Baulkham Hills High School

Chemistry 2022

Trial HSC Examinations

Instructions:

- Reading time, 5 minutes
- Working time, 3 hours
- Read all instructions carefully
- Attempt ALL questions
- Write using black or blue pen
- Diagrams and graphs in pencil
- Write your student number in the space provided on the Answer Booklet
- SHOW ALL WORKING
- Extra writing paper is provided at the back of the section II

Total Marks:

This paper has two sections.

Part A

20 Multiple choice questions

Part B

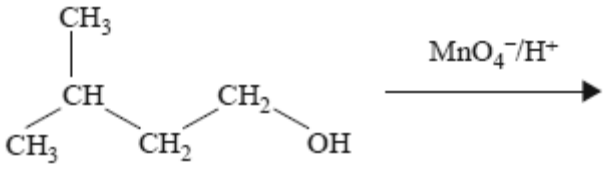
13 Extended response

Notes:

There will be no remarking (or adjustments) of written responses that are:

- Written in pencil
- Inserted by a caret (^) or
- Contain illegible writing that needs explanation of the author
- Written in the margin.
- All additional paper must be clearly referenced in the question (" Continued on extra paper") and annotated clearly with the question number
- Responses are expected to be coherent (ordered), succinct and legible.

Question 1

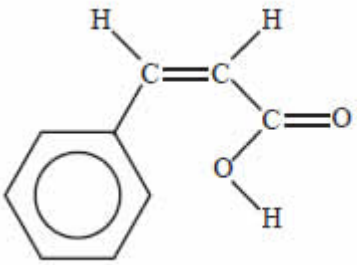


What is the systematic name for the product of the reaction above?

A 2-methylpentanoic acid
B 4-methylpentanoic acid
C 2-methylbutanoic acid
D 3-methylbutanoic acid

Question 2

Cinnamic acid is an organic substance that partly contributes to the flavour of oil of cinnamon. A structure of cinnamic acid is given below.

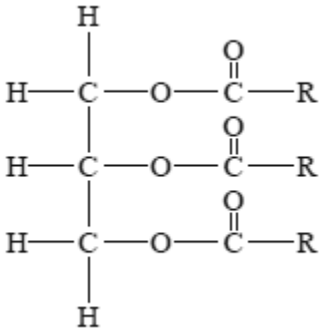


Which of the following reagents would you expect to react with cinnamic acid under the conditions given

	CH_2CH_2 and catalyst	$Br_2(aq)$ at room temperature	CH_3OH and H_2SO_4 catalyst
A.	Yes	Yes	Yes
B.	Yes	No	Yes
C.	No	Yes	Yes
D.	No	Yes	No

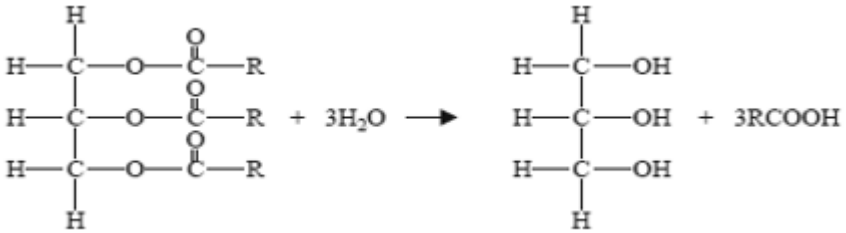
Question 3

The general formula of a triglyceride can be represented as follows.

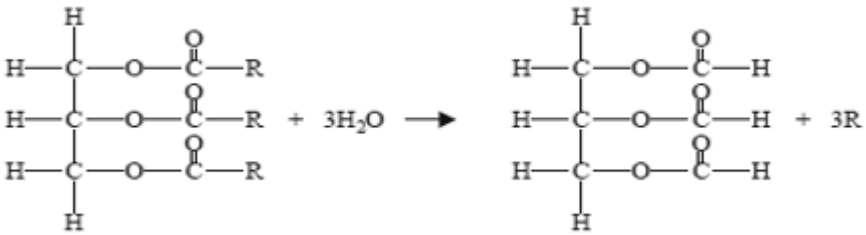


Which one of the following equations represents the hydrolysis of a triglyceride?

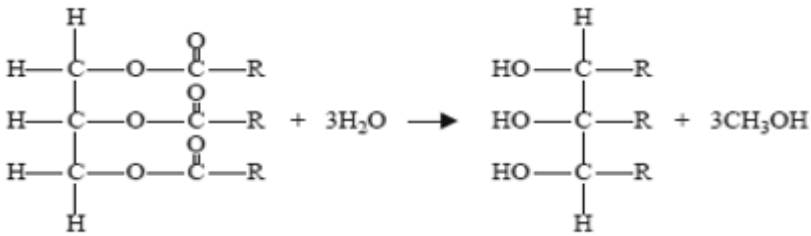
A



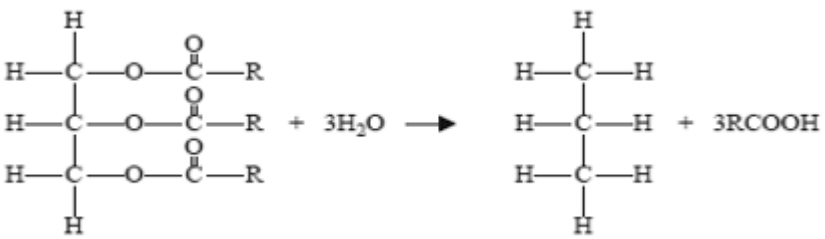
B



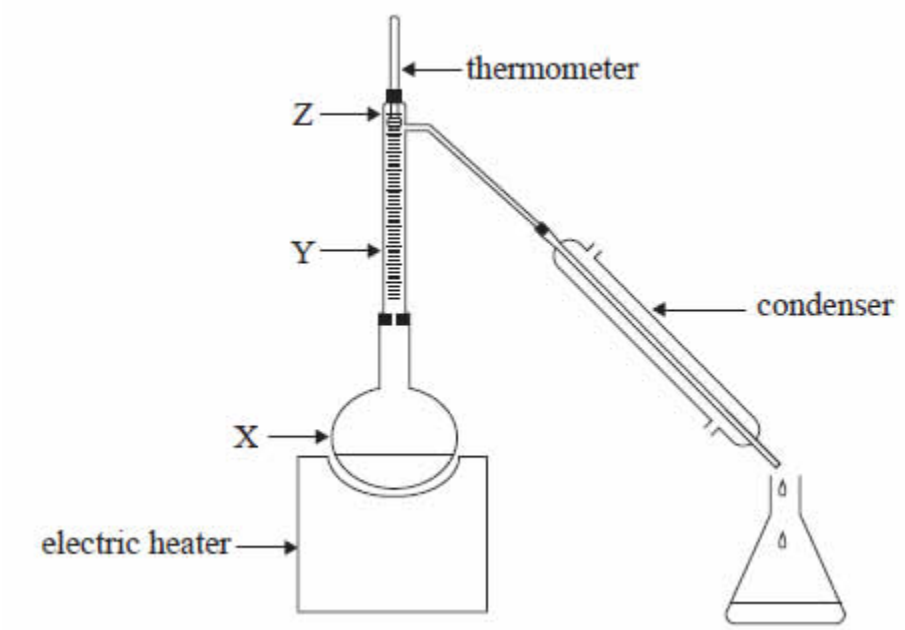
C



D



Question 4



A liquid mixture of 50% ethanol and 50% water was distilled in the apparatus shown above. The boiling point of ethanol is 78°C and that of water is 100°C. As the mixture was heated the temperature shown by the thermometer initially rose but then remained constant at 78°C for some time.

Which one of the following statements about percentage of ethanol in the vapours shown at points X, Y and Z, when the temperature is at a constant 78°C, is true?

A The percentage of ethanol in the vapours at X is equal to 50%.

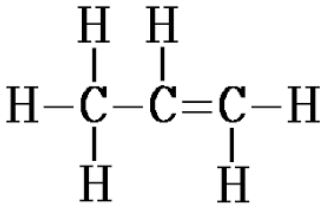
B The percentages of ethanol in the vapours increase in order at positions X, Y and Z

C. The percentages of ethanol in the vapours at Y and Z are equal but greater than at X.

D The percentages of ethanol in the vapours at X, Y and Z are equal but greater than 50%.

Question 5

The diagram below shows the structural formula of Prop-1-ene.



How many signals would it show in C-13 NMR and Proton NMR?

	Proton NMR	C-13 NMR
A	3	3
B	4	4
C	3	4
D	4	3

Question 6

Nitrogen dioxide (a brown gas) and dinitrogen tetroxide (a colourless gas) are both forms of oxides of nitrogen. They are in equilibrium according to the equation

$$2NO_2(g) \quad \rightleftharpoons \quad N_2O_4(g)$$

An equilibrium mixture of the two gases at room temperature is light brown but at higher temperatures the colour becomes a much deeper brown. What conclusion can be drawn from this observation?

A The reverse reaction in the equation is endothermic.
B The forward reaction in the equation is endothermic
C The brown colour is due to the strong nitrogen–oxygen bonds in NO_2.
D The equilibrium concentration of N_2O_4 is not dependent on temperature

Question 7

Hydrogen gas reacts with iodine gas to form hydrogen iodide according to the following equation.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \text{ at } 700 \text{ k}$$

At equilibrium, the concentrations for H_2, I_2 and HI are as follows: 0.214 mol L^{-1}, 0.214 mol L^{-1} and 1.57 mol L^{-1} respectively.

What is the value of the equilibrium constant for this reaction?

A 0.018
B 0.029
C 34.3
D 53.8

Question 8

What will happen when sulfuric acid is added to a saturated solution of sparingly soluble calcium sulphate? [K_{sp} ($CaSO_4$) = 2.4 x10^{-5}]

A The concentration of calcium and sulphate ions will increase over time due to the presence of H^+ ions.
B The concentration of calcium and sulphate ions will decrease over time due to the presence of H^+ ions
C The concentration of calcium and sulphate ions will increase over time due to the presence of SO_4^{2-} ions.
D The concentration of calcium and sulphate ions will decrease over time due to the presence of SO_4^{2-} ions.

Question 9

At a certain temperature, the K_{eq} for the following reaction is 75.

$$2O_3(g) \rightleftharpoons 3O_2(g)$$

0.3 mol of O_3 and 1.5 mol of O_2 were introduced to a 5 L reaction vessel.

Which row of the table correctly identifies the direction of the equilibrium shift and the reason for the shift?

	Direction favoured	Reason
A	Left	$Q > K_{eq}$
B	Left	$Q < K_{eq}$
C	Right	$Q > K_{eq}$
D	Right	$Q < K_{eq}$

Question 10

Hydrogen, H_2, is produced on an industrial scale from methane, CH_4.

The equation for the reaction is

$$2H_2O(g) + CH_4(g) \rightleftharpoons CO_2(g) + 4H_2(g)$$

If an inert gas is added to the equilibrium system at a constant temperature and a constant volume, the concentration of H_2 will

A increase.
B decrease.
C not change.
D decrease then increase

Questions 11, 12 and 13 refer to the following information.

The sulphate (SO_4^{2-}) content of a plant fertiliser is to be determined by gravimetrically analysing a 2.5g sample of fertiliser.

Question 11

The first part of this analysis would involve

A producing a precipitate
B filtering the sulphate ions from the insoluble material in the fertiliser
C dissolving the sulphate from the fertiliser into water
D adding an indicator to an aliquot of the sulphate solution

Question 12

An important part of gravimetric analysis is to react the chemical under analysis with an excess solution to produce a precipitate. This solution is known as precipitating reagent. Which precipitating reagent would be the most suitable for this analysis?

A NaCl (aq)
B Ba(NO3)2 (aq)
C KCl (aq)
D CuSO4 (aq)

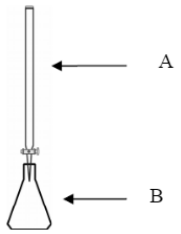
Question 13

Which of the following errors in experimental procedure would produce a % of sulphate in the fertiliser that would be LESS than the true value?

A Failure to wash the precipitate with distilled water
B Failure to dry the precipitate to a constant mass.
C Failure to add an excess amount of precipitating reagent.
D Failure to let the precipitate dry in an oven.

Questions 14, 15 and 16 refer to the following information.

A 20 mL aliquot of vinegar is titrated with 15mL of 0.10M NaOH. Some of the equipment used for this titration is shown below.



Question 14

The piece of equipment labelled A on the diagram should be

A rinsed with distilled water and filled with 20 mL of vinegarOH. Some of the
B rinsed with distilled water and filled with 0.10 M NaOH.
C rinsed with 0.10 M NaOH and filled with 0.10 M NaOH
D rinsed with vinegar and filled with 20 mL of vinegar

Question 15

If the equipment labelled A is rinsed with distilled water only prior (before) to the titration

A the volume of NaOH used will be 15 mL
B the volume of vinegar used will be less than 15 mL
C the volume of NaOH used will be greater than 15 mL
D the volume of NaOH used will be exactly 20 ML

Question 16

If the equipment labelled B is rinsed with distilled water prior to the titration

A the volume of NaOH used will be 15 mL
B the volume of vinegar used will be less than 15 mL
C the volume of NaOH used will be greater than 15 mL
D the volume of NaOH used will be exactly 20 mL

Question 17

Which of the following rows correctly corresponds with the symbols that describe the thermodynamic properties of a system?

	ΔG	ΔH	ΔS
A	Change in Gibbs free energy	Change in heat content	Change in randomness
B	Total Gibbs free energy	Total heat content	Total randomness
C	Initial Gibbs free energy	Initial heat content	Initial randomness
D	Change in randomness	Change in Gibbs free energy	Change in heat content

Question 18

For a chemical equilibrium $A + B \leftrightarrow 2C$, the value of the equilibrium constant (K_{eq})

is 4.2×10^{-5}.

What is the value of the equilibrium constant in reverse reaction?

A 2.38×10^{-5}

B 1.54×10^{2}

C 2.38×10^{4}

D 4.2×10^{5}

Question 19

When an ionic solid dissolves in water and forms a saturated solution, the process can be described in stages. These stages include:

I. When two opposing rates are equal, the system reaches equilibrium.
II. Aqueous ions arrive at the solid lattice and become part of it.
III. The ionic lattice dissociates into individual ions
IV. The ionic lattice is surrounded by water molecules

Which of the following gives the correct order of stages?

A I, II, III, IV

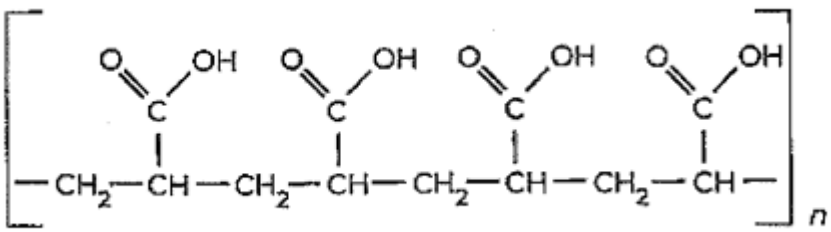
B III, I, IV, II

C IV, II, III, I

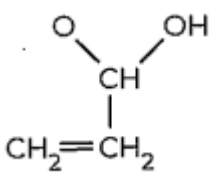
D II, IV, I, III

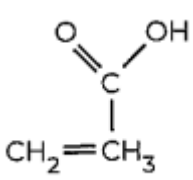
Question 20

The diagram shows a portion of a polymer



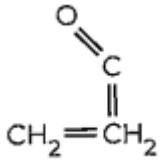
Which the structures represent the monomer?

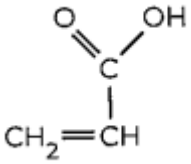
A 

B 

C

D





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Student ID _____

Section I –Multiple Choice Answer Sheet

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

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

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 ○

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2022 **HIGHER SCHOOL CERTIFICATE**
TRIAL EXAMINATION

Baulkham Hills High School

Chemistry

Section II

Answer Booklet

80 marks

Attempt Questions 21–33

Allow about 2 hours 25 minutes for this section

Instructions

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

Please turn over

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Question 21 (10 marks)

Carbon monoxide, CO, reacts with ammonia, NH_3, to produce highly toxic hydrogen cyanide, HCN, as well as carbon dioxide, CO_2, and hydrogen, H_2. This reaction is endothermic and the equation for this reaction is shown below.

$$2CO(g) + NH_3(g) \rightleftharpoons HCN(g) + CO_2(g) + H_2(g)$$

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

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ii. In one experiment, a mixture of CO and NH_3, together with a suitable catalyst, was injected into a sealed 100 mL gas syringe and allowed to come to equilibrium. When the equilibrium mixture was analysed at a particular temperature, the following concentrations were determined.

[CO] = 0.0025 M [NH_3] = 0.00125 M [HCN] = 0.0042 M

Calculate the equilibrium constant for the reaction at this temperature**.** **2**

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b. Analysts then investigated the effect of two different changes on the equilibrium system by monitoring the amount of HCN (in moles) present in the gas mixture over a period of time.

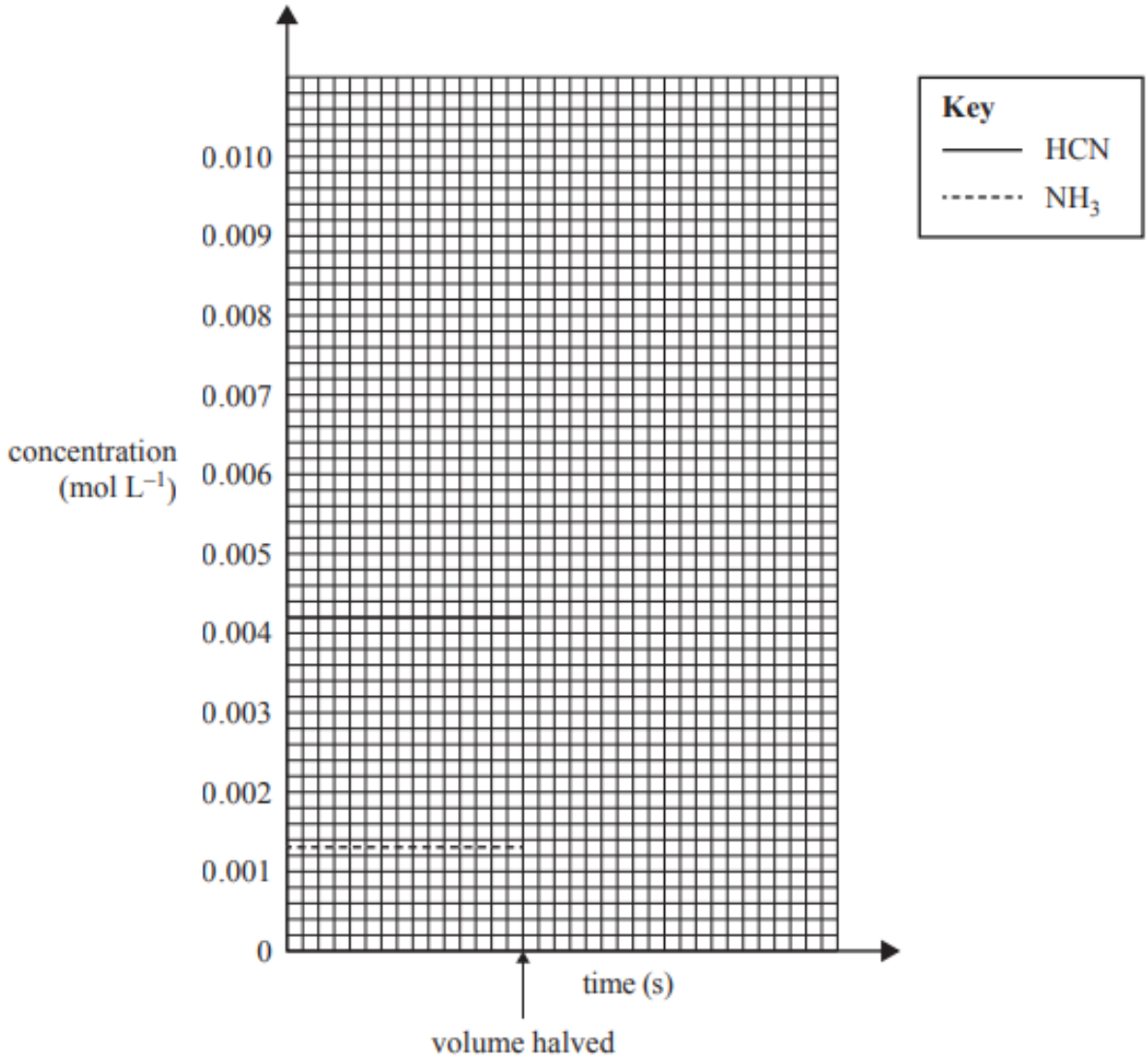
i. Tick (√) the appropriate box in the table below to show the expected effect on the amount of HCN (in moles) present in the gas mixture as a result of each change. **2**

Change investigated	Expected effect on the amount of HCN		
	Increase	Decrease	No effect
Halve the volume of the gas mixture, keeping the temperature constant.			
Return the volume of the gas mixture to 100 mL, then inject some powdered palladium into the gas syringe. (Palladium absorbs H_2 gas onto its surface.)			

Question 21 Continued …

ii. Complete the concentration–time graph on the axes provided below, to show what will happen to the concentrations of HCN and NH_3 in an equilibrium mixture when the volume of the gas mixture is suddenly halved at a constant temperature **2**

Concentration–time graph for the equilibrium system



Question 21 Continued …

c. CO gas is produced when a hydrocarbon fuel, such as butane, C_4H_{10}, is burnt in a limited air supply. Write the balanced equation for the combustion of C_4H_{10} in a limited air supply, assuming that CO is the only carbon-based oxidation product. **1**

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CO poisoning is one danger faced by rescuers entering a burning building, so it is essential

that rescuers wear appropriate breathing apparatus.

Haemoglobin in red blood cells takes up O_2 from the air in an equilibrium reaction represented by Equation 1.

Equation 1 $Hb_4(aq) + 4O_2(aq) \rightleftharpoons Hb_4O_8(aq)$ K_1

haemoglobin haemoglobin-oxygen complex

CO molecules can also attach to haemoglobin molecules. The equilibrium reaction involved is represented by Equation 2.

Equation 2 $Hb_4(aq) + 4CO(aq) \rightleftharpoons Hb_4(CO)_4(aq)$ K_2

haemoglobin haemoglobin-carbon monoxide complex

If the concentration of CO in the air inside a burning building increase to 800 ppm, anyone who is exposed to this will quickly lose consciousness, even if oxygen is present. To revive them, they must be given pure oxygen.

d) What conclusions can be made about the relative values of equilibrium constants K_1 and K_2? **2**

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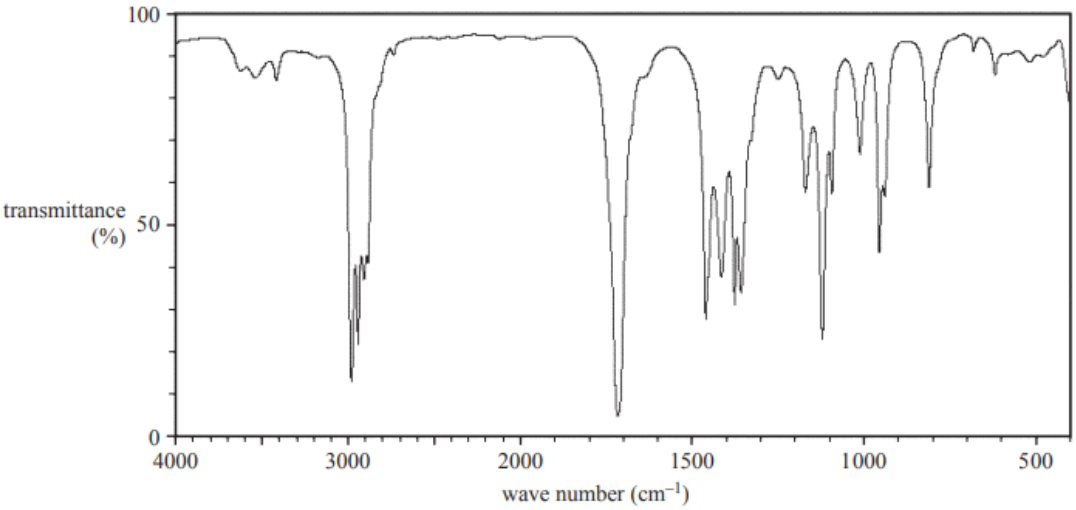
Question 22 (6 marks)

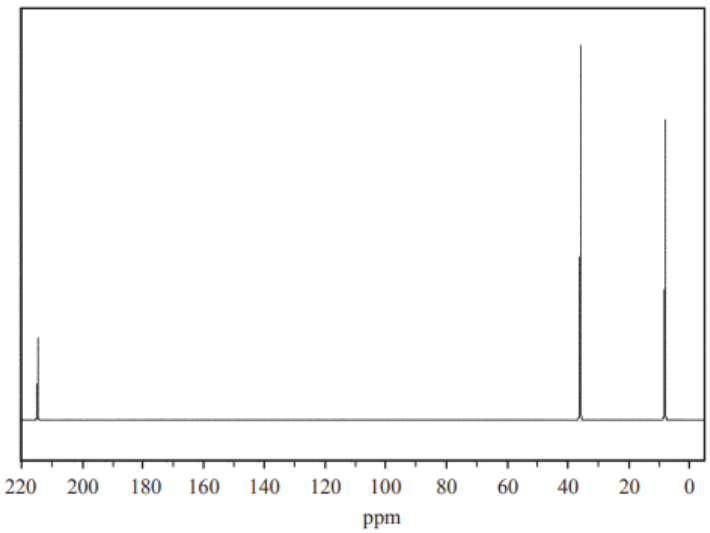
Claire is analysing a sample of paint to determine the organic solvents that are present. She separates the different compounds and analyses each one using infra-red (IR) spectroscopy, and 13C and 1H NMR spectroscopy. Claire finds that one of the compounds that she isolates has a molecular formula of $C_5H_{10}O$. The results for this compound for each type of spectroscopy used are shown in the spectra on pages. Use the information provided to answer the questions on the **next two pages**.

IR spectrum



Data: SDBSWeb; http://sdbs.db.aist.go.jp,
National Institute of Advanced Industrial Science and Technology

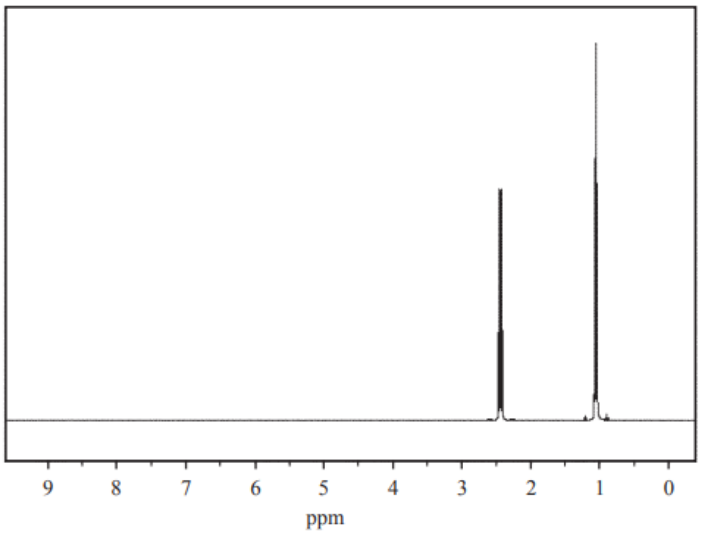
^{13}C NMR spectrum



Data: SDBSWeb; http://sdbs.db.aist.go.jp,
National Institute of Advanced Industrial Science and Technology

Question 22 Continued …

^{1}H NMR spectrum



Data: SDBSWeb; http://sdbs.db.aist.go.jp,
National Institute of Advanced Industrial Science and Technology

^{1}H NMR data

Chemical shift	Splitting pattern
1.0	3
2.4	4

a. From the IR spectrum of the compound, identify the organic family to which this compound belongs. Justify your answer by referring to the relevant wave number.

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Question 22 Continued …

Question 23 (9 marks)

a) Using IUPAC nomenclature, name the compounds shown below: **3**

b. Draw a structural formula for this compound that is consistent with the data provided. Explain your reasoning by referring to this data. 4

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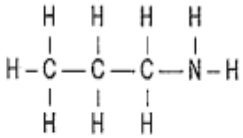
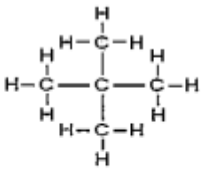
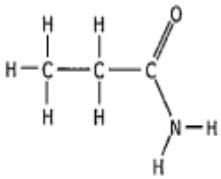


Compound 1



Compound 2



Compound 3

Compound 1 …….

Compound 2 …….

Compound 3 …….

b) Compare the intermolecular forces in the above three molecules and predict the order of boiling points (lowest to the highest) of these molecules.

Explain your predictions. **4**

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Question 23 Continued …

c) Identify how compound 3 (in part a) above) could be produced by a chemical reaction.

Include an equation in your response. **2**

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Question 24 (7 marks)

The table below shows the acid dissociation constants at 25°C

Acid	Formula	K_a
Acetic acid	CH_3COOH	1.8×10^{-5}
Chlorous acid	$HClO_2$	1.1×10^{-2}
Formic acid	$HCOOH$	1.8×10^{-4}
Hydrocyanic acid	HCN	6.2×10^{-10}
Hydrofluoric acid	HF	6.6×10^{-4}
Water	H_2O	1.0×10^{-14}
Lactic acid	$CH_3CHOHCOOH$	1.4×10^{-4}
Nitrous acid	HNO_2	7.2×10^{-4}
Phenol	C_6H_5OH	1.3×10^{-10}

a) Identify the weakest acid in the table and determine the pK_a value for this acid. **2**

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b) Calculate the pH of 0.10 M solution of hydrocyanic acid. **2**

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Question 24 Continued …

c) A buffer solution prepared by combining 100 mL of 0.10 M HCN and 100 mL of 0.10 M NaCN.

Calculate the pH of this buffer solution and explain the classification of the solution as a buffer**.** **3**

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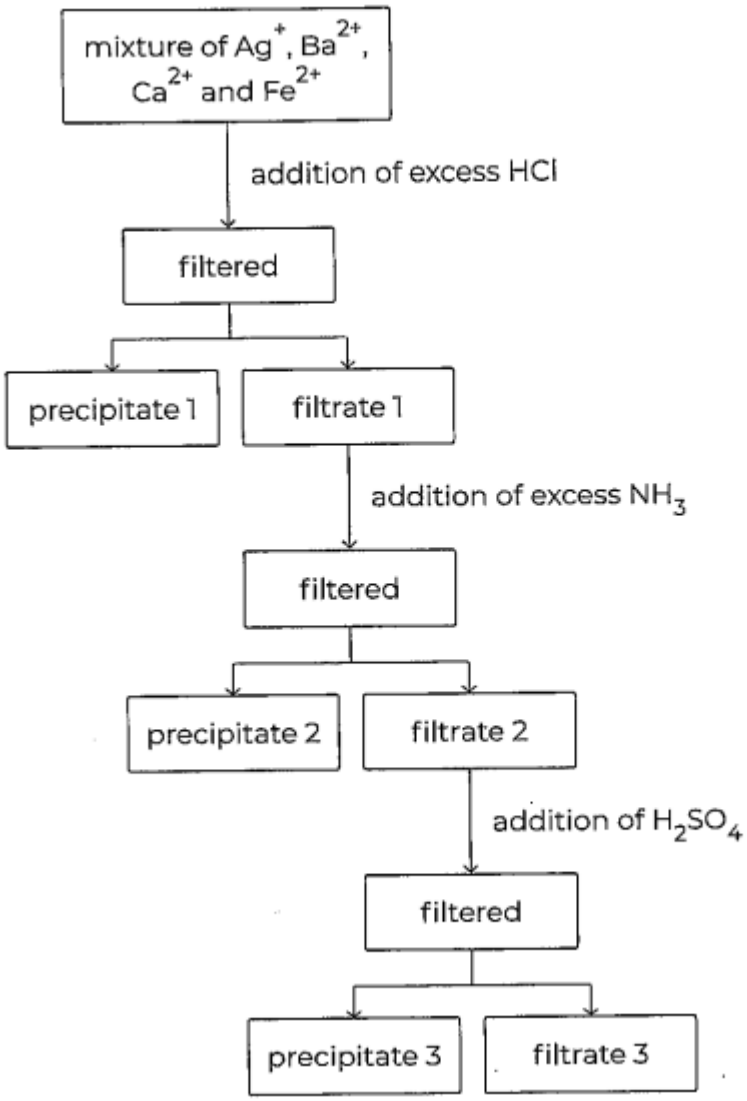
Question 25 (6 marks)

A solution contains four cations: Ag^{+}, Ba^{2+}, Ca^{2+} and Fe^{2+}. The following flow chart represents steps taken to identify each cation.



Question 25 Continued …

Name precipitates 1,2 and 3 and write the ionic equation for the formation of all precipitates. Suggest a test to confirm the identity of the remaining cation in filtrate **3**

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Question 26 (5 marks)

Different tests are used to distinguish between primary, secondary, and tertiary alcohols. Describe **ONE** test for each type of alcohol and include the chemical reaction.

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Question 27 (5 marks)

The K_{sp} value for magnesium hydroxide is 5.61×10^{-12}.

a. Write the equation for the solubility equilibrium for magnesium hydroxide. **1**

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b. Write the K_{sp} expression for magnesium hydroxide**.** **1**

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c. Calculate the solubility of magnesium hydroxide at 25°C. **3**

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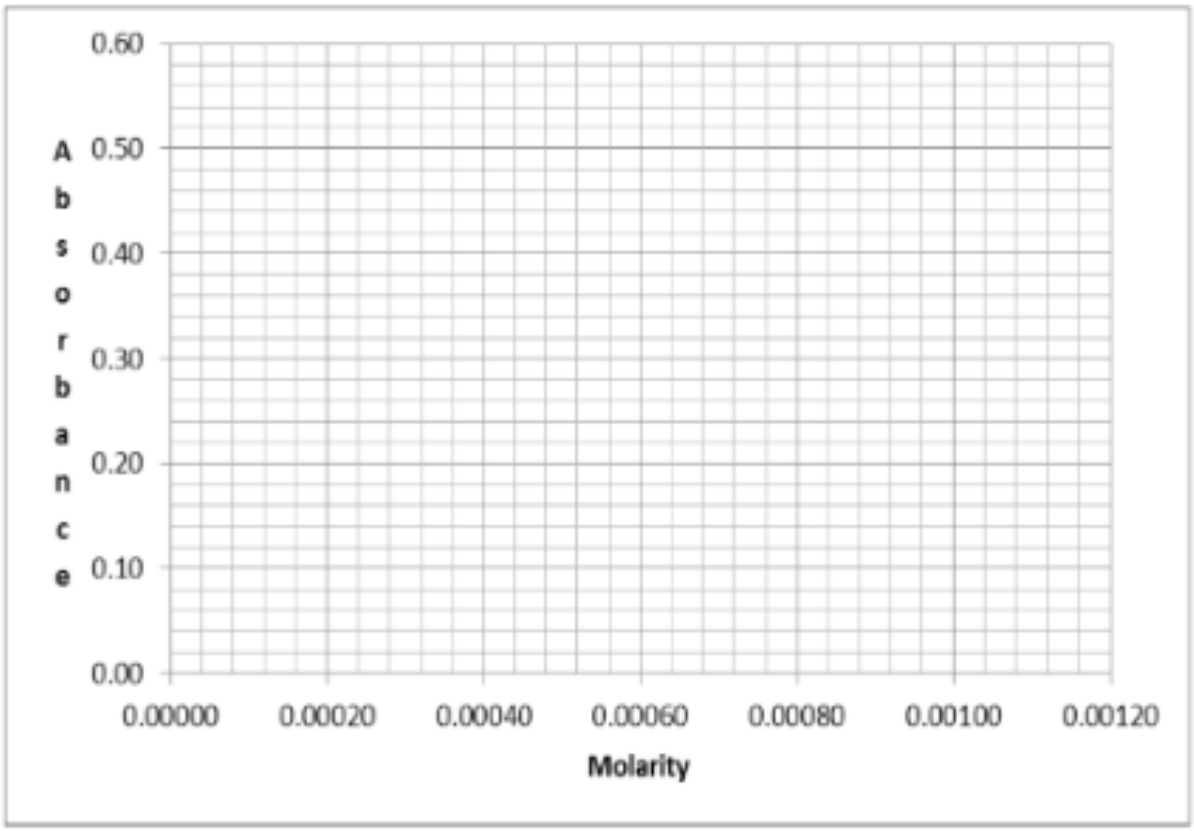
Question 28 (8 marks)

spectroscopy. The chlorophyll from the leaf is extracted and allowed to dissolve in 250mL of solvent. A small sample of the chlorophyll solution is placed in a uv-visible spectrometer that has the wavelength selector set at 410nm. The absorbance of the chlorophyll solution at this wavelength is 0.21. The absorbance values of 4 standard chlorophyll solutions are given in the table below

Concentration (M)	Absorbance
2.5×10^{-4}	0.12
5.0×10^{-4}	0.239
7.5×10^{-4}	0.351
1.0×10^{-3}	0.483

a) using the grid below, construct a calibration graph using the table showing the absorbance of the chlorophyll standards. **2**



Question 28 Continued …

mL

solution of chlorophyll extracted from the leaf? M_r (chlorophyll) is 893.5 g/mol **2**

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c. What is the percentage by mass of chlorophyll in the leaf? **3**

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d. Why was light with a wavelength of 410 nm chosen for this analysis? **1**

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Question 29 (7 marks)

A solution of hydrochloric acid was standardised by titration against sodium carbonate solution using the following procedure:

- All glassware was rinsed correctly to remove possible contamination
- Hydrochloric acid was placed in the burette.
- 25.0 mL of sodium carbonate solution was pipetted into the conical flask.

The titration was performed, and the hydrochloric acid was found to be 0.200 mol L^{-1}

a) Identify the chemical used to rinse the pipette and justify your answer. **2**

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b) Explain why sodium carbonate solution, rather than sodium hydroxide solution, is used to standardise the hydrochloric acid. **2**

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Question 29 Continued …

c) Seashells contain a mixture of carbonate compounds.

The standard hydrochloric acid was used to determine the percentage by mass of carbonate ions in a seashell using the following procedure:

- A 0.154 g sample of the seashell was placed in a conical flask
- 50.0 mL of standardised hydrochloric acid was added to the conical flask.
- At the completion of the reaction, the mixture in the conical flask was titrated with 0.250 mol L^{-1} sodium hydroxide.

The volume of sodium hydroxide used in the titration was 29.5 mL.

Calculate the percentage by mass of the carbonate ions in the sample of the seashell. **3**

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Question 30 (6 marks)

A student was researching calcium sulfate ($CaSO_4$) and calcium carbonate ($CaCO_3$). Their first step was to look at the solubility constants (K_{sp}) and equilibrium expressions for the two compounds.

a) Discuss the solubilities of these two compounds at 25°C**.** **2**

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b) Derive the equilibrium expression for calcium sulfate and use this to calculate the solubility (in mol L^{-1}) for calcium sulfate. Show your working. 2

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c) Outline ONE practice of Aboriginal and Torres Strait Islander Peoples that uses solubility equilibria. 2

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Question 31 (5 marks)

20 mL of 0.010 mol/L calcium nitrate is added to 20 mL of 0.010 mol/L sodium sulphate. Determine whether precipitation of calcium sulphate will occur.
($K_{sp}(CaSO_4) = 4.93 \times 10^{-5}$)

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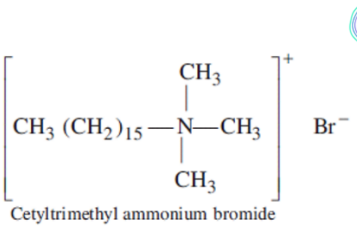
Question 32 (6 marks)

a) Label the detergents shown as anionic, cationic, or non-ionic. **3**

(i)



Cetyltrimethyl ammonium bromide

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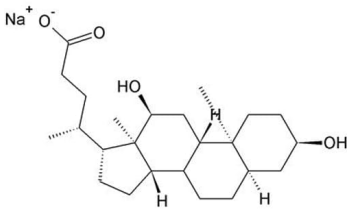
(ii)



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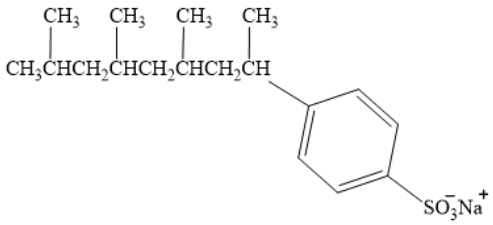
(iii)



Sodium alkylbenzenesulfonate

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Question 32 Continued

b) Soaps can remove fats and oils from the skin because of their structure. **3**

Discuss this statement.

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END OF EXAM

EXTRA WRITING PAPER

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Question	Answer	Explanation
1	D	The structure is a primary alkanol and will produce an organic acid. The structure of the reactant is 3-methylpropan-1-ol. So the product is 3-methylpropanoic acid
2	A	Cinnamic acid contains a C=C double bond and may be expected to partake in similar chemical reactions to ethene $CH_2 = CH_2$. Like ethene it can be involved in addition polymerisation and might be expected to react with ethene to form a co-polymer. Cinnamic acid will undergo addition reaction with Br_2. As cinnamic acid has a carboxyl group -COOH group, it will react with methanol to produce the ester methyl cinnamate
3	A	In hydrolysis of a triglyceride, water reacts across each ester group to form carboxyl, -COOH and hydroxyl, -OH groups
4	B	The temperature of the vapour mixture decreases as it moves up the column. Hence the vapour pressure rises, the relative amount of ethanol increases (and the amount of water vapour decreases). Therefore, the percentage of present is the greatest at Z and lowest at X. So, it increases in order from XZ to Y to Z
5	A	
6	A	When temperature is Increased, the equilibrium will, according to LCP, use up the heat. If this reaction was an endothermic reaction, then the mixture will turn lighter brown. The forward reaction is, therefore, an exothermic reaction and so the reverse reaction is endothermic
7	D	$K = [HI]^2 / [H_2] [I_2] = (1.57)^2/(0.214)\ (0.214) = 53.823$
8	D	When a **sparingly soluble salt** is mixed with water a dynamic equilibrium is established in which salt is constantly dissolving and crystallising at the same rate when the solution is saturated, and the maximum constant concentration is achieved. • e.g. for calcium sulphate: $\mathbf{CaSO_{4(s)}}$ + aq ⇌ $\mathbf{Ca^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)}}$ o the equilibrium expression is: $K = [Ca^{2+}_{(aq)}] [SO_4^{2-}{}_{(aq)}] / [\ CaSO_{4(s)}]$ However, since the concentration of water and the solid is effectively constant the equilibrium expression is simplified to: $\mathbf{K_{sp} = [Ca^{2+}_{(aq)}]\ [SO_4^{2-}{}_{(aq)}] = 2.4 \times 10^{-5}\ mol^2\ dm^{-3}}$ $\mathbf{K_{sp}}$ is called the **solubility product** of the ions concerned and is constant at constant temperature for a **saturated solution** i.e. when no more will dissolve. **The solubility product for a sparingly soluble strong electrolyte is defined as the product of the concentration of the ions raised to their appropriate**

		powers in a saturated solution at a specific temperature. At the saturation solution point, controlled by the K_{sp} expression, it doesn't matter how much solid you add, no more can dissolve. The solubility of the sparingly soluble salt is governed by the **K_{sp} expression**, i.e. whatever ion concentrations are present of the compound, then the expression must be obeyed. If on mixing solutions containing the two constituent ions the K_{sp} expression is exceeded, precipitation will take place until the product of the ion concentrations equals the K_{sp} value. If the Ksp expression is not exceeded, no precipitation will take place.
9	D	$[OI_3] = 0.3/5L = 0.06M$ $[O_2] = 1.5/5 = 0.3M$ $Q = [O_2]^3/[O_3]^2 = (0.3)^3/(0.06)^2 = 7.5$ $Q < K_{eq}$ So equilibrium will shift to increase $[O_2]$ to increase the Q to 75
10	C	
11	C	It is important to get all the SO_4^{2-} from the fertiliser first
12	B	Barium sulphate is the only one in the options that will form a precipitate. Na_2SO_4 , K_2SO_4 and $CuSO_4$ are all soluble in water.
13	C	If excess precipitating agent is not used, then ALL sulphate will not be precipitated If you dry it in the oven, the mass of the precipitate will not be affected. Failure to dry to constant mass will give you a higher % of sulphate. If distilled water is not used then there could be contamination which will increase the amount of sulphate
14	C	Aliquot of a sample, in chemistry or the other sciences, **an exact portion of a sample or total amount of a liquid** (e.g. exactly 25 mL of water taken from 250 ml). A titrant is **a substance (such as a reagent solution of precisely known concentration) that is added in titration**. Sodium hydroxide is in the burette and vinegar is in the conical flak. So rinse the burette with distilled water first and then with NaOH
15	C	If the burette is not rinsed with vinegar at first then when vinegar is added after washing it with distilled water, the vinegar concentration will decrease slightly. So, a slightly greater volume of NaOH will be needed to get to the end point
16	A	Rinsing the conical flask with water will not affect the number of moles of vinegar added to it even if it is not dry. So the volume of NaOH will not be affected.
17	A	ΔG is Change in Gibbs Energy, ΔH is Change in heat content, ΔS is Change in randomness
18	C	For reverse reaction, $K = ¼.2 \times 10^{-5} = 23809 = 2.38 \times 10^4$

19	C	
20	D	

2022 TRIAL HSC CHEMISTRY EXAM

MARKING GUIDELINES

SECTION II

Question 21

a)

(i)

Criteria	Marks
Correct expression for equilibrium constant	1

$K = [HCN]\,[CO_2]\,[H_2] / [CO]^2\,[NH_3]$

(ii)

Criteria	Marks
• Correct substitution of values • Correct answer	2
• Correct substitution of values OR • Correct answer	1

Answer:

$K = [HC]\,[CO_2]\,[H_2] / [CO]^2\,[NH_3]$

(ii) $K = [HCN]\,[CO_2]\,[H_2] / \lceil CO \rfloor^2\,[NH_3]$

$= [0.0042]\,[0.0042]\,[0.0042] / [0.0025]^2\,[0.00125]$

$= 9.483264$

$= 9.5$

b) (i)

Criteria	Marks
• Both ticks correct	2
• One tick correct	1

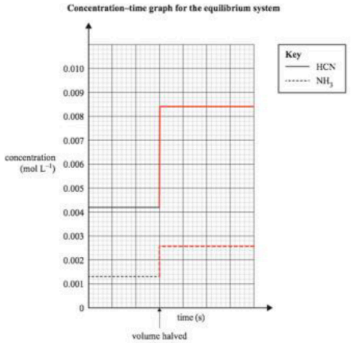
Answer:

Change investigated	Expected effect on the amount of HCN		
	Increase	Decrease	No effect
Halve the volume of the gas mixture, keeping the temperature constant.			√
Return the volume of the gas mixture to 100 mL, then inject some powdered palladium into the gas syringe. (Palladium absorbs H_2 gas onto its surface.)	√		

b) (ii)

Criteria	Mark
One mark for each correct indication of where [HCN] must finish at 0.0084M and [NH_3] must finish at 0.0026M in the graph	2

Answer:



c)

Criteria	Mark
• Correct balanced equation AND states	1

Answer:

$2\ C_4H_{10}\ (g) + 9O_2)\ (g) \rightarrow 8CO\ (g) + 10H_2O\ (g)$

OR

$C_4H_{10}\ (g) + 9/2O_2(g) \rightarrow 4CO\ (g) + 5H_2O\ (g)$

d)

Criteria	Mark

• State that value of K_2 is much larger than K_1 • Provide a thorough explanation of the reason for the observed large value of K_2 based on the information given	2
• Explanation NOT thorough	1

Explanation:

Both O_2 and co are competing for haemoglobin – even if the concentration of co is far less than O_2 (0.08% CO_2 compared to 21% O_2 which is the average oxygen content of air respectively) the CO still binds with the Hb more favourably, hence the equilibrium constant K_2 must be much larger than K_1.

Another sample answer:

The value of K_2 is much greater than K_1 ($K_2 >> K_1$). Equation 2 is more favourable and $Hb4(CO)_4$ complex is more readily formed because of the more affinity of the CO towards Hb compared to O_2, even when small amount of CO (as low as 800ppm) is present. In other words, CO and O_2 both compete with Hb (even if [CO] is less than [O_2]) and CO still binds with the Hb more favourably, leading to a much larger equilibrium constant value than K_1. The equilibrium of reaction 2 is far to the right indicating a higher K_2 value compared to equilibrium of K_1, where despite the presence of oxygen the equilibrium position is not far enough right to produce enough haemoglobin oxygen complex compared to haemoglobin carbon monoxide complex (higher affinity).

Question 22

a)

Criteria	Mark
• Identifying the correct organic family - aldehyde or ketone using the data sheet wavenumber • Thoroughly justifying the identification	2
• Identify the correct organic family -aldehyde or ketone using the data sheet wavenumber OR justification not thorough	1

Organic Family: aldehyde or ketone

Justification:

- Transmittance band at 1700cm^{-1} corresponds to a C=O (carbonyl group) from either an aldehyde (1660 – 1745 cm^{-1}) or ketone (1680 – 1850 cm^{-1})
- Absence of an O-H (hydroxyl group) indicates that this is not a carboxylic acid.
- C=O at 1720 – 1840 cm^{-1} corresponds to an ester group, although the molecular formula contains only one oxygen atom, so the molecule cannot be an ester
- Transmittance band at 3000 cm^{-1} corresponds to a C=H (2850 – 3090 cm^{-1}), present in all organic families

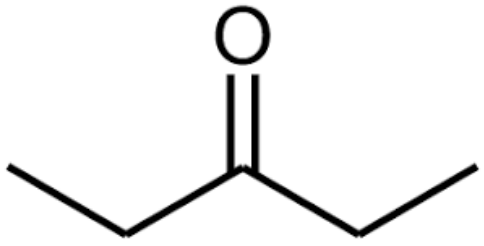
Another sample answer:

From the molecular formula, $C_5H_{10}O$, there is only one oxygen atom, so the molecule is an aldehyde, ketone or alcohol and cannot be a carboxylic acid or ester. The strong sharp IR peak at 1710 cm^{-1} corresponds to C=O (carbonyl group) from either an aldehyde (1660-1745cm^{-1}) or Ketone (1680-1850 cm^{-1}). Absence of O-H group peak (3230-3550 cm^{-1}) indicate that it is not an alcohol. Therefore, the molecule belongs to the ketone or aldehyde family.

b)

Criteria	Marks
• Correct structure drawn • Indicate presence of symmetry in the molecule as seen in ^{13}C NMR and ^{1}HNMR • Analyse ^{13}C NMR chemical shift /peak (using data sheet) • Analyse ^{1}H NMR chemical shift peak and splitting pattern (using data sheet)	4
• Correct structure drawn • Only TWO explanations given, one from each NMR	3
• Correct structure drawn • Only ONE explanation used, one from any 2NMR	2
• Incorrect structure drawn • Only ONE explanation used, one from each NMR	1

Structure:



^{13}C NMR:

3 peaks indicate only three different carbon environments for the five carbon atoms. Hence some carbon atoms must be in the same environment

- 9 ppm peak suggests a methyl group (R-CH_3 at 8-25 ppm)
- 35 ppm peak
  - R-CH_2-R at 20-45 ppm
  - R_3-CH at 40-60 ppm

- 215 ppm peak
  - $R_2C=O$ at 205-220 ppm carbonyl in ketone

  ^1H NMR:

  Two peaks indicate two different hydrogen environments

- 1.0 ppm peak
  $R\text{-}CH_3$ at 0.9-1.0 ppm,
  splitting pattern: 2 H on adjacent carbon atom ($\text{-}CH_2\text{-}$)

- 2.4 ppm peak
  $RCOCH_3$ at 2.1-2,7 ppm
  Splitting pattern: 3 H on adjacent carbon atom ($\text{-}CH_3$)
  2 H environments with correct splitting patterns

  Another sample answer:

^{13}C NMR spectra shows 3 different carbon environments as there are 3 peaks observed in the spectra for a 5-carbon compound. This indicates that the molecule is symmetrical and the other two carbon atoms must be in the same environment. This is consistent with the pentan-3-one structure given above. The most deshielded carbon signal (downfield shifted) at 215ppm indicate an electron withdrawing oxygen atom attached to the carbon and corresponds to $R_2\text{-}C=O$ functional group in a ketone. Peaks at 35 ppm and 9 ppm corresponds to $R\text{-}CH_2\text{-}R$ and $R\text{-}CH_3$ carbons. This symmetry in the molecule is further supported by two peaks observed in the 1H NMR spectra indicating two unique hydrogen environments. The peak at 1.0 ppm corresponds to $R\text{-}CH_3$, terminal methyl group and the triplet splitting pattern of the signal is due to 2 hydrogens on the adjacent carbon atom (n+1 rule of spin-spin coupling). Similarly, the downfield shifted peak at 2.4 ppm corresponds to $R\text{-}CO\text{-}CH_2\text{-}CH_3$ and its quartet splitting pattern of the signal is due to 3 hydrogens on the adjacent carbon atom. This is possible only if the structure of the compound is a symmetrical ketone as shown above of pentan-3-one, otherwise there will more than 3 carbon or two proton NMR peaks for an aldehyde molecule. Thus, the spectral information from the IR, $^{13}CNMR$ and ^1H NMR data are consistent with the pentan-3-one structure.

Question 23

a)

Criteria	Marks
● Names THREE compounds correctly	3
● Names TWO compounds correctly	2
● Names ONE compound correctly	1

Compound 1 – Propan – 1 amine (also accepted 1-propamine and propanamine)

Compound 2 – 2,2-dimethylpropane

Compound 3 – Propanamide (also accepted 1-propanmine and propanamide)

Note: N- prefix not accepted

b)

Criteria	Marks
● Predicts correct order of boiling points ● Explains thoroughly the impact of the different intermolecular forces ● Identifies that compound 1 has hydrogen bonding between the N- H as the strongest intermolecular force. ● Identifies that compound 2 has dispersion forces only ● Identifies that compound 3 has hydrogen bonding between N-H and O-H (2 hydrogen bonds form between adjacent molecules) forming dimers or network of bonding.	4
● Predicts the correct order of boiling points ● Explains thoroughly the impact of the different intermolecular forces ● Identifies the intermolecular force in only TWO of the three compounds	3
TWO of: ● Predicts the correct order of boiling points ● Explains thoroughly the impact of the different intermolecular forces. ● Identifies the intermolecular forces in 2 out of 3 compounds	2
ONE of: ● Predicts the correct order of boiling points ● Explains thoroughly the impact of the different intermolecular forces. ● Identifies the intermolecular forces in out of 3 compounds	1

The order of increasing boiling point is Compound 2, Compound 1, Compound 3

The stronger the intermolecular forces, the higher the boiling point, as greater energy is needed to separate the liquid molecules to form gas.

Compound 2 is non-polar and has only weak intermolecular forces (dispersion or temporary dipole-dipole forces) caused by the electrical interaction of molecules as they collide (protons from 1 molecule being attracted to electrons from the other as the molecules are temporarily distorted on collision).

Compound 1 is polar and would experience hydrogen bonding forces, as well as weaker temporary and permanent dipolar forces, as molecules interact. These are strong intermolecular forces where the electronegativity of the nitrogen results in a very polar bond with hydrogen in the N-H group. This hydrogen is attracted to the nitrogen of a neighbouring amine molecule. The geometry of the molecule only allows 1 H-bond pair of molecules at any instant

Compound 3 is an amide and has a very polar -CONH functional group. The hydrogen atom of the -CONH can form a hydrogen bond with an oxygen of the neighbouring amide molecule. The planar nature of this -CONH group allows 2 H bonds per pair of molecules forming dimers.

Hence the intermolecular forces and thus boiling points are higher in compound 3 and lowest in compound 2

c)

Criteria	Marks
● Identifies a chemical reaction that produces compound 3 AND writes an appropriate equation	2
● Identifies an appropriate chemical reaction that produces compound 3	1

React propanoic acid with ammonia (heat) to produce propanamide and water

$$CH_3\text{-}CH_2\text{-}COOH_{(l)} + NH_{3\,(aq)} \rightarrow CH_3\text{-}CH_2\text{-}CONH_{2\,(aq)} + H_2O_{(l)}$$

Note: Had to mention heat to obtain full marks. States were not marked for.

Question 24

a)

Criteria	Marks
• Identifies the weakest acid • Calculates the pH value with the correct number of significant figures	2
• Identifies the weakest acid OR • Final calculations not to correct sig fig AND/OR • Water not named correctly; however final calculation was to correct sig fig.	1

Water. H_2O

$pK_a = -\log(K_a) = -\log (1.0 \times 10^{-14}) = 14.00$ (2 s.f.) (same rule for s.f. in pK_a calculations as in pH; see below)

NOTE: if more than ONE named then no marks awarded.

b)

Criteria	Marks
• pH calculated correctly to 2 decimal places	2
• pH not calculated to 2 decimal places	1

$HCN\ (aq) + H_2O\ (l) \rightleftharpoons CN^-\ (aq) + H_3O^+\ (aq)$

$$K_a\ HCN = \frac{[CN^-]\,[H_3O^+]}{[HCN]} = 6.2 \times 10^{-10}$$

Let x moles of HCN ionise, forming x moles of H_3O^+

$$K_a\ HCN = \frac{[x]\,[x]}{[0.10 - x]} = 6.2 \times 10^{-10}$$

Since x will be small by comparison with 0.10

Hence $[x]^2 = 6.2 \times 10^{-10} \times 0.10 = 6.2 \times 10^{-11}$

$[H_3O^+] = \sqrt{(6.2 \times 10^{-11})} = 7.87 \times 10^{-6}$ mol/L

Hence $pH = -\log_{10}(7.87 \times 10^{-6}) = 5.10$ (2 s.f.)

c)

Criteria	Marks
• Calculates the pH of the buffer solution • Explains thoroughly what a buffer is and how it works to adjust the addition of small amounts of strong acids and bases.	3
• Calculates the pH of the buffer solution • Explanation of what a buffer is not thorough	2
• Calculates the pH of the buffer solution	1

$HCN\ (aq) + H_2O\ (l) \rightleftharpoons CN^-\ (aq) + H_3O^+\ (aq)$

$$K_a\ HCN = \frac{[CN^-]\ [H_3O^+]}{[HCN]} = 6.2 \times 10^{-10}$$

Initial [HCN] = 0.10 mol/L

Initial $[CN^-]$ = 0.10 mol/L

On mixing, the volume is doubled.

So, the concentration of each is halved.

After mixing, [HCN] = 0.050 mol/L

After mixing, $[CN^-]$ = 0.050 mol/L

Let x mol/L HCN ionise at equilibrium.

At equilibrium

[HCN] = (0.050 – x) mol/L

$[CN^-]$ = (0.050 + x) mol/L

$[H_3O^+]$ = x mol/L

$$K_a\ HCN = \frac{[CN^-]\ [H_3O^+]}{[HCN]} = 6.2 \times 10^{-10} = \frac{(0.05 + x)\ (x)}{(0.05 - x)}$$

Since x is small by comparison with 0.05 mol/L

$[H_3O^+] = x = 6.2 \times 10^{-10}$ mol/L

pH = 9.21

A buffer solution is one which will maintain an almost constant pH, even if small quantities of strong acid or base are added to it. As long as there are close to equal moles of equal concentration solutions making up the buffer mixture, and the acid and base are both only moderately strong as acids and bases, the solution will stay at close to the pH value 9.21, as calculated above. By Le Chatelier's Principle, if [x] is small by comparison with the concentrations of the acid and base, if the concentration of H^+ in the buffer mixture changes slightly, the proportions of HCN and CN^- will change to keep the pH close to 9.21.

Question 25

Criteria	Marks
• Names precipitate 1, 2 & 3 • THREE correct ionic equations • Test to confirm the identity of remaining cation in filtrate 3	5-6
• Names precipitate 1, 2 & 3 • THREE correct ionic equations • Test to confirm the identity of remaining cation in filtrate 3 is not suggested. OR • Names precipitate 1, 2 & 3 • Two correct ionic equations • Test to confirm the identity of remaining cation in filtrate 3	3-4
• Names precipitate 1, 2 & 3 • ONE correct ionic equation • NO test to confirm the identity of remaining cation in filtrate 3	2
• Names ONE precipitate OR • ONE correct ionic equation	1

Sample Answer:

Precipitate 1 is AgCl

Precipitate 2 is $Fe(OH)_2$

Precipitate 3 is $BaSO_4$

(2 marks if all 3 identified correctly, 1 mark if 1-2 identified correctly)

Precipitate 1: $Ag^{+}_{(aq)} + Cl^{-}_{(aq)} \rightarrow AgCl_{(s)}$

Precipitate 2: $Fe^{2+}_{(aq)} + OH^{-}_{(aq)} \rightarrow Fe(OH)_{2\,(s)}$

Precipitate 3: $Ba^{2+}_{(aq)} + SO_4{}^{2+}_{(aq)} \rightarrow BaSO_{4\,(s)}$

(3 marks – 1 mark for each correct equation)

Remaining cation is Ca^{2+}

Test: Add NaOH solution to Ca^{2+} and a precipitate will be formed, and the precipitate will not disappear when NaOH is added in excess OR Flame test to give an orange-red colour.

(1 mark)

Question 26

Criteria	Marks
● THREE tests AND TWO chemical equations.	5
● Any ONE aspect of test and equation is not correct	4
● Any TWO aspect of test and equation is not correct	3
● Any THREE aspect of test and equation is not correct	2
● Any FOUR aspect of test and equation is not correct	1

Sample Answer:

Use an oxidising agent like acidified potassium permanganate solution

When added to a primary alkanol, the solution will change from purple to colourless to produce an acid. When a carbonate is added to the solution, a gas will be produced.

$CH_3CH_2\text{-}OH_{(l)} \xrightarrow{KMnO_4/H^{\pm}} CH_3COOH_{(aq)}$

$CH_3COOH_{(aq)} + Na2CO_3 \rightarrow CH_3COO^{-}{}^{+}Na + CO_{2\,(g)} + H_2O_{(l)}$

When added to a secondary alkanol, the solution will change from purple to colourless to produce a ketone. When a carbonate is added to the solution, a gas will not be produced.

$CH_3CH_2OHCH_{3(l)} \xrightarrow{KMnO_4/H^{\pm}} CH_3COCH_{3\,(aq)}$

A tertiary alkanol will not react with the oxidising agent and so will remain purple when an oxidising agent is added

Question 27

a)

Criteria	Mark
Correct equation with states	1

$Mg(OH)_{2\,(s)} \rightarrow Mg^{2+}_{(aq)} + OH^{-}_{(aq)}$

b)

Criteria	Mark
Correct K_{sp} expression	1

$K_{sp} = [Mg^{2+}] \times [OH^{-}]^2$

c)

Criteria	Marks
• Correct equation • Correct K_{sp} expression • Correct calculations	3
• Correct equation • Correct expression • Incorrect calculation	2
• Correct equation	1

$Mg(OH)_{2\,(s)} \rightarrow Mg^{2+}_{(aq)} + 2OH^{-}_{(aq)}$

x x 2x

$K_{sp} = (x)(2x)^2$

$5.61 \times 10^{-12} = 4x^3$

$x^3 = 1.4025 \times 10^{-12}$

$x = \sqrt[3]{1.4024 \times 10^{-12}}$

$= 1.12 \times 10^{-4}$ mol/L

$\lceil Mg^{2+} \rfloor = 1.12 \times 10^{-4}$ mol/L $\lceil OH^{-} \rfloor = 2 \times 1.12 \times 10^{-4} = 2.24 \times 10^{-4}$

Question 28

a)

Criteria	Marks
• Four points plotted correctly • A straight line of best fit is drawn that does not go to the origin	2
• Four points NOT plotted accurately **OR** • Line of best fit is not accurate	1

b)

Criteria	Marks
• Correct interpretation of the concentration from the graph • Correct calculation in g/L of chlorophyll	2
	1

From the graph, concentration is 0.00043 M

C = 0.00042 x 893.5

= 0.384205g/L

= 0.375g/L

(1 mark for correct reading from the graph, 1 mark for calculation)

c)

Criteria	Marks
• Detailed working of calculation of mass in • Answer in 3 sig figs	3
• Correct calculation of mass by percentage •	2
• Correct calculation of mass by percentage • Answer NOT in 3 sig figs	1

% by mass = (0.375g/L x 0.250L) x 100

= 29.3%

d)

Criteria	Mark
Provides a reason for the use of wavelength	1

The wavelength at 410 nm provides the best absorbance of light by chlorophyll. It corresponds to blue/violet light being absorbed by plant and so, provides a measurable standard. (Any incorrect statement such that red light is at 410 nm forfeits mark).

Question 29

a)

Criteria	Marks
• Identifies sodium carbonate as the solution used to rinse the pipette AND justifies the answer	2

• Identifies sodium carbonate as the substance used to rinse the pipette	1

Sample Answer:

Standard sodium carbonate is the solution to be placed in the flask and transferred by pipette. The pipette must be cleaned and then rinsed with the standard sodium carbonate solution provided. Any other substance would cause a dilution of the standard solution and results obtained would no longer be accurate or valid.

b)

Criteria	Marks
• Explains, giving at least 2 valid reasons, why sodium carbonate is used rather than sodium hydroxide as a standard	2
• Outlines one valid reason	1

Sample answer:

A primary standard solution is one that can be used as the starting point in a series of titrations to determine the concentration of other solutions. The primary standard used to make the primary standard solution is normally a crystalline solid, which can be weighed out accurately (will not absorb water or carbon dioxide from the atmosphere) and has a relatively high molar mass (so that errors in transferring the solid are minimised in terms of moles). Sodium carbonate is suitable as it can be obtained pure, as crystals, can be weighed out accurately without absorbing water or reacting with carbon dioxide from the air and has a higher molar mass (106 g/mol) than NaOH (40 g/mol). Sodium hydroxide is not obtainable as pure crystals (lumps, which absorb water and react with CO_2).

c)

Criteria	Marks
● Correctly calculates the percentage by mass of carbonate ions in the seashell	3
● Determines the mass of carbonate ions in the seashell	2
● Determines the moles of HCl in excess or other relevant information. Working needs to be logical.	1

Sample Answer. (E1 and E2 are notations indicating that an error has been found in your working. Two errors mean loss of two marks).

There were 4 steps in the process:

- The sample (0.145 g) was placed in a conical flask.
- 50.0 mL of standard hydrochloric acid (0.200 mol/L) was pipetted into the flask
- The excess HCl was titrated with NaOH to determine the no. of moles of HCl in excess and hence the no. of moles and mass of carbonate ions
- The percentage of carbonate ions, by mass, was determined

CO_3^{2-} (in the seashell) + 2HCl (aq) $\rightarrow$ $2Cl^-$ (aq) + CO_2 (g) + H_2O (l)

Moles HCl added initially to react and dissolve carbonate ions
= cV = 0.200 x 0.050 = 0.0100 mol

Moles NaOH required for titration excess HCl = 0.0295 x 0.250 = 0.007375 mol
Hence moles of excess HCl = 0.007375 (as NaOH and HCl react in 1:1 ratio)

Moles of HCl which had reacted with seashell = 0.0100 – 0.00738 = 0.00262 mol

Moles CO_3^{2-} = ½ moles HCl (from balanced equation)

Hence moles CO_3^{2-} in seashell = 0.0013125 mol

Mass of CO_3^{2-} in seashell = n x M = 0.0013125 x 60.0089 = 0.0788 g (3 s.f.)

% CO_3^{2-} - in seashell = 0.0788/0.154 x 100 = 51.2% (Answers accepted to 3 sig. fig. 51.1% - 51.2%)

Question 30

a)

Criteria	Marks
• Discusses the solubilities of each compound. AND • Links the discussion to the solubility constant	2
• Gives details of solubilities	1

Sample Answer

The two compounds are relatively insoluble (low solubility constants). The solubility constant for calcium sulfate is related to its molar solubility by the following equation:

$Ksp = [Ca^{2+}]\ [SO_4^{2-}]$

4.93×10^{-5}

The solubility constant for calcium carbonate is related to its molar solubility by the following equation:

$Ksp = [Ca^{2+}]\ [CO_3^{2-}]$

$= 3.39 \times 10^{-9}$

It therefore follows that calcium sulfate is more soluble because it has a higher solubility constant than calcium carbonate.

b)

Criteria	Marks
• Derives correct equilibrium expression. AND • Calculates solubility	2
• Derives correct equilibrium expression	1

Sample Answer

$CaSO_{4\,(s)} \rightarrow Ca^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)}$

$Ksp = [\ Ca2+\ ]\ [\ SO4^{2-}]$

4.93×10^{-5}

$\sqrt{K_{sp}} = \sqrt{4.93 \times 10^{-5}} = 7.02 \times 10^{-3}$

c)

Criteria	Marks
● Gives an appropriate example. AND ● Gives an outline with at least TWO relevant points	2
● Gives an outline with some relevant information	1

Sample Answer

Some Aboriginal and Torres Strait Islander groups in northern Australia use the seeds of cycad plants as a food source. These seeds contain toxins and are poisonous if eaten untreated. The solubility of these toxins in water is much greater than the solubility of the nutriments in the cycad seeds. Prolonged soaking of the cycad seeds in water leaches (removes) the toxins. This process depends upon the toxins being more soluble than the non-toxic nutriments.

Question 31

Criteria	Marks
● Calculate the moles of Ca^{2+} and SO_4^{2-} ● Calculate the concentration of the two ions ● Calculate the ionic product ● Show that IP < K_{sp} ● Draw correct conclusion	5
● Calculate the moles of Ca^{2+} and SO_4^{2-} ● Calculate the concentration of the two ions ● Calculate the ionic product ● Show that IP < K_{sp} ● Draw incorrect conclusion	4
● Calculate the moles of Ca^{2+} and SO_4^{2-} ● Calculate the concentration of the two ions ● Calculate the ionic product	3
● Any TWO correct calculations	2
● Any ONE correct calculation	1

Sample Answer

$N(Ca^{2+}) = n\ (Ca\ (NO_3)_2$

$= (0.010 \times 0.020) = 2.0 \times 10^{-4}$ mol

$n\ (SO_4^{2-}) = n(Na_2SO_4)$

$= (0.010) \times (0.020) = 2.0 \times 10^{-4}$ mol

Volume on mixing = 20 +20 = 40 mL = 0.040L

$[Ca^{2+}] = n/V = (2.0 \times 10^{-4}) / 0.040 = 5.0 \times 10^{-3}$ mol/L

$[SO_4^{2-}] = n/V = (2.0 \times 10^{-4}) / 0.040 = 5.0 \times 10^{-3}$ mol/L

$Ca^{2+}_{(aq)} + SO_4^{2-}_{(aq)} \rightarrow CaSO_{4\,(s)}$

Ionic product = $[Ca^{2+}]\ [SO_4^{2-}] = (5.0 \times 10^{-3})\ (5.0 \times 10^{-3}) = 2.5 \times 10^{-5}$

$IP < K_{sp}$

Therefore, no precipitate will form

Question 32

a)

Criteria	Marks
• Labels each correctly	3
• Labels TWO correctly	2
• Labels ONE correctly	1

Sample Answer

(i) Cationic
(ii) Non-ionic
(iii) Anionic

b)

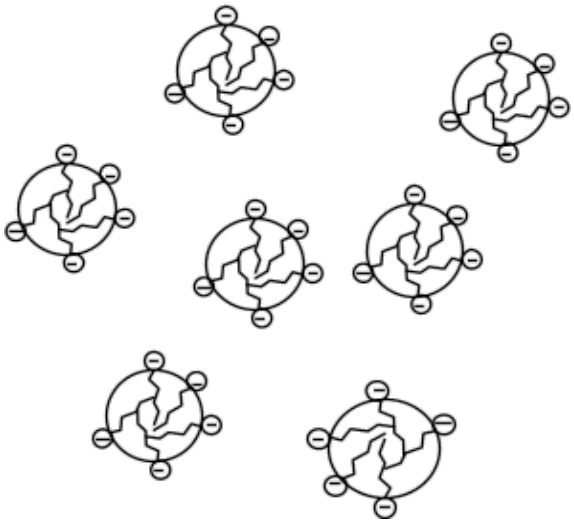
Criteria	Marks
• Discusses the statement • Clearly explains the structure of soap • Links the structure to the removal of fats and oils	3
• Clearly explains the structure of soap • Links the structure to the removal of fats and oils	2
• Outlines some correct information of the structure or cleaning action of soap	1

Sample answer

Soap is the sodium or potassium salt of a long-chain fatty acid. It has a hydrophobic, hydrocarbon tail – which is attracted to the oil or grease – and a negatively charged hydrophilic head – which is attracted to water. The dual nature of the molecule allows the tail to be attracted to (and hence remove) the oil and the head to be attracted to the water. The dirty soap, with oily dirt attached, goes down the drain with the water.

Soap is a surfactant. A surfactant is a substance which disperses dirt and grease as small particles throughout water.

In water, the soap and the dirt form spherical units called micelles.



The dirt is represented by the circle. The hydrophobic tails are attracted to the fat or oil (the dirt), while the anionic heads are on the outer surface of the "micelle" (the dispersed particle), closest to the water. Surfactants also decrease the surface tension of water (they get between the water particles and reduce the force of attraction between them). This reduction in surface tension allows the water particles to wet (spread out over) the surface of a dirty object rather than stay together as a drop of water.

Hence soap, because of its structure and ability to form micelles, is able to remove fats and oils from the skin when the soap is rubbed over the skin with water present.