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Student Number



Barker
College

2022

TRIAL HIGHER SCHOOL
CERTIFICATE EXAMINATION

Chemistry

AM WEDNESDAY 10th AUGUST

106 copies

Section I - Multiple Choice

Choose the best response and fill in the response oval completely

Start
Here →

- 1 A ○ B ○ C ○ D ○
2 A ○ B ○ C ○ D ○
3 A ○ B ○ C ○ D ○
4 A ○ B ○ C ○ D ○
5 A ○ B ○ C ○ D ○
6 A ○ B ○ C ○ D ○
7 A ○ B ○ C ○ D ○
8 A ○ B ○ C ○ D ○
9 A ○ B ○ C ○ D ○
10 A ○ B ○ C ○ D ○

- 11 A ○ B ○ C ○ D ○
12 A ○ B ○ C ○ D ○
13 A ○ B ○ C ○ D ○
14 A ○ B ○ C ○ D ○
15 A ○ B ○ C ○ D ○
16 A ○ B ○ C ○ D ○
17 A ○ B ○ C ○ D ○
18 A ○ B ○ C ○ D ○
19 A ○ B ○ C ○ D ○
20 A ○ B ○ C ○ D ○

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CERTIFICATE EXAMINATION

Chemistry

Staff Involved:

AM WEDNESDAY 10th AUGUST

- NJD*
- DLM
- RJP
- AXC

TIME: 3 hours

106 copies

**General
Instructions:**

- Reading time - 5 minutes
- Working time - 3 hours
- Write using black pen
- Draw diagrams using pencil
- NESA approved calculators may be used
- A separate Periodic Table and Data Sheet are provided with this paper
- For questions in Section II, show all relevant working in questions involving calculations

**Total marks:
100**

Section I - 20 marks (pages 3 - 10)

- Attempt Questions 1 - 20
- Allow about 35 minutes for this section

Section II - 80 marks (pages 11 - 35)

- Attempt Questions 21 - 33
- Allow about 2 hour and 25 minutes for this section

Section I

20 marks

Attempt Questions 1 – 20

Allow about 35 minutes for this section

Use the multiple-choice answer sheet for Questions 1 - 20

Sample	2 + 4 =	A	2	B	6	C	8	D	9
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A ○ B ○ C ○ D ○

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A B C D

If you change your mind and have crossed out what you consider to be the correct answer, then indicate this by writing the word *correct* and drawing an arrow as follows.

1. A partly filled water bottle is sealed and left on a bench in a room with constant temperature. After several minutes, it is noted that the water level in the bottle remains constant. In the water bottle, the rate of evaporation is

A. Less than the rate of condensation.
B. Greater than the rate of condensation.
C. Equal to the rate of condensation and equal to zero.
D. Equal to the rate of condensation but not equal to zero.

2. When some ionic compounds dissolve in water, the entropy of the solution actually decreases instead of increasing.

At 298K, magnesium chloride has an enthalpy of solution of -160 kJ mol^{-1} and a Gibbs Free Energy of solution of -125 kJ mol^{-1} .

Using the data, calculate the entropy of solution of magnesium chloride.

A. $-13.15 \text{ kJ mol}^{-1}$
B. $-34.2 \text{ kJ mol}^{-1}$
C. $-0.117 \text{ kJ mol}^{-1}$
D. -1.4 kJ mol^{-1}

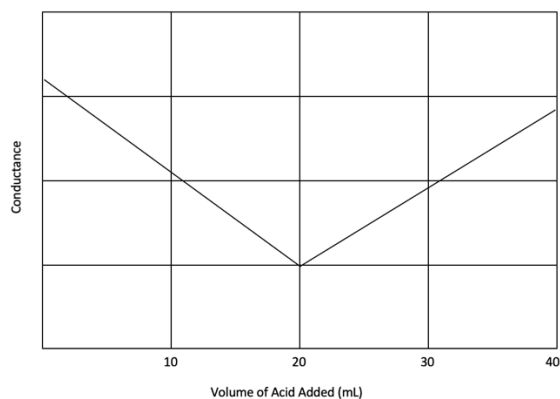
3. Which of the following substances is an amphoteric salt?

A. Sodium phosphate
B. Sodium chloride
C. Sodium hydroxide
D. Sodium hydrogen carbonate

4. 947 J of energy is required to raise the temperature of 125 g of stainless steel by 15.7°C . The specific heat capacity of the stainless steel, in $\text{J/g}^\circ\text{C}$, is

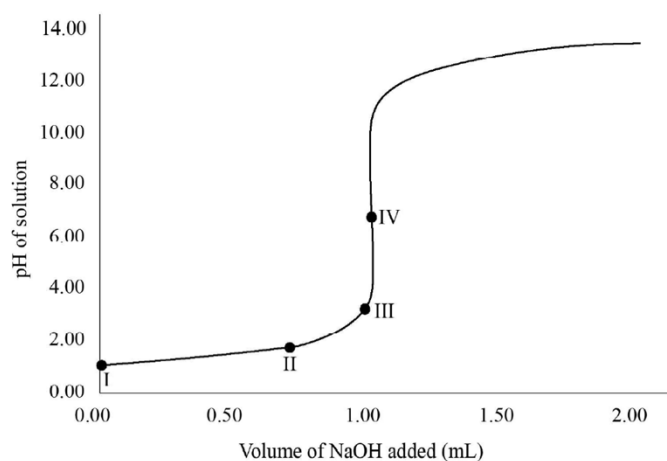
A. 8.41×10^{-3}
B. 0.483
C. 7.54
D. 119

5. 25mL of NaOH solution was titrated with 0.15 molL^{-1} HNO_3 solution in a conductivity cell. The data obtained was plotted to give the graph shown below:



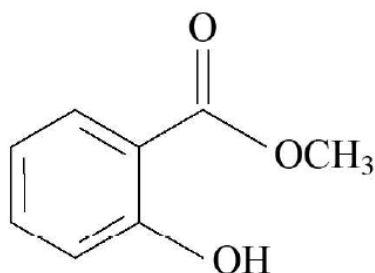
What is the concentration of the NaOH solution?

- A. 0.12 molL^{-1}
 - B. 0.20 molL^{-1}
 - C. 0.075 molL^{-1}
 - D. 0.15 molL^{-1}
6. Identify the equivalence point on the titration curve.



- A. I
- B. II
- C. III
- D. IV

7. Oil of wintergreen is a chemical compound with the following chemical structure.



Identify the classes of compounds represented by the functional groups present in oil of wintergreen.

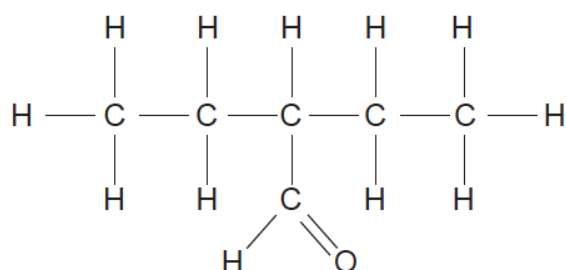
- A. alcohol and ester
 B. alcohol and ketone
 C. alcohol and aldehyde
 D. alcohol and carboxylic acid
8. Which of the following sets of equations corresponds correctly to the acid-base theory of the chemist/s who proposed it?

	<i>Chemist</i>	<i>Equations</i>
A	Bronsted/Lowry	$\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l})$
	Arrhenius	$\text{CO}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_2\text{CO}_3(\text{aq})$
B	Bronsted/Lowry	$\text{CaO}(\text{s}) + \text{SO}_3(\text{g}) \rightleftharpoons \text{CaSO}_4(\text{s})$
	Arrhenius	$\text{CH}_3\text{NH}_2(\text{aq}) + \text{HF}(\text{aq}) \rightleftharpoons \text{CH}_3\text{NH}_3^+(\text{aq}) + \text{F}^-(\text{aq})$
C	Bronsted/Lowry	$\text{HCl}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_3\text{O}^+(\text{aq}) + \text{Cl}^-(\text{aq})$
	Arrhenius	$\text{HNO}_3(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_3\text{O}^+(\text{aq}) + \text{NO}_3^-(\text{aq})$
D	Bronsted/Lowry	$\text{NH}_3(\text{aq}) + \text{CH}_3\text{OH}(\text{aq}) \rightleftharpoons \text{NH}_4^+(\text{aq}) + \text{CH}_3\text{O}^-(\text{aq})$
	Arrhenius	$\text{NaOH}(\text{s}) \rightarrow \text{Na}^+(\text{aq}) + \text{OH}^-(\text{aq})$

9. Which of the following solutions has the greatest electrical conductivity?

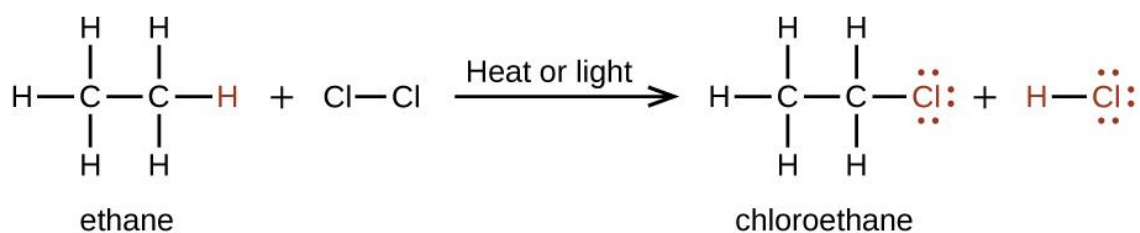
- A. 0.010 molL⁻¹ methanoic acid, HCOOH(aq) ($K_a = 1.8 \times 10^{-4}$)
- B. 0.100 molL⁻¹ methanoic acid, HCOOH(aq) ($K_a = 1.8 \times 10^{-4}$)
- C. 0.010 molL⁻¹ hypochlorous acid, HClO(aq) ($K_a = 3.5 \times 10^{-8}$)
- D. 0.100 molL⁻¹ hypochlorous acid, HClO(aq) ($K_a = 3.5 \times 10^{-8}$)

10. What is the IUPAC name of the following compound?



- A. 3-methylpentan-3-al
- B. 2-ethylbutanal
- C. 2,2-diethylethanal
- D. 2-methylbutanal

11. Which type of reaction does the following general chemical equation represent?



- A. Addition
- B. Hydrohalogenation
- C. Substitution
- D. Esterification

12. Below is a table of reactions involving organic compounds.

<i>Reaction</i>	<i>Product</i>
Ethene + hydrogen	1
Ethanal + permanganate ion	2
Ethanol + acetic (ethanoic) acid	3
Acetic (ethanoic) acid + sodium carbonate	4

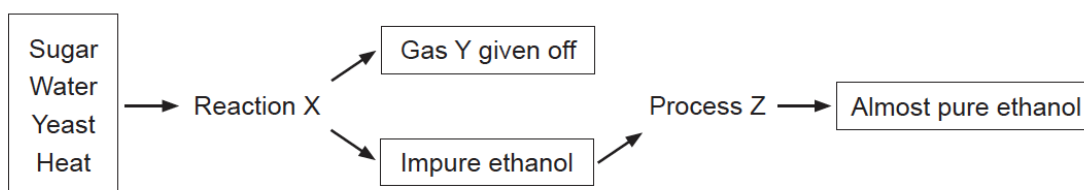
Which row of the table below identifies a product of each reaction correctly?

	<i>Product 1</i>	<i>Product 2</i>	<i>Product 3</i>	<i>Product 4</i>
A	An alkane	A carboxylic acid	An aldehyde	An ester
B	An alkene	A carboxylic acid	An ester	Carbon dioxide
C	An alkane	Carbon dioxide	An aldehyde	A carboxylic acid
D	An alkane	A carboxylic acid	An ester	Carbon dioxide

13. Which of the following gives the correct general formula for each homologous series?

	<i>Alkanes</i>	<i>Carboxylic acids</i>	<i>Alcohols</i>	<i>Cycloalkanes</i>
A	C_nH_{2n+2}	$C_nH_{2n}COOH$	$C_nH_{2n+2}OH$	C_nH_{2n+2}
B	C_nH_{2n+2}	$C_nH_{2n+1}COOH$	$C_nH_{2n+1}OH$	C_nH_{2n}
C	C_nH_{2n}	$C_nH_{2n}COOH$	$C_nH_{2n+1}OH$	C_nH_{2n+2}
D	C_nH_{2n}	$C_nH_{2n-1}COOH$	$C_nH_{2n+2}OH$	C_nH_{2n}

Question 14, 15 and 16 relate to the flow diagram below showing a process for making ethanol.



14. Reaction X is called

- A. neutralisation
- B. fermentation
- C. condensation
- D. esterification

15. Gas Y is

- A. oxygen
- B. hydrogen
- C. carbon dioxide
- D. carbon monoxide

16. Process Z is

- A. fractional distillation
- B. condensation
- C. filtration
- D. precipitation

17. A precipitate forms when 200 mL of a 0.001 M silver nitrate solution and 200 mL of a potassium chromate solution are mixed. What is the concentration of the chromate ion in the mixture at equilibrium?

(K_{sp} for $\text{Ag}_2\text{CrO}_4 = 1.2 \times 10^{-12}$)

- A. 8.4×10^{-5}
- B. 1.2×10^{-6}
- C. 4.8×10^{-6}
- D. 3.0×10^{-7}

18. In order to identify a compound, an organic chemist performed a series of qualitative and quantitative experiments to obtain the following data:

i. molecular formula of $C_3H_6O_2$

ii. properties:

- soluble in water
- decolourised acidified potassium permanganate
- neutral to litmus
- does not decolourise bromine water

What is the name of this compound based on the formula and properties listed above?

- A. Propan-2-ol
B. Propanoic acid
C. Methyl ethanoate
D. 2-hydroxypropanal
19. Analyse the following table of experimental data to determine the relative strength of the acids from strongest to weakest.

<i>Acid</i>	<i>Concentration (M)</i>	<i>pH</i>
H_3PO_4	2.0×10^{-2}	1.9
HCN	1.5×10^{-1}	5.0
H_2SO_4	9.0×10^{-2}	1.0
CH_3COOH	1.0×10^{-1}	2.8

- A. $H_2SO_4 > H_3PO_4 > HCN > CH_3COOH$
B. $H_2SO_4 > H_3PO_4 > CH_3COOH > HCN$
C. $HCN > CH_3COOH > H_2SO_4 > H_3PO_4$
D. $HCN > CH_3COOH > H_3PO_4 > H_2SO_4$

20. An experiment was conducted to determine the heat of combustion of an alcohol by placing a spirit burner of the alcohol underneath an aluminium can containing a specific volume of water and recording the temperature until a 20 degree change had occurred.

Among the many possible source of error in this experiment, there is the potential for some of the water in the can to have evaporated during heating without the experimenter realising.

How would this particular source of error affect the experimental enthalpy of combustion calculated by the student?

- A. Enthalpy of combustion would be smaller as less alcohol would be combusted.
- B. Enthalpy of combustion would be larger as less alcohol would be combusted.
- C. Enthalpy of combustion would be smaller as more alcohol would be combusted.
- D. Enthalpy of combustion would be larger as more alcohol would be combusted.

End of Section I



Barker
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**TRIAL HIGHER SCHOOL
CERTIFICATE EXAMINATION**

Chemistry

Section II Answer Booklet

80 marks

Attempt Questions 21 - 33

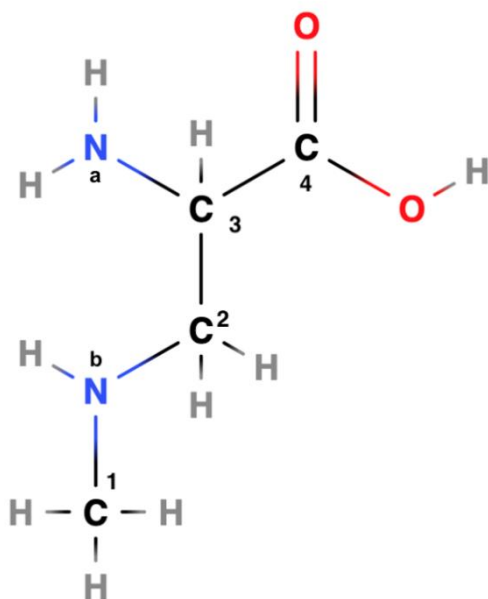
Allow about 2 hour and 25 minutes for this section.

Instructions

- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
- Show all relevant working in questions involving calculations.
- Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering.

Question 21 (4 marks)

The seeds of some cycad plants used by Aboriginal and Torres Strait Islander Peoples contain the toxin, BMAA (beta-N-Methylamino-L-alanine), shown below. This toxin contains the hydroxyl and amine functional groups:



- (i) Before consumption of the cycad, this toxin can be removed by leaching with water. Explain how the presence of the functional groups allows for this leaching to be effective. 2

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- (ii) The nitrogens in this molecule have been labelled a and b. Which of these nitrogens is a secondary amine? Explain your choice. 1

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Question 21 continues on page 13

Question 21 (continued)

(iii) Compare the geometry around carbons 3 and 4 of the BMAA molecule.

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End of Question 21

Question 22 (6 marks)

A natural indicator can be made from blueberries by adding some hot water, crushing the blueberries and filtering the juice. The purple indicator solution was tested on a range of substances. The results are recorded below.

<i>Substance</i>	<i>Colour</i>
0.1 M ammonia	Yellow
0.1 M nitric acid	Pink
Lemon juice	Red
Oven cleaner	Blue
Pure water	Purple

- (i) Assess the usefulness of the purple indicator solution as an acid-base indicator. **3**

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Question 22 continues on page 15

Question 22 (continued)

- (ii) In the first hand experiment completed in class with red cabbage, as in the experiment outlined above, the aim was to assess the usefulness of the indicator solution as an acid-base indicator. Certain steps were included in the method to make this investigation more valid.

Define validity in terms of these experiments and outline any particular steps taken to make these experiments using natural indicators as valid as possible. **3**

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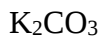
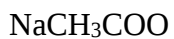
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End of Question 22

Question 23 (4 marks)

- (i) The following list of ionic compounds contains both acidic, basic and neutral salts. Complete the table below by correctly allocating each of the listed ionic salts into its correct category. 2



<i>Salt</i>	<i>Ionic Compound</i>
Acidic	
Basic	
Neutral	

- (ii) Use appropriate equations to explain the basic nature of one of the salts you identified above as being a basic salt. 2

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Question 24 (5 marks)

A student prepared two solutions; the first containing just sodium hydrogen carbonate and the second solution containing equimolar amounts of sodium hydrogen carbonate and sodium carbonate. The student then measured the pH of each solution as HCl was added. The pH readings are shown in the table below.

<i>Volume of HCl added (mL)</i>	<i>pH</i>	
	<i>NaHCO₃ solution</i>	<i>NaHCO₃ / Na₂CO₃ solution</i>
2	4.3	10.0
4	3.4	9.8
6	2.5	9.5
8	1.8	9.2
10	1.1	8.9
12	0.7	8.5

- (i) Referring to the data in the table, and by stating TWO essential requirements of a buffer, justify why the sodium hydrogen carbonate / sodium carbonate solution can be classified as a buffer solution. 2

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- (ii) Using relevant chemical equations, explain the changes in the pH of each solution when equal amounts of HCl were added. 3

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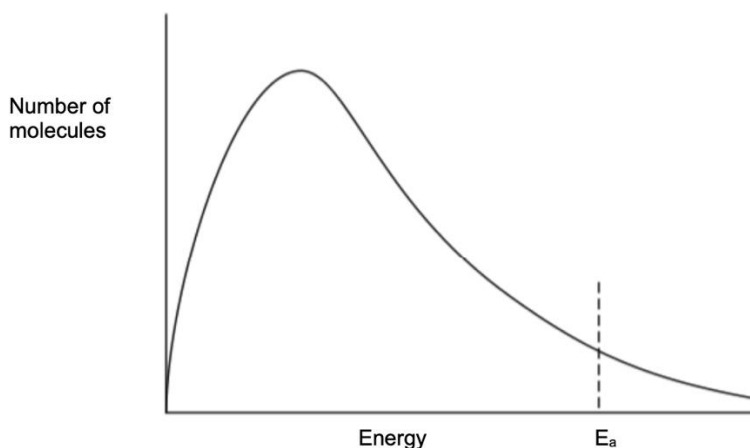
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Question 25 (4 marks)

Methanol can be produced industrially by the reaction of carbon monoxide gas and hydrogen gas:



The graph below shows the distribution of molecular energies of a mixture of carbon monoxide and hydrogen at 250°C.



If the temperature is increased, there is an increase in the rate of reaction.

- (i) Sketch a curve on the graph above to show how the distribution of molecular energies changes when the temperature increases. 1

- (ii) With reference to the graph, use collision theory to explain how a small increase in temperature causes a large increase in the rate of reaction. 3

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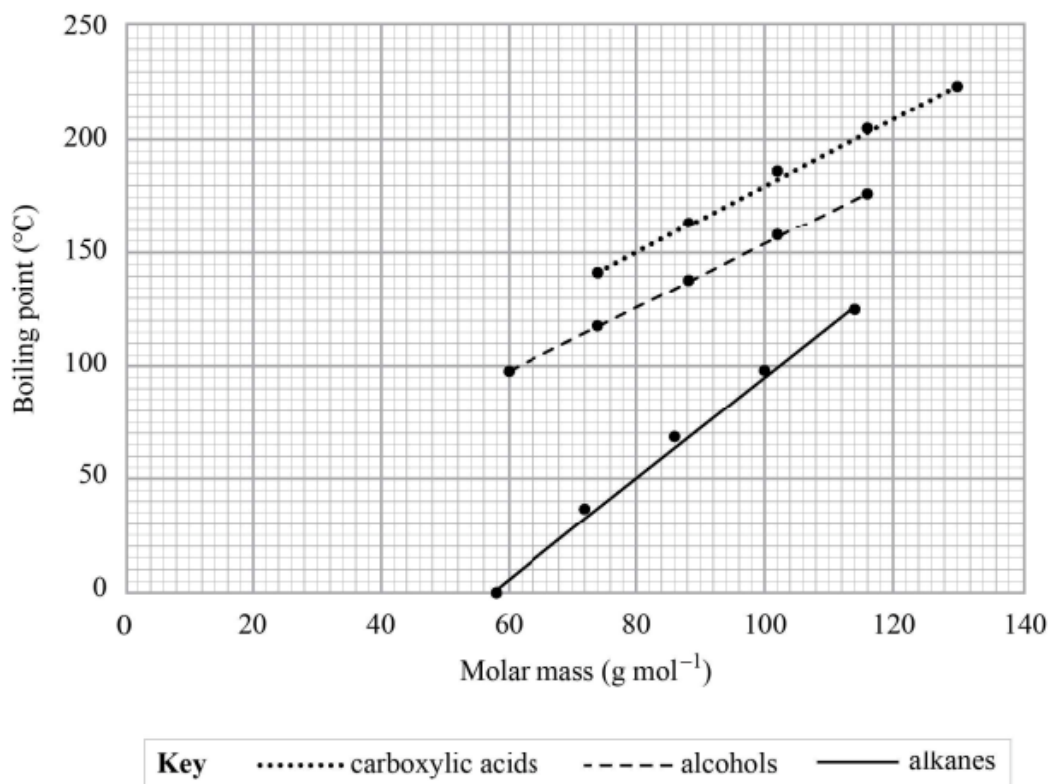
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Question 26 (5 marks)

The following graph shows the relationship between the molar mass and boiling point of unbranched carboxylic acids, alcohols and alkanes.



- (i) Using data from the graph, outline the relationship between the molar mass and boiling point of unbranched carboxylic acids.

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Question 26 continues on page 20

Question 26 (continued)

- (ii) Contrast the trends in boiling point for alkanes and alcohols.

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- (iii) Infrared spectroscopy and NMR were used to identify an unknown alcohol. The alcohol was found to contain a total of 2 carbons. Determine the boiling point of the alcohol at standard pressure. Explain your reasoning.

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End of Question 26

Question 27 (3 marks)

Use the following information to name the compounds X, Y and Z.

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- Compound X has the molecular formula C_3H_7I .
- When heated with a solution of potassium hydroxide, compound Y, with molecular formula C_3H_8O , is formed.
- Reacting compound Y with a suitable oxidiser yields compound Z.
- Compound Z can react with a carbonate to produce carbon dioxide.

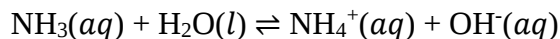
Compound X:

Compound Y:

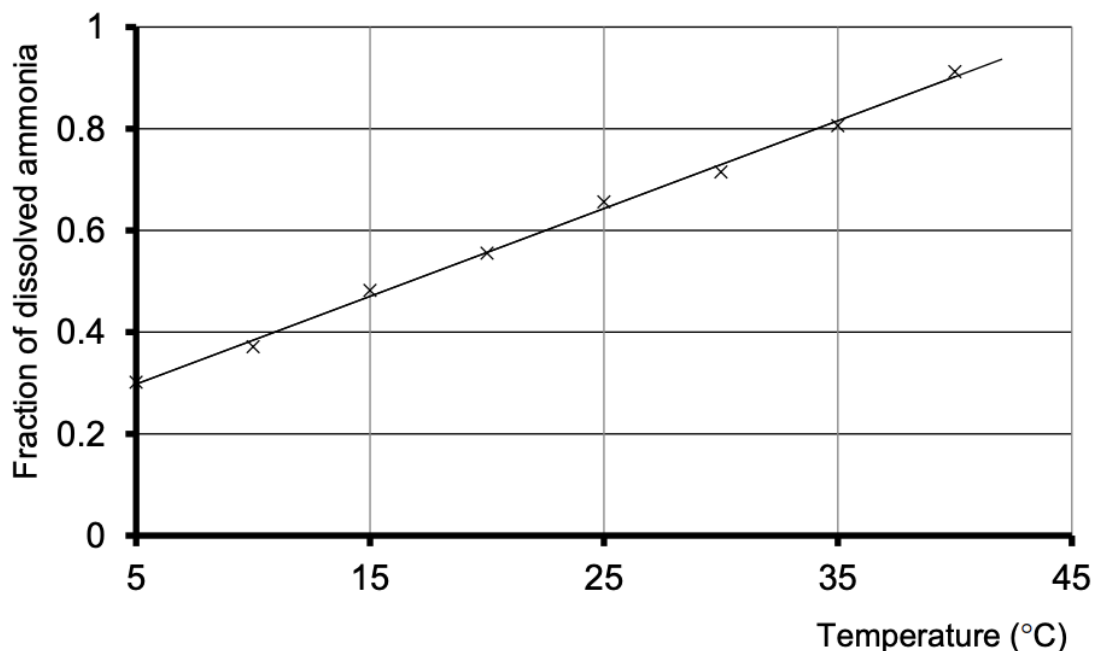
Compound Z:

Question 28 (10 marks)

Ammonia is a waste product in fish tanks. In water it occurs in two forms – dissolved ammonia, $\text{NH}_3(aq)$, and the dissolved ammonium ion, $\text{NH}_4^+(aq)$. Whilst the ammonium ion is non-toxic, ammonia is highly toxic to fish. The following chemical equilibrium exists in water in a fish tank:



The graph below shows how the fraction of nitrogen existing as dissolved ammonia, $\text{NH}_3(aq)$, in a fish tank varies with temperature at constant pH.



- (i) On this graph sketch a line to show how the dissolved ammonium ion fraction, $\text{NH}_4^+(aq)$, in the fish tank changes with temperature.

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- (ii) Use Le Châtelier's Principle to show that the forward reaction is exothermic.

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Question 28 continues on page 23

Question 28 (continued)

- (iii) If the pH of the water in a fish tank at 25°C is 8.22, show that the concentration of the hydroxide ion, $\text{OH}^-(aq)$, is about $1.7 \times 10^{-6} \text{ mol L}^{-1}$.

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The equilibrium expression, K_{eq} , for the above reaction is defined as:

$$K_{eq} = \frac{[\text{NH}_4^+(aq)][\text{OH}^-(aq)]}{[\text{NH}_3(aq)]} = 1.76 \times 10^{-5} \text{ at } 25^\circ\text{C}$$

- (iv) Calculate the ratio of the two nitrogen forms in the fish tank water, at 25°C when the pH of the water is 8.22.

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$$\frac{[\text{NH}_3(aq)]}{[\text{NH}_4^+(aq)]}$$

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Question 28 continues on page 24

Question 28 (continued)

- (v) Does the ratio, $\frac{[\text{NH}_3(aq)]}{[\text{NH}_4^+(aq)]}$, increase, stay the same, or decrease as the pH of the fish tank water increases? Explain.

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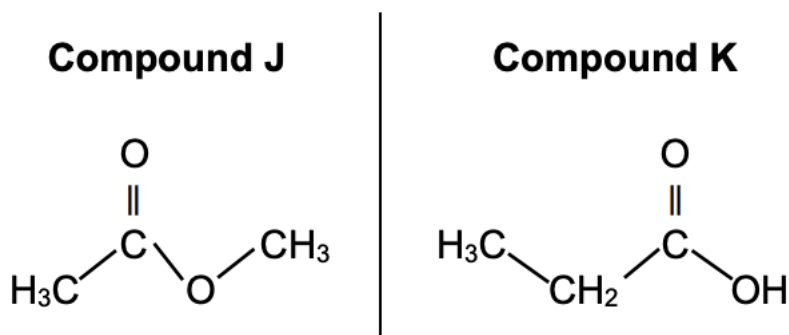
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End of Question 28

Question 29 (8 marks)

The formulae of two isomers, labelled compounds J and K, are shown below:



- (i) Name compound J. **1**

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- (ii) State whether these two isomers are chain, position or functional group isomers and justify your choice. **1**

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An experiment was carried out using a chemical procedure to distinguish between the two isomers, J and K.

- (iii) Identify a reagent, or combination of reagents, that could be used. **1**

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Question 29 continues on page 26

Question 29 (continued)

- (iv) State the expected observation(s). **2**

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- (v) Write a balanced chemical equation for one of your successful reactions. **1**

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Compound J is prepared in the laboratory. After adding the reagents to a test tube and warming it for 10 minutes, the contents of the test tube are poured into a beaker containing water.

- (vi) Write a chemical equation, using structural formulae for the organic compounds, to represent the production of compound J. State any additional reactants that are essential and are not part of the chemical equation. **2**

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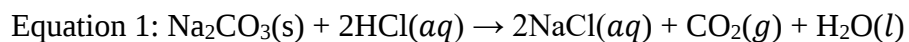
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End of Question 29

Question 30 (4 marks)

The enthalpy change occurring when solid sodium carbonate, $\text{Na}_2\text{CO}_3(s)$, reacts with hydrochloric acid solution was determined experimentally. The chemical reaction occurring is represented as:



The results from the experiment are recorded below:

- 0.0300 mol of sodium carbonate reacted.
- 50 mL of hydrochloric acid of concentration 2.10 mol L^{-1} was added to the solid sodium carbonate.
- The temperature increased by 4.9°C . Assume that the solution produced by the reaction has the same density and specific heat capacity as water.

(i) Show that the amount of sodium carbonate reacting is the limiting quantity. 2

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Question 30 continues on page 28

Question 30 (continued)

- (ii) Show that the heat of reaction for the chemical reaction represented by equation 1 is about 34 kJ mol^{-1} .

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End of Question 30

Question 31 (3 marks)

Ethanol can be produced by the fermentation of glucose or the hydration of ethene.

- (i) Describe the reactants and conditions required for the production of ethanol by fermentation. Include a balanced equation and indicating if a catalyst is required.

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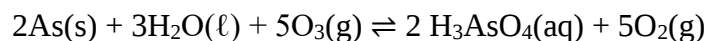
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Question 32 (4 marks)

Arsenic acid, $\text{H}_3\text{AsO}_4(\text{aq})$, is a weak, triprotic acid that can be produced from the element directly through the reaction with water and ozone, $\text{O}_3(\text{g})$. This reaction can be represented by the equation below:



- (i) Write the equilibrium constant expression for this reaction. **1**

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The arsenate ion, $\text{HAsO}_4^{2-}(\text{aq})$, is amphoteric, meaning it can act as an acid and as a base.

- (ii) With the aid of equations, describe the amphoteric nature of $\text{HAsO}_4^{2-}(\text{aq})$ in this aqueous solution. **3**

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Question 33 (20 marks)

A range of different organic compounds are used as cleaning agents. Some of these are shown in the table below.

<i>Solvent</i>	<i>Composition of cleaning solvent</i>	<i>Boiling Point (°C)</i>	<i>Molecular Weight (g/mol)</i>
vinegar	Acetic acid (ethanoic acid)	118	60.05
Nail polish remover	propanone	56	58.08
ethanol	ethanol	78	46.07
Rubbing alcohol	propan-2-ol	82.5	60.10

Rubbing alcohol has been referred to as the very first petrochemical and was first produced in the 1920s by hydrating propene isolated from crude oil.

- (i) Use structural formula to write an equation to show this reaction. 2

Propanone can be produced from propan-2-ol.

- (ii) Name the type of reaction occurring to convert propan-2-ol to propanone. 1

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- (iii) State suitable reagents/conditions required for this reaction to occur, providing a specific example of any chemicals needed. 1

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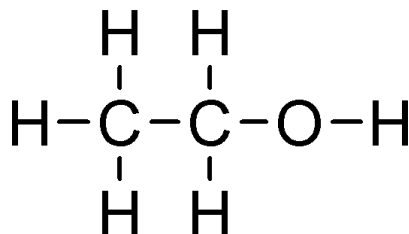
Question 33 continues on page 32

Question 33 (continued)

The best cleaning agents for dirt and grease are solvents that are highly miscible with water and contain both non-polar and polar regions.

- (iv) Using the structural formula of ethanol shown below, identify the polar and non-polar regions of this molecule.

1



- (v) Refer to the intramolecular bonding in these two regions to explain why they are polar or non-polar.

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Question 33 continues on page 33

Question 33 (continued)

- (vi) Acetic acid, propanone and propan-2-ol have almost identical molecular weights but very different boiling points. With reference to the intermolecular bonding present, explain the differences in these boiling points.

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Question 33 continues on page 34

Question 33 (continued)

There are a number of hazards to be aware of when working with organic compounds.

- (vii) State TWO safety considerations when working with organic compounds and identify measures to reduce these risks.

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Question 33 continues on page 35

Question 33 (continued)

Rubbing alcohol and nail polish remover are just two out of hundreds of useful substances in society that can be produced from hydrocarbons isolated from crude oil.

The mining and use of hydrocarbons has both advantages and disadvantages.

(viii) Outline some of the environmental, economic and sociocultural implications of obtaining and using hydrocarbons from the earth.

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Section II Extra writing space

If you choose to use this space, clearly indicate what question you are answering.

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