3	0	9	7	7	9	7	1

Student Number

Sydney Girls High School

2019

TRIAL
HSC
EXAMINATION

Chemistry

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 data sheet, formulae sheet and Periodic Table are provided at the back of this paper
- For questions in Section II, show all relevant working in questions involving calculations

Total Marks: 100

Section I – 20 marks (pages 2-10)

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

Section II – 80 marks (pages 11-27)

- Attempt Questions 21-37
- Allow about 2 hours and 25 minutes for this section

Section I

20 marks
Attempt Questions 1 - 20
Allow about 35 minutes for this part.

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

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1 Cycad seeds contain the toxin cycasin. In order to safely consume the seeds, Indigenous Australians used various methods to remove the cycasin.

One method used in the detoxification process involved crushing the seeds to expose the inner kernels and then soaking the crushed seeds in water.

The property of the cycasin toxin upon which this method relies is:

A. The solubility of the toxin in water.

B. The reactivity of the toxin with water.

C. The immiscible nature of the toxin in water.

D. The higher density of the toxin compared to water.

2 Which of the following statements about chemical systems is correct?

A. An open system can transfer energy but not matter with its surroundings.

B. An open system can transfer matter but not energy with its surroundings.

C. A closed system can transfer energy but not matter with its surroundings.

D. A closed system can transfer neither energy nor matter with its surroundings.

3 Iron (III) ions and thiocyanate ions are in equilibrium with the iron (III) thiocyanate ion according to the following equation:

$$Fe^{3+}(aq) + SCN^{-}(aq) \rightleftharpoons Fe(SCN)^{2+}(aq)$$

The pressure in the system is increased. What effect will this have on the equilibrium?

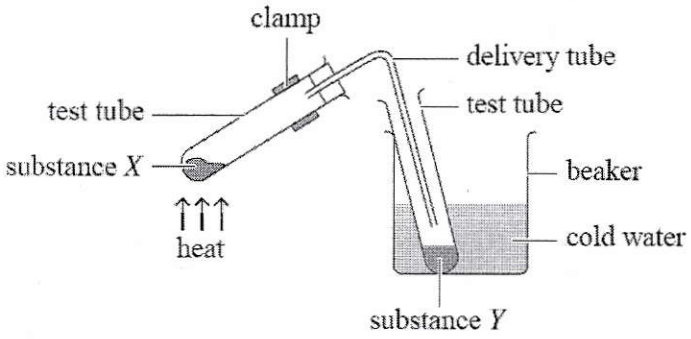
A. $[Fe^{3+}]$ will increase

B. $[SCN^{-}]$ will decrease

C. $[Fe(SCN)^{2+}]$ will increase

D. There will be no change to the concentrations

4 The diagram shows hydrated cobalt (II) chloride after it has been heated and all signs of a reaction have ceased.



Which row of the table correctly shows the most likely identities of the substances X and Y?

	Substance X	*Substance Y*
A.	water	dehydrated cobalt (II) chloride
B.	dehydrated cobalt (II) chloride	water
C.	dehydrated cobalt (II) chloride	chlorine
D.	cobalt (II) oxide	water

5 Which alternative contains only amphiprotic substances?

A. SiO_2, SO_2, SnO

B. H_2CO_3, HCO_3^-, CO_3^{2-}

C. HS^-, H_3PO_4, H_2O

D. HCO_3^-, HSO_4^-, H_2O

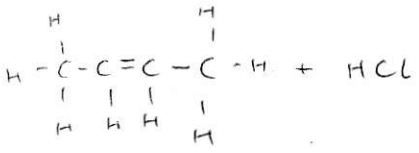
6 How many products are possible when but-2-ene reacts with hydrogen chloride?

A. One

B. Two

C. Three

D. Four



7 Arrange the following reactions in order of their increasing tendency to reach completion.

For each reaction, the equilibrium constant was determined under certain conditions.

I. $2O_3\ (g) \rightleftharpoons 3O_2\ (g)$ $K_{eq} = 2.0 \times 10^{57}$

II. $2SO_2\ (g) + O_2\ (g) \rightleftharpoons 2SO_3\ (g)$ $K_{eq} = 4.3$

III. $N_2\ (g) + 3H_2\ (g) \rightleftharpoons 2NH_3\ (g)$ $K_{eq} = 9.0$

IV. $NH_3\ (g) + H_2O\ (l) \rightleftharpoons NH_4^+\ (aq) + OH^-\ (aq)$ $K_{eq} = 1.8 \times 10^{-5}$

A. III, II, IV, I

B. I, III, II, IV

C. IV, II, III, I

D. II, III, I, IV

8 1.0 mL of 10 mol L^{-1} nitric acid solution was diluted to 1 L with distilled water. 100 mL of this resulting solution was then further diluted to 1 L using distilled water.

What pH is the final solution closest to?

A. 1

1mL 10m/L

B. 2

C. 3

D. 4

9 The equilibrium constant for the reaction below has an equilibrium constant of 159 at 500K.

$$H_2\ (g) + I_2\ (g) \rightleftharpoons 2HI\ (g)$$

$K_{eq} = \frac{[HI]^2}{[H_2][I_2]} = 159$

At the same temperature and pressure, what is the equilibrium constant for the reaction:

$$HI\ (g) \rightleftharpoons \tfrac{1}{2} H_2\ (g) + \tfrac{1}{2} I_2\ (g)$$

A. 0.00629

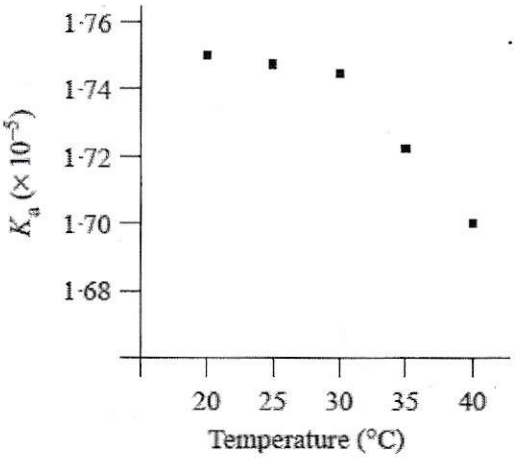
B. 0.0793

C. 12.6

D. 79.5

eqm dissociation of acid

10 The K_a of ethanoic acid changes with temperature as shown in the graph below.



The graph indicates that within the temperature range shown, as temperature decreases the acid becomes

A. more ionised

B. less ionised

C. less concentrated

D. more concentrated

11 A solution was prepared by dissolving a pure compound in water. The solution was subjected to a series of tests. The results are shown in the table below.

Test	*Reaction*
Flame test	The flame turns lilac/pink
Adding $BaCl_2$ (aq)	A white precipitate forms
Adding HCl (aq)	Bubbles of gas form

Nitrates
A
Group 1
Sulfates **
A
Group 17 *

A. Sodium sulfate

B. Potassium sulfate

C. Calcium carbonate

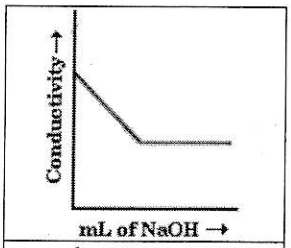
D. Potassium carbonate

PHS
Castro Bear

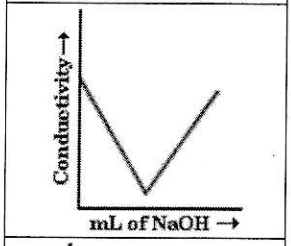
12 Which graph best represents the electrical conductivity changes that occur when an aqueous solution of acetic acid is titrated with an aqueous solution of sodium hydroxide?

strong base

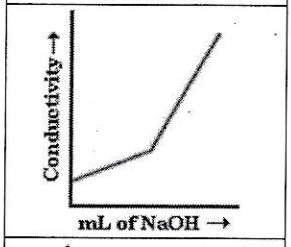
A.



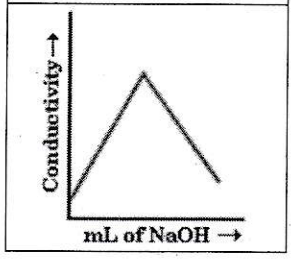
B.



C.



D.



13 The K_{sp} of calcium hydroxide at 25 °C is 5.02×10^{-6}.

What is the molar solubility of calcium hydroxide at this temperature?

A. 1.71×10^{-2} mol L^{-1}

B. 1.08×10^{-2} mol L^{-1}

C. 2.24×10^{-3} mol L^{-1}

D. 5.06×10^{-4} mol L^{-1}

NaI $Ba(NO_3)_2$

14 Samples of sodium iodide solution were tested with solutions of barium nitrate, silver nitrate and lead (II) nitrate.

Identify the response that correctly identifies the observations.

	Dilute $Ba(NO_3)_2$	*Dilute $AgNO_3$*	*Dilute $Pb(NO_3)_2$*
A.	no reaction	pale-yellow precipitate	bright-yellow precipitate
B.	white precipitate	no reaction	white precipitate
C.	no reaction	pale-yellow precipitate	white precipitate
D.	white precipitate	no reaction	pale-cream precipitate

15 Which statement about Atomic Absorption Spectroscopy (AAS) is correct?

A. The nebuliser measures the absorbance of light by metal ions in the flame.

B. AAS measures the wavelengths of light emitted when electrons fall back to their ground state.

C. The monochromator selects two wavelengths of light emerging from the hallow cathode lamp.

D. A hallow cathode lamp made from the metal to be analysed generates specific wavelengths of light.

16 The enthalpy of combustion of ethanol is -1367 kJ mol^{-1}. A sample of ethanol was burnt to heat 200 mL sample of water. The temperature rose from 20 °C to 30.3 °C. Assuming 50% of the heat produced was lost to the surroundings, calculate the mass of ethanol burnt.

A. 0.065 g

B. 0.13 g

C. 0.29 g

D. 0.58 g

$\Delta H > 0$ endo
$\Delta H < 0$ exo

$mC\Delta T$
$4.18 \times 20.6 = -1367$

17 Which of the following solutions, upon mixing will produce the solution with the highest temperature change?

A. 50 mL of 0.05 M HNO_3 + 100 mL of 0.4 M NaOH

B. 100 mL of 0.1 M H_2SO_4 + 50 mL of 0.4 M KOH

C. 50 mL of 0.2 M HCl + 100 mL of 0.025 $Ba(OH)_2$

D. 200 mL of 0.05 M CH_3COOH + 100 mL of 0.01 M NaOH

18 In an experiment, 4-hydroxybutanoic acid [$HO(CH_2)_3COOH$] forms a polymer containing 1000 monomer units.

Which of the following is closest to the approximate molar mass of this polymer?

A. 2.0×10^2 g mol^{-1}

B. 1.4×10^4 g mol^{-1}

C. 8.6×10^4 g mol^{-1}

D. 1.0×10^5 g mol^{-1}

19 Water self-ionises as shown by the equation: $2H_2O\ (l) \rightleftharpoons H_3O^+\ (aq) + OH^-\ (aq)$

This ionisation is temperature dependent.

Temperature (°C)	*Ionisation constant (K_w)*
5	1.9×10^{-15}
15	4.5×10^{-15}
25	1.0×10^{-14}
35	2.1×10^{-14}

What can be inferred from this data?

A. The pH of pure water at 35 °C is less than 7.

B. The equilibrium position lies well to the right.

C. The ionisation of water is an exothermic process.

D. In pure water at 15 °C [OH^-] is lower than [H_3O^+]

12.5 mg/kg

20 A sample of soil was analysed and found to contain 12.5 ppm of lead. The lead was extracted from a 50.0 g sample of soil and precipitated using excess sodium carbonate solution.

What mass of precipitate could be obtained assuming no experimental error?

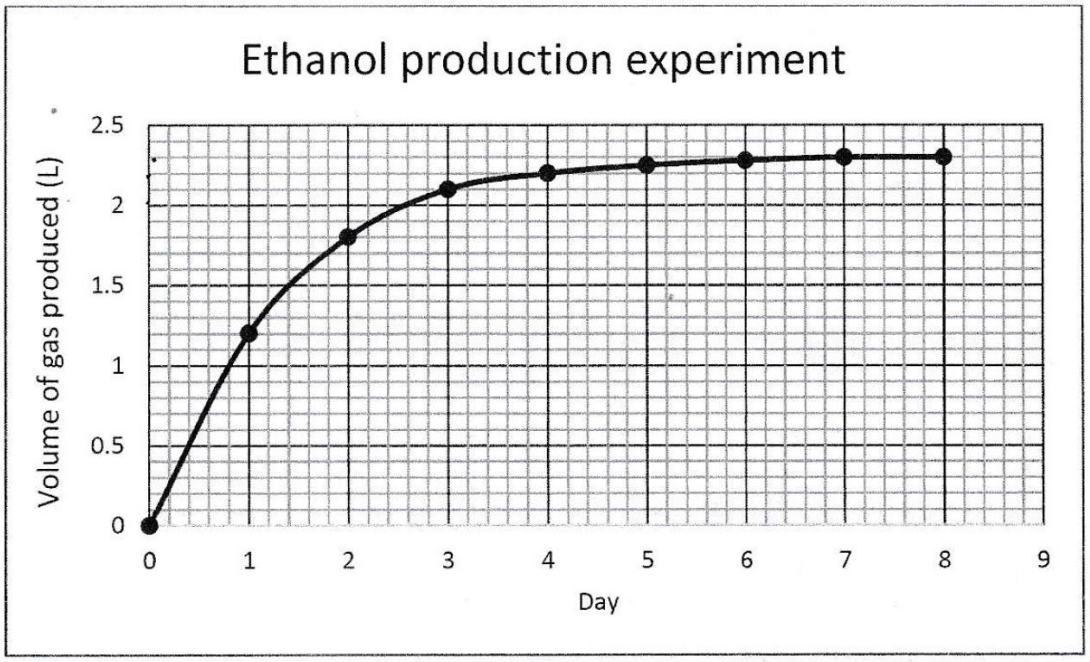
A. 6.25×10^{-4} g

B. 8.06×10^{-4} g

C. 4.68×10^{-3} g

D. 6.45×10^{-3} g

A student conducted an experiment to produce ethanol from glucose during which a gas was evolved. The graph below shows the volume of gas produced during the reaction over 8 days. The reaction was carried out at 25°C and 100 kPa.



Assuming that all of the gas produced comes from the fermentation of glucose, calculate the mass of glucose that reacted over the 8 days. **3**

Question 22 (6 marks)

Bromine water can be used to test for the presence of saturated and unsaturated hydrocarbons.

(a) Explain the expected observations that would be made when bromine water is added to an alkane and an alkene. Include relevant chemical equations in your answer. **4**

(b) Describe ONE safety hazard and risk precaution involved when carrying out the above test. **2**

Question 23 (7 marks)

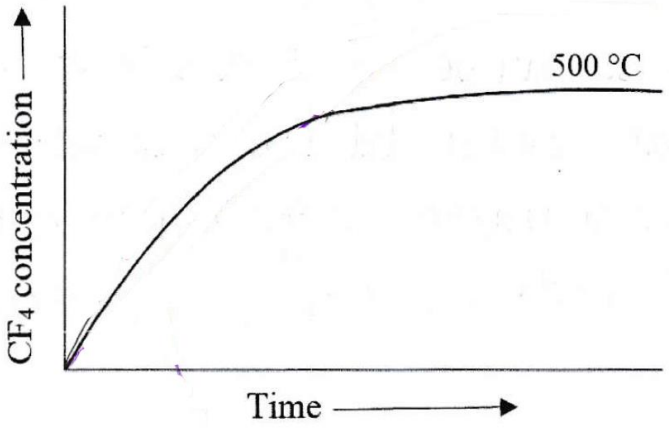
The gas carbon oxyfluoride (COF_2) decomposes to the gases carbon tetrafluoride (CF_4) and carbon dioxide, releasing heat.

(a) Write the equilibrium constant expression for this reaction. **2**

(b) The reaction is carried out at 500 °C in a 10 L container. Initially there is 2.0 moles of carbon oxyfluoride gas in the container. At equilibrium, 80% of the carbon oxyfluoride has decomposed.

Calculate the value of the equilibrium constant. **3**

(c) On the graph below, sketch a second curve on the same axes to demonstrate the production of carbon tetrafluoride over time when the reaction is carried out at 200 °C. **2**



Question 24 (8 marks)

A student carried out an experiment to compare the energy changes that occur when ionic compounds dissolve in water.

The student observed that the temperature fell when potassium chloride dissolved but rose when sodium hydroxide dissolved.

(a) Explain these observations, by discussing the process involved in the dissolution of ionic substances in water. **3**

(b) "The dissolution of potassium chloride and sodium hydroxide both occur spontaneously."

Account for the spontaneity of these physical processes in terms of the changes in enthalpy, entropy and Gibbs free energy. **3**

(c) Some small crystals of copper sulfate solid were observed in a beaker which contained a saturated solution of copper sulfate. The beaker was covered (so that water could not evaporate) and the beaker and cover were weighed. Over a period of time, the shape of the crystals changed but the weight of the beaker and its content did not change.

Explain these observations. **2**

Question 25 (3 marks)

To maintain the correct pH of a swimming pool, hypochlorous acid (HOCl) is added. This acid ionises into hydronium ions and hypochlorite ions (OCl^-).

The pK_a of HOCl is 7.3. Calculate the pH of a 0.01 M solution of hypochlorous acid. **3**

Question 26 (3 marks)

Using a specific example, explain the importance of buffers in natural systems. Include relevant chemical equations. **3**

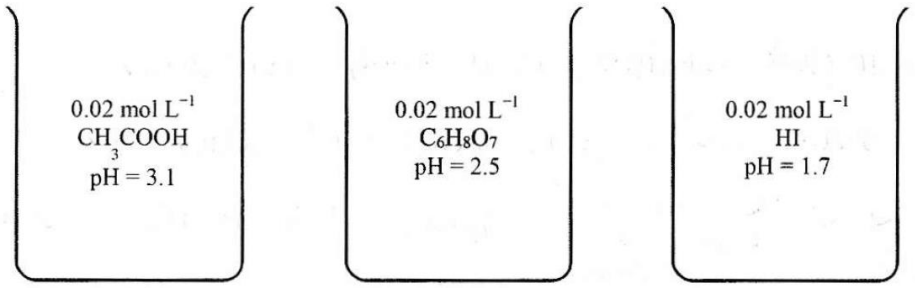
Question 27 (4 marks)

A bottle of solution is missing its label. It is either NaOH, Na_2SO_4 or Na_3PO_4.

Describe a sequence of steps that could be followed to confirm the identity of the solution in the bottle. Include observed results and ionic equations in your answer. **4**

Question 28 (5 marks)

The pH of three acidic solutions was measured.



(a) Explain the difference in pH between the three acids with reference to appropriate chemical equations. **3**

(b) Although 0.02 mol L^{-1} solutions of CH_3COOH and HI have different pH values, explain why they require the same amount of sodium hydroxide to neutralise them. **2**

Question 29 (3 marks)

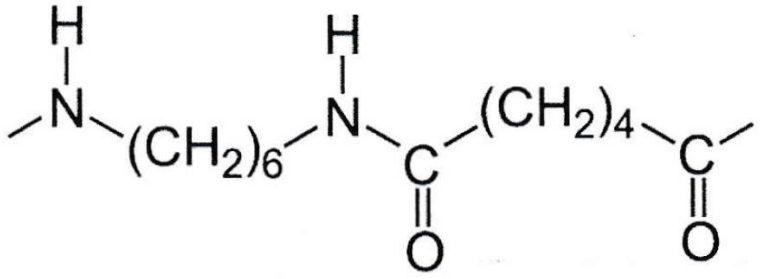
Explain how soapy water is able to clean dishes covered with grease or fat while fresh water is not. Support your answer with a labelled diagram. **3**

Question 30 (3 marks)

Draw the structural formulae of THREE isomers of C_4H_8O and name these isomers using IUPAC nomenclature. **3**

Question 31 (5 marks)

The diagram below represents a repeated unit of a nylon polymer.

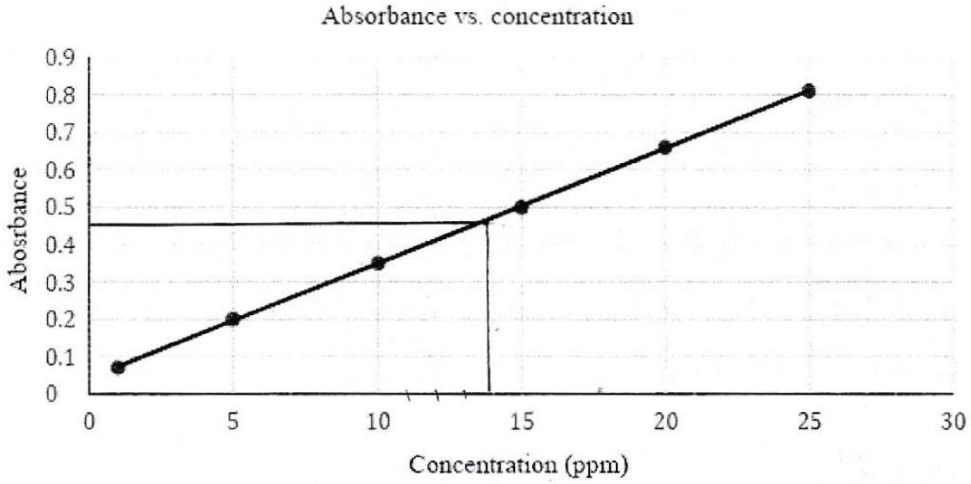


(a) Draw the structural formulae of the two monomers that were used to make this polymer and identify their effect on universal indicator. **2**

(b) Compare a condensation polymer to ONE addition polymer in terms of their structure, properties and uses. **3**

Question 32 (4 marks)

A manufacturer claimed that their bone remineralisation tablets contained 10% calcium nitrate by mass. An analytical chemist tested this claim using atomic absorption spectroscopy.



One tablet with a mass of 0.30 g was dissolved in 100 mL of acidified water. The absorbance of the solution was measured four times and the results are shown below.

Sample	*Absorbance*
1	0.44
2	0.42
3	0.32
4	0.46

4

Is the manufacture's claim correct? Show your working.

Question 33 (5 marks)

Identify and compare one laboratory technique to determine the concentration of ethanoic acid in vinegar and one laboratory technique to determine the concentration of chloride ions in a sample. 5

Question 34 (3 marks)

An acid, *X*, has the molecular formula $C_4H_4O_6$ and a pH of 1.7 when dissolved in water. A titration against a standardised sodium hydroxide solution was performed to determine if it is a monoprotic, diprotic or triprotic acid.

In the titration, a 2.46 g solid sample of acid *X* was dissolved in distilled water to make 200 mL of solution. An average of 33.2 mL of 0.10 mol L^{-1} sodium hydroxide was needed to reach the end point for a 20.0 mL aliquot of acid X, with phenolphthalein as the indicator.

Determine if acid *X* is monoprotic, diprotic or triprotic. 3

Question 35 (6 marks)

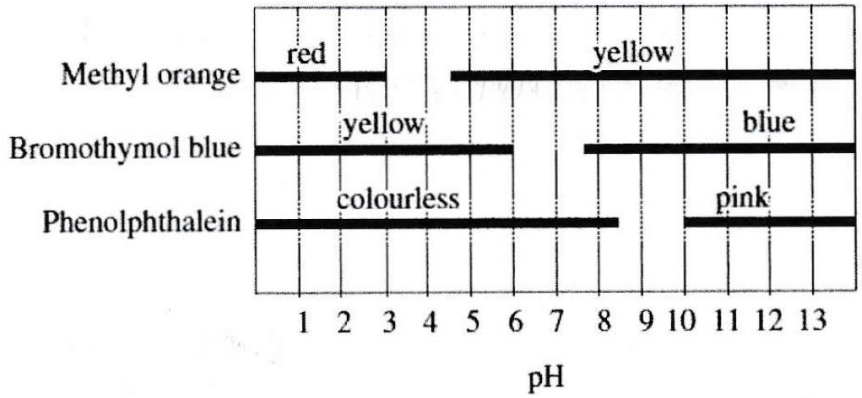
The boiling points of some carboxylic acids and primary amines are given in the table.

Carboxylic acid	*Carboxylic acid boiling point (°C)*	*Amine*	*Amine boiling point (°C)*
Methanoic acid	101	Methanamine	-6.3
Ethanoic acid	118	Ethanamine	18
Propanoic acid	141	Propanamine	49
Pentanoic acid	186	Pentanamine	104
Hexanoic acid	205	Hexanamine	131

(a) Using the data provided, construct a graph that shows the relationship between carbon chain length and boiling point. 3

(b) Explain the trends shown in the graph. 3

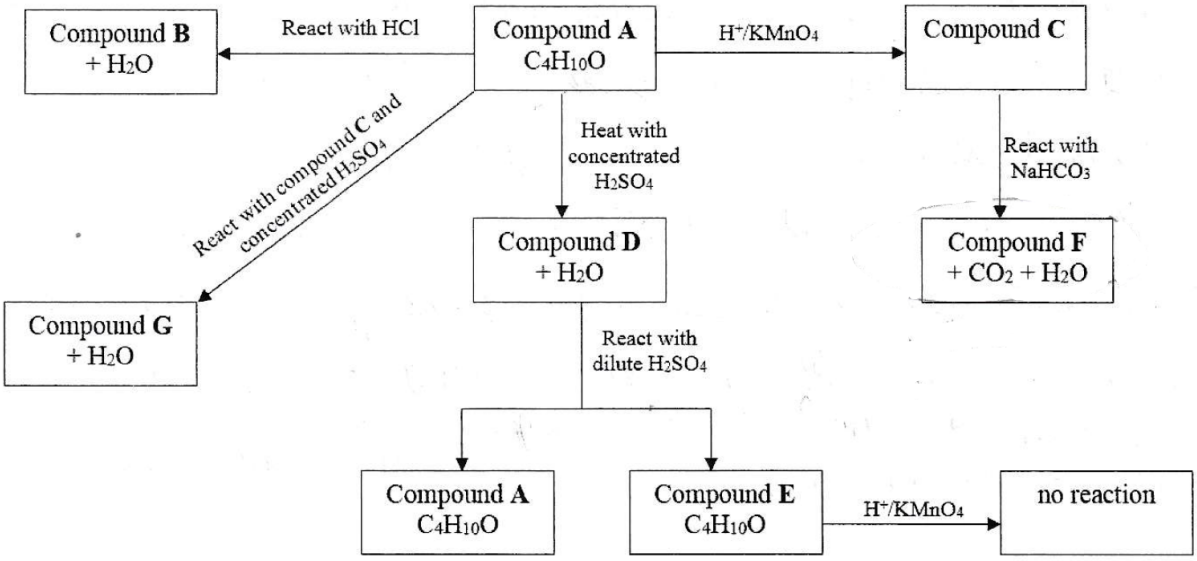
Question 36 (3 marks)



Explain why a solution of ammonium chloride makes bromothymol blue turn yellow, while a sodium sulfate solution of the same concentration makes bromothymol blue turn green. Include relevant chemical equations. 3

Question 37 (9 marks)

This flow chart shows the reactions of seven different organic compounds (**A** to **G**).



(a) Complete the table by drawing the structural formulae for the compounds and justifying your answers with reference to the information provided. **7**

Compound	**Structural formula**	**Justification**
A		
B		

C		
D		
E		
F		
G		

(b) Explain why it is necessary to reflux to obtain compound G. 2

2019

TRIAL
HSC
EXAMINATION

3	1	3	0	5	3	7	3

Student Number

Chemistry

Section II
Answer Booklet

80 marks
Attempt Questions 21-37
Allow about 2 hours and 25 minutes for this section

Instructions

- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of the 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.

84

193

TOTAL : 85/100
RANK : 12/116

(25) 16K 9A

clove
9K 11A

~~20~~

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Sydney Girls High School

3	1	3	0	5	3	7	3

Student Number

2019

TRIAL HSC EXAMINATION

Chemistry

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

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

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:

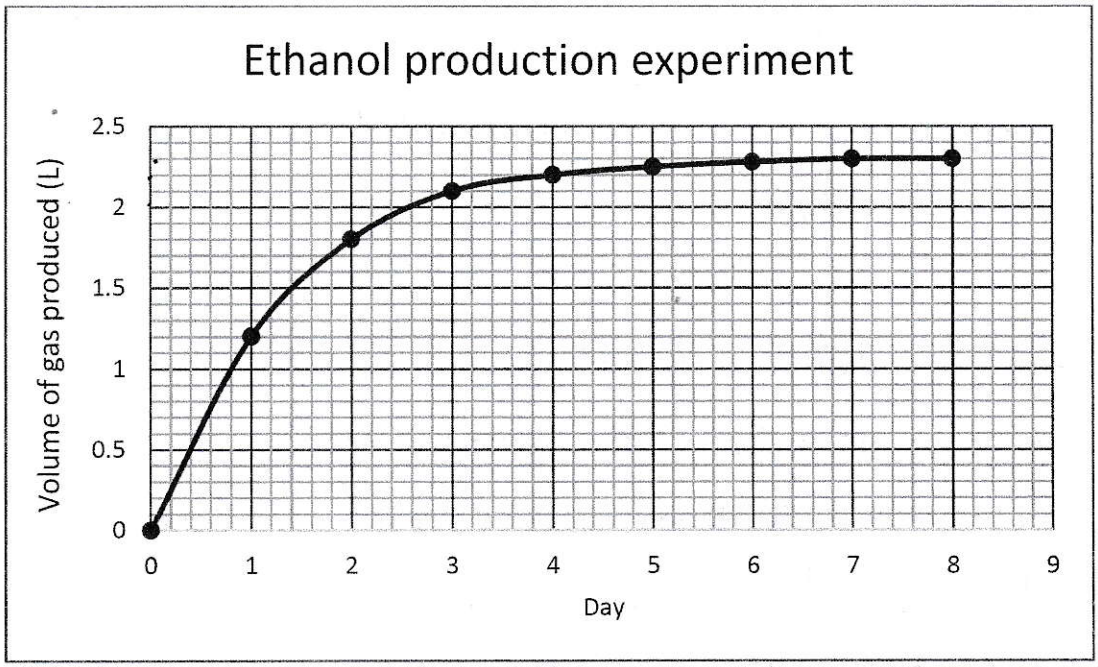
correct

A ⊗ B ⊗ C ○ D ○

1	A ●	B ○	C ○	D ○	✓
2	A ○	B ○	C ●	D ⊗	✓
3	A ○	B ○	C ●	D ○	✗ D
4	A ○	B ●	C ○	D ○	✓
5	A ○	B ○	C ○	D ●	✓
6	A ●	B ○	C ○	D ○	✓
7	A ○	B ●	C ○	D ○	✗ C
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 ●	✗ C
19	A ●	B ○	C ○	D ○	✓
20	A ○	B ●	C ○	D ○	✓

17

A student conducted an experiment to produce ethanol from glucose during which a gas was evolved. The graph below shows the volume of gas produced during the reaction over 8 days. The reaction was carried out at 25°C and 100 kPa.



Assuming that all of the gas produced comes from the fermentation of glucose, calculate the mass of glucose that reacted over the 8 days. **3**

$C_6H_{12}O_6(aq) \xrightarrow{\text{yeast}} 2C_2H_5OH_{(aq)} + 2CO_2(g)$

$V(CO_2) = 2.3\,L$

$PV = nRT$

$n = \frac{100 \times 2.3}{298.15 \times 8.314} = 0.092786$

$n(C_6H_{12}O_6) = \frac{0.092786}{2}$

$n = \frac{m}{MM}$

$M(C_6H_{12}O_6) = \frac{0.092786}{2}(6(12.01) + 12(1.008) + 6(16))$

$= 8.358$

$= 8.49$ ✓

3

Question 22 (6 marks)

Bromine water can be used to test for the presence of saturated and unsaturated hydrocarbons.

(a) Explain the expected observations that would be made when bromine water is added to an alkane and an alkene. Include relevant chemical equations in your answer. **4**

Bromine water added to alkane in the presence of UV light

- $Br_2(l) + C_2H_6(aq) \rightarrow C_2H_5Br(aq) + HBr(aq)$
- There would be no visible colour change } no reaction.
- no distinct layers

Bromine water added to alkene

- $Br_2(l) + C_2H_4(aq) \rightarrow C_2H_4Br_2(aq)$
- The ethene decolourises bromine water as it adds onto the double bond (brown → clear)
- Two distinct layers would form due to difference in densities

3

(b) Describe ONE safety hazard and risk precaution involved when carrying out the above test. **2**

The reactants used in the experiment are toxic as they release fumes which can be poisonous - damaging human health. Thus, carry out experiment in a well ventilated area, or in a fume cupboard if available.

Question 23 (7 marks)

The gas carbon oxyfluoride (COF_2) decomposes to the gases carbon tetrafluoride (CF_4) and carbon dioxide, releasing heat. exo.

(a) Write the equilibrium constant expression for this reaction. **2**

$2COF_2(g) \rightarrow CF_4(g) + CO_2(g) + heat$

$K_{eq} = \dfrac{[CO_2][CF_4]}{[COF_2]^2}$

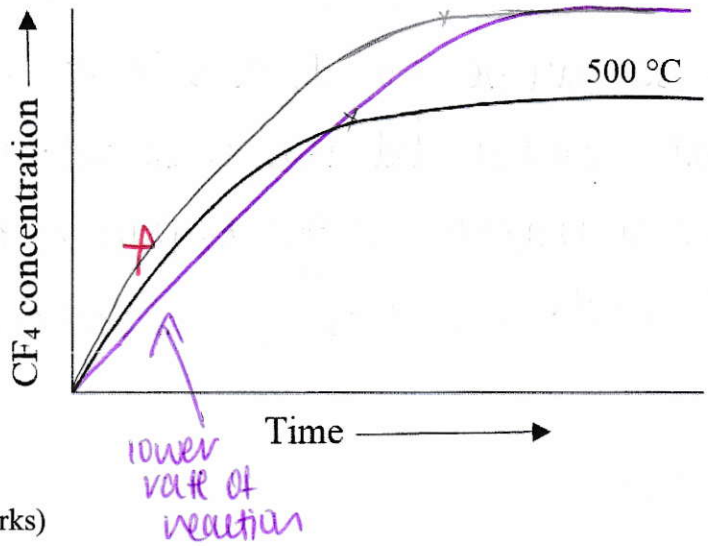
(b) The reaction is carried out at 500 °C in a 10 L container. Initially there is 2.0 moles of carbon oxyfluoride gas in the container. At equilibrium, 80% of the carbon oxyfluoride has decomposed.

Calculate the value of the equilibrium constant. **3**

	$2COF_2$	CF_4	CO_2
I	$\frac{2}{10} = 0.2$	0	0
C	-0.16	$+0.08$	$+0.08$
E	0.04	0.08	0.08

$K_{eq} = \dfrac{0.08 \times 0.08}{0.04^2} = 4$

(c) On the graph below, sketch a second curve on the same axes to demonstrate the production of carbon tetrafluoride over time when the reaction is carried out at 200 °C. **2**



↓ temp
- ↓ collisions.
- favours forward exo reaction.

↗ higher eq concentration.

Question 24 (8 marks)

A student carried out an experiment to compare the energy changes that occur when ionic compounds dissolve in water. ΔH = products - reactants.

The student observed that the temperature fell when potassium chloride dissolved but rose when sodium hydroxide dissolved. $\Delta H > 0$

(a) Explain these observations, by discussing the process involved in the dissolution of ionic substances in water. **3**

$KCl(s) \rightarrow K^+ + Cl^-$

when potassium chloride dissolves in water, the ionic bond between K^+ and Cl^- breaks. The ions are attracted to the H_2O water molecules, forming an ion-dipole. Since the energy required to form the products > energy received to break the reactants, $\Delta H > 0$, thus endothermic reaction, temperature decreases. However, dissolving NaOH is an exothermic process, as the energy of Na-OH bond < energy received to form an ion dipole between Na^+ and water molecules. Thus $\Delta H < 0$, reaction is exothermic thus temperature increases.

(b) "The dissolution of potassium chloride and sodium hydroxide both occur spontaneously."

Account for the spontaneity of these physical processes in terms of the changes in enthalpy, entropy and Gibbs free energy. **3**

spontaneous reactions occur when $\Delta G = \Delta H - T\Delta S < 0$

The dissolution of KCl is endothermic ($\Delta H > 0$), entropy change > 0. Thus ΔG will be < 0 as $T\Delta S > \Delta H$.

NaOH is exothermic ($\Delta H < 0$) and has a positive entropy change. Since the spontaneous reaction for both enthalpy and entropy is favoured, overall reaction is spontaneous.

Question 24 continues on page 17

(c) Some small crystals of copper sulfate solid were observed in a beaker which contained a saturated solution of copper sulfate. The beaker was covered (so that water could not

evaporate) and the beaker and cover were weighed. Over a period of time, the shape of the crystals changed but the weight of the beaker and its content did not change.

$CuSO_4(s) \rightleftharpoons Cu^{2+}(aq) + SO_4^{2-}(aq)$

Explain these observations. 2

dynamic

since the saturated solution of copper solution is in equilibrium, both the forward and reverse reactions are occuring. Over time, some of the $CuSO_4(s)$ would dissolve into solution, however the ions will also crystallise back into solid. This accounts for the change in shape of the crystals. Since the beaker was covered and matter could not evaporate, the closed system ensured that matter would not be lost, thus weight & content did not change and system remains in equilibrium.

End of Question 24

Question 25 (3 marks)

To maintain the correct pH of a swimming pool, hypochlorous acid (HOCl) is added. This acid ionises into hydronium ions and hypochlorite ions (OCl^-).

The pK_a of HOCl is 7.3. Calculate the pH of a 0.01 M solution of hypochlorous acid. 3

$HOCl(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + OCl^-(aq)$

I	0.01	0	0
C	$-x$	$+x$	$+x$
E	$0.01-x$	x	x

$pK_a = 7.3$

$K_a = 10^{-7.3} = \frac{[OCl^-][H_3O^+]}{[HOCl]}$

$10^{-7.3} = \frac{x^2}{0.01-x}$

x is negligible compared to 0.01

$10^{-7.3} = \frac{x^2}{0.01}$

$x^2 = 5.012 \times 10^{-10}$

$x = 2.24 \times 10^{-5}$

$pH = -\log[H_3O^+]$
$= -\log(2.2 \times 10^{-5})$
$= 4.65$

Question 26 (3 marks)

Using a specific example, explain the importance of buffers in natural systems. Include relevant chemical equations. **3**

Buffers contain large comparable amounts of a weak acid and the conjugate salt of its conjugate base. This ensures that when a change is made to the system, pH is maintained. e.g. in the human body $H_2CO_3(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + HCO_3^-(aq)$ when humans excercise lactic acid increases the concentration of H_3O^+, thus equilibrium shifts to the left to counteract this change (LCP) to restore pH. Similarly, when OH^- ions are added, the system would shift to the right to neutralise the OH^- with H_3O^+, thus restoring pH.

3

Question 27 (4 marks) use pH probe

A bottle of solution is missing its label. It is either NaOH, Na_2SO_4 or Na_3PO_4.

Describe a sequence of steps that could be followed to confirm the identity of the solution in the bottle. Include observed results and ionic equations in your answer. **4**

$Cu(OH)_2(s) \rightleftharpoons Cu^{2+} + 2OH^-$ * *

$Cu_3(PO_4)_2(s) \rightleftharpoons 3Cu^{2+} + 2PO_4^{3-}$ *

arrows in wrong direction

① Add $Cu(NO_3)_2$ (aq) into the unknown solution. If a precipitate is formed, the solution is either (NaOH or Na_3PO_4). If no precipitate the solution is Na_2SO_4. confirm presence of SO_4^{2-} by reacting with Ba^{2+}. A precipitate would form.

② Filter out the initial precipitate in step ①, leaving a solution with OH^- and PO_4^{3-} ions.

③ Add $Fe(NO_3)_2$ solution into the unknown sample. If a precipitate forms, the presence of OH^- can be confirmed.

$Fe(OH)_2(s) \rightarrow Fe^{2+}(aq) + 2OH^-$ (aq) * $Fe_3(PO_4)_2$ is also solid.

④ Filter the precipitate out, leaving PO_4^{3-} ions left.

2

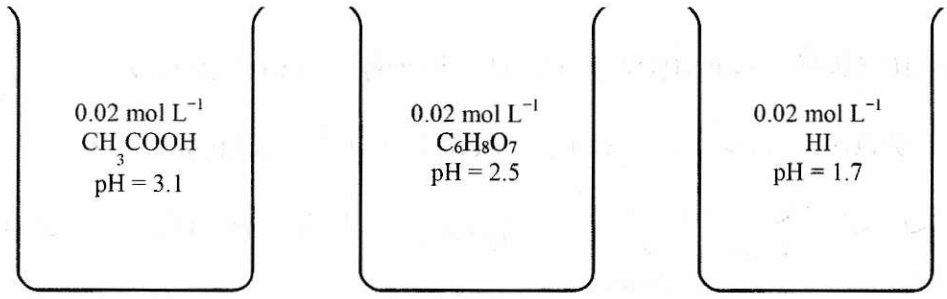
⑤ confirm by adding $Ca(NO_3)_2$ (aq). A precipitate should form

$Ca_3(PO_4)_2 \rightarrow 3Ca^{2+}_{(aq)} + 2PO_4^{3-}$ (aq) *

Question 28 (5 marks)

* need to show that HI is a strong acid by using $-\log[0.02] = 1.7$ ∴ fully dissociates.

The pH of three acidic solutions was measured.



(a) Explain the difference in pH between the three acids with reference to appropriate chemical equations. given equal concentrations, **3**

HI is a strong acid, thus fully ionises to release H_3O^+ ions. $HI_{(aq)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + I^-_{(aq)}$. This explains why it has the lowest pH (of 1.7), as it is the most acidic. CH_3COOH and $C_6H_8O_7$ are both weak acids. Citric acid however is a triprotic acid, meaning it ionises in 3 steps. Thus it releases more H_3O^+ ions than acetic acid ($CH_3COOH_{(aq)} + H_2O_{(l)} \rightleftharpoons CH_3COO^-_{(aq)} + H_3O^+_{(aq)}$) thus explaining its lower pH of 2.5.

2

(b) Although 0.02 mol L^{-1} solutions of CH_3COOH and HI have different pH values, explain why they require the same amount of sodium hydroxide to neutralise them. **2**

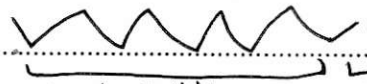
$CH_3COOH_{(aq)}$ and HI are both monoprotic acids that ionise in one step. Thus, regardless of pH, the same amount of OH^- ions from NaOH would be required to neutralise the H_3O^+ ions. The only difference would be the pH of the resulting salt.

2

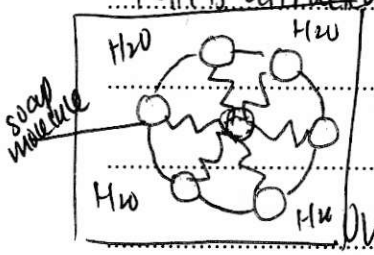
Question 29 (3 marks)

Explain how soapy water is able to clean dishes covered with grease or fat while fresh water is not. Support your answer with a labelled diagram. **3**

Soap is an ionic salt consisting of a long non-polar hydrocarbon chain and a polar head. In water, the



polar head is attracted to polar water molecules, while the non polar tail is attracted to non-polar grease and fat. This interaction forms a micelle

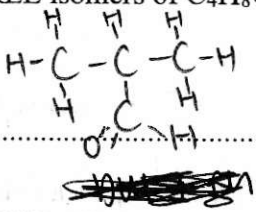


keeping the oil inside the water, thus allowing it to be washed away together, effectively cleaning the dishes. On the other hand, fresh water, a polar molecule, is not able to bond with the non-polar ~~fats~~ grease and fat. As a result, they will not be removed from the dishes as the force is not strong, rendering them ineffective at cleaning.

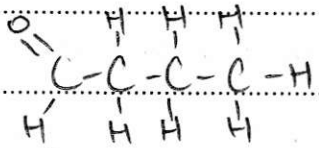
3

Question 30 (3 marks)

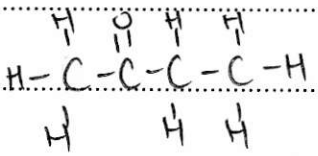
Draw the structural formulae of THREE isomers of C_4H_8O and name these isomers using IUPAC nomenclature. **3**



2-methyl propanal ✓



butanal ✓

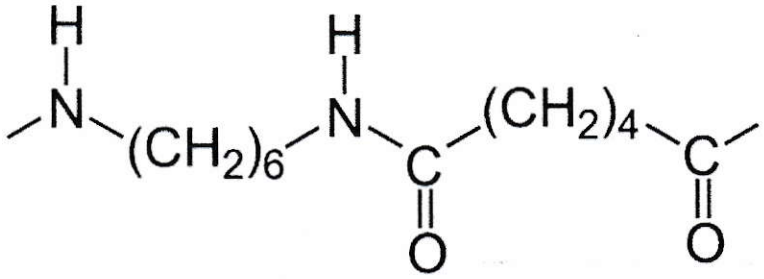


butanone ✓

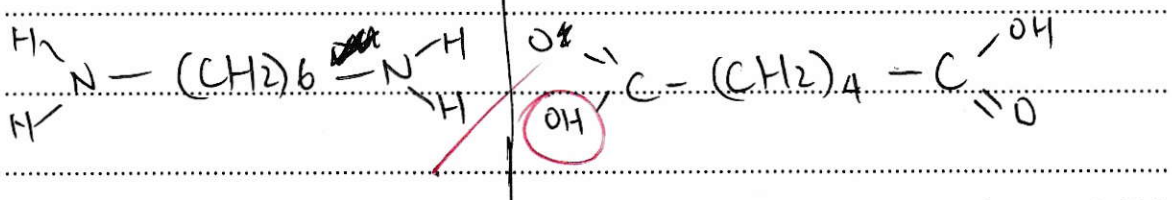
3

Question 31 (5 marks)

The diagram below represents a repeated unit of a nylon polymer.



(a) Draw the structural formulae of the two monomers that were used to make this polymer and identify their effect on universal indicator. **2**



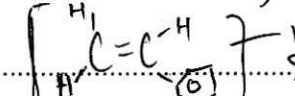
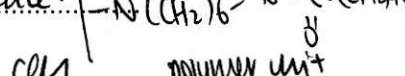
the amine molecule is basic, thus would appear blue/purple, depending on the exact pH.

The carboxylic acid is acidic, and would appear red/pink, depending on the exact pH.

1

Nylon Polystyrene.

(b) Compare a condensation polymer to ONE addition polymer in terms of their structure, properties and uses.

Polystyrene is made from many styrene monomers through the breaking of the double bond  monomer. Polystyrene is strong, water resistant and has low reactivity, thus is used as packaging material for electrical and white goods. The benzene ring contributes to its strength thus it is shock resistant. The thermal properties are often used when polystyrene is made into foam, and used as polystyrene cups. Nylon is a condensation polymer, formed through the elimination of a small water molecule:  polymer unit

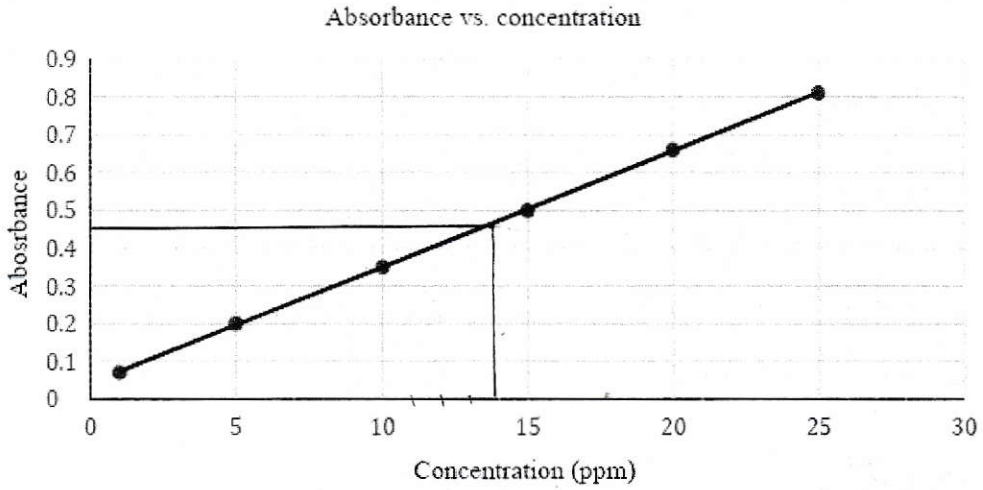
Nylon is also strong and water resistant, however it can be made into thread and is thus used in clothing such as rain jackets. The strength of nylon makes it also suitable for use in ropes.

3

Question 32 (4 marks)

A manufacturer claimed that their bone remineralisation tablets contained 10% calcium nitrate by mass. An analytical chemist tested this claim using atomic absorption spectroscopy.

CaNO3



0.03

One tablet with a mass of 0.30 g was dissolved in 100 mL of acidified water. The absorbance of the solution was measured four times and the results are shown below.

Sample	*Absorbance*
1	0.44
2	0.42
3	0.32
4	0.46

outlier

$c = \frac{n}{V}$ $n = \frac{m}{mm}$

4

3

Is the manufacture's claim correct? Show your working.

Average absorbance = 0.439

At absorbance 0.44, concentration = 14 ppm

n(Ca^{2+}) = 14 ppm × 0.1

claim = 0.039 / 100ml = 14 ppm = n(CaNO$_3$)

0.39 / L

0.1439 M(CaNO$_3$) = 14 ppm × (40.08 + 14.01 + 3×16)

since 0.3 = 1429.26 ppm

the manufacturers claim is incorrect. = 142.926 mg/L

0.1439 g/L

Question 33 (5 marks)

Identify and compare one laboratory technique to determine the concentration of ethanoic acid in vinegar and one laboratory technique to determine the concentration of chloride ions in a sample.

5

Titration to determine an unknown concentration of CH_3COOH. The CH_3COOH will be titrated against a base with a known concentration e.g. NaOH. The amount of base used can then calculate the unknown concentration. Results produced will be fairly accurate as the burette, volumetric flask, pipette used are all precise instruments. To determine the concentration of Cl^- ions, gravimetric analysis can be conducted by precipitating out the Cl^- with a solution such as silver nitrate. Once complete precipitation has been reached, the mass of the precipitate can be calculated to then work out the concentration of Cl^- ions in the sample. Assuming the experiment is valid, gravimetric analysis is also an accurate method.

Question 34 (3 marks)

An acid, *X*, has the molecular formula $C_4H_4O_6$ and a pH of 1.7 when dissolved in water. A titration against a standardised sodium hydroxide solution was performed to determine if it is a monoprotic, diprotic or triprotic acid.

In the titration, a 2.46 g solid sample of acid *X* was dissolved in distilled water to make 200 mL of solution. An average of 33.2 mL of 0.10 mol L^{-1} sodium hydroxide was needed to reach the end point for a 20.0 mL aliquot of acid X, with phenolphthalein as the indicator.

remainder given 3/3

Determine if acid *X* is monoprotic, diprotic or triprotic.

3

$C_4H_4O_6 + NaOH \Rightarrow \ldots H_2O$

$n(NaOH) = \frac{33.2}{1000} \times 0.1 = 0.00332$

$\frac{n(NaOH)}{n(C_4H_4O_6)} = \frac{0.00332}{0.00166} = 2$

$\therefore C_4H_4O_6 + 2NaOH \Rightarrow \ldots$

$\therefore$ acid is diprotic.

$n(X) = \frac{2.46}{4(12.01)+4(1.008)+6(16)} = 0.0166$

$c[X] = \frac{0.0166}{0.2} = 0.08307$

n in 20ml $= 0.08307 \times 0.02$

$n(C_4H_4O_6) = 0.00166$

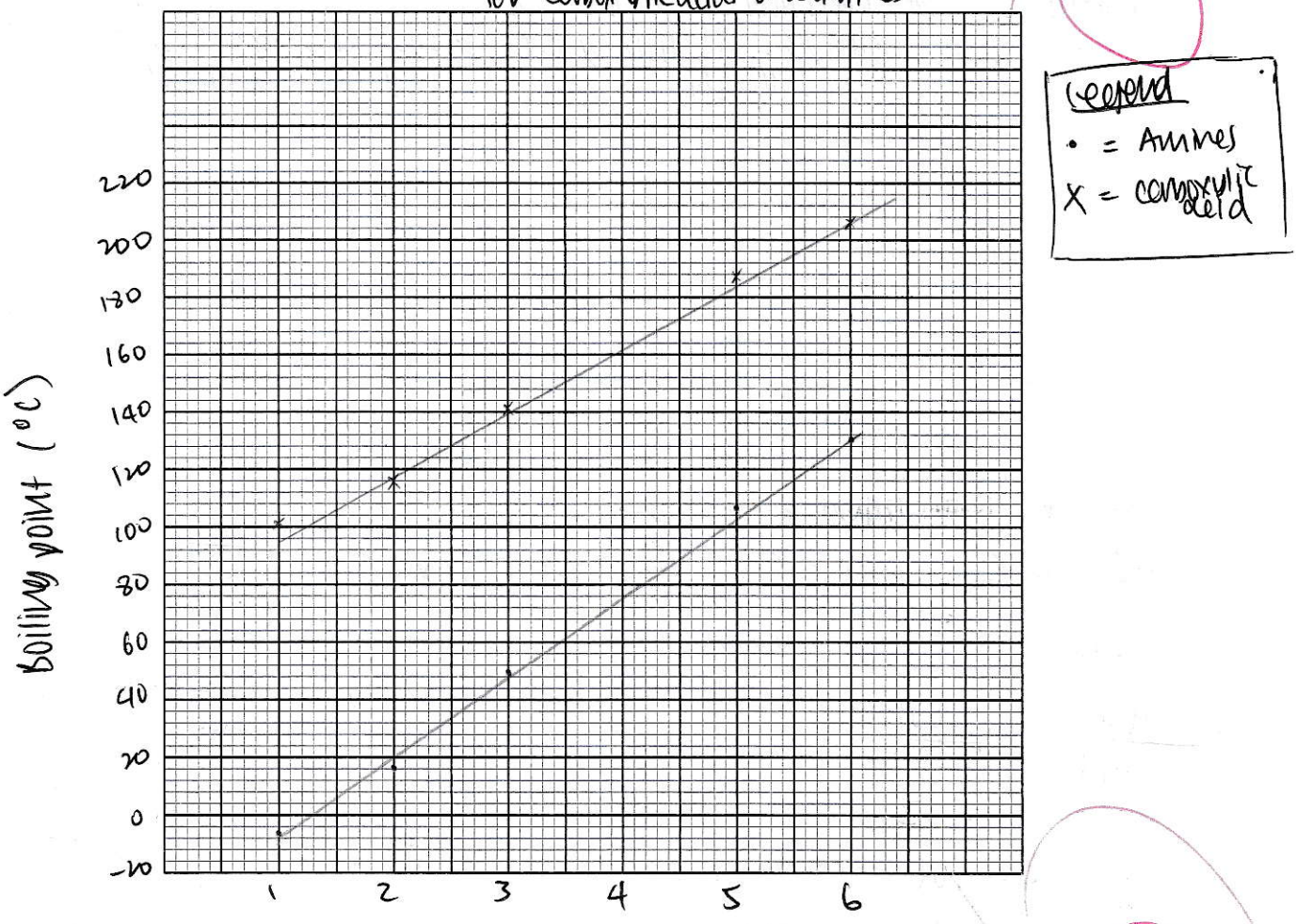
Question 35 (6 marks)

The boiling points of some carboxylic acids and primary amines are given in the table.

Carboxylic acid	*Carboxylic acid boiling point (°C)*	*Amine*	*Amine boiling point (°C)*
Methanoic acid	101	Methanamine	-6.3
Ethanoic acid	118	Ethanamine	18
Propanoic acid	141	Propanamine	49
Pentanoic acid	186	Pentanamine	104
Hexanoic acid	205	Hexanamine	131

4 -

(a) Using the data provided, construct a graph that shows the relationship between carbon chain length and boiling point. Relationship between chain length and boiling point for carboxylic acids and amines **3**



3

Question 35 continues on page 25

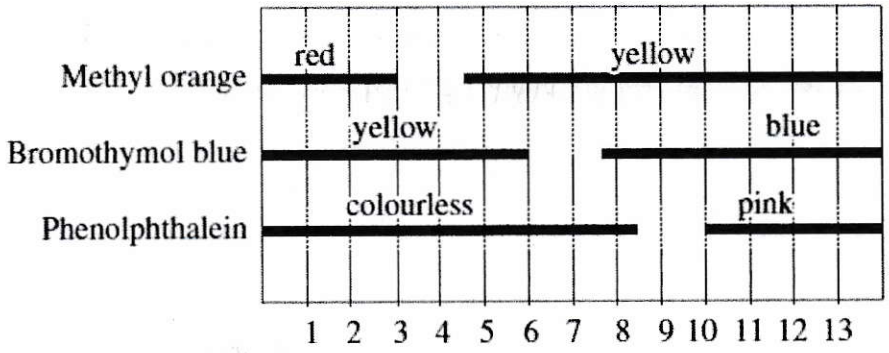
$N{=}H$ $C{=}O$
H $-OH$

(b) Explain the trends shown in the graph. 3

For all chain lengths, amines have an overall lower boiling point than carboxylic acids. This is because carboxylic acids contain a strong (OH) hydrogen bond as well as dispersion forces between the C=O bond. Amines on the other hand, although they contain N-H hydrogen bonding, this isn't as strong as the OH and C=O combined, thus require less energy to break and have a lower boiling point. Moreover, as chain length increases, boiling point increase. This is due to the longer hydrocarbon chain containing C-H bonds with dispersion forces. As all these intermolecular forces increase (as does the energy required to break them, thus boiling point increases.

End of Question 35

Question 36 (3 marks)



NH_4Cl

Explain why a solution of ammonium chloride makes bromothymol blue turn yellow, while a sodium sulfate solution of the same concentration makes bromothymol blue turn green. Include relevant chemical equations. 3

$NH_4Cl(aq) \rightleftharpoons NH_4^+(aq) + Cl^-(aq)$ $NH_4^+(aq) + H_2O(l) \rightleftharpoons NH_3(aq) + H_3O^+(aq)$

NH_4^+ is the conjugate acid of a weak base, thus it is a strong acid.

Cl^- is the conjugate base of a strong acid (HCl) thus it is weak.

NH_4Cl is therefore acidic, explaining why it turns bromothymol blue yellow.

$Na_2SO_4(aq) \rightleftharpoons 2Na^+ + SO_4^{2-}$

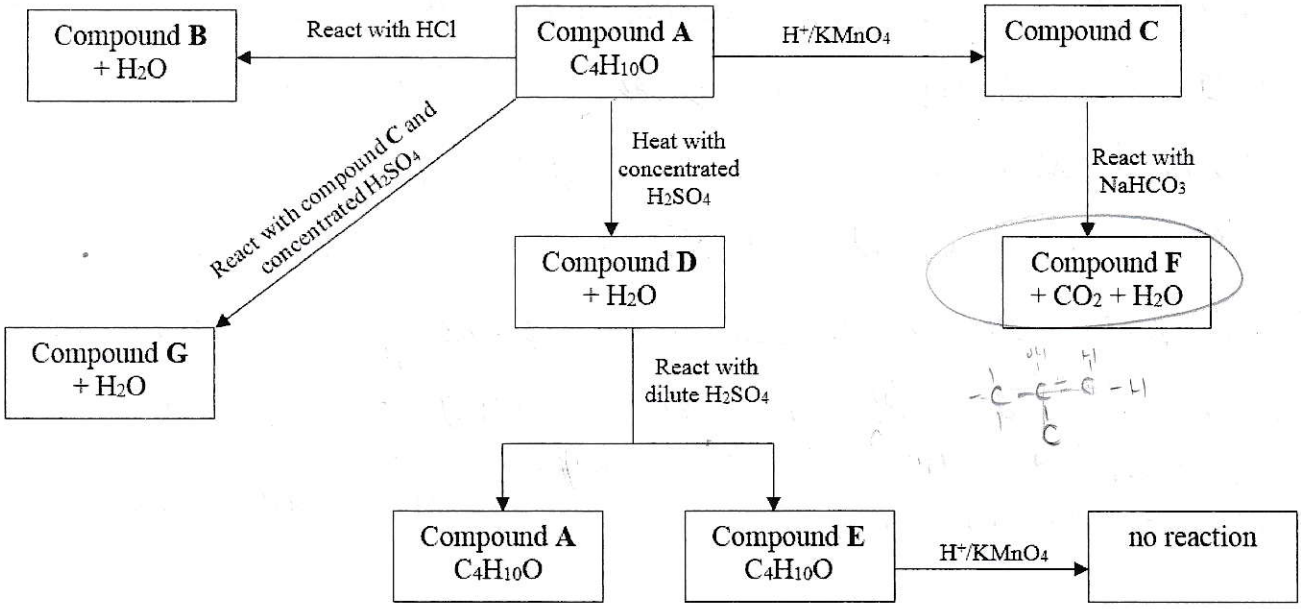
Na^+ is the conjugate acid of a strong base ($NaOH$) thus it is weak.

SO_4^{2-} is the conjugate base of a strong acid H_2SO_4 thus it is weak.

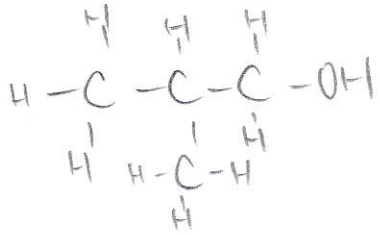
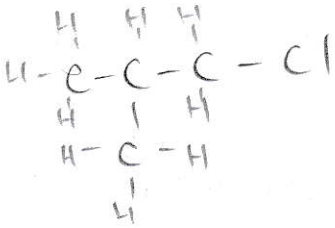
Once Na_2SO_4 is mixed with a strong base and strong acid, the pH of the salt ≈ 7 ∴ thus bromothymol blue green.

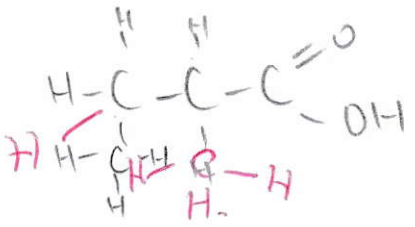
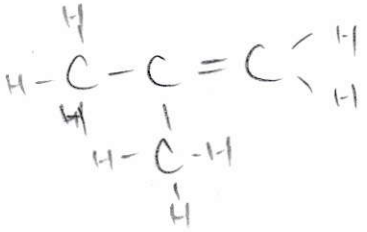
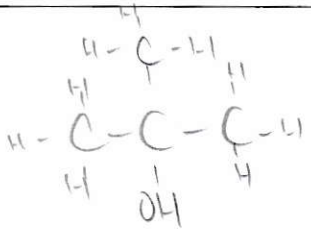
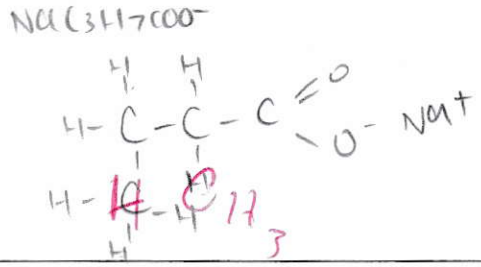
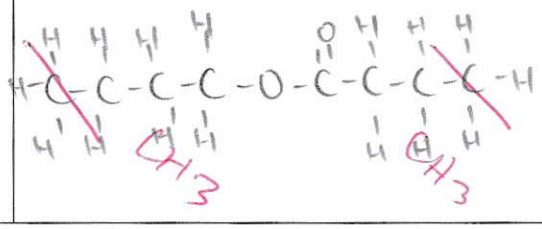
Question 37 (9 marks)

This flow chart shows the reactions of seven different organic compounds (**A** to **G**).



(a) Complete the table by drawing the structural formulae for the compounds and justifying your answers with reference to the information provided. 7

Compound	Structural formula	Justification
A		primary alcohol – oxidises to product C (an acid) that reacts to release CO_2 (g)
B		substitution reaction. OH ⇔ Cl

C		H is oxidised to an alkene and reacts to produce CO_2 (g)
D		Alkanol ⇒ alkene dehydration.
E		tertiary alcohol - doesn't oxidise
F		salt produced when carboxylic acid reacts with carbonate.
G		A+C ⇒ esterification. alcohol + carboxylic acid.

(b) Explain why it is necessary to reflux to obtain compound G. **2**

Refluxing during esterification is necessary so that the reaction is able to be carried at high temperatures without the loss of volatile ingredients. The reactants are able to condense and then fall back into the reaction flask as they cool. increase rate of reaction.

1

1