Student number

PEM

Chemistry

2019 TRIAL HSC EXAMINATION

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 formulae sheet, data 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 3–8)

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

Section II – 80 marks (pages 9–25)

- 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

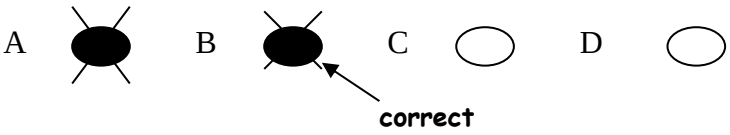
Use the multiple-choice answer sheet.

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

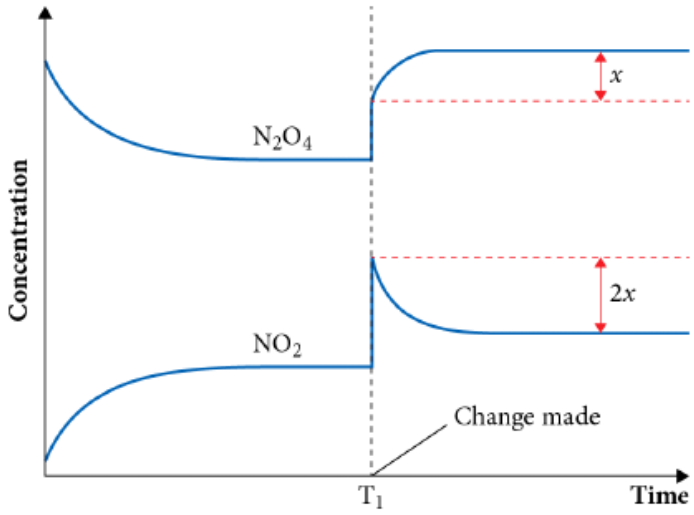
Sample: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

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

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



1. Consider the reaction: $2NO_2(g) \rightleftharpoons N_2O_4(g)$
The imposed change at T1 is most likely to be:



(A) an addition of NO_2.

(B) an addition of N_2O_4.

(C) an increase in the volume of the container.

(D) a decrease in the volume of the container.

2. Which of the following statements about acids and bases is FALSE?

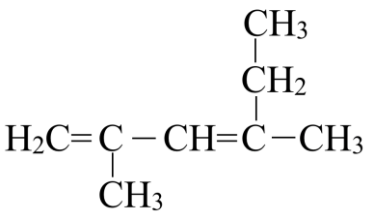
(A) Acids are able to produce hydrogen ions in solutions.

(B) A hydrogen ion attached to water forms a hydronium ion.

(C) Bases are able to produce hydroxide ions in solution.

(D) All oxides are basic.

3. The structural formula represents a compound. The IUPAC systematic name for this compound is:



(A) 3,5-dimethyl-3,5-hexane.

(B) 2,4-dimethyl-1,3-hexadiene.

(C) 2-methyl-4-ethyl-1,3-pentadiene.

(D) 2-ethyl-4-methyl-2,4-pentadiene.

4. Which of following alcohols have been classified correctly?

	Names of alcohols and their classification		
	Primary, 1º	**Secondary, 2º**	**Tertiary, 3º**
(A)	Propan-1-ol	Pent-3-ol	2-methylpropan-2-ol
(B)	Butan-2-ol	2-methylpropan-1-ol	2-methylpropan-2-ol
(C)	2,2-dimethylpropan-1-ol	Butan-1,4-diol	Ethanol
(D)	Propan-2-ol	Butan-2-ol	Pentan-3-ol

5. The equilibrium expression for the K_{sp} of $CaCO_3$ is:

(A) $[Ca^{2+}][CO_3^{2-}]/[CaCO_3]$

(B) $1/[Ca^{2+}][CO_3^{2-}]$

(C) $[Ca^{2+}][CO_3^{2-}]$

(D) $[CaCO_3] /[Ca^{2+}][CO_3^{2-}]$

6. The pH of pure water at 50°C ($K_w = 5.5 \times 10^{-14}$) is:

(A) 7

(B) 6.63

(C) 13.2

(D) 13.6

7. Which of the following hydrocarbons have the molecular formula $C_5H_{10}O$?

(I) Pentanoic Acid
(II) Pentan-3-ol
(III) Pentanal
(IV) Pentan-3-one

(A) I, II and III.

(B) I, III and IV.

(C) IV only.

(D) III and IV.

8. The purpose of the flame in the flame atomic absorption spectroscopy is to:

(A) desolvate and atomise the analyte atoms in a sample.

(B) purify the sample.

(C) ionise the analyte atoms.

(D) excite the analyte atoms.

9. The equation describes an equilibrium reaction occurring in a closed system.

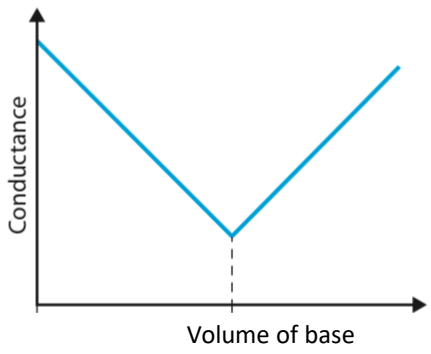
$$X(g) + Y(g) \rightleftharpoons 4Z(g); \qquad \Delta H = +58 \text{ kJ}$$

Under which set of conditions would the highest yield of $Z(g)$ be obtained?

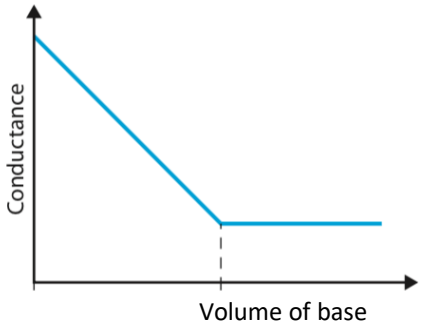
	Temperature (°C)	***Pressure (kPa)***
(A)	50	100
(B)	50	200
(C)	300	100
(D)	300	200

10. Which of the following conductivity graphs represent the titration of acetic acid and ammonium hydroxide.

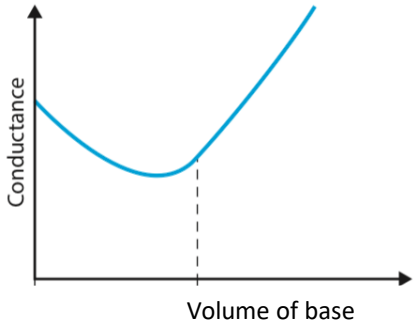
(A)



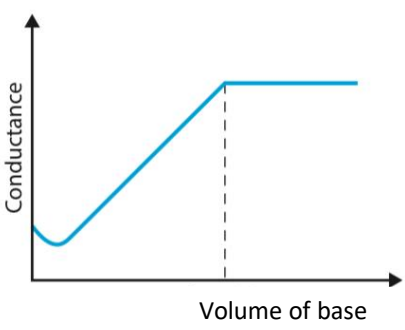
(B)



(C)



(D)



11. The low boiling point of liquid hydrocarbons are often classified as being volatile. This means that:

(A) they can ignite, even without an ignition source.

(B) they can easily change into a gas at normal temperature.

(C) their products of combustion are toxic.

(D) they all give out the same amount of energy when combusted.

12. Which of the following statements regarding mass spectroscopy is incorrect?

(A) Only cations can be detected by a normal mass spectrometer.

(B) Molecular ion peaks always have an even-numbered values of mass charge ratio (*m/z*).

(C) In a normal mass spectrometer, electron impact causes a molecule to lose an electron an become a molecular radical cation which decomposes into fragment cations and radicals.

(D) A compound whose molecules contain just one bromine atom shows two molecular peaks of similar intensity, one at +1 and one and -1 of the average *m/z* value.

13. The solubility product expression for tin (II) hydroxide is:

(A) $[Sn^{2+}][OH^-]$

(B) $[Sn^{2+}]^2[OH^-]$

(C) $[Sn^{2+}][OH^-]^2$

(D) $[Sn^{2+}]^3[OH^-]$

14. Choose the LEAST appropriate response.
A chemical industry such as the production of ammonia should be located:

(A) close supplies to raw materials.

(B) in an urban area.

(C) close to transport facilities for removing the product.

(D) where workers can easily access the site.

15. A student uses their data table to find out that the heat of combustion of 1-propanol is 2021 kJ mol^{-1}. What value would the student calculate for the heat of combustion of 1-propanol in kJ g^{-1}?

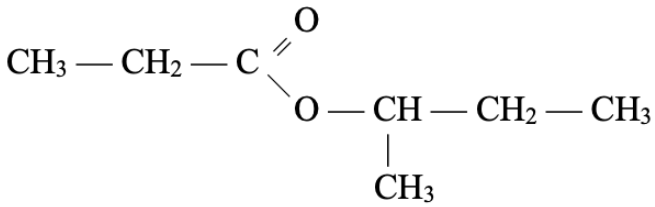
(A) 23.0

(B) 27.3

(C) 33.7

(D) 43.9

16. A compound has the structure shown below:



Hydrolysis of this compound will produce:

(A) butan-2-ol and propanoic acid.

(B) propan-1-ol and butanoic acid.

(C) propan-1-ol and 2-methylbutanoic acid.

(D) butan-1-ol and propanoic acid.

17. What mass of acetic acid will produce 2.5 L of solution having a pH of 5.50?

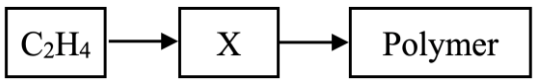
(A) 0.11 g

(B) 4.8×10^{-4} g

(C) 1.9×10^{-4} g

(D) 8.3×10^{-5} g

18. Which of the following compounds is represented by X in the flow chart?



(A) Cellulose

(B) Styrene

(C) Glucose

(D) Ethanol

19. A student determines the percentage of sodium chloride in a food sample by the following procedure. The food sample is dissolved in water and the chloride ion is precipitated by adding an excess of silver nitrate solution. The precipitate is washed and dried. If the food sample had a mass of 20.0 g and the final precipitate a mass of 0.376 g.

What is the percentage of sodium chloride in the food?

(A) 0.220%

(B) 0.465%

(C) 0.767%

(D) 1.88%

20. The concentration of reactants and products were studied for the following reactions:

$H_2(g) + F_{2(g)} \rightleftharpoons 2HF(g)$; $K_{eq} = 313$ at 25°C

In an experiment, the initial concentrations of the gases were
$[H_2] = 0.0120$ M, $[F_2] = 0.0200$ M, and $[HF] = 0.500$ M.

When the reaction reaches equilibrium at 25°C, the concentration of HF will be:

(A) 0.550 M

(B) 0.25 M

(C) less than 0.500 M

(D) between 0.0500 M and 0.550 M

Student number

Chemistry

2019 TRIAL EXAMINATION

Section II
80 marks

Attempt Questions 21-37
Allow about 2 hour and 25 minutes for this part

Answer the questions in the spaces provided.
Show all relevant working in questions involving calculations.

Question 21 (3 marks)

Consider the following mixture of gases in a closed 5.0 L vessel at 730°C.

Gas	*Quantity (mol)*
CH_4	2.00
H_2O	1.25
CO	0.75
H_2	0.75

The following reaction occurs:

$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \quad \triangle H = +206$ kJ

The equilibrium constant, *K*, is 0.26 at 1003K.

Determine whether the system is at equilibrium. **3**

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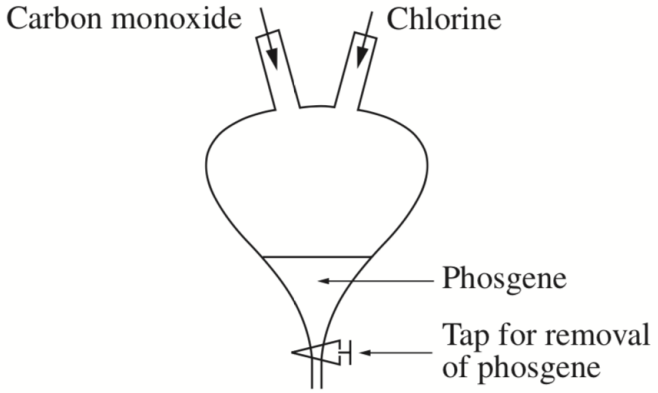
Question 22 (4 marks)

Carbonyl chloride, $COCl_2$, is a colourless, poisonous gas that is also known as phosgene. It is needed for the production of insecticides, polyurethane plastics and polycarbonate. It is produced from the exothermic equilibrium reaction of carbon monoxide gas and chlorine gas. When the reaction vessel is cooled below 8°C the phosgene is a liquid.



Reaction vessel for the formation of phosgene at 4°C

(a) Write a balanced equation for the formation of phosgene. **2**

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(b) Explain how industry could maximise the production of phosgene. **2**

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Question 23 (3 marks)

A saturated solution of white silver chloride is prepared in water at 35^{o}C. Hydrogen sulphide gas is bubbled through this saturated solution and the hydrogen sulphide reacts with silver ions to form highly insoluble black silver sulphide. Explain how this change will affect the silver chloride equilibrium.

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Question 24 (7 marks)

(a) Lead (II) chloride is sparingly soluble in water, and this equilibrium is set up between the solid and its ions in solution. Calculate the concentration of Pb^{2+} and Cl^{-} in the solution at 25^{o}C.

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Question 24 continues on page 12

Question 24 (continued)

(b) Calculate and compare the solubility of the lead chloride when dissolved in 0.25 mol L^{-1} of NaCl. **3**

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Question 25 (4 marks)

A green solution was made containing a weak acid, *HA* (which is a yellow molecule) and its conjugate base, A^- (which is blue).

(a) Write an equation for the reaction which occurs when a strong base such as sodium hydroxide is added to this solution. **1**

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(b) Write an equation for the reaction which occurs when a strong acid such as hydrochloric acid is added to this solution. **1**

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(c) Use your equations from part (a) and (b) to explain why this solution can act as an indicator. **2**

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Question 26 (5 marks)

Sodium hydrogen carbonate, $NaHCO_3$, is a common laboratory chemical.

Explain why the Arrhenius acid/base definition is unable to account for the acid/base properties of this species, whereas the Lowry-Bronsted theory can.

Include chemical equations to illustrate your explanation.

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Question 27 (5 marks)

A titration was carried out to determine the concentration of a sulfuric acid solution, using previously standardised 0.105 mol L^{-1} sodium hydroxide solution.

(a) Outline the method used to standardise the sodium hydroxide solution. **1**

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(b) Calculate the concentration of the sulfuric acid solution, if 25.0 mL of this solution reacted completely with 27.7 mL of the sodium hydroxide solution. **2**

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(c) Identify an indicator which is suitable for use in this titration and justify this choice of indicator. **2**

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Question 28 (4 marks)

Calculate the pOH of 0.20 M H_2CO_3. (K_a = 4.3 x 10^{-7}).

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Question 29 (5 marks)

Complaints have been made about a particular brand of orange juice being too acidic. Recommended levels of citric acid in orange juice must be below 1%.

To test this claim, a student accurately measured 6 g of orange juice and transferred it into a 150ml beaker. Approximately 45 mls of distilled water was added to the sample so the depth was sufficient to cover the glass electrode of the pH probe. This was titrated against standardised 0.1003 mol L^{-1} NaOH solution. The results are shown below.

	Volume of titrant used (mls)
1	6.830
2	6.750
3	6.700
4	6.680

Assess whether the concentration of citric acid in this brand of juice is within the recommended levels.

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Question 30 (5 marks)

The boiling points and molar masses of these compounds are shown:

Compound	***Boiling point (°C)***	***Molar mass, g mol^{-1}***
Acetic Acid	118	60
Butan-1-ol	117	74
Butyl acetate	116	116

Discuss why Acetic acid, butan-1-ol and butyl acetate have very similar boiling points but different molar masses.

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Question 31 (4 marks)

During a school camp, a student uses methylated spirits which is mostly C_2H_5OH as a source of energy to boil his drinking water.

(a) Write a balanced equation for the reaction of methylated spirits with oxygen. **1**

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(b) Calculate the amount of energy released when 1.0 g of methylated spirits is completely burnt in excess oxygen. Assume the enthalpy of combustion of ethanol is 1364 kJ mol^{-1}. **1**

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(c) A camping stove that uses methylated spirits as its fuel source heats a kettle containing 950 ml of water at 12ºC. What mass of methylated spirits must be burnt to heat the water to its normal boiling temperature? Assume only 40% of the energy provided by the combustion reaction of the methylated spirits is used to heat the water. **2**

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Question 32 (4 marks)

(a) In the space below, draw the structural formula for each reactant required to produce pentyl acetate in the laboratory. Name each reactant. **2**

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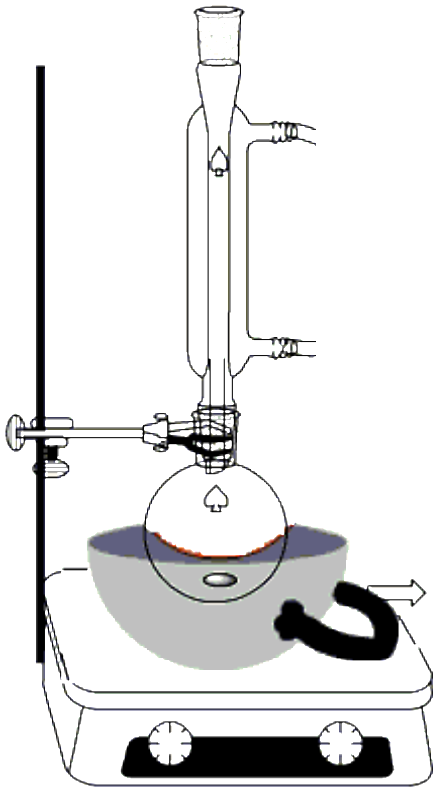
(b) The image below shows the equipment used for this reaction.



Explain reasons for using the apparatus above in this technique. **2**

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Question 33 (4 marks)

Polyvinyl alcohol is a water-soluble addition polymer used in adhesives and paints. The monomer used has the following structure:

$$CH_2 = CHOH$$

(a) Draw a structural formula for a 3-unit segment of the polymer. **1**

(b) Explain how bromine water can be used to distinguish between a solution of the monomer and a solution of the polymer.

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(c) State the systematic name for the monomer used in forming polystyrene.

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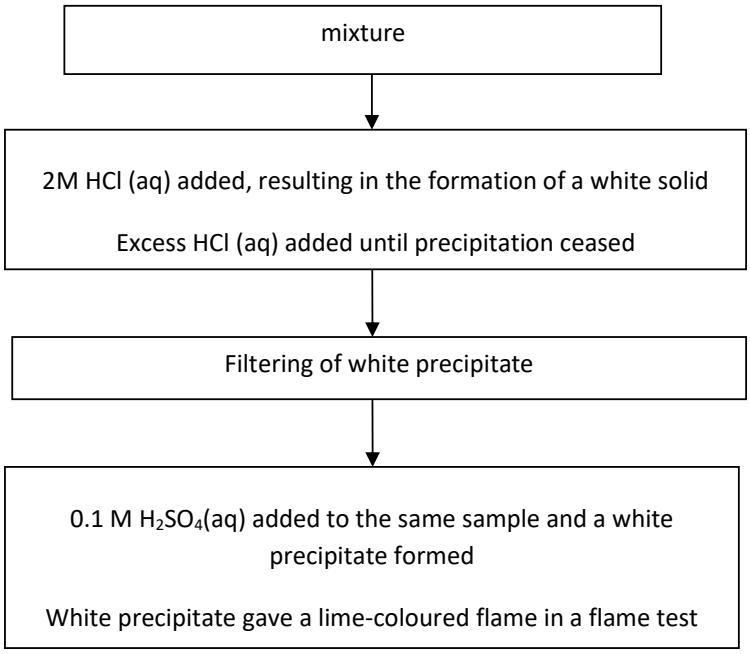
Question 34 (5 marks)

An aqueous solution was known to contain two of the following cations: Ca^{2+}; Ba^{2+}; Cu^{2+}; Pb^{2+}; Fe^{2+}.

The procedure a student used to identify the two cations is shown in the following flowchart.



(a) Identify the cation responsible for the white precipitate formed upon addition of HCl.

…… **1**

(b) Write a net ionic equation for the reaction which produced the white precipitate upon addition of H_2SO_4.

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(c) Justify the procedure used to identify the two unknown cations.

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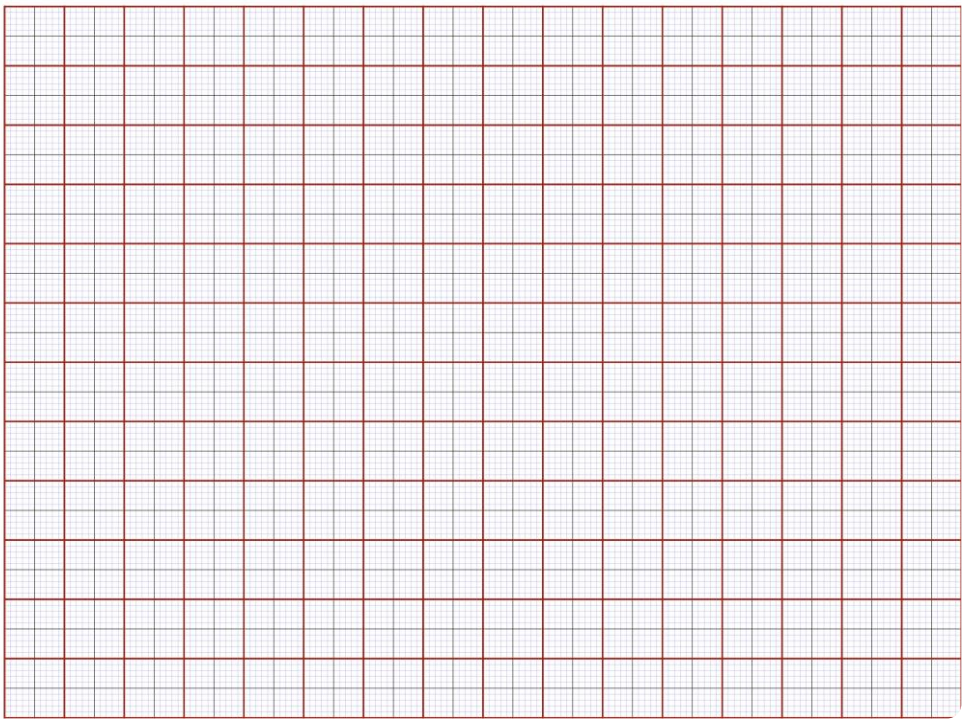
Question 35 (7 marks)

In monitoring the effect of discharge effluent on river quality, a chemist uses *atomic absorption spectroscopy* to compare the sodium ion concentrations above and below the discharge point in the Lachlan River. The table below shows the absorption values at a wavelength of 589 nm, for water samples, and also for a range of standard solutions.

Solution	***Na^+ concentration (mg L^{-1})***	***Absorbance at 589 nm (%)***
Standard	10	16
Standard	20	34
Standard	40	63
Standard	60	98
Up river sample 1		4
Up river sample 2		5
Down river sample 1		54
Down river sample 2		43

(a) Plot the standards on the grid below. (Label axes) **3**



(b) Complete the entries for Na^+ concentrations of water samples **in the table above.** **2**

(c) Assess the downstream water quality for the fresh water organisms, for the maximum sodium ion concentration is 100 ppm. Explain why water quality might change in periods of low rain fall. **2**

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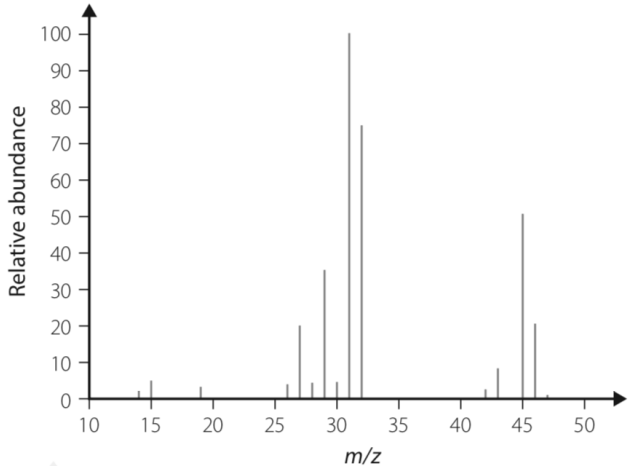
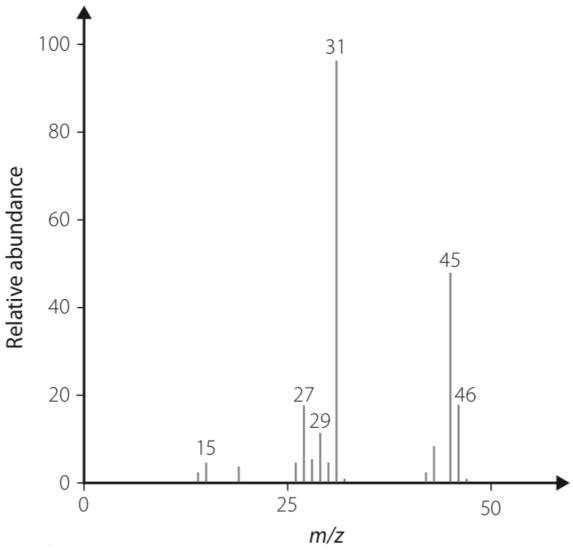
Question 36 (4 marks)

Quality control in a bioethanol plant displayed concern that their ethanol had been contaminated with methanol. Mass spectroscopy was completed on the suspected sample. These results were compared with the known mass spectrum of ethanol. Results are shown below.



Mass spectrum of contaminated sample



Mass spectrum of ethanol

(a) Explain how the quality control determined the sample was contaminated **2**

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Question 36 continues on page 24

Question 26 (continued)

(b) Justify the contaminant was methanol **2**

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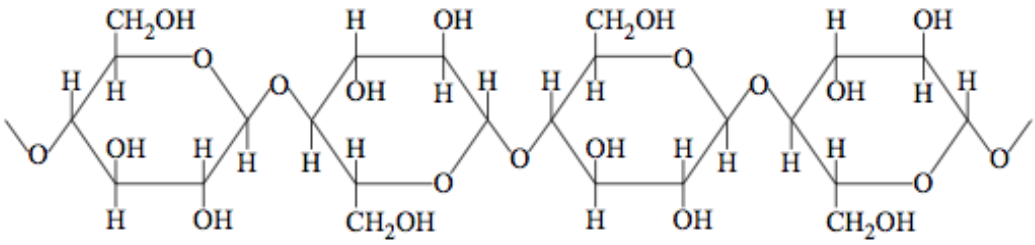
Question 37 (7 marks)

The cellulose that is present in plant matter cannot be directly fermented to produce bioethanol. The cellulose polymer must first be broken down into its constituent monomers. A section of cellulose polymer is shown below.



(a) What is the name of the monomer from which cellulose is formed? **1**

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(b) Complete the following chemical equation to show the formation of ethanol by the cellulose monomer. **1**

$C_6H_{12}O_6\ (aq) \rightarrow$ …….. + ……..

(c) Ethylene can be produced from ethane by the thermal cracking of ethane at very high temperatures. Write a balanced chemical equation for this reaction. **1**

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Question 37 continues on page 25

Question 37 (continued)

(d) Evaluate the use of a recently developed biopolymer. **4**

End of Section II

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2019 Year 12 Chemistry Trial examination. Marking Guidelines and model Answers.

Section I Multiple Choice

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
D	D	B	A	C	B	D	A	C	D	B	B	C	B	C	A	D	B	C	C

Section II

21.

Marking guidelines	Marks
• Correctly calculates the value of *Q* and states that the system is not at equilibrium	3
• Uses equilibrium expression in some form but gets incorrect answer	2
• States the equilibrium expression in some form	1

Sample answer

To determine if the system is at equilibrium it is necessary to calculate Q, the reaction quotient, and see if it is the same as K.

$Q = \frac{[CO][H_2]^3}{[CH_4][H_2O]}$

$= \frac{(0.15)(0.15)^3}{(0.4)(0.25)}$

$Q = 5.06 \times 10^{-3}$

$K = 0.26$

$Q \neq K.$

$[CH_4] = 2.00/5 = 0.4$

$[H_2O] = 1.25/5 = 0.25$

$[CO] = 0.75/5 = 0.15$

$[H_2] = 0.75/5 = 0.15$

Therefore, the system is not at equilibrium.

22. a.

Marking guidelines	Marks
• Writes the correct balanced equation using chemical symbols	2
• Writes a correct word equation OR • Gives the correct formula for carbon monoxide and for chlorine gas	1

Sample answer

$CO_{(g)} + Cl_{2(g)} \Leftrightarrow COCl_{2(l)} \quad \triangle H = -ve$

22. b

Marking guidelines	Marks
• Correctly identifies one factor which influences the equilibrium and describes the way in which this factor can be used to maximise production of phosgene, using their answer in part (a)	2
• Correctly identifies one factor which influences the equilibrium OR • Relates Le Chatelier's principle to maximising production by indicating correct equilibrium shift	1

Sample answer

Increasing the pressure/decreasing the volume of the reaction vessel will shift the equilibrium in the forward direction. According to Le Chatelier, a shift in the forward direction will counteract the change which results in more product being formed.

23.

Marking guidelines	Marks
• Correct solubility expression and applies this value to the solubility AND • Correctly explains shift in equilibrium AND • Correctly deduces the continued use of hydrogen sulphide in solution.	3
Correctly addresses TWO of the criteria above	2
Correctly addresses ONE of the criteria above	1

Sample answer

$AgCl_{(s)} \Leftrightarrow Ag^{+}_{(aq)} + Cl^{-}_{(aq)}$

Silver chloride is very insoluble with a K_{sp} of 1.77×10^{-10}. This means very little reactant will be converted to their ions in water at equilibrium.

The reaction between silver ions and hydrogen sulphide will reduce the silver ion concentration. This decreases the silver ion concentration shifting the equilibrium in the forward direction to produce more silver ions. This more silver chloride will dissolve as the equilibrium is counteracted.

If hydrogen sulphide continues to be bubbled through the solution, eventually all silver chloride will dissolve and be replaced by black silver sulphide.

24. a.

Marking guidelines	Marks
• Provides correct balanced equation • Correctly calculates the value of the unknown using the Ksp expression • Calculates the concentration of Pb^{2+} in water • Calculates the concentration Cl^{-} in water	4
Correctly addresses THREE of the criteria above	3
Correctly addresses TWO of the criteria above	2
Correctly addresses ONE of the criteria above	1

Sample answer

$PbCl_{2(s)} \rightleftharpoons Pb^{2+}_{(aq)} + 2Cl^{-}_{(aq)}$ $\quad K_{sp} = 1.7 \times 10^{-5}$

$K_{sp} = [Pb^{2+}][Cl^{-}]^2$

$1.7 \times 10^{-5} = s \times (2s)^2$

$= 4s^3$

$s^3 = 4.25 \times 10^{-6}$

$s = 1.6 \times 10^{-2}$

$\therefore [Pb^{2+}] = 1.6 \times 10^{-2}$ mol L^{-1} $\quad [Cl^{-}] = 2 \times 1.6 \times 10^{-2} = 3.2 \times 10^{-2}$ mol L^{-1}

24. b.

Marking guidelines	Marks
• Provides assumption of $[Cl^{-}]$ • Correctly calculates the solubility of $PbCl_2$ • Qualitatively and quantitively compares the differences in solubility	3
Correctly addresses TWO of the criteria above	2
Correctly addresses ONE of the criteria above	1

Sample answer

$PbCl_2(s) \rightleftharpoons Pb^{2+}(aq) + 2Cl^-(aq)$

	Pb^{2+}	Cl^-
I	0	0.25
C	+s	+2s
E	s	0.25+2s

$[Cl^-] \approx 0.25$

$K_{sp} = [Pb^{2+}][Cl^-]^2$

$1.7 \times 10^{-5} = s \times 0.25^2$

$s = 2.7 \times 10^{-4}$

$\therefore$ Solubility of $PbCl_2$ in $0.25\ mol\ L^{-1}$ NaCl is $2.7 \times 10^{-4}\ mol\ L^{-1}$

$PbCl_2$ is approximately 59× more soluble in H_2O.

25. a.

Marking guidelines	Marks
• Correct equation	1

Sample answer

$OH^-(aq) + HA(aq) \rightarrow H_2O(l) + A^-(aq)$

Blue

25. b.

Marking guidelines	Marks
• Correct equation	1

Sample answer

$H_3O^+(aq) + A^-(aq) \rightarrow H_2O(l) + HA(aq)$

yellow

25. c.

Marking guidelines	Marks
• Explains why the solution can act as an indicator, as the colour changes with changes in pH / changes in concentration of H_3O^+ • AND • Refers to the reactions in parts (a) and (b)	2
• Explains why the solution can act as an indicator, as the colour changes with changes in pH / changes in concentration of H_3O^+	1

Sample answer

The solution is a green equilibrium mixture of HA (yellow) and A^- (blue).
The equilibrium in the solution can be represented:

$HA(aq) + H_2O(l) \Leftrightarrow A^-(aq) + H_3O^+(aq)$

yellow *blue*

When a strong base is added, the reaction in (a) occurs and the indicator solution turns blue. Considering the equilibrium reaction above, the green solution turns blue, as the concentration of H_3O^+ decreases and the indicator equilibrium shifts to the right.
When a strong acid is added, the reaction in (b) occurs. Considering the equilibrium reaction above, the green solution turns yellow, as the equilibrium shifts to the left as the concentration of H_3O^+ increases.
Hence the green solution can act as an indicator as it is a different colour in acidic and basic solutions; i.e. in solutions of different pH.

26.

Marking Guidelines	Marks
• outlines the Arrhenius and Lowry-Bronsted definitions of acids and bases • explains why the Arrhenius definition cannot account for $NaHCO_3$ or being a base • **identifies that the Arrhenius definition cannot account for $NaHCO_3$ being amphiprotic** • explains how the Lowry-Bronsted definition accounts for its amphiprotic behaviour • includes two or more correct, relevant chemical equations	5
Correctly addresses FOUR of the criteria above	4
Correctly addresses THREE of the criteria above	3
Correctly addresses TWO of the criteria above	2
Addresses ONE of the criteria above	1

Sample answer

The Arrhenius definition of acids/bases is that they ionise in water to give H^+ ions, and bases ionise in water to produce OH^- ions. This definition does not account for the behaviour of $NaHCO_3$:

- *it gives basic aqueous solutions even though it does not contain OH^- ions*
- *it reacts with both acids and bases*

The Lowry-Bronsted definition is that acids are proton donors and that bases are proton acceptors. $NaHCO_3$ can be classified as an acid or a base using this definition, depending on reaction conditions. Thus, it produces basic aqueous solutions because when it dissolves it ionises to give Na^+ ions and HCO_3^- ions. The hydrogencarbonate ions accept a proton from water, producing OH^- ions and hence a pH greater than 7: $HCO_3^- + H_2O \rightarrow H_2CO_3 + OH^-$. In this case it is behaving like a Lowry-Bronsted base. However, in solutions of weak bases it can act as an acid, donating a proton: $HCO_3^- + PO_4^{2-} \rightarrow HPO_4^- + CO_3^{2-}$. Thus the Lowry-Bronsted definition can account for the basic and amphiprotic behaviour of $NaHCO_3$.

27. a.

Marking Guidelines	Marks
Outlines the steps in a method used to standardise sodium hydroxide solution by reacting it with an acid of known concentration	1

Sample answer

The sodium hydroxide solution must be standardised by titrating it with an acid of exactly known concentration. This can be a primary standard (can be accurately weighed out) such as oxalic acid or a solution of, for example, hydrochloric acid which has been previously standardised against a primary standard such as anhydrous sodium carbonate.

27. b.

Marking Guidelines	Marks
Correct answer to 3 significant figures	2
Correct answer to incorrect number of sig. figs.	1

Sample answer

$n(NaOH) = cV$
$= 0.105 \times 0.0277$
$= 0.00291 \text{ mol}$

$\therefore n(H_2SO_4) = 0.00291 \times \frac{1}{2}$
$= 0.00145 \text{ mol}$ (1:2 ratio)

$\therefore c(H_2SO_4) = n/V$
$= \frac{0.00145}{0.0250}$
$= 0.0582 \text{ mol L}^{-1}$ (3sf)

27. c.

Marking Guidelines	Marks
• Identifies an appropriate indicator and justifies the choice in terms of the indicator colour change • the pH at the equivalence point of the titration	2
Correctly addresses ONE of the above criteria	1

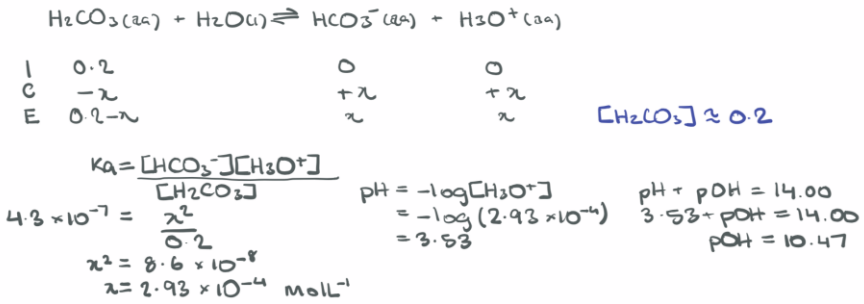
Sample answer

The titration involves a strong acid and a strong base. As a result, at the equivalence point, the pH will be at 7. Litmus solution and bromothymol blue are the best indicators as they change colour at pH = 7. (However, because of the rapid change in pH within a drop of the equivalence point, any of methyl orange, phenolphthalein, litmus and bromothymol blue can be used as answers as long as they are correctly justified.)

28.

Marking Guidelines	Marks
• Correct balanced equation • Correctly calculates pH • Correctly calculates concentrations of species at equilibrium with assumption made • Correctly calculates pOH	4
• Correctly addresses THREE of the criteria above OR • Correctly addresses all criteria without making an assumption	3
Correctly addresses TWO of the criteria above	2
Addresses ONE of the criteria above	1

Sample answer



29.

Marking Guidelines	Marks
• Calculates average titrant used AND • Correctly writes the balanced chemical equation AND • Calculates moles and mass of citric acid AND • Calculates percentage of citric acid in orange juice AND • Assessment is made	5
Correctly addresses FOUR of the criteria above	4
Correctly addresses THREE of the criteria above	3
Correctly addresses TWO of the criteria above	2
Addresses ONE of the criteria above	1

Sample answer

Avg = 6.710 ml

$C_3H_5(COOH)_{3(aq)} + 3NaOH_{(aq)} \longrightarrow Na_3C_3H_5(COO)_{3(aq)} + 3H_2O_{(l)}$

$n(NaOH) = cv$
$= 0.1003 \times 0.006710$
$= 6.730 \times 10^{-4}$ mol

$\therefore n(C_6H_8O_7) = 6.730 \times 10^{-4} \times \frac{1}{3}$
$= 2.243 \times 10^{-4}$ (1:3 ratio) per 6g of orange juice

$m(C_6H_8O_7) = n \times Mm$
$= 2.243 \times 10^{-4}$ mol $\times$ 192.124 gmol^{-1}
$= 0.04310$ g per 6g of orange juice

% of $C_6H_8O_7$ in Orange Juice $= \frac{0.04310\,g}{6g} \times 100$
$= 0.7183\%$

Within recommended levels

30.

Marking Guidelines	Marks
• Thoroughly explains the intermolecular forces and polarity of Butyl acetate • Thoroughly explains the intermolecular forces and polarity of Butan-1-ol • Thoroughly explains the intermolecular forces and polarity of Acetic acid • Compares the structure of all three compounds. • Compares and contrast all three compounds with regards to their boiling point and molar masses.	**5**
• Correctly addresses FOUR of the criteria	**4**
• Correctly addresses THREE of the criteria	**3**
• Provides a limited understanding of intermolecular bonding and structure of all three compounds	**2**
• Identifies the types of intermolecular forces present with all three compounds	**1**

Sample answer

Despite having different molar masses, all three molecules have similar boiling points due to the different structures and resulting intermolecular forces.

Butyl acetate has the largest molar mass and therefore greatest dispersion forces but is only slightly polar and has no hydrogen bonding.

Butan-1-ol has lower molar mass than butyl acetate and therefor smaller dispersion forces but it is polar and contains a hydrogen bound to an oxygen. Therefore, it exhibits hydrogen bonding resulting in strong intermolecular forces.

Acetic acid has the lowest molar mass and so the weakest dispersion force, but it is polar and contains a hydrogen bound to an oxygen allowing the formation of hydrogen bonds between molecules. The presence of a second oxygen in acetic acid increases the hydrogen bonding compared with butan-1-ol.

Therefore all three molecules have similar total strength of intermolecular forces and similar boiling points.

31.a.

Marking Guidelines	Marks
• Correct balanced equation with states	**1**

Sample answer

$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$

31.b.

Marking Guidelines	Marks
• Correct heat released with units and 2 significant figures	**1**

Sample answer

$n(C_2H_5OH) = \frac{1\,g}{46.068\,g\,mol^{-1}}$
$= 0.0217\ mol$

Heat released for 1.0 g = 0.0217×1364
$= 30\ kJ$ (2sf)

31.c.

Marking Guidelines	Marks
• Calculates energy produced from combustions AND • Calculates mass of ethanol	**2**
• Calculates energy from released from the camping stove	**1**

Sample answer

$Q = mc\Delta T$
$= 950 \times 4.18 \times (100-12)$
$= 349\,448\ J$
$= 349\ kJ$ @ 40%

Energy from combustion $= \frac{349\,kJ}{40} \times 100$
$= 874\ kJ$

$n(C_2H_5OH) = \frac{874\,kJ}{1364\,kJ\,mol^{-1}}$
$= 0.6405\ mol$

$m(C_2H_5OH) = 0.6405\ mol \times 46.068\,g\,mol^{-1}$
$= 29.5\,g$
$= 30\,g$ (2sf)

32. a

Marking Guidelines	Marks
• Shows structural formulas for 1-pentanol AND acetic acid	2
• Shows a structural formula for 1-pentanol OR acetic acid	1

Sample answer

1-pentanol: $CH_3(CH_2)_3CH_2OH$ acetic acid: CH_3COOH

32. b.

Marking Guidelines	Marks
• Explains TWO reasons for using the reflux technique	2
• Explains ONE reason for using the reflux technique	1

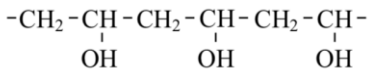
Sample answer

The reaction mixture is boiled under reflux, using an open condenser. This enables the reaction to be carried out at the boiling point, to maximise rate, without loss of reactants by vaporisation. The use of an open condenser avoids any hazardous build-up of pressure in the system.

33. a.

Marking Guidelines	Marks
• Correct structural formula	1

Sample answer



33. b.

Marking Guidelines	Marks
• Explains how to distinguish between saturated an unsaturated hydrocarbons	2
• Fails to mention that Bromine water reacts with double bond	1

Sample answer
Bromine water is decolourised instantly by the monomer reacting with the double bond. The polymer has single bonds only and reacts very slowly or not at all.

33. c.

Marking Guidelines	Marks
• Correctly identifies it as Phenyl Benzene OR Ethenyl Benzene	1

34. a.

Marking Guidelines	Marks
• Correctly identifies Pb^{2+}	1

34. b.

Marking Guidelines	Marks
• Correct ionic equation with states	1

Sample answer
$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

34. c.

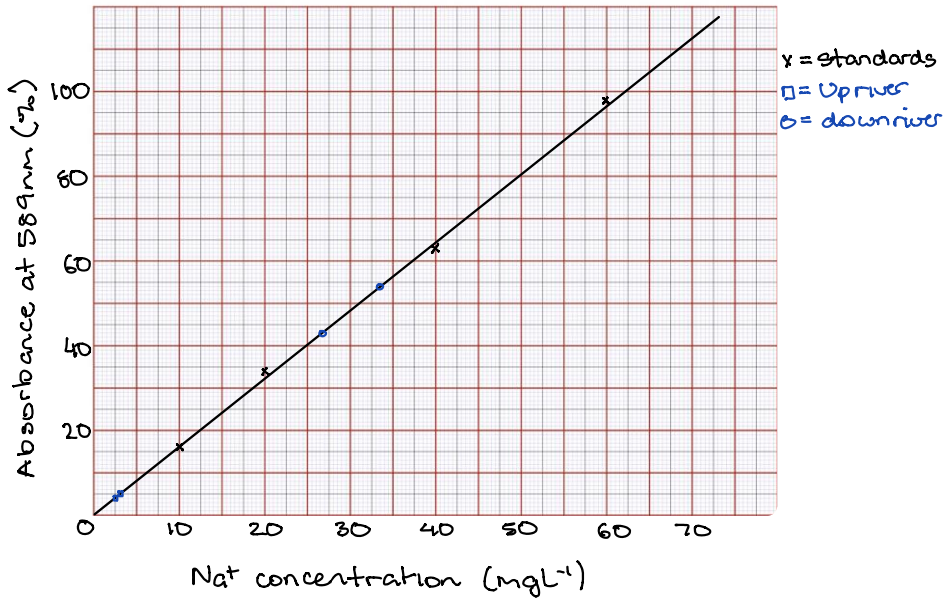
Marking Guidelines	Marks
• Justifies the order of adding HCl, and H_2SO_4, and the addition of excess HCl to prevent precipitation of $PbSO_4$.	3
• Justifies the order of adding HCl and H_2SO_4, and the addition of excess HCl to remove Pb^{2+}	2
• Justifies the order of adding HCl and H_2SO_4 OR gives a justification of adding excess HCl.	1

Sample answer
The student knew there were two cations. The HCl was added first because from the list of possible cations, it precipitates only Pb^{2+}. If he had added H_2SO_4 first, it would have precipitated both the Pb^{2+} and the Ba^{2+} and there would have been no way of telling that both cations were in the ppt. HCl was added until ppt of the Pb^{2+} ceased in order to prevent remaining Pb^{2+} from precipitating with SO_4^{2-}, which would have provided a false positive in the sulfate precipitation test. The Pb^{2+} had to be removed to ensure that any precipitate in the sulfate test was not Pb^{2+}, but rather Ba^{2+}.

35. a.

Marking Guidelines	Marks
• Correct scale AND • Labels axes with units AND • Correct plots	3
• Correctly addresses TWO of the criteria above	2
• Correctly addresses ONE of the criteria above	1

Sample answer



35. b.

Marking Guidelines	Marks
• Correct upriver plots AND down river plots	2
• Correctly addresses ONE of the criteria above	1

Sample answer
*See above in **35. a.***

35. c.

Marking Guidelines	Marks
• Identifies sodium concentration is within safe limits AND • Correctly explains the change in sodium concentration	2
• Correctly addresses ONE of the criteria above OR • Describes the change in sodium concentration	1

Sample answer
The concentration of sodium ions downriver are within safe limits for fresh water organisms. During low rainfall periods, the river flow will decrease, reducing the dilution effect. As a result, the sodium ion concentration down river will increase, possibly above the maximum level.

36. a.

Marking Guidelines	Marks
• Correctly identifies TWO inconsistencies in the mass spectrum and explains why the sample is contaminated	2
• Identifies One inconsistency and explains why the sample is contaminated	1

Sample answer
Results show an additional peak at 32, and a larger peak at 29 which is not in the standard mass spectrum of ethanol. Therefore, the sample is contaminated.

36. b.

Marking Guidelines	Marks
• Relates both peaks to the mass of possible fragments of methanol	2
• Relates one peak to a fragment of methanol	1

37. a.

Marking Guidelines	Marks
• Correct identifies monomer glucose	1

37. b.

Marking Guidelines	Marks
• Completes balanced equation with state symbols	1

Sample answer
$C_6H_{12}O_6\,(aq) \rightarrow 2CO_2\,(g) + 2H_2O(l)$

37. c.

Marking Guidelines	Marks
• Completes balanced equation with state symbols	1

Sample answer
$C_6H_6\,(g) \rightarrow C_2H_6\,(g) + H_2\,(g)$

37. d.

Marking Guidelines	Marks
• Describes the development and use of a named biopolymer and makes a judgement on its use based on described advantages and limitations of the biopolymer.	4
• Outlines a recent biopolymer AND identifies an advantage and limitation of the biopolymer	3
• Outlines the recent development of a named biopolymer	2
• Identifies a recently developed biopolymer or states an advantage or limitation of the biopolymers in general.	1

Sample answer
From the fractional distillation of crude oil, followed by thermal and catalytic cracking, we obtain ethylene which can be polymerised into a number of synthetic polymers. The polymers produced from these monomers have very useful properties, and have transformed the modern world. Products such as food wrapping, polystyrene insulation, PVC drainpipes, and all of the ubiquitous plastic around us, are relatively recent modern phenomena. The biggest issue with these plastics is that they are non-biodegradable, and contribute to the vast amount of landfill we generate, and also destroy habitat, both terrestrial and aquatic, killing large numbers of marine animals for example. Fossil fuels are also non-renewable resources and are therefore dwindling and becoming more expensive as a result.

Biopolymers are an alternative source of these materials, and one such biopolymer, polyhydroxybutanoate (PHB) already finds commercial applications. PHB is produced by fermentation, using the bacteria Alcaligenes eutrophus, by feeding it on a nutrient rich diet to increase its population, and then restricting the supply of nitrogen in its food. This causes it to produce PHB as an energy storage compound. Once the production of PHB is complete it is harvested by solvent extraction. PHB has properties

similar to polypropene, and has found commercial use as plastic bottles and containers, for example for shampoo packaging. It has a high melting point, is strong, water resistant and relatively rigid, making it ideal for these sorts of applications. However it is also biodegradable, which means that once disposed of, and exposed to bacteria in the environment, it is broken down completely, eliminating the issue of land and sea pollution. It is also a renewable material since it is made by living organisms, eliminating the issue of dwindling fossil fuel resources. On the other hand, currently biopolymers are more expensive than polymers obtained from fossil fuels, but this will change as fossil fuels continue to dwindle and their price increases. As a result this biopolymer is an excellent alternative to some of the materials currently obtained from fossil fuels.