PEM

Professional Educational Materials

Student Number

2022 HIGHER SCHOOL CERTIFICATE TRIAL EXAMINATION

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- NESA approved calculators may be used
- A 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 3–10)

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

Section II – 80 marks (pages 11–32)

- Attempt Questions 21–35
- Allow about 2 hours and 25 minutes for this section

Section I
20 marks

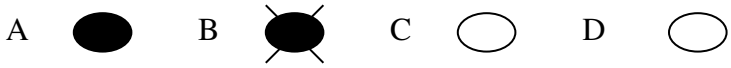
Attempt Questions 1-20
Allow about 35 minutes for this part

Use the multiple-choice answer sheet.

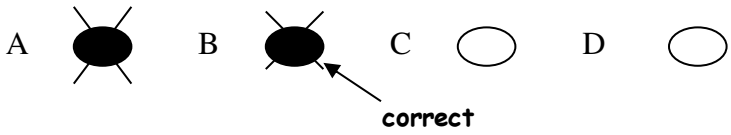
Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

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.



Section I

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

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

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1. The reaction described below represents a reversible reaction in an aqueous solution. The iron (III) ions Fe^{3+} are yellow, while the iron thiocyanate ions $FeSCN^{2+}$, are bright red. At the beginning of the reaction, the solution is yellow.

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

What would be observed when this reaction has reached equilibrium?

A. Gas will begin to be produced.

B. A precipitate will form.

C. The solution will be yellow.

D. The solution will stop changing colour.

2. The conjugate base of carbonic acid is:

A. carbonate ion.

B. hydrogen carbonate ion.

C. hydronium ion.

D. hydroxide ion.

3. Iron (III) hydroxide dissolves in water according to the following equation:

$$Fe(OH)_3(s) \rightleftharpoons Fe^{3+}(aq) + 3OH^{-}(aq)$$

The K_{sp} expression for the solubility equilibrium involving iron (III) hydroxide in water is:

A. $[Fe^{3+}l][OH^{-}]$

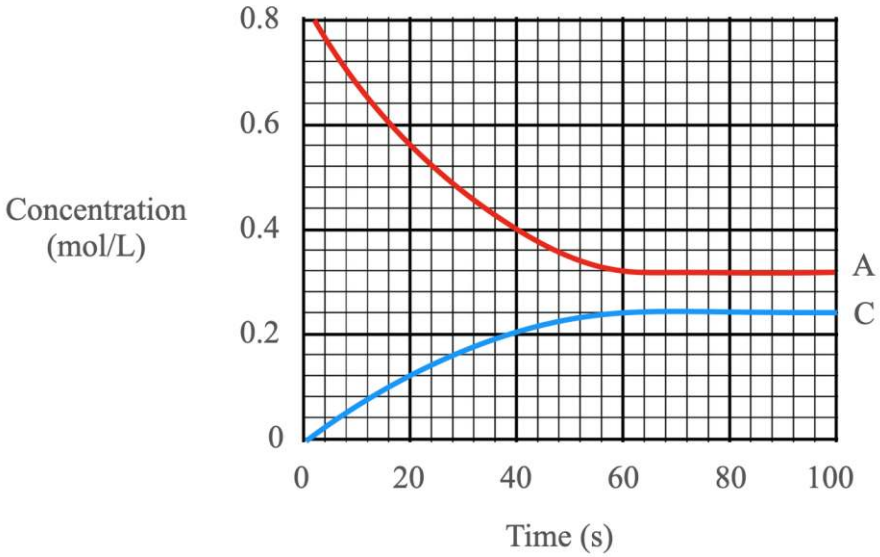
B. $[Fe^{3+}]^2[OH^{-}]^3$

C. $[Fe^{3+}][OH^{-}]^3$

D. $[Fe^{3+}][OH^{-}]^3/[Fe(OH)_3]$

4. The following graph shows changes in concentration versus time for the following equilibrium:

$$2A\ (g) \rightleftharpoons B\ (g) + C\ (g)$$



Assume that substance A is the only chemical at t = 0.

Select the correct statement about this equilibrium.

A. The concentration of B at equilibrium is 0.24 mol/L.

B. Equilibrium is reached at 40s.

C. 0.32 mol/L is the decrease in the concentration of A as it decomposes.

D. The rate of decomposition of A is greater at 45s than at 10s.

5. The following equilibrium is set up in solution

$H_2O(l) + HF(aq) \rightleftharpoons F^-(aq) + H_3O^+(aq)$

In this equilibrium, the water molecule acts as:

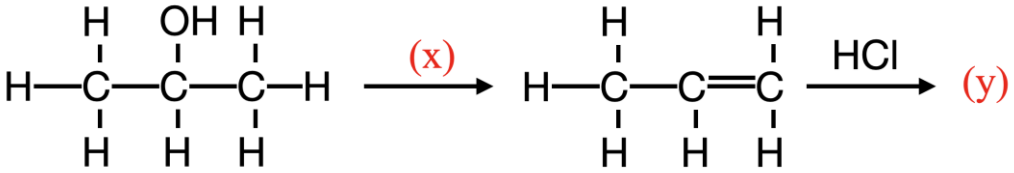
A. A proton acceptor.

B. A proton donor.

C. A hydrogen atom acceptor.

D. A hydrogen atom donor.

6. Identify the missing conditions and products found in the following reaction scheme



	Condition X	Product Y
A.	Dilute H_2SO_4	1-chloropropane
B.	Dilute H_2SO_4	2-chloropropane
C.	Concentrated H_3PO_4 + heat	1-chloropropane
D.	Concentrated H_3PO_4 + heat	2-chloropropane

7. A 0.10 mol/L solution of a weak acid HA is 5% dissociated at 25°C. Calculate the concentration of hydronium ions in the acid solution.

A. 0.50 mol/L

B. 0.050 mol/L

C. 0.0050 mol/L

D. 2.0%

8. Acid *X* is 0.1 mol/L hydrochloric acid. Acid *Y* is 1.0 mol/ L acetic acid (ethanoic acid).

How does acid *X* compare with acid *Y*?

A. *X* is weaker and more concentrated than *Y*.

B. *X* is stronger and more concentrated than *Y*.

C. *X* is weaker and more dilute than *Y*.

D. *X* is stronger and more dilute than *Y*.

9. The halogenation of a 2-methylbut-2-ene with iodine will produce:

A. 1,2-iodo-2-methylbutane.

B. 2,3-diiodo-2-methylbutane.

C. 2,3-iodo-2-methylbutane.

D. 2,3-diiodopentane.

10. The following list of steps refers to an experimental plan for making an ester in a flask. Some of the steps in the list may NOT be required for this experiment. The steps are NOT in the correct sequence.

1. Heat the mixture under reflux.
2. Add three drops of concentrated sulfuric acid.
3. Add 1 mL of ethanol.
4. Add 1 mL of ethene.
5. Add 1 mL of ethanoic acid.
6. Distil the mixture.
7. Add three drops of phenolphthalein indicator.

Which alternative is the best sequence for making an ester?

A. 3, 5, 7, 1

B. 4, 3, 7, 6

C. 5, 4, 2, 6

D. 5, 3, 2, 1

11. Which of the following statement is false for mass spectroscopy?

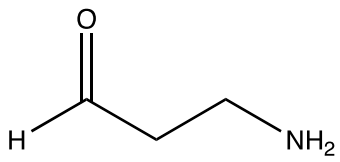
A. Mass spectroscopy is used to identify unknown compounds within a sample, and to elucidate the structure and chemical properties of different molecules.

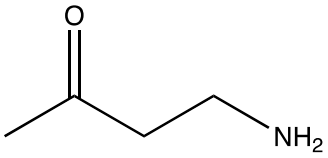
B. Particle are characterized by their mass to charge ratios (m/z) and relative abundances.

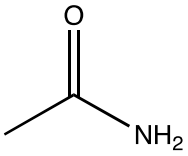
C. This technique basically studies the effect of ionizing energy on molecules.

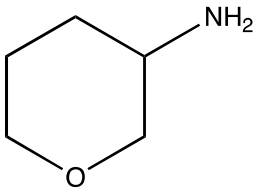
D. This technique can be used on all state of matter.

12. Which one of the following compounds is both an amine and a ketone?

A. 

B. 

C. 

D. 

13. A student prepares a standard solution in the following way.

i. 2.5 g of pure sodium hydroxide was dissolved into a clear, dry beaker using distilled water
ii. The solution is funnelled into a volumetric flask, and the beaker and funnel set to one side without washing.
iii. The volumetric flask was filled with distilled water, however the student went slightly over the calibration line.
iv. The volumetric flask was shaken to ensure consistency

Despite the errors in the method, the student calculates the concentration of the standard solution. The standard solution is likely to be:

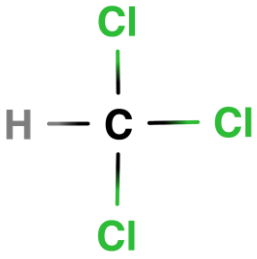
A. Weaker than calculated.

B. Stronger than calculated.

C. Less concentrated than calculated.

D. More concentrated than calculated.

14. A student was conducting an experiment with chloroform as his solvent.



After finishing working with the experiment, the student disposes of it in a non-halogenated organic disposal container.

Which is the most likely potential safety risk to the student?

A. None – this is the most correct disposal method for chloroform.
B. The waste undergoes a neutralisation reaction with the organic base to produce high amounts of heat.
C. Explosion risk with other organic material.
D. None – halogenated compounds are separated for economic reasons.

15. An aqueous sample containing the following anions is analysed.

$$Cl^- \quad CO_2^{3-} \quad SO_2^{2-}$$

In which order should the reagents be added to determine the amount of chloride in the sample?

	Reagent 1	**Reagent 2**	**Reagent 3**
A.	$AgNO_3$	H_2SO_4	$BaSO_4$
B.	HCl	$Pb(NO_3)_2$	$AgNO_3$
C.	HNO_3	$Ba(NO_3)_2$	$AgNO_3$
D.	$Ba(NO_3)_2$	$AgNO_3$	CH_3COOH

16. Limestone ($CaCO_3$) can be eroded by acids. What volume (in mL) of 11.5 mol/L nitric acid (HNO_3) is required for complete reaction with 24.7 g of limestone?

A. 42.9 mL

B. 21.5 mL

C. 11.5 mL

D. 10.7 mL

17. Which of the following changes takes place when 500 mL of water is added to 500 mL of 1 mol/L acetic acid?

A. pH increases, percentage ionisation increases

B. pH increases, percentage ionisation does not change

C. pH decreases, percentage ionisation does not change

D. pH decreases, percentage ionisation decreases

18. The table shows the heat of combustion of four straight chain alkanols.

Number of C atoms in straight chain alkanol	Heat of combustion (kJ/mol)
1	726
3	2021
5	3331
7	4638

What is the mass of water that could be heated from 20°C to 45°C by the complete combustion of 1.0 g of heptan-1-ol?

A. 0.032 kg

B. 0.044 kg

C. 0.36 kg

D. 0.38 kg

19. A solution is prepared by mixing 100.0 mL of 0.1 mol/L of $NaNO_3$ with 200.0 mL of 0.100 mol/L HCl and then adding sufficient water to give it a final volume of 500 mL. What is the pH of the solution?

A. 1.00

B. 1.12

C. 1.40

D. 1.70

20. In the titration of a 0.1 mol/L monoprotic acid with 0.2 mol/L sodium hydroxide (NaOH), using methyl red as indicator, which one of the following statements correctly describes the system at the equivalence point?

A. the number of moles of hydroxide ion added and the number of moles of monoprotic acid initially present are equal.

B. the concentrations of each of the hydroxide ion and hydronium ion (H_3O^+) are equal.

C. the number of moles of the hydroxide ion added and the number of moles of the hydronium ion initially present are equal.

D. the volume of sodium hydroxide solution added and the volume of acid solution initially present are equal.

Student number

Chemistry

2022 TRIAL EXAMINATION

Section II
80 marks

Attempt Questions 21- 35
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 (8 marks)

Colourless nitrous oxide (N_2O) reacts with oxygen gas to form brown nitrogen dioxide gas, according to the following equilibrium:

$$2N_2O\,(g) + 3O_2\,(g) \rightleftharpoons 4NO_2\,(g);\ \Delta H = -32\ kJmol^{-1}$$

0.27 mol of N_2O was placed in a 5 L vessel with 0.42 mol of oxygen. The system was allowed to reach equilibrium. At equilibrium 0.15 mol of N_2O remained. The temperature of the vessel was monitored over this time.

(a) Identify whether the temperature of the reaction mixture has increased or decreased as the reaction occurred. ***1***

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(b) Describe the colour change during the reaction. ***1***

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Question 21 continues on the next page

(c) Calculate a value for the equilibrium constant. ***4***

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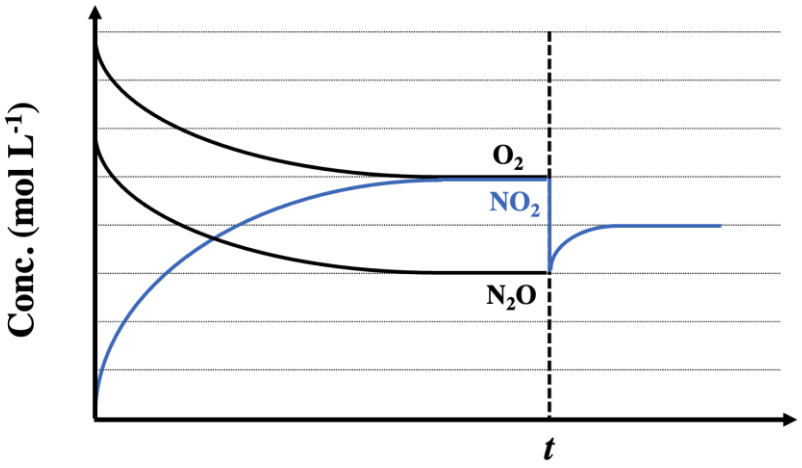
(d) The following graph shows the equilibrium concentrations of three of the compounds involved in the reaction at 298K. Some of the NO_2 was removed and allowed to reach a new equilibrium. Complete the remainder of the graph by adding lines which reflect the new concentrations involved when reaching this new equilibrium. ***2***



Question 22 (3 marks)

A lab assistant was presented with the following boiling points for some common alkanes. Explain the differences in boiling point between the different alkanes, as shown in the table

Alkane	Boiling Point (oC)
Methane	-162
Ethane	-89
Propane	-42
Butane	0

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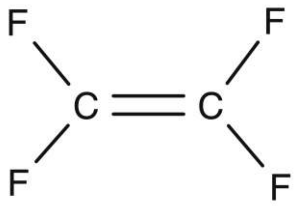
Question 23 (3 marks)

The image below shows the structural formula of a halogenated alkene.



(a) Identify the IUPAC name of this molecule *1*

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(b) The name of this molecule is polymerised using a catalyst. The product is called Teflon or PTFE.

Identify the type of polymerisation occurring and draw the repeating structure of Teflon. *2*

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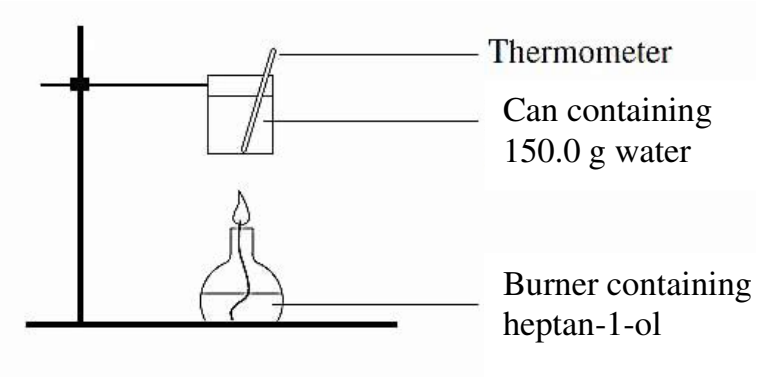
Question 24 (5 marks)

150.0 g of water was heated in a calorimeter (as shown below) to measure the heat of combustion of heptan-1-ol. The initial temperature of the water was 20.0°C, the final temperature was 63.0°C and the mass of heptan-1-ol burnt was 0.750 g. Using this information answer the following questions.



(a) Write a balanced chemical equation for the complete combustion of heptan-1-ol. ***1***

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(b) Calculate the enthalpy of combustion measured for heptan-1-ol. ***4***

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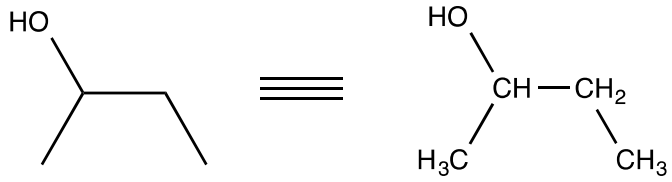
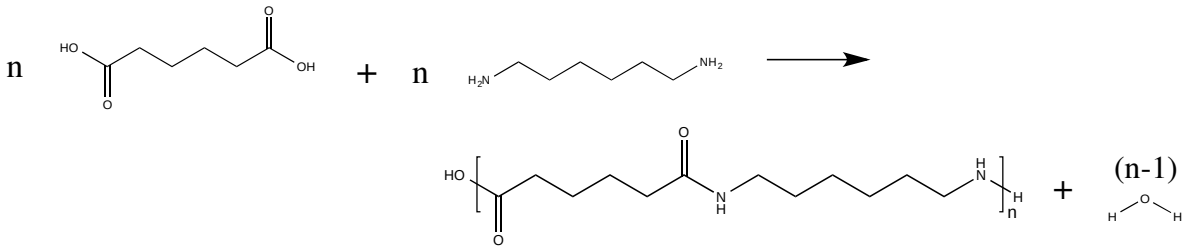
Question 25 (7 marks)

In organic chemistry, skeletal structures are often used to represent organic molecules. We do not draw the carbon atoms or hydrogen atoms which are attached to carbon atoms.



The nylons are a familiar group of polymers to many people as they are used widely in clothing.

Some can synthesised by using a diamine and a dicarboxylic acid. For example, Nylon 6,6 is synthesised as below. The 6,6 indicates the number of carbons in the diamine and the number of carbons in the dicarboxylic acid respectively.



(a) Explain the uses of nylon 6,6 in terms of their structure and properties. ***3***

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Question 25 continues on the next page

(b) Draw the structure of the polymer for Nylon 4,4 ***2***

(c) Nylon 12 is produced using a different monomer than that used in Nylon 4,4 or 6,6. What is the structure of the monomer given the polymer? ***2***

Question 26 (4 marks)

The phosphate content of a laundry powder was determined as follows. 6.85 g of the powder was dissolved in approximately 500 mL of water. A slight excess of a solution of magnesium chloride in an ammonia/ammonium chloride buffer was added, with stirring, until precipitation was complete. The precipitate was filtered, dried and its mass determined. The mass of precipitate was found to be 1.89 g.

The precipitate is magnesium ammonium phosphate hexahydrate ($Mg(NH_4)PO_4.6H_2O$). Calculate the percentage phosphorus in the original laundry powder.

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Question 27 (3 marks)

Describe the chemical tests that could be used to distinguish between alkenes, alkanols and alkanoic acids.

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Question 28 (3 marks)

Human blood has a pH of about 7.4. A condition known as acidosis develops if the pH of blood falls below 7.35. Below 7.0 the person will enter a coma, and if the pH rises above 7.45 a condition known as alkalosis occurs, and above 7.8 this condition is life threatening. The presence of buffers in the blood maintains the pH between 7.35 and 7.45.

Explain, in terms of Le Chatelier's principle and with the use of appropriate equations, how the blood's buffer system is able to maintain a constant pH despite an increase of lactic acid from muscles after exercise.

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Question 29 (6 marks)

(a) Lead (II) chloride is sparingly soluble in water, and this equilibrium is set up between the solid and its ions in solution. Given its $Ksp = 1.7 \times 10^{-5}$, determine the solubility of Lead (II) chloride. ***3***

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(b) Calculate and compare the solubility of the lead chloride when dissolved in 0.35mol/L of NaCl. ***3***

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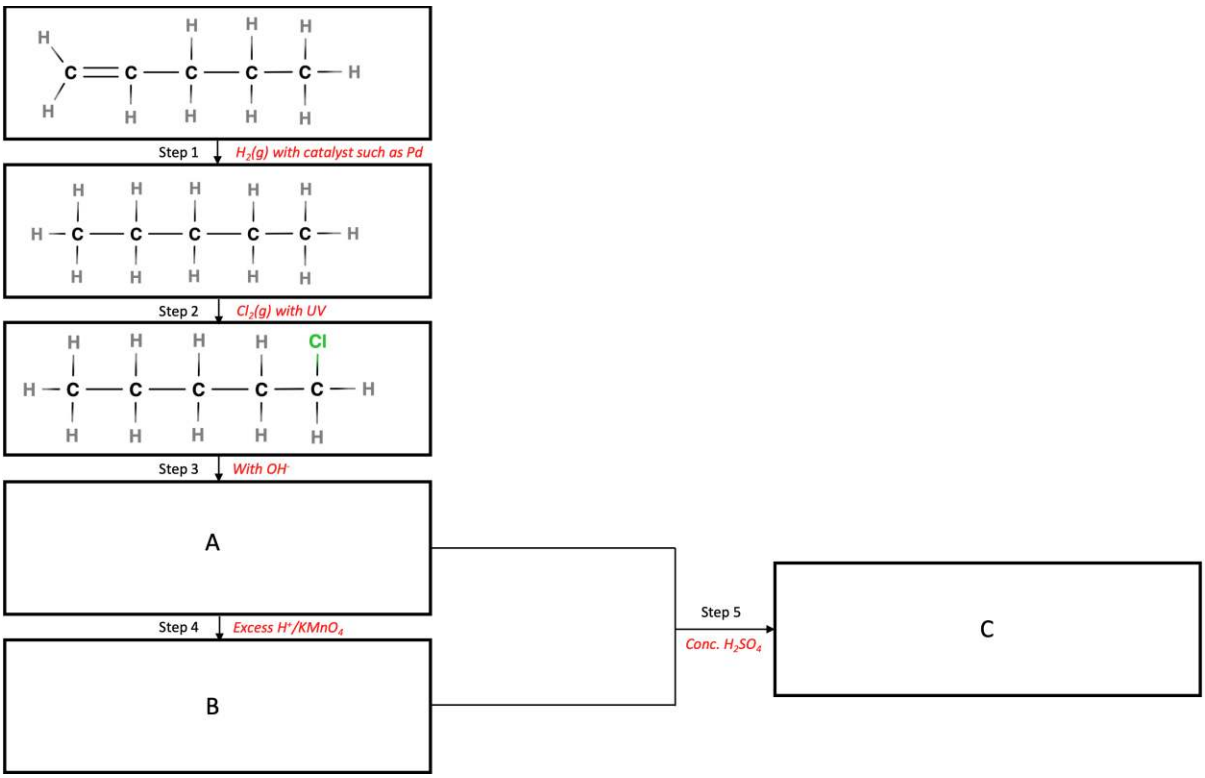
Question 30 (7 marks)

The flowchart below shows some reactions of the carbon compound pent-1-ene.



Use the flowchart to answer the following questions.

(a) Draw and systematically name the compounds formed in Step 3 and Step 4 (Compounds A and B) ***4***

Compound A	Compound B

Question 30 continues on the next page

(b) Draw the complete structural formula for compound C. Name the chemical reaction that occurs in step 5 and the product produced from the chemical process. ***3***

Compound C

Question 31 (4 marks)

(a) Justify the continued use of the Arrhenius definition of acids and bases, despite the development of the more sophisticated Brönsted–Lowry definition. ***3***

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(b) Why does the neutralisation of any strong acid in an aqueous solution by any strong base always result in a heat of reaction of approximately –57 kJ/mol? ***1***

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Question 32 (12 marks)

(a) High strength aspirin ($C_9H_8O_4$) tablets were purchased overseas by the schools chemistry teacher. Puzzled by the low cost, he encouraged their students to perform a chemical analysis on the concentration of Aspirin in each tablet.

Students were given 6 tablets each and were instructed to use sodium hydroxide solution with an approximate concentration of 0.1 mol/L, which was standardised using oxalic acid $(COOH)_2$.

Four flasks were prepared each containing a mixture of 25 mL of water and 10 mL of ethanol. 2 aspirin tablets were dissolved in each flask for titration against the sodium hydroxide.

Justify in detail a method the students could use to determine the concentration of aspirin in the tablets. ***6***

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Question 32 continues on the next page

Question 32 continued

(b) Three 25.00 mL samples of a 0.1034 mol/L solution of oxalic acid were titrated to standardise the NaOH solution according to the following equation:

$$H_2C_2O_4\,(aq) + 2NaOH\,(aq) \rightarrow Na_2C_2O_4\,(aq) + 2H_2O\,(l)$$

The average volume required for neutralisation was 25.75 mL. Calculate the molarity of the NaOH solution. ***2***

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Question 32 continues on the next page

Question 32 continued

(c) Four flasks were prepared each containing a mixture of 25 mL of water and 10 mL of ethanol. Two aspirin tablets was dissolved in each flask. The aspirin in each solution was titrated with the standardised NaOH solution according to the following equation:

$$C_9H_8O_4\,(aq) + NaOH\,(aq) \rightarrow C_9H_7O_4Na\,(aq) + H_2O\,(l)$$

The students achieved the following titration results:

Trial	Volume (mL)
1	16.55
2	16.50
3	16.60
4	16.85

The packaging claims the tablets contain 150 mg of aspirin per tablet.

Using the information provided, calculate the mass (mg) of aspirin per tablet, and justify whether the claim is true. ***4***

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Question 33 (4 marks)

Outline the use of solubility equilibria by Aboriginal and Torres Strait Islander Peoples when removing toxicity from foods.

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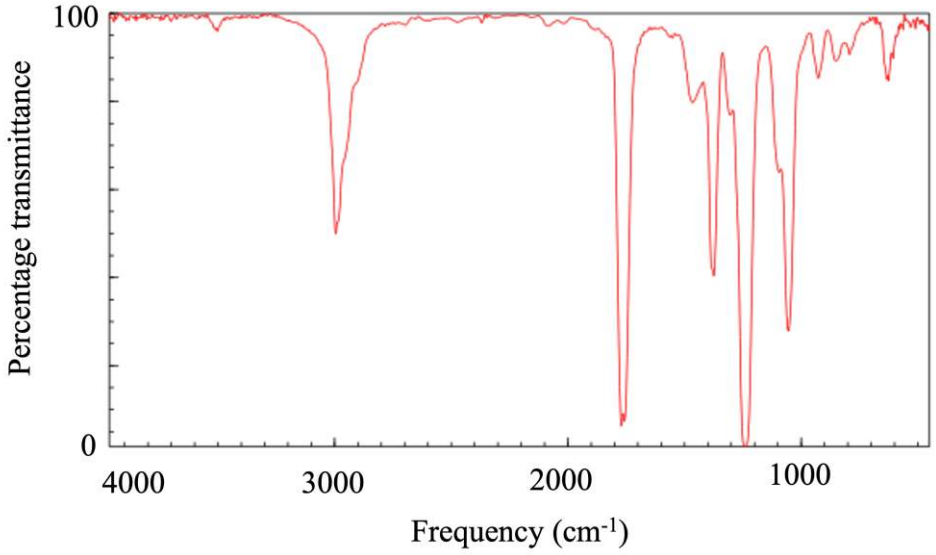
Question 34 (6 marks)

The empirical formula of a liquid organic compound is C_2H_4O. Samples of this compound were tested with sodium, bromine water and sodium carbonate solution each producing a negative result.

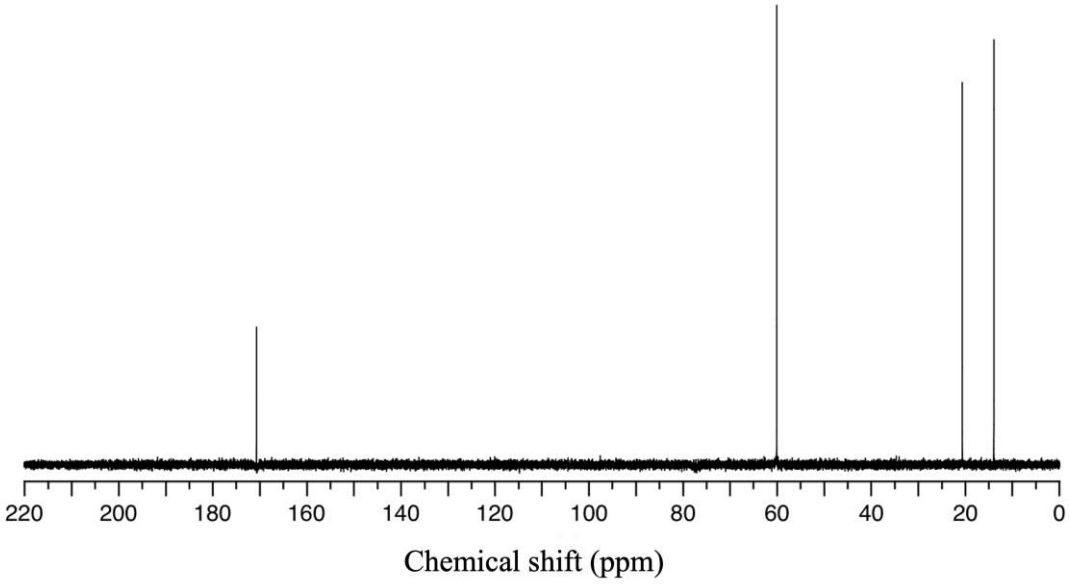
Analysis via mass spectroscopy showed the compound had a molar mass of 88.1g/mol.

Further testing of this compound using infrared spectroscopy and carbon-13 NMR are shown below.

Organic compound IR Spectra:



Organic compound C-13 NMR Spectra



Question 34 continues on the next page

Question 34 continued

Use this information to determine the possible names and structural formulas of the compound.

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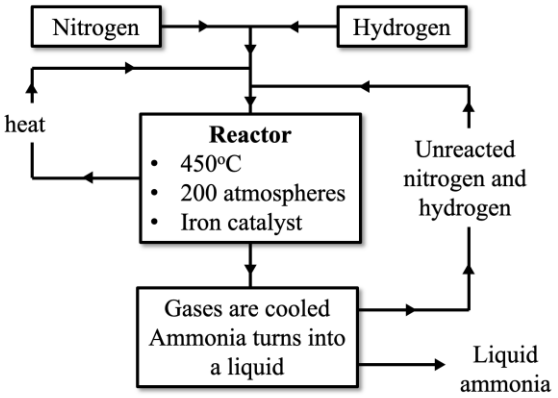
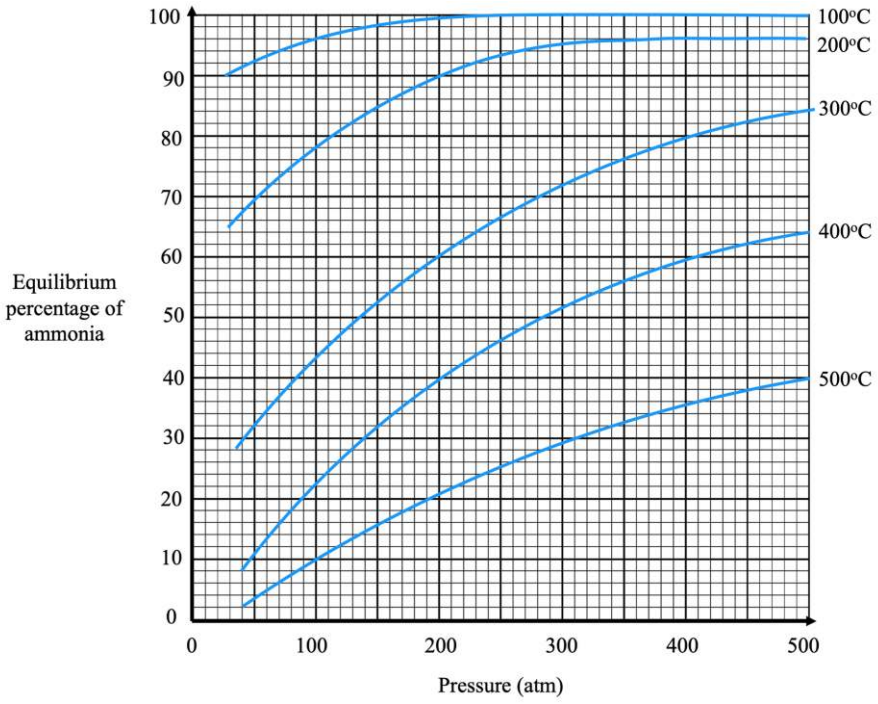
Question 35 (5 marks)

The diagram below is a simplified flowchart of the production of Ammonia via the Haber Process and a graph representing the conditions for its production.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2HN_3(g) \qquad \Delta H = \text{-ve}$$





Question 35 continues on the next page

Question 35 continued

Explains three other factors that should be considered to produce ammonia, which may not be evident from the flow chart and provide reasons for their importance

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End of paper

2022 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	B	C	A	A	D	C	D	B	D	D	B	C	D	C	A	A	D	D	A

Section II

Question 21a (1 mark)

Criteria	*Marks*
• increased	1

Question 21b (1 mark)

Criteria	*Marks*
• From colourless to more brown	1

Question 21c (4 marks)

Criteria	*Marks*
• K_{eq} expression • Equilibrium concentration of N_2O • Equilibrium concentrations per litre • Calculates K_{eq}	4
• Missing any of the above	1-3

Sample answer

$$K_{eq} = \frac{[NO_2]^4}{[N_2O]^2\,[O_2]^3}$$

	$\mathbf{2N_2O\ (g)}$	+	$\mathbf{3O_2\ (g)}$	⇌	$\mathbf{4NO_2\ (g)}$	
I	0.027		0.42		0	
C	-0.12		-0.18		+0.24	
E	0.15		0.242		0.24	@ 5L
	0.03		0.048		0.048	@ 1L

$$= \frac{0.048^4}{0.03^2 \times 0.0483^3}$$

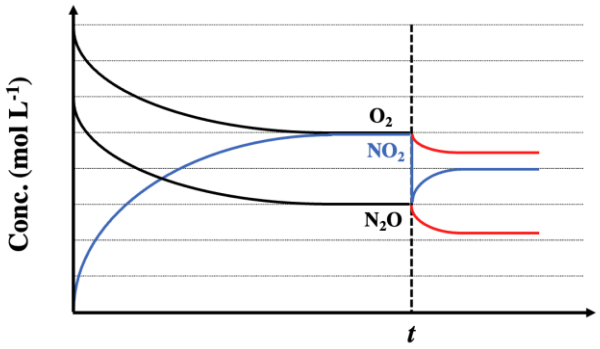
$$= 53.38$$

$$= 53$$

Question 21d (2 marks)

Criteria	*Marks*
• Correct sketch applying stoichiometry	2
• Correct pattern without applying stoichiometry	1

Sample answer



Question 22 (3 marks)

Criteria	*Marks*
• Identify the first four alkanes • Explains the trend of dispersion forces with reference to molecular weight • References choices to boiling point	3
• Addresses **TWO** of the criteria above	2
• Any relevant information	1

Sample answer

The identification of the four alkanes will be methane, ethane, propane and butane in increasing order of boiling points. This is due to the increasing amount of carbons present in each alkane resulting in an increase in the strength of dispersion forces between neighbouring molecules. Furthermore, as the number of carbons increase, so does the molecular weight and the number of available electrons present. A high number of electrons makes it more likely for a temporary dipole to form, creating stronger dispersion forces. As such, a larger amount of energy is required to break these bonds to change state, so the boiling point increases with the number of carbons. Alkanes with 5 carbons or more are likely to require more heat energy, hence their boiling point will be much higher than 0^{o}C.

Question 23a (1 marks)

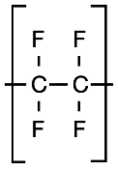
Criteria	*Mark*
• Correct IUPAC name	1

Sample Answer
Tetrafluoroethene

Question 23b (2 marks)

Criteria	*Marks*
• Addition polymerisation • Correct structural unit	2
• Any relevant information	1

Sample answer
Addition Polymerisation



Question 24a (1 mark)

Criteria	*Mark*
• $2C_7H_{16}O(g) + 21O_2(g) \rightarrow 14CO_2(g) + 16H_2O(g)$	1

Question 24b (4 mark)

Criteria	*Mark*
• Correctly calculates energy released • Correctly calculates moles of heptanol • Correctly calculates enthalpy • 3 significant figures	4
• Addresses **THREE** of the above criteria	3
• Addresses **TWO** of the above criteria	2
• Any relevant calculation	1

Sample answer

$q = mc\Delta T$
$= 150 \times 4.18 \times (63-20)$
$= 26\,961 J$
$= 26.961 kJ$

$$n(\text{heptanol}) = \frac{0.750}{116.198} = 0.00645467$$

$$\Delta H = \frac{-q}{n} = \frac{-26.961\ kJ}{0.00645467} = -4176.96 = -4180\ kJmol^{-1}$$

Question 25a (3 marks)

Criteria	*Marks*
• Lists at least **TWO** to properties • Relates at least **TWO** properties to uses	3
• List at least **THREE** properties with no relation to use OR • Lists at least **TWO** properties with at least one relation to use	2

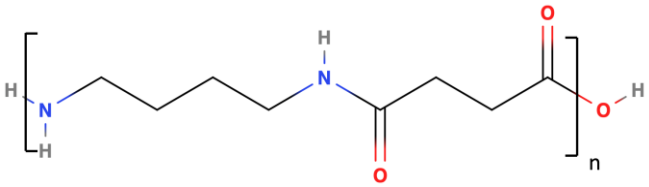
• Any relevant information	1

Sample answer
Nylon is strong, elastic, resistant to heat and chemicals, and dries quickly. This makes it ideal for clothing, life vests and parachutes due to the flexible, yet robust structure.

Question 25b (2 marks)

Criteria	***Marks***
• Correctly polymer unit • Correct use of brackets to indicate repeating unit	2
• Any relevant diagram	1

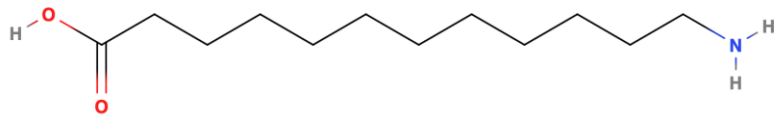
Sample answer
NB: Skeletal structure not required



Question 25c (2 marks)

Criteria	***Marks***
• Correctly number of carbons • Correctly placed functional group	2
• Any relevant diagram	1

Sample answer
NB: Skeletal structure not required



Question 26 (4 marks)

Criteria	***Marks***
• Correct molar mass • Correct calculation of moles of phosphorus in the precipitate • Correct mass of powder • Correct %(w/w)	4
• Address **ONE** to **THREE** of the above criteria	1-3

Sample answer

Molar mass of magnesium ammonium phosphate hexahydrate ($Mg(NH_4)PO_4.6H_2O$) = 245.42

n(precipitate) = 1.89/245.42
= 0.007701 mol

n(P in precipitate) = 0.007701 mol
m(P) = 0.007701 x 30.97
= 0.2385 g per 6.85 g powder

%(w/w) of P in powder = 0.2385/6.85 x100
= 3.48%

Question 27 (3 marks)

Criteria	*Marks*
• Appropriate tests to distinguish alkenes from the others • Appropriate tests to distinguish alkanoic acids from the others • Appropriate tests to distinguish alkanols from the others	3
• Addresses **TWO** of the above criteria • OR • Describes **THREE** test with no expected results	2
• Any relevant information	1

Sample answer
Alkanes can be distinguished by their reaction with bromine water. If a few drops of bromine water is added to the alkene, the bromine water is decolourised. Alkanols and alkanoic acids do not react with bromine water.

Alkanoic acids react with sodium hydrogen carbonate to produce carbon dioxide. This will be evident in the bubbling of the solution. Alkenes and alkanols do not react with sodium hydrogen carbonate.

When alkanols are warmed with acidified potassium dichromate solution the colour changes from orange to green as the alkanol reduces the dichromate ion. Alkenes and alkanoic acids do not react with this reagent.

Question 25 (3 marks)

Criteria	*Marks*
• Provides relevant equation • Describes shift in equilibrium • Identifies changes in concentrations	3
• Addresses **TWO** of the criteria above	2
• Any relevant information	1

Sample answer
Lactic acid in the blood produces lactate ions and hydrogen ions. The blood's buffering system $H_2CO_3(aq) + H_2O(l) \rightleftharpoons HCO_3^-(aq) + H_3O^+(aq)$ responds by combining the extra hydrogen ions with the hydrogen carbonate ions, thus shifting the system to the left and decreasing their concentration.

Question 29a (3 marks)

Criteria	*Marks*
• Correct equilibrium expression • Working out • Correct concentration of solution	3
• Omitting <u>one</u> to <u>two</u> of the criteria above	1-2

Sample answer

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

K_{sp} = $[Pb^{2+}][Cl^-]^2$
1.7×10^{-5} = $s \times (2s)^2$
1.7×10^{-5} = $4s^3$
s^3 = 4.25×10^{-6}
s = 1.6×10^{-2}
The solubility of $PbCl_2$ is 1.6×10^{-2} $molL^{-1}$

Question 29b (3 marks)

Criteria	*Marks*
• Correct concentration of Cl^- • Correct final concentration of $PbCl_2$ • Makes a qualitative comparison on solubility	3
• Omitting <u>one</u> to <u>two</u> of the criteria above	1-2

Sample answer

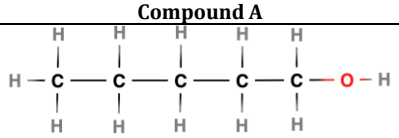
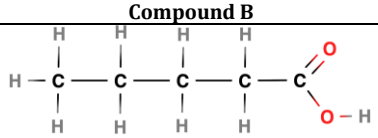
	$PbCl_2$ (s) ⇌	Pb^{2+} (aq)	+ $2Cl^-$ (aq)
I		0	0.35
C		+s	+2s
E		s	0.35 + 2s
			~ 0.35

K_{sp} = $[Pb^{2+}][Cl^-]^2$
1.7×10^{-5} = $s \times 0.35^2$
1.7×10^{-5} = $s \times 0.1225$
s = 1.3877551×10^{-4}
Solubility of $PbCl_2$ is 1.39×10^{-4} $molL^{-1}$ in 0.35 $molL^{-1}$ NaCl
$PbCl_2$ is 115 times more soluble in water

Question 30a (4 marks)

Criteria	*Marks*
• correctly drawn the structure for compound A • correctly named compound A • correctly drawn the structure for compound B • correctly named compound B	4

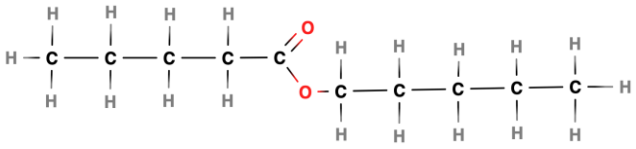
Sample answer

Compound A	**Compound B**
 Pentan-1-ol	 Pentanoic acid

Question 30b (3 marks)

Criteria	*Marks*
• correctly drawn the structural formula for compound C • correctly named the process • correctly named the product (compound C)	3
• **<u>One</u>** to **<u>Two</u>** criteria correctly addressed	1-2

Sample answer



Esterification / Pentyl pentanoate

Question 31a (3 marks)

Criteria	*Marks*
• Demonstrates thorough knowledge and understanding of the Arrhenius AND Brönsted–Lowry definitions of acids and bases • Supports the statement with evidence	3
• Demonstrates a sound knowledge and understanding of the Arrhenius AND Brönsted–Lowry definitions **OR** • Demonstrates a sound knowledge and understanding of EITHER the Brönsted–Lowry OR the Arrhenius definition • Supports the statement with evidence **OR** • Demonstrates a basic knowledge and understanding of the Arrhenius AND Brönsted–Lowry definitions • Supports the statement with evidence	2
• Demonstrates a sound knowledge and understanding of EITHER the Arrhenius OR the Brönsted–Lowry definition **OR** • Provides a justification	1

Sample Answer
Arrhenius defines an acid as a substance that ionises in water to produce hydrogen ions (H+). He defines a base as a substance that ionises in water to produce hydroxide ions (OH–). Alternatively, Brönsted-Lowry defines the acid-base reaction as a transfer of a proton. They define acids as proton donors and bases as proton acceptors. The Arrhenius definition continues to be used despite the fact it only applies to aqueous solutions. This is because Arrhenius's theory is encompassed by the Brönsted-Lowry definition, most acid-base reactions occur in aqueous solutions, and the theory demonstrates the formation of salt and water during neutralisation reactions.

Question 31b (1 mark)

Criteria	*Marks*
• Provides a reason why the heat of reaction is approximately –57 kJ/mol for neutralisation reactions of strong acids and strong bases	1

Sample Answer
There is the same net ionic equation for neutralisation of strong acid and strong base:
$H^+(aq) + OH^-(aq) \rightarrow H_2O$
The heat of reaction is the same for these neutralisation reactions because the spectator ions do not influence the heat of reaction, and strong acids and bases completely dissociate into their H^+/OH^- ions respectively.

Question 32a (6 marks)

Criteria	*Marks*
• Thorough justification, including standardisation of sodium hydroxide by titration against oxalic acid using appropriate and correctly cleaned glassware • Uses a valid method to conduct the titrations to achieve reliable results for ascorbic acid concentration	5-6
• Relevant procedures described, but no justification	3-4
• Briefly describes titration process	1-2

Sample answer
The NaOH provided needs to be standardised using the Oxalic acid.

The dried oxalic acid was weighed and transferred to a clean small beaker contained a small volume of distilled water and dissolved. This was then transferred to a clean 250 mL volumetric flask and made to 250 mL with distilled water

Oxalic acid is a suitable primary standard due to its solubility and relatively high molecular mass which reduces errors and reacts completely with sodium hydroxide. Distilled water is also used as it is free of contaminants which allows for the accurate calculation of the unknown concentration. Phenolphthalein indicator has a clear and distinct colour change close to the equivalence point, making its use appropriate.

To perform the titration, the burette (accurate to+/- 0.5 mL) and pipette (accurate to+/- 0.1 mL) were washed and finally rinsed with the solutions to be used in them. Sodium hydroxide was transferred to the burette using a funnel and the initial volume recorded. For the standardising of sodium hydroxide titration 20.0 mL aliquots of oxalic acid were pipetted into clean conical flasks and 3 drops of phenolphthalein added. Sodium hydroxide was titrated against the oxalic acid solution until the endpoint was reached. The final volume was recorded and the procedure was repeated until concordance was achieved.

The prepared aspiring tablets was then titrated against the standardised sodium hydroxide solution using phenolphthalein (the pH at the equivalence point will be similar to that of the endpoint, hence it is a suitable indicator). A mixture of water and ethanol is added to the aspirin samples to improve the solubility of the aspirin.

Question 32b (2 marks)

Criteria	*Marks*
• Correctly calculates NaOH molarity	2
• Calculates [NaOH] with ONE error OR • Calculates moles of HCl or NaOH	1

Sample answer

$H_2C_2O_4$ (aq) + 2NaOH (aq) → $Na_2C_2O_4$ (aq) + $2H_2O$ (l)

$n(H_2C_2O_4)$ = cv
= 0.1034 x 0.25
= 2.85×10^{-3} mol
= n(NaOH) x 2
n(NaOH) = 0.00517 mol (1:2 ratio)

$$c(NaOH) = \frac{c}{v} = \frac{0.00517}{0.02575}$$
= 0.2008 mol L^{-1}

Question 32c (4 marks)

Criteria	*Marks*
• Correctly calculates the mass of aspirin (average) • Justifies if the claim is true	3-4
• Calculates mass of aspirin with ONE error OR • Calculates moles of $NaOH/C_9H_8O_4$ and molar mass aspirin	2
• Calculates moles of $NaOH/ C_9H_8O_4$ OR • Calculates molar mass aspirin $C_9H_8O_4$	1

Sample answer

Avg. vol. = 16.55 mL (trial 4 is an outlier)
n(NaOH) = cv
= 0.2008 x 0.01655
= 3.323 mol
= $n(C_9H_8O_4)$ (1:1 ratio)
$m(C_9H_8O_4)$ = n x Mm
= 3.323 x 180.154 *(9×12.01+8×1.008+4×16.00)*
= 0.5986 g
= 598.6 mg

$$m(C_9H_8O_4) = \frac{598.6}{\text{Per tablet } 2}$$
= 299.3 mg

The claim about the table is true.

Question 33 (4 marks)

Criteria	*Marks*
• A named example • Refers to toxicity • Makes reference to solubility equilibria • Makes reference to LCP or reducing toxicity over time	4
• Address **ONE** to **THREE** of the above criteria	2-3
• Any relevant information	1

Sample answer

Although the formal idea of chemical equilibria is relatively recent, communities have exploited these principles for tens of thousands of years.

An example of this is the highly toxic cycad fruit. ATSI needed a way to reduce toxicity so that it could be dietary staple. One method was to cut the fruit open and leave it in a running stream. This achieved the solubility equilibria of toxins (s) ⇋ toxins (aq). Overtime, the aqueous toxin dissolves into the water and its concentration will decrease.

By LCP, the equilibrium will shift to the right as the aqueous toxins is swept away (conc. Is lowered) since there is a constant water source. Thus, the longer ATSI wait, the less toxic the fruit will be.

Question 34 (6 marks)

Criteria	*Marks*
• Determines molecular formula • Eliminates possibility of alkanol, alkene and alkanoic acid • Identifies compound as an ester • Correctly names and draws structural formula of 1-propyl methanoate • Correctly names and draws structural formula of ethyl ethanoate • Correctly names and draws structural formula of methyl propanoate	6
• Address **TWO** to **FIVE** of the above criteria	2-5
• Any relevant information	1

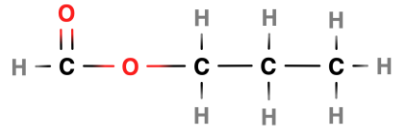
Sample answer
C_2H_4O = 44.05 g/mol. The empirical molar mass is half the molar mass (88.1 g/mol). Thus the molecular formula is $C_4H_8O_2$.
The negative tests show the compound is not an alkanol, alkene or. alkanoic acid.

The IR spectrum shows the presence of a carbonyl group (C=O) as well as a single-bonded O atom (C-O-C).

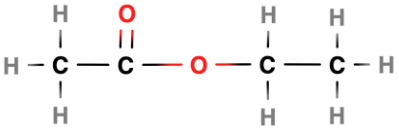
The C-13 NMR spectrum shows characteristic chemical shifts for a carbonyl group (171 ppm) and a C-O group (59 ppm).
The carbon atoms are in four different chemical environments.

Hence, the compound is most likely to be an ester.

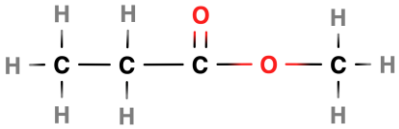
Below are possible structures and names of esters with a molar mass of 88.1 g/mol. In these compounds there are four different chemical environments of each of the carbon atoms.



1-propyl methanoate



ethyl ethanoate



methyl propanoate

Question 35 (5 marks)

Criteria	*Marks*
• Thoroughly explains **THREE** other factors for consideration • Provides reasons for all **THREE** factors	5
• Thoroughly explains **THREE** other factors for consideration • Provides reasons for **TWO** of the factors OR • Strongly explains **TWO** other factors for consideration • Provides reasons for **THREE** of the factors	4
• Provide **THREE** other factors for consideration with some explanation	3
• Provide **THREE** other factors with no explanation	2
• Any relevant information	1

Sample answer
The proximity of the reagents to the ammonia production is important, to reduce cost of long haulage, which can also contribute to reducing CO_2 emissions and reduced vehicle accidents in transit.

Having access to a qualified workforce for the operation of the process as the labour costs are usually more than 10% of the production costs. An isolated location would incur higher labour costs due to higher incentives and remuneration for skilled staff.

Close proximity to cheap and reliable energy sources would also reduce the production cost, as well as relying on a combination of renewable and non-renewable sources.

Other factors to be considered:
- *Transportation costs*
- *Ideal operating conditions with highest % rate and yield of ammonia (according to graph)*