Student Number

Girraween High School

2019 **TRIAL EXAMINATION**

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- Calculators approved by NESA may be used
- A data sheet, formulae sheet and Periodic Table are provided with this examination

Total Marks: 100

Section I – 20 marks

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

Section II – 80 marks

- Attempt questions 21-35
- Allow about 2 hour 25 minutes for this section

Section I

20 marks

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

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

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

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

A ○ B● C ○ D ○

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

A ○ B✕ C ○ D ○

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

correct ↘

A✕ B● C ○ D ○

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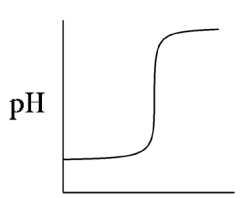
1. Which of the following chemical systems represents an exothermic chemical change?

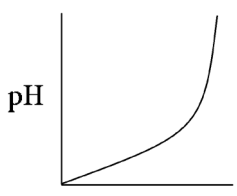
   A. $H_2O_{(l)} \rightarrow H_2O_{(g)}$
   B. $H_2O_{(g)} \rightarrow H_2O_{(l)}$
   C. $H_{2(g)} + ½\ O_{2(g)} \rightarrow H_2O_{(l)}$
   D. $H_2O_{(l)} \rightarrow H_{2(g)} + ½\ O_{2(g)}$

2. Which of the following curves would represent the change in pH in a conical flask when a solution of hydrochloric acid (from a burette) is added to a solution of sodium hydroxide (in the conical flask)?

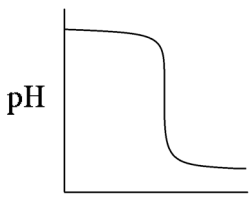
A.



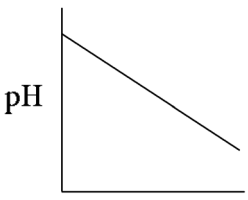
B.



C.



D.



3. Which of the following combinations could be used to produce a buffer solution?

   A. CH_3COOH and CH_3COONa

   B. NH_4OH and CH_3COOH

   C. NaOH and NaCl

   D. HCl and NaCl

4. Bromothymol blue is an acid/base indicator which can be used to test the pH of swimming pools and fish tanks.

   It changes from yellow to blue across a pH range of 6.0 – 7.5.

   Which alternative matches the solutions shown with the correct indicator colour?

	$SO_{2(aq)}$	$NH_{3(aq)}$	$NaCl_{(aq)}$	$Na_2CO_{3(aq)}$
A.	Yellow	Blue	Green	Blue
B.	Blue	Blue	Green	Yellow
C.	Green	Yellow	Blue	Green
D.	Blue	Green	Blue	Yellow

5. If equal volumes of 0.10 mol L^{-1} HCl solution and 0.10 mol L^{-1} HNO_2 solution are compared, which would be true of the HNO_2 solution?

   A. It would have a higher pH.

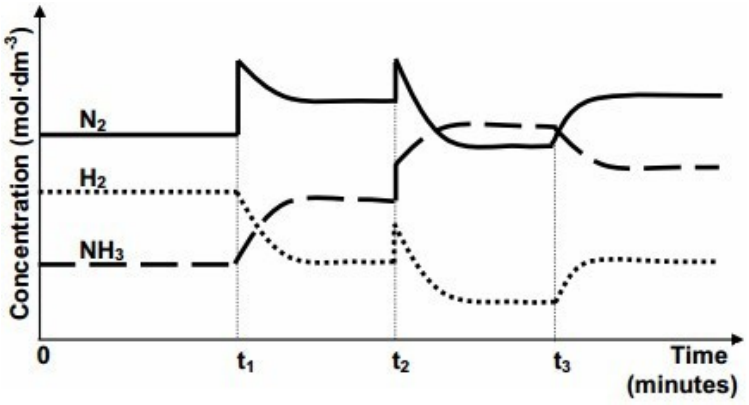
   B. It would have a higher hydronium ion concentration.

   C. It would produce a smaller volume of hydrogen gas when reacted with magnesium.

   D. It would require a smaller volume of 0.10 mol L^{-1} NaOH solution for neutralisation.

6. The figure below shows the change in the concentration of reactant and products as a function of time for the reaction:

$$2NH_{3\,(g)} \rightleftharpoons N_{2\,(g)} + 3H_{2\,(g)} \qquad \Delta H = 92.4\ kJ$$



(Image from: http://www.smartlearner.mobi/science/VideoPastPapers/Equilibrium/Equilibrium.htm)

Which of the following correctly describes the change that occurred at time $\mathbf{t_2}$?

A. The temperature was suddenly increased.

B. The pressure of the system was decreased.

C. The volume of the vessel was suddenly decreased.

D. Additional nitrogen gas was injected into the vessel.

7. Which of the following is a correct statement about compounds of a homologous series?

A. Each homologue has at least 2 isomers.

B. Each subsequent molecular mass increases by 14 g/mol.

C. All compounds in the series have the same empirical formula.

D. Each molecular formula varies from the next by the addition of CH_3.

8. Which two species act as Brønsted-Lowry acids in the following reaction?

$$H_2SO_{3\,(aq)} + H_2O_{(aq)} \rightleftharpoons H_3O^+_{(aq)} + HSO_3^-{}_{(aq)}$$

A. H_2SO_3 and H_3O^+

B. H_2O and H_2SO_3

C. H_2O and H_3O^+

D. H_2O and HSO_3^-

9. Carbon dioxide can be produced from carbon monoxide and oxygen gas. At 1000°C the reaction reaches equilibrium as shown below:

$$2CO_{(g)} + O_{2(g)} \rightleftharpoons 2CO_{2(g)} \qquad \Delta H = -566 \text{ kJ mol}^{-1}$$

Which of the following changes would not result in a larger yield of $CO_{2(g)}$?

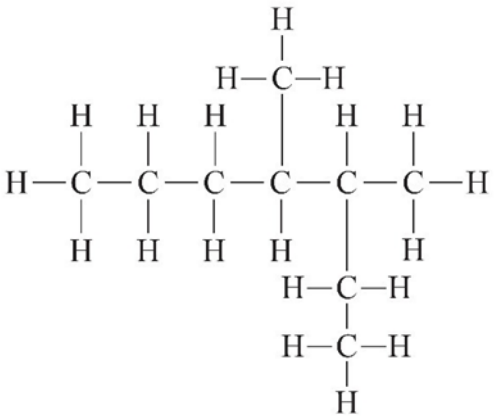
A. Adding a catalyst

B. Decreasing the volume

C. Decreasing the temperature

D. Increasing the partial pressure of $CO_{(g)}$

10.



Identify the systematic IUPAC name for the compound shown above.

A. 4-methyl-5-ethylhexane

B. 2-ethyl-3-methylhexane

C. 3,4-dimethylheptane

D. 4,5-dimethylheptane

11. Which of the following is the strongest acid?

A. CH_3COOH $pK_a = 4.76$

B. HCO_3^- $pK_a = 10.25$

C. HF $pK_a = 3.17$

D. $H_2C_2O_4$ $pK_a = 1.27$

12. A student measured the heat of combustion of butan-1-ol, by heating 300 g of water, initially at 21 °C. Exactly 0.750 g of butan-1-ol was burnt in the reaction. The theoretical value for the heat of combustion of butan-1-ol is 2077 kJ mol^{-1}. If 50% of the heat produced was lost to the environment, what would be the final temperature of the water?

    A. 29.4 °C

    B. 33.6 °C

    C. 57.2 °C

    D. 71.3 °C

13. How many structural isomers are these with the molecular formula $C_2H_2Br_2$?

    A. 2

    B. 3

    C. 4

    D. 5

14. The type of structural isomerism present in molecules with the molecular formula of $C_2H_2Br_2$ is:

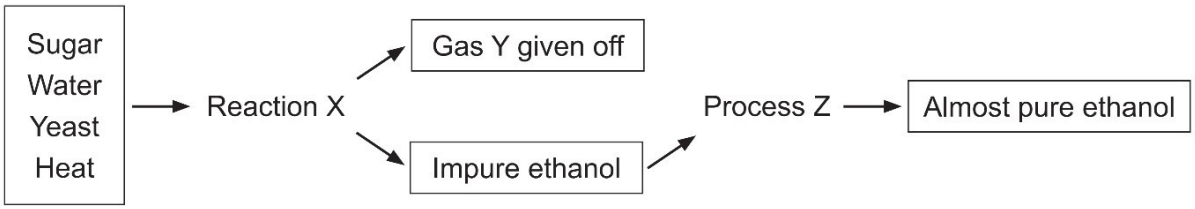
    A. Functional group isomerism

    B. Cis-trans isomerism

    C. Chain isomerism

    D. Position isomerism

Questions 15 and 16 relate to the flow diagram below showing a process for making ethanol.



15. Process Z is called:

    A. Filtration.

    B. Precipitation.

    C. Condensation.

    D. Fractional distillation.

16. Gas Y is:

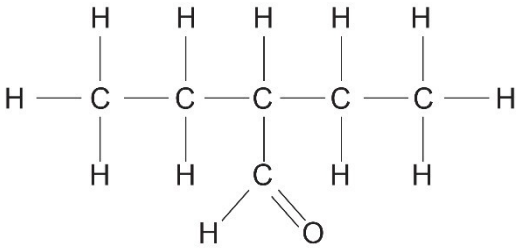
    A. Oxygen.

    B. Hydrogen.

    C. Carbon dioxide.

    D. Carbon monoxide.

17.



What is the IUPAC name of the compound shown above?

    A. 2-ethylbutanal

    B. 2-methylbutanal

    C. 2,2-diethylethanal

    D. 3-methylpentan-3-al

18. A 0.0100 M solution of an acid, HA, is 15% ionised. What is the acid dissociation constant, K_a, for this acid?

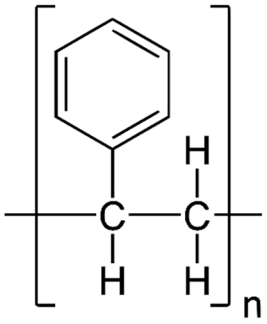
A. 2.25×10^{-4}

B. 2.25×10^{-6}

C. 2.65×10^{-4}

D. 2.65×10^{-6}

19.



The name for the polymer whose structural formula is shown above is:

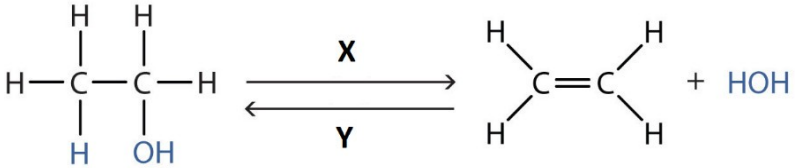
A. Polyethylene

B. Polyester

C. Polystyrene

D. Polyvinyl chloride

20. Which of the following options outline the correct reaction name and the reagent required for the reactions listed as X and Y?



	Name of reaction		Reagent required	
	X	**Y**	**X**	**Y**
A.	Dehydration	Hydration	Concentrated H_2SO_4	Dilute H_2SO_4
B.	Dehydration	Hydration	Dilute H_2SO_4	Concentrated H_2SO_4
C.	Hydration	Dehydration	Concentrated H_2SO_4	Dilute H_2SO_4
D.	Hydration	Dehydration	Dilute H_2SO_4	Concentrated H_2SO_4

End of Section I

Student Number	
Mark / 80	

Chemistry
Section II
Answer Booklet

80 Marks
Attempt Questions 21–35
Allow about 2 hour and 25 minutes for this part

Instructions

- Write your Student Number at the top of this page
- Answer the questions in the space provided. These spaces provide guidance for the expected length of response.
- Show all relevant working in questions involving calculations.

Question 21 (7 marks)

A Year 12 student was given the task to determine the % of calcium carbonate in an egg shell.

After washing and drying the eggshell, a 0.496 g sample was placed in a conical flask. 20.0 mL of 0.486 mol L^{-1} hydrochloric acid was added, and the mixture was gently warmed until all evidence of the reaction had stopped.

The unreacted acid was then back-titrated against a standardised solution of 0.100 mol L^{-1} of sodium hydroxide. The volume of sodium hydroxide required to reach the end-point was 28.5 mL.

a) Write an equation to show the chemical process that occurs when hydrochloric acid was added. **1**

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b) Calculate the moles of unreacted hydrochloric acid. **2**

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Question 21 continues on the following page.

c) Calculate the %(w/w) of calcium carbonate in the egg shell. **4**

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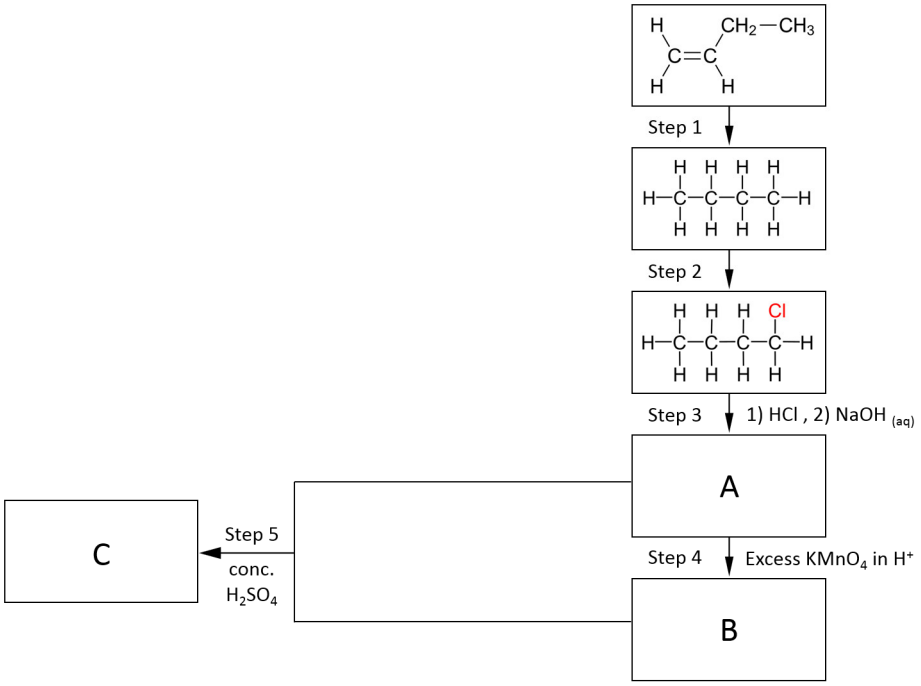
Question 22 (9 marks)

The flowchart below shows some reactions of the carbon compound but-1-ene (1-butene).



Use the flowchart to answer the following questions.

a) Identify the reagents and conditions required for the reactions at Step 1 and Step 2. **2**

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Question 22 continues on the following page.

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

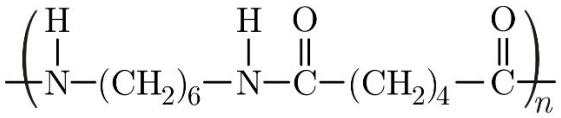
Compound A	Compound B

c) 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**

Name of process: …… Name of product: ……...

Question 23 (4 marks)

The diagram below shows the structure of a polymer called nylon 6,6.



Nylon 66

a) Construct an equation showing the structural formula for the formation of nylon 6,6. **2**

b) Identify a property of nylon and relate this property to its use. **2**

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Question 24 (3 marks)

Using polyethylene and nylon 6,6 as examples, compare condensation polymers to addition polymers with respect to their structure and polymerisation processes. **3**

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Question 25 (8 marks)

The research and development unit of a chemical company is studying the reaction of CH_4 and H_2S, two components of natural gas which react together to form an equilibrium system shown below:

$$CH_{4\,(g)} + 2H_2S_{\,(g)} \rightleftharpoons CS_{2\,(g)} + 4H_{2\,(g)} \qquad \Delta H > 0$$

a) Write the equilibrium constant expression for this reaction. **1**

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b) Explain how the value of the position of equilibrium and the equilibrium constant would change if the temperature of the reaction was increased. **3**

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c) In one experiment, 1.00 mol of CH_4, 1.00 mol of CS_2, 2.00 mol of H_2S, and 2.00 mol of H_2 are mixed in a 250.0 mL vessel. **3**

The vessel was heated to 960 °C and 5.56 moles of $CH_{4\,(g)}$ was present at equilibrium.

Determine the concentrations of all species at equilibrium.

	$CH_{4\,(g)}$ +	$2H_2S_{\,(g)}$ ⇌	$CS_{2\,(g)}$ +	$4H_{2\,(g)}$
Initial concentration				
Change in concentration				
Equilibrium concentration				

d) Determine the value of the equilibrium constant for this reaction at 960 °C. **1**

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Question 26 (5 marks)

When combusted, ethanol releases 1364 kJ mol^{-1} at 298 K and 101.3 kPa.

a) Write an equation to show the complete combustion of ethanol and its molar enthalpy of combustion **2**

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b) When students conduct experiments to determine the enthalpy of combustion of different alcohols they often yield results much less than the theoretical results. Explain why this is and suggest how it can be minimised. **3**
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Question 27 (5 marks)

20.0 mL of 0.010 M $Ba(NO_3)_2$ is mixed with 20.0 mL of 0.0050 M Na_2SO_4 at room temperature of 25 °C and stirred.

a) Determine whether a precipitate will form from this reaction. Your answer should include the equilibrium expression for the insoluble salt that may form. **3**

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b) Calculate the solubility of AgBr in gL^{-1}. **2**

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Question 28 (2 marks)

Outline an example of the use of solubility equilibria by Aboriginal and Torres Strait Islander Peoples when removing toxins from foods. **2**

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Question 29 (7 marks)

To perform an esterification reaction in the laboratory a student was provided with methanol and propanoic acid, which she heated together under reflux with a catalyst.

a) Name a suitable catalyst for this reaction and suggest a reason why the catalyst is used in this process. **2**

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b) Justify the use of heating under reflux for this experiment. **2**

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c) Draw a labelled scientific diagram of the experimental setup for this reaction. **3**

Question 30 (6 marks)

The boiling point of some organic compounds with equal carbon chain length are shown below.

Organic compound	Boiling point (°C)
Propane	– 42.1
Propanoic acid	141
propanamine	49
Propanamide	213

Using appropriate diagram(s) of the substances, explain the difference in boiling points of these compounds. **6**

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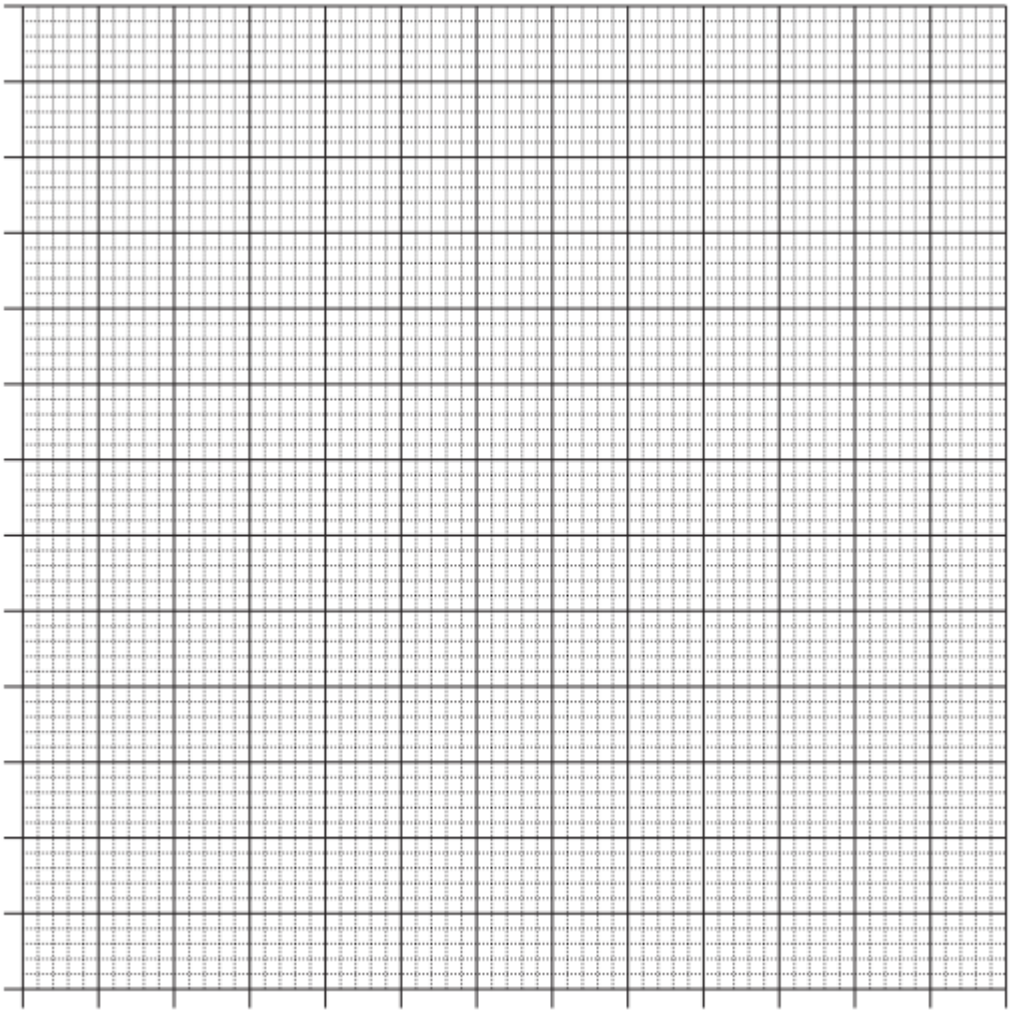
Question 31 (7 marks)

The table below lists the boiling points and solubility of six primary alkanols

Compound	Molecular mass (g/mol)	Boiling point (°C)	Solubility (g/100 mL)
Ethanol	46	78	Infinitely soluble
Propan-1-ol	60	97	Infinitely soluble
Butan-1-ol	74	118	8.3
Pentan-1-ol	88	*x*	2.7
Hexan-1-ol	102	158	0.6
Heptan-1-ol	116	176	0.18

a) Using an appropriate scale to draw a graph of molecular mass vs. the boiling point in the space below. **3**



Question 31 continues on the following page.

b) Use your graph to predict the boiling point of pentan-1-ol. **2**

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c) Explain the trend in solubility of these primary alcohols shown in the table. **2**

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Question 32 (3 marks)

The use of ethanol as an alternative fuel has been proposed because it can be obtained from renewable resources by fermentation and it also burns more cleanly than petrol. With the aid of chemical equations, explain these two properties of ethanol. **3**

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Question 33 (3 marks)

Calculate the pOH of the resulting solution from the combination of 15 mL of 0.10 M NaOH and 25 mL of 0.10 M HCl solutions. **3**

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Question 34 (4 marks)

With the aid of a diagram, explain the cleansing action of soap. **4**

Question 35 (7 marks)

A student has three bottles of chemicals which have faded labels. He knows that of the three chemicals, one is pentane, one is ethanol, and one is propanoic acid. **7**

Design a safe, valid and reliable first-hand investigation to correctly identify the three substances. You can use any common chemical substances and materials in the science laboratory. In your answer you must include at least one relevant chemical equation.

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End of Section II

Examiner's Use Only		

Student Number								
Section I / 20								
Final Mark / 100								

2019 Year 12 Chemistry

Trial Examination

Write your student number at the top of this Section I Response Sheet
This page can be removed from the Section II answer booklet.
Section I: Objective Response – 20 marks

Select the alternative A, B, C or D that best answers the question and fill in the response circle completely. Use black pen for your answers.

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 ○
13.	A ○	B ○	C ○	D ○
14.	A ○	B ○	C ○	D ○
15.	A ○	B ○	C ○	D ○
16.	A ○	B ○	C ○	D ○
17.	A ○	B ○	C ○	D ○
18.	A ○	B ○	C ○	D ○
19.	A ○	B ○	C ○	D ○
20.	A ○	B ○	C ○	D ○

Student Number

Girraween High School

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20 marks

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A ○ B● C ○ D ○

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

A ○ B✕ C ○ D ○

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

correct ↘

A✕ B● C ○ D ○

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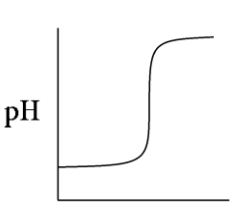
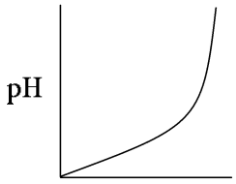
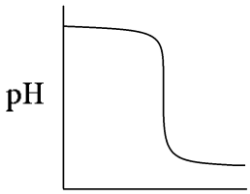
1. Which of the following chemical systems represents an exothermic chemical change?

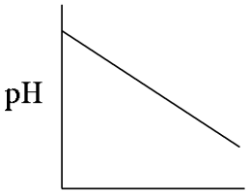
   A. $H_2O_{(l)} \rightarrow H_2O_{(g)}$
   B. $H_2O_{(g)} \rightarrow H_2O_{(l)}$
   C. $H_{2(g)} + ½\ O_{2(g)} \rightarrow H_2O_{(l)}$
   D. $H_2O_{(l)} \rightarrow H_{2(g)} + ½\ O_{2(g)}$

2. Which of the following curves would represent the change in pH in a conical flask when a solution of hydrochloric acid (from a burette) is added to a solution of sodium hydroxide (in the conical flask)?

A. 

B. 

C. 

D. 

3. Which of the following combinations could be used to produce a buffer solution?

   A. CH_3COOH and CH_3COONa

   B. NH_4OH and CH_3COOH

   C. NaOH and NaCl

   D. HCl and NaCl

4. Bromothymol blue is an acid/base indicator which can be used to test the pH of swimming pools and fish tanks.

   It changes from yellow to blue across a pH range of 6.0 – 7.5.

   Which alternative matches the solutions shown with the correct indicator colour?

	$SO_{2(aq)}$	$NH_{3(aq)}$	$NaCl_{(aq)}$	$Na_2CO_{3(aq)}$
A.	Yellow	Blue	Green	Blue
B.	Blue	Blue	Green	Yellow
C.	Green	Yellow	Blue	Green
D.	Blue	Green	Blue	Yellow

5. If equal volumes of 0.10 mol L^{-1} HCl solution and 0.10 mol L^{-1} HNO_2 solution are compared, which would be true of the HNO_2 solution?

   A. It would have a higher pH.

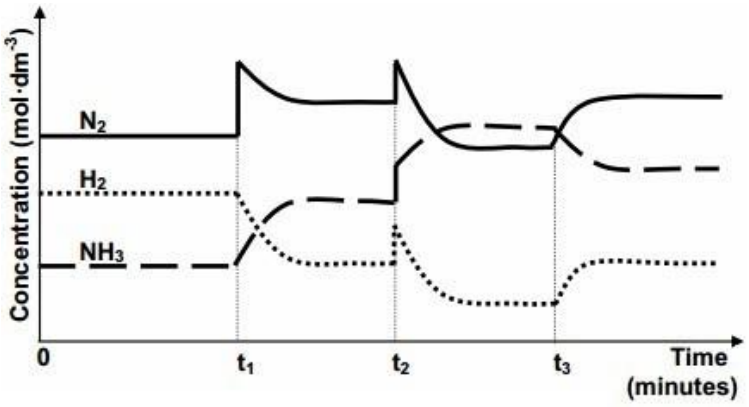
   B. It would have a higher hydronium ion concentration.

   C. It would produce a smaller volume of hydrogen gas when reacted with magnesium.

   D. It would require a smaller volume of 0.10 mol L^{-1} NaOH solution for neutralisation.

6. The figure below shows the change in the concentration of reactant and products as a function of time for the reaction:

$$2NH_{3\,(g)} \rightleftharpoons N_{2\,(g)} + 3H_{2\,(g)} \qquad \Delta H = 92.4\ kJ$$



(Image from: http://www.smartlearner.mobi/science/VideoPastPapers/Equilibrium/Equilibrium.htm)

Which of the following correctly describes the change that occurred at time $\mathbf{t_2}$?

A. The temperature was suddenly increased.

B. The pressure of the system was decreased.

C. The volume of the vessel was suddenly decreased.

D. Additional nitrogen gas was injected into the vessel.

7. Which of the following is a correct statement about compounds of a homologous series?

A. Each homologue has at least 2 isomers.

B. Each subsequent molecular mass increases by 14 g/mol.

C. All compounds in the series have the same empirical formula.

D. Each molecular formula varies from the next by the addition of CH_3.

8. Which two species act as Brønsted-Lowry acids in the following reaction?

$$H_2SO_{3\,(aq)} + H_2O_{(aq)} \rightleftharpoons H_3O^+_{(aq)} + HSO_3^-{}_{(aq)}$$

A. H_2SO_3 and H_3O^+

B. H_2O and H_2SO_3

C. H_2O and H_3O^+

D. H_2O and HSO_3^-

9. Carbon dioxide can be produced from carbon monoxide and oxygen gas. At 1000°C the reaction reaches equilibrium as shown below:

$$2CO_{(g)} + O_{2(g)} \rightleftharpoons 2CO_{2(g)} \qquad \Delta H = -566 \text{ kJ mol}^{-1}$$

Which of the following changes would not result in a larger yield of $CO_{2(g)}$?

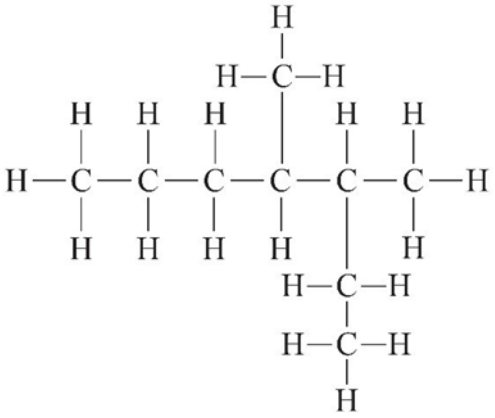
A. Adding a catalyst

B. Decreasing the volume

C. Decreasing the temperature

D. Increasing the partial pressure of $CO_{(g)}$

10.



Identify the systematic IUPAC name for the compound shown above.

A. 4-methyl-5-ethylhexane

B. 2-ethyl-3-methylhexane

C. 3,4-dimethylheptane

D. 4,5-dimethylheptane

11. Which of the following is the strongest acid?

A. CH_3COOH $pK_a = 4.76$

B. HCO_3^- $pK_a = 10.25$

C. HF $pK_a = 3.17$

D. $H_2C_2O_4$ $pK_a = 1.27$

12. A student measured the heat of combustion of butan-1-ol, by heating 300 g of water, initially at 21 °C. Exactly 0.750 g of butan-1-ol was burnt in the reaction. The theoretical value for the heat of combustion of butan-1-ol is 2077 kJ mol^{-1}. If 50% of the heat produced was lost to the environment, what would be the final temperature of the water?

A. 29.4 °C

B. 33.6 °C

C. 57.2 °C

D. 71.3 °C

13. How many structural isomers are these with the molecular formula $C_2H_2Br_2$?

A. 2

B. 3

C. 4

D. 5

14. The type of structural isomerism present in molecules with the molecular formula of $C_2H_2Br_2$ is:

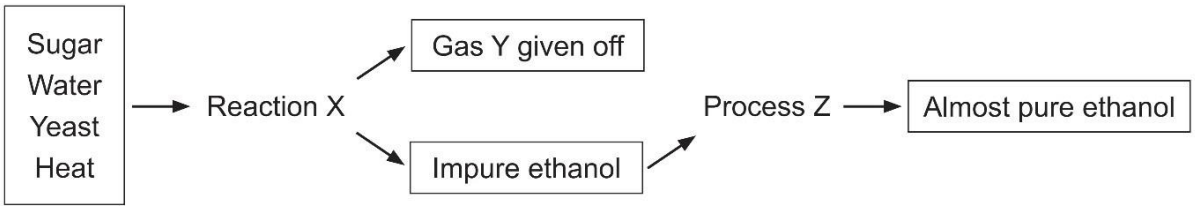
A. Functional group isomerism

B. Cis-trans isomerism

C. Chain isomerism

D. Position isomerism

Questions 15 and 16 relate to the flow diagram below showing a process for making ethanol.



15. Process Z is called:

A. Filtration.

B. Precipitation.

C. Condensation.

D. Fractional distillation.

16. Gas Y is:

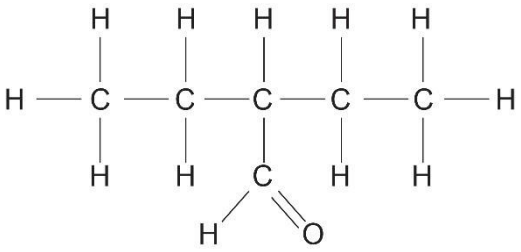
A. Oxygen.

B. Hydrogen.

C. Carbon dioxide.

D. Carbon monoxide.

17.



What is the IUPAC name of the compound shown above?

A. 2-ethylbutanal

B. 2-methylbutanal

C. 2,2-diethylethanal

D. 3-methylpentan-3-al

18. A 0.0100 M solution of an acid, HA, is 15% ionised. What is the acid dissociation constant, K_a, for this acid?

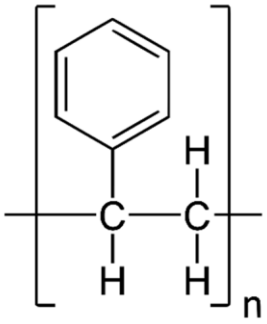
A. 2.25×10^{-4}

B. 2.25×10^{-6}

C. 2.65×10^{-4}

D. 2.65×10^{-6}

19.



The name for the polymer whose structural formula is shown above is:

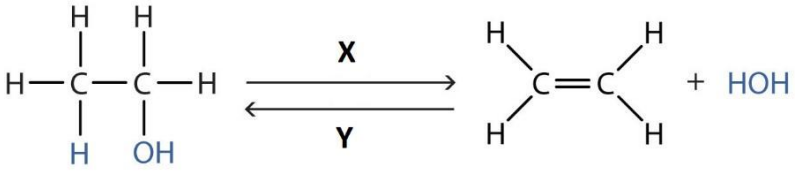
A. Polyethylene

B. Polyester

C. Polystyrene

D. Polyvinyl chloride

20. Which of the following options outline the correct reaction name and the reagent required for the reactions listed as X and Y?



	Name of reaction		Reagent required	
	X	Y	X	Y
A.	Dehydration	Hydration	Concentrated H_2SO_4	Dilute H_2SO_4
B.	Dehydration	Hydration	Dilute H_2SO_4	Concentrated H_2SO_4
C.	Hydration	Dehydration	Concentrated H_2SO_4	Dilute H_2SO_4
D.	Hydration	Dehydration	Dilute H_2SO_4	Concentrated H_2SO_4

End of Section I

Student Number	
Mark / 80	

Chemistry
Section II
Answer Booklet

80 Marks
Attempt Questions 21–35
Allow about 2 hour and 25 minutes for this part

Instructions

- Write your Student Number at the top of this page
- Answer the questions in the space provided. These spaces provide guidance for the expected length of response.
- Show all relevant working in questions involving calculations.

Question 21 (7 marks)

A Year 12 student was given the task to determine the % of calcium carbonate in an egg shell.

After washing and drying the eggshell, a 0.496 g sample was placed in a conical flask. 20.0 mL of 0.486 mol L^{-1} hydrochloric acid was added, and the mixture was gently warmed until all evidence of the reaction had stopped.

The unreacted acid was then back-titrated against a standardised solution of 0.100 mol L^{-1} of sodium hydroxide. The volume of sodium hydroxide required to reach the end-point was 28.5 mL.

a) Write an equation to show the chemical process that occurs when hydrochloric acid was added. **1**

$CaCO_{3(s)} + 2HCl_{(aq)} \rightleftharpoons CaCl_{2(aq)} + CO_{2(g)} + H_2O_{(l)}$

Criteria	Mark
• correctly wrote the balanced chemical equation for the reaction (no penalty for states)	1

b) Calculate the moles of unreacted hydrochloric acid. **2**

$$n_{NaOH} = n_{HCl}$$

$$\therefore n_{HCl} = 0.100 \times 0.0285$$
$$= 2.85 \times 10^{-4} mol$$

Criteria	Mark
• Stated that n(NaOH) = n(HCl).	1
• Hence calculated the correct number of moles of unreacted HCl	1

c) Calculate the %(w/w) of calcium carbonate in the egg shell. **4**

n_{HCl} added = 0.486 x 0.020 = 9.72 x 10^{-3} mol

n_{HCl} reacted with $CaCO_3$ in the egg shell = n_{HCl} added - n_{HCl} unreacted
= 9.72 x 10^{-3} – 2.85 x 10^{-4}
= 6.87 x 10^{-3}

Since the molar ratio of $CaCO_3$:HCl is 1:2, n$CaCO_3$ reacted with HCl = 3.435 x 10^{-3} mol

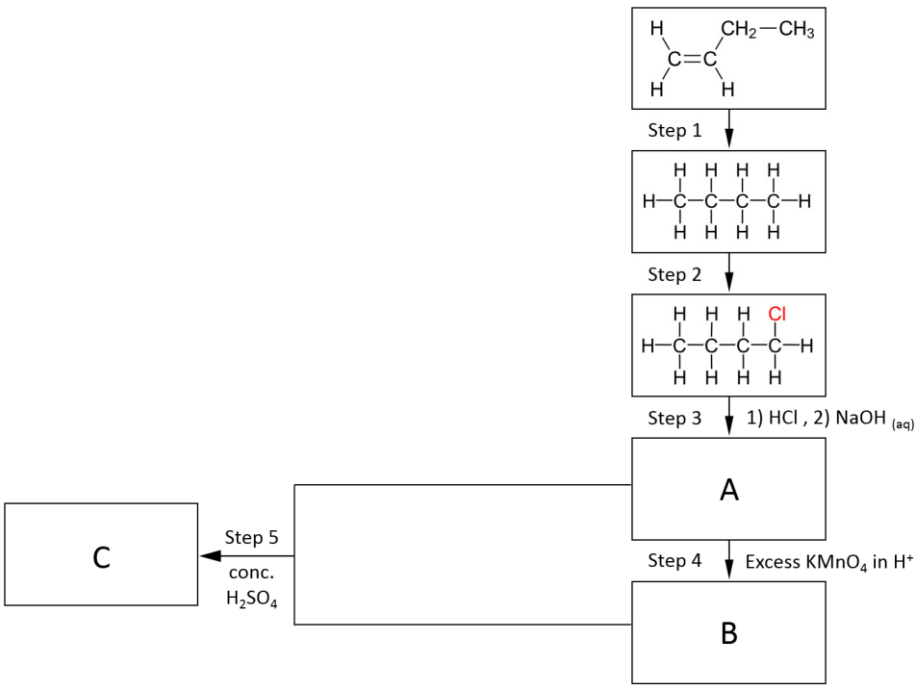
Therefore, the mass of $CaCO_3$ in egg shell = (3.435 x 10^{-3}) x (40.08+12.01+48) = 0.344 g

%(w/w) of $CaCO_3$ in the egg shell = (0.344 / 0.496) x 100 = 69.3 %

Criteria	Mark
• correctly calculated the nHCl added to the egg shell	1
• correctly calculated the nHCl reacted with $CaCO_3$ in the egg shell	1
• correctly calculated the n$CaCO_3$ reacted with HCl using the molar ratio of 1:2	1
• correctly calculated the %(w/w) of $CaCO_3$ in the egg shell	1
Carry on error considered	

Question 22 (9 marks)

The flowchart below shows some reactions of the carbon compound but-1-ene (1-butene).



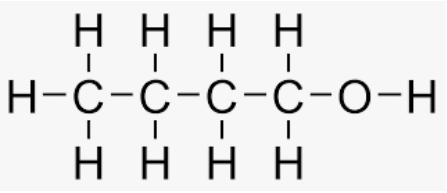
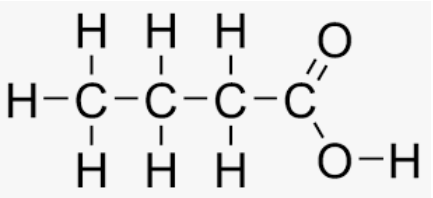
Use the flowchart to answer the following questions.

a) Identify the reagents and conditions required for the reactions at Step 1 and Step 2. **2**

Step 1: H_2 (with catalyst such as Ni)
Step 2: Cl_2 (U.V)

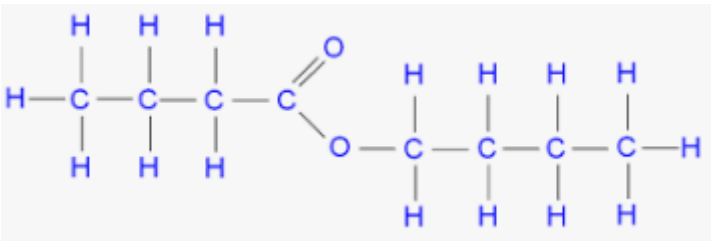
Criteria	Mark
• correctly identified the reagent and condition for Step 1	1
• correctly identified the reagent and condition for Step 1	1

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

Compound A	Compound B
 **butan-1-ol**	 **butanoic acid**

Criteria	Mark
• correctly drawn the structure for compound A	1
• correctly named compound A	1
• correctly drawn the structure for compound B	1
• correctly named compound B	1

c) 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**

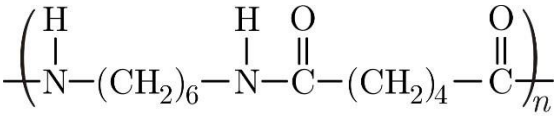


Name of process: Esterification Name of product: butyl butanoate

Criteria	Mark
• correctly drawn the structural formula for compound C	1
• correctly named the process	1
• correctly named the product (compound C)	1

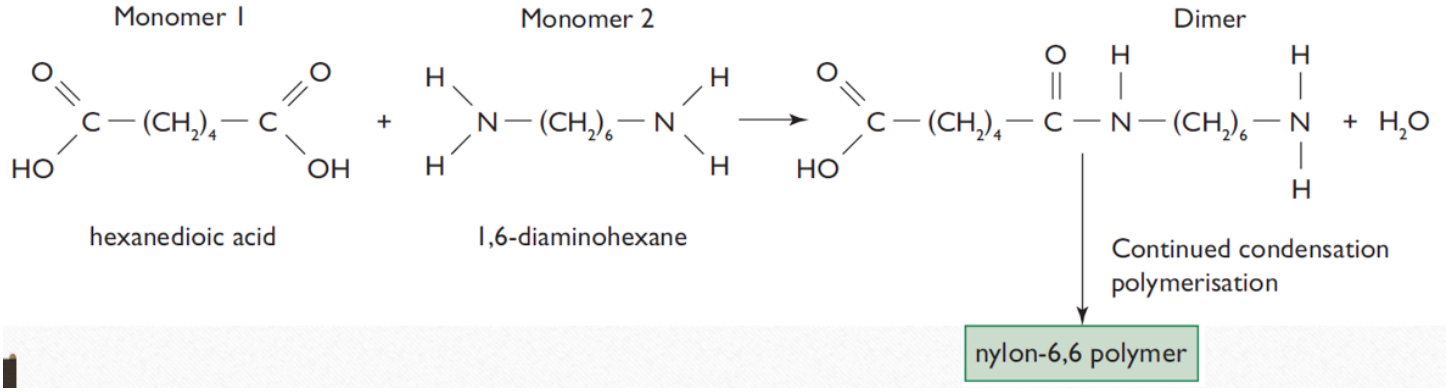
Question 23 (4 marks)

The diagram below shows the structure of a polymer called nylon 6,6.



Nylon 66

a) Construct an equation showing the structural formula for the formation of nylon 6,6. **2**



b) Identify a property of nylon and relate this property to its use. **2**

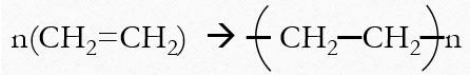
Properties of Nylon	Uses of Nylon
High tensile strength **Strong** **Lightweight**	**Clothes including rainwear** **Ropes** **Fishing line** **Parachutes** **Guitar strings** **Pipes** **Machinery**

Criteria	Mark
• correctly identified one property of nylon AND	1
• related this property to its use	1

Question 24 (3 marks)

Using polyethylene and nylon 6,6 as examples, compare condensation polymers to addition polymers with respect to their structure and polymerisation processes. **3**

Addition polymerisation involves the opening up of double (or triple bonds), which are used to link monomers to form a polymer. Hence it is limited to the use of unsaturated monomers.
During addition polymerisation, monomer molecules are added together without the loss of any atoms. Monomers simply add to the growing polymer so that all the atoms present in the monomer are also present in the polymer. For example, polyethylene is a polymer formed by adding ethene molecules.



Condensation polymers are polymers that form by the elimination of a small molecule (often water) when pairs of monomer molecules join together. Condensation polymerisation requires monomer(s) with two functional groups, one on each end of the monomer, which chemically react with the functional groups on neighbouring monomers linking them into long polymer chains. Unlike addition polymerisation, condensation polymerisation does not require unsaturated monomers.
For example, nylon 6,6 can be formed using two monomers, hexanedioic acid and 1,6-diaminohexane. When these monomers undergo condensation polymerisation, water molecules are eliminated at every region where the two monomers join.

Criteria	Mark
• compared differences in structures of condensation polymers to addition polymers	1
• correctly described the difference in their processes	1
• used polyethylene and nylon 6,6 as examples in the response	1

Question 25 (8 marks)

The research and development unit of a chemical company is studying the reaction of CH_4 and H_2S, two components of natural gas which react together to form an equilibrium system shown below:

$$CH_{4\,(g)} + 2H_2S_{\,(g)} \rightleftharpoons CS_{2\,(g)} + 4H_{2\,(g)} \qquad \Delta H > 0$$

a) Write the equilibrium constant expression for this reaction. **1**

$$k_{sp} = \frac{[CH_4][H_2S]^2}{[CS_2][H_2]^4}$$

Criteria	Mark
• correctly wrote the expression for equilibrium constant	1

b) Explain how the value of the position of equilibrium and the equilibrium constant would change if the temperature of the reaction was increased. **3**

Since this is an endothermic reaction, given that the value of ΔH is positive, increasing the temperature will favour the forward reaction increasing the yield of the products.
Hence the concentrations of both the products will increase whilst those of the reactants will decrease until the equilibrium is re-established, reaching the new equilibrium constant.
Therefore, the new equilibrium constant will be higher than the value prior to the temperature increase.

Criteria	Mark
• identified that it is an endothermic reaction	1
• hence described that increasing temperature will favour the forward reaction, producing more products	1
• therefore concluded that the new equilibrium constant will be higher than the previous value	1

c) In one experiment, 1.00 mol of CH_4, 1.00 mol of CS_2, 2.00 mol of H_2S, and 2.00 mol of H_2 are mixed in a 250.0 mL vessel. **3**

The vessel was heated to 960 °C and 5.56 moles of $CH_{4\,(g)}$ was present at equilibrium.

Determine the concentrations of all species at equilibrium.

	$CH_{4\,(g)}$ +	$2H_2S_{\,(g)}$ ⇌	$CS_{2\,(g)}$ +	$4H_{2\,(g)}$
Initial concentration	4	8	4	8
Change in concentration	+18.24	+36.48	-18.24	-72.96
Equilibrium concentration	22.24	44.48	-14.24	-64.96

d) Determine the value of the equilibrium constant for this reaction at 960 °C. **1**

……

……

……

……

Question 26 (5 marks)

When combusted, ethanol releases 1364 kJ mol^{-1} at 298 K and 101.3 kPa.

a) Write an equation to show the complete combustion of ethanol and its molar enthalpy of combustion **2**

$CH_3CH_2OH_{(l)} + 3O_{2(g)} \rightarrow 2CO_{2(g)} + 3H_2O_{(l)}$ $\Delta H = -1364 kJ/mol$

(ethanol can be written as C_2H_5OH or C_2H_6O in this equation)

Criteria	Mark
• correctly wrote the balanced chemical equation including states	1
• stated the correct value of ΔH next to the chemical equation	1

b) When students conduct experiments to determine the enthalpy of combustion of different alcohols they often yield results much less than the theoretical results. Explain why this is and suggest how it can be minimised. **3**

Criteria	Mark
• explained one reason of why the experimental results are often much less than the theoretical ones	1
• suggested one method of reducing the difference between the two values and why it will be effective	2

Question 27 (5 marks)

20.0 mL of 0.010 M $Ba(NO_3)_2$ is mixed with 20.0 mL of 0.0050 M Na_2SO_4 at room temperature of 25 °C and stirred.

a) Determine whether a precipitate will form from this reaction. Your answer should include the equilibrium expression for the insoluble salt that may form. **3**

$Ba(NO_3)_{2(aq)} + Na_2SO_{4(aq)} \rightarrow 2NaNO_{3(aq)} + BaSO_{4(s)}$

$n(Ba(NO_3)_2) = 2.0 \times 10^{-4}$ mol $\quad n(Na_2SO_4) = 1.0 \times 10^{-4}$ mol

$\therefore n(BaSO_4) = 1.0 \times 10^{-4}$ mol (as SO_4^{2-} is the limiting reagent)

$[Ba^{2+}] = (1.0 \times 10^{-4}) / 0.040 = 2.5 \times 10^{-3}$ M

$BaSO_{4(s)} \rightarrow Ba^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)}$

k_{sp} for $BaSO_4 = [Ba^{2+}][SO_4^{2-}] = 1.08 \times 10^{-10}$

$Q(BaSO_4) = [Ba^{2+}][SO_4^{2-}] = (2.5 \times 10^{-3})^2 = 6.25 \times 10^{-6}$

Since $Q > k_{sp}$, precipitate will form from this reaction.

Criteria	Mark
• correctly wrote the balanced chemical equation	1
• correctly wrote the equilibrium expression	1
• calculated the Q value and stated that since the Q value is larger than k_{sp} value, precipitate will form	1

b) Calculate the solubility of AgBr in gL^{-1}. **2**

$$AgBr_{(s)} \rightarrow Ag^{+}_{(aq)} + Br^{-}_{(aq)}$$

k_{sp} *for* $AgBr = [Ag^{+}][Br^{-}] = 5.35 \times 10^{-13}$

$$\therefore [Ag^{+}] = \sqrt{5.35 \times 10^{-13}} = 7.31 \times 10^{-7} M$$

$$\therefore Solubility\ of\ AgBr = (7.31 \times 10^{-7}) \times (107.9 + 79.90) = 1.37 \times 10^{-4} g/L$$

Criteria	Mark
• correctly calculated the concentration of Ag^{+} using the k_{sp} value	1
• hence correctly calculated the solubility of AgBr in g/L	1

Question 28 (2 marks)

Outline an example of the use of solubility equilibria by Aboriginal and Torres Strait Islander Peoples when removing toxins from foods. **2**

Criteria	Mark
• Outlined with sufficient details, an example of the use of solubility equilibria by Aboriginal and Torres Strait Islander People when removing toxins from foods	2

Question 29 (7 marks)

To perform an esterification reaction in the laboratory a student was provided with methanol and propanoic acid, which she heated together under reflux with a catalyst.

a) Name a suitable catalyst for this reaction and suggest a reason why the catalyst is used in this process. **2**

Concentrated H_2SO_4

- *it's a dehydrating agent → removes water as it is formed during esterification reaction → hence favours the forward reaction to form more esters*
- *it acts as a catalyst → lowers the activation energy for the reactants to undergo reaction to form esters*

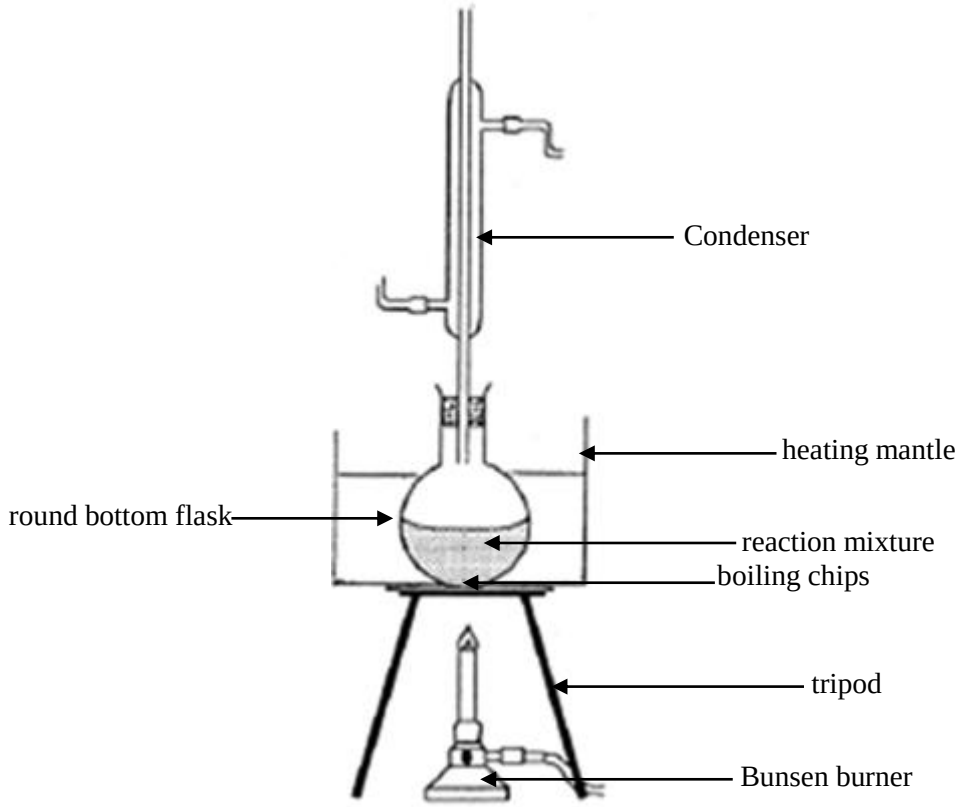
Criteria	Mark
• correctly identified a suitable catalyst for the reaction AND	1
• suggested one reason why it is used in this process	1

b) Justify the use of heating under reflux for this experiment. **2**

***Heating**: to provide the activation energy to enhance the reaction*
***Refluxing**: to prevent the loss of volatile substances (reactants and products) during the reaction, hence to increase the yield of the product formed*

Criteria	Mark
• justified the use of heating under reflux using two valid reasons Or	2
• justified the use of heating under reflux using only one valid reason	1

c) Draw a labelled scientific diagram of the experimental setup for this reaction. **3**



Criteria	Mark
• drew a scientific diagram for the experimental setup required for esterification using a ruler	2
• correctly labelled all apparatus involved	2
or	
• drew a scientific diagram for the experimental setup required for esterification without a ruler	1
• correctly labelled most of the apparatus involved	1
or	
• drew a poor diagram for the experimental setup required for esterification without a ruler	0
• incorrectly labelled or not labelled most of the apparatus involved	0

Question 30 (6 marks)

The boiling point of some organic compounds with equal carbon chain length are shown below.

Organic compound	Boiling point (°C)
Propane	– 42.1
Propanoic acid	141
Propanamine	49
Propanamide	213

Using appropriate diagram(s) of the substances, explain the difference in boiling points of these compounds.

Propane

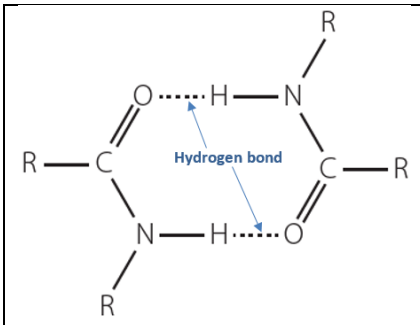
- dispersion forces only with short hydrocarbon chain length → low b.p.

Propanoic acid and Propanamide

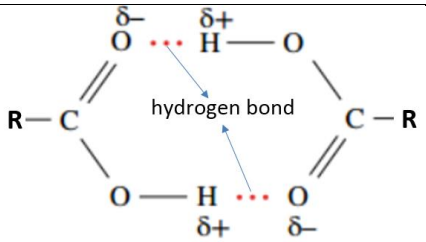
- combination of dispersion, dipole-dipole and extensive hydrogen bonding → much higher b.p. than propane which only has dispersion forces and propanamine which does not form extensive hydrogen bonding
- BUT propanoic acid have lower b.p. than propanamide as it only has one hydrogen off the oxygen at the end of the molecule compared to propanamide which has two hydrogens off the nitrogen which can form more extensive hydrogen bonding with nearby molecules

Propanamine

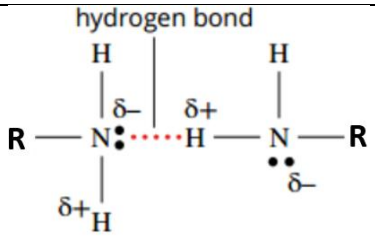
- dispersion forces, dipole-dipole and hydrogen bonding as intermolecular forces → much higher b.p. than propane but lower than propanoic acid and propanamide which can form extensive hydrogen bonding as intermolecular forces



extensive hydrogen bonding in amides



extensive hydrogen bonding in carboxylic acids



hydrogen bonding in amines

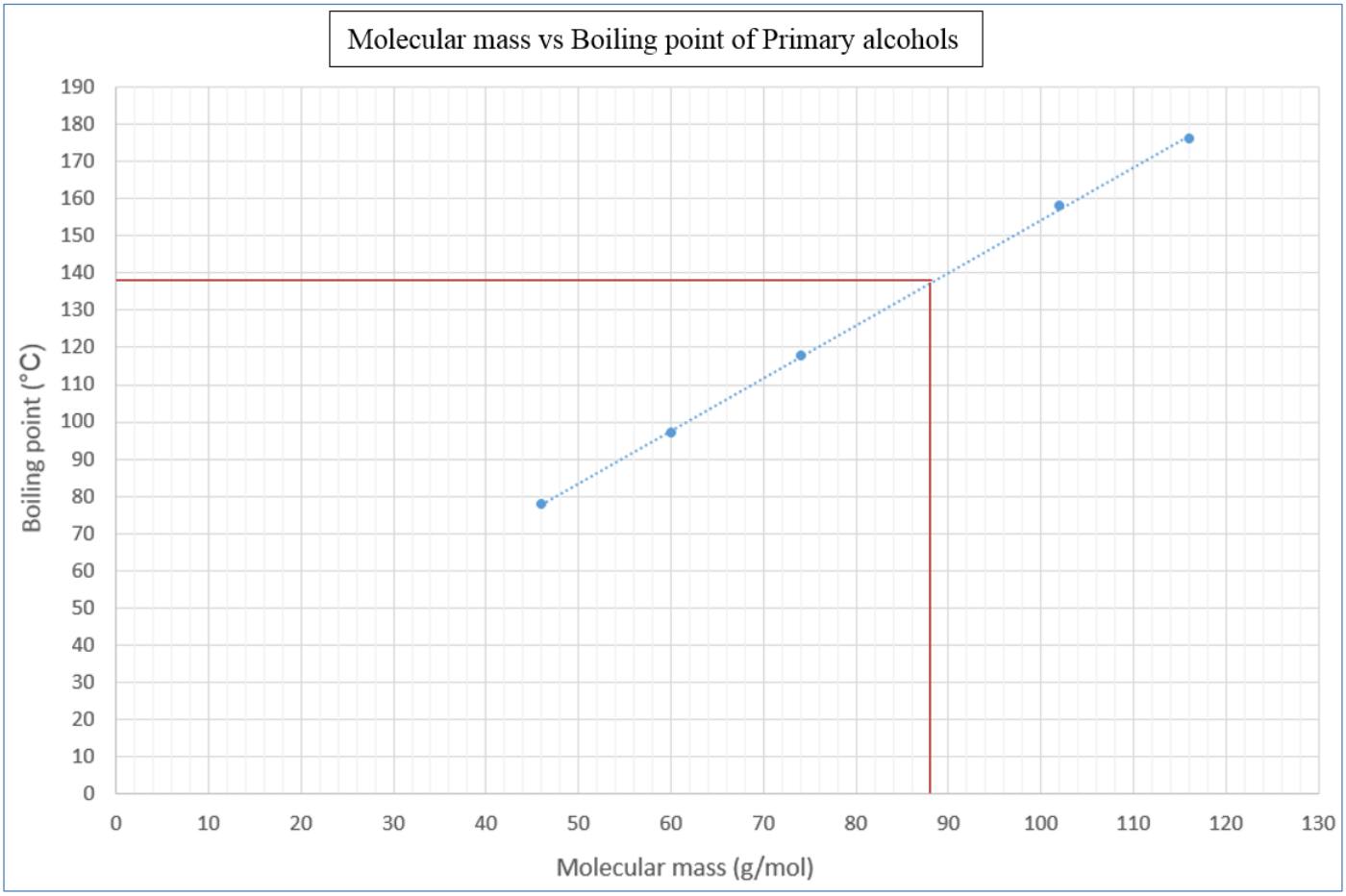
Criteria	Mark
Explanation • correctly identified the type of intermolecular forces present in two of the compounds • correctly identified the type of intermolecular forces present in all of the compounds • Stated that propanamide and propanoic acid have extensive hydrogen bonding • Stated that propanamide have more extensive hydrogen bonding as compared to propanamide as there are two hydrogens to the nitrogen compared to only one off the oxygen in propanoic acid	1 1 1 1
Diagrams • drew three labelled diagrams to show the different types of intermolecular forces present in these compounds **OR** • drew two labelled diagrams to show the different types of intermolecular forces present in these compounds	2 1

Question 31 (7 marks)

The table below lists the boiling points and solubility of six primary alkanols

Compound	Molecular mass (g/mol)	Boiling point (°C)	Solubility (g/100 mL)
Ethanol	46	78	Infinitely soluble
Propan-1-ol	60	97	Infinitely soluble
Butan-1-ol	74	118	8.3
Pentan-1-ol	88	*x*	2.7
Hexan-1-ol	102	158	0.6
Heptan-1-ol	116	176	0.18

a) Using an appropriate scale, draw a graph of molecular mass vs. the boiling point in the space below. **3**



Criteria	Mark
• appropriate graph title and axis titles including scales on both axis with units	1
• correctly plotted all the points given in the table	1
• drew an appropriate line of best fit	1

b) Use your graph to predict the boiling point of pentan-1-ol. **2**

approximately 138°C

Criteria	Mark
• the answer the is in the range of 136 – 139°C	2
or	or
• the answer is not in the range of 130 – 136°C	1

c) Explain the trend in solubility of these primary alcohols shown in the table. **2**

- *the hydrocarbon chain lengths increases → dispersion forces become more dominant type of intermolecular forces in alcohols → hydrogen bonding with water molecules weakens → the solubility of primary alcohol decreases (e.g. solubility of butan-1-ol is 8.3 g/100mL when that of heptan-1-ol is only 0.18 g/100mL)*

Criteria	Mark
• correctly explained the trend in solubility of primary alcohols using at least one specific data given in the table or • correctly explained the trend in solubility of primary alcohols without using any data given in the table	2 1

Question 32 (3 marks)

The use of ethanol as an alternative fuel has been proposed because it can be obtained from renewable resources by fermentation and it also burns more cleanly than petrol. With the aid of chemical equations, explain these two properties of ethanol. **3**

Ethanol can be produced using fermentation reaction of glucose obtained from plant materials such as sugar cane and wheat. $C_6H_{12}O_{6(aq)} \xrightarrow{yeast} 2C_2H_5OH_{(aq)} + 2CO_{2(g)}$

Ethanol can be used as an alternative fuel since it readily combust to produce heat.

$C_2H_5OH_{(aq)} + 3O_{2(g)} \rightarrow 2CO_{2(g)} + 3H_2O_{(l)}$

It required much less oxygen compared to octane which is a typical type of fuel currently used.

$2C_8H_{18(l)} + 25O_{2(g)} \rightarrow 16CO_{2(g)} + 18H_2O_{(l)}$

Hence ethanol burns more cleanly than petrol producing much less pollutants such as CO and soot.

Criteria	Mark
• explained how ethanol can be obtained from renewable sources by fermentation including a chemical equation of fermentation of glucose	1
• explained why ethanol can combust more cleanly than petrol by using chemical equations or	2
• explained why ethanol can combust more cleanly than petrol without using chemical equation(s)	1

Question 33 (3 marks)

Calculate the pOH of the resulting solution from the combination of 15 mL of 0.10 M NaOH and 25 mL of 0.10 M HCl solutions. **3**

Neutralisation reaction of NaOH and HCl:

$$NaOH_{(aq)} + HCl_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$$

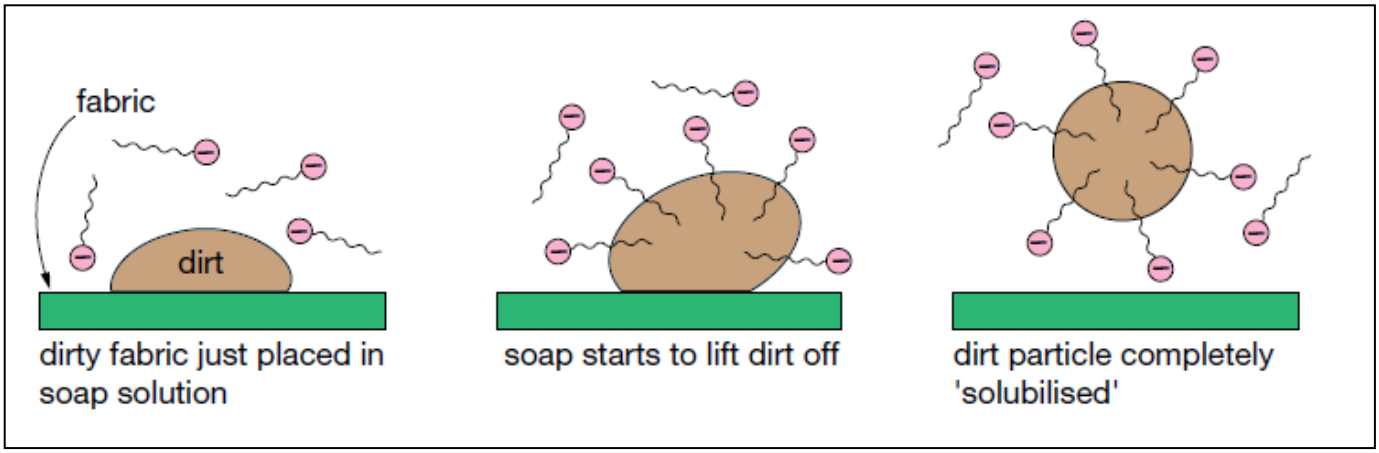
n(NaOH) = 0.10 x 0.015 = 0.0015 mol
n(HCl) = 0.10 x 0.025 = 0.0025 mol
NaOH is the limiting reagent.
n(HCl) unreacted = 0.001 mol
[H+] = 0.001 / 0.040 = 0.025
pH = -log[H+] = 1.6

$\therefore pOH = 14 - pH = 12$ *(2 significant figues)*

Criteria	Mark
• correctly calculated the number of moles of NaOH and HCl used for the reaction	1
• identified that NaOH is the limiting reagent, hence correctly determined the number of moles of HCl unreacted	1
• correctly calculated the pH of the solution, hence calculated the pOH	1

Question 34 (4 marks)

With the aid of a diagram, explain the cleansing action of soap. **4**



Soap has a long hydrocarbon tail that readily dissolves in oily and waxy substances (hydrophobic) and an ionic head that easily dissolves in water (hydrophilic).

When soap is added to water in which dirty clothes are soaked, the two parts of the soap molecule dissolves in two different mediums. The organic tail dissolves in the oily dirt, grime or grease and the ionic head dissolves in water. When the clothes are rinsed or agitated, the dirt gets pulled out of the clothes in the water by the soap molecule by soap molecules forming a closed structure called a micelle. The micelle pulls out the dirt and grime more efficiently.

Criteria	Mark
• explained about the two regions of soap (hydrophobic and hydrophilic)	1
• described the process including the formation of micelles	1
• explained the cleansing action of soap in sequential details	1
• diagram illustrated the cleansing action of soap	1

Question 35 (7 marks)

A student has three bottles of chemicals which have faded labels. He knows that of the three chemicals, one is pentane, one is ethanol, and one is propanoic acid. **7**

Design a safe, valid and reliable first-hand investigation to correctly identify the three substances. You can use any common chemical substances and materials in the science laboratory. In your answer you must include at least one relevant chemical equation.

An example of a quick method students could use would be:

Add water to a sample of each, pentane can be identified as it will form an immiscible layer.

Add sodium carbonate to the remaining two (ethanol and propanoic acid), the acid will react to form CO_2 (can confirm with limewater) and the ethanol will not react.

$$CH_3CH_2COOH_{(aq)} + Na_2CO_{3(aq)} \rightarrow CH_3CH_2COONa_{(aq)} + CO_{2(g)} + H_2O_{(l)}$$

Criteria	Mark
• risk assessment (identified the risks involved, methods of managing them and associated with handling organic substances)	2
• impregnation of reliability in the method (repetition of investigation)	1
• included relevant chemical equation (e.g. reaction between acid and sodium carbonate)	1
• method is written sequentially/step-wise (i.e. it is in logical procedure and it will actually work to meet the aim)	3

End of Section II