Baulkham Hills High School

2020 **Trial HSC Examination**

Chemistry

General Instructions

- Reading time - 5 minutes
- Working time - 3 hours
- Write using black pen
- Draw diagrams using pencil
- NESA-approved calculators may be used
- Data sheets and a Periodic Table are provided as a separate sheet
- Use the Multiple-Choice Answer Sheet provided
- Write your Student Number at the top of this page, and on the Multiple-Choice Answer Sheet
- Clearly indicate whether work is continued on extra paper
- Responses written using a "^" or in the margin will NOT be considered for remarking.

Total Marks: 100

Section I - 20 marks

- Attempt Questions 1-20
- Allow about 35 minutes for this section
- Pages 2 - 7

Section II - 80 marks

- Attempt Questions 21-31
- Allow about 2 hours and 25 minutes for this section
- Pages 8 - 26

Section I - 20 marks

Attempt Questions 1-20

Allow about 35 minutes for this section

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1 Which equation would represent the greatest decrease in entropy?

A. $2O_3\ (g) \rightarrow 3O_2\ (g)$
B. $C\ (s) + O_2\ (g) \rightarrow CO_2\ (g)$
C. $2H_2O_2\ (s) \rightarrow 2H_2O\ (l) + O_2\ (g)$
D. $HCl\ (g) + NH_3\ (g) \rightarrow NH_4Cl\ (s)$

2 One litre of buffer solution is made by combining which two substances?

A. 0.2 mol acetic acid and 0.2 mol sodium acetate
B. 0.1 mol hydrofluoric acid and 1.0 mol sodium fluoride
C. 0.1 mol hydrochloric acid and 0.1 mol sodium chloride
D. 0.2 mol sodium hydrogen carbonate and 0.2 mol potassium hydrogen carbonate

3 When a student added 25 mL of 0.10 mol L^{-1} NaOH to 25 mL of 0.10 mol L^{-1} HNO_3 the temperature increased by 0.66°C.

What is the enthalpy of neutralisation for this reaction?

A. -55.2 kJ mol^{-1}
B. -0.137 kJ mol^{-1}
C. 27.59 kJ mol^{-1}
D. 55.2 kJ mol^{-1}

4 How many different structural isomers are there for C_3H_6BrCl?

A. 2
B. 3
C. 4
D. 5

5 The conjugate base of the ammonium ion is

A. NH_3
B. NH_4
C. NH_2^-
D. NH_3^+

6 Which of the following combinations is correct for the molecular shape around single, double and triple bonds in organic molecules?

	Single Bond	Double Bond	Triple Bond
A.	Trigonal Pyramidal	Trigonal Planar	Linear
B.	Trigonal Pyramidal	Bent	Linear
C.	Tetrahedral	Trigonal Planar	Linear
D.	Tetrahedral	Bent	Linear

7 How many products are possible when but-2-ene reacts with HCl (g)?

A. 1
B. 2
C. 3
D. 4

8 The table below shows pK_{ind}, the pH range, and the colour changes of three indicators

Indicator	pK_{ind}	pH range	colour at lower pH	colour at higher pH
bromophenol blue	4.0	3.0 – 4.6	yellow	blue
methyl red	5.1	4.2 – 6.3	red	yellow
phenolphthalein	9.3	8.3 – 10.0	colourless	red

At a pH of 4 which option below correctly identifies the colour of the resulting solution:

	Bromophenol blue	Methyl red	Phenolphthalein
A.	Yellow	red	Colourless
B.	Yellow	Yellow	Colourless
C.	Green	Orange	Colourless
D.	Green	Red	Colourless

9 The table below shows the boiling points of a number of alcohols:

Alcohol	Boiling Point (°C)
Methanol	65
Ethanol	78
Propan-1-ol	97
Butan-1-ol	117

What is the cause of the trend observed in the boiling points?

A. Increasing chain length results in stronger dispersion forces
B. Increasing chain length results in stronger hydrogen bonding
C. Hydrogen bonding between hydroxyl groups is stronger in larger molecules
D. Hydrogen bonding between hydroxyl groups is stronger in smaller molecules

10 A compound with the formula $C_6H_{12}O_2$ has the following features:

- It is unbranched
- It has only one type of functional group
- All carbon-to-carbon bonds are single bonds

The compound could be classified as:

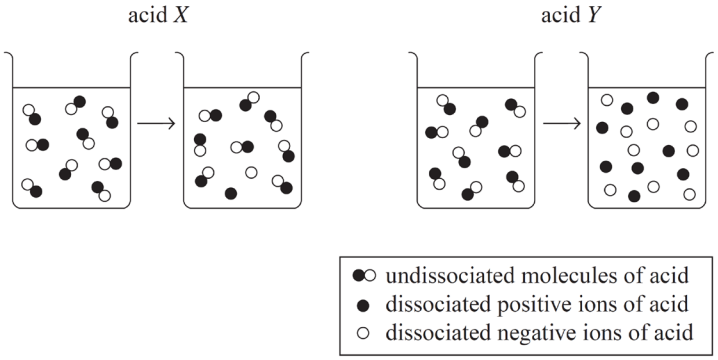
A. Ester
B. Amide
C. Alcohol
D. Aldehyde

11 Nitric acid completely dissociates in aqueous solutions. 1.0 mL of 10 mol L^{-1} solution was diluted to 1 L with distilled water. 100 mL of this resulting solution was then further diluted to 1 L using distilled water

What pH is the final solution closest to?

A. 1
B. 2
C. 3
D. 4

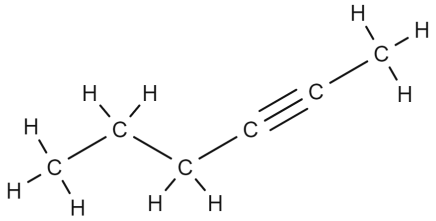
12 The diagram shows the behaviour of two different acids when they are dissolved in distilled water.



Which row of the table correctly describes the two acids?

	Acid X	Acid Y
A.	concentrated	dilute
B.	dilute	concentrated
C.	strong	weak
D.	weak	strong

13



The correct name of the compound above is:

A. hex-4-yne
B. hex-2-yne
C. hex-2-ene
D. hept-2-yne

14 The equation describes an equilibrium reaction occurring in a closed system.

$$P\,(g) + Q\,(g) \rightleftharpoons 4R\,(g) \qquad \Delta H = +48\ kJ$$

Under which set of conditions would the highest yield of R be obtained?

	Temperature (°C)	Pressure (kPa)
A.	150	200
B.	150	400
C.	300	200
D.	300	400

15 A student mixed 20.0 mL of 0.0800 mol L^{-1} H_2SO_4 with 25.0 mL of 0.35 mol L^{-1} KOH.

What is the pH of the resulting solution?

A. 0.80
B. 0.91
C. 13.09
D. 13.20

16 Which equation represents esterification?

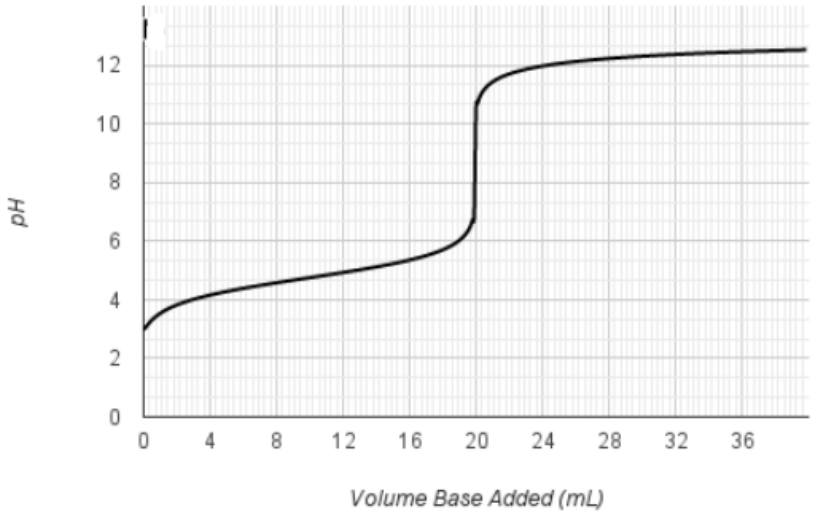
A. $C_6H_{12}O_6$ (aq) → $2C_2H_5OH$ (aq) + $2CO_2$ (g)
B. $C_6H_{12}O_6$ (aq) + $C_6H_{12}O_6$ (aq) → $C_{12}H_{22}O_{11}$ (aq) + H_2O ∗ l)
C. CH_3COOH (l) + NaOH (aq) → CH_3COONa (aq) + H_2O (l)
D. CH_3COOH (l) + C_2H_5OH (l) → $CH_3COOC_2H_5$ (l) + H_2O (l)

17 An organic compound has a molar mass of 88 g mol^{-1}
The ^{13}C NMR spectrum of the organic compound shows four distinct peaks.

The organic compound is most likely

A. Butan-1-ol
B. 2-methyl-butan-1-ol
C. 2-methyl-butan-2-ol
D. 2,2-dimethyl-propan-1-ol

18 The diagram below represents the titration curve for the reaction between an acid and a base.



The equation that best represents the reaction described by the titration curve is

A. HCl (aq) + NH_3 (aq) → NH_4Cl (aq)
B. HCl (aq) + NaOH (aq) → NaCl (aq) + H_2O (l)
C. CH_3COOH (aq) + NH_3 (aq) → CH_3COONH_4 (aq)
D. CH_3COOH (aq) + NaOH (aq) → CH_3COONa (aq) + H_2O (l)

19 The oxidation of sulfur dioxide, SO_2, to sulfur trioxide, SO_3, can be represented by the following equation:

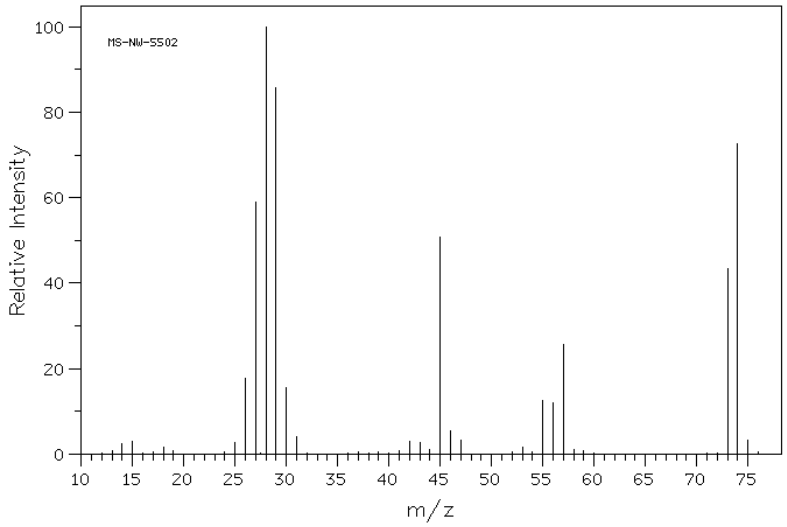
$$2SO_2\ (g) + O_2\ (g) \rightleftharpoons 2SO_3\ (g) \qquad K_{eq} = 1.75 \text{ at } 1000°C$$

An equilibrium mixture has a concentration of 0.12 M SO_2 and 0.16 M oxygen gas, O_2. The temperature of the container is 1000°C.

The equilibrium concentration of SO_3 at 1000°C is

A. 1.5×10^{-4} M
B. 4.0×10^{-3} M
C. 1.2×10^{-2} M
D. 6.3×10^{-2} M

20 The mass spectrum of propanoic acid, CH_3CH_2COOH, is shown below.



The peak at m/z 74

A. represents the parent ion containing the carbon-13 isotope
B. represents the species $[CH_3CH_2COOH]^+$
C. represents the species CH_3CH_2COOH
D. is commonly known as the base peak

End of Section I

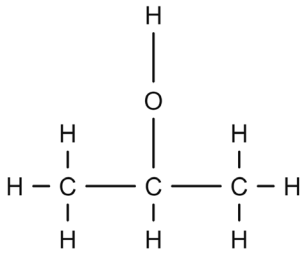
Section II - 80 marks

Attempt Questions 21-31.

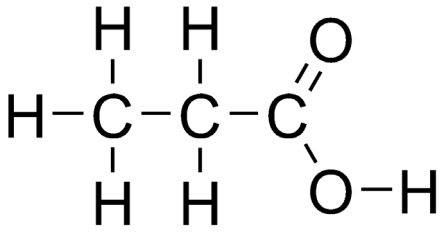
Allow about 2 hours and 25 minutes for this section.

Question 21 (5 marks)

The structures of two organic compounds, A and B, are shown below



Compound A



Compound B

a) Name compounds **A** and **B** **2**

b) Identify an isomer of **A** which can be converted to compound **B** **1**

c) Draw the structural formula of the organic compound, **C**, which is formed when compound **A** is oxidised using acidified potassium dichromate solution and name this compound **C** **2**

Question 22 (4 marks) **4**

Using ammonia as an example, explain how a substance can be classified as a Bronsted-Lowry base, but not as a base by the Arrhenius theory. Use equations in your response.

Question 23 (11 marks)

Ethanoic acid, CH_3COOH, is the active ingredient in white vinegar. A sample of white vinegar is analysed to accurately determine the concentration of CH_3COOH using the following steps:

1. Dilute a 10.00 mL sample of the white vinegar to 100.00 mL in a volumetric flask
2. Rinse the burette with the standardised sodium hydroxide solution, NaOH, that is provided
3. Fill the burette with the standardised NaOH solution
4. Pipette 20.00 mL of the diluted white vinegar solution into a 250 mL conical flask
5. Add several drops of phenolphthalein indicator to the conical flask. Titrate the diluted white vinegar solution against the standardised NaOH solution.
6. Repeat Steps 3-5 until concordant results are obtained

The equation for this analysis is:

$$CH_3COOH\ (aq) + NaOH\ (aq) \rightarrow CH_3COONa\ (aq) + H_2O\ (l)$$

Data

aliquot of diluted white vinegar solution	20.00 mL
mean titre of NaOH solution	25.60 mL
concentration of standardised NaOH solution	0.1123 M

a) Calculate the concentration of CH_3COOH in the undiluted white vinegar sample **3**

b) If the burette is rinsed with water instead of the standardised NaOH solution, what would be the effect, if any, on the experimental value obtained for the concentration of CH_3COOH in white vinegar? Justify your answer. **2**

c) CH_3COOH is a weak acid and has an acid dissociation constant of 1.8×10^{-5} **2**
Write the equation for the ionisation of ethanoic acid in water

Write the expression for K_a for ethanoic acid

d) An alternative method of determining the concentration of CH_3COOH in white vinegar is to measure the pH of the vinegar. Using a digital probe, the undiluted vinegar is found to have a pH of 2.31. Given the K_a for acetic acid in part (c), calculate the concentration of the acetic acid in the undiluted vinegar solution using this method. **2**

e) Explain a reason for the different values of the concentration of ethanoic acid determined using the 2 different methods (from part (a) and (d) above) **2**

Question 24 (12 marks)

a) Write the net ionic equation for the reaction of solutions of lead (II) nitrate and sodium hydroxide **1**

b) Using the solubility product information from the data pages, determined which of lead (II) hydroxide and lead (II) carbonate has the greater solubility in water, in units of mol/L, at 25°C **4**

Show all working and reasoning

c) Would a precipitate of lead carbonate form if 50 mL of 2.0×10^{-4} mol/L sodium carbonate were added to a solution of 150 mL of 5.0×10^{-3} mol/L lead(II) nitrate **3**

Show all working and reasoning

d) A lump of solid lead (II) carbonate, which contained radioactive lead ions, was added to a saturated solution of lead (II) carbonate and left to stand for several hours. **2**

Predict the distribution of the radioactive lead (II) ions after some hours and explain your prediction.

e) Use the example in part (d) above to explain the difference between static and dynamic equilibrium. **2**

Question 25 (8 marks)

The table below shows base dissociation constants at 25°C

Base	Formula	K_b
phosphine	PH_3	1.0×10^{-14}
hydroxylamine	NH_2OH	9.1×10^{-9}
ammonia	NH_3	1.8×10^{-5}
methanamine	CH_3NH_2	4.4×10^{-4}

a) Identify the strongest base in the table and determine the $\boldsymbol{pK_b}$ value for this base **2**

b) Calculate the pH of a 0.10 M solution of ammonia **3**

c) For any conjugate acid-base pair, what is the relationship between the $\boldsymbol{pK_a}$ and the $\boldsymbol{pK_b}$ at 25°C? **3**

Use ammonia as an example.

For NH_3, $K_b = 1.8 \times 10^{-5}$ and $K_a = 5.6 \times 10^{-10}$

Question 26 (7 marks)

A change in the position of equilibrium can be demonstrated visually using two forms of cobalt (II) ions. Solutions of the $Co(H_2O)_6^{2+}$ ion are pink and solutions of the $CoCl_4^{2-}$ ion are blue.

A solution made from 0.5 M $Co(H_2O)_6^{2+}$ ions and 5 M Cl^- ions reaches the following equilibrium.

$$\underset{\text{pink}}{Co(H_2O)_6^{2+}}\ (aq) + 4Cl^-\ (aq) \rightleftharpoons \underset{\text{blue}}{CoCl_4^{2-}}\ (aq) + 6H_2O\ (l)$$

At room temperature, the mixture is blue when this solution is at equilibrium.

a) 5 mL of the equilibrium mixture was poured into a test tube with 5 drops of 4M HCl/ **2**

Use Le Chatelier's principle to predict the impact on this reaction and describe its appearance

b) 10 g of $AgNO_3$ crystals is mixed with another 20 mL sample of the equilibrium mixture. What effect will the addition of $AgNO_3$ crystals to the second solution have on the position of equilibrium? **3**

Explain your answer in terms of collision theory. Write an equation for the reaction involving $AgNO_3$

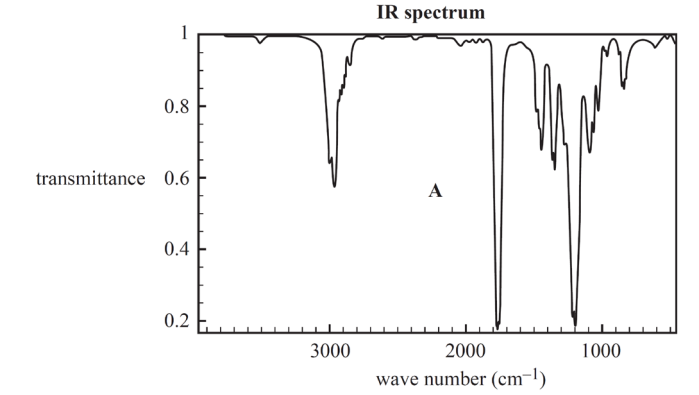
c) Samples of the original equilibrium solution are pink when refrigerated at 4°C and blue when kept at 25°C. **2**

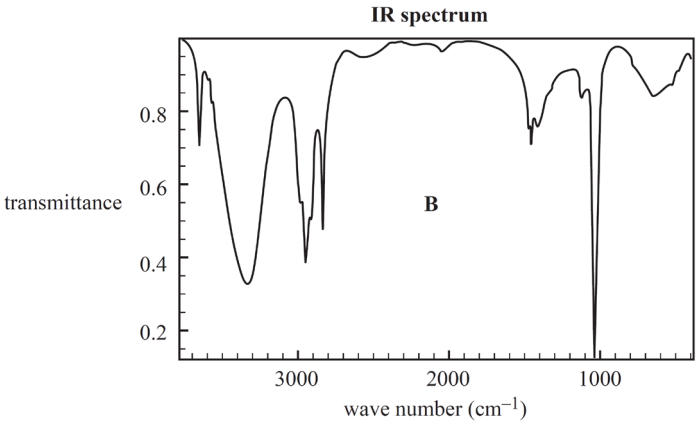
Is the reaction in the original equilibrium solution endothermic or exothermic?

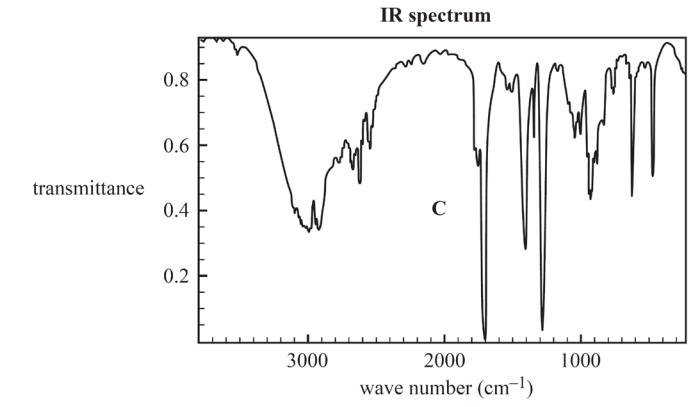
Explain your reasoning

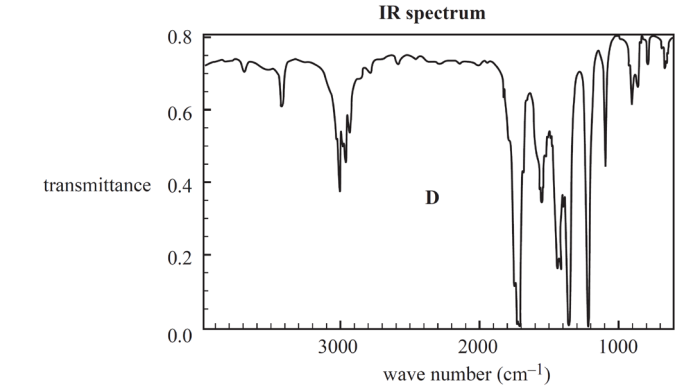
Question 27 (11 marks)

A student prepared the compound methyl propanoate in a school laboratory using two organic reactants. The infra-red (IR) spectra for the two reactants and two other related compounds are given below.









a) Name and draw the structural formulae for each of the organic reactants used to produce methyl propanoate **4**

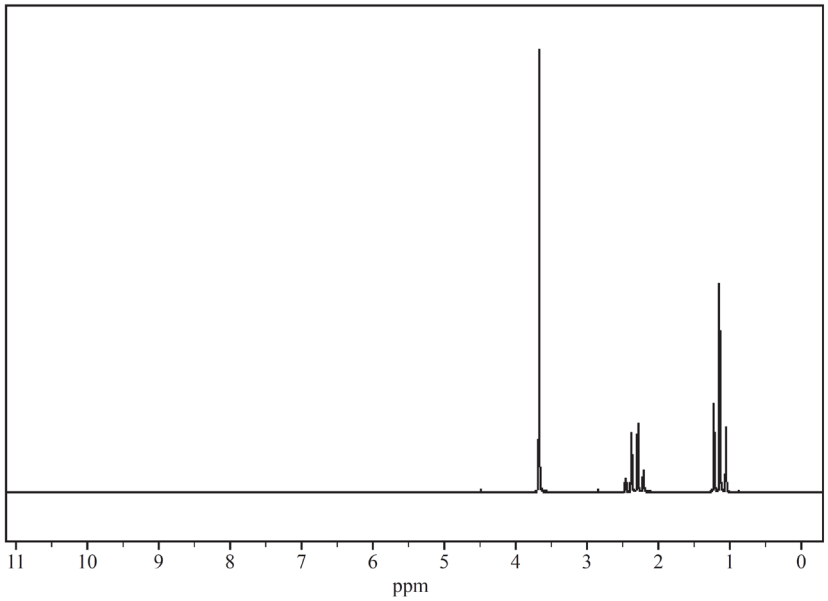
	Name	**Structural Formulae**
I		
II		

b) For **each** of the reactants named in **part (a) above**, identify its corresponding IR spectrum from the spectra A to D above. **4**

Justify your answer using data from the spectrum

Reactant	**Spectra**	**Justification**
I		
II		

c) The high resolution proton NMR spectrum, ^{1}H NMR, for methyl propanoate is shown below **3**



Describe **three** features of this spectrum that confirm it is methyl propanoate

Question 28 (5 marks)

Sulfur trioxide is an unstable gas that can decompose according to the equation:

$$2SO_3\ (g) \rightleftharpoons 2SO_2\ (g) + O_2\ (g) \quad \Delta H > 0$$

a) A mixture of the three gases was added to a gas syringe and the contents allowed sufficient time to reach equilibrium. The volume of the syringe was then halved and the temperature was held constant. **2**

Identify the impact of this volume change on

- the value of the equilibrium constant

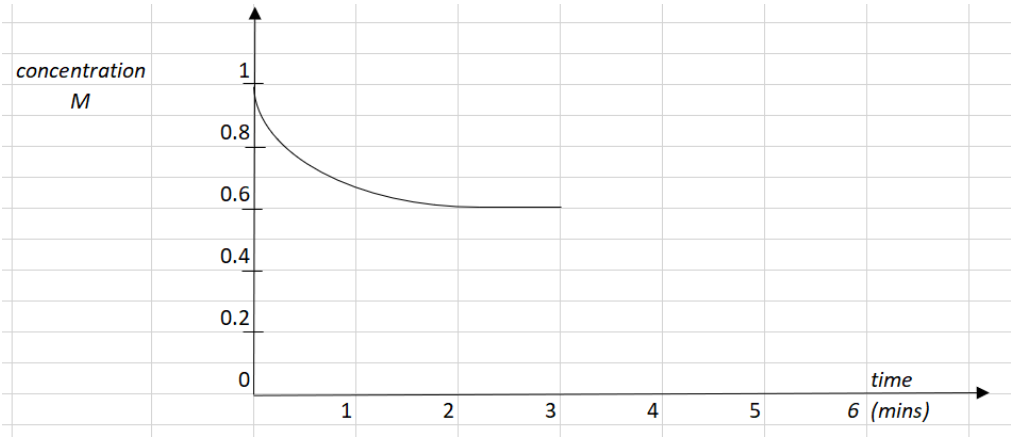
_____

- the amount of SO_2 gas

_____

b) A sample of sulfur trioxide gas was added to an empty sealed flask and its concentration was plotted over the next 3 minutes. **2**

The SO_3 concentration is plotted on the graph below



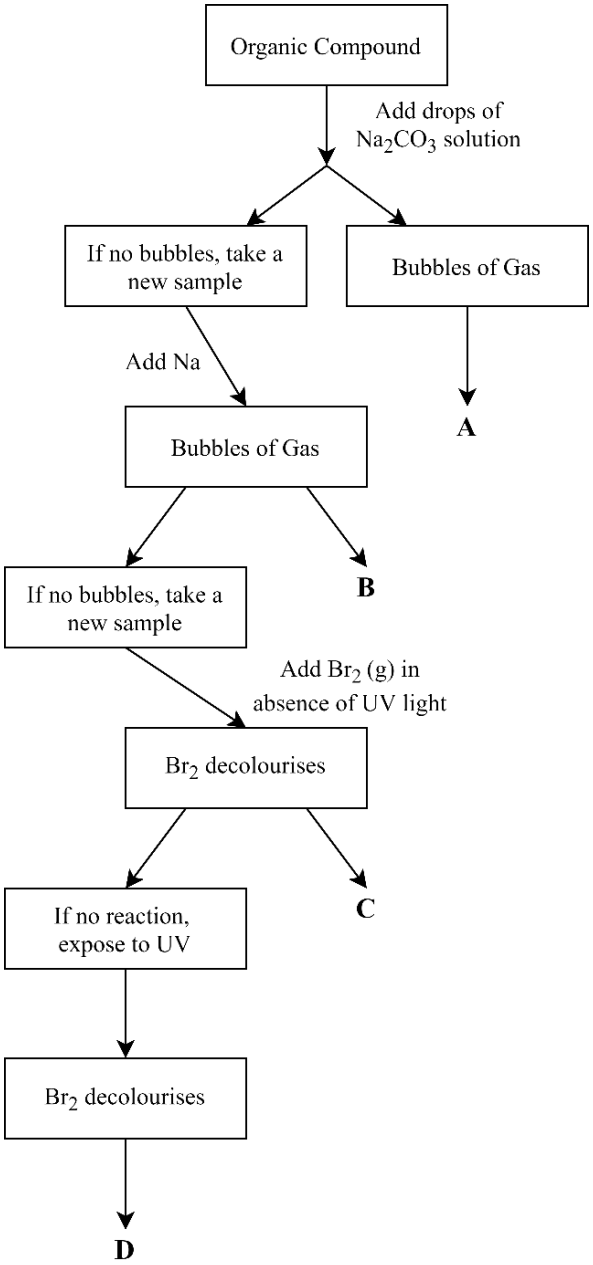
Draw on the graph the corresponding concentrations for the sulfur dioxide and oxygen gases during the first 3 minutes.

c) At the three minute mark the temperature of the system is increased over two minutes, until a higher temperature is maintained. On the graph provided in part (b), show the impact of this change on the SO_3 concentration **1**

Question 29 (6 marks)

A student designed a flowchart to distinguish between samples of an alkene, alkane, alcohol and organic acid. Each example contained 3 carbons ONLY.

Use the flowchart to answer the questions below:



a) Identify the functional group isolated using the above flowchart **2**

A =

B =

C =

D =

b)

i. Write the equation for the reaction which identifies **A**. **1**
Name the product formed

ii. The ionic product of this reaction is isolated and re-dissolved in water. Will the solution be acidic, basic or neutral? Explain your reasoning. **2**

c) Write the equation for the reaction which identifies **C**. **1**
Name the product formed.

Question 30 (6 marks)

a) Explain, using labelled diagrams, the action of soap **4**

b) When would you use detergents rather than soap? Give reasons to support your response. **2**

Question 31 (5 marks)

Polymers are long chained molecules consisting of repeating monomers.

a) Name an addition polymer and draw its monomer molecules **2**

b) Explain ONE use of the polymer in part (a) in terms of its structure and properties **3**

End of Paper

Multiple choice

1	2	3	4	5	6	7	8	9	10
D	A	A	D	A	C	A	D	A	A
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
C	D	B	C	C	D	C	D	D	B

Question 21:

(a) i. 2-propanol **or propan-2-ol**

ii. propanoic acid

(b) **1-propanol** (Not propanol and any unclear writing NOT accepted eg Propanal)

(c) Accepted answer in line with IUPAC standards. 2-propanone or more correctly, **propan-2-one**.
Propanone and Dimethyl ketone Not accepted.

IUPAC Standards Online

[Acetone]

Keywords:	Chemical Compound, Acetone
Document Type:	Chemical Compound

IUPAC Name	propan-2-one
Alternative Names	2-propanone propanone Dimethyl ketone
Molecular Formula	C_3H_6O
Molar Mass	58.08 g/mol
InChI	InChI=1S/C3H6O/c1-3(2)4/h1-2H3
InChI Key	CSCPPACGZOOCGX-UHFFFAOYSA-N
CAS Number 67-64-1	
PubChem CID 180	

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Overview ›

Correct structure AND Name 2 marks

Correct structure OR Correct Name 1 mark no carry error. Full structure to be shown.

Q22

Criteria	Marks
• Differentiate between the two definitions • Using example and equation, thoroughly demonstrates that ammonia is not an Arrhenius base • Using an example and equation, thoroughly demonstrates ammonia is a Bronsted-Lowry base.	4
• Differentiates between the two definitions • Using ammonia as an example, one of the examples and equation is not explained thoroughly	3
• Both the definitions are correctly stated • At least one equation is correctly written	2
• One definition is correctly stated OR one correct equation is written	1

Sample answer:

Arrhenius Theory states that a base is substance that contains a hydroxide ion in aqueous solution. When ammonia is added to water, it reacts with water to produce ammonium ions and hydroxide ions

$NH_{3\,(aq)} + H_2O(l) \leftrightarrow NH_4^{+}{}_{(aq)} + OH^{-}{}_{(aq)}$

This is a reversible reaction and 99% of ammonia remains as ammonia molecules. There are hydroxide ions there and those react with hydrogen ions in just the same way as hydroxide ions, which does not fit the Arrhenius definition.

This same reaction also happens between ammonia gas and hydrogen chloride gas.

$NH_{3\,(g)} + HCl_{(g)} \rightarrow NH_4Cl_{(s)}$

In this case there are no hydrogen ions or hydroxide ions in solution, because there is no solution. The Arrhenius Theory would not count this as an acid- base reaction despite the fact it produces the same product as when the two substances are in aqueous solution.

+ NH_3 is a gas. Arrhenius theory only true for aqueous solutions.

Bronsted-Lowry Theory of acids/base state that

- An acid is a proton donor
- A base is a proton acceptor.

Ammonia reacts with water as follows:

$NH_{3\,(g)} + H_2O_{(l)} \leftrightarrow NH_4^{+}{}_{(aq)} + H_3O^{+}{}_{(aq)}$

Here ammonia acts as a base, as it accepts a proton from water. In the ammonia/HCl reaction this is no longer a problem as whether you are talking about the reaction in solution or in the gas state. Ammonia is a base as it accepts a proton

Marking Criteria Q23 (11 marks)

a) Calculate the concentration of CH_3COOH in the undiluted white vinegar sample. (3 marks)

Answer:

- $c_1v_1 = c_2v_2$

Concentration of aliquot of diluted white vinegar, c_1 = (25.60 x 0.1123) / 20 = 0.143744 M

- Concentration of Undiluted vinegarx10 mL= 100mLx 0.1437M

Concentration of undiluted vinegar, c_1 = (100 x 0.1437)/ 10 = 1.437 M (4s.f.)

OR

Use n=cV

# of moles of NaOH

Criteria	Mark
Correctly calculates the concentration of undiluted CH_3COOH in the white vinegar sample, show correct substitution and give answer (units) to 4 significant figures	3
Calculates the concentration of CH_3COOH in the undiluted white vinegar sample (answer not to 4 significant figures or no unit or not show substitution)	2
Calculate the number of moles of NaOH and mention its equivalent to the number of moles of acetic acid or concentration of diluted acetic acid	1

b) If the burette is rinsed with water instead of the standardised NaOH solution, what would be the effect, if any, on the experimental value obtained for the concentration of CH_3COOH in white vinegar? Justify answer. (2 marks)

Answer:

- Dilution of NaOH -------not standardised NaOH (lower concentration
- Final undiluted and aliquot of diluted white vinegar concentration greater than actual (over estimation)

Criteria	Mark
Identify effect of rinsing burette with water on NaOH and on the experimental CH_3COOH concentration value	2
Identifies only the effect of rinsing burette with water on NaOH OR the experimental CH_3COOH concentration value	1

c) CH_3COOH is a weak acid and has an acid dissociation constant of 1.8×10^{-5}. (2 marks)

Write the equation for the ionisation of ethanoic acid in water.

$CH_3COOH + H_2O \rightleftharpoons CH_3COO^- + H_3O^+$	1 mark

Write the expression for K_a for ethanoic acid.

$K_a = [CH_3COO^-][H_3O^+] / [CH_3COOH]$	1 mark

Criteria	Mark
Correctly write the equation for the ionisation of CH_3COOH in water (with reversible arrow) AND Expression for K_a	2
Provides the ionisation equation without a reversible arrow or water as reactant and an expression for K_a	1

d) An alternative method of determining the concentration of CH_3COOH in white vinegar is to measure the pH of the vinegar. Using a digital probe, the undiluted vinegar is found to have a pH of 2.31. Given the K_a for acetic acid in part (c) above, calculate the concentration of the acetic acid in the undiluted vinegar solution using this method. (2 marks)

Answer:

pH =2.31 (data), $[H^+] = 10^{-2.31}$ M $= 4.89 \times 10^{-3}$ M $= 0.005$M

$[CH_3COOH] = [H^+][CH3COO^-] / Ka = (4.89 \times 10^{-3})^2 / 1.8 \times 10^{-5} = 2.398 \times 10^{-5} / 1.8 \times 10^{-5} = 1.332685$ M $= 1.33$M

Criteria	Mark
Calculates the correct concentration of CH_3COOH in the undiluted vinegar using pH value and Ka value in moles/L or M units	2
Calculates only the concentration of H+ from pH or give the concentration of CH_3COOH in the undiluted vinegar without units	1

e) Explain a reason for the different values of the concentration of ethanoic acid determined using the 2 different methods (from parts (a) and (d) above). (2 marks)

Identify titration method drives the reaction to completion. Adding excess base drives the reaction to complete and consume all [H^+]
pH measures H^+ ion concentration, that are dissociated. Does not account for molecular (undissociated) component.

Criteria	Mark
Identifies that titration drives the reaction to completion and all [H^+] consumed due to complete dissociation of vinegar by adding excess base. AND Using digital probe, pH measures only dissociated [H^+] concentration does not account for undissociated molecular component.	2
Identify that digital probe only measures dissociated [H^+] concentration OR titration drives the reaction to completion	1

Q24 a)

Criteria	Mark
• Correct ionic equation with states	1

Sample Answer:

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

b)

Criteria	Marks
• Correctly calculates the solubility of the two salts, using equations and equilibrium expressions • Identifies the salt more soluble	4
• One salt solubility calculation incorrect • Identifies the salt more soluble	3
• Both calculations are incorrect but identifies the more soluble salt based on their calculation	2
• A balanced chemical equation OR correct equilibrium expression	1

Sample Answer:

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

$K_{sp} = [Pb^{2+}]\,[OH^-]^2 = 1.43 \times 10^{-15}$

$X \quad (2X)^2 = 4X^3 = 1.43 \times 10^{-15}$

$X = 7.10 \times 10^{-6}$ mol/L

$PbCO_{3\,(s)} \rightarrow Pb^{2+}_{(s)} + CO_3^{-}{}_{(aq)}$

$K_{sp} = [Pb^{2+}]\,[CO_3] = 7.4 \times 10^{-14}$

$X \quad X = X^2 = 7.4 \times 10^{-14}$

$X = 2.72 \times 10^{-7}$ mol/L

So, $Pb(OH)_2$ is more soluble than $PbCO_3$

c)

Criteria	Marks
• Calculate correctly [Pb^{2+}] and [CO_3^{2-}] • Calculate ionic product • Predict correctly if a precipitate is formed	3
• Calculate correctly [Pb^{2+}] OR [CO_3^{2-}] • Ionic product calculation not correct • Predict formation of precipitate based on their calculations	2
• At least any one calculation OR correct prediction based on their calculations	1

Sample Answer:

$Na_2CO_{3\,(aq)}$ + $Pb(NO_3)_{2\,(aq)}$ → $PbCO_{3\,(s)}$ + $2NaNO_{3\,(aq)}$

n = $2.0 \times 10^{-4} \times 0.05$ $5.0 \times 10^{-3} \times 0.15$

1.0×10^{-5} 7.5×10^{-4}

$[Pb^{2+}] = 1.0 \times 10^{-5} / 0{,}2 = 5.0 \times 10^{-5}$ M

$[CO_3^{2-}] = 7.5 \times 10^{-4} / 0.2 = 3.75 \times 10^{-3}$ mol/L

Ionic Product = $5.0 \times 10^{-5} \times 3.75 \times 10^{-3} = 1.875 \times 10^{-7}$

Since Ionic product is greater than K_{sp}, a precipitate is formed

d)

Criteria	Marks
• Use K_{sp} value to show it ionises a very small amount • Most of the radioactive lead will be in the solid state	2
• Identifies that most of the lead atoms will be in the solid state without justification	1

Sample Answer:

$PbCO_{3\,(s)}$ ---------- $Pb^{2+}{}_{(aq)}$ – $CO_3^{2-}{}_{(aq)}$ $K_{sp} = 7.4 \times 10^{14}$

This indicates that a very small amount of ionisation (10^{-7} mol/L) of each ions.

So, most of the radioactive lead isotopes will be in the solid state.

e)

Criteria	Marks
• Using the example, differentiates dynamic and static equilibrium	2
• Differentiates dynamic and static equilibrium without the example	1

Sample Answer:

A dynamic equilibrium, reactants are converted to products and products are converted to reactants at an equal and constant rate. Reactions do not necessarily—and most often do not—end up with equal concentrations. Equilibrium is the state of equal, opposite rates, not equal concentrations.

Static equilibrium occurs when all particles in the reaction are at rest and there is no motion between reactants and products. Dynamic forces are not acting on the potential energies of the reverse and forward reactions. An example of static equilibrium is graphite turning into diamond, shown below. This reaction is considered at static equilibrium after it occurs because there are no more forces acting upon the reactants (graphite) and products (diamond).

In the example shown in part d), the reaction Has reached a state of dynamic equilibrium, where the rate of forward reaction is equal to the rate of reverse reaction

Q25 a)

Criteria	Marks
• Correctly identifies strongest base • Calculates pK_b correctly	2
• Correctly identifies strongest base OR calculates pK_b correctly	1

Sample answer

Methanamine is the strongest base.

$pK_b = -\log k_b$

$= -\log 4.4 \times 10^{-4}$

$= 3.36$

b)

Criteria	Marks
• Using K_{vb}, caulculates the $[OH^-]$ • Calculates $[H^+]$ • Calculates pH of the solution • Answer given to 2 sig fig	3
• Answer not calculated to 2 sig fig	2
• Correct expression for K_b OR correct expression for calculating pH (-log $[H^+]$	1

Sample Answer

$NH_3 + H_2O \rightarrow NH_4^+ + OH^-$

$K_b = [NH_4^+][OH^-] / [NH_3]$

$K_{vb} \times [NH_3] = x^2$

$X\ (OH^-) = \sqrt{1.8 \times 10^{-5} \times 0.10} = 1.34 \times 10^{-3}$

$[H^+] = 1.0 \times 10^{-14} / 1.34 \times 10^{-3} = 7.46 \times 10^{-12}$

$pH = -\log 7.46 \times 10^{-12} = 11.13$

c)

Criteria	Marks
• States that $pK_a + pK_b = 14.00$ • Calculates pK_a and pK_b values • Adds the two values to be equal to 14.00	3
• Any one of the above steps missing	2
• Any ONE correct calculation	1

Sample Answer

$pK_a + pK_b = 14.00$

For ammonia,

$K_b = 1.8 \times 10^{-5}$

$pK_b = -\log K_b$

$= -\log 1.8 \times 10^{-5} = 4.75$

$K_a = 5.6 \times 10^{-10}$

$pK_a = -\log K_b$

$= -\log 5.6 \times 10^{-10} = 9.25$

$pK_a + pK_b = 4.75 + 9.25 = 14.00$

Question 26 a)

Criteria	Mark
• Response includes outline of change in conditions that affect equilibrium (increase concentration of chloride ions) and how the system adjusts to counteract change (increase rate of forward reaction to reduce concentration of chloride ions). • Response includes colour of solution due to change in equilibrium position (blue)	2
• Response is lacking sufficient detail from above OR • Response contains an error OR • Response includes relevant information	1

Sample:
With the addition of HCl to the solution, there will be an increase in chloride ions due to the complete dissociation of the acid. The system will adjust to counteract this change by increasing the rate of the forward reaction, thus shifting the equilibrium to the right to increase the formation of products and reduce the concentration of chloride ions, as predicted by Le Chatelier's Principle. The mixture will appear blue due this change.

Question 26 b)

Criteria	Mark
• Response includes an outline of the change to the equilibrium system, due to the introduction of silver ions (from the silver nitrate), which reacts with the chloride ions (on the left side of the equation) and precipitates out of solution. • A correct balanced chemical equation is included that shows the process above. • Response includes an outline of how the process above will affect the frequency of successful collisions between the species in the forward reaction, reducing the reaction rate and how in comparison the reaction rate of the reverse reaction will be unchanged and will be relatively higher than the forward reaction, resulting in a shift toward the left, in order to increase the concentration of species, which will result in the solution appearing pink.	3
• Response lacks sufficient detail, however covers all of the concepts above. OR • Response lacks a balanced chemical equation, showing precipitation of silver chloride (indicated by the symbol (s) for the solid state of silver chloride)	2
• Response includes relevant information	1

Sample:
The silver nitrate will dissociate into silver and nitrate ions, the silver ions will collide with the chloride ions in the forward reaction to react and produce a precipitate of silver chloride, i.e. $Ag^+_{(aq)} + Cl^-_{(aq)} \rightarrow AgCl_{(s)}$. This will reduce the concentration of chloride ions and reduce the frequency of successful collisions between the hexaaquacobalt(II) ions - $Co(H_2O)_6^{2+}$, reducing reaction rate of the forward reaction. Whilst the rate of the reverse reaction will be higher relative to the forward reaction, resulting in the equilibrium shifting towards the left to replace the chloride ions consumed by the precipitation reaction, resulting in a solution that will be pink coloured.

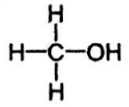
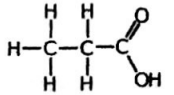
Question 26 c)

criteria	Mark
• Endothermic reaction is correctly identified. • Response includes a detailed explanation as to why the forward reaction is endothermic using the process of LCP	2
• Endothermic reaction is correctly identified • Explanation is lacking sufficient detail.	1

Sample:
The forward reaction is endothermic. This can be explained by the fact that when the temperature is increased the solution appears blue, indicating that the equilibrium shifts to the right to counteract the increase in temperature by absorbing heat.

Note: also accepted an explanation of the reverse process - decrease temperature, shifts to left to produce heat.

Question 27

27 a)	
Methanol	
Propanoic acid	
• **1 mark for each correct cell (correctly named and correct structure)** • *NOTE: be mindful of how many bonds each atom can make*	

27 b)	
Spectra	Justification
B	1. Broad peak from 3200 – 3600 which repsents a alcohol O-H group 2. Intense signal at 1000 which represents a C-O bond
C	1. VERY Broad peak at 2850 – 3300 which represents a acidic O-H group 2. 1700 = C=O OR 3. 1300 = C-O
1 Mark for each correct cell. Must have at least two justifications for a positive identification and correct spectra identified	

27 c)	
Mark	**Criteria**
1	Some relevant information identified
2	Clearly describes three features of the spectrum used to clearly identify methyl propanoate ***OR*** Refers to direct data points on the spectrum
3	Clearly describes three features of the spectrum used to clearly identify methyl propanoate ***AND*** Refers to direct data points on the spectrum

Possible features:

1) Three peaks represent the three unique hydrogen environments in methyl propanoate
2) 3-4ppm: no splitting due to the absence of adjacent hydrogens and hence further down field
3) 2ppm: 3 adjacent hydrogens (quartet)
4) 1ppm: triplet and therefore two neighbouring hydrogens
5) If diagram was drawn with direct reference to the spectrum it was very clear to see the thought process. (Description was still necessary to answer the question)

Question 28 a), i. & ii

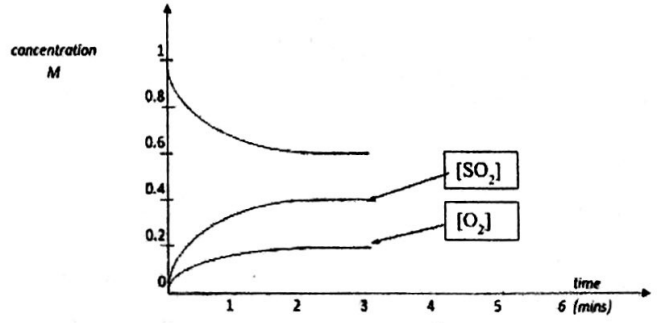
Criteria	Mark
• Both responses correct	2
• One response correct	1

Sample:
i) There is no change to the equilibrium constant
ii) There will be a decrease in the amount of SO_2

Question 28 b)

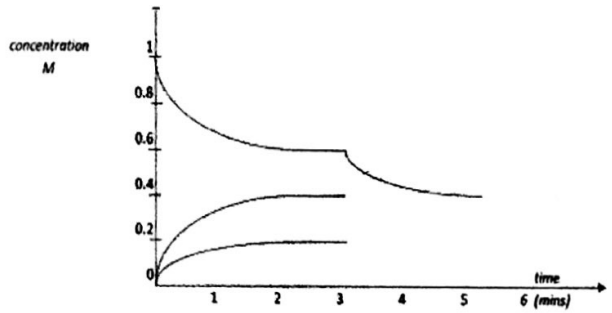
Criteria	Mark
• Both lines are correct, in terms of concentration • Both lines are labelled	2
• Both lines are correct, however are unlabelled OR • Only one line is correct, in terms of concentration OR • Both lines are incorrect, in terms of concentration, however they are both labelled	1

Sample:



Question 28 c)

Criteria	Mark
• Line is a smooth decline in concentration over 2 minutes	1



Question 29

Identify: draw or name **FUNCTIONAL** group All correct 2 marks

3,2 or 1 correct 1 mark

(a)

- A= carboxyl or carboxylic acid group -COOH. **NOT** carboxylate, not organic acid
- B= hydroxyl (-OH) **NOT** alcohol nor hydroxide.
- C= Alkene (C=C) or unsaturated
- D= Alkane (C-C) or saturated

(b) i. Correct equation (balanced) AND correct Name 1 (1/2 marks awarded)

$2C_2H_5COOH + Na_2CO_3 \rightarrow 2\ C_2H_5COONa + CO_2 + H_20$: **sodium propanoate**

ii. Solution will be basic. Supported by relevant equation or DETAILED description.

$C_2H_5COONa + H_2O \leftrightarrow C_2H_5COOH + OH^- + Na^+$

iii.Correct Equation AND name (State of Br_2 important)

$C_3H_6 + Br_{2(g)} \rightarrow C_3H_6Br2$ **1,2-dibromopropane** (1/2 marks awarded)

Question 30 a)

• Clear demonstration/ of definition/ chemistry of what a soap is • Dissolution, mentioning **hydrophilic and hydrophobic** interactions • **Agitation** with water forms micelle which holds small droplet of oil • Polar heads of **micelles** with a negative charge point outwards **repelling** each other forming an emulsion • oil/grease **washed away** • Clear annotated diagram showing all steps including diagram of labelled soap molecule	4
4-5 points adequately covered	3
4-5 points covered	2
Only 3 points covered	1

Question30 b)

• Correct identification of example • Thorough justification	2
• Only one of the above adequately covered.	1

Question 31 a)

• Correctly named polymer • Correctly drawn monomer	2
• Only one of the above correct	1

Question 31 b)

• Identification of use • Properties related to the identified use • **Adequate explanation** of properties based on structure	3
• Only two of the above points met Or • Explanation insufficient with identification of function and properties.	2
• Only one of the above points met	1