Exam Choice

Student Number

2019

TRIAL EXAMINATION

Chemistry

General Instructions

- Reading time – 5 minutes.
- Working time – 3 hours.
- Write using black pen.
- Draw diagrams using pencil.
- For questions in Section II, show all relevant working in questions involving calculations.
- NESA approved calculators may be used.

Total marks: 100

Section I – 20 marks (pages 3 – 11)

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

Section II – 80 marks (pages 12 – 30)

- Attempt questions 21 – 33
- Allow about 2 hours and 25 minutes for this section.

Section I – 20 marks

Attempt Questions 1-20

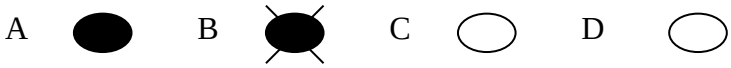
Allow about 35 minutes for this section

Use the multiple-choice answer sheet.

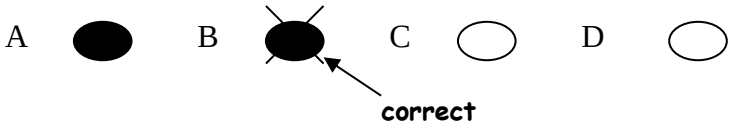
Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

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. Indigenous Australians detoxified seeds of cycad plants, which contain the toxin cycasin, to allow the seeds to be eaten safely.

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 higher density of the toxin compared to water.

(B) the reactivity of the toxin with water.

(C) the solubility of the toxin in water.

(D) the immiscible nature of the toxin in water.

2. Which one of the following is an example of an equilibrium system?

(A) Burning propane gas in a barbeque.

(B) A saturated solution of sodium chloride.

(C) Reacting magnesium with oxygen in a Bunsen flame.

(D) The production of glucose by photosynthesis.

3. Which of the following lists contains members of the same homologous series?

(A) C_2H_6, C_4H_{10}, C_6H_{14}

(B) C_2H_2, C_2H_4, C_2H_6

(C) C_2H_5Cl, C_2H_5OH, $C_2H_5NH_2$

(D) CH_3Cl, CH_2Cl_2, $CHCl_3$

4. Identify the insoluble compound from the following options.

(A) $Na_2Cr_2O_7$

(B) $Sr(NO_3)_2$

(C) NH_4CH_3COO

(D) $NiCO_3$

5. Which of the following statements is true of a system at equilibrium?

(A) The concentration of reactants and products are equal.

(B) The forward and reverse reactions are no longer occurring.

(C) The rates of the forward and reverse reactions are equal.

(D) The concentration of reactants and products changes constantly.

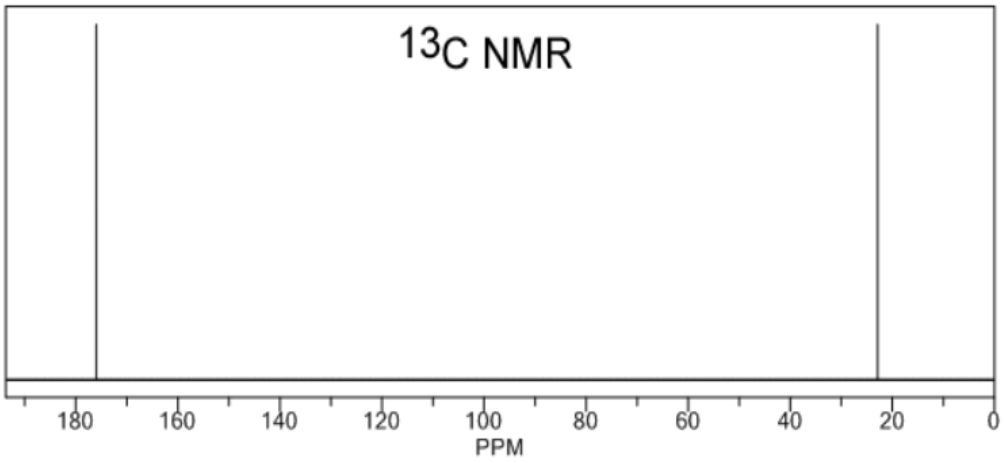
6. Below is a table of reactions involving organic compounds.

Reaction	Product
ethene + hydrogen chloride	1
ethanal + permanganate ion	2
ethanol + ethanoic acid	3
ethanoic acid + sodium carbonate	4

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

	Product 1	**Product 2**	**Product 3**	**Product 4**
(A)	chloroethane	ethanoic acid	ethanal	sodium ethanoate
(B)	chloroethene	ethanoic acid	ethyl ethanoate	carbon dioxide
(C)	chloroethane	ethanal	ethanoate ion	carbon dioxide
(D)	chloroethane	ethanoic acid	ethyl ethanoate	carbon dioxide

7. This question refers to the C13-NMR spectrum below.



The spectrum above could be produced by which of the following compounds?

(A) propanol

(B) methane

(C) ethanoic acid

(D) ethyl methanoate

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

(A) 50mL of 0.050M HNO_3 + 100mL of 0.4M NaOH

(B) 200mL of 0.05M CH_3COOH + 100mL of 0.01M NaOH

(C) 100mL of 0.1M H_2SO_4 + 50mL of 0.4M KOH

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

9. How many products are possible when 2-butene reacts with HCl?

(A) one

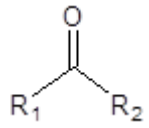
(B) two

(C) three

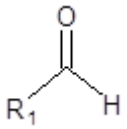
(D) four

10. Many carbon compounds contain functional groups that include the C=O double bond.

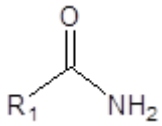
Three examples are shown below, in which R_1 and R_2 are any hydrocarbon chain.



X



Y



Z

To which homologous series does each structure above belong?

	X	**Y**	**Z**
(A)	Ketone	Alcohol	Amine
(B)	Aldehyde	Ketone	Carboxylic acid
(C)	Aldehyde	Ketone	Amine
(D)	Ketone	Aldehyde	Amide

11. The indicator HIn/In^- is used in a titration between nitric acid and barium hydroxide solutions.
The following equation represents how the indicator works.

$$\underset{\text{(green)}}{\mathbf{HIn}} \leftrightarrow \mathbf{H^+} + \underset{\text{(purple)}}{\mathbf{In^-}}$$

The indicator is added to 20mL of the barium hydroxide solution in a conical flask and the nitric acid is added via a burette until the endpoint is reached. The nitric acid and barium hydroxide solutions are of similar concentrations and the flask is swirled continuously as the acid is added.

Which one of the following statements describes the expected observations for the colour of the solution in the conical flask?

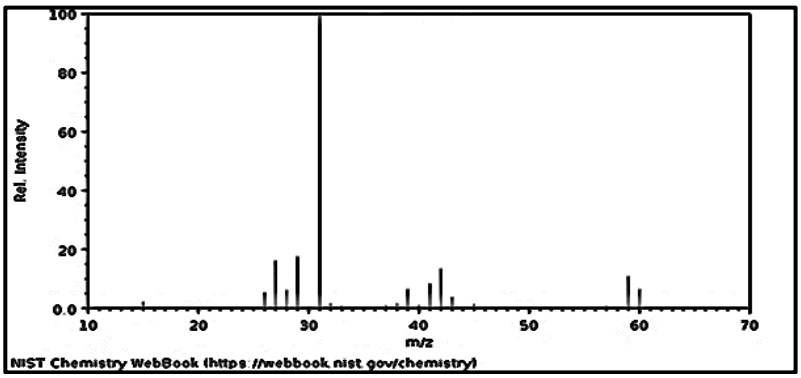
(A) It starts green and turns purple after adding approximately 10mL of HNO_3.

(B) It starts green and turns purple after adding approximately 40mL of HNO_3.

(C) It starts purple and turns green after adding approximately 10mL of HNO_3.

(D) It starts purple and turns green after adding approximately 40mL of HNO_3.

12. The mass spectrum for an alkanol is shown below.



Which one of the following alkanols could have the spectrum shown above?

(A) methylpropanol

(B) 1-propanol

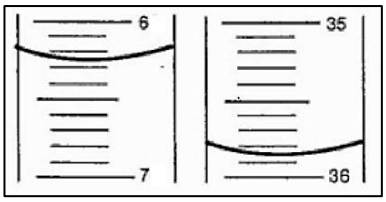
(C) 2-butanol

(D) 1-butanol

13. Read the information box below about uncertainty.

- Every measurement has an associated uncertainty value.
- For glassware, the uncertainty value is taken as half the value of the smallest interval.
- Any uncertainty in measurements should be added when the measurements themselves are added or subtracted.

The diagram below shows the level of acid before and after the acid was added to reach endpoint with a base.



Which of the following is the correct titre, with its uncertainty?

(A) 29.6 mL

(B) 29.60 ± 0.05 mL

(C) 29.62 ± 0.05 mL

(D) 29.60 ± 0.10 mL

14. Ethanol is an important biofuel which releases energy when combusted. It can be produced from the fermentation of glucose, which in turn is produced by photosynthesis.

The following equations represent the reactions in this process.

Reaction 1: $6CO_2(g) + 6H_2O(l) \rightarrow C_6H_{12}O_6(aq) + 6O_2(g)$

Reaction 2: $C_6H_{12}O_6(aq) \rightarrow 2CH_3CH_2OH(l) + 2CO_2(g)$

Reaction 3: $CH_3CH_2OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$

Which statement correctly summarises the amount of $CO_2(g)$ in this process?

(A) More CO_2 is produced than consumed.

(B) More CO_2 is consumed than produced.

(C) The amount of CO_2 produced is the same as that consumed.

(D) The moles of CO_2 consumed is the same as the amount of ethanol produced.

15. When solid sodium ethanoate is dissolved in water, the following reaction takes place.

$CH_3COO^-(aq) + H_2O\ (l) \leftrightarrow CH_3COOH\ (aq) + OH^-$

Given the pK_a of ethanoic acid is 4.76 at 25°C, what is the pH of a 0.420M solution of sodium ethanoate?

(A) 2.6

(B) 4.8

(C) 9.2

(D) 11.4

16. 2.1g of an alkene that contains one double bond per molecule is reacted completely with 8.0 g of bromine liquid.

Which one of the following is the molecular formula of the alkene?

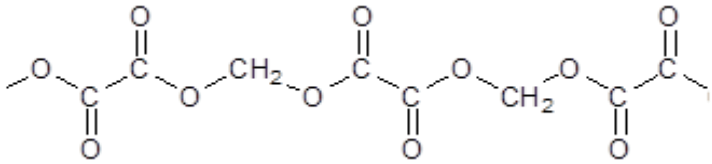
(A) C_5H_{10}

(B) C_4H_8

(C) C_3H_6

(D) C_2H_4

17. The structure shown below represents a fragment of a polymer made from two different monomers.



Which option is correct with respect to the synthesis of this polymer?

	Type of polymerization	**Reaction products**
(A)	Condensation	Polymer and water
(B)	Addition	Polymer only
(C)	Condensation	Polymer only
(D)	Addition	Polymer and water

18. The molar masses of 4 fuels are shown in the table below.

Each fuel is a liquid at room temperature.

Fuel name	Molar mass ($gmol^{-1}$)
butane	58.12
1-butanol	74.12
pentane	72.146
1-pentanol	88.146

Fuel "X" is one of the fuels in the table above. It has a heat of combustion value of 3329 $kJmol^{-1}$.

Combustion of 0.44g of this fuel causes an increase in the temperature of 200.0g of water of 19.9^{o}C.

Assuming negligible heat loss to the environment outside of the water, which of the following identifies fuel "X"?

(A) 1-butanol

(B) butane

(C) 1-pentanol

(D) pentane

19. An acid "HA" has an acid dissociation constant, K_a, in aqueous solution.

What is the expression for the equilibrium constant for the reaction below, in terms of K_a?

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

(A) K_w / K_a

(B) K_a / K_w

(C) K_a

(D) $1/K_a$

20. Some metal ions can affect the quality of the wine. In particular, zinc, copper and iron which can result in cloudiness in bottled wine. It is therefore recommended that winemakers screen for these metals prior to bottling. It is essential to ensure that levels are below the maximum recommended of 0.5 mg/L for copper and 30 mg/L for iron.

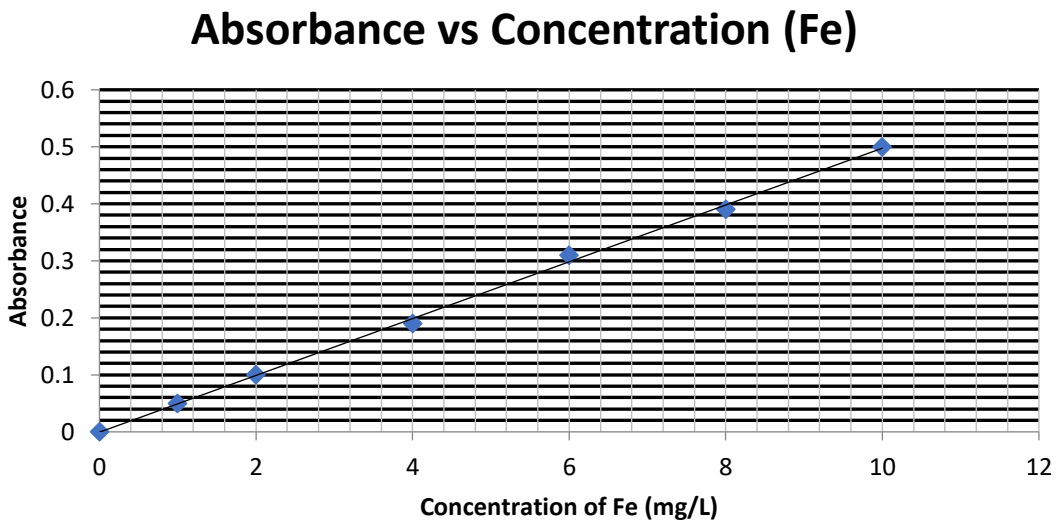
AAS can be used to test for iron levels in wine.

In an experiment, five 10.0mL samples of wine were measured using a volumetric pipette and made up into 50.0mL samples by the addition of distilled water.

The absorbance (at 248 nm) was measured for each sample.

Sample	Absorbance
1	0.22
2	0.24
3	0.23
4	0.34
5	0.21

Using an appropriate mean absorbance, the concentration of Fe in each sample was estimated using the calibration curve below.



Which of the following is the best estimate for Fe concentration (in mg/L) for the wine sample tested?

(A) 4.7 mg/L

(B) 5.0 mg/L

(C) 23.5 mg/L

(D) 25 mg/L

2019 | **TRIAL EXAMINATION**

Chemistry

Section II
Answer Booklet

80 marks

Attempt Questions 21 – 33

Allow about 2 hours and 25 minutes for this part

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 questions you are answering.

Marks

Question 21 (3 marks)

Describe the relationship between the structure of soaps and their cleaning action.

Include an appropriate diagram with your answer. **3**

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Marks

Question 22 (7 marks)

The following questions refer to the list of ionic compounds below.

- **$LiCH_3COO$**
- **$Mg(NO_3)_2$**
- **$CaCl_2$**
- **Na_2SO_4**
- **NH_4Cl**
- **KF**
- **Na_2CO_3**

(a) From the list above, select one acidic, neutral and basic salt to complete the table below. **2**

Acidic Salt	Neutral Salt	Basic salt

(b) Explain, using an appropriate equation, the acidic nature of the salt you identified in (a) above. **2**

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(c) When gaseous ammonia and hydrogen chloride react, a white solid forms.

Explain why this reaction is difficult to classify as a neutralisation using the Arrhenius theory of acids and bases, but is able to be classified as neutralisation using Bronsted-Lowry's theory. **3**

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Marks

Question 23 (5 marks)

An equilibrium reaction involving 3 gases X, Y and Z has the following equilibrium constant expression:

$$K = \frac{[Y]^2}{[X]^3[Z]}$$

K = 3.2 for this system at 80^{o}C.

(a) Write a balanced chemical equation to represent this equilibrium. **1**

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(b) The concentration of gases X, Y and Z were measured at a particular point in time (at 80^{o}C) and found to be 0.45M, 0.21M and 0.25M respectively.

Show that the system was not at equilibrium at this time. **2**

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(c) Identify whether the forward or reverse reaction has the highest rate at this time. Justify your answer. **2**

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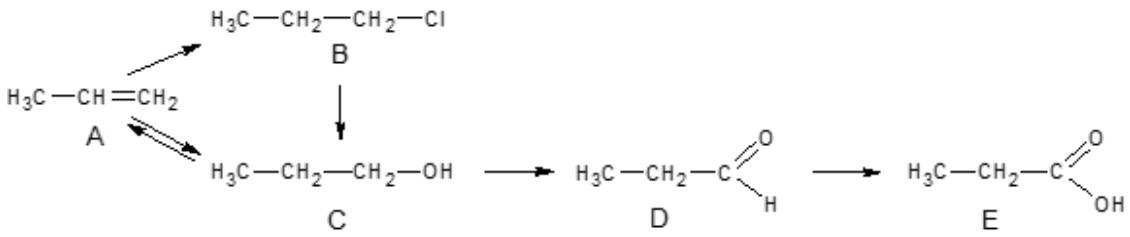
Marks

Question 24 (6 marks)

Consider the reactions shown below.



(a) Identify the systematic name of compound A. **1**

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(b) Draw the structural formula of compound C. **1**

(c) (i) Identify the systematic name of compound D. **1**

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(ii) Identify a reagent that will convert compound D into compound E. **1**

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(d) Write an equation using structural formulae, to show the reaction of compound E with methanol in the presence of concentrated H_2SO_4, and name the organic product. **2**

Marks

Question 25 (6 marks)

In order to demonstrate some solution chemistry, a science teacher prepares a number of practical tasks.

In the first task she mixes 25 mL of 0.1 M $BaCl_2$ with 25 mL of 0.1 M $CuSO_4$.

(a) Write a balanced chemical equation to represent this reaction, including states. **1**

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(b) Write the net ionic equation for this reaction. **1**

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In another demonstration the teacher makes a saturated solution.

She adds 1.52 g of $Cu(OH)_2$ (s) to 100.0 mL of water, and tells her students that the K_{sp} of $Cu(OH)_2$ is 2.2×10^{-20}.

(c) Write the dissociation equation of $Cu(OH)_2$ (s). **1**

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(d) Use the K_{sp} value to calculate the concentration of OH^- ions in this saturated solution of $Cu(OH)_2$. **3**

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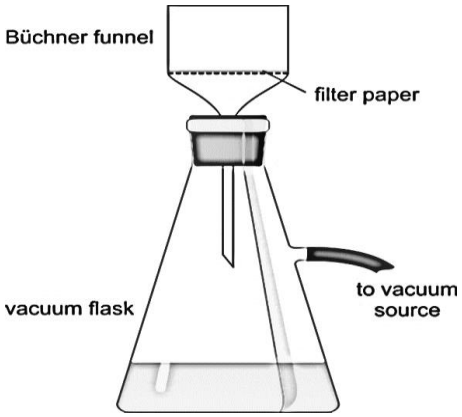
Marks

Question 26 (7 marks)

The following data may be helpful when answering this question.

Name	Formula	Solubility in water at 25°C (g/100g water)
Lead(II) ethanoate	$Pb(CH_3COO)_2$	55
Lead(II) iodide	PbI_2	0.076
Lead(II) nitrate	$Pb(NO_3)_2$	60
Potassium iodide	KI	142

Some brands of hair dye still contain lead (II) ions in an active ingredient, lead (II) ethanoate.
In an investigation to estimate the amount of lead (II) ions in a particular brand of dye, 10.0g of the dye was measured. Enough solid potassium iodide is measured and dissolved in water to produce a 0.10M solution of potassium iodide.
An excess of the 0.1M potassium iodide was added to the dye sample. The precipitate that formed was filtered through pre-weighed filter paper, using the apparatus below.



The precipitate was washed in distilled water and the filter paper and precipitate heated gently.

The mass of the filter paper and precipitate was measured after several periods of gentle heating. The results are shown below.

Mass of filter paper (g)	0.298
Mass of filter paper + precipitate (g) *(after 1 period of heating)*	1.567
Mass of filter paper + precipitate (g) *(after 2 periods of heating)*	1.454
Mass of filter paper + precipitate (g) *(after 3 periods of heating)*	1.387
Mass of filter paper + precipitate (g) *(after 4 periods of heating)*	1.387

Marks

Question 26 (continued)

(a) Explain why potassium iodide is an appropriate reagent for this particular investigation. **2**

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(b) Explain why the filter paper and precipitate was heated and weighed for several cycles, instead of just being heated and weighed once. **2**

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(c) Use the results of the investigation and the data provided to calculate the concentration of lead (II) ions (as a % w/w) in the dye sample. **3**

Include an appropriate balanced equation in your answer.

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Question 27 (8 marks)

An unknown organic compound with a molecular formula $C_4H_8O_2$ was supplied to a laboratory spectroscopist for identification.

An infrared absorption spectrum (Image A), mass spectrum (Image B) and a C-13NMR spectra (Image C) for the compound were produced.

These are shown below.

Image A

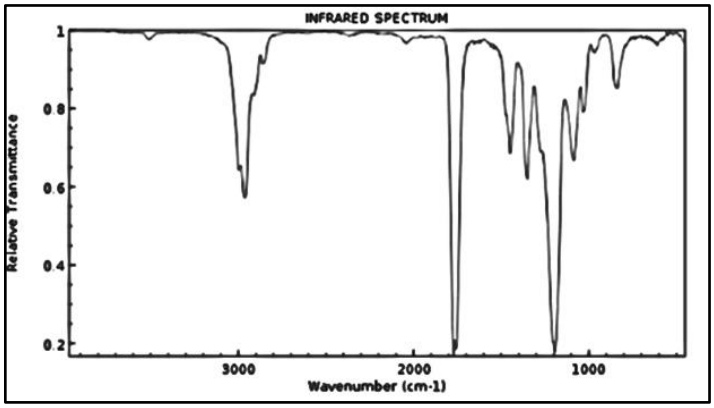


Image B

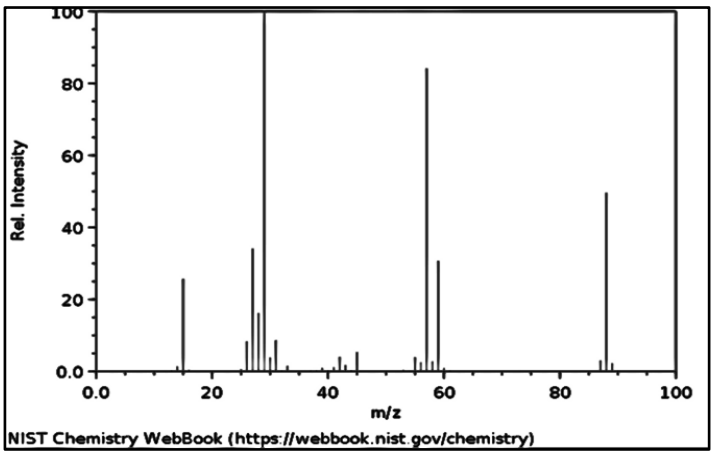
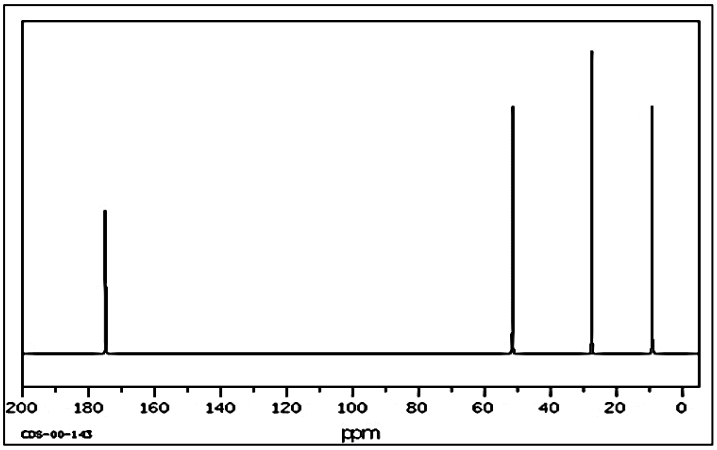


Image C



Marks

Question 27 (continued)

The analytical chemist concluded that the compound was *methyl propanoate* using various characteristics of each spectra produced in the analysis.

(a) Complete the table below by drawing the structural formula of methyl propanoate, and explaining how information from each spectrum supports the conclusion that the compound is methyl propanoate. **6**

Spectroscopic technique	Information from spectrum which supports the identification as methyl propanoate
IR spectra	
Mass spectra	
C-13 Nuclear Magnetic Resonance Spectra	

Marks

Question 27 (continued)

(b) A sample of the same compound was decomposed into its constituent elements and found to contain 54.5% carbon, 9.1% hydrogen, the remainder being oxygen, by mass.

Do these data support the chemist's conclusion that the compound is methyl propanoate? Justify your answer.

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Marks

Question 28 (6 marks)

Nitric acid is a significant industrial chemical that is synthesized in two stages.

The first stage involves the oxidation of ammonia by heating the gas to a moderate temperature of 600^{o}C, in the presence of oxygen and a catalyst such as platinum with 10% rhodium, to form nitric oxide and steam.

Pressures of between 400-1000 kPa are employed.

An equation for the reaction is shown below.

$$4NH_3(g) + 5O_2(g) \leftrightarrows 4NO(g) + 6H_2O(g) \qquad \Delta H = -900\ kJ/mol$$

(a) Apply an appropriate chemical principle to justify the reaction conditions employed in the production of nitrogen oxide. **4**

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(b) Describe TWO factors, other than those associated with rate of production or yield, that need to be considered when designing a process used to synthesise important chemical products. **2**

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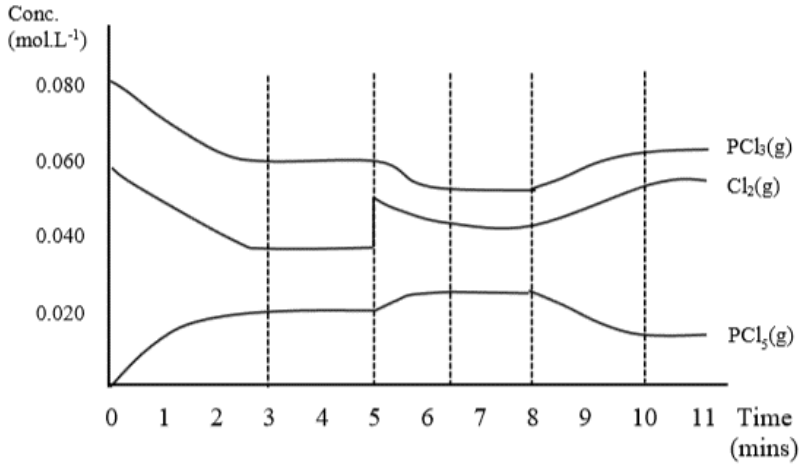
Marks

Question 29 (6 marks)

Consider the graph below, which shows the concentration of each species in the equilibrium system:

$$PCl_3(g) + Cl_2(g) \leftrightarrow PCl_5(g) \quad \Delta H = -92 \text{ kJ/mol}$$

This is measured over 11 minutes, during which time various changes are imposed on the system.



(a) When does the system first reach equilibrium? Justify your answer. **2**

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(b) What change was imposed at t = 5 minutes? Explain what would happen to the rates of the forward and reverse reactions immediately after this change. **2**

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(c) Calculate the value of K for the reaction using the data from t = 4 minutes. **2**

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Marks

Question 30 (6 marks)

Discuss the environmental and economic implications of using hydrocarbons as fuels and in the production of polymers, and assess the importance of finding alternative ways to meet these needs. **6**

Include relevant chemical equations in your answer.

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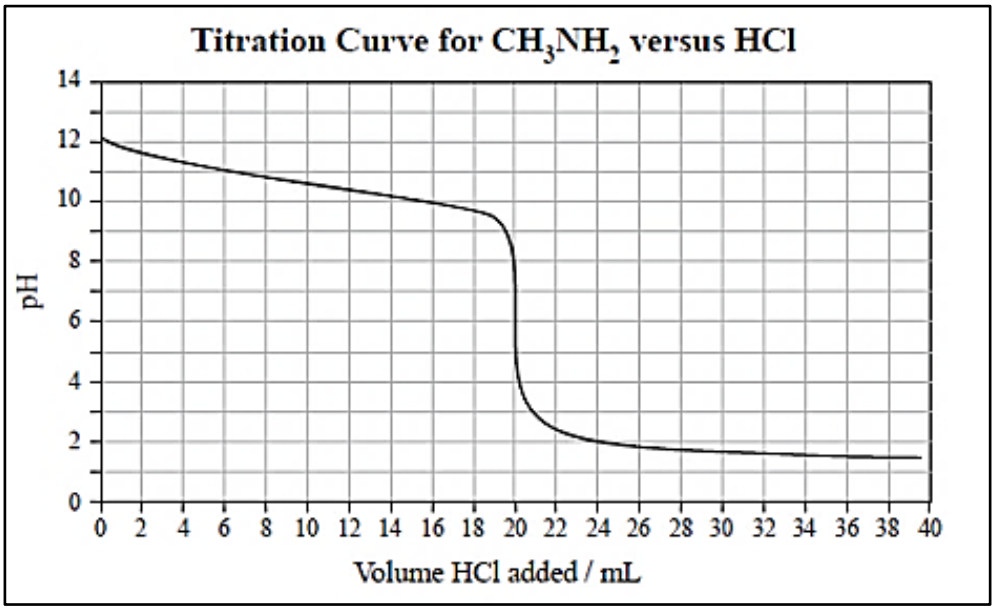
Question 31 (9 marks)

A titration was carried out by adding 0.155 $molL^{-1}$ hydrochloric acid, to 25.0mL of unknown methanamine (CH_3NH_2).

The pH of the solution in the comical flask was monitored using a pH probe and data logger, as was the volume added from the burette, with a drop counter and data logger.

The titration curve produced is shown below.



The equation for the reaction is:

$$HCl(aq) + CH_3NH_2(aq) \rightarrow CH_3NH_3^+ + Cl^-$$

$K_a(CH_3NH_3^+) = 2.51 \times 10^{-11}$

(a) Define the term 'equivalence point' as it is used in volumetric analysis and mark the approximate equivalence point with a cross on the graph above. **2**

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Question 31 continues on page 27.

Marks

Question 31 (continued)

(b) Another method to estimate the equivalence point of a titration is to use a carefully selected acid-base indicator.

Based on the data in the graph, identify an appropriate indicator and justify your choice, referring to specific data about the indicator. **2**

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(c) Use the graph to determine the molarity of the methanamine solution being analysed. Show your working. **2**

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(d) Clearly show on the given titration curve the region known as the 'buffer region' and explain how a buffer is formed in this area during the titration. **3**

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Marks

Question 32 (5 marks)

In a beaker, enough sodium hydroxide of concentration 0.0288M is added to10.5mL of 0.0355M of sulfuric acid to make a total volume of 50.0mL.

(a) Describe TWO practical methods which could be used to determine if enough NaOH was added to neutralise the acid? **2**

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(b) Calculate the pH of the remaining mixture. **3**

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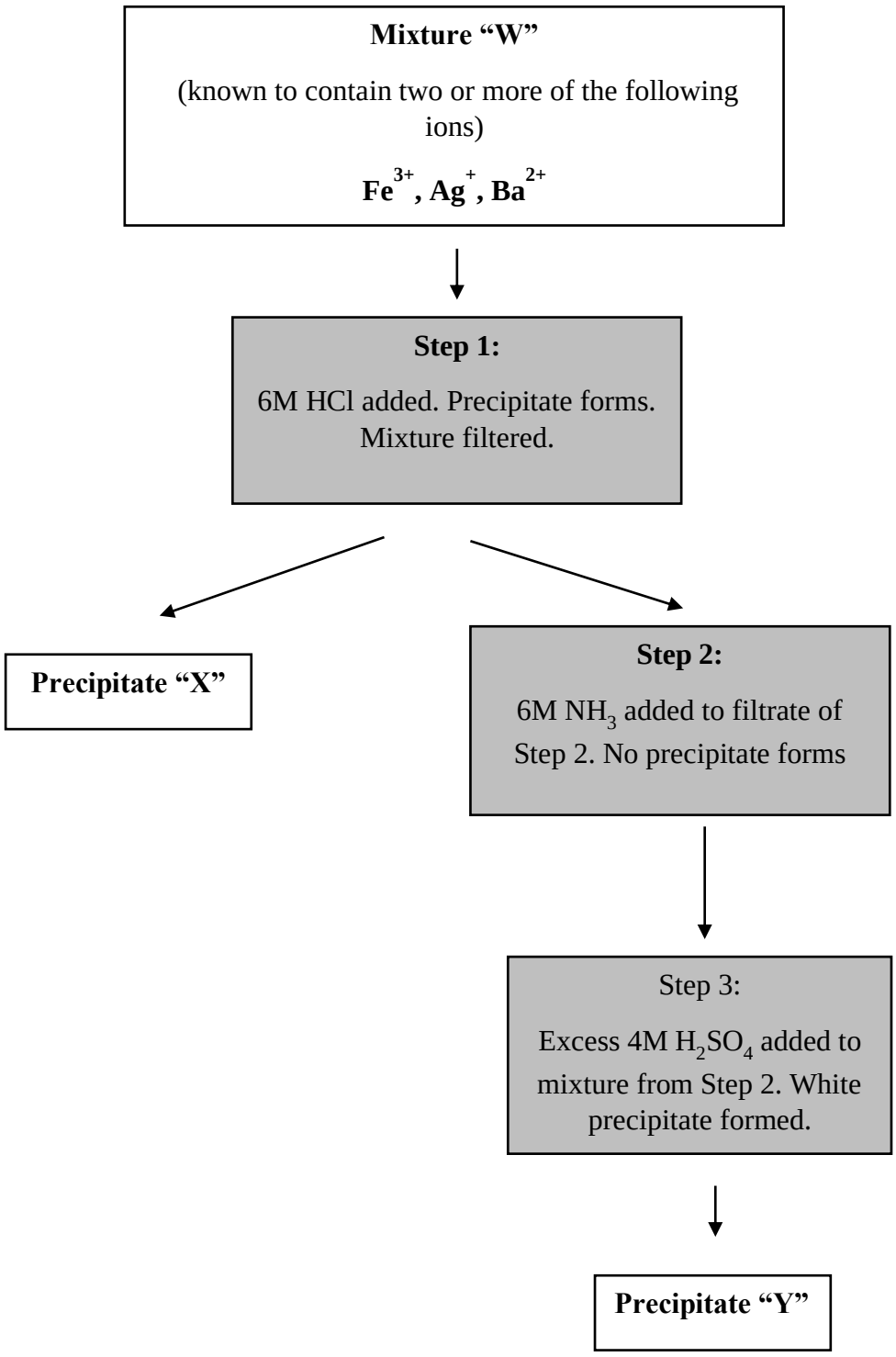
Question 33 (6 marks)

The flow chart below shows how a mixture of nitrate solutions (containing at least two of the cations shown) was analysed by a chemistry student.



Question 33 continues on page 30.

Marks

Question 33 (continued)

(a) Identify the cation present in precipitate "X". **1**

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(b) Explain why Step 1 must be carried out in order to make this scheme a valid way to analyse the unknown mixture. **2**

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(c) In the space below, draw a flowchart to show how each of the following anions (carbonate, chloride, sulfate) could be identified and removed from a mixture of their sodium salts. **3**

For each Step, clearly identify the anion identified

Section II extra writing space.

If you use this space indicate clearly which question you are answering.

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Exam Choice

2019 Chemistry Trial Examination.

Marking Guidelines and Model Answers.

Section I Multiple Choice

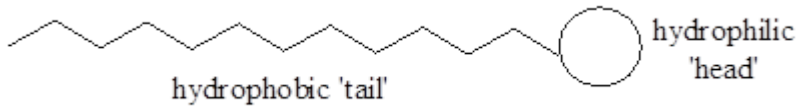
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
C	B	A	D	C	D	C	C	A	D	D	B	D	C	C	C	A	D	A	C

Section II

21.

Marking Criteria	Marks
• Describes the structure of soap and detergents and relates this to their cleaning action using appropriate scientific language.	3
• Outlines the structure of soap and/or detergents and relates this to their cleaning action.	2
• Response contains one correct, relevant statement.	1

Soaps and detergents are long-chain species with a non-polar, hydrophobic 'tail' and a hydrophilic 'head'. For soaps the hydrophilic 'head' is the carboxylate ion, whereas for detergents it can be anionic (benzenesulfonate), cationic (quaternary ammonium salts) or non-ionic (polyether). The structure of these species can be represented as:



Oil and water are not miscible. When soap or detergent is added to a mixture of oil and water the hydrophobic end dissolves in the oil droplets. The hydrophilic end dissolves in the water. When the mixture is agitated a spherical particle called a micelle is formed in which the oil droplet is surrounded by soap/detergent particles, which are in turn surrounded by water molecules. In this way the soap/detergent acts as an emulsifying agent and an emulsion of oil and water is formed. This allows the oil to be washed away and accounts for the cleaning action of soaps and detergents.

22.a.

Marking Criteria	Marks
• Completes the table correctly by identifying one acidic, neutral and basic salt from the list provided.	2
• Completes any TWO cells of the table correctly.	1

Acidic Salt	Neutral Salt	Basic salt
NH_4Cl	Na_2SO_4	$LiCH_3COO$

22.b.

Marking Criteria	Marks
• Explains the acidic nature of the salt identified as being acidic, using the concept of hydrolysis, and including an appropriate chemical equation for the ion undergoing hydrolysis.	2
• Demonstrates a partial understanding of what makes a salt acidic OR • Includes an appropriate chemical equation for ion undergoing hydrolysis.	1

Ammonium chloride dissociates as follows:

$NH_4Cl\ (s) \rightarrow NH_4^+\ (aq) + Cl^-\ (aq)$

The Cl^- is the conjugate base of a very strong acid (HCl) and is thus a very weak conjugate base-not strong enough to react with water.
However, the NH_4^+ is a conjugate acid of a weak base (NH_3) and is thus a strong enough acid to react with water. It undergoes hydrolysis shown in the equation below, increasing the $[H_3O^+]$ and decreasing the pH.

$NH_4^+(aq) + H_2O(l) \leftrightarrow NH_3(aq) + H_3O^+(aq)$

22.c.

Marking Criteria	Marks
• Explains why the Arrhenius theory of acids/bases is unable to classify the reaction between gaseous NH3 and HCl as neutralisation, whereas the Bronsted-Lowry model is able to classify the reaction as neutralisation AND • Includes a balanced chemical equation to support the explanation.	**3**
• Explains why the Arrhenius theory of acids/bases is unable to classify the reaction between gaseous NH3 and HCl as neutralisation OR why the Bronsted-Lowry model is able to classify the reaction as neutralisation OR • Defines neutralisation in the Arrhenius AND Bronsted-Lowry theories with one balanced chemical equation.	**2**
• Defines neutralisation using either the Arrhenius or Bronsted-Lowry theory.	**1**

The Arrhenius theory states that acids ionise in water to produce H^+ ions and bases ionise to form OH^- ions, and when acids and bases react with each other, the neutralisation reaction that occurs is between H^+ and OH^- ions to form water:

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

Since the reaction between ammonia and hydrogen chloride does not occur in water, the Arrhenius theory cannot classify the reaction as neutralisation.
The Bronsted-Lowry theory stated that acids are proton donors and bases are proton acceptors, and neutralisation reactions are those in which a proton is transferred from the acid to the base.
In the reaction between ammonia and hydrogen chloride:

$NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$

The NH_3 is behaving as a base donating the proton. The HCl accepts the proton, behaving as an acid. This can be classified as neutralisation using the Bronsted-Lowry theory, even though the reaction does not occur in water.

23.a

Marking Criteria	Marks
• Writes the correct balanced chemical equation.	**1**

$3X(g) + Z(g) \leftrightarrow 2Y(g)$

23.b.

Marking Criteria	Marks
• Correctly shows that the system is not at equilibrium by calculating Q and comparing it with K.	**2**
• Correctly calculates Q.	**1**

$Q = 0.21^2/(0.45^3 \times 0.25) = 1.94.$

Because Q does not equal K the system is not at equilibrium.

23.c

Marking Criteria	Marks
• Correctly identifies that the forward reaction has the fastest rate at this time with the correct justification.	**2**
• Correctly identifies that the rate of the forward reaction is fastest at this time OR that the equilibrium position is shifting to the right.	**1**

Q < K and as a result the system is shifting to the right in order to increase [Y] and increase the value of Q until it equals K. This means that the forward reaction has the fastest rate at this time.

24.a.

Marking Criteria	Marks
• Identifies propene.	**1**

propene

24.b.

Marking Criteria	Marks
• Correctly draws the structural formula for 1-propanol.	**1**

24.c.i.

Marking Criteria	Marks
• Identifies the name as propanal	**1**

propanal

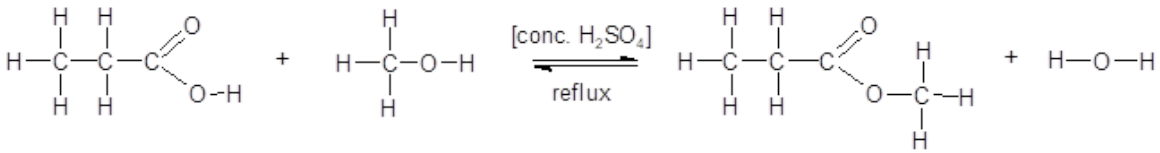
24.c.ii.

Marking Criteria	Marks
• Identifies acidified dichromate (or potassium/sodium dichromate)	**1**

acidified dichromate solution.

24.d.

Marking Criteria	Marks
• Writes the correct esterification equation using structural formulae and correctly names the organic product.	**2**
• Response contains one correct feature.	**1**



methyl propanoate

25.a.

Marking Criteria	Marks
• Writes the correct balanced chemical equation including states.	**1**

$BaCl_2(aq) + CuSO_4(aq) \rightarrow BaSO_4(s) + CuCl_2(aq)$

25.b.

Marking Criteria	Marks
• Writes the correct net ionic equation.	**1**

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

25.c.

Marking Criteria	Marks
• Writes the correct balanced chemical equation including states.	**1**

$Cu(OH)_2(s) \leftrightarrow Cu^{2+}(aq) + 2OH^-(aq)$

25.d.

Marking Criteria	Marks
• Correctly calculates $[OH^-]$.	**3**
• Response contains one error.	**2**
• Response contains one correct step.	**1**

$Cu(OH)_2(s) \leftrightarrow Cu^{2+}(aq) + 2OH^-(aq)$.

If $[Cu^{2+}] = x$ then $[OH^-] = 2x$.

$K_{sp} = [OH^-]^2[Cu^{2+}] = (2x)^2.x = 4x^3$

$2.2x10^{-20} = 4x^3$

$x^3 = 5.5x10^{-21}$ M

$x = 1.77x10^{-7}$

Therefore $[OH^-] = 2 \times 1.77x10^{-7} = 3.53x10^{-7}$ M.

26.a.

Marking Criteria	Marks
• Explains two properties of KI that make it useful as a reagent to determine the concentration of the lead in the sample.	**2**
• Explains one property of KI that make it useful as a reagent to determine the concentration of the lead in the sample.	**1**

Potassium iodide is a useful reagent in this analysis because it has a high solubility in water, and so is able to be made up into an aqueous solution to add to the test solution. Lead(II) iodide is insoluble and hence addition of the KI solution will result in formation of a lead iodide precipitate, which can be filtered off and weighed.

26.b.

Marking Criteria	Marks
• Explains why the filter paper and precipitate are heated and weighed over several cycles.	**2**
• Identifies that heating dries out the precipitate and removes water.	**1**

Heating and weighing the filter paper over several cycles allows you to heat and dry to constant mass, ensuring all of the water is removed from the precipitate, so the mass remaining is that of pure lead(II) iodide.

26.c.

Marking Criteria	Marks
• Calculates the concentration of lead in the dye as a % (w/w), including an appropriate balanced equation.	**3**
• Calculates the concentration of lead in the dye as a % (w/w) OR • Calculates the moles of PbI2 in the precipitate AND includes an appropriate balanced equation.	**2**
• Completes ONE correct step in the calculation OR • Includes an appropriate balanced equation.	**1**

$m(PbI_2) = 1.387 – 0.298 = 1.089$ g
$n(PbI_2) = m/MM = 1.089/461.0 = 0.00236226$ moles

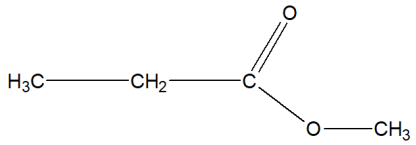
Reaction: $Pb^{2+}(aq) + 2I^{-}(aq) \rightarrow PbI_2(s)$

Thus $n(Pb^{2+}) = 0.00236226$ moles (1:1 ratio)
$m(Pb^{2+}) = nxMM = 0.00236226 \times 207.2 = 0.48946$ g (in 10g sample)

$\%(Pb^{2+}) = (0.48946/10) \times 100 = 4.894\ \%$

27.a.

Marking Criteria	Marks
• Demonstrates an excellent understanding of the structure of methyl propanoate and how the structure relates to the spectra shown, by completing each row of the table accurately and in sufficient detail.	**5-6**
• Demonstrates a sound understanding of the structure of methyl propanoate and how the structure relates to the spectra shown, by including at least one accurate example of data about each type of spectra.	**3-4**
• Demonstrates a limited understanding of the structure of methyl propanoate and how the structure relates to the spectra shown. At least one feature of any two of the spectra identified and related to the structure of methyl propanoate.	**2**
• One feature of any of the spectra is identified and related to the structure of methyl propanoate OR draws the structural formula of methyl propanoate.	**1**

Spectroscopic technique	Information from spectrum that justifies the identification
IR spectra	The IR spectrum shows a medium absorbance at 3000 cm^{-1} due to C-H bonds, and a strong absorbance band at 1700cm^{-1} due to the carbonyl bond (C=O). The molecular formula of the chemical being tested is $C_4H_8O_2$ (which matches the general formula $C_nH_{2n}O_2$) which can represent alkanoic acids and alkyl alkanoates. The fact that there is no broad band from 2700-3600 cm^{-1}, which corresponds to -OH bond, suggests the molecule is not an alkanoic acid. This suggests the unknown could be an alkyl alkanoate, which is consistent with the unknown being methyl propanoate ($CH_3O_2CH_2CH_2CH_3$).
Mass spectra	The molecular mass of methyl propanoate is 88, and the ion peak in the mass spectra of the unknown is at 88 amu, another piece of evidence the molecule may be methyl propanoate or an isomer of the compound (eg ethyl ethanoate). One peak on the spectrum is at 15amu, consistent with a CH_3 group fragment that could be broken off the methyl propanoate molecule
C-13 Nuclear Magnetic Resonance Spectra	The four shifts in the C-13NMR spectrum for the unknown suggests it contains 4 different carbon environments, with the peak around 175 consistent with the carbon in the carbonyl group. Four different carbon environments would be consistent with the structure of methyl propanoate, shown below. 

27.b

Marking Criteria	Marks
• Uses the data to determine the empirical formula of the compound and shows that this is also the empirical formula of methyl propanoate.	**2**
• Uses the data to determine the empirical formula of the compound OR • Shows the empirical formula of methyl propanoate.	**1**

In 100g of the compound:

Element	Mass of element (g)	Moles
Carbon	54.5	4.5
Hydrogen	9.1	9.1
Oxygen	36.4	2.3

Simplest ratio: C: 4.5/2.3 = 1.95 H: 9.1/2.3= 3.96 O = 2.3/2.3 = 1
EF= C_2H_4O which is consistent with the empirical formula of methyl propanoate ($C_4H_8O_2$).

28.a.

Marking Criteria	Marks
• Explains THREE conditions, referring to Le Chatelier's Principle where appropriate.	**4**
• As above with one error or omission.	**3**
• Explains at least one condition, referring to Le Chatelier's Principle where appropriate, and identities another key condition.	**2**
• Identifies the key conditions for the reaction OR demonstrates an understanding of Le Chatelier's Principle.	**1**

Systems involving reversible reactions may come to a state of equilibrium and Le Chatelier's Principle states that when systems at equilibrium are disturbed by changes in conditions, a shift to the side that minimises the disturbance occurs. This Principle can be employed when selecting reaction conditions which will favour shifts to the product side.
Condition 1: Moderate temperature of 600^{o}C.
The forward reaction is exothermic. Low temperatures favour the reaction that releases heat and thereby minimises the effect of lowering the temperature. Thus low temperatures favour the forward reaction to produce a higher % yield. However, if low temperatures are employed, the reaction rate is too low to be economically viable. Thus, moderate temperatures are used to produce a compromise between a good yield at a high enough rate

Condition 2: The platinum catalyst will have a high surface area and will act as a surface where the reactants can combine and lower the activation energy for the reaction, thus increasing the rate of the reaction.
Condition 3: Low pressures favour the side of the reaction producing more moles of gas, which would be the forward reaction. However, rate is increased by high pressure.
**Since the number of moles of gas produced by both reactions is similar 9 mol vs 10 mol, high pressure to increase rate is more important than lowering pressure to produce a slightly better yield.*
**(Individual teachers' may feel this last part of sample answer is not required, and may accept low pressure as a reaction condition).*

28.b.

Marking Criteria	Marks
• Describes TWO factors that may be considered when designing a process used to synthesise important chemical products.	**2**
• Identifies TWO factors that may be considered when designing a process used to synthesise important chemical products OR describes one factor that may be considered when designing a process used to synthesise important chemical products.	**1**

Two factors that would be considered when designing a process to synthesise chemicals are proximity to raw materials (eg a nitric acid facility would need access to a source of ammonia) and proximity to a transport system to carry the product to consumers (eg close to a shipping port).

29.a.

Marking Criteria	Marks
• Identifies t = 3 minutes with a correct justification.	**2**
• Identifies t = 3 minutes.	**1**

The system first reaches equilibrium at t = 3 minutes. This is clear from the graph because it is when the concentrations of each species in the system start to remain constant.

29.b.

Marking Criteria	Marks
• Identifies that the concentration of Cl_2 was increased and explains subsequent changes in rates until t=7min.	**2**
• Identifies that concentration of CL_2 was increased OR describes changes in the rates of the forward and reverse reactions.	**1**

The concentration of Cl_2 gas was increased, and more collisions between the reactants will immediately increase the rate of the forward reaction (we 'see' this as a shift to the right, which is why the $[Cl_2]$ falls after the initial spike. Since the forward reaction is favoured, reactant particles then fall, reducing the rate of the forward reaction, while the rate of the reverse speeds up, due to more collisions in products made from the initial shift. The rates equalise at 6.5 min and remain equal until 7min (i.e. system at equilibrium).

29.c.

Marking Criteria	Marks
• Correctly calculates K using concentration values for t = 4 minutes.	**2**
• Writes the correct equilibrium constant expression.	**1**

$K = [PCl_5]/[PCl_3][Cl_2]$
$K = 0.02/(0.04x0.06)$
$K = 8.33$

30.

Marking Criteria	Marks
• Discusses the economic and environmental effects of the use of hydrocarbons as both fuels and in polymer production, and assesses the need to find alternatives. Includes relevant, correct chemical equations.	**6**
• Discusses the economic and environmental effects of the use of hydrocarbons as both fuels and in polymer production, and includes relevant, correct chemical equations.	**4-5**
• Outlines the economic and/or environmental effects of the use of hydrocarbons as both fuels and in polymer production.	**2-3**
• Response contains one correct, relevant statement or equation.	**1**

Hydrocarbons obtained from fossil fuels are currently used as both fuels and as feedstocks for the production of polymers. For example, the fractional distillation of crude oil provides octane, which is used as motor vehicle fuel, releasing energy when it is combusted:
$C_8H_{18}(l) + O_2(g) \rightarrow 8CO_2(g) + 9H_2O(l)$ + energy. The supply of octane is increased by cracking longer chain hydrocarbons, and this reaction also produces ethene, for example:
$C_{10}H_{22}(l) \rightarrow C_8H_{10}(l) + C_2H_4(g)$. The ethene produced in these cracking reactions is used to produce one of the most abundant polymers, polyethylene: $nC_2H_4(g) \rightarrow -(CH_2\text{-}CH_2)_n-$. The use of hydrocarbons as fuels and in the production of polymers has serious environmental and economic consequences, and it is crucial that we find alternative ways of meeting our need for energy and materials as soon as possible.

Burning hydrocarbons to produce energy also releases carbon dioxide into the atmosphere. There is global scientific consensus that the rising CO_2 concentration is causing large scale and very serious climatic change. Sea levels are rising, polar ice caps are melting, ocean currents are changing, the frequency and severity of droughts, bushfires, floods and hurricanes are increasing. These extreme weather events destroy habitat, cause water and air pollution – all devastating environmental consequences. The economic impact of climate change and extreme weather events is also massive and increasing. Whole island nation states, for example the Marshall

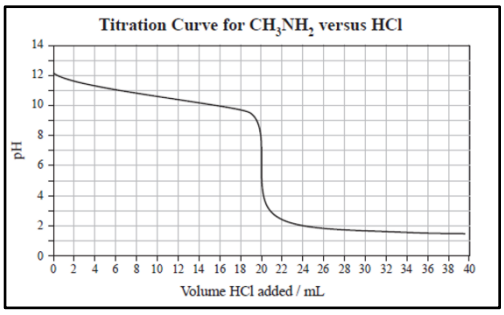
Islands in the Pacific Ocean are at risk of disappearing, which will bring large repatriation costs. Extreme weather events also bring large clean-up and repair costs. Another economic impact of using hydrocarbons as fuels is that crude oil is a finite resource and as it is consumed it becomes less abundant, and as a result more expensive.

Polymers produced from fossil fuels are inexpensive and abundant, but they are not biodegradable, and in global terms are not widely recycled. Societies all over the world have benefitted from affordable materials for plumbing, food preservation and safety equipment, but the environmental costs of using plastics outweighs these benefits. Non-biodegradable plastics have increased the need for landfill, produced large amounts of land and sea pollution, and have directly led to the large-scale death of large numbers of marine animals and birds which mistake them for food or become entangled in them. There are alternatives to hydrocarbons for both fuels and materials such as polymers. Fuels such as ethanol, hydrogen and biodiesel are all viable options, as are electric vehicles. Biopolymers made from plant derivatives are also becoming more widespread. For both economic and environmental reasons, it is imperative that we eliminate our dependence on hydrocarbons as soon as possible.

31.a.

Marking Criteria	Marks
• Defines the term equivalence point and uses a cross to show where the equivalence point is for the titration shown.	**2**
• Defines the term equivalence point OR uses a cross to show where the equivalence point is for the titration shown.	**1**

The equivalence point in a titration is the moles of H^+ in the conical flask equal the moles of OH^-.



31.b.

Marking Criteria	Marks
• Selects an appropriate indicator to use in a titration between the two reagents and justifies the choice in sufficient detail. Answer includes specific data relating to chosen indicator.	**2**
• Identifies an appropriate indicator for this titration (where pH at equivalence is in acidic range)	**1**

For a titration to produce an accurate result, the point at which the indicator changes colour (the endpoint) must occur as close to the actual equivalence point. The pH at the endpoint must therefore correspond to the pH at equivalence. The pH at equivalence for the titration is approximately 5.5. Therefore, an indicator that changes colour in an acidic range (over 4-7, which corresponds to the steepest part of the titration curve) will ensure the endpoint corresponds to the equivalence point for this particular titration. Methyl red changes colour in the range 4.8-6 and this range includes the pH at equivalence, thus minimising the titration error, and contributing to the overall accuracy of result produced.

31.c.

Marking Criteria	Marks
• Calculates the concentration of the CH_3NH_2 to 3 significant figures.	**2**
• Completes one step in the calculation correctly.	**1**

n(HCl) required = cV = 0.155 x 0.02 = 0.0031 moles
$n(CH_3NH_2)$= 0.0031 moles
$c(CH_3NH_2) = n/V = 0.0031 / 0.025 = 0.124$ $molL^{-1}$

31.d.

Marking Criteria	Marks
• Labels the buffer region on the curve clearly and explains how a buffer forms during with region of the titration, showing understanding of the composition of a buffer.	**3**
• Labels the buffer region on the curve clearly and explains how the buffer forms in such a titration OR • Demonstrates sound knowledge and understanding of buffers-their function and composition.	**2**
• Labels the buffer region on the curve OR • Describes how the buffer forms in such a titration OR • Demonstrates some knowledge and understanding of buffers-their function OR composition.	**1**

This titration begins with a weak base in the conical flask (the CH_3NH_2). As strong HCl is added, the acid reacts with the base to produce the conjugate acid of CH_3NH_2, which is $CH_3NH_3^+$. Since CH_3NH_2 is a weak base, this conjugate acid is strong enough to hydrolyse. Hence after 10mL of HCl being added, the solution in the conical flask contains a high concentration of both a weak base and its conjugate acid. Such a solution has buffering properties. The buffering region is indicated in yellow on the graph.

32.a.

Marking Criteria	Marks
• Describes TWO methods to measure the pH of the final solution.	**2**
• Describes ONE method to measure the pH of the final solution OR • Identifies TWO methods to measure the pH of the final solution.	**1**

A few drops of universal indicator could be added to the final mixture and the colour of the liquid compared to a colour chart.
A pH probe or meter could be immersed into the final solution to obtain a digital pH reading.

32.b.

Marking Criteria	Marks
• Calculates the pH of the final mixture.	**3**
• Calculates the pH of the final mixture but makes one error.	**2**
• Completes one step in the calculation correctly.	**1**

$2NaOH\ (aq) + H_2SO_4\ (aq) \rightarrow Na_2SO_4\ (aq) + 2H_2O$

$n(NaOH) = cV = 0.0288 \times 0.0395 = 0.0011376$
$n(H_2SO_4) = cV = 0.0355 \times 0.0105 = 0.00037275$
LR: NaOH: $0.0011376/2 = 0.0005688$
H_2SO_4: $0.0037275 /1 = 0.00037275$

NaOH is in excess
$NaOH_{\ reacting} = 0.00037275 \times 2 = 0.0007455$
$n(NaOH)_{\ remaining} = 0.0011376 - 0.0007455 = 0.0003921$
$[OH^-]_{\ final} = n/V = 0.0003921/0.05 = 0.007842M$
$pOH = -\log 0.007842 = -2.106$

$pH = 11.9$

33.a.

Marking Criteria	Marks
• Identifies the cation in precipitate "X".	**1**

Ag^+

33.b.

Marking Criteria	Marks
• Explains why Step 1 must be carried out in order to make this scheme a valid way to analyse the unknown mixture.	**2**
• Identifies that only Ag^+ forms a precipitate with the Cl^- OR that two ions could precipitate with the OH^-.	**1**

The mixture contains at least 2 cations, thus one cation present may mask the presence of the other or interfere with the next test. Ag^+ is the only cation that forms a precipitate with Cl^-, so the first step is to add the Cl^- to remove the Ag^+, so that the Ag^+ does not remain to form precipitates with OH^- or SO_4^{2-}. If OH^- was added first, two precipitates could form (AgOH and $Fe(OH)_3$) depending on which ions are present. For these reasons, the Cl^- should be added before the OH^-.

33.c

Marking Criteria	Marks
• Draws a well-formatted flowchart to show how each of the anions could be identified and separated out from a mixture of their sodium salts AND clearly identify the anions identified.	**3**
• Draws a satisfactory flowchart to show how at least two anions could be identified.	**2**
• Identifies a positive test for at least one of the anions.	**1**