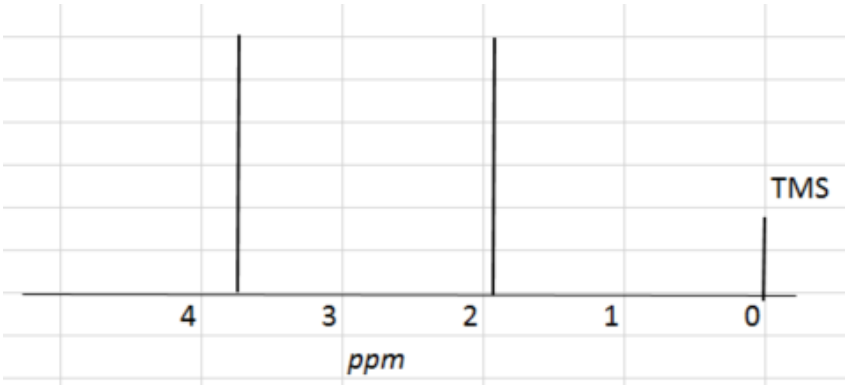
B. propanoic acid.

C. methyl propanoate.

D. butanoic acid.

Question 17

A high resolution proton NMR spectrum for a molecule is drawn below.



The molecule tested is

A. ethane.

B. ethanol.

C. methyl ethanoate.

D. ethanoic acid.

Question 18

A sample of nitrogen gas is sitting on a bench in a room at 26°C. The sample is moved into an oven that is set at 52°C.

Select the alternative that best compares the nitrogen particles at 52°C with the particles at 26°C.

A. All particles now have twice the kinetic energy as the temperature has been doubled.

B. The average kinetic energy is now double the initial value.

C. All particles are moving faster at the new temperature.

D. Many of the particles are moving faster at the higher temperature but not all.

Question 19

0.1 M solutions of the following three weak acids are compared at 25°C:

benzoic acid

ethanoic acid

methanoic acid

Which alternative correctly lists the acid with the highest value in each category?

	pH	$[H_3O^+]$	$[OH^-]$
A.	ethanoic	methanoic	methanoic
B.	ethanoic	benzoic	ethanoic
C.	methanoic	ethanoic	methanoic
D.	ethanoic	methanoic	ethanoic

Question 20

The pH of pure water is 7.0 at 25°C and it is 7.4 at 2°C. A correct conclusion that can be drawn from this information is that

A. the percentage ionisation of water increases as the temperature drops.

B. the self-ionisation of water is an endothermic reaction.

C. water becomes alkaline at low temperatures.

D. the $[OH^-]$ must be $10^{-6.6}$ at 2°C.

Question 21

In a particular reversible reaction two gaseous reactants combine to form a single gaseous product. The numerical value for the equilibrium constant for this reaction at 100°C is 0.5. An equilibrium mixture of the gases at 100°C is found to have the following concentrations:

Reactant I: 2 M

Reactant II: 2 M

Product: 2 M

From the data provided, the reaction in this question is most likely to be

A. $H_2(g) + I_2(g) \rightleftarrows 2HI(g)$

B. $C_2H_6(g) \rightleftarrows C_2H_4(g) + H_2(g)$

C. $2SO_2(g) + O_2(g) \rightleftarrows 2SO_3(g)$

D. $N_2(g) + 3H_2(g) \rightleftarrows 2NH_3(g)$

Question 22

Most forms of coal contain a high proportion of carbon. The equation for the combustion of carbon in air is:

$C(s) + O_2(g) \rightarrow CO_2(g)$

The amount of energy released by the combustion of 1.00 tonne (10^6 g) of carbon is closest to

A. 32.8 GJ

B. 394 kJ

C. 32.8 MJ

D. 3.28×10^4 kJ

Question 23

When 0.050 mol of sodium metal is added to water in a calorimeter, 18.3 kJ of energy is released.

What is the value of ΔH, in kJ mol^{-1}, for the reaction of sodium in water?

A. –366

B. –732

C. +732

D. –1830

Question 24

A 0.0020 mole sample of fuel is burnt completely, releasing 5750 J of energy. Identify the fuel used.

A. butane

B. ethanol

C. methane

D. hydrogen

Question 25

Alkaline cells have been in production since the 1960s. They are popular in devices that use high currents.

The overall equation for a zinc alkaline galvanic cell is:

$Zn(s) + 2MnO_2(s) \rightarrow ZnO(s) + Mn_2O_3(s)$

The anode half-equation in this cell is:

$Zn(s) + 2OH^-(aq) \rightarrow ZnO(s) + H_2O(l) + 2e^-$

The cathode half-equation is

A. $Mn_2O_3(s) + 2e^- \rightarrow 2MnO_2(s) + H_2O(l)$

B. $MnO_2(s) + H_2O(l) + e^- \rightarrow ZnO(s) + Mn_2O_3(s)$

C. $2MnO_2(s) + H_2O(l) \rightarrow 2OH^-(aq) + Mn_2O_3(s) + 2e^-$

D. $2MnO_2(s) + H_2O(l) + 2e^- \rightarrow 2OH^-(aq) + Mn_2O_3(s)$

Question 26

A student records the following observations from metal displacement reactions:

- When cadmium metal is added to cobalt chloride, $CoCl_2$, a reaction occurs.
- When cadmium metal is added to barium chloride, $BaCl_2$, no reaction occurs.

Based on this information, the strongest oxidant amongst these three substances will be

A. Co^{2+}

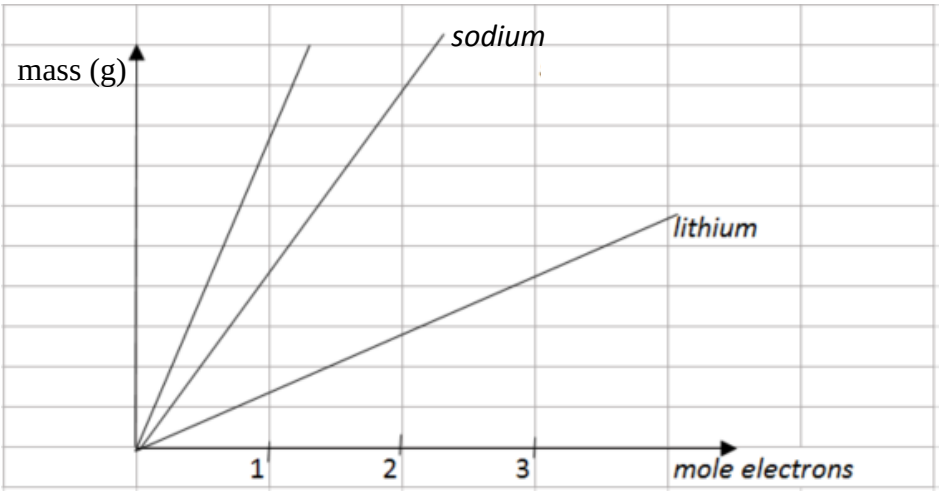
B. Co

C. Ba^{2+}

D. Ba

Use the following information to answer Questions 27 and 28.

Electrolysis is conducted on molten solutions of lithium, sodium and a third metal. The graph below shows the mass of each metal formed at the negative electrode as the amount of charge increases.



Question 27

Which of the following metals could be the third metal?

A. silver

B. magnesium

C. potassium

D. calcium

Question 28

The same data is used to plot a different graph that replaces mass on the vertical axis with number of mole of metal. On this graph

A. all metals should produce the same line.

B. the line for lithium should be the same as that of sodium.

C. the line for sodium should have a lower gradient than the line for lithium.

D. the line for sodium will still have a higher gradient than the line for lithium.

Question 29

The amount of charge passed through a molten ionic solution is 48 300 C. A metal is deposited at the cathode and the mass deposited is measured as 4.50 g.
The metal deposited is most likely to be

A. sodium.

B. calcium.

C. copper.

D. aluminium.

Question 30

Electrolysis of an aqueous ionic solution is observed to produce a gas at both electrodes. The solution could be

A. NaI(aq)

B. LiCl(aq)

C. $CuSO_4$(aq)

D. $ZnCl_2$(aq)

END OF SECTION A

SECTION B

Instructions for Section B

Answer **all** questions in the spaces provided. Write using black or blue pen.
To obtain full marks for your responses, you should:

- give simplified answers, with an appropriate number of significant figures, to all numerical questions; unsimplified answers will not be given full marks
- show all working in your answers to numerical questions; no marks will be given for an incorrect answer unless it is accompanied by details of the working
- make sure chemical equations are balanced and that the formulas for individual substances include an indication of state; for example, $H_2(g)$, NaCl(s).

Question 1 (11 marks)

A student is conducting an investigation into different methods for determining the concentration of sulfuric acid solutions. She tries two very different techniques as outlined below.

Method A: Gravimetric analysis. Barium nitrate solution is added to the sulfuric acid to produce a precipitate, which is then filtered, dried and weighed.

Method B: Volumetric analysis. A titration is conducted with 0.320 M NaOH solution.

a. For method A, the student adds 20.0 mL of the sulfuric acid solution to a beaker. She then adds 30 mL of 0.100 M barium nitrate, $Ba(NO_3)_2(aq)$.

The mass of dried precipitate formed is 0.444 g.

i. Write a balanced equation for the reaction occurring.

1 mark

_____

ii. Write a partial ionic equation for the reaction occurring.

1 mark

_____

iii. Use the data provided to determine the concentration of the sulfuric acid.

3 marks

b. For method B, 20.0 mL aliquots of sulfuric acid are used and the average titre of NaOH required is found to be 24.8 mL.

i. Write a balanced equation for the reaction occurring.

1 mark

ii. Use the data provided to determine the concentration of the sulfuric acid solution.

3 marks

c. The results obtained for **part b.** suggest a serious flaw in the procedure the student has used in **part a**.

i. Explain the problem with the procedure for **part a.**

1 mark

_____

_____

_____

_____

ii. What impact has this flaw had on the concentration of sulfuric acid obtained?

1 mark

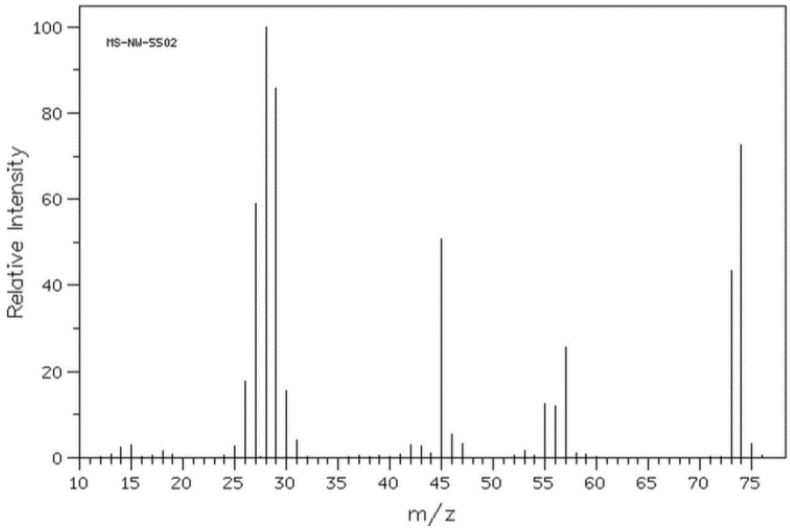
_____

_____

Question 2 (10 marks)

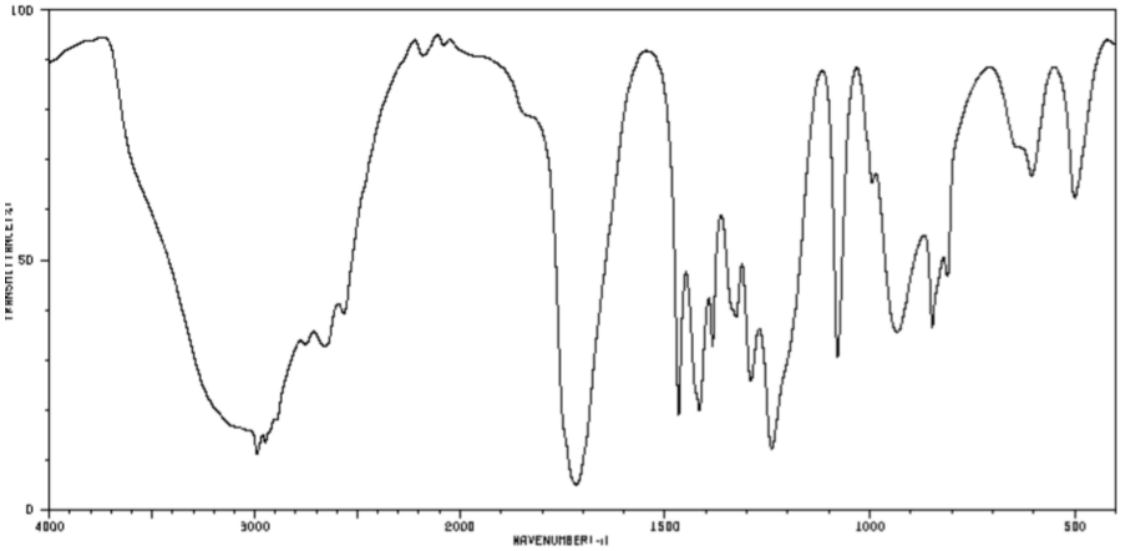
The empirical formula of an organic molecule is found to be $C_3H_6O_2$. The substance is tested further to enable its structure to be determined.
The spectra obtained are shown below. Use this information to answer the questions about the structure of this molecule.

Mass spectrum



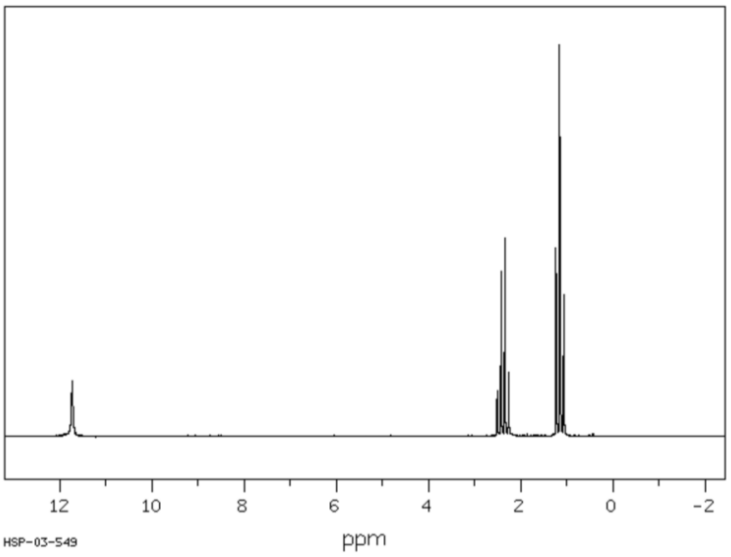
Source: http://sdbs.db.aist.go.jp/sdbs/cgi-bin/direct_frame_top.cgi

Infrared (IR) spectrum



Source: http://sdbs.db.aist.go.jp/sdbs/cgi-bin/direct_frame_top.cgi

^{1}H NMR spectrum



Source: http://sdbs.db.aist.go.jp/sdbs/cgi-bin/direct_frame_top.cgi

a. **i**. Suggest a fragment that could have caused the mass spectrum peak with an *m/z* ratio of 45.

1 mark

_____

ii. Based on the mass spectrum, what is the molecular formula of the molecule?

1 mark

_____

iii. Draw two possible structures with this molecular formula.

2 marks

b. Based on the IR spectrum, determine whether the molecule is a carboxylic acid or an ester. Provide a reason for your answer.

1 mark

_____

_____

_____

_____

c. Name the molecule in question.

1 mark

_____

d. **i**. What functional group has caused the NMR peak with a shift of 11.8 ppm?

1 mark

_____

ii. The ^{1}H NMR spectrum for this molecule shows three different hydrogen environments.
Refer to the molecule to explain the splitting pattern on the NMR spectrum.

3 marks

_____

_____

_____

_____

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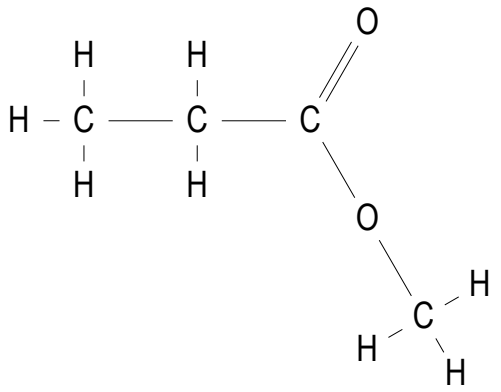
Question 3 (9 marks)

The molecule shown below is an ester molecule.



a. **i**. Name this ester.

1 mark

_____

ii. What is the empirical formula of the ester?

1 mark

_____

b. **i**. The ester was made from the reaction between an alkanol and a carboxylic acid. Draw both molecules in the boxes provided below.

2 marks

alkanol	carboxylic acid

ii. Write a balanced equation for the reaction between these two molecules, showing the catalyst required.

2 marks

_____

_____

c. Write a balanced chemical equation for the complete combustion of the alkanol in **part b.**

1 mark

_____

_____

d. **i.** Write a balanced equation, using semi-structural formulas, for the reaction of the carboxylic acid in **part b.** and water.

1 mark

_____

_____

ii. Write an expression for K_a for this reaction.

1 mark

_____

_____

Question 4 (7 marks)

Hydrogen peroxide is a colourless liquid with a chemical formula of H_2O_2. It is an effective disinfectant and bleach, used to whiten teeth or hair.

The oxidation state of hydrogen in hydrogen peroxide is +1.

a. What is the oxidation state of oxygen in hydrogen peroxide?

1 mark

_____

b. Hydrogen peroxide appears in two different half-equations on the electrochemical series.

i. Use the electrochemical series to write a balanced equation for the decomposition of hydrogen peroxide.

2 marks

_____

_____

_____

ii. Hydrogen peroxide is considered relatively stable, especially if stored carefully. Suggest a reason why it can be stored despite the evidence of the electrochemical series.

1 mark

_____

iii. List one action to take to prolong the shelf-life of hydrogen peroxide. Use collision theory to explain your action.

1 mark

_____

_____

_____

c. The addition of crushed potato to hydrogen peroxide leads to a more rapid decomposition.

Explain how the addition of the potato is able to change the rate of decomposition.

2 marks

_____

_____

Question 5 (8 marks)

Give a concise explanation for each of the following.

a. The molar mass of glucose is 180 g mol^{-1}. However, if two glucose molecules combine, then the molar mass of the disaccharide formed is not 360 g mol^{-1}.

2 marks

_____

_____

_____

b. Biodiesel can be used in diesel cars in place of traditional diesel. If the biodiesel molecules are formed from plant oils, the biodiesel can be used in cold climates of Australia. If the biodiesel is formed from animal fats, it is not suited to use in cold climates.

2 marks

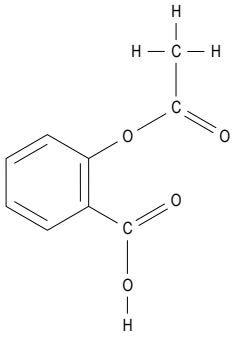
_____

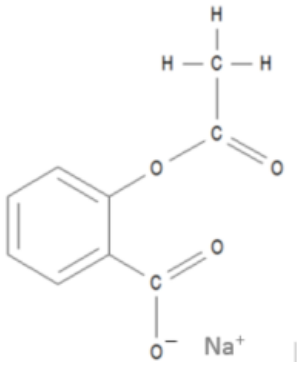
_____

_____

c. The structure of aspirin is shown on the left below. Aspirin can be reacted with sodium hydrogen carbonate to form the sodium salt shown on the right below. This salt is marketed as a 'fast-action' painkiller because it takes less time to affect the human body than normal aspirin.

2 marks





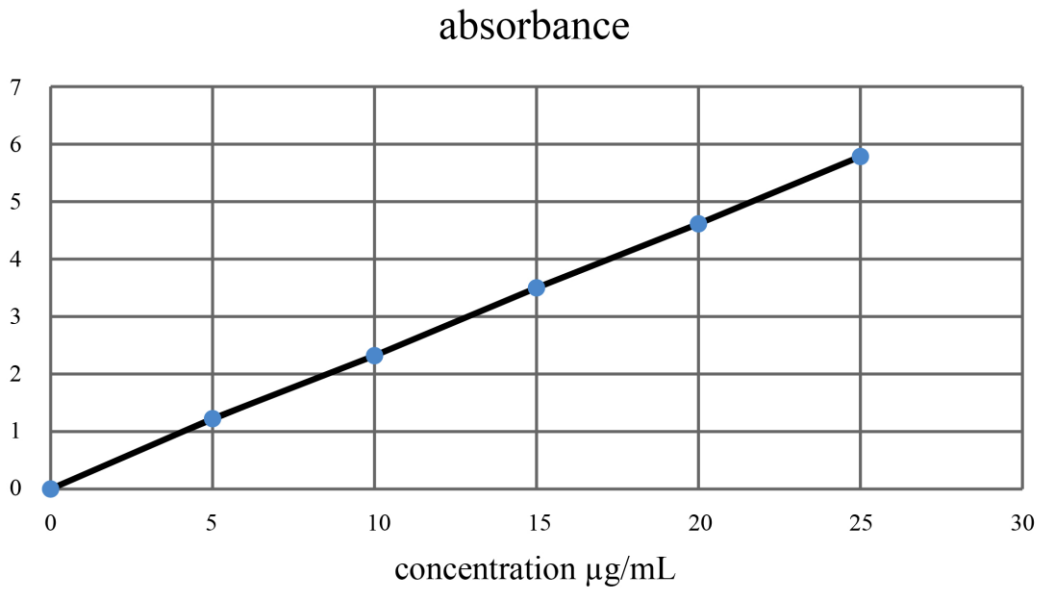
d. The melting point of two separate strands of DNA is compared. Both strands contain 20 base units but one strand has a significantly higher melting point than the other.

2 marks

Question 6 (3 marks)

Many old paints contained lead. The lead concentration can be determined by dissolving the paint in sulfuric acid and testing the solution using atomic absorption spectroscopy (AAS).

The calibration curve below has been drawn from testing the absorption of a series of standard lead solutions.



A 2.0 g sample of paint is dissolved in acid and made up to the mark in a 100.0 mL volumetric flask.

The absorbance of this solution is 4.1

a. What is the lead concentration in this sample?

1 mark

_____

b. Determine the mass of lead, in mg, in the solution.

1 mark

_____

c. Calculate the percentage of lead in the paint.

1 mark

_____

Question 7 (4 marks)

The equation for the decomposition of phosgene, $COCl_2$, is:

$$COCl_2(g) \rightleftarrows CO(g) + Cl_2(g)$$

a. In an experiment, 0.50 mol of phosgene and 0.60 mol of chlorine gas are added to a 1.0 litre reactor. At equilibrium the amount of chlorine is found to be 0.68 mole.

Calculate the value of the equilibrium constant, *K*.

3 marks

b. The amount of chlorine in another equilibrium mixture is found to be 0.46 mol. The volume is changed and the amount of chlorine is measured as 0.42 mol when equilibrium is re-established.

Was the change an increase or decrease in volume? Explain your answer.

1 mark

Question 8 (7 marks)

Hypochlorous acid, HOCl, is a weak acid.

a. Write a balanced equation for the reaction of hypochlorous acid in water.

1 mark

_____

b. **i**. Use the K_a value in your data book to complete the table below.

Assume the temperature is 25°C.

Assume the equilibrium HOCl concentration is equal to the initial concentration.

4 marks

_____

_____

_____

_____

_____

_____

_____

_____

[HOCl] M	**$[H_3O^+]$ (M)**	**Percentage ionisation**
0.1		
0.0001		

ii. To complete the table in **part b.i.**, you made the assumption that the initial and equilibrium concentrations of HOCl were the same. Use the values in the table to comment on whether this assumption can be justified.

2 marks

_____

_____

_____

Question 9 (5 marks)

A biogas generator is built at a metropolitan sewage works. The gas generated is purified and passed into a methane fuel cell to produce electrical energy.

a. **i**. What is biogas?

1 mark

_____

_____

ii. Explain why biogas is considered a renewable fuel.

1 mark

_____

b. Assuming the fuel cell is operating in alkaline conditions, write balanced equations or half-equations for the

i. reaction at the anode: _____

1 mark

ii. reaction at the cathode: _____

1 mark

iii. overall equation: _____

1 mark

Question 10 (9 marks)

When an acid and a base react, energy is released. For the reaction between hydrochloric acid and sodium hydroxide solutions the equation and heat of neutralisation is:

$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l) \qquad \Delta H = -57.2 \text{ kJ mol}^{-1}$

a. When nitric acid, HNO_3, and potassium hydroxide, KOH, are reacted, the heat of neutralisation should be the same value as that of hydrochloric acid and sodium hydroxide.

Write partial ionic equations for both reactions to explain why the value of ΔH should be the same.

2 marks

_____

_____

_____

_____

b. In a particular experiment performed in a calorimeter at a starting temperature of 25°C, 50.0 mL of 0.128 M hydrochloric acid is to be added to 40.0 mL of 0.136 M sodium hydroxide.

i. What is the pH of the sodium hydroxide solution before the solutions are mixed?

2 marks

_____

_____

ii. Calculate the amount of energy that will be released in the reaction.

3 marks

_____

_____

_____

_____

iii. Calculate the temperature change expected in the calorimeter.

2 marks

_____

_____

Question 11 (8 marks)

An experimental galvanic cell is being trialled that uses lithium metal and sulfur as reactants. The overall equation for the reaction in the cell is:

$$16Li + S_8 \rightarrow 8Li_2S$$

States are not shown in this equation as a polymer electrolyte is used in the cell, rather than an aqueous solution. The cell produces a voltage of 2.4 volts, it is light in weight and the reactants are relatively cheap.

a. Explain why an aqueous solution is not used in this cell. Include a balanced equation to justify your answer.

2 marks

_____

_____

b. Write balanced half-equations for the reactions occurring at the anode and the cathode in this cell.

2 marks

anode: _____

cathode: _____

c. This cell is rechargeable. Write a balanced equation for the recharging reaction in this cell.

1 mark

_____

d. In one trial the cell produces a current of 2.5 amps for 15 minutes. Calculate the mass change at the lithium electrode during this time.

3 marks

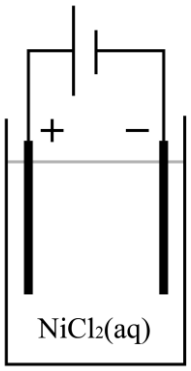
_____

_____

_____

Question 12 (9 marks)

Graphite electrodes are placed into a dilute nickel(II) chloride solution and a power supply is connected.



a. Use the electrochemical series to predict the reactions that will occur in this cell when the power supply is switched on.

4 marks

_____

_____

_____

anode: _____

cathode: _____

overall equation: _____

b. Describe what you will observe happening at each electrode.

2 marks

anode: _____

_____

cathode: _____

_____

c. The circuit operates until 2.50 g of nickel has been deposited. Calculate the volume of gas produced if the cell is running at SLC conditions.

3 marks

_____

_____

_____

_____

END OF QUESTION AND ANSWER BOOKLET