PENRITH SELECTIVE HIGH SCHOOL

HSC CHEMISTRY

2019

Trial HSC Examination

General Instructions

- Reading time – 5 minutes
- Exam time – 3 hrs
- Board-approved calculators may be used
- Write using blue or black pen
- Answers written in pencil may be disqualified from review

A Multiple Choice Answer Sheet, Data Sheet and Periodic Table are provided on separate paper.

Total marks (100)

Section A – Twenty 1-Mark Multiple Choice Questions

- 20 marks
- Attempt Questions 1 – 20
- Allow about 30 minutes for this part

Section B - Free Response Questions

- 80 marks
- Attempt Questions 21 – 34
- Allow about 2.5 hours for this part

Student number: .....

Teacher: BURNS / LAM / WALLACE

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Section A: 20 Multiple Choice Questions (20 marks)

Mark your answer A, B, C or D on the separate multiple choice answer sheet.

1. Which of the following is an example of static equilibrium?

(A) The reaction of a metal with an acid

(B) A saturated solution of calcium hydroxide

(C) The ionisation of a weak acid in water

(D) Carbon dioxide in a can of soft drink

2. Photosynthesis uses energy in sunlight to convert carbon dioxide and water into glucose and oxygen according to the following equation

$$6CO_{2(g)} + 6H_2O_{(g)} \rightarrow C_6H_{12}O_{6(aq)} + 6O_{2(g)} \qquad \Delta H = +2802 \text{ kJ}$$

Photosynthesis is an example of an endothermic reaction because

(A) Entropy (ΔS) increases and enthalpy (ΔH) decreases

(B) Entropy (ΔS) decreases and enthalpy (ΔH) decreases

(C) Entropy (ΔS) decreases and enthalpy (ΔH) increases

(D) Entropy (ΔS) increases and enthalpy (ΔH) increases

3. A solution of potassium hydroxide (KOH) was standardised using titration techniques with a 0.0020 M solution of HCl.

The concentration of the KOH solution was determined to be 0.0150 M.

The pH of the KOH solution would be

(A) 1.8

(B) 2.7

(C) 11.3

(D) 12.2

4. Iron III thiocynate ($FeSCN^{2+}$) forms an equilibrium according to the following equation

$$Fe^{3+}_{(aq)} + SCN^{-}_{(aq)} \rightleftharpoons FeSCN^{2+}_{(aq)} + \text{heat}$$
Brown *Blood Red*

Which of the following statements is correct?

(A) An increase in pressure will cause the equilibrium to move to the right

(B) A decrease in temperature will form a more blood red solution

(C) Increasing the concentration of iron III thiocynate will cause the equilibrium to move to the right.

(D) Adding a catalyst to the system will move the position of equilibrium to the right

5. The table shows the pH and pK_a for two acids.

Solution	***pH***	***pK_a***
Acid Solution 1	2.3	6.2×10^{-4}
Acid Solution 2	3.2	6.3

Based on the information in the table, which statement is correct?

(A) Solution 1 is a dilute weak acid and Solution 2 is a concentrated strong acid

(B) Solution 1 is a concentrated weak acid and Solution 2 is a dilute strong acid

(C) Solution 1 is a dilute strong acid and Solution 2 is a dilute weak acid

(D) Solution 1 is a dilute strong acid and Solution 2 is a concentrated weak acid

6. Which substance is amphiprotic?

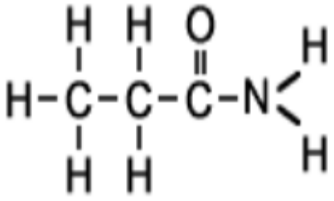
(A) H_2SO_4

(B) NH_4^+

(C) HSO_4^-

(D) SO_4^{2-}

7. The correct name for the following organic compound is



(A) Propanamide

(B) Propanamine

(C) Propanol

(D) Propanoic Acid

8. The number of structural isomers for the compound with the formula $C_3H_5Cl_3$ is

(A) 3

(B) 4

(C) 5

(D) 6

9. Cracking of hydrocarbons is used to produce useful products for the petrochemical industry. One example of this is given by the following chemical equation.

$$C_{10}H_{22} + \text{heat} \rightarrow C_2H_4 + C_8H_{18}$$

Which homologous series do the two products from this reaction belong?

(A) One product is an alkane and the other product is an alkene

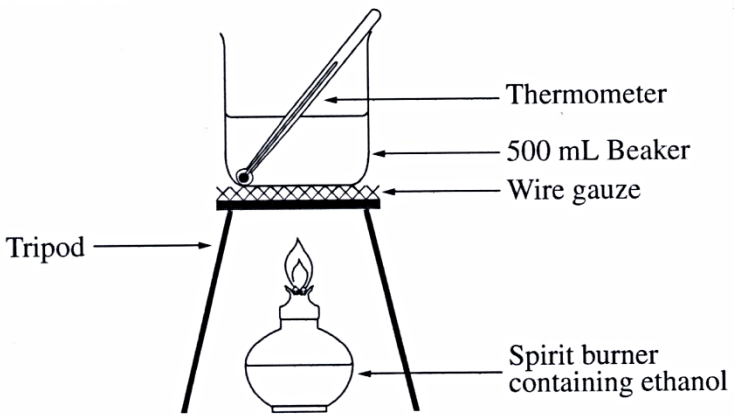
(B) One product is an alkene and the other product is an alkanol

(C) One product is an alkane and the other product is an alkanol

(D) Both products are alkenes

10. A student set up the following equipment for an investigation into the Molar Heat of Combustion of Ethanol

Apparatus used:



The validity of the experiment could be improved by

(A) repeating the experiment three times and calculating an average

(B) using a ring clamp and changing the beaker to a metal calorimeter

(C) using a digital thermometer instead of an alcohol thermometer

(D) changing the independent variable to another alcohol

11. The following reaction is performed on an organic compound using an acidified solution of potassium dichromate.

$$C_4H_9OH \xrightarrow{Cr_2O_7^{2-}/H^+} C_4H_8O \xrightarrow{Cr_2O_7^{2-}/H^+} \text{no reaction}$$

The organic compound is

(A) a primary alcohol

(B) a secondary alcohol

(C) a tertiary alcohol

(D) a quartenary alcohol

12. The table shows the pH range for four indicators.

Indicator	*pH Range*	*Colour Change*
Thymol Blue	1.2 – 2.8	Red - Yellow
Bromothymol Blue	6.0 – 7.6	Yellow - Blue
Alizarin Red	4.0 – 5.6	Red - Yellow
Phenolphthalein	8.0 – 10.0	Colourless - Scarlet

Solution A was tested with the four indicators and the following results recorded.

	Thymol Blue	Bromothymol Blue	Alizarin Red	Phenolphthalein
Solution A Colour	Yellow	Yellow	Red	Colourless

Solution A has a pH between

(A) 2.8 – 6.0

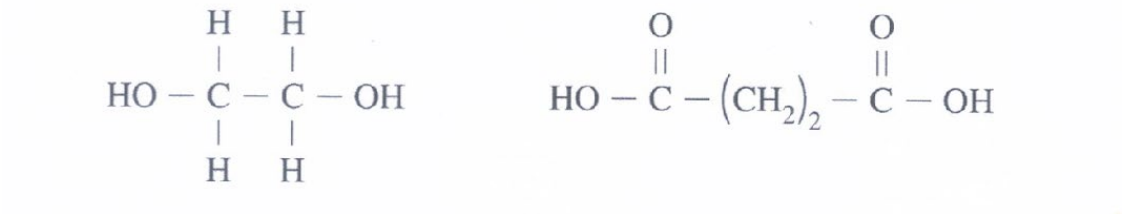
(B) 4.0 – 6.0

(C) 2.8 – 4.0

(D) 5.6 – 8.0

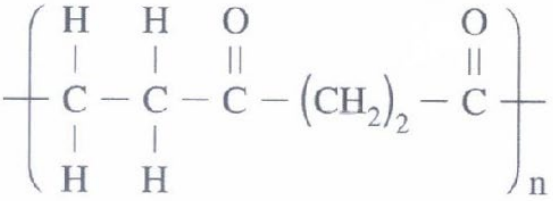
13. The condensation polymers known as polyesters can be produced by the polymerisation of a number of organic molecules.

A polyester is formed by polymerisation of the following two monomers

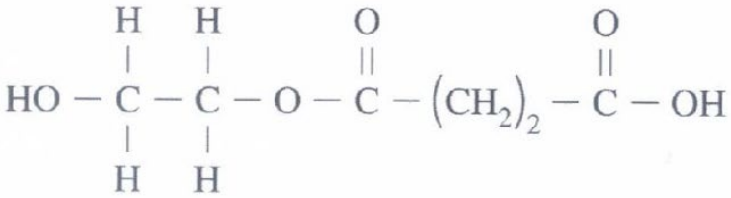


The correct structure of the polymer formed between these two monomers is

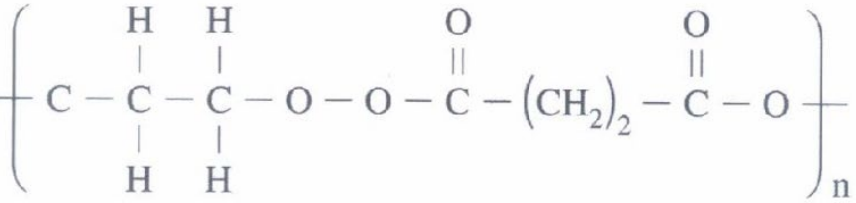
(A)



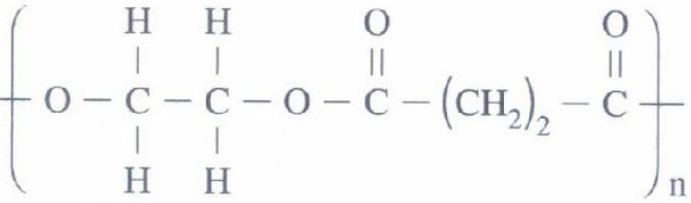
(B)



(C)



(D)



14. In which of the following alternatives are the three compounds listed in order of increasing boiling point?

(A) Pentane, butan-1-ol, propanoic acid

(B) Propanoic acid, butan-1-ol, pentane

(C) Propanoic acid, pentane, butan-1-ol

(D) Butan-1-ol, propanoic acid, pentane

15. Soaps and detergents are classified as surfactants because

(A) They reduce the hardness of water

(B) They reduce the surface tension of water

(C) They are polar molecules

(D) They are biodegradable

16. The table gives the heat of combustion (kJ/g) for a number of different fuels.

Fuel	*Heat of combustion kJ /g*
Butanol	30.8
Pentanol	36.5
Hexanol	41.2
Octane	47.8

The heat of combustion for one of the fuels was calculated as 3218 kJ mol^{-1}. What was the fuel?

(A) Hexanol

(B) Octane

(C) Butanol

(D) Pentanol

17. A student set up a condenser in order to reflux a mixture of propanol, ethanoic acid and sulfuric acid to produce an ester in the laboratory.

Which of the following safety precautions would be used for this experiment?

(A) The use of a fume cupboard and a strong heating flame for the mixture

(B) Boiling chips in the mixture and a water bath for heating the mixture

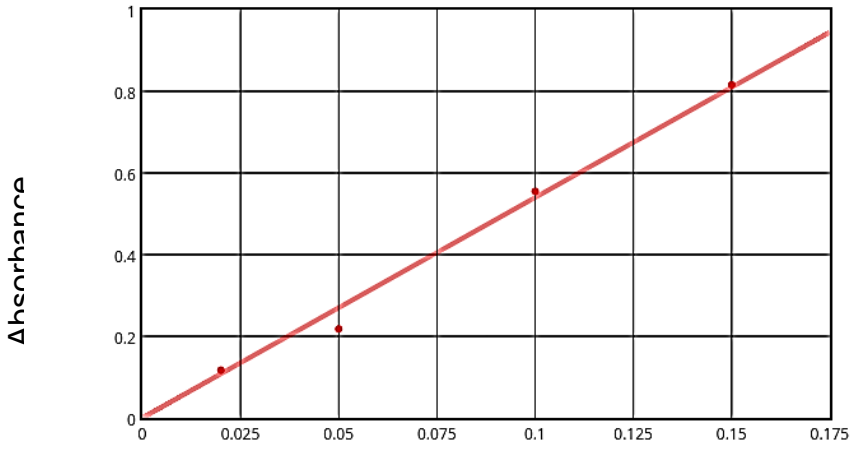
(C) A dilute solution of sulfuric acid and a fume cupboard for refluxing

(D) A heating mantle for the mixture and a stopper for the condenser

18. An orange food colouring (E160a) is added to a soft drink to give a citrus colour to the product. The concentration of the additive can be determined using colorimetry techniques.

The soft drink is first diluted by mixing 10.0 mL of the soft drink with 90.0 mL of water. The colour of the diluted sample is then compared to a standard calibration curve for the orange food colouring.

Standard Calibration Curve for Orange Food Additive E160a



Concentration (g/L)

The absorbance of the diluted soft drink was found to be 0.40

Using the calibration curve, the concentration of the orange food colour in the original soft drink is

(A) 15 mg/L

(B) 75 mg/L

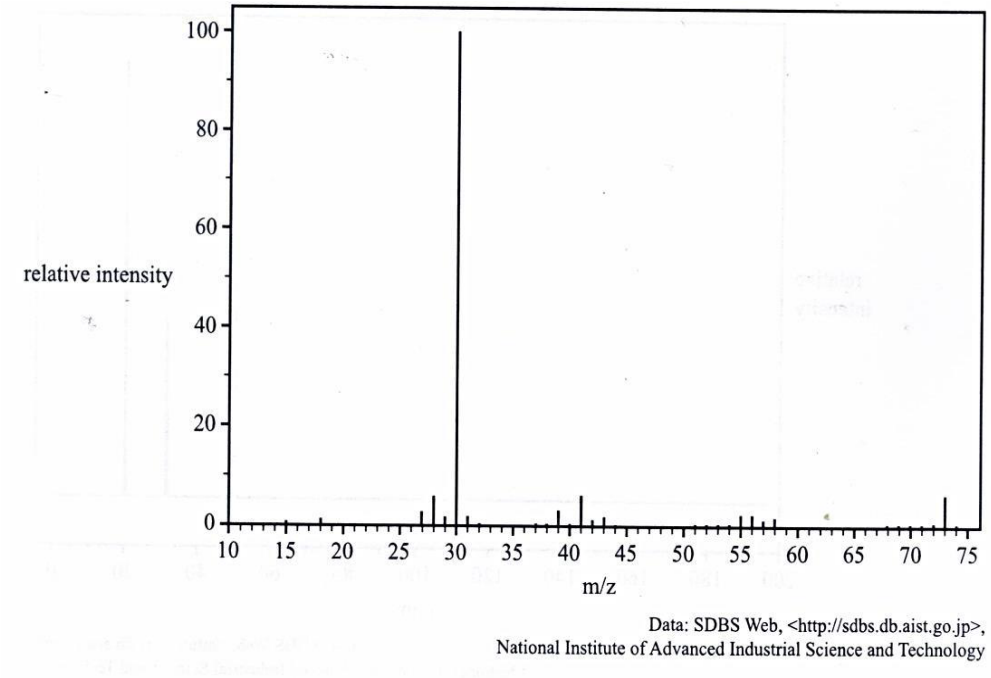
(C) 150 mg/L

(D) 750 mg/L

19. Which alternative gives the correct combination for a natural organic acid and a natural organic base?

	Natural Organic Acid	*Natural Organic Base*
(A)	Sulfuric Acid	Cytosine
(B)	Acetic Acid	Sodium Hydroxide
(C)	Citric Acid	Thymine
(D)	Formic Acid	Ethanol

20. Mass spectrometers use electrons to break up compounds to show a fragmentation pattern for the compound. This is like a fingerprint of the compound; compounds fragment in particular ways. The following fragmentation pattern was formed by a compound.



Data: SDBS Web, <http://sdbs.db.aist.go.jp>,
National Institute of Advanced Industrial Science and Technology

The fragmentation pattern shows the molecular mass of each of the fragments (m/z) and the relative number of each fragment (intensity). Not all molecules are broken and the highest m/z value shows an intact molecule.

Which of the following compounds could produce this fragmentation pattern?

(A) C_4H_8O

(B) C_4H_9O

(C) $C_4H_8O_2$

(D) $C_4H_9O_2$

Section B: Long Response Questions (80 marks)
For Questions 21 to 34 write answers in the spaces provided in the paper.

Question 21 (3 marks)

Hypochlorous acid is a weak acid with the following dissociation reaction

$$HClO_{(aq)} \rightleftharpoons H^+_{(aq)} + ClO^-_{(aq)}$$

The pH of a 0.100M solution of HClO is 4.23.

Calculate the K_a of the hypochlorous acid solution. **3m**

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Question 22 (7 marks)

A student is investigating the following reaction system

$$2NO_{2(g)} \rightleftharpoons N_2O_{4(g)} \qquad \Delta H = \text{negative}$$
Brown *Colourless*

a) The reaction can be observed in a sealed round bottom flask, which allows the student to investigate the impact on temperature on the equilibrium position of the reaction.

State the colour change expected when the student places the round flask containing the gas mixture in a beaker of hot water at 80ºC. Explain why the colour change occurs. **3m**

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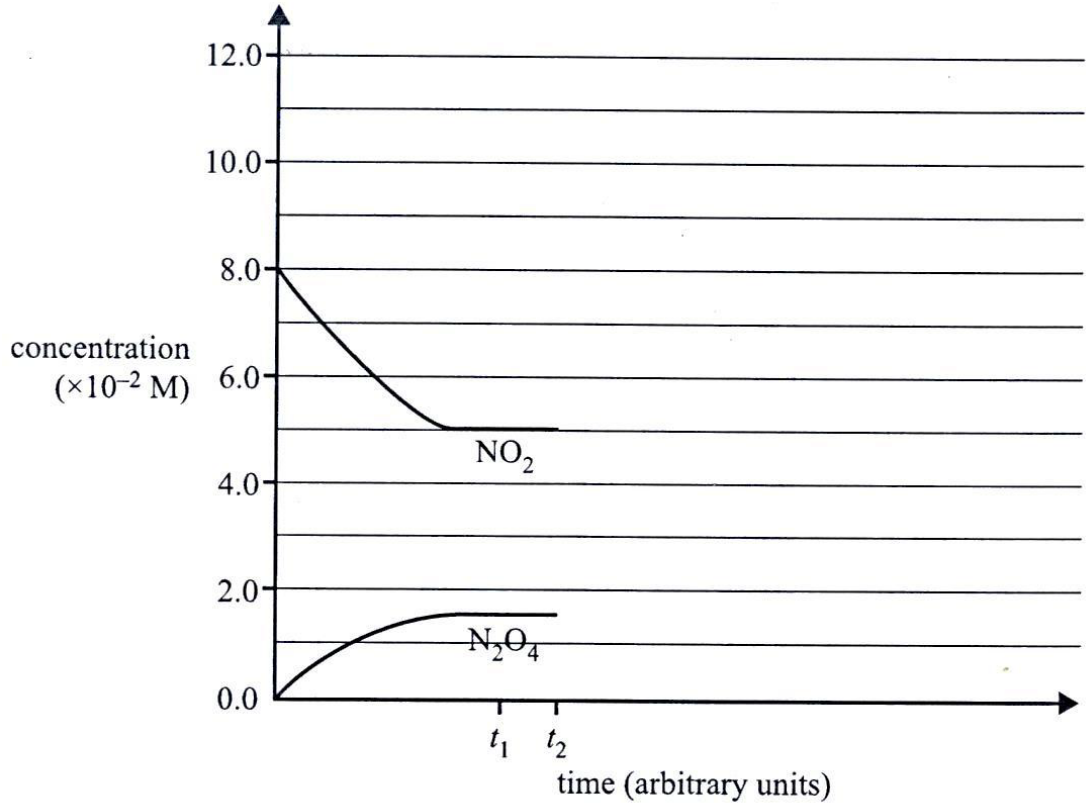
b) Below is a concentration versus time graph for the same reaction system.



i) Time t_1 is shown on the graph above. Calculate the equilibrium constant at time t_1. **2m**

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ii) At time t_2 the volume of the system is halved, keeping the temperature constant.

Continue the graph to show how this change would affect the reaction system, and how the system would respond to this change until equilibrium is restored. **2m**

Question 23 (6 marks)

Sulphur dioxide (SO_2) can react reversibly with oxygen (O_2) to form sulfur trioxide (SO_3) as shown in the following reaction equation:

$$2\ SO_2\,(g) \ + \ O_2\,(g) \ \rightleftharpoons \ 2\ SO_3\,(g)$$

The equilibrium constant (K_{eq}) of this reaction is 10.3

a) 2.00 litre (2 L) vessel containing a mixture of SO_2, O_2 and SO_3 is at equilibrium. It is found that the container has 0.264 mol of O_2 and 0.200 mol of SO_2.

Determine the concentration of SO_3 in the container at equilibrium. **3m**

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b) A 0.200 mol sample of SO_2 was added to the container.

Explain the effect on the position of equilibrium, using both Le Chatelier's Principle and collision theory. **3m**

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Question 24 (6 marks)

A sample of hard water contains 6.00×10^{-4} mol L^{-1} of magnesium carbonate.

a) Use the Ksp value for magnesium carbonate from the data sheet to determine if the solution is saturated. **3m**

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b) Calculate the mass, in mg, of magnesium carbonate in 150 mL of this sample. **3m**

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Question 25 (9 marks)

Definitions and models of acids and bases have changed over time.

Assess the role of water in solutions of acids and bases using TWO acid/base theories. **9m**

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Question 26 (6 marks)

Sodium hydrogen carbonate ($NaHCO_3$) is a soluble salt.

a) Use a labelled diagram to demonstrate the intramolecular forces and intermolecular interactions that allow sodium hydrogen carbonate to dissolve in water. **3m**

b) Use two ionic equations to demonstrate the amphiprotic nature of the hydrogen carbonate ion in water and indicate the conjugate acid/base pairs for both equations. **3m**

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Question 27 (8 marks)

a) A student in an investigation needs to mix 75.0 mL of a 0.155 M hydrochloric acid solution with 55.0 mL of a 0.210 M sodium hydroxide solution.

Calculate the pH of the final mixture. **3m**

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b) Justify if this mixture could be used as a buffer. **2m**

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c) A solution is prepared by using equal volumes and concentrations of acetic acid and sodium acetate.

Explain how the pH of this solution would be affected by the addition of a small amount of sodium hydroxide solution. Include an equation in your answer. **3m**

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Question 28 (6 marks)

Barium hydroxide and sulfuric acid react according to the following equation:

$$Ba(OH)_{2(aq)} + H_2SO_{4(aq)} \rightarrow BaSO_{4(s)} + 2H_2O_{(l)}$$

a) Name this type of chemical reaction. **1m**

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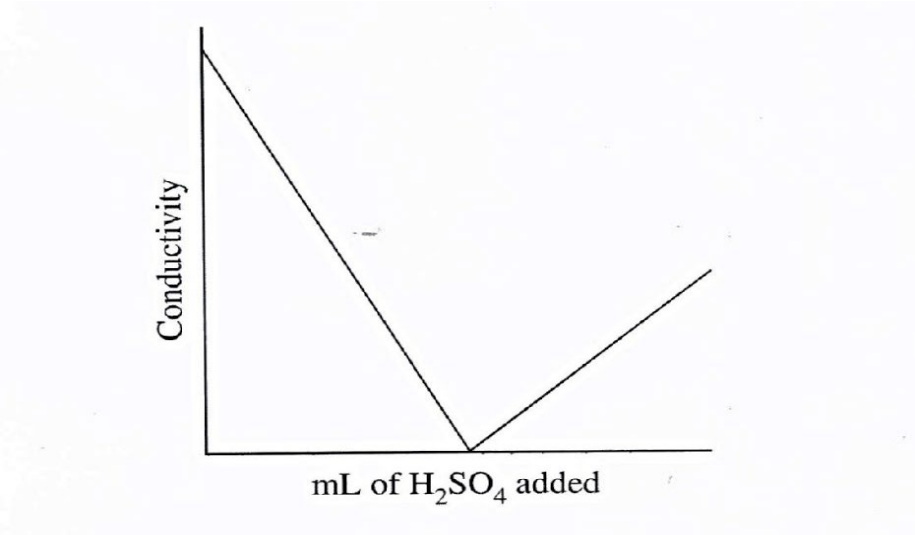
A 20.0 mL sample of barium hydroxide solution was titrated with a 0.120 $molL^{-1}$ sulfuric acid solution. The conductivity of the solution was measured throughout the titration and the results graphed, as shown.



b) Explain why acids and bases conduct electricity, and why the changes in conductivity shown by the graph occur. **3m**

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c) It was found that the endpoint occurred when 22.5 mL of the sulfuric acid was added to the barium hydroxide solution. Determine the concentration of the barium hydroxide solution. **2m**

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Question 29 (4 marks)

Cycads have been a source of food and medicine for many people who live in proximity to these plants. These plants are well-known to be highly poisonous and must be carefully processed to remove soluble toxins before they are edible. If they are not properly processed they can cause vomiting, liver damage and even death. There is also evidence the toxins have neurotoxic effects. To remove the toxins, different methods of processing are used by different cultures, including Aboriginal and Torres Strait Islander Peoples.

Fig A: Cycad Fruit

Simon wanted to try the cycads so he soaked the cycads in a bucket full of water for 48 hours. After 2 hours of consuming the cycad fruit he became ill. Explain, with respect to solubility equilibria, why Simon's method was ineffective in removing the toxins. Include a simple modification to the method to completely remove the toxin. **4m**

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Question 30 (7 marks)

Ethanol and Octane are both used as fuels for cars.

Ethanol can be formed by the fermentation of natural sugars like glucose ($C_6H_{12}O_6$) in the absence of oxygen using yeast, while liquid octane is obtained from the fractional distillation of fossil fuels like petroleum.

a) Give a balanced chemical equation for the formation of ethanol by the fermentation of glucose **1m**

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b) Give the balanced chemical equation for the complete combustion of octane. **1m**

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c) Assess the impacts of obtaining and using ethanol and octane as a fuel. **5m**

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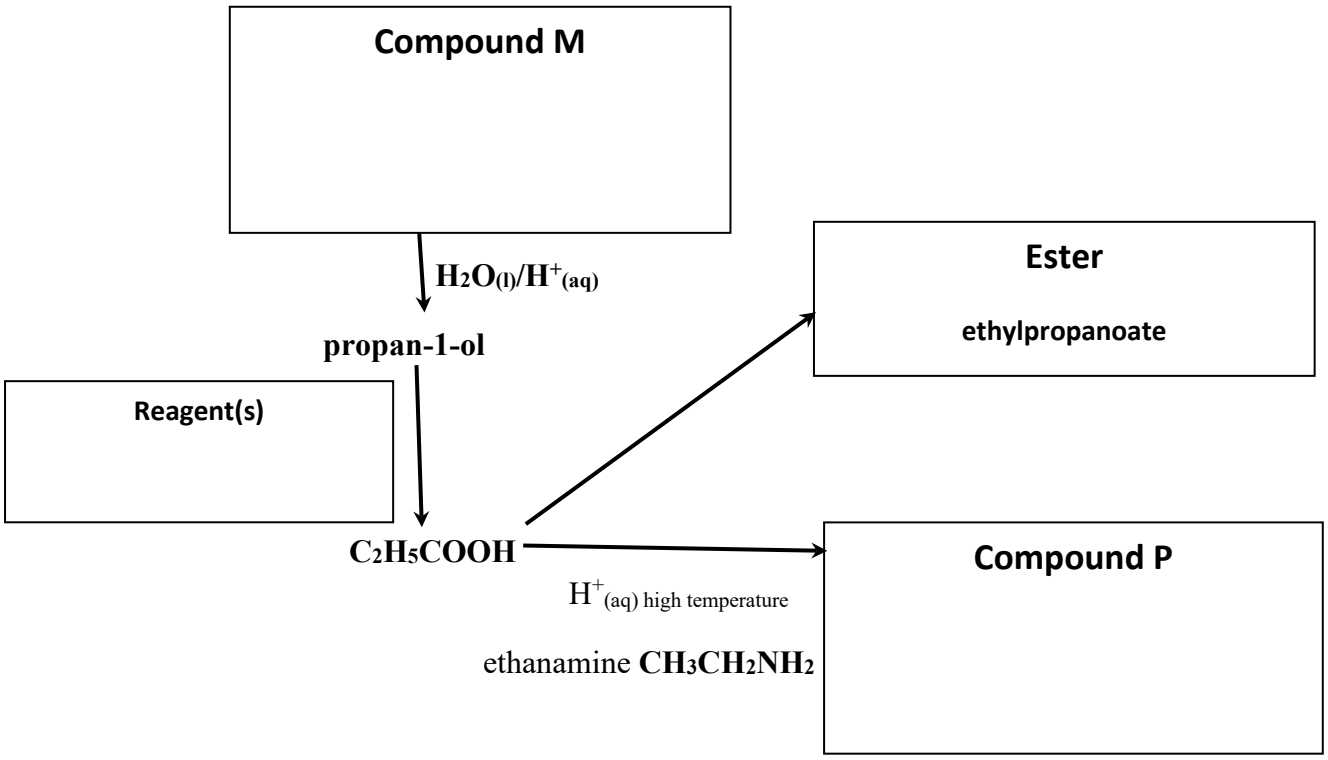
Question 31 (6 marks)

The flow chart represents a reaction pathway for the synthesis of Compound P.



a) Draw the structural formula for Compound M in the box provided on the flow chart. **1m**

b) Give the chemical formula for the reagent(s) used to convert propan-1-ol to C_2H_5COOH in the box provided on the flow chart. **1m**

c) Name Compound P in the box provided on the flow chart. **1m**

d) Construct a balanced chemical equation using structural formula to show how the ester ethyl propanoate was produced, including a catalyst required, in the space below. **3m**

Question 32 (5 marks)

Outline the chemical processes and explain ONE property of the polymer linked to its use in the production of ONE of the following

- a polytetrafluoroethylene (PTFE) non stick pan
- a polyvinyl chloride (PVC) pipe
- a polystyrene foam cup
- a high density polyethylene (PE) bottle
- a nylon parachute

Include a relevant chemical equation in your answer. **5m**

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Question 33 (3 marks)

A group of students were given the task to identify the organic compound contained in two separate bottles. They know that one bottle contains but-1-ene and that the other bottle contains butan-1-ol.

Describe a chemical test that can identify which bottle contains the alkene. Include a chemical equation. **3m**

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Question 34 (4 marks)

A solution is thought to contain the following cations – lead (Pb^{2+}), copper (Cu^{2+}) and barium (Ba^{2+}).

Draw a flow chart to show how precipitation and/or flame tests could be used to confirm the presence of the three cations in the solution. **4m**

End of Examination

Spare Page

Section A Multiple Choice Answer Sheet

Total marks (20). Attempt Questions 1 – 20. Allow about 30 minutes.

Student Number:_____

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) ⬭

HSC Chemistry Marking guide
Year 12 Trial Exam 2019

Multiple Choice (1—20)

1	2	3	4	5	6	7	8	9	10
A	**C**	**D**	**B**	**B**	**C**	**A**	**C**	**A**	**B**

11	12	13	14	15	16	17	18	19	20
B	**C**	**D**	**A**	**B**	**D**	**B**	**D**	**C**	**B**

Question 21

Criteria	Marks
● Calculates $[H^+] = [ClO^-] = 10^{-pH} = 5.89 \times 10^{-5}$ ● A correct Ka expression for HClO ● Calculation of Ka = 3.47×10^{-8}	**3**
● Calculates $[H^+] = [ClO^-] = 10^{-pH} = 5.89 \times 10^{-5}$ ● A correct Ka expression for HClO	**2**
● Performs a relevant calculation for pH	**1**

Markers Comments:
Calculations were excellent by the majority of students. Students used the pH to determine the [H+] and then applied it to the equilibrium expression for Ka. Some students did not understand the [HClO] was the concentration of the solution (minus the small value of [H+]).

Sample Answer

pH = - log [H+] = 4.23 $\quad$ $[H^+] = 10^{-4.23} = 5.89 \times 10^{-5}$ moles/Litre = $[Cl^-]$

$$Ka = \frac{[H^+][Cl^-]}{[HClO]} = \frac{(5.89 \times 10^{-5})^2}{(0.100 - 5.89 \times 10^{-5})} = \frac{3.47 \times 10^{-9}}{0.0999} = 3.47 \times 10^{-8}$$

Question 22 (a)

Criteria	Marks
● Identifies the reaction is exothermic ● Describes increased temperature shifts equilibrium to the left to absorb heat ● Describes the colour of the mixture will become a darker brown due to increased $[NO_2]$	**3**
● Describes increased temperature shifts equilibrium to the left ● Describes the colour of the mixture will become a darker brown	**2**

● Describes increased temperature shifts equilibrium to the left OR ● Describes the colour of the mixture will become a darker brown	**1**

Markers Comments:
Most students were able to describe the correct effect on the equilibrium using Le Chatelier's Principle. Many did not indicate that the reaction was exothermic as written before applying the principle. Some students used symbols to indicate increases/decreases. In the HSC it is important to indicate what these symbols mean e.g. LCP (Le Chatelier's Principle)

Sample Answer:
The reaction is exothermic. An increase in temperature will cause the reaction to move to the left to absorb heat and reduce the temperature increase. The concentration of NO_2 will increase causing the flask to become a darker brown colour.

Question 22 (b i)

Criteria	Marks
● Determines the correct concentration of gases from the graph $[NO_2] = 5.0 \times 10^{-2}$ M $[N_2O_4] = 1.5 \times 10^{-2}$ M ● Calculates correct value for K = 6	**2**
● Uses values obtained from the graph to calculate a value for K	**1**

Markers Comments:
Most students correctly calculated the value of K using the correct units from the graph. The concentrations were given to the value of 10^{-2}. Some students left this out of their calculation.

Sample Answer:

$[N_2O_4] = 1.5 \times 10^{-2}$ M and $[NO_2] = 5.0 \times 10^{-2}$ M from the graph

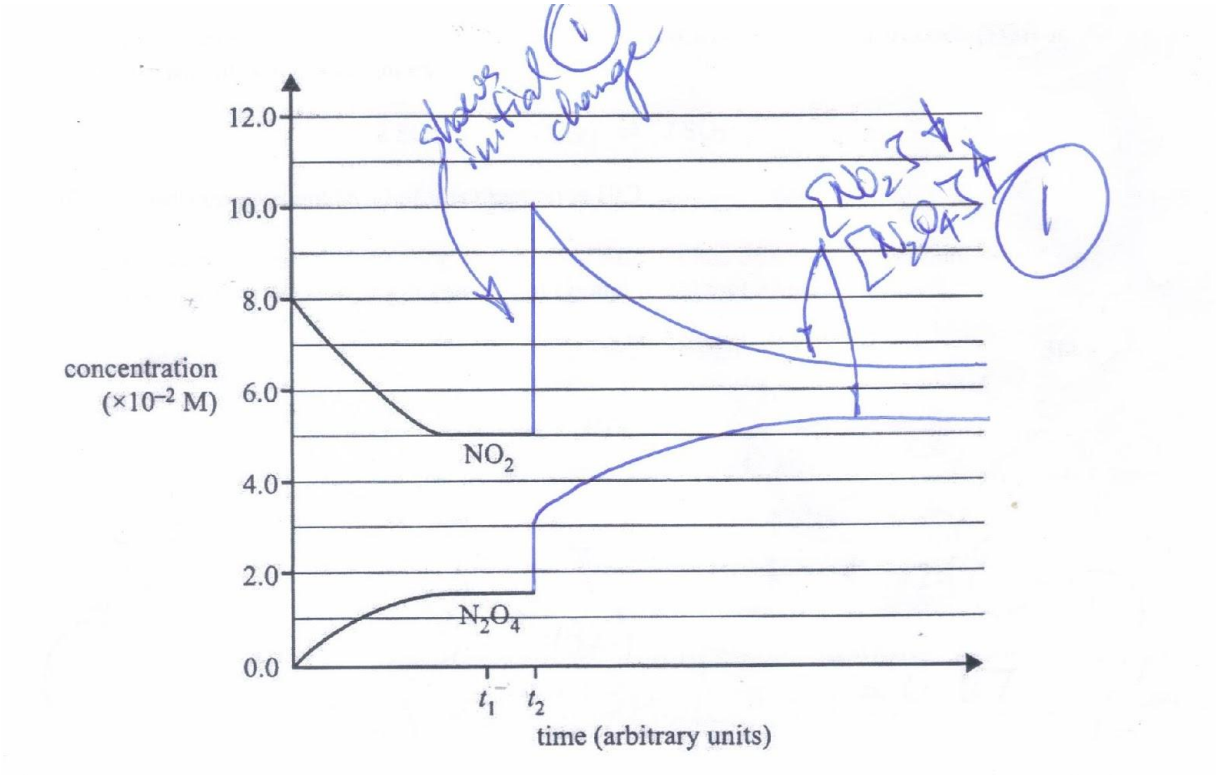
$$K = \frac{[N_2O_4]}{[NO_2]^2} = \frac{(1.5 \times 10^{-2})^2}{(5.0 \times 10^{-2})^2} = 6$$

Question 22 (b ii)

Criteria	Marks
● Shows correct increase in the concentration of both gases on the graph (both gases double concentration) ● Draws the correct graph for the gases returning to equilibrium	**2**
● Shows correct increase in the concentration of both gases on the graph (both gases double concentration) OR ● Draws the correct graph for the gases returning to equilibrium	**1**

Markers Comment:
Some students failed to recognize that a decrease in volume by a factor of 2 would increase the concentration of both reactant and product by a factor of 2 initially. Most students were able to demonstrate that the equilibrium would readjust so that $[NO_2]$ would decrease and the $[N_2O_4]$ would increase due to less moles of gas to decrease the initial increase in pressure/concentration.

Sample Answer:



Question 23 (a)

Criteria	Marks
• Determines the concentration of $SO_2 = 0.100$ and $O_2 = 0.132$ • Uses equilibrium expression to calculate $[SO_3] = 0.117$ M • Correct sig. fig. (3)	**3**
• Determines the concentration of $SO_2 = 0.100$ and $O_2 = 0.132$ • Uses equilibrium expression to calculate $[SO_3] = 0.117$ M	**2**
• Performs a valid calculation for moles OR provides a correct equilibrium expression	**1**

Markers Comment:
Many students used an ICE table but realized that the final concentrations could be directly determined using the number of moles divided by the volume (2L). Most students were able to determine the $[SO_3]$ using the value of K = 10.3 and gave the answer to the correct sig. fig (3)

Sample Answer:

$K = \dfrac{[SO_3]^2}{[SO_2][O_2]}$ $\quad [SO_2] = 0.200/2 = 0.100M \quad [O_2] = 0.264/2 = 0.132M$

$[SO_3] = K[SO_2]^2[O_2] = 10.3 \times (0.100)^2 \times (0.132) = 0.117$ mol/L

Question 23 (b)

Criteria	**Marks**
● Defines Le Chatelier's Principle OR Collision Theory ● Describes equilibrium moves to the right due to increased pressure/concentration of SO_2 due to Le Chatelier ● Explains how increased pressure/concentration results in more successful collisions and a change in the position of equilibrium	**3**
● Describes equilibrium moves to the right due to increased pressure/concentration of SO_2 due to Le Chatelier ● Explains how increased pressure/concentration results in more successful collisions and a change in the position of equilibrium	**2**
● Describes equilibrium moves to the right due to increased pressure/concentration of SO_2 due to Le Chatelier OR ● Explains how increased pressure/concentration results in more successful collisions and a change in the position of equilibrium	**1**

Markers Comments:
Most students understood that the equilibrium would move to the right and used collision theory or Le Chatelier to explain the change. Better students defined LCP and related the change directly to increases in concentration or pressure.

Sample Answer:
Le Chatelier's Principle states that a system at equilibrium when disturbed, will move in a direction to minimize the change. Collision theory is based on collisions of reacting particles. Adding 0.200 moles of SO_2 to the sample increases the concentration/pressure of the reactants, and the system will move to the right to reduce the concentration/pressure (less moles of gas). This is supported by collision theory, as a

greater concentration/pressure of reactants will result in more successful collisions with sufficient KE to produce products and move the equilibrium to the right.

Question 24 (a)

Criteria	Marks
● Uses Ksp (6.82×10^{-6}) to determine the saturation concentration of $[Mg^{2+}] = [CO_3^{2-}] = 2.61 \times 10^{-3}$ M OR uses concentration of the hard water to calculate a value for Q = 3.6×10^{-7} ● Indicates that the hard water $[MgCO_3] = 6.00 \times 10^{-4}$ M is less than the saturation concentration for $MgCO_3$ OR that Q < Ksp ● States that the solution is NOT saturated	**3**
● Determines the saturation concentration of $[Mg^{2+}] = [CO_3^{2-}]$ OR uses concentration of the hard water to calculate a value for Q	**2**
● Performs a relevant calculation related to Ksp	**1**

Markers Comments:
Many students calculated a value for Q and correctly compared the value to the Ksp for magnesium carbonate from the data sheet. Some students confused the concentration of the sample as being a Q value.

Sample Answer:

Based on Concentrations

$Ksp = [Mg^{2+}][CO_3^{2-}] = 6.82 \times 10^{-6}$

$[Mg^{2+}] = \sqrt{6.82 \times 10^{-6}} = 2.61 \times 10^{-3}$

$[Mg^{2+}]_{sat} > [Mg^{2+}]_{sample}$

Based on Q Value

$Q = [Mg^{2+}][CO_3^{2-}] = (4.00 \times 10^{-6})^2$

$Q = 3.6 \times 10^{-7}$

$Q < Ksp = 6.82 \times 10^{-6}$

Hard Water is NOT saturated

Question 24 (b)

Criteria	Marks
● Calculates the moles of $MgCO_3$ in 150 mL = 9.0×10^{-5} moles ● Calculates the molar mass of $MgCO_3$ = 84.32 g/mole ● Calculates the mass of $MgCO_3$ = 7.59×10^{-3} g = 7.59 mg	**3**
● Calculates the moles of $MgCO_3$ in 150 mL = 9.0×10^{-5} moles ● Calculates the molar mass of $MgCO_3$ = 84.32 g/mole	**2**
● Calculates the molar mass of $MgCO_3$ = 84.32 g/mole	**1**

Markers Comments:

Most students could perform this calculation but some did not give the units as asked by the question (mg). Better students set out their working clearly.

Sample Answer:

Moles of $MgCO_3$ in 0.150 L = c x v = 6.00×10^{-4} x 0.150 = 9.0×10^{-5} moles

Molar Mass of $MgCO_3$ = 24.31 + 12.01 + (16.00 x 3) = 84.32 g/mole

Mass of $MgCO_3$ in sample = moles x g/mole = 7.59×10^{-3} grams = 7.59 mg

Question 25

Criteria	Marks
• Defines TWO acid/base theories e.g. Arrhenius and Bronsted/Lowry • Describes ONE similarity and ONE difference for water as a solvent in both theories • Explains that water for Bronsted Lowry is AMPHIPROTIC • Explains the role of water for BOTH theories • Gives ONE advantage and ONE disadvantage for BOTH theories • Provides a judgement statement about the role of water in acid/base solutions • Propose ideas that demonstrate coherence and logical progression and include correct use of scientific principles and ideas	**9**
• Propose ideas that demonstrate a logical progression of most scientific principles and ideas related to Acid/Base theories	**8 - 7**
• Propose ideas that demonstrate a logical progression of some scientific principles and ideas to Acid/Base theories	**6 - 5**
• Propose ideas that demonstrate a basic understanding of some scientific principles and ideas related to Acid/Base theories	**4 - 3**
• Propose ideas that demonstrate an elementary understanding of some scientific principles and ideas related to Acid/Base theories	**2 - 1**

Markers Comments:
This is an area that students need to revise. Many students had a poor understanding of acid/base theory and many confused concepts. Most students did try to deal with water as the main focus but lacked specific detail to be awarded marks. This is a direct enquiry question from the syllabus and students should prepare for these sorts of questions by using ALARM strategies to prepare a logical response.

Sample Answer:

Acid and Base theories have evolved over time from observational theories of acid/base reactions to conceptual theories at the molecular level. Arrhenius and Bronsted Lowry are two conceptual theories that incorporate water as part of the theory.

Arrhenius states that acids ionize in aqueous solutions to produce hydrogen ions (H+) and bases ionize in aqueous solutions to produce hydroxide ions (OH^-). Water is the solvent required but does not play a direct role in the formation of ions. This theory was able to explain strong and weak acids (degree of ionization) but was unable to explain non aqueous acid/base behavior or acidic and basic salts.

Bronsted Lowry Theory states that acids are proton donors and bases are proton acceptors. Water can be the solvent but differs to Arrhenius in that water is an AMPHIPROTIC substance, able to act as both an acid and a base and has a specific role in acid/base solutions as a proton donor or acceptor, as shown by the self-ionization of water equation below.

$$\underset{\textit{Base 1}}{H_2O} + \underset{\textit{Acid 2}}{H_2O} \rightleftharpoons \underset{\textit{Acid 1}}{H_3O^+} + \underset{\textit{Base 2}}{OH^-}$$

Bronsted Lowry is able to explain acid/base behavior of some salts and non-aqueous solutions but still had some difficulties explaining non proton solutions and substances e.g BF_3, reactions of acidic/basic oxides.

The role of water has changed in acid/base theory, from the medium required for ionization in Arrhenius Theory to the amphiprotic nature of water and its role in aqueous acid/base behavior. Acid theory will continued to evolve to explain the nature of aqueous and non-aqueous solutions and mixtures.

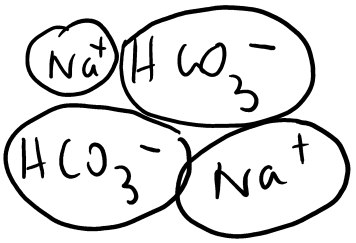
Question 26 (a)

Criteria	**Marks**
• Labels a scientific model of water molecules showing dipoles and Na^+, HCO_3^- OR CO_3^{2-} ions • Identifies intramolecular covalent bonds for water OR ionic bonds in $NaHCO_3$ • Identifies intermolecular ion-dipoles between the cations and anions and the dipoles of water OR demonstrates hydrogen bonding between water molecules	**3**
• Completes 2 of the above requirements	**2**
• Some relevant chemistry in relation to 1 above requirement	**1**

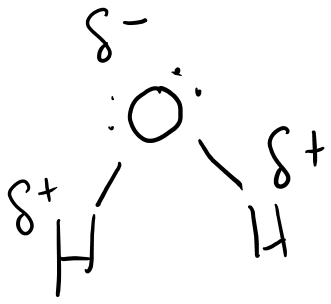
Markers Comments: Many students drew diagrams that contained water molecules, better students identified the dipoles on both the hydrogen and oxygen molecules in water and demonstrated hydrogen bonding between water molecules. Many students did not state that covalent bonding in water and ionic bonding in $NaHCO_3$ demonstrated the intramolecular forces that occurred.

Sample Answer:
$NaHCO_3$ contains ionic bonds due to an ionic lattice in the solid, water contains covalent bonds due to bonding of non-metallic elements. Water demonstrates a dipole that exists due to the electronegativity of oxygen, the electrons from hydrogen are drawn towards oxygen forming a dipole.
Sodium ions are surrounded by water molecules as are the hydrogen carbonate ions – the ion dipole interaction allows the NaHCO3 lattice to dissolve in the water.

Intramolecular interaction

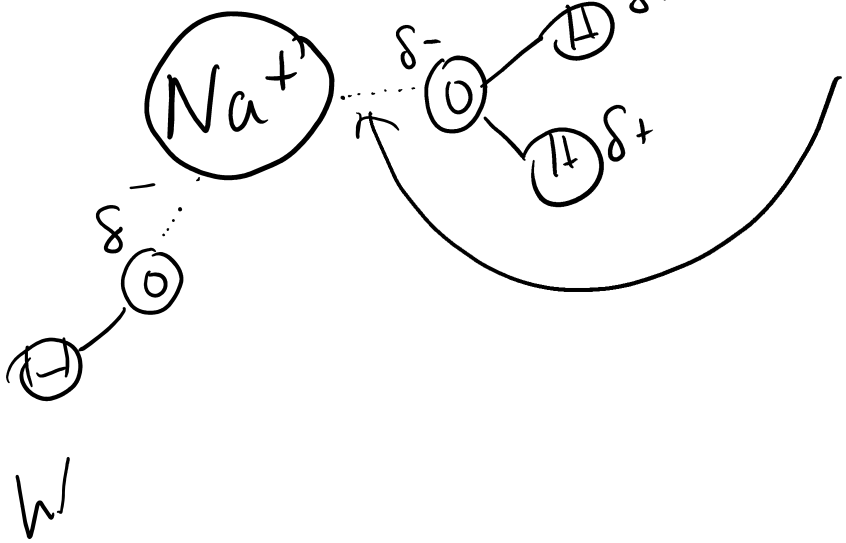


Ionic lattice structure, positively charged ions attracted to negatively charged ions.



Water molecules contain covalent bonds, dipole exists due to electronegativity of oxygen.

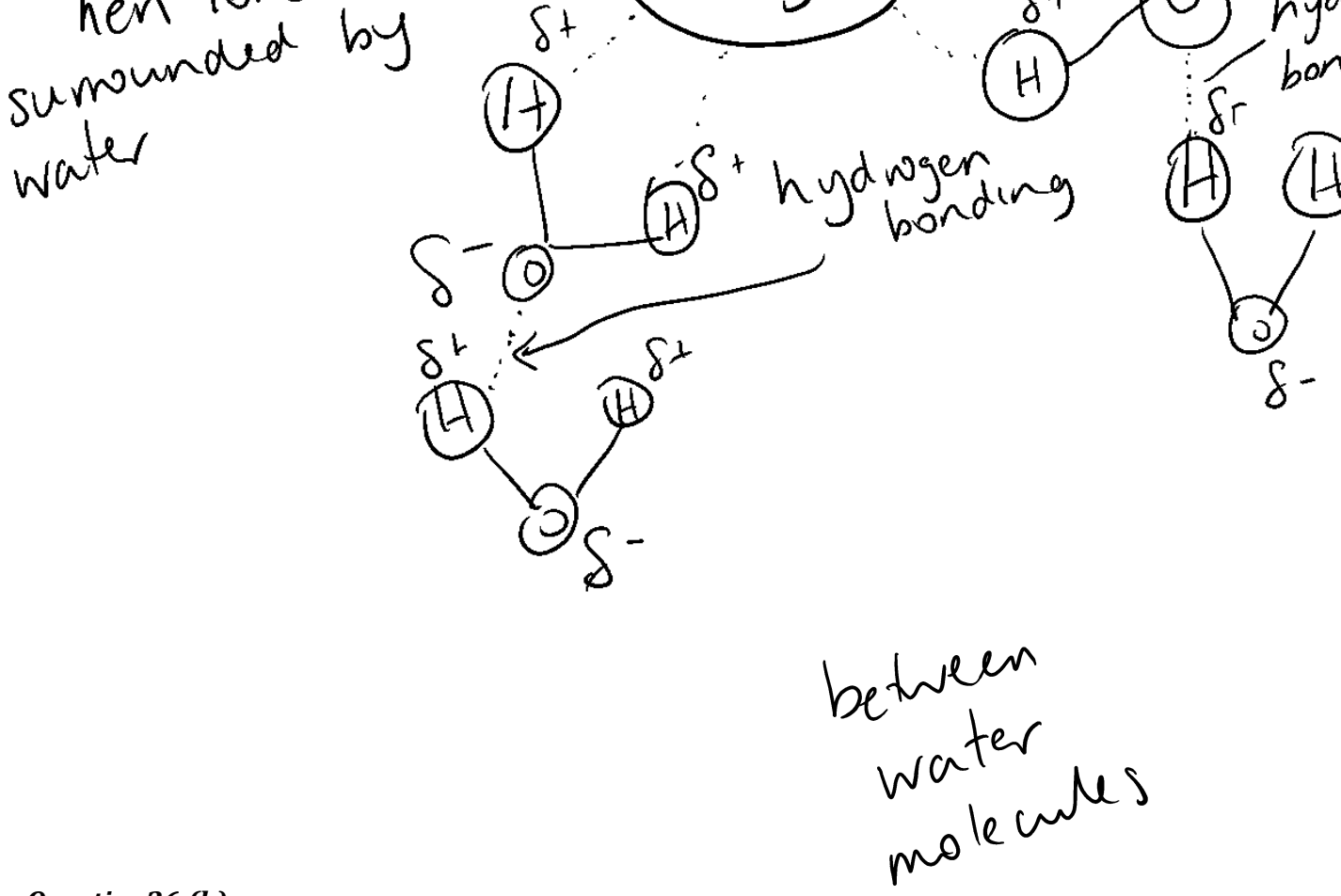
Intermolecular interaction



Ion-dipole intermolecular interaction

W

dissolution occurs.

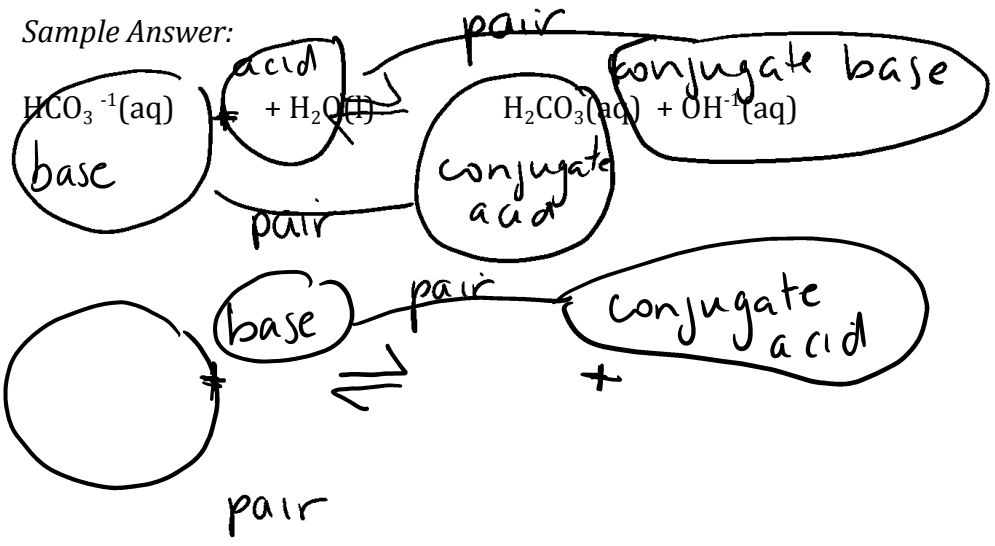


Question26 (b)

Criteria	Marks
• Constructs TWO balanced ionic equations showing HCO_3^- acting as an acid and a base • Clearly identifies acid/base conjugate pairs for both equations • Shows all correct states	**3**
• Constructs TWO balanced equations with correct states OR ONE balanced equation with correct conjugate pairs identified and correct states	**2**
• Constructs ONE balanced equation OR defines the terms conjugate acid and conjugate base	**1**

Markers Comments: Students need to clearly identify <u>both</u> conjugate pairs in each reaction. Many students only identified ONE conjugate acid/ base pair in the equations that they wrote.

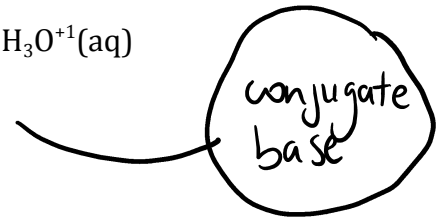
Sample Answer:



$HCO_3^{-1}(aq)$ + $H_2O(l)$

$CO_3^{-2}(aq) + H_3O^{+1}(aq)$

acid



Question 27 (a)

Criteria	Marks
• Calculates the moles of excess HCl = 7.5 x 10^{-5} moles • Calculates the [HCl] = 5.77 x 10^{-4} moles/L • Calculates the pH = 3.24	**3**
• Constructs a balanced chemical equation • Calculate number of moles of HCl and NaOH	**2**
• Constructs a balanced chemical equation	**1**

Markers Comments: Many students correctly determined the pH of the final solution. Those who did not divide by the total volume of the solution (0.130L) calculated an incorrect pH.

Sample Answer:

$HCl(aq) + NaOH(aq) \rightarrow H_2O(l) + NaCl(aq)$

HCl n=c*V
= 0.155M * 0.0750L
= 0.011625 moles

NaOH n= c*V
= 0.210M * 0.0550L
= 0.01155 moles

Ratio 1:1 for HCl:NaOH

HCl is in excess. Excess = 0.011625 moles - 0.01155 moles
= 0.0000750 moles

Conc. of H^+ in final mixture = n/V
= 0.0000750 moles / 0.130L
= 0.0005769 M

pH = -log[0.0005769]
= 3.24

Question 27 (b)

Criteria	Marks
• Identifies that the mixture is NOT a buffer • Provides a valid reason/justification	**2**
• Identifies that the mixture is NOT a buffer	**1**

Markers Comments: Many students gained one mark for their response in this question. Equimolar volumes/concentrations of the weak acid and the salt of the conjugate base need to be stated as the reason for a buffer.

Sample Answer: The mixture is NOT a buffer solution. A buffer consists of equimolar volumes of a weak acid and the salt of the conjugate base. HCl is a strong acid and is not suitable for producing a buffer, NaOH is a strong base and is not the salt of the conjugate base of HCl so it is also unsuitable for use as part of a buffer.

Question 27 (c)

Criteria	Marks
● Provides a balanced equation for the buffer ● Describes that OH^- ions are neutralised by H_3O^+ causing a shift in the position of equilibrium ● Explains that the shift in the equilibrium of the buffer is able to maintain a stable pH	**3**
● Explains that the shift in the equilibrium of the buffer is able to maintain a stable pH ● Provides a balanced equation for the buffer	**2**
● Explains that the shift in the equilibrium of the buffer is able to maintain a stable pH	**1**

Markers Comments: Most students recognized that a buffer minimises the change in pH if a strong acid or base is added to the buffer. Many students did not write the correct expression for the buffer and as such did not explain how equilibrium would shift if OH^- was added.

Sample Answer: $CH_3COOH + H_2O \rightleftharpoons CH_3COO^{-1} + H_3O^{+1}$

A buffer is a solution which minimizes the change in pH in a system when small amounts of acid or base are added.
The reaction ids an equilibrium reaction and as such Le Chatelier's Principle (LCP) is applied, if the system is disturbed the equilibrium will move in such a way as to minimize the change and return the system to equilibrium. The addition of OH^{-1} will result in H_3O^{+1} being used up, so by LCP the system, is disturbed, to minimize this change the equilibrium will shift to the right and produce more H_3O^{+1} and CH_3COO^{-1} by reducing the $CH_3COOH + H_2O$. As the OH^{-1} reacts with H_3O^{+1} more CH_3COO^{-1} is produced and this minimizes the pH change.

Question 28 (a)

Criteria	Marks
● Names the reaction as NEUTRALISATION	**1**

Markers Comments: Most students correctly identified the reaction although a small number stated precipitation.

Sample Answer: Neutralisation

Question 28 (b)

Criteria	Marks
• Describes that acids and bases produce ions in solution which conduct e^- • Explains the decrease and increase in conductivity due to an endpoint of the neutralisation reaction • Explains that the conductivity at endpoint is zero as the Barium Sulfate salt formed is insoluble, providing no ions for conduction	**3**
• Describes that acids and bases produce ions in solution which conduct e^- • Explains the decrease and increase in conductivity due to an endpoint of the neutralisation reaction	**2**
• Describes that acids and bases produce ions in solution which conduct e^- OR • Explains the decrease and increase in conductivity due to an endpoint of the neutralisation reaction	**1**

Markers Comments: Many students did not understand that conductivity dropped to zero due the formation of water (that did not conduct electricity) and the solid $BaSO_4$ (that did not conduct electricity) as there are no ions in the solution to conduct electricity.

Sample Answer: Acids and bases ionise when placed into water form ions in solution, the ions produced allow electricity to be conducted through the solution. Initially the conductivity is high as there are a large number of barium ions and hydroxide ions present in the solution. As the volume of sulfuric acid increases neutralisation occurs and the number of ions present in the solution decreases (H^{+1} reacts with OH^{-1} so less ions and Ba^{+2} and SO_4^{-1} reacts to produce a solid, so less ions in solution) and the conductivity drops to zero. As more sulfuric acid is added the number of ions in solutions increases and the conductivity of the solution increases.

Question 28 (c)

Criteria	Marks

• Calculates moles of $Ba(OH_2) = H_2SO_4 = 2.7 \times 10^{-3}$ moles • Calculates $[H_2SO_4] = 0.135$ moles/L	**2**
• Calculates moles of $Ba(OH_2) = H_2SO_4 = 2.7 \times 10^{-3}$ moles OR • Calculates $[H_2SO_4] = 0.135$ moles/L	**1**

Markers Comments: Many students correctly answered this question.

Sample Answer:
Ratio of $Ba(OH)_2 : H_2SO_4$ is 1:1

H_2SO_4 n=c*V
= 0.120M * 0.0225L
= 0.00270 moles

From ratio amount of $Ba(OH)_2$ is 0.00270 moles.

$Ba(OH)_2$ c= n/V
= 0.00270 moles/ 0.0200L
= 0.135 M

Question 29

Criteria	**Marks**
• Describes how the method could remove soluble toxins • Relates method to solubility equilibria • Explains why the method is ineffective due to solution becoming saturated • Describes a suitable modification (replacing water regularly, flowing stream)	**4**
• Describes how the method could remove soluble toxins • Relates method to solubility equilibria • Describes a suitable modification (replacing water regularly, flowing stream)	**3**
• Describes how the method could remove soluble toxins • Describes a suitable modification (replacing water regularly, flowing stream)	**2**
• Describes how the method could remove soluble toxins OR • Describes a suitable modification (replacing water regularly, flowing stream)	**1**

Markers Comments: Many students understood that as the toxin is soluble washing with water will assist in removing toxin. Better students constructed and equilibrium equation to demonstrate the equilibrium between the solid toxin and the aqueous toxin.

Many students did not state that the solution became saturated and this is why the water needs to be replaced.

Sample Answer: The toxin is soluble in water and soaking will assist in removing the toxin.
Toxin (s) $\rightleftharpoons$ Toxin (aq). A static equilibrium occurs between the solid toxin and aqueous toxin, the solution of water becomes saturated and no more toxin can dissolve, so the concentration of toxin in the water and the cycad does not change. The bucket replicates a closed system. If the water is replaced then the concentration of the aqueous toxin is initially low, as more toxin dissolves the solution will reach equilibrium again. To produce dynamic equilibrium and remove the toxin from the cycad Simon needs to place the cycad material into a water permeable bag that is placed in running water. As the toxin(aq) is continually removed the equilibrium will shift to the right, this means more solid toxin dissolves in the water and the concentration of toxin is reduced.

Question 30 (a)

Criteria	Marks
● Gives a correct equation for fermentation	**1**

Markers Comments:
It was surprising to see that not ALL students got this question correct as fermentation is one of the simpler chemical reaction studied. Students MUST remember to include relevant conditions in any chemical reaction as it is PART of the requirements of a balanced chemical reaction – the reaction would not otherwise take place. However, marks were not deducted in this exam but students are encouraged to avoid this in the HSC Examination.

Sample Answer:

$$C_6H_{12}O_6 \xrightarrow[37°C]{yeast} 2CH_3CH_2OH + 2CO_2$$

Question 30 (b)

Criteria	Marks
● Gives a balanced equation for the combustion of octane	**1**

Markers Comments:
Combustion reaction has been studied since year 10. It was disappointing to see that some students left this incomplete and/or not properly balanced. Students are advised to practise balancing equations as calculations are dependent on whether the equation is balanced.

Sample Answer:

$$C_8H_{18} + \frac{25}{2}O_2 \rightarrow 8CO_2 + 9H_2O$$

OR

$$2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$$

Question 30 (c)

Criteria	**Marks**
• Describes ethanol as a RENEWABLE fuel and octane as a NONRENEWABLE fuel • Describes how ethanol and octane are obtained • Gives ONE advantage and ONE disadvantage of ethanol as a fuel • Gives ONE advantage and ONE disadvantage of octane as a fuel • Provides a valid judgement statement about the impacts of the fuels with respect to their obtainment and use	**5**

Markers Comments:
The average mark was 2-3 marks. Students could generally identify that ethanol is renewable while octane is not and managed to provide 1-2 advantages and/or disadvantages. Unfortunately the description of how both fuels are obtained was vague or non-existent. Most students overall assessment was weak and was not enough to push them to a 5 marker.

There were some misconceptions that ethanol is non-renewable and was obtained from fossil fuel. While it is possible to produce ethanol through the hydration of ethylene, also derived from fossil fuel – it is not how ethanol is mass produced in industry. Also, octane is NOT obtained from COAL. It is strictly retrieved from fractional distillation of crude oil. Crude oil is extracted through oil rigs drilled into the Earth.

Sample Answer: Note that the criteria only asks for 1 adv and 1 disadv for each.

	Ethanol	Octane
Adv	- Renewable fuel made from the fermentation of sugar under anaerobic conditions. - Undergoes complete combustion, thus does not produce soot (bad for respiratory system) or CO which is toxic. - Relatively carbon neutral due to CO2 produced being used by plants to photosynthesize.	- Produces sufficient energy per mole. - Cheaper to obtain than ethanol, due to vast energy reserves and efficient processing

Disadv	- Requires large arable land to grow sugarcane which reduces available land for other agricultural purposes. - Less energy is produced thus more is required to burn to do the same work as octane. - Only 15% of ethanol is produced during fermentation. Thus energy input is greater to mass produce ethanol to support demands. - Energy, sourced from fossil fuel, is used to harvest plants, conduct the fermentation process and transport the fuel. - Requires engine modification = high costs; as ethanol reacts with water and is corrosive to engines.	- Non-renewable fuel obtained through fractional distillation of crude oil (500°C) - Oil rigs may leak during extraction of crude oil offshore causing harm to the aquatic organisms and ecosystems. - Undergoes incomplete combustion producing soot and CO. Contributes to photochemical smog.

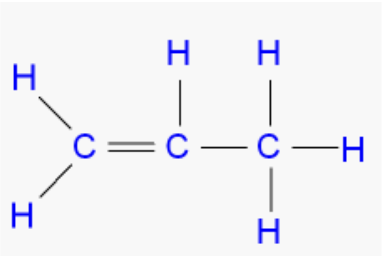
Overall, ethanol and octane can both be used as fuels. Octane is currently cheaper to obtain and while it has a negative impact on the environment it is highly efficient in providing the energy required to run current machinery, benefiting societal needs. However, depleting resources of octane means alternate fuel sources must be sought after, thus ethanol has a potential to replace octane given its renewability and positive environmental impacts. However, manufacturing and using ethanol as a fuel is not economically viable given high energy expenditure and costs.

Question 31 (a)

Criteria	Marks
● Draws structural formula for propene	**1**

Markers Comments:
Students need to take care drawing their structures to ensure that C only forms a total of 4 bonds. A number of students drew propane which awarded no marks as students had to demonstrate the understanding that propene was the starting material that reacted with H_2O/H^+ to make propan-1-ol by hydrolysis.

Sample Answer:



Question 31 (b)

Criteria	Marks

● Identifies a correct oxidising reagent	**1**

Markers Comments:
Students either knew the reagents or they didn't. The reagent must include the acidification of either $Cr_2O_7^{2-}$ or MnO_4^- as this is the condition in which it will only work.

Sample Answer:
$H^+/Cr_2O_7^{2-}$ OR H^+/MnO_4^-

Question 31 (c)

Criteria	Marks
● Correctly names the compound	**1**

Markers Comments:
Students need to revisit the series of reactions that organic compounds can undertake to convert from one form into another. It would be great practice to draw a range of flow diagrams to illustrate this as this is considered a Band 6 level question. Students must also take care to relearn the naming conventions (IUPAC).

Answer*: ethyl propanamide (NOTE: naming is similar to the ester identified above For an Amide - Short chain ethyl Long chain propan)*

Question 31 (d)

Criteria	Marks
● Draws the correct structural formula for the reactants ethanol and propanoic acid ● Gives the equilibrium arrow and the catalyst required ● Draws the correct structural formula for ethyl propanoate and water as the products	**3**
● Provides 2 of 3 of the criteria above	**2**
● Provides 1 criterion.	**1**

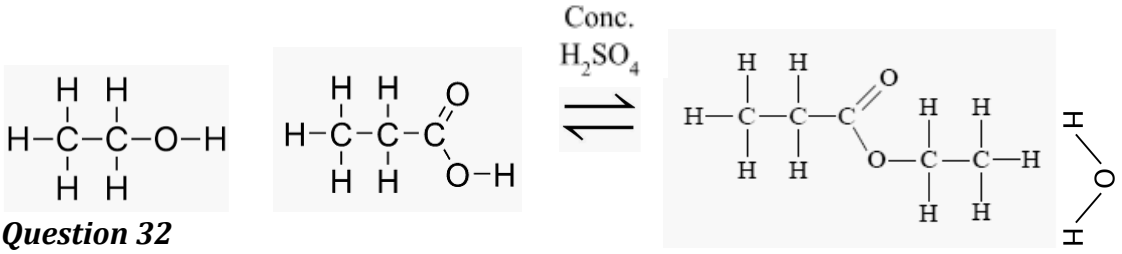
Markers Comments:
Some students did not read the question carefully and did not draw the structural formula. Some students lost marks for not including WATER as the product.

Most students lost 1 mark for not including the equilibrium arrow. This is an equilibrium reaction which is why concentrated sulfuric acid is required as a dehydrating agent. The role of sulfuric acid is to remove the water as it is produced, encouraging the reaction to go forward.

Other errors include drawing methanol or propanol instead of ethanol OR drawing ethanoic acid instead of propanoic. Remember the alkyl group of ester is derived from

the alkanol and the alkanoate is derived from the alkanoic acid. Students do need to take care to also draw OH carefully where O is actually attached to the C atom.

Sample Answer:



Question 32

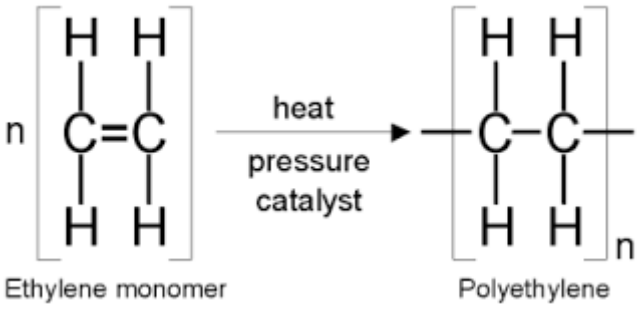
Criteria	Marks
Students must ● extensively describe the polymerization process undertaken to produce the polymer ● represent the formation of the polymer correctly using a relevant, balanced chemical equation. ● identify a property of the polymer ● specifically relate this property to the use of the polymer stated.	**5**
Demonstrates some knowledge of the properties of polymers and their use in a named product.	**3 - 4**
Students mention some basic information related to production and/ or use of the polymer.	**1 -2**

Markers Comments:

Students could mostly identify the type of polymerization that took place – either addition or condensation polymerization. However, very little outlined the chemical processes involved in its production i.e. the role of free radicals in initiating the polymerization; the propagation and termination process. No student addressed nylon and it is important that students are prepared for the HSC KNOWING about condensation polymerization as well.

Sample Answer:

High density polyethylene is formed from ethylene monomer units via ***addition polymerization***. Conditions: low pressure and mild temperature, in the presence of a catalyst (Ziegler-natta).



The process occurs in 3 stages:

Initiation: the addition of a free radical is used to break the double bond across the C-C bonds.
Propagation: reaction proceeds by repeating additions of monomer units as they collide
Termination: occurs by combination of radical polymer chains
HDPE is linear (unbranched), allowing for greater packing between polymer molecules. It is commonly used to make bottles as it is resistant to water, therefore will not degrade and/or leak. It is rigid and has a high tensile strength so it does not break easily whilst holding liquids or during transport of liquids.

Question 33

Criteria	Marks
Students ● describe a suitable chemical test for alkenes or alkanols, stipulating the colour change that indicates a positive test ● provides a relevant balanced equation	**3**
Students ● describe a suitable chemical test for alkenes or alkanols and either stipulates the colour change OR provides a relevant balanced equation	**2**
Students identifies a suitable test	**1**

Markers Comments:
Students generally chose the bromine water test. It is important that students revisit the practical experiments conducted throughout the course.

Alkenes are not coloured and they do NOT decolourise. Bromine water is yellow/brown and will decolourise when added to alkenes when it undergoes addition reaction.

Students must take care with how they express themselves in their responses. E.g. "it will decolourise" – the IT needs to be stipulated clearly for the marker to know you mean the bromine water or not. They will not give you the benefit of the doubt.
Students must understand that HBr or Br^{2+} is NOT bromine water. Acceptable formula to use is either Br_2 or BrOH.

Sample Answer:
Bromine water test. Bromine water is yellow/brown and when added to but-1-ene (colourless) will decolourise as it undergoes addition reaction in the absence of UV light. Butan-1-ol which is also colourless, will not react with the bromine water, so no colour change in the bromine water will be observed.

$$C_4H_8 + Br_2 \rightarrow C_4H_8Br_2$$

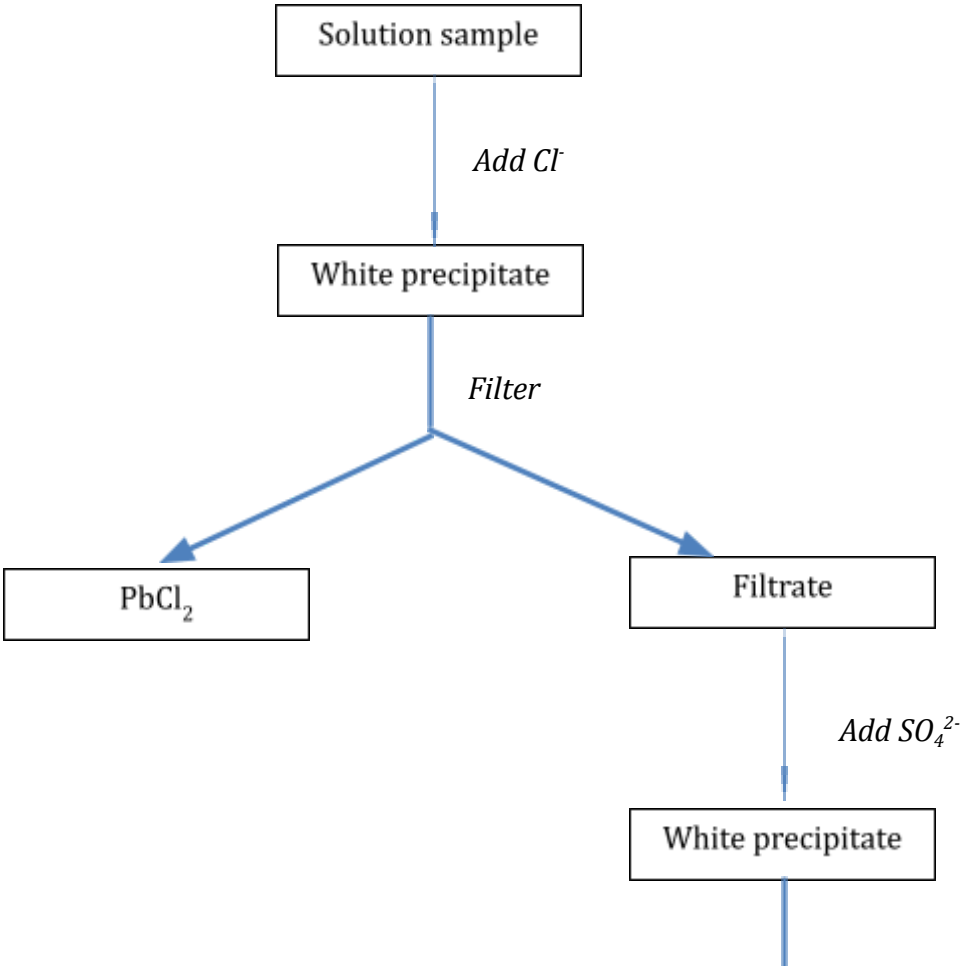
Question 34

Criteria	Marks
• Draws a flow chart using shapes and arrows • Produces a logical order for testing and confirming the presence of all 3 cations using anions (Cl^- then SO_4^{2-}) • Filters off the precipitates before retesting solution • Correctly confirms the 3 cations	**4**
• Draws a flow chart to identify all 3 cations using precipitation and/or flame test but NO evidence of filtering samples	**3**
• A flow diagram is drawn with no logical sequence and only 1-2 cations are correctly confirmed.	**2**
• A flow diagram is drawn with 1 pertinent information provided linked to the identification of a cation.	**1**

Markers Comments:
Students need to make sure that they draw a flow diagram that addresses the question – that is, confirming the presence of ALL three cations. It was not asking to identify which cation was present in solution therefore a 'yes/no' format was not appropriate.

Students mostly failed to filter their samples to remove the precipitate. It is important to understand that flame tests cannot be conducted when more than 1 cation is present as there will be a clash in flame colour.

Sample Answer:



Filter

Add OH^-

The last step for Cu^{2+} can be a flame test