STUDENT NUMBER: _____

Pymble Ladies' College

2019 Chemistry Trial Examination

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- NESA approved calculators may be used
- A formulae sheet, data sheet and Periodic Table are provided separately
- For questions in Section I, record your responses on the multiple choice answer sheet provided at the back of this paper.
- For questions in Section II, show all relevant working in questions involving calculations.

Total Marks: 100

Section I – 20 marks (pages 2 – 8)

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

Section II – 80 marks (pages 9 – 27)

- Attempt Questions 21 – 34
- 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 for Questions 1 – 20.

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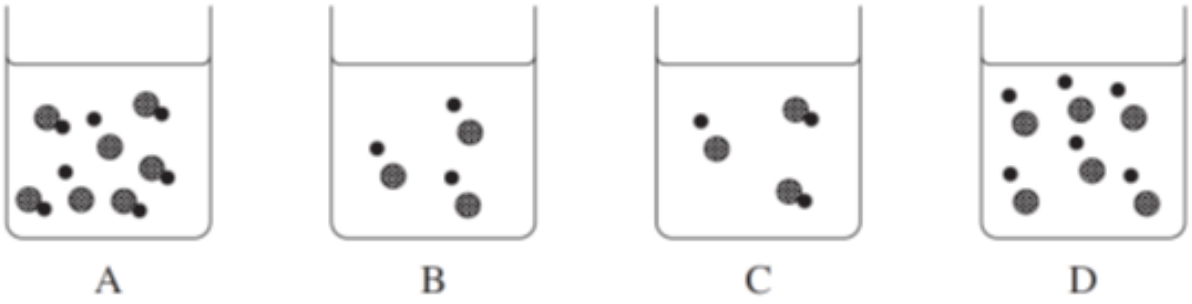
1 Which statement best represents Arrhenius's definition of an acid?

A. Acids contain oxygen
B. Acids are proton donors
C. Acids contain replaceable hydrogen
D. Acids ionise in solution to form hydrogen ions

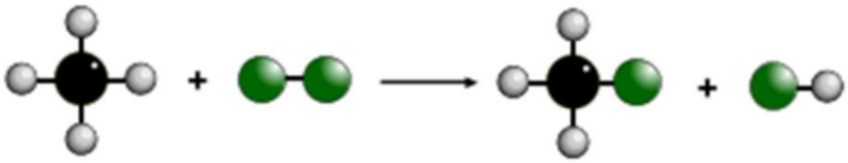
2 Which of the following is NOT an environmental impact arising from the use of hydrocarbons obtained from the Earth?

A. Ocean acidification
B. Ozone layer depletion
C. Acid rain
D. Global warming

3 Which beaker contains a dilute weak acid?



4 The chemical reaction of a hydrocarbon with a halogen is modelled below.



Which of the following best describes this type of chemical reaction?

A. Addition
B. Substitution
C. Condensation
D. Polymerisation

5 What would be the pH of a 0.1 mol L^{-1} solution of sulfuric acid?

A. Less than 1.0
B. Exactly 1.0
C. Between 1.0 and 7.0
D. Greater than 7.0

6 For this reaction at equilibrium, which combination of temperature and pressure would give the greatest equilibrium yield of products?

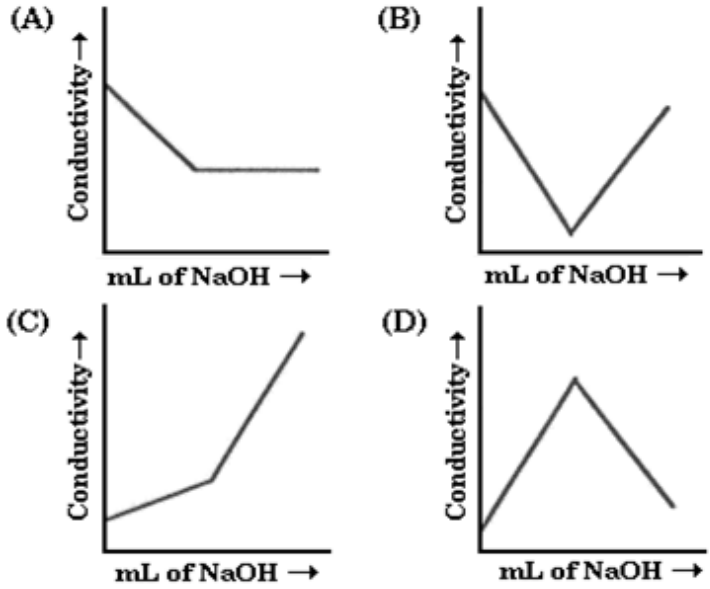
$$W(g) + X(g) \rightleftharpoons 2Y(g) + Z(g) \qquad \Delta H = +47 \text{ kJ mol}^{-1}$$

A. Low pressure and high temperature
B. Low pressure and low temperature
C. High pressure and high temperature
D. High pressure and low temperature

7 Which of the following is a correct IUPAC name?

A. But-3-yne
B. 1-chloro-4-bromopentane
C. 1,3-dimethylbutane
D. 2-bromo-3-fluorobutane

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



9 Which of the following correctly lists the compounds in order of increasing boiling point?

A. Propanone < Propane < Propan-1-ol < Propanamide
B. Propane < Propan-1-ol < Propanone < Propanamide
C. Propane < Propanone < Propan-1-ol < Propanamide
D. Propanone < Propane < Propanamide < Propan-1-ol

10 A neutralisation reaction takes place between 50 mL of 0.1 mol L^{-1} sulfuric acid and 75 mL of 0.15 mol L^{-1} sodium hydroxide.

What is the pOH of the solution after the reaction has occurred?

A. pOH 2
B. pOH 3
C. pOH 7
D. pOH 12

11 A student placed some calcium carbonate in a flask with excess acid. What is this reaction an example of?

A. Dynamic equilibrium
B. Static equilibrium
C. Synthesis
D. Combustion

12 Which indicator should be used in a titration to find the concentration of a solution of methanamine using 0.01 mol L^{-1} of hydrochloric acid?

A. Bromophenol blue (pH range 3.0 – 4.6)
B. Litmus (pH range 4.5 – 8.2)
C. Phenol red (pH range 6.8 – 8.4)
D. Phenolphthalein (pH range 8.3 – 10.0)

13 Which is **NOT** a method used by Aboriginal people to remove toxins and toxicity from foods?

A. Yams are placed in running water for several hours.
B. Cycads are fermented in large containers for several months.
C. Cycads are cut open and ground up and placed in water.
D. Using the native lily to treat green ant bites.

14 Consider the following equilibrium reaction, which is endothermic.

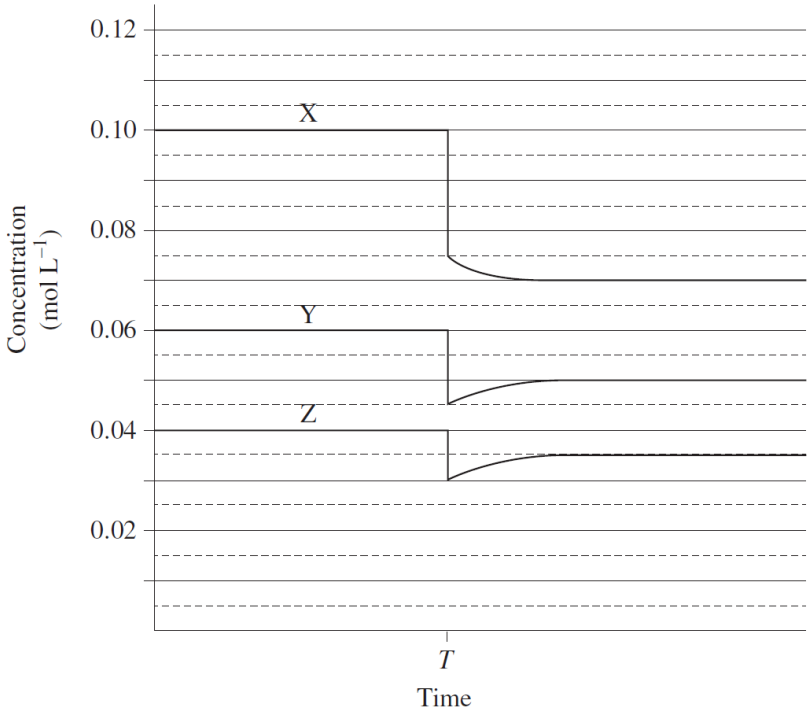
$$[Co(H_2O)_6]^{2+} + 4Cl^- \rightleftharpoons [CoCl_4]^{2-} + 6H_2O(l)$$

Pink solution *Blue solution*

What should be done to the mixture in order for the solution to turn pink?

A. Increase the pressure
B. Add sodium chloride
C. Heat the solution
D. Add silver nitrate

15 Three gases X, Y and Z were mixed in a closed container and allowed to reach equilibrium. A change was imposed at time T and the equilibrium was re-established. The concentration of each gas is plotted against time.



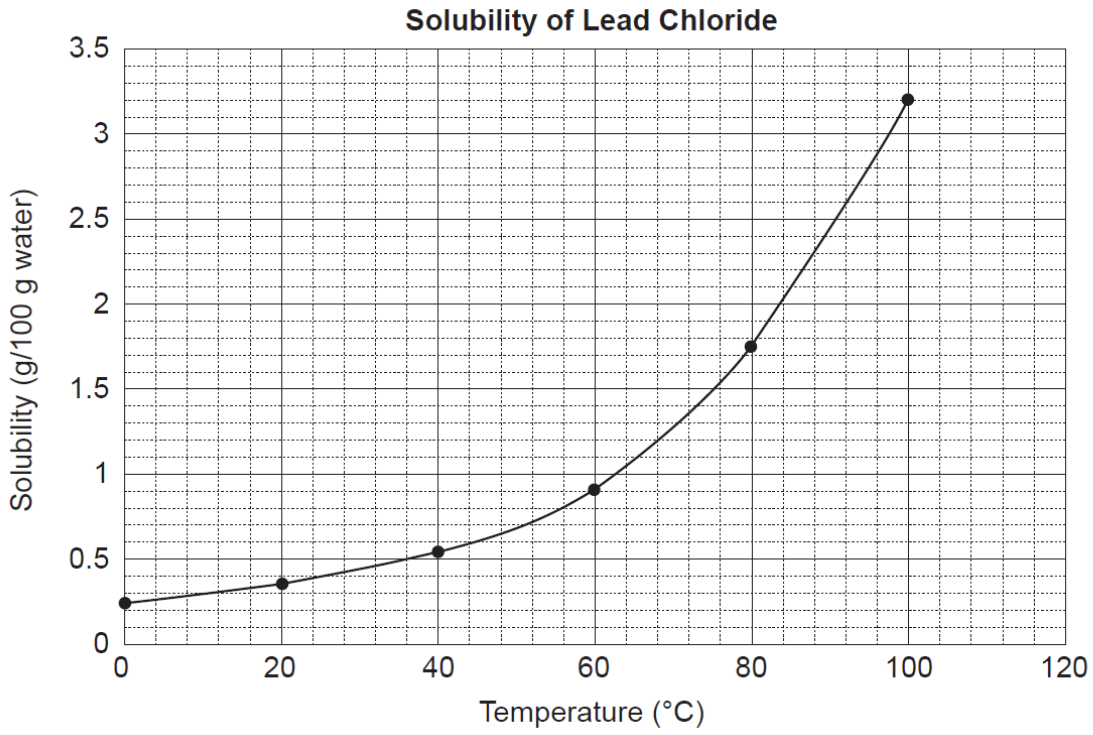
What change was imposed at time T?

A. An increase in volume
B. A decrease in volume
C. An increase in temperature
D. A decrease in temperature

16 Which of the following statements is correct about polymeric esters?

A. They are used for flavourings and perfumes.
B. They are addition polymers made by reacting dialcohols with dicarboxylic acids.
C. They are condensation polymers made by reacting diamines with dicarboxylic acids.
D. They are manufactured for use as textile fabrics.

17 The graph shows how the solubility of lead chloride is affected by temperature.



What is the solubility product (Ksp) for lead chloride at 60 °C?

A. 0.9
B. 1.36×10^{-4}
C. 6.78×10^{-5}
D. 1.36×10^{-7}

18 Which of the following correctly matches the hydrocarbon to the molecular shape?

	Hydrocarbon	Molecular Shape
A.	C_2H_2	Tetrahedral
B.	C_2H_4	Planar
C.	C_2H_4	Trigonal pyramidal
D.	C_2H_6	Linear

19 The chemical equation for the combustion of glucose during cellular respiration is shown below.

$$C_6H_{12}O_6(aq) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(\ell) \qquad \Delta H = -2816 \text{ kJ mol}^{-1}$$

If the glucose content of an energy bar is 36.7 g, how much energy would a person obtain from eating one energy bar?

A. 2.35 kJ
B. 15.6 kJ
C. 574 kJ
D. 2816 kJ

20 Which of the following correctly shows the key stages of a mass spectrometer in order?

	Stage 1	Stage 2	Stage 3	Stage 4
A.	ionisation	deflection	acceleration	detection
B.	ionisation	detection	acceleration	deflection
C.	deflection	acceleration	ionisation	detection
D.	ionisation	acceleration	deflection	detection

Chemistry

Section II

Answer Booklet

80 marks

Attempt Questions 21 – 34

Allow about 2 hours and 25 minutes for this section

Instructions

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

Please turn over

Question 21 (5 marks)

Polyvinyl chloride is a commercially important polymer.

(a) Identify one use of polyvinyl chloride. **1**

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(b) Draw the structure of polyvinyl chloride, showing 3 repeat units. **1**

(c) Explain how the structure of this polymer makes it suitable for the use identified in (a). **3**

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Question 22 (4 marks)

The Contact Process used for the production of sulfuric acid includes a step whereby sulfur dioxide is converted to sulfur trioxide in an equilibrium reaction:

$$SO_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons SO_3(g) \quad \Delta H = -99 \text{ kJ mol}^{-1}$$

SO_2 and O_2 were added to a closed container.

At a certain temperature, the equilibrium constant K_{eq}, is 12.1 for this reaction as written in the equation above.

At the same temperature, 1.0 mol SO_2 and 1.0 mol O_2 were added to a 1.0 L closed container. At a point in time, the amount of SO_3 in the container was measured as 0.7 mol/L.

(a) Write an equilibrium expression for this reaction. **1**

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(b) Has equilibrium been reached in the container at this point? Use calculations to justify your answer. **3**

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Question 23 (5 marks)

There are several stages in the industrial production of methanol from methane.

The first stage involves a gaseous equilibrium between the reactants, methane and steam, and the products, hydrogen and carbon monoxide.

Figures 1 and 2 show the percentage conversion of methane into the gaseous products, hydrogen and carbon monoxide, under different conditions at equilibrium.

Figure 1

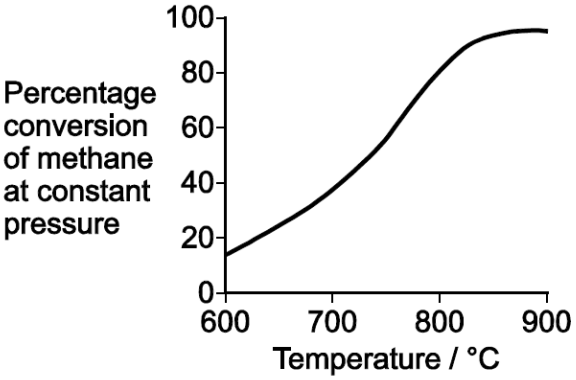
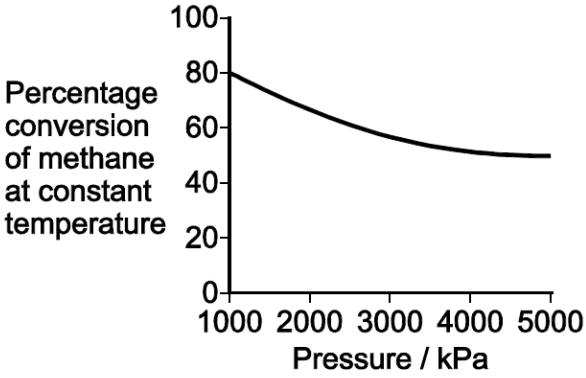


Figure 2



(a) Write a balanced chemical equation for this reaction. **1**

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(b) Explain the effect of temperature and pressure on the rate of reaction and yield of the products. **4**

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Question 24 (4 marks)

An antacid tablet is known to contain calcium carbonate. To determine the mass of calcium carbonate in the tablet, the following procedure was used.

- The tablet was crushed and then placed in a conical flask.
- A pipette was used to add 25.0 mL of 0.600 mol L^{-1} hydrochloric acid to the crushed tablet in the beaker.
- Once the reaction between the calcium carbonate and hydrochloric acid had stopped, phenolphthalein indicator was added to the reaction mixture.
- A burette was then used to add 0.100 mol L^{-1} sodium hydroxide to the conical flask to neutralise the excess hydrochloric acid.
- The phenolphthalein changed from colourless to pink after 12.1 mL of the sodium hydroxide solution had been added.

Calculate the mass of calcium carbonate in the original antacid tablet. **4**

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Question 25 (7 marks)

Ethanoate buffers are used in biochemical studies of enzymes and other chemical components of cells to prevent pH changes.

(a) Explain how ethanoate buffers work to resist pH change. Use equation/s in your answer. **3**

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A buffer solution was made by dissolving 0.0250 mol of sodium ethanoate in 500 mL of 0.0700 mol L^{-1} ethanoic acid.

(b) Calculate the pH of this buffer solution (Ka for ethanoic acid is 1.76×10^{-5}) **4**

In your calculations, assume the amount of ethanoate ions produced when the ethanoic acid ionises is negligible compared to the amount added.

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Question 26 (4 marks)

(a) Draw the structural formulae and name all possible isomers of $C_4H_{10}O$ which are alcohols. **3**

(b) Identify which of the isomers above would quickly react to give a positive test when treated with $ZnCl_2$ and concentrated HCl. **1**

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Question 27 (4 marks)

The table shows a range of organic compounds which have similar molar masses.

Compound	Molar Mass
$CH_3CH_2CH_2CH_3$	58
$CH_3CH_2CH_2NH_2$	59
CH_3COOH	60

Compare the solubility of these compounds in water, with reference to the intermolecular forces present. **4**

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Question 28 (3 marks)

Photosynthesis is a chemical reaction that takes place inside a plant, producing food for the plant to survive. The reaction is shown below:

$$6\ CO_2 + 6\ H_2O \xrightarrow[\text{chlorophyll}]{\text{sunlight}} C_6H_{12}O_6 + 6\ O_2 \qquad \Delta H = +\ 2816\ \text{kJ/mol}$$

Analyse the effect of the changes in enthalpy and entropy for this reaction and the effect this has on the spontaneity of the reaction. **3**

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Question 29 (6 marks)

Magnesium chloride is a highly soluble salt.

(a) Draw a labelled diagram to show the dissolution of this salt in water. **3**

(b) Sodium carbonate and potassium hydroxide solutions were added to separate samples of magnesium chloride solution. Which one of these is more likely to form a precipitate? Justify your answer. **3**

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Question 30 (6 marks)

(a) Distinguish between soap and detergents in terms of their structures. **2**

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(b) Account for the cleaning action of soap and detergents. Include a labelled diagram in your answer. **4**

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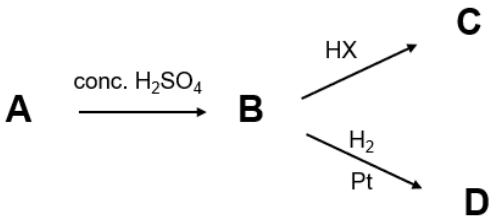
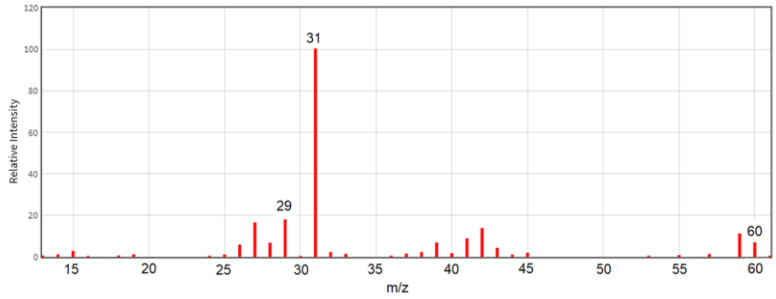
Question 31 (7 marks)

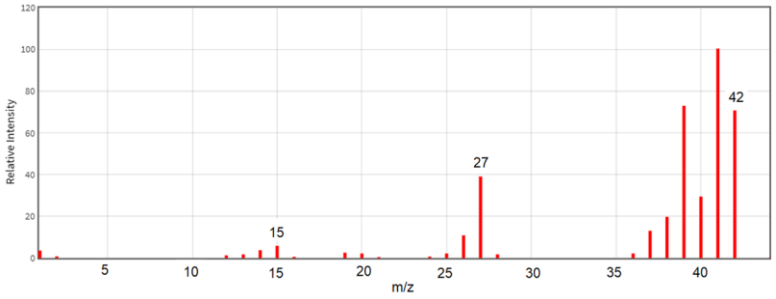
This flowchart shows reactions involving four different organic compounds (**A** to **D**) and the mass spectra of the compounds are shown.



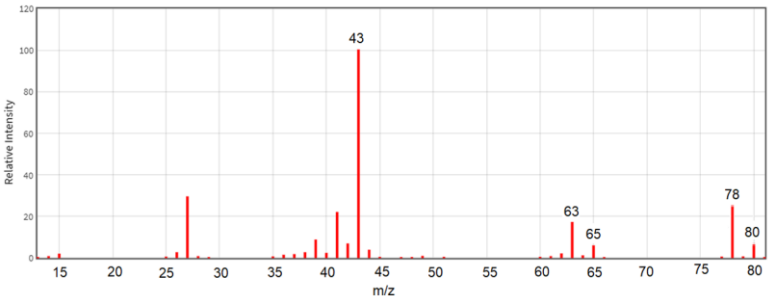
Mass Spectrum of **A**



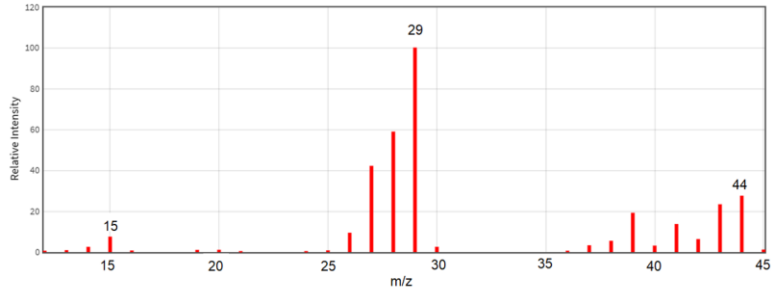
Mass Spectrum of **B**



Mass Spectrum of **C**



Mass Spectrum of **D**



Question 31 continues on page 21

Question 31 (continued)

Draw and name the possible structures of compounds **A** to **D**, justifying your answer with reference to the information provided. **7**

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End of Question 31

Question 32 (9 marks)

Esters are used in the perfume and food industries because they have pleasant smells and tastes.

(a) Construct a flowchart to show a reaction pathway for the chemical synthesis of the ester, ethyl ethanoate, from glucose. **3**

(b) Describe a procedure that can be used in the school laboratory to produce the ester, ethyl ethanoate, in the esterification reaction step. **4**

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Question 32 continues on page 23

(c) Describe a safety precaution that must be implemented in the school laboratory during the production of the ester, ethyl ethanoate, in the esterification reaction step. **2**

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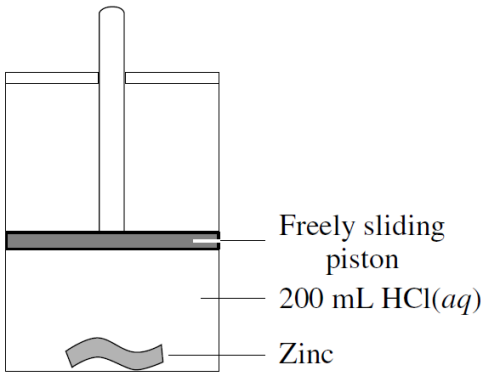
End of Question 32

Question 33 (9 marks)

A student carried out a first-hand investigation to identify the relationship between the mass of a metal used in a reaction and the volume of gas produced. The first-hand investigation was carried out at 25°C and 100 kPa.

In each experiment, 200 mL of hydrochloric acid was added to some zinc, and the volume of gas produced was recorded.

The diagram shows the equipment used and the table contains the student's results and the theoretical results.



Mass of zinc /g	Experimental volume of gas collected kPa /mL	Theoretical volume of gas collected kPa /mL
0.33	110	229
0.63	260	577
0.96	390	667
1.22	425	848
1.93	425	

(a) Write a balanced chemical equation for this reaction. **1**

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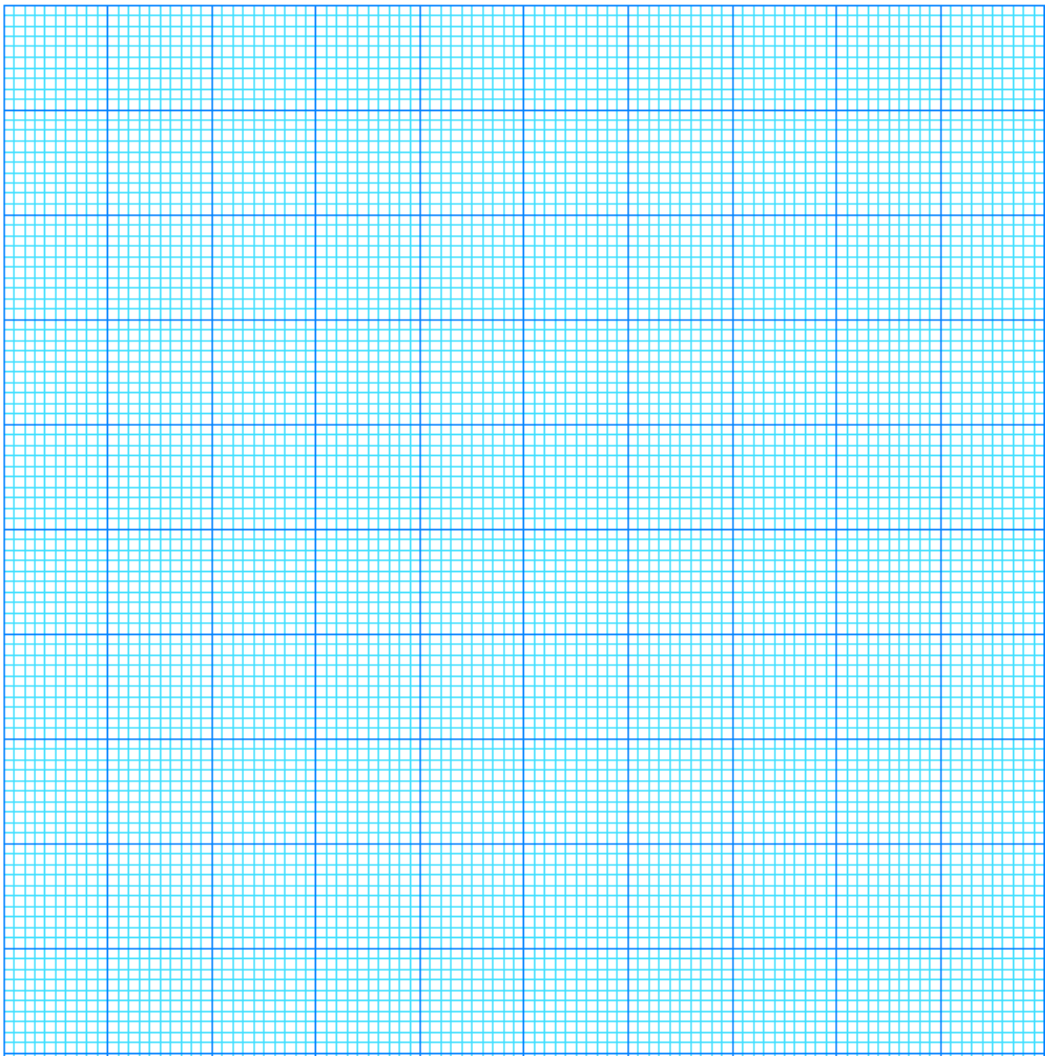
Question 33 continues on page 25

Question 33 (continued)

(b) Plot this data on the graph paper provided. **3**



Question 33 continues on page 26

Question 33 (continued)

(c) Discuss the results of the student's investigation. In your answer comment on the validity of the experiment as well as any improvements that could be made. **5**

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End of Question 33

Question 34 (7 marks)

A 2007 Australian Government report entitled “Biofuels in Australia” stated:

> *Australia’s land and water resources will be increasingly contested for animal, food, fibre and energy production. The choices we make about biofuels will have far reaching implications for the nation’s economy, environment and society.*

With reference to the statement above, evaluate the suitability of biofuels as an alternate source of energy. **7**

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End of Examination

Section II extra writing space

If you use this space, clearly indicate which questions you are answering.

Section II extra writing space

If you use this space, clearly indicate which questions you are answering.

Student Number: ……

Chemistry Multiple Choice Answer Sheet

Select the alternative A, B, C or D that best answers the question.

Fill in the response space completely. 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 this by writing the word ***correct*** and drawing an arrow.

Start Here

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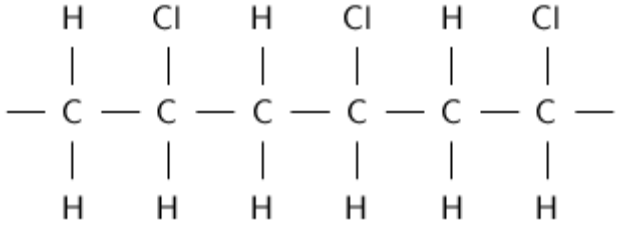
14.	A ⬭	B ⬭	C ⬭	D ⬭
15.	A ⬭	B ⬭	C ⬭	D ⬭
16.	A ⬭	B ⬭	C ⬭	D ⬭
17.	A ⬭	B ⬭	C ⬭	D ⬭
18.	A ⬭	B ⬭	C ⬭	D ⬭
19.	A ⬭	B ⬭	C ⬭	D ⬭
20.	A ⬭	B ⬭	C ⬭	D ⬭

2019 CHEMISTRY TRIAL MARKING GUIDELINES

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

	Marking Guideline	Suggested Answer	
21 a)	Criteria: Identifies an appropriate use of PVC — Marks: 1	Drainpipes and gutters	Mostly well done. Credit card aren't strictly PVC but this was allowed(they are pvca)
21 b)	Criteria: • Draws correct structure of PVC showing 3 repeat units — Marks: 1		Well done. The structure does not need an n at the end, but this was allowed.
21 c)	Criteria: Explains the relationship between the structure, properties and identified use in part a) — Marks: 3 Describes a relationship between the structure and a use — 2 Provides some relevant information — 1	The large chlorine atoms along the carbon chain cause the chain to be quite stiff and rigid. The polarity of the carbon-chlorine bonds also enable the formation of dipole-dipole interactions between the polymer chains which also impart strength and rigidity to the polymer. This means that drainpipes and gutters made of PVC will maintain their shape in the outdoors environment.	Many girls neglected to relate the structure and properties to the actual use they gave in part a. Be careful that you don't say irrelevant properties (sewage pipes don't need to have a high boiling point!)
22 a)	Criteria: • Correctly writes an equilibrium expression for this reaction — Mark: 1	$\frac{[SO_3]}{[SO_2].[O_2]^{\frac{1}{2}}}$	Some girls double the equation. It is important that they write the equilibrium expression for the equation as written.

22 b)

Criteria:	Marks
• Draws a correct conclusion • Justifies conclusion using correct calculations	3
• Draws a conclusion • Justifies the conclusion with substantially correct calculations	2
• Provides some relevant calculations	1

Concentration of gases in 1.0 L container, mol L^{-1}.

	Moles SO_2	**Moles O_2**	**Moles SO_3**
Initial	1.0	1.0	0
Used/made	0.70	0.35	0.70
Final	0.30	0.65	0.70

$$\frac{[SO_3]}{[SO_2].[O_2]^{\frac{1}{2}}} = \frac{0.7}{0.3 \times 0.65^{\frac{1}{2}}} = 2.9$$

Since $2.9 \neq 12.1$, equilibrium has not been reached.

Mostly well done. The major error was forgetting to include the mole ratio for the O_2 . ECF applied if the equation was doubled.

23 a)

Criteria:	Marks
• writes a correct balanced equilibrium equation	1

$CH_4(g) + H_2O(g) \rightleftharpoons 3H_2(g) + CO(g)$

Did not penalize if states were not included. Many did not know the formula for methane. Some not balanced and a few used O_2 instead of H_2O which was referred to as steam in the question

23 b)

Criteria:	Marks
• Explains the effect of temperature and pressure on yield using Le Chatelier's principle • Explains the effect of temperature and pressure on rate of reaction using collision theory • Refers to the graph	4
• Explains temperature and pressure on yield or rate • Refers to the graph	3
• Describes the effect of temperature and pressure on yield and or rate of reaction	2
• Provides some relevant information	1

Temperature
The graph shows that increasing the temperature increases the yield of hydrogen and carbon monoxide. This means that the reaction is an endothermic reaction as increasing heat energy drives the reaction to the right in order to minimise the disruption to the system. (LCP states that a system at equilibrium if disturbed will adjust itself to minimise the disturbance)
The reaction rate will increase as particles have more energy, therefore there will be more collisions, and more successful collisions.

Pressure
The graph shows that increasing pressure will decrease the yield of hydrogen and carbon monoxide. This reaction has 2:4 moles of gas, therefore increasing the pressure will favour the reverse reaction as the system will adjust itself to lower the pressure.
Increasing the pressure will increase the number of collisions between particles as they will be closer together and therefore more chance of a successful collision. This means the rate of reaction will increase as pressure is increasing

Very few addressed the entire question. Most only focusing on yield when referring to the graphs and LCP principle. The maximum for this was 3.
LCP was done well with a clear understanding.
Most students did not address rate in terms of collision theory for temperature AND pressure.

24

Criteria	Marks
• Calculates the mass of calcium carbonate, showing all working, significant figures and units	4
• Calculates the mass of calcium carbonate, showing all working	3
• Provides some correct steps in the calculation	2
• Calculates moles of hydrochloric acid OR • Writes a correct balanced equation either of the reactions OR • Calculates the molar mass of calcium carbonate OR • Calculates the moles of NaOH	1

$HCl + NaOH \rightarrow NaCl + H_2O$

original mol of HCl = C = n/V = 0.6 x 0.025 = 0.015 mol

mol NaOH used = C = n/V = 0.1 x 0.121 = 0.00121 mol

mol of acid that is unreacted = 0.015 – 0.00121 = 0.01379 mol

$2HCl + CaCO_3 \rightarrow CaCl_2 + H_2O + CO_2$

mol HCl = 0.01379 mol

mol ratio = 2 mol HCl : 1 mol $CaCO_3$

mol $CaCO_3$ = 0.01379/2 = 0.006895 mol

mm of CaCO3 = 40.08 + 12.01 + (16 x 3) = 100.09

mass of CaCO3 = n=m/mm = 0.006895 x 100.09 = 0.690 g

Generally answered well across the cohort. Some common errors included; using the wrong formula for calcium carbonate, or incorrect mass from the data sheet. Others did not state 3 significant figures only going to 2.
Error carried forward was applied.

25 a)

Criteria:	Marks
• Writes a correct balanced equation for the buffer • Explains using Le Chateliers principle the effect of adding an acid and a base to the buffer	3
• Describes the effect of adding an acid and a base to the buffer	2
• Provides some relevant information	1

$CH_3COOH + H_2O \rightleftharpoons CH_3COO^- + H_3O^+$

A buffer is a mixture of a weak acid and its conjugate base. In this buffer, the acid is CH_3COOH and its conjugate base is CH_3COO^-
This buffer resists change to pH as follows.
If an acid is added to the buffer solution, the system will adjust itself to minimise the disturbance by driving the reaction to the left. It does this by the CH_3COO^- ions reacting with the acid added. As the solution is made up of the acid and the ions, there is lots of these in solution, so it is able to absorb a lot of hydronium ions thus maintaing the pH
If a base is added to the buffer system, the OH^- ions will react with the hydronium ions in the solution, the system will adjust itself to minimise the disturbance by driving the reaction to the right to produce more hydronium ions. As the CH_3COOH is a weak acid, there are lots of molecules of this acid that are able to ionise to produce hydronium ions, thus maintaining the pH

Many left out the equilibrium equation altogether and just requoted the question. Several girls were unable to

25 b)

Criteria:	Marks
• Correctly determines the pH of the buffer solution, showing all working	4
• Calculates the pH but with a small error	3
• Provides some correct steps in the calculation	2
• Writes the equilibrium expression OR • Determines the concentration of sodium ethanoate	1

$K_a = \frac{[H_3O^+][CH_3COO^-]}{[CH_3COOH]}$ = 1.76 x 10^{-5} (1)

C of $NaCH_3COO$ = C = n/V = 0.025/0.5 = 0.05 mol/L (1)

1.76 x 10-5 = $\frac{0.05 \times [H_3O^+]}{0.07}$

= 1.232 x 10^{-6} = 0.05 x $[H_3O^+]$

= $\frac{1.232 \times 10^{-6}}{0.05}$ = 2.464 x 10^{-5} (1)

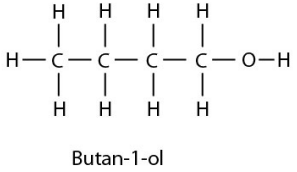
pH = - log$[H^{+}]$ = -log [2.464 x 10^{-5}] = 4.61

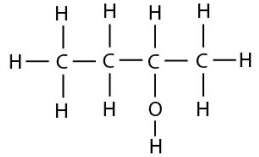
therefore pH = 4.61 (1)

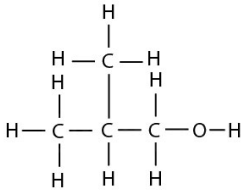
Poorly answered. Most were able to write the Ka expression, and to calculate the pH at the end.
Many wrote and ice table, and then got moles when the Ka uses concentrations.
Many assumed that acetate concentration was equal to the H3O+ conc. One big mistake came form trying to abbreviate formulae and leaving off hs and

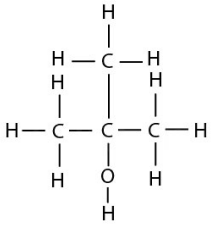
26a

Criteria:	Marks
• Correctly draws and names the structural formula for all 4 isomers	3
• Correctly draws and names some isomers	2
• Provides some relevant information	1


Butan-1-ol


Butan-2-ol


2-methylpropan-1-ol


2-methylpropan-2-ol

Answered well, common error was not identifying all 4 isomers. Some drew isomers that were the same as others already identified. You can't have a methyl group branched on the first carbon, remember that for a chain the longest continuing chain is counted this isn't always in a straight line.
Accepted methylpropane-1ol and methylpropane-2-ol.

<table>
<tr>
<td>26
b)</td>
<td>
<table>
<tr><td>Criteria</td><td>Marks</td></tr>
<tr><td>• Correctly identifies the tertiary alcohol</td><td>1</td></tr>
</table>
</td>
<td>2-methylpropanol</td>
<td>Error carried forward was applied here if no 3º alcohol was identified in part a then they need to sate the 2º alcohl.

If multiple alcohols were listed that included both the 2° and 3° alcohol no mark was awarded as the question asks for the fastest reaction.</td>
</tr>
<tr>
<td>27</td>
<td>
<table>
<tr><td>Criteria:</td><td>Marks</td></tr>
<tr><td>• Correctly identifies solubilities of all 3 substances
• Correctly describes or has diagrams linking polarity to intermolecular forces for all 3 substances</td><td>4</td></tr>
<tr><td>• Identifies solubilities of all 3 substances
• Outlines or has diagrams linking polarity to intermolecular forces for some substances</td><td>3</td></tr>
<tr><td>• Correctly identifies intermolecular forces with water for substances
OR
• Explains the solubility of 1 compound</td><td>2</td></tr>
<tr><td>• Provides some relevant information</td><td>1</td></tr>
</table>
</td>
<td>Water is a polar molecule which is able to form hydrogen-bonding intermolecular forces. In order for an organic compound to dissolve in water it must form favourable intermolecular force interactions with water which are of sufficient strength to overcome the water molecules hydrogen bonding with each other.

Since butane is a non-polar molecule it will be the least soluble in water. This is because the weak dispersion forces between the water and the butane molecules are not strong enough to overcome the strong attraction between the water molecules, so the substances will remain separate and do not mix.

Propanamine is a polar molecular which is able to establish extensive hydrogen bonding interactions with water via the lone pair of electrons on the nitrogen atom and the two hydrogens of the NH_2 group. Similarly, ethanoic acid is a polar molecule which is able to establish extensive hydrogen bonding interactions with water via the hydroxyl -OH group and carbonyl C=O group. Therefore both propanamine and ethanoic acid will be readily soluble with water.

Water solubility generally decreases as molar mass increases but this will have a limited impact on the comparative solubility of the 3 compounds since they have the approximately the same molar mass.</td>
<td>most students could identify the intermolecular forces between water and the substances but made no link to why they had these particular types of intermolecular force

some students got the solubility the wrong way round. Remember like dissolves like

wording was poor in a lot of cases, with students saying things like:
• hydrogen bonded polar water
• water has strong hydrogen bonds
• strong hydrogen bonding between the NH_2 bond
• propanamine has hydrogen bonding between its N and H
please be careful. The hydrogen bonding is between different molecules and not within a molecule.

many students thought the amine was an amide (although you were not penalised for this)
the acid was ethanoic acid not methanoic acid or methanol
many students cannot spell soluble (it doesnt have an “a” in it)</td>
</tr>
</table>

28

Criteria:	Marks
• Correctly relates enthalpy, entropy and spontaneity to the reaction of photosynthesis	3
• Correctly relates 2 of the above to the reaction of photosynthesis	2
• One correct statement	1

Entropy: The reaction shows that 12 molecules go to 7 molecules. This means the system has become more ordered. Entropy has therefore decreased.

Enthalpy: The reaction is an endothermic reaction. This means that it needs a constant input of energy for the reaction to proceed.

Spontaneity: Since ΔH is positive (endothermic) and ΔS is negative (decreased entropy) the reaction is therefore a non spontaneous reaction (ΔG is positive).

NOT NEEDED FOR CORRECT ANSWER BUT:
many small spontaneous reactions drive photosynthesis, and these small reactions will release heat to the surroundings which increases the entropy of the Universe as a whole

Poorly answered.

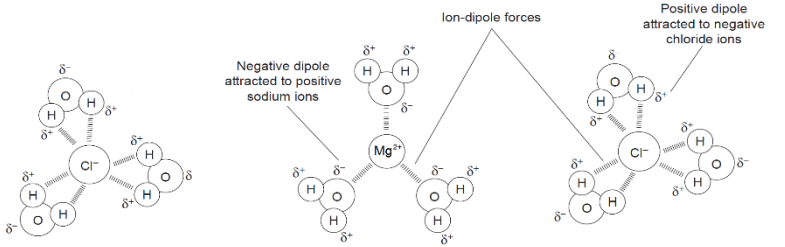
Many students did not know these concepts and confused them with reaction rates, activation energy, kinetic energy, yield of products, collision theory or equilibrium shifts.

Some students had memorised the $\Delta H/\Delta S$ combinations which led to spontaneuos/non-spontaneous reactions but were unable to apply these to the question

Expression was also an issue. A reaction is either spontaneous, non-spontaneous or an equilibrium. You can not have increasing or decreasing spontaneity.

29 a)

Criteria:	Marks
• Draws a labelled diagram that clearly shows the dissociation of $MgCl_2$ into ions, the dipole on water molecules and the formation of ion-dipole bonds	3
• Provides a substantially correct labelled diagram	2
• Provides some relevant information	1



(dont need to do two Cl^- ions)

Many students only showed Mg^{+2} and Cl^- separate but did not show any interactions with water

Please make sure covalent bonds and IMFs have differently drawn lines e.g. solid vs dashed. Some students had solid lines for everything which makes it less clear what any unlabelled solid lines are

Quite a number of students gave the magnesium a 1+ charge in their diagram

Some students had basic diagrams with circles in a beaker only – you need a key/labelling to show what the circles represent

29 b)

Criteria:	Marks
• Identifies the precipitates formed • Draws a correct conclusion and justifies this with Ksp data	3

$MgCl_{2(aq)} + Na_2CO_{3(aq)} \rightarrow MgCO_{3(s)} + 2NaCl_{(aq)}$ Ksp = 6.82×10^{-6}

$MgCl_{2(aq)} + KOH_{(aq)} \rightarrow Mg(OH)_{2(s)} + 2KCl_{(aq)}$ Ksp = 5.61×10^{-12}

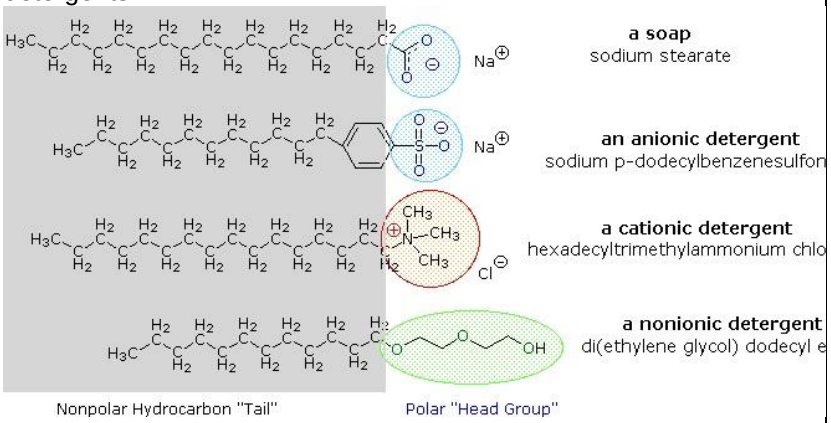
The precipitates formed are magnesium carbonate and magnesium hydroxide.

A large number of students had incorrect chemical formulas in their equations, particularly for $Mg(OH)_2$ and/or did not balance their equations

Many students referred to general ideas about the solubility rules rather than look

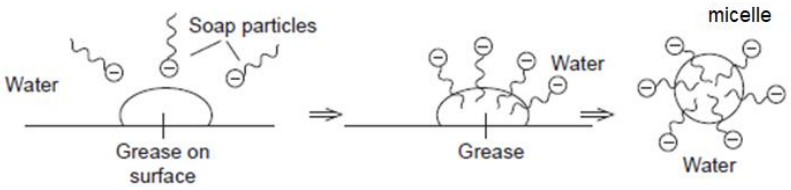
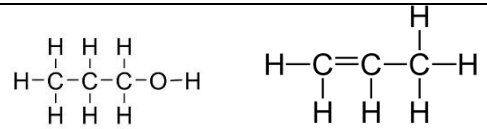
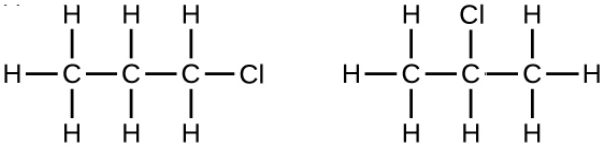
<table>
<tr>
<td></td>
<td>
<table>
<tr><td>• Draws a conclusion
• Justifies the conclusion with substantially correct information</td><td>2</td></tr>
<tr><td>• One correct statement</td><td>1</td></tr>
</table>
</td>
<td>As the Ksp for magnesium hydroxide is much more likely to form a precipitate than magnesium carbonate as it has a much smaller Ksp.</td>
<td>up Ksp values. This then led to the misconception that hydroxides are generally more soluble than carbonates or vice versa. As such many students concluded that only one of the reactions could possibly produce a precipitate.

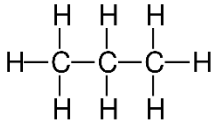
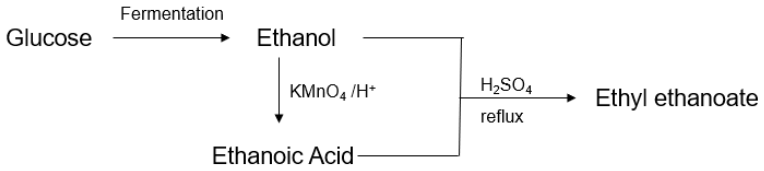
Another common misconception was that the larger Ksp made $MgCO_3$ more likely to precipitate

The actual Ksp values from the data sheet should be stated in your justification</td>
</tr>
<tr>
<td>30 a)</td>
<td>
<table>
<tr><td>Criteria:</td><td>Marks</td></tr>
<tr><td>• Recognises that both soaps and detergents have a hydrophobic tail and a hydrophilic head
• Gives a correct specific difference between soap and a detergent
OR
• Correctly draws the structure of soap and a detergent</td><td>2</td></tr>
<tr><td>• Recognises that both soaps and detergents have a hydrophobic tail and a hydrophillic head
OR
• Correctly draws the structure of soap OR a detergent</td><td>1</td></tr>
</table>
</td>
<td>Soap and detergent molecules all consist of two parts: a hydrophobic ‘tail’ consisting of fatty acids; and a hydrophilic, charged ‘head’. The head groups vary between soap and detergents.
 
</td>
<td>Saying that soap has a negative head and a detergent has a positive head was not enough to earn marks

soaps do not have a polar head – the head of soaps and detergents (except the non-ionic ones) are IONIC
Na+ is not the end of the soap or detergent molecule. As the soap dissolves in water, the sodium ion dissociates from the soap molecule
sope does not have a glycerol “backbone” – Soap is made from tricycerides and the triglyceride does but this is converted into two seperate species, gycerol and a soap</td>
</tr>
<tr>
<td>30 b)</td>
<td>
<table>
<tr><td>Criteria:</td><td>Marks</td></tr>
<tr><td>• Thoroughly explains how soap/detergent can be used to remove grease and supports answer with a detailed diagram</td><td>4</td></tr>
</table>
</td>
<td>The hydrophobic tails will form dispersion forces with the non-polar grease and will embed themselves in the grease particle. The hydrophilic heads will form ion-dipole interactions with the water. With agitation, a micelle is formed around the grease which is lifted off a surface and becomes suspended in the water. When the water is removed the cleaning is complete</td>
<td>GENERAL COMMENT
dont just write down everything you know

better responses talked about the intermolecular forces that occured between soap, water and oil</td>
</tr>
</table>

	• describes how soap/detergent can be used to remove grease and supports answer with a correct diagram	3		some students had the soap particles drawn the wrong way round, with the ionic heads interacting with the grease soaps, cationic and anionic detergents do not have polar heads, they have IONIC heads. They form ion-dipoles with water molecules
	• Outlines how soap/detergent and detergent can be used to remove grease	2		
	• Provides some relevant information	1		
31	Criteria: / Marks • Correctly draws the structures and names all of the compounds with comprehensive justifications including the possible isomers of compound C — 7 • Correctly draws the structures and names all of the compounds with relevant justifications — 6 • Correctly names and draws some of the structures with limited justifications — 4-5 • Identifies some characteristics of the compound(s) — 2-3 • Provides some relevant information — 1		 A: Propan-1-ol B: Propene Compound A must be an alcohol and compound B an alkene beacuse conc. H_2SO_4 is used to dehyrdate an alcohol. Compound A has a molar mass of 60 g/mol which means the alcohol must have the molecular formula C_3H_7OH. There are 2 possible isomers with this molecular formula – propan-1-ol and propan-2-ol. The fragment with an m/z of 29 corresponds to $CH_2CH_3^+$ while m/z of 31 corresponds to CH_2OH^+. These two fragments indicate compound A must be propan-1-ol. Dehydration of propan-1-ol produces propene. Propene has a molar mass of 42 g/mol which coresponds with the highest m/z in the mass spectrum. The m/z of 15 and 27 corresponds with CH_3^+ and CH_2CH^+ fragments respectively. Compound B must therefore be propene. C:  1-chloropropane OR 2-chloropropane	This question was generally well done. The majority of students could identify the 4 compounds. Marks were lost where they did not use the mass spec data to justify the structures. not many students identiftied the possible isomers for A and C

		Addition of HX across the double bond of propene produces a haloalkane. The halogen must be chlorine because the chlorine-35 and chlorine-37 isotopes have a 3:1 natural abundance which corresponds with the 3:1 intensity of the peaks at m/z 78 and 80. The molar mass of 78 g/mol and 80 g/mol similarly correspond with $C_3H_7Cl^{35}$ and $C_3H_7Cl^{37}$ respectively. Addition of HCl across a double bond can produce 2 isomers – 1-chloropropane and 2-chloropropane. The m/z of 43 corresponds with a $C_3H_7^+$ fragment where the chlorine atom has been lost. The fragments at m/z of 63 and 65 correspond with the loss of a CH_3 group. It is possible for both of the isomers to produce these fragments so it is unclear from the mass spectrum which isomer of chloropropane was produced. Therefore Compound C must be either 1-chloropropane or 2-chloropropane. D:  Addition of H_2 across the double bond of propene produces propane. Propane has a molar mass of 44 g/mol which corresponds with the highest m/z in the mass spectrum. The m/z of 15 and 29 correspond with a CH_3^+ and $CH_2CH_3^+$ fragment respectively. Compound D must therefore be propane.	
32 a)	<table><tr><td>Criteria:</td><td>Marks</td></tr><tr><td>• Provides all the key steps and reagents for the chemical pathway</td><td>3</td></tr><tr><td>• Provides some steps and/or reagents</td><td>2</td></tr><tr><td>• Provides some relevant information</td><td>1</td></tr></table>		Most students were able to identify the fermentation and esterification steps. Many students did not state the sulfuric acid catalyst required for esterification Many students worked out that ethanoic acid was required but did not identify how it could be obtained – you should have seen this previously in a highly similar question in the set questions for the chemical synthesis pathways in your notes

<table>
<tr>
<td>32
b)</td>
<td>
<table>
<tr><td>Criteria:</td><td>Marks</td></tr>
<tr><td>• Provides a suitable procedure specifying chemicals for making ethyl ethanoate, including the catalyst and amounts</td><td>4</td></tr>
<tr><td>• Provides a suitable procedure for making an ester</td><td>3</td></tr>
<tr><td>• Provides some steps for making an ester</td><td>2</td></tr>
<tr><td>• Provides some relevant information</td><td>1</td></tr>
</table>
</td>
<td>1. Pour 10 mL ethanol into a flask and add 20 mL of glacial acetic acid.
2. Add 1 mL of concentrated sulfuric acid to the mixture and boiling chips
3. Heat under reflux for 45 minutes.
4. Allow to cool and then transfer contents of the flask to a separating funnel.
5. Wash with distilled water to remove any excess alcohol and acetic acid. The ester layer will float on top of the aqueous layer so expel the lower aqueous layer in the separating funnel.
6. Finally, add a solution of 1 mol L^{-1} sodium carbonate to remove any final traces of acid.</td>
<td>Poorly done in terms of writing a <u>procedure</u> – i.e. a sequence of steps that can be followed by someone in the lab. Most students started well by specifying the reactants and reflux set up but drifted away from giving a procedure as the response progressed – for example just generally stating “separate” with no details on how to do this

Many students did not provide amounts of each chemical and/or did not specify the catalyst

You had to at least separate the ester from the mixture. There was some confusion between separating vs filtration funnel.

Did not penalise if didn’t rinse with a base. The physical state of the sodium carbonate should be specified i.e. sodium carbonate <u>solution</u>

Some students had confusion from part a) and tried to include parts of fermentation or oxidation in the esterification procedure.</td>
</tr>
<tr>
<td>32
c)</td>
<td>
<table>
<tr><td>Criteria:</td><td>Marks</td></tr>
<tr><td>• Identifies a risk and describes an appropriate safety precaution</td><td>2</td></tr>
<tr><td>• Provides some relevant information</td><td>1</td></tr>
</table>
</td>
<td>Ethanol is flammable. Use a hot plate rather than a Bunsen burner to heat the solution to prevent fires.</td>
<td>Any correct risk and precaution was accepted but you should really prioritise the hazards and give the most significant one – chemical risks should come first

You should state a specific chemical and not generalise “esters” or “reactants”. A very specific ester was named in the question so that is what you should address.

Some of the organic chemicals cause eye irritation – I did not accept “corrodes” or “damages” eyes as these are different levels of risk</td>
</tr>
</table>

33 a)

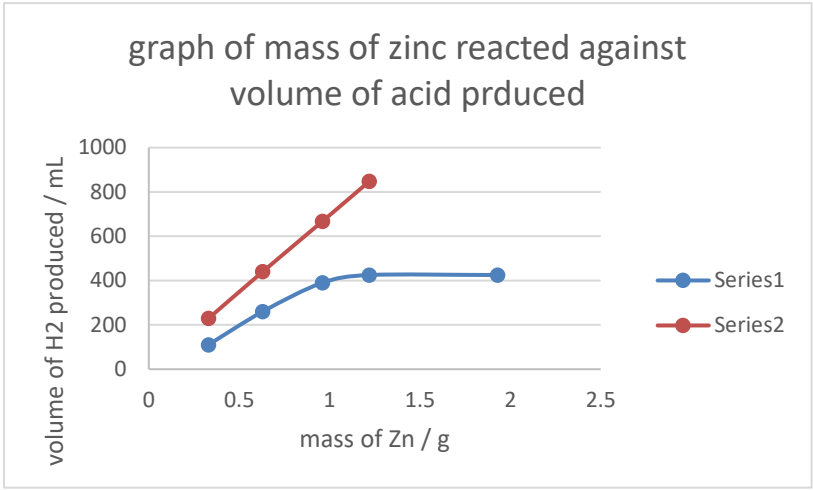
Criteria:	Mark
• Writes a correct balanced equation with states	1

$Zn_{(s)} + 2HCl_{(aq)} \rightarrow ZnCl_{2(aq)} + H_{2(g)}$

not well done – a lot of students had the wrong formula for zinc chloride and also had a charge on zinv metal

33 b)

Criteria:	Marks
• Labels axes appropriately • Plots data correctly • Draws a line of best fit • Gives a key	3
• Provides a substantially correct graph	2
• Provides a partially correct graph	1



not well done

many students only plotted 1 line
many students did not do the correct lines of best fit

33 c)

Criteria:	Marks
• Interprets the results of the experiment • Thoroughly describes issues and provides points for and/or against the validity of the investigation • describes at least one plausable improvement that could be made • recognises that HCl is a limiting reagent	5
• interprests the results of the experiment • Describes issue(s) and/or provides point(s) for and/or	3 - 4

The theoretical values show that as the mass of zinc increases, the volume of hydrogen gas increases.
The experimental results show that to begin with, as the mass of zinc increased, the volume of hydrogen increased until the mass of zinc reached 1.22g. After this mass, the volume of hydrogen gas stayed the same. This shows us that the hydrochloric acid was a limiting reagent, and had completely reacted, as the zinc was in excess.
The slope of the graphs for the first 3 values are not parallel, the slope of the theoretical values being steeper than the experimental values. This shows that the volume of gas collected got proportionately less as the mass of zinc increased. This could be due to the gas syringe not holding the gas as the pressure increased.
The experiment is not valid as it does not answer the aim of determining the relationship between the mass of a metal and the volume of gas used because of the non linear relationship. Even though the variables were controlled in the experiment such as the

this question was poorly done

weaker responses just said that it answered the aim and the variables were controlled with no other link to the experiment

hardly any students said that the HCl was a limiting reagent

a lot of students could not identify a way to improve the experiment but could say what an error was

surface area

having specific masses

	against the validity of the investigation • describes an improvement that could be made		way the gas was collected and that the experiment was carried out at the same temperature and pressure. Ways in which the experiment could be improved are: - Using a much more concentrated HCl solution so that the zinc is a limiting reagent - Collecting the gas by a different method. The syringe could be connected to the reaction by tubing to ensure that all the gas is collected and measured – or by displacing water in a measuring cylinder - The mass of the gas could be collected instead by carrying out the experiment on a balance. This mass could then be converted to moles and then to a volume	
	• identifies issue(s) and/or point(s) for and/or against the validity of the investigation • Identifies an improvement that could be made or identifies an error OR • Identifies trend for experiment	2		
	• One correct statement	1		
34			**Identifies definition of a biofuel** A biofuel is any fuel source that's made from biological materials. The most common kinds of biofuels currently are the petrol alternatives or additives, ethanol and biodiesel. **Describes production of biofuel from a renewable resource and the use of biofuels in Australia** Corn is the source material for 90 percent of the ethanol produced in Australia, but any plant material can be used. The starch in corn can be broken down to sugars which, when fermented using yeast give ethanol and carbon dioxide. $C_6H_{12}O_{6(aq)} \xrightarrow{\text{yeast}} 2C_2H_5OH_{(l)} + 2CO_{2(g)}$ In Australia, ethanol is usually mixed with petrol to improve fuel economy in cars and trucks. The resulting fuel is called E10. E85, with 85 percent ethanol and 15 percent gas is also used in some racing cars. **Explains the chemistry of combustion with an equation** Bioethanol is suitable for use as a fuel because it releases energy when it is combusted: $CH_3CH_2OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$ + energy **Analyse impact on economy** • corn, soy and other biomass can be grown indefinitely so the biofuel supply is renewable which would keep petrol costs stable	Majority of students failed to include an equation – a basic requirement in chemistry Majority also failed to organise their ideas in any way – either by positives vs negatives or by society/economy/ environment Better answers used headings to organise the analysis of economy, environment & society impacts – this tended to make the flow more logical, ensured each point was linked to a category and made it easy to see whether there were multiple points provided for each category. Most students were able to provide a range of positive and negative effects, though not all students addressed each category well, consistently related their points to a category or provided enough supportive detail/explanation for the statements they made. Many students kept quoting the stimulus rather than elaborating on the concepts mentioned in

Criteria:	Marks
• Demonstrates extensive knowledge and understanding about the use of biofuels as a source of energy and their impact on the economy, environment and society • Includes a balanced chemical equation • Provides a justification • Logical and concise progression of ideas	6-7
• Demonstrates thorough knowledge and understanding about the impact of biofuels on the environment, society and economy • Includes a balanced chemical equation and/or a justification	4-5
• Outlines the use or production of biofuels and/or their use as a source of energy	2-3

	OR • Outlines some impacts of using biofuels		• Engine modification is required to run cars on 100% ethanol requiring cost for consumers to convert • Ethanol does not produce as much energy per gram when combusted which increases cost per km travelled • Ethanol is a good solvent and can absorb water and dirt which can damage a car engine requireing more car maintenance and repair • Production costs of biofuel are quite high as fermentation requires a lot of energy, this would increase the cost of the biofuel • Australia exports agricultural products, these could be reduced if land has to be used for biofuel instead **Analyse impact on environment** • E85 produces 39 percent less carbon dioxide than regular gasoline • Carbon dioxide produced by combustion is mitigated by the carbon dioxide absorbed by crops during photosynthesis • fewer particulates produced when combustion ethanol compared to petrol thus decreasing air pollution **Analyse impact on society** • When fossil fuels run out, our current lifestyles which are highly dependent on energy and transportation would remain stable as there is an avaliable alternative which is renewably sourced. • farmland that could be used for food production is instead used to grow fuel – Austuralia relies heavily on agricultrual farming of both crops and animals • new jobs would be created in farming and biofuel manufacturing to sustain demand by consumers but would be possibly lost in the petrochemical industry as fossil fuels are phased out for use as fuel • large amounts of water are required to grow crops for biofuels which puts increasing strain on our limitied water supply and lead to further water restrictions as a drought affected country. **Evaluates suitability by providing a judgement**	it – you must give new ideas to what was provided Most students jumped straight into the analysis and provided little background context about HOW biofuel is a source of energy (combustion) – the underlying chemistry must always be explained in a long response. Similarly, many students identified biofuel is renewable/sourced from biomass without relating this to the chemistry of fermentation. Few students also provided background on how biofuel is actually used. Many students provided a judgment about the statement or the “sustainability” of biofuel rather than the suitability of biofuel as a source of energy. Better answers addressed the Australian context of producing and using biofuel as was stated in the stimulus. Good answers also picked up the reference to water in the stimulus and considered how this applies to growing crops for biofuel.
	• One correct statement	1		