EXP

PUNGGOL SECONDARY SCHOOL
SECONDARY 4
EXPRESS
2024 PRELIMINARY EXAMINATION

QUESTION & ANSWER BOOKLET

NAME			
CLASS		INDEX NUMBER	

Chemistry **6092**

Paper 2

26 August 2024

1 hour 45 minutes

READ THESE INSTRUCTIONS FIRST

Write your class, register number and name on all the work you hand in.
Write in dark blue or black ink on both sides of the paper.
You may use a soft pencil for any diagrams, graphs, tables or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A (70 marks)
Answer **all** questions.

Section B (10marks)
Answer **one** question.

Write your answers in the spaces provided.
A copy of the Periodic Table is printed on page 25.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.
The use of an approved scientific calculator is expected, where appropriate**.**

For Examiner's use	
Section A	/70
Section B	/10
-	-
Total	/80

Parent's Signature

This paper consists of **25** printed pages and **1** blank page.

Section A

Answer **all** the questions in the spaces provided.

1 The list below shows the chemical formulae of some compounds.

NH_4Cl	Na_2CO_3	CaI_2
$ZnCl_2$	$CaCl_2$	V_2O_5
PbO	$Al(NO_3)_3$	SiO_2

(a) State one aqueous substance that produces a white precipitate that is soluble in excess aqueous ammonia.

…….. [1]

(b) State one substance that reacts with both an acid and an alkali.

…….. [1]

(c) Contact process is the industrial process used to make sulfuric acid. State one substance that can be used to catalyse contact process.

…….. [1]

(d) **(i)** State one substance that reacts with aqueous sodium hydroxide on heating to give a pungent gas that turns moist red litmus paper blue.

…….. [1]

(ii) Write an equation for the reaction in **(d)(i)**.

…….... [1]

[Total: 5]

2 The composition of three isotopes of an element, **G**, is shown in the **Table 2.1** below.

Table 2.1

particle	number of protons	number of electrons	number of neutrons
G_1		16	16
G_2			18
G_3		16	

G_1 is electrically neutral.
G_2 is negatively charged, with a fully filled valence electron shell.
The mass number of G_3 is higher than that of G_1 by 4.

(a) Define isotopes.

……

…… [1]

(b) **(i)** Use the information provided to complete **Table 2.1**. [2]

(ii) Determine the nuclide notation of atom G_2, showing clearly the chemical symbol found in Periodic Table, mass number and proton number in your answer.

…… [1]

[Total: 4]

3 **Fig 3.1** shows a set-up for measuring the rates of diffusion of gases at a constant temperature. The rate of diffusion is measured in terms of the time taken for the water level to rise from **A** to **B** as the gas diffuses out of the diffusion plug.

.

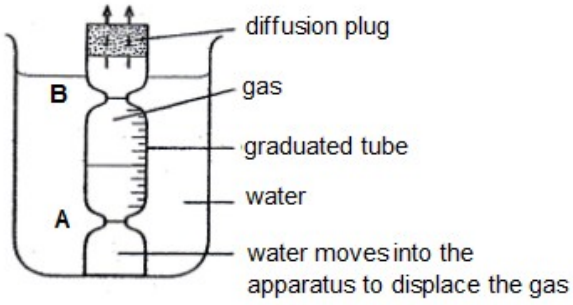


Fig 3.1

Table 3.1 shows the results of this experiment.

Table 3.1

gases	time/s	relative molecular mass
carbon monoxide, CO	119	
chlorine, Cl_2	190	
methane, CH_4	90	
oxygen, O_2	127	

(a) (i) Complete **Table 3.1** with the relative molecular mass of the gases. [1]

(ii) Peter makes this conclusion:

"The time taken for the water level to rise from **A** to **B** is directly proportional to the relative molecular mass of each gas."

Do the measurements obtained in the experiment support this conclusion?

Explain your reasoning.

[2]

(b) Jane repeated the experiment with sulfur dioxide gas. She found that the time taken for the water level to rise from **A** to **B** is 72 seconds.

Using the data in **Table 3.1** and relative molecular mass of sulfur dioxide, predict the time taken for the water level to rise from **A** to **B** for sulfur dioxide gas. Explain the deviation of the actual time taken from your prediction.

……..

……..

…….. [2]

[Total: 5]

4 Brick-red copper(I) oxide dissolves in dilute sulfuric acid to produce copper(II) sulfate, copper metal and water as shown in the equation below.

$$Cu_2O\ (s)\ +\ H_2SO_4\ (aq) \rightarrow Cu(s)\ +\ CuSO_4\ (aq)\ +\ H_2O(l)$$

(a) A disproportionation reaction is a redox reaction in which one substance is simultaneously oxidised and reduced.

In terms of oxidation states, explain why the reaction between copper(I) oxide and sulfuric acid is a disproportionation reaction.

……..

……

……..

……..

……

…… [3]

(b) (i) Paramelaconite is a rare, dark coloured oxide of copper that was discovered in Arizona in 1890.

Paramelaconite has the following percentage composition by mass:

Cu: 84.1% O: 15.9%

The relative molecular mass of paramelaconite is 304. Prove that the molecular formula of paramelaconite is Cu_4O_3.

[2]

(ii) Paramelaconite reacts with sulfuric acid to undergo a disproportionation reaction.

The word equation for the reaction is as shown.

paramelaconite + sulfuric acid → copper(I) oxide + copper(II) sulfate + water

Complete the balanced equation for the reaction.

Cu_4O_3 + …… → ……..…….. + …… + …… [1]

[Total: 6]

5 Chromium can be used as a protective metal for both steel and pure iron.

Stainless steel is an alloy of iron which contains approximately 20% chromium mixed with iron and some small amounts of other metals.

Fig 5.1 shows the arrangement of atoms in stainless steel.

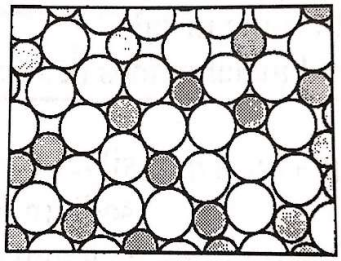


Fig. 5.1

When chromium metal is added to nitric acid, rapid effervescence is observed. However, effervescence stops after a short while when chromium is added to sulfuric acid.

(a) Stainless steel is harder than pure iron.
Use ideas about the arrangement of atoms in stainless steel to explain why.

……..

……

…… [2]

(b) **(i)** Describe a test for the gas produced when chromium metal is added to nitric acid. State the observation.

……..

…… [1]

(ii) Using information provided on the reaction between chromium and sulfuric acid, predict and explain the solubility of chromium sulfate in water.

……..

……..

……..

…….. [2]

(iii) Using your answer in **(b)(ii)**, describe a method to prepare pure and dry chromium sulfate salt.

……..

……..

……..

……..

…….. [2]

(c) The chromium in the stainless steel reacts with oxygen in the air to form chromium(III) oxide. Chromium(III) oxide forms a layer on the surface of the stainless steel. This layer stops the iron in the stainless steel from rusting.

Suggest how the layer of chromium(III) oxide stops the iron in the stainless steel from rusting.

……..

…….. [1]

(d) **(i)** Using the information provided on the reaction of chromium metal with nitric acid, deduce and explain the relative reactivity of chromium and iron.

……..

……..

…….. [2]

(ii) Door handles and trims on some cars are made from iron coated with chromium.

If the chromium coating is scratched, would you expect the iron underneath to rust? Explain your answer.

……..

…….. [1]

[Total: 11]

6 Lithium aluminium hydride, $LiAlH_4$ and trimethylamine, $(CH_3)_3N$ react to give the compound with the formula, $(CH_3)_3NAlH_3$.

The reaction occurs in three steps shown below.

Step 1: $AlH_4^- + FeCl_3 \rightarrow AlH_3 + AlHCl_3^-$
Step 2: $AlHCl_3^- + Li^+ \rightarrow FeCl_3 + LiH$
Step 3: $AlH_3 + (CH_3)_3N \rightarrow (CH_3)_3NAlH_3$

(a) (i) Iron(III) chloride is the catalyst for this reaction. Use the equations to explain why iron(III) chloride acts as the catalyst.

……..

…….. [1]

(ii) Explain, in terms of collisions and energy, why iron(III) chloride increases the rate of reaction between lithium aluminium hydride and trimethylamine,

……..

……..

……..

……..

…….. [2]

(b) (i) The structure of the product compound, $(CH_3)_3NAlH_3$ is shown in **Fig 6.1**.

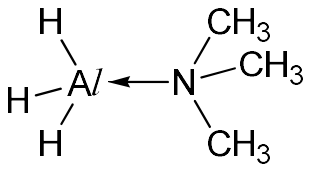


Fig 6.1

What is unusual about the bond indicated by an arrow?

……..

……. [1]

(ii) Boron trifluoride, BF_3 has a melting point of –127 °C and does not conduct electricity in molten state.

Name the structure of boron trifluoride.

…….. [1]

(iii) Boron trifluoride reacts with ammonia to form a product compound similar to the compound shown in **Fig 6.1**.

Using your answer in **(b)(ii)**, draw the structure of the product. Include in your structure the bond represented by the arrow.

[1]

[Total: 6]

7 Bioethanol is a type of alcohol that is obtained from different types of plants rich in cellulose such as sugar cane. Today, the leading country in the production and consumption of bioethanol is Brazil.

The enthalpy change and chemical equation for the reaction of 2 moles of ethanol with oxygen is shown below.

$$2CH_3CH_2OH(l) + 7O_2(g) \rightarrow 4CO_2(g) + 6H_2O(l) \quad \Delta H = -2736 \text{ kJ}$$

(a) Explain, in terms of bond breaking and bond making, why this reaction is exothermic.

……..

……..

…….

……. [2]

(b) **(i)** Calculate the enthalpy change for the reaction for **one mole** of ethanol.

enthalpy change for one mole of ethanol: …….. kJ/mol [1]

(ii) Draw an energy profile diagram for the reaction of 1 mole of ethanol with excess oxygen. Indicate the enthalpy change, ΔH, and activation energy, E_a, on the diagram clearly.

[2]

(c) **(i)** Explain why burning ethanol made from sugarcane causes less harm to the environment than burning ethanol made from ethene.

……..

……..

…….. [1]

(ii) Explain why ethanol obtained from sugarcane is a renewable fuel and that made from ethene obtained from crude oil is a non-renewable fuel.

……..

……..

……..

…….. [2]

(iii) State one disadvantage of using bioethanol as a source of fuel.

……..

……... [1]

[Total: 9]

8 **Fig 8.1** shows the carbon cycle.

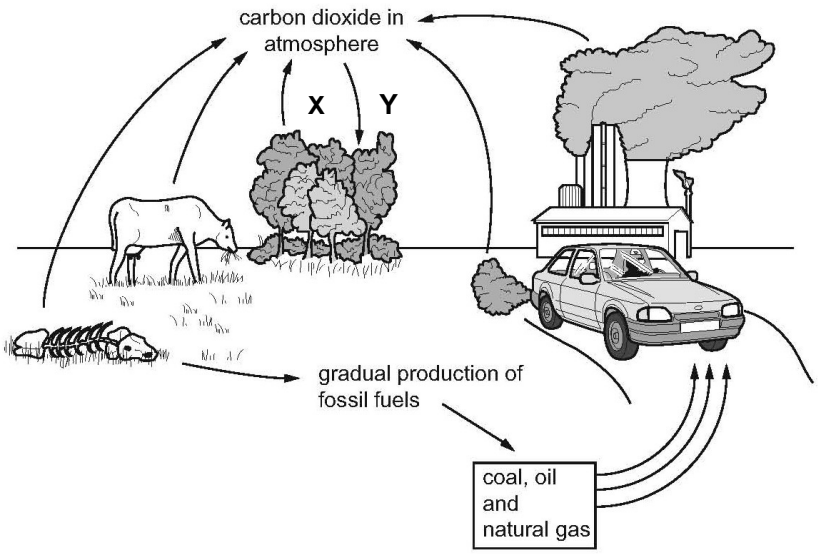


Fig 8.1

(a) **(i)** Name the processes labelled **X** and **Y** in **Fig 8.1**.

X: ……..

Y: …….. [1]

(ii) Explain how the processes of **X** and **Y** help to regulate the amount of carbon dioxide in the atmosphere.

……..

……..

……..

……..

…….. [2]

(b) Carbon dioxide is emitted in large amounts as shown in **Fig 8.1**. Describe how large amounts of carbon dioxide in the atmosphere lead to flooding of low-lying lands.

……..

…….. [1]

[Total: 4]

9 An industrial method for the production of ethanol, C_2H_5OH, is outlined in **Fig 9.1**.

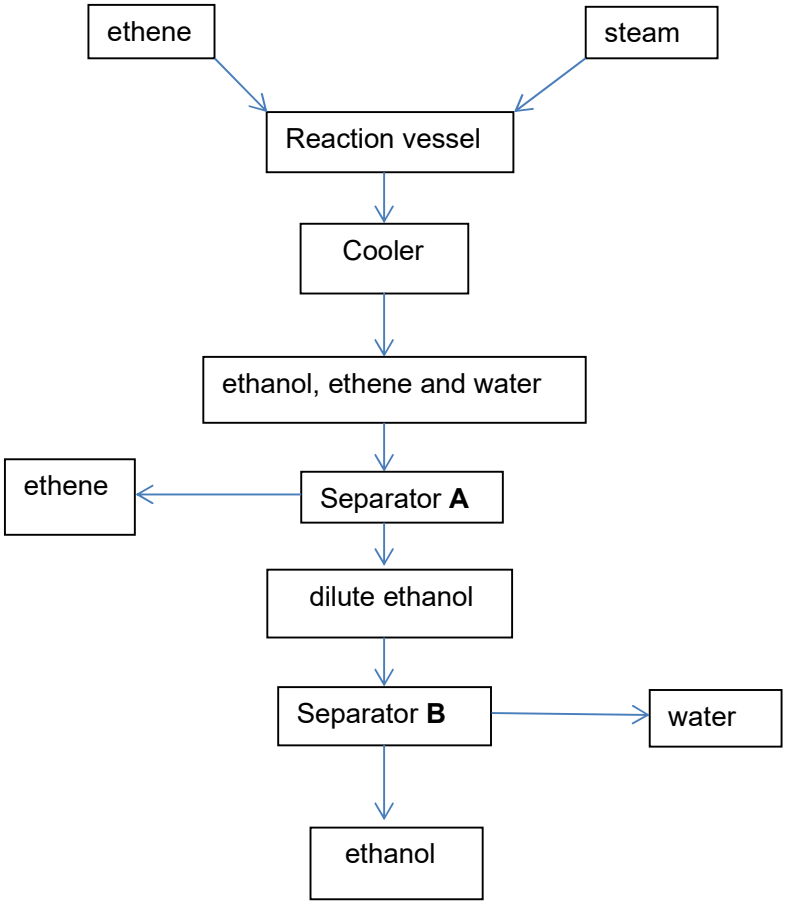


Fig 9.1

(a) **(i)** Ethene is separated out from separator **A** to pump back to the reaction vessel. Suggest an advantage for this.

……

…… [1]

(ii) Name the separation process that occurs at separator **B**.

…… [1]

(b) **(i)** If 8.4 kg of ethanol is produced from 10.0 kg of ethene, calculate the percentage yield of ethanol.

[2]

(ii) Suggest a reason to account for the low percentage yield of ethanol calculated in **(b)(i)**.

…….. [1]

(c) The structural formula of dichloroethene is shown in **Fig. 9.2**.

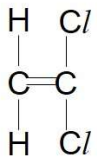


Fig 9.2

(i) Dichloroethene can be made from ethene using chlorine under certain conditions.

State the type of reaction.

…….. [1]

(ii) Dichloroethene is used to make poly(dichloroethene) which is a plastic used for wrapping food.

Draw the structure of poly(dichloroethene) in the space provided.

[1]

(iii) The melting point range of poly(dichloroethene) is from 140 °C to 260 °C. The melting point range of poly(ethene) is from 120 °C to 130 °C.

In term of structure and bonding, explain the difference in melting point range between poly(dichloroethene) and poly(ethene).

……..

……..

……..

……..

……..

…….. [2]

(iv) Cracking is a chemical method for recycling plastics such as poly(dichloroethane) and poly(ethene). State the advantage of this method.

……..

…….. [1]

[Total: 10]

10 Water Chemistry of Aquarium

Water chemistry plays an important role in aquarium and governing every factor within the aquarium directly affects the health of fishes and aquatic plants. Water from the tap can be unfit for direct use in the aquarium. In these cases, tap water may need to be adjusted to the needs of the species of fish or plants in the aquarium.

For disinfection purposes, chlorine, Cl_2, and chloroamine, NH_2Cl, are introduced into tap water to destroy bacteria and viruses. However, these two chlorine-containing compounds are extremely harmful to fishes as they cause gill burns and blood poisoning.

Table 10.1 shows the concentration of some substances found in one sample of tap water after adding chlorine and chloroamine.

Table 10.1

substances	average reading / g/dm^3
$Cl_2(aq)$	0.023
$NH_2Cl(aq)$	0.020
PO_4^{3-}	12.1
Ca^{2+}	62.1
CO_3^{2-}	31.1
HCO_3^-	42.5

Hardness of aquarium water

The degree of water hardness relates to the amount of dissolved minerals, especially calcium ions. It is important to monitor water hardness in aquariums as excessively soft water can cause problems such as breathing difficulty in fishes. The ideal hardness of aquarium water is moderately hard according to the classification shown in **Table 10.2**.

Table 10.2

concentration of Ca^{2+} ions mol/dm^3	classification of hardness of water
below 1.9	soft
1.9 to 3.8	moderately hard
3.8 to 7.6	hard
above 7.6	extremely hard

Changing water in aquarium

During a water change, a water conditioner containing thiosulfate ions, $S_2O_3^{2-}$, is added to the tank to remove both the aqueous chlorine and chloroamine present in tap water which are introduced into tap water to destroy bacteria and viruses.

The equation for the reaction that occurs between chloroamine and thiosulfate ion is given below:

$$NH_2Cl + 2S_2O_3^{2-} + H_2O \rightarrow NH_3 + Cl^- + S_4O_6^{2-} + OH^-$$

dKH of aquarium water

Most fishes survive well in aquarium water at pH levels between 6.5 to 8.0. To maintain pH of aquarium water, the water usually contains carbonate ions, CO_3^{2-}, and hydrogen carbonate ions, HCO_3^-.

When a small amount of excess acid is present, the excess H^+ ions are removed by CO_3^{2-}:

$$CO_3^{2-}(aq) + H^+(aq) \rightarrow HCO_3^-(aq)$$

When a small amount of excess alkali is present, the excess OH^- ions are removed by HCO_3^-:

$$HCO_3^-(aq) + OH^-(aq) \rightarrow CO_3^{2-}(aq) + H_2O(l)$$

dKH measures the amount of carbonates in water, which affects the ability of the aquarium water to resist a sudden change in pH. One dKH is equivalent to 10.7 g/dm^3 of carbonate ions.

Extraction of bromine from seawater

If the fishes in the aquarium are seawater species, seawater is sometimes used as the aquarium water. However, seawater contains a low concentration of bromide ions which is harmful to some species of seawater fishes. Bromide ions are commercially removed from seawater by the following series of steps. Liquid bromine extracted is sold for commercial profit.

1	Chlorine is passed into acidified seawater and bromine is formed which is then removed in a stream of air. The concentration of bromine in the gas phase is too low at this stage for it to be condensed efficiently.
2	Thereafter, the bromine produced is converted to hydrogen bromide by adding sulfur dioxide and a small excess of water vapour. $Br_2(g) + SO_2(g) + 2H_2O(g) \rightarrow 2HBr(g) + H_2SO_4(g)$ A moderately concentrated aqueous mixture of hydrobromic and sulfuric acids is obtained and the vapour is cooled and condensed.
3	The concentrated mixture of acids is treated with chlorine and steam, producing bromine vapour from which liquid bromine is condensed on cooling. The sulfuric acid remains in the solution.
4	The crude bromine is purified by fractional distillation.

(a) Using the data from **Table 10.1** and **Table 10.2**, calculate the concentration of calcium ions in mol/dm^3, and determine whether the sample of tap water in **Table 10.1** has the hardness ideal for aquarium water.

[1]

(b) **(i)** When changing aquarium water, thiosulfate ions are added to the tank to remove both the aqueous chlorine and chloroamine present in tap water. Aqueous chlorine reacts with thiosulfate ions in a similar manner as chloroamine, NH_2Cl.

Write an equation for the reaction that occurs between chlorine, Cl_2, and thiosulfate ion, $S_2O_3^{2-}$.

…….. [1]

(ii) A rectangular tank typically can hold 360 dm^3 of water.

Calculate the volume of a 0.010 mol/dm^3 sodium thiosulfate solution that would be required for a 50% water change in the tank with the sample of tap water in **Table 10.1** to remove both the aqueous chlorine and chloroamine present.

[3]

(c) Calculate the dKH of the water after 186 mol of hydrogen ions, H^+, are added to 360 dm^3 of the sample of tap water in **Table 10.1**. Excess H^+ ions are removed by CO_3^{2-} present in the tap water.

Assume that only carbonate ions react with hydrogen ions in the sample of tap water.

[2]

(d) **(i)** With reference to **step 1** of the extraction of bromine from seawater, explain why chlorine can be used to obtain bromine from bromide ions in seawater.

……..

……..

…….. [2]

(ii) Suggest the purpose of introducing steam into the mixture in **step 3** of the extraction of bromine from seawater.

……..

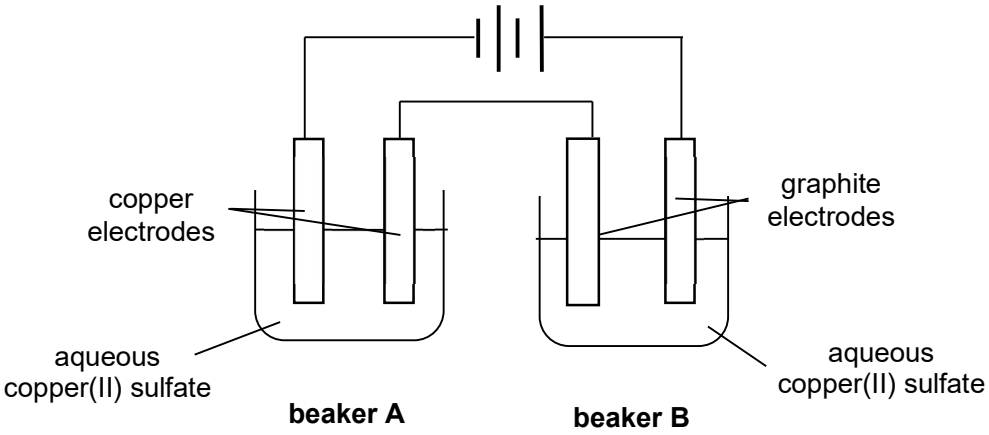
…….. [1]

[Total: 10]

Section B

Answer **one** question from this section.

11 A student sets up an experiment to study the effect of graphite and copper electrodes in the electrolysis of aqueous copper(II) sulfate.



(a) Graphite electrodes are inert. What is meant by “inert”?

…….. [1]

(b) With the aid of half equations, describe and explain the observations at the anodes of both beakers.

……..

……..

……..

……..

……..

……..

…….. [2]

(c) The mass of the substance (m) deposited or liberated at any electrode is directly proportional to the quantity of electricity or charge (Q) passed. In the experiment, 193000 coulomb of charge (Q) passed through the circuit. These charges are carried by electrons.

Given that the Faraday's constant is 96 500 coulomb per mole and using the following equation:

Q = number of moles of electrons x Faraday's constant

(i) Calculate the number of moles of electrons supplied.

[1]

(ii) Using your answer in **(c)(i)**, calculate the mass of copper formed at the cathode of beaker **B**.

[2]

(iii) After a long time, it was observed that the anode in beaker **B** decreased slightly in size. With the aid of an equation, including state symbols, explain the observation.

……..

……. [2]

(d) The student repeated the experiment with aqueous potassium sulfate as the electrolyte in both beakers and added a few drops of Universal Indicator at the start of the experiment.

Describe the change in the solution colour at the anode of beaker **B**. Explain your answer.

……..

……..

…….. [2]

[Total: 10]

12 The strength of an acid can be indicated by its dissociation constant. The larger the dissociation constant value, the stronger the acid. The dissociation constant values for some organic acids are given in **Table 12.1**.

Table 12.1

Acid	Dissociation constant
methanoic acid, HCOOH	1.8×10^{-4}
ethanoic acid, CH_3COOH	1.75×10^{-5}
propanoic acid C_2H_5COOH	1.34×10^{-5}
oxalic acid, HOOCCOOH	5.9×10^{-2}

(a) (i) Based on the dissociation constant, state the strongest acid in **Table 12.1**.

…….. [1]

(ii) In terms of the structure of the acids and concentration of hydrogen ions, explain your answer in **(a)(i)**.

……..

……..

……..

…….. [2]

(iii) Suggest a value for the dissociation constant for butanoic acid.

…….. [1]

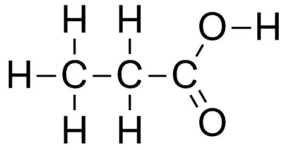
(b) *"Oxalic acid is a member of the carboxylic homologous series."*

Give one piece of evidence that agrees and disagrees with the statement above.

Agree	
Disagree	

[2]

(c) (i) The diagram shows the structural formula of propanoic acid.



Name the reagent and condition needed to produce ethyl propanoate from propanoic acid. Draw the full structural formula of ethyl propanoate.

Reagent and condition:

……..

……..

Full structural formula of ethyl propanoate:

[3]

(ii) State the reagent and condition to convert ethyl propanoate back to its alcohol and carboxylic acid.

…….. [1]

[Total: 10]

End of paper

The Periodic Table of Elements

Group																	
1	2											13	14	15	16	17	18
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9		Key proton (atomic) number atomic symbol name relative atomic mass									5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24	3	4	5	6	7	8	9	10	11	12	13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

The Avogadro constant, $L = 6.02 \times 10^{23}$ mol^{-1}