
Student Number

CHELTENHAM GIRLS HIGH SCHOOL

2022

YEAR 12 HSC Chemistry
HSC Trial Examination

Chemistry

General Instructions

- **Reading time – 5 minutes**
- **Working time – 3 hours**
- Write using black pen
- Draw diagrams using pencil
- Use the multiple-choice answer sheet provided
- Calculators approved by NESA may be used
- A formulae sheet, data sheet and Periodic Table are provided at the back of this paper
- Write your Student Number at the top of this page and on the multiple-choice answer sheet write BOTH your number AND name.

Total marks - 100

Section I: Multiple Choice Section (20 marks)

- Allow 35 minutes for this section.
- Attempt Questions 1-20

Section II: Extended Responses (80 marks)

- Allow 2 hours 25 minutes for this section.
- Attempt Questions 21- 33

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SECTION I: MULTIPLE CHOICE QUESTIONS (20 MARKS)

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

Use the multiple-choice answer sheet for Questions 1 – 20

1. The conjugate base of the ammonium ion is

   A. NH_3

   B. NH_4

   C. NH_2^-

   D. NH_3^+

2. Which of the equations below is correct for the reaction of sulfuric acid and aluminium carbonate solid?

   A. $Al_2CO_3\,(s) + 3H_2SO_4\,(aq) \rightarrow Al_2(SO_4)_3\,(aq) + H_2O(l) + CO_2\,(g)$

   B. $Al_2\,(CO_3)_3\,(aq) + 3H_2SO_4\,(aq) \rightarrow Al_2(SO_4)_3\,(aq) + 6H_2O(l) + 3CO_2\,(g)$

   C. $2Al_2CO_3\,(s) + 3H_2SO_4\,(aq) \rightarrow 2Al_2(SO_4)_3\,(aq) + 6H_2O(l) + 3CO_2\,(g)$

   D. $Al_2\,(CO_3)_3\,(s) + 3H_2SO_4\,(aq) \rightarrow Al_2(SO_4)_3\,(aq) + 3H_2O(l) + 3CO_2\,(g)$

3. What is the solubility of MgF_2 ($K_{sp} = 6.8 \times 10^{-9}$) in pure water?

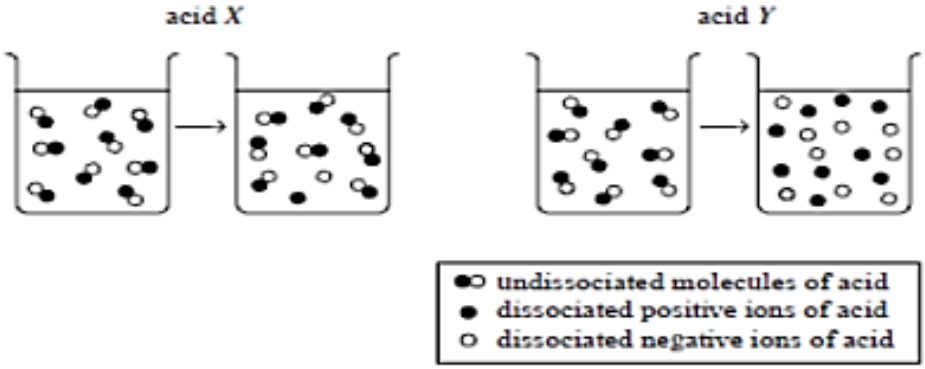
   A. 6.8×10^{-9} mol L^{-1}

   B. 5.8×10^{-5} mol L^{-1}

   C. 8.2×10^{-5} mol L^{-1}

   D. 1.2×10^{-3} mol L^{-1}

4. 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

5. How many different structural isomers are there for C_3H_6BrCl?

A. 2

B. 3

C. 4

D. 5

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

A 1

B 2

C 3

D 4

7. Nitrous acid, HNO_2, has Ka = 4.5 x 10^{-4}. What is the best description of the species present in a 0.1 M solution of nitrous acid?

   A. $HNO_{2\,(aq)}$ is the predominant species; much smaller amounts of $H^+_{(aq)}$ and $NO_2^-{}_{(aq)}$ are present.

   B. $H^+_{(aq)}$ and $NO_2^-{}_{(aq)}$ are the predominant species; much smaller amounts of $HNO_{2\,(aq)}$ are present.

   C. Only $H^+_{(aq)}$ and $NO_2^-{}_{(aq)}$ are present in measurable amounts.

   D. $HNO_{2\,(aq)}$, $H^+_{(aq)}$ and $NO_2^-{}_{(aq)}$ are all present in comparable amount

8. Phenolphthalein is a common indicator. It contains (by mass) 75.46% carbon, 4.43% hydrogen and 20.10% oxygen. It contains four oxygen atoms in each molecule, two of which are connected to hydrogen atoms.

   A. $C_{10}H_7O_2$

   B. $C_{10}H_7O_4$

   C. $C_{20}H_{12}O_4$

   D. $C_{20}H_{14}O_4$

9. For the reaction: $Br_2\,(g) + I_2\,(g) \rightarrow 2IBr\,(g)$ Keq = 1.2 x 10^2 at 150°C

   Given this reaction above, what is the Keq for the reaction shown below?

   $4IBr\,(g) \rightarrow 2Br_2\,(g) + 2I_2\,(g)$ at 150°C

   A. 1.6 x 10^{-2}

   B. 4.1 x 10^{-3}

   C. 6.9 x 10^{-5}

   D. 8.03 x 10^{-5}

10. A student wants to use a physical property to distinguish between two alcohols, octan-1-ol and propan-1-ol. Both alcohols are colourless liquids at standard laboratory conditions. The student should use,

    A. density because propan-1-ol has a much higher density than octan-1-ol.

    B. boiling point because octan-1-ol has a higher boiling point than propan-1-ol.

    C. electrical conductivity because octan-1-ol has a higher conductivity than propan-1-ol.

    D. solubility because octan-1-ol will has a higher solubility in water than propan-1-ol.

11. 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 an

    A. Ester

    B. Amide

    C. Alcohol

    D. aldehyde

12. "X" is prepared from the reaction of "Y" and "Z" as described in the following equation.

$$Y(g) + Z(g) \rightleftharpoons 3X(g) \qquad \Delta H = -50 \text{ kJ mol}^{-1}$$

    Which set of conditions would increase the rate at which X (g) is initially produced?

    A. High pressure, high temperature.

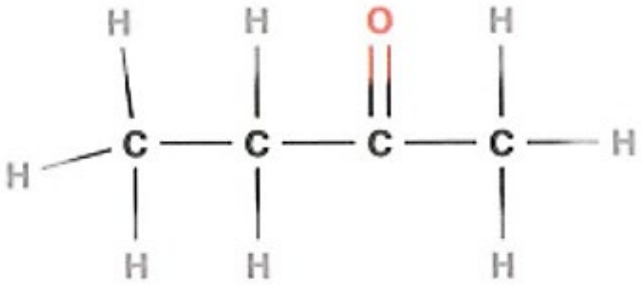
    B. Low pressure, low temperature.

    C. High pressure, low temperature.

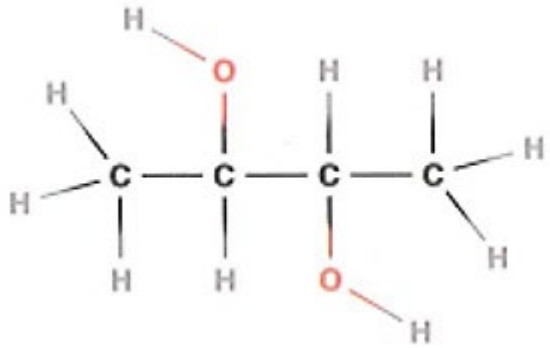
    D. Low pressure, high temperature.

13. Which of the molecules below is a functional group isomer of butanoic acid?

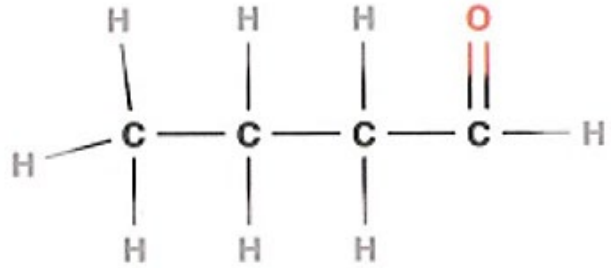
A.



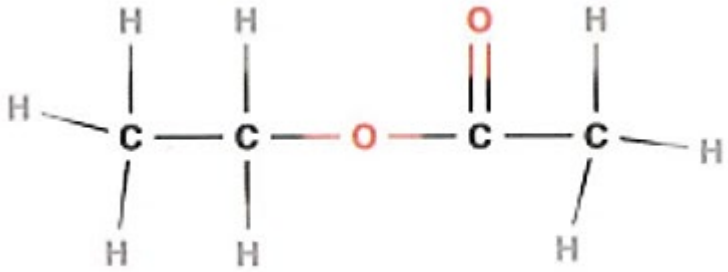
B.



C.



D.



14.

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

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

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

	Bromophenol Blue	**Methyl Red**	**Phenolphthalein**
A.	yellow	red	colourless
B.	yellow	yellow	colourless
C.	green	orange	colourless
D.	green	red	colourless

15. A student is told that an unlabelled solution may contain one or more nitrate salts of Mg^{2+}, Pb^{2+} and/or Ba^{2+}.

They are required to determine which cation/s are present in the solution and are provided with several solid ionic compounds for this analysis.

Which compound below, when added to water, would form an effective reagent for the first step in this analysis?

A. Silver Chloride

B. Potassium Chloride

C. Lithium Sulfate

D. Copper (II) Sulfate

16. The tetrachlorocopper (II) anion forms a green solution and reacts with water to form the blue hexaaquacopper (II) cation according to the following equation:

$$CuCl_4^{2-}(aq) + 6H_2O(l) \rightleftharpoons Cu(H_2O)_6^{2+}(aq) + 4Cl^-(aq) \quad \Delta H = \text{negative}$$

At a constant pressure and temperature, the appearance of a solution containing these ions remains pale blue.

Which alternative correctly predicts an identified change and its effect on the system?

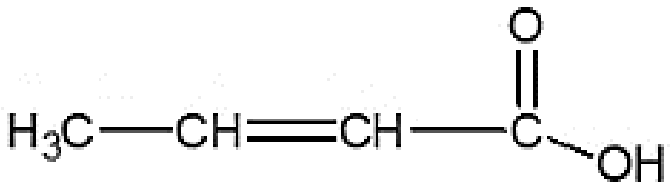
A. Adding water causes the solution to turn green.

B. Cooling the reaction vessel increases the rate of the reverse reaction.

C. Increasing the temperature causes the solution to turn blue.

D. Adding concentrated hydrochloric acid causes the solution to turn green.

17. The structure of an organic compound is shown below.



What mass of chlorine molecules would react completely with 0.250 moles of the compound?

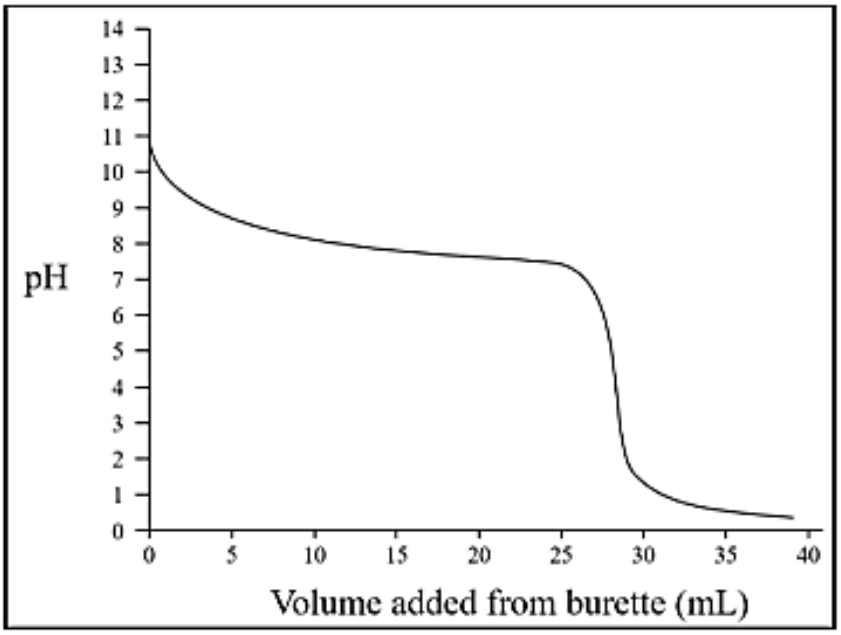
A. 8.86 g

B. 26.59 g

C. 17.73 g

D. 35.45 g

18. The curve below shows the change in pH vs the volume of solution added from a burette during an acid-base titration.



Which alternative identifies the type of solution present in the conical flask and burette during this titration.

	Solution in the conical flask	**Solution in the burette**
A.	Strong Base	Strong Acid
B.	Weak Base	Strong Acid
C.	Weak Acid	Weak Base
D.	Strong Acid	Weak Base

19. A student mixed 10.0 mL of 0.0400 mol L^{-1} H_2SO_4 with 40.0 mL of 0.35 mol L^{-1} KOH. What is the pH of the resulting solution?

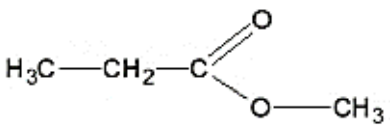
A. 0.26

B. 0.58

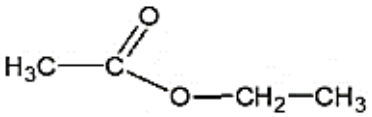
C. 13.42

D. 13.45

20. The structural formulae of five organic compounds, labelled A-E, are shown below.



A



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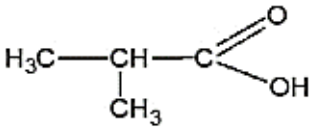
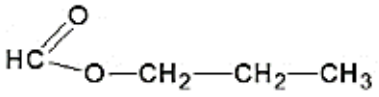
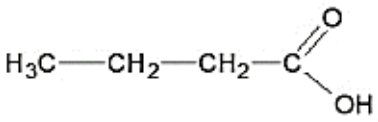


C



D



E

Which alternative below identifies a pair of these compounds which are examples of each type of structural isomer?

	Chain Isomers	**Functional Group Isomers**	**Position Isomers**
A.	C and E	A and C	B and D
B.	A and C	A and E	A and D
C.	E and C	A and B	B and E
D.	D and E	B and C	A and B

End of Section I

SECTION II

Attempt Questions 21 to 33

Allow about 2 hour and 25 minutes for this part

Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.

Question 21 (8 Marks) **Marks**

(a) Compare and contrast the relative solubility of lead (II) hydroxide and lead (II) phosphate. **2**

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(b) The solubility product, K_{sp} of $Ca(OH)_2$ is 6.4×10^{-6} at 298K. **3**

Calculate the solubility (in gL^{-1}) of calcium hydroxide in pure water at 298K.

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(c) Using the information below, explain the effect a temperature increase would have on the quoted K_{sp}. **3**

Thermodynamic data (at 25 °C, 100 kPa)

	$\triangle H^{o}_{f}$ /kJ mol^{-1}
Ca^{2+} (aq)	-543
OH^{-} (aq)	-230
$Ca(OH)_2$ (s)	-986

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Question 22 (8 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.

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

pink colourless blue

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

(a) Write the equilibrium expression, K_{eq}, for the equation above. **1**

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(b) One 20 mL sample is diluted by adding 10 mL of deionised water, H_2O, at room temperature. The solution immediately becomes a paler blue due to the dilution. **2**

Use Le Chatelier's principle to explain the colour change expected from this paler blue colour until a new equilibrium is reached.

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(c) 10 g of $AgNO_3$ crystals is mixed into a second 20 mL sample of the equilibrium mixture. **3**

What effect will the addition of $AgNO_3$ crystals to the second solution have on the position of equilibrium?

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

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(d) 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.

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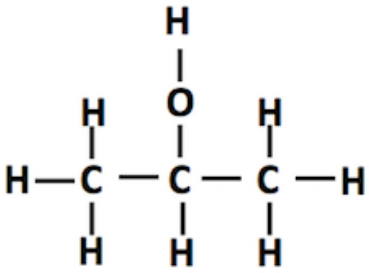
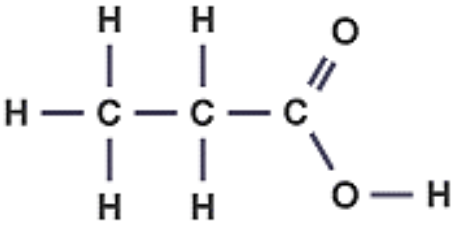
Question 23 (5 Marks)

The structures of 2 organic compounds, A and B, are shown below.



Compound **A**



Compound **B**

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

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

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(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 24 (4 Marks)

A student heated 250g of water by combusting 1.8g of butanol. The starting temperature of the water was 23^0C. Calculate the final temperature of the water if there is 20% heat loss to the surroundings, given that the molar heat of combustion of butanol is 2871 kJ/mol. **4**

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Question 25 (6 Marks)

Sodium fluoride forms a solution with a pH around 8.6 when added to water, whereas amphiprotic sodium hydrogen sulfate forms a solution with a pH of 1. Compare and contrast how each of these salts affects the pH of water. **6**

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Question 26 (5 Marks)

(a) Calculate the volume of CO_2 gas produced (measured at 25ºC and 100 kPa), when 5.00 g of $CaCO_3$ is dissolved in excess hydrochloric acid. **2**

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(b) 1.22 g of an unknown gas has a volume of 15.0 L at 100 kPa and 25^0C. **2**

i) Calculate the molar mass of the gas.

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ii) Predict the identity of the gas. **1**

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Question 27 (9 Marks)

(a) Using *structural* formulae, write a balanced equation for the production of an ester using acetic (ethanoic) acid and 1-propanol. *Name* the ester produced. **2**

(b) Explain the conditions needed to efficiently and safely carry out this reaction in the school laboratory. **4**

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(c) The table below shows the boiling points of some organic compounds. **3**

Name	*Molar mass (g mol^{-1})*	*Boiling point (^{o}C)*
Acetic acid	60.1	117.9
Propan-1-ol	60.1	97.2
Ethyl methanoate	60.1	54.2

Explain the *difference* in boiling points between these three compounds.

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Question 28 (7 Marks)

(a) During your study of chemistry, you performed an analysis to estimate the acid content in vinegar against sodium hydroxide by *titration*. **4**

Describe AND justify *four* steps you took in performing your analysis, to reduce experimental errors and thus ensure your titration results were valid and reliable.

Step taken	Justification

(b) Citric acid, the predominant acid in lemon juice, is a triprotic acid. A student titrated 25.0 mL samples of lemon juice with 0.550 mol L^{-1} NaOH. The mean titration volume was 29.50 mL. The molar mass of citric acid is 192.12 g mol $L^{-1.}$ **3**

What was the concentration of citric acid in the lemon juice in gL^{-1}?

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Question 29 (4 Marks)

Hydrogen iodide can be produced by the reversible reaction of hydrogen gas and iodine gas according to:

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

K_{eq} for this reaction is 2.25×10^3 at a temperature of 753°C.

(a) Calculate the concentration of HI in an equilibrium mixture if the concentration of H_2 is 0.15 M and the concentration of I_2 is 0.25 M. **2**

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(b) 2.4 moles of H_2(g) and 1.5 moles of I_2(g) were placed in a sealed 2.0 L vessel maintained at a temperature of 753°C. After 2 hours, the number of moles of each gas present were as follows. **2**

Moles of $H_2(g)$	Moles of $I_2(g)$	Moles of $HI(g)$
1.7	0.8	1.4

Show by calculation whether the forward or reverse reaction must increase for the system to come to a state of dynamic equilibrium.

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Question 30 (8 Marks)

E10 engine fuel is a blend of 10% ethanol and 90% petrol. One of the issues with its use is the absorption of water vapour from the atmosphere.

(a) Referring to its molecular structure, explain how ethanol is able to blend with petrol and also causes water retention in the fuel blend. **3**

(b) Discuss the basis of the claim that ethanol as a fuel is *carbon-neutral*, and does not increase atmospheric CO_2. **3**

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(c) In a fermentation experiment, 6.50 g of glucose was completely converted to ethanol and carbon dioxide. **2**

What is the mass of carbon dioxide produced?

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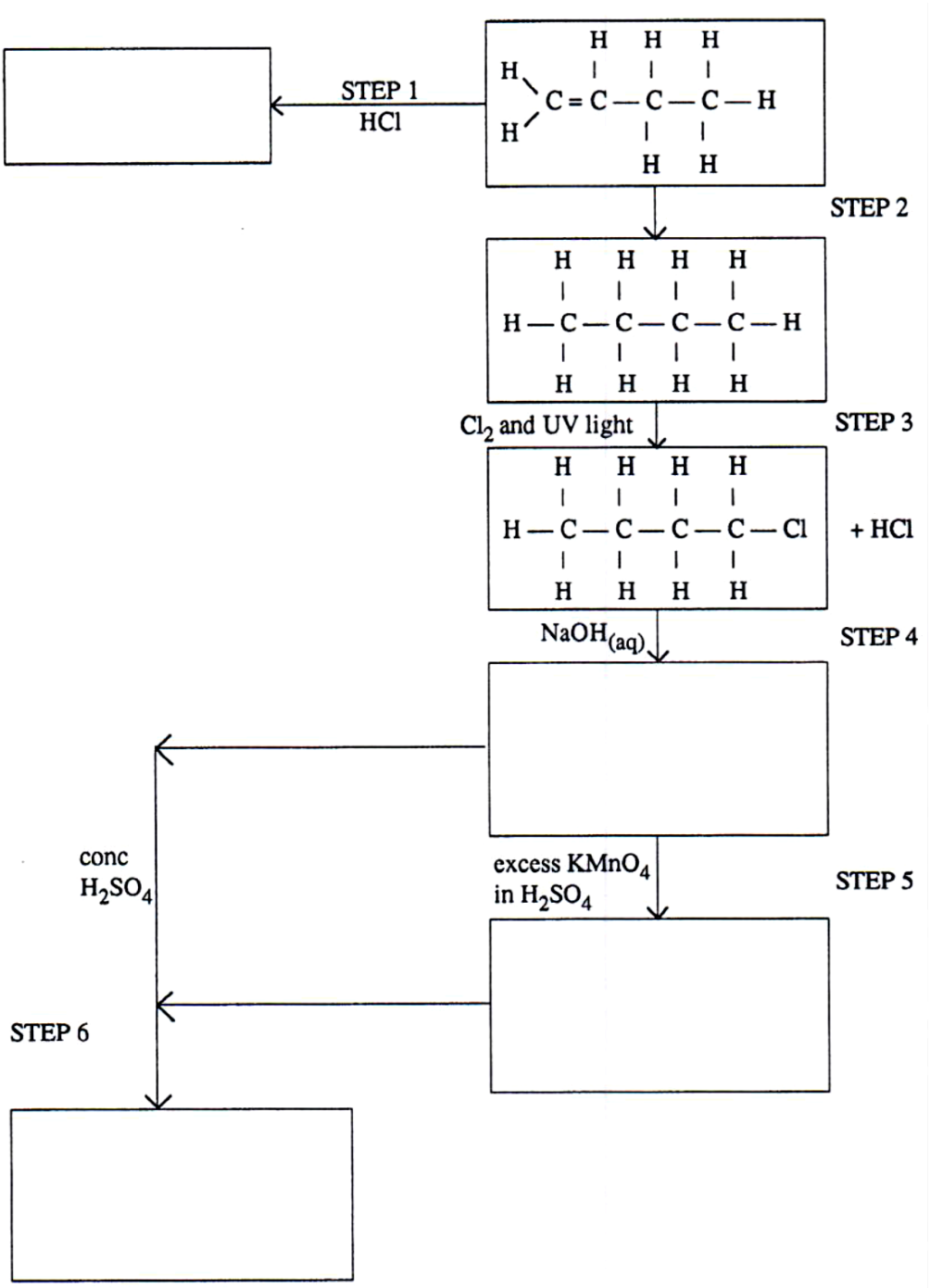
Question 31 (7 Marks)

Use the flow diagram below to answer the following questions:



(a) Name and draw the structural formula for the compound formed in Step 1. **2**

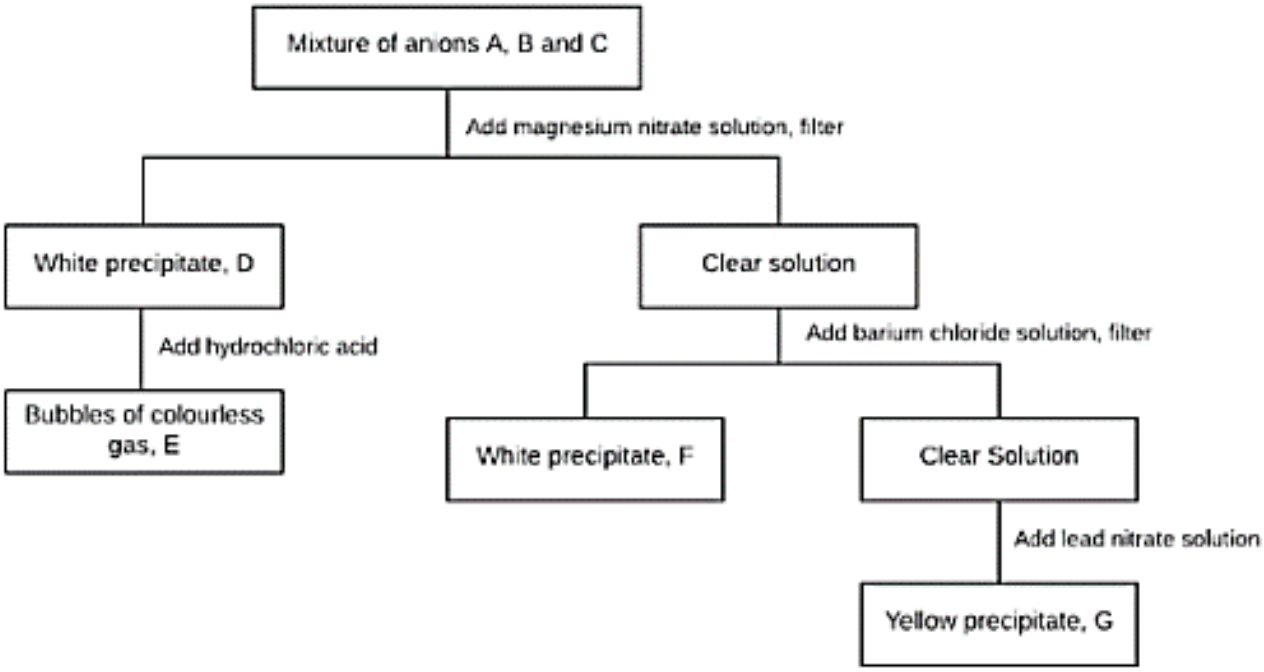
(b) Name and draw the structural formula for the compound formed in Step 4 **2**

(c) Give a chemical equation for the reaction involved in Step 5. **1**

(d) Name and draw the compound formed in Step 6. **2**

Question 32 (6 Marks)

To identify the three anions present in a solution, the following procedure was performed:



(a) Identify precipitate D and gas E. **2**

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(b) Write net ionic equations for the formation of precipitates F and G. **2**

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(c) A compound is known to be either calcium chloride or iron(III) chloride. Describe a simple test that could be used to distinguish between the two. **2**

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Question 33 (3 Marks)

Explain why 0.1M solutions of sulfuric acid, acetic acid, and hydrochloric acid have different pH values. **3**

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End of Section II

Student Name: ……

Student Number

2022 YEAR 12 EXAMINATION
CHEMISTRY

Use the multiple-choice answer sheet provided for Questions 1-20

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

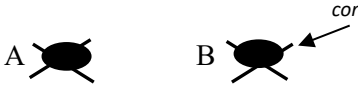
Sample 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

A ○ B ● C ○ D ○

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

A ● B ⊗ C ○ D ○

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



Start Here →

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

Section I

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

Section II

Question 21 (8 marks)

(a)

Criteria	Mark
• Correctly identifies which compound is more soluble AND that both compounds have low solubility	2
• Correctly identifies which compound is more soluble OR that both compounds have low solubility	1

Sample Answer:

From the data sheet, lead(II) hydroxide has a K_{sp} value of 1.43×10^{-15} and lead(II) phosphate has a K_{sp} value of 8.0×10^{-43}. Both of these K_{sp} values are very small, indicating that they both have low solubility. However, lead(II) phosphate has a significantly lower K_{sp} value, so would be less soluble than lead(II) hydroxide.

(b)

Targeted Performance Bands: 3-6

Criteria	Marks
• Correctly calculated solubility, with the correct sig fig	3
• Calculated solubility with one error	2
• Some relevant information	1

Sample answer:

$K_{sp} = 6.4 \times 10^{-6} = [Ca^{2+}][OH^-]^2 = x(2x)^2$, where x = solubility

$x(4x^2) = 6.4 \times 10^{-6}$

$4x^3 = 6.4 \times 10^{-6}$

$x^3 = 6.4 \times 10^{-6}/4$

$x = \sqrt[3]{\frac{6.4 \times 10^{-6}}{4}}$

$x = 1.17 \times 10^{-2}$ mol L^{-1}

Molar mass is $40.08 + 2(16.00 + 1.008) = 74.096$ $gmol^{-1}$

To convert to g/L from mol/L

$1.17 \times 10^{-2} \times 74.096$

= 0.8669232 g/L

= 0.87 g/L

(c)

Targeted Performance Bands: 3-6 Criteria	Marks
• Correctly calculated $\triangle H^o_f$ and explained the effect on quoted Ksp when temperature is increased	3
• Correctly calculated $\triangle H^o_f$	2
• Some relevant information	1

Sample answer:

$Ca(OH)_2\,(s) \rightleftharpoons Ca^{2+}(aq) + 2OH^-(aq)$

$\triangle H^o_f = \Sigma \triangle H^o_f$ products - $\Sigma \triangle H^o_f$ reactants

$= [(-543) + 2(-230)] - (-986)$

$= -17\ kJ\ mol^{-1}$

According to LCP, when $\triangle H^o$ is less than 0 and temperature is increased, the equilibrium will shift to counteract the change in temperature, therefore Ksp will decrease.

Question 22 (8 marks)

(a) (1 mark)

Outcomes Assessed: CH12–4, CH12-7, CH12–12

Targeted Performance Bands: 2-3

Criteria	Mark
• Writes the correct equilibrium constant expression	1

Sample answer

$K_{eq} = \dfrac{[CoCl_4^{2-}]}{[Co(H_2O)_6^{2+}]\,[Cl^-]^4}$

(b) (2 marks)

Outcomes Assessed: CH12–4, CH12–7, CH12–12

Targeted Performance Bands: 3-5

Criteria	Marks
• Predicts the colour change from light blue to pink in terms of the concentrations of ions using Le Chatelier's Principle	2
• Predicts the colour change from light blue to pink but without correct explanation	1

Sample answer

The dilution of the sample will have greater impact on the reactants than products (5 ions on LHS vs 1 on RHS). By Le Chatelier's Principle, the equilibrium position will shift to counteract the change. This means the equilibrium will move to the left to produce more pink hydrated cobalt ions and colourless chloride ions. The solution will become more pink (less blue).

(c) (3 marks)

Outcomes Assessed: CH12–6, CH12-7, CH12–12

Targeted Performance Bands: 3-5

Criteria	Marks

• Predicts that the equilibrium will move to the left as chloride ions are removed by formation of a precipitate AND • Uses collision theory to explain the change AND • Writes a correct ionic equation	3
• Predicts that the equilibrium will move to the left as chloride ions are removed by formation of a precipitate AND 1 of the following • Uses collision theory to explain the change OR • Writes a correct ionic equation	2
• Predicts that the equilibrium will move to the left as chloride ions are removed by formation of a precipitate OR • Writes a correct ionic equation	1

Sample answer
The $AgNO_3$ solid will dissolve in the equilibrium mixture. The equilibrium will move to the left as the silver ions react with the chloride ions to form a white precipitate of silver chloride.

The backward reaction can continue but the rate of the forward reaction is reduced by the removal of the chloride ions from the equilibrium mixture. Hence the blue $CoCl_4^{2-}$ will react to form more pink $Co(H_2O)_6^{2+}$ ions. A new equilibrium is reached which contains a smaller proportion of blue ions and a larger proportion of pink ions.

(Note: The equilibrium will be not be destroyed as only 0.06 mol Ag^+ has been added but there are 0.10 moles of Cl^- in 20 mL of the equilibrium mixture.)

$Ag^+ (aq) + Cl^- (aq) \rightarrow AgCl (s)$

(d) (2 marks)
Outcomes Assessed: CH12–5, CH12–7, CH12–12
Targeted Performance Bands: 3-5

Criteria	Marks
• Explains (using collision theory or Le Chatelier's Principle) that the reaction is endothermic as the equilibrium shifts to the right when the temperature increases	2
• States that the forward reaction to form blue $CoCl_4^{2-}$ is endothermic	1

Sample answer
In a reaction at equilibrium, an increase in temperature will always increase the rate of the endothermic reaction more than the rate of the exothermic reaction.
An increase in temperature will always favour the reaction that cools the reaction vessel (the endothermic reaction).

With an increase in temperature, a greater proportion of the particles will have energy equal to or greater that the activation energy. This means the rate of the endothermic forward reaction will temporarily increase more than the rate of the exothermic reaction.

The equilibrium will shift to the right and more blue $CoCl_4^{2-}$ will form. A new equilibrium with a greater proportion of $CoCl_4^{2-}$ than previously will be established at the higher temperature.

Question 23 (5 marks)

(a) (2 marks)

Outcomes Assessed: CH12–7, CH12–14

Targeted Performance Bands: 2-3

Criteria	Marks
• Correctly names TWO compounds	2
• Correctly names ONE compound	1

Sample answer

A = propan-2-ol

B = propanoic acid

(b) (1 mark)

Outcomes Assessed: CH12–7, CH12–14

Targeted Performance Bands: 2-3

Criteria	Mark
• Identifies propan-1-ol	1

Sample answer

Propan-1-ol (by name or correct formula)

(c) (2 marks)

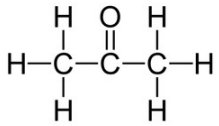
Outcomes Assessed: CH12–7, CH12–14

Targeted Performance Bands: 2-4

Criteria	Marks
• Identifies propanone as compound **C** AND draws the correct structure	2
• Identifies propanone as compound **C** OR draws the correct structure	1

Sample answer

Propanone



Question 24 (4 marks)

Targeted Performance Bands: 2-6

Criteria	Marks
• Correctly calculates moles of butanol AND • Correctly calculates heat transferred AND • Correctly calculates 20% heat loss AND • Correctly calculate final temperature,	4
• As above with one error	3
• As above with two errors	2
• Demonstrates some relevant understanding	1

Sample answer:

n (butanol) = m/M = 1.8/74.121 = 0.024 mol

$\Delta H_c = q/n$, so $q = \Delta H_c \times n$

$q = 2871 \times 0.024 = 69.7$ kJ

20% is lost to the environment, so available q is $69.7 \times 80/100 = 55.8$ kJ

$\Delta T = q/mC$ where m is the mass of water and C is its specific heat capacity.

$= 55\,800/(0.250 \times 4.18 \times 10^{3}) = 53.4\ ^0C$

$T_{final} = 53.4 + 23 = 76\ ^0C$

Question 25 (6 marks)

Targeted Performance Bands: 3-6

Criteria	Marks
• Identifies sodium fluoride as a basic salt AND • Identifies sodium hydrogen sulfate as amphiprotic AND • Provides relevant equations for both to clearly identify and explain similarity and differences.	5-6
• Identifies sodium fluoride as a basic salt AND • Identifies sodium hydrogen sulfate as amphiprotic AND • Explains similarity and differences. BUT • Missing relevant equations OR • Identifies basic and amphiprotic salt AND provides a relevant equation AND • Identifies similarities and differences between basic and amphiprotic salts.	3-4
• Identifies basic and amphiprotic salt AND provides a relevant equation. OR • Identifies salts, identifies a difference AND/OR a similarity.	2
• Identifies NaF as a basic salt OR identifies Hydrogen sulfate as amphiprotic.	1

Sample Answer:

Sodium fluoride, a soluble salt, is the product of a strong base (NaOH) and a weak acid (HF). This means the fluoride, F^-, can act as a Bronsted – Lowry base, accepting a hydrogen ion from water and forming OH^- (aq) in solution, making it alkaline with a higher pH, as shown below. The sodium ion does not have the ability to accept hydrogen ions from water, so Na^+ has no pH effect on the water.

F^- (aq) + H_2O (aq) ⇌ HF (aq) + OH^- (aq)

Sodium hydrogen sulfate is soluble and is amphiprotic. It is able to donate and accept an H^+ ion.

In the presence of hydronium or hydroxide ion the following reactions occur:

(1) HSO_4^- (aq) + H_3O^+ (aq) ⇌ H_2SO_4 (aq) + H_2O (l) showing basic behaviour.
(2) HSO_4^- (aq) + OH^- (aq) ⇌ SO_4^{2-} (aq) + H_2O (l) showing acidic behavior.

In water the following reactions occur:

(1) HSO_4^- (aq) + H_2O (l) ⇌ H_2SO_4 (aq) + OH^- (l) showing basic behaviour.
(2) HSO_4^- (aq) + H_2O (l) ⇌ SO_4^{2-} (aq) + H_3O^+ (l) showing acidic behavior.

In water, reaction (2) is more likely, hence producing an acidic solution with a lower pH.

In summary, sodium fluoride, NaF is a basic salt, whereas sodium hydrogen sulfate is acidic. Both can accept hydrogen ions to produce some hydroxide ions in solution. However, hydrogen sulfate is able to donate hydrogen ions to water to produce H_3O^+. Hydrogen sulfate solutions are acidic.

Feedback: Need to discuss about amphiprotic nature of HSO_4^- and then relate and link to question where it is acting as an acid. Didn't accept just defining amphiprotic generally.

Question 26(a)

Criteria	Mark
• Uses reaction stoichiometry to calculate the molar quantity of $CO_{2\,(g)}$. (*1 mark*) • Converts moles of gas to a volume under standard conditions. (*1 mark*)	**2**

Answer may include:

$CaCO_3$ + 2 HCl ®-→← $CaCl_2$ + $CO_{2\,(g)}$ + $H_2O_{\,(l)}$

n = m / M = 5.00 g / 100.09 g mol^{-1} = 0.04995504… mol $CaCO_3$

1 mol CO_2 / 1 mol $CaCO_3$ x 0.049955 mol $CaCO_3$ = 0.0500 mol CO_2

n = V / MV .

V = n x MV = 0.049955 mol CO_2 x 24.79 L mol^{-1} = 1.24 L CO_2 gas

Feedback: did not mark units/ sig fig this time but in HSC, unis is marked for every question.

(b)(i)

Criteria	Marks
• Correct moles and molar mass	2

• Correct moles	1

Feedback: did not mark units/ sig fig this time but in HSC, unis is marked for every question. Sig fig: Must look at what you used in calculations, not conditions.

Suggested answer:

At 100kPa and 25^0C , the molar volume is 24.79L

Molar mass of the gas = 24.79 X 1.22= 2.02g/mol

15

(b)(ii)

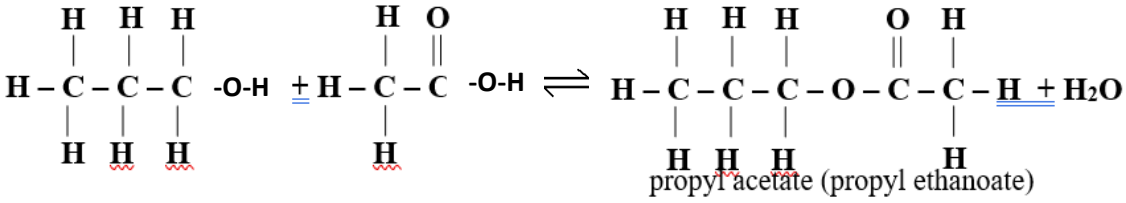
Criteria	Marks
• Correctly identify gas	1

Suggested answer:
Hydrogen gas

Question 27(a)(i)

Criteria	Mark
• Constructs structural formulas for 1-propanol, acetic acid and propyl acetate. • Assigns a systematic name for propyl acetate.	**2**

Answer may include:



Feedback: Did not look for catalyst (conc H2SO4) / refluxing heat

(b)

Criteria	Marks
• Explains conditions under which esterification can be carried out safely and efficiently in a school laboratory	4
• Outlines some conditions necessary for esterification to be carried out safely and/or efficiently and explains at least ONE condition	3
• Identifies some conditions necessary for esterification to be carried out safely and/or efficiently OR • Outlines a relevant condition	2
• Provides some relevant information	1

Sample answer:

Concentrated sulfuric acid is added to the reaction mixture of alkanol and alkanoic acid.

The concentrated acid acts as a catalyst increasing the rate at which the ester is produced. It also acts as a dehydrating agent, shifting position of equilibrium to the right and thereby increasing the yield of ester.

The mixture is heated with a heating mantle or water bath. This allows for safe heating of flammable chemicals as there are no naked flames.

Answers could include:

The mixture is heated under reflux.

This allows the vessel to be heated for an extended period without the loss of volatile reactants and products and without danger of gas pressure build up which could cause an explosion.

Part c)

Criteria	Mark
• Relates the boiling point of a substance to the strength of its intermolecular forces. (*1 mark*) • Identifies that polarity and hydrogen bonding are significant forces between molecules. (*1 mark*) • Correctly ascribes the differences in these substances to variations in polarity and hydrogen bonding. (*1 mark*)	**3**

Answer may include:

- The boiling point of a substance is determined by the strength of its intermolecular forces. The stronger the forces, the higher the boiling point.
- Ethyl methanoate has lower polarity than acetic acid and 1-propanol and so has weaker dipole-dipole attractions between molecules.
- Acetic acid and 1-propanol also contain -OH groups and so can also establish hydrogen bonding between molecules, giving them higher boiling points.
- The more extensive hydrogen bonding in acetic acid gives it a higher boiling point than 1-propanol.

Question 28

Criteria	Mark
Identifies and justifies FOUR measures taken to ensure accuracy of the titration result.	4

Answer may include: Any four of the below, or other valid measures. Titration was used to estimate the acid content in vinegar.

Steps taken	Justification
The burette was given a final rinse with standardised NaOH solution	To ensure the concentration of the NaOH was unaltered when placed in burette.
The pipette was given a final rinse with diluted vinegar solution	To ensure the concentration of the vinegar solution was unaltered when placed in the pipette
The conical flask was given a final rinse with distilled water	To ensure the flask was clean and that only the correct number of moles of NaOH was present when delivered by the pipette
The NaOH was standardised against a primary standard solution prior to use	To ensure the concentration of the NaOH solution was accurately known as NaOH solutions are unstable in air
Phenolphthalein indicator was used	The range of this indicator is above pH 7 which matches the pH of the equivalence point of this weak acid strong base titration.
The titration was repeated and an average titre used to perform the calculations	To increase the reliability if the results
White paper/ tile was placed under the conical flask	So that the colour change of the indicator could be more easily seen.

b)

Criteria	Marks
• Correct moles NaOH, Citric acid, and correct concentration in gL^{-1}	3
• Correct moles NaOH, Citric acid, but correct concentration not in gL^{-1}	2
• Correct moles NaOH or Citric acid,	1

Sample answer:

No of moles of NaOH= $0.550X29.50X10^{-3} = 0.016225$mol

No of moles of Citric acid =0.016225 /3 = 0.005408 mol

[Citric acid] = $\frac{0.005408}{25X10^{-3}} = 0.216M$

[Citric acid] = 0.216 X 192.12 = 41.6 gL^{-1}

Question 29

Marking Criteria	Marks
• Correctly calculates the concentration of HI.	2
• Response contains one error.	1

$$K_{eq} = \frac{[HI]^2}{[H_2][I_2]} = 2.25 \times 10^3$$

$$[HI] = \sqrt{2.25 \times 10^3 \times 0.15 \times 0.25}$$

$$[HI] = 9.2 \text{ M}$$

Part b)

Marking Criteria	Marks
• Calculates Q for the system and compares Q to K to explain which reaction must proceed at a faster rate for the system to reach equilibrium.	2
• Calculates Q for the system OR • Demonstrates an understanding of how comparing Q to K can determine which reaction (forward or reverse) must be higher in order for equilibrium to be reached.	1

$$Q = \frac{[HI]^2}{[H_2][I_2]}$$

$[HI] = n/V = 1.4/2 = 0.7 \text{ molL}^{-1}$

$[H_2] = n/V = 1.7/2 = 0.85 \text{ molL}^{-1}$

$[I_2] = n/V = 0.8/2 = 0.4 \text{ molL}^{-1}$

$$Q = \frac{[0.7]^2}{[0.85][0.4]}$$

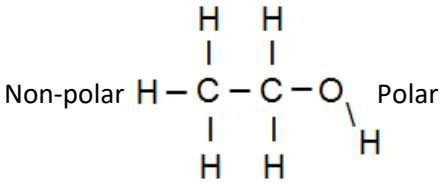
$=1.44$

Since Q<K, the system is not at equilibrium and the forward reaction must proceed at a higher rate than the reverse in order for the system to reach equilibrium.

Question 30(a)

Criteria	Mark
• Describes the structure of ethanol and explains its ability to act as a solvent for both polar and non-polar substances	3
• Describes the structure of ethanol and identifies its ability to act as a solvent for both polar and non-polar substances	2
• Identifies the polar and non-polar nature of ethanol	1

Answer may include: The ethanol molecule has both a polar −OH group and a non-polar CH_3CH_2− group.



The non-polar end can form weaker dispersion forces with other non-polar molecules such as hydrocarbons. The polar end attracts other polar molecules such as water, and ethanol is a solvent for both water and petrol. Hence, the ethanol in E10 absorbs water from the air.

Question 30(b)

Criteria	**Mark**
• Explains that $CO_2(g)$ released during the combustion of ethanol was absorbed from the atmosphere during photosynthesis • Considers other CO_2 production in the ethanol fuel cycle	**3**
• Identifies that $CO_2(g)$ released during the combustion of ethanol was absorbed from the atmosphere during photosynthesis • Refers to the ethanol fuel cycle	**2**
• Provides some relevant information	**1**

Answer may include: Ethanol, like petrol, produces carbon dioxide when used as a fuel.

$$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(g)$$

However, carbon is absorbed from the atmosphere in the process of photosynthesis.

$$6CO_2(g) + 6H_2O(l) \rightarrow C_6H_{12}O_6 + 6O_2(g)$$

This supports the claim that ethanol is carbon-neutral, as all carbon dioxide released is balanced by that absorbed in photosynthesis.

However, this does not take into account any $CO_2(g)$ produced in the cultivating, harvesting and transporting of the source crop, often sugar cane or wheat. Energy is also required to separate the ethanol by distillation. Hence, the overall use of ethanol is not really 'carbon neutral' as claimed.

c)

Marking Criteria	Marks
Correct moles of glucose and CO_2 and correct CO_2 mass	2
Correct moles of glucose or CO_2	1

Sample answer:

No of moles of $C_6H_{12}O_6$ = 6.50/180.16 =0.036079mol

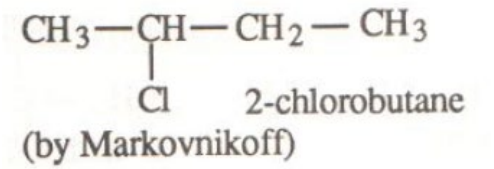
No of moles of CO_2 = 2X0.036079mol

Mass of CO_2 = 2X0.036079 X 44.01 =3.18g

Question 31 (a)

Marking Criteria	Marks
Correct structure and name	2
Correct structure or name	1

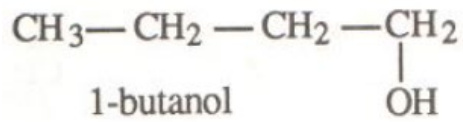
Suggested answer:



(b)

Marking Criteria	Marks
Correct structure and name	2
Correct structure or name	1

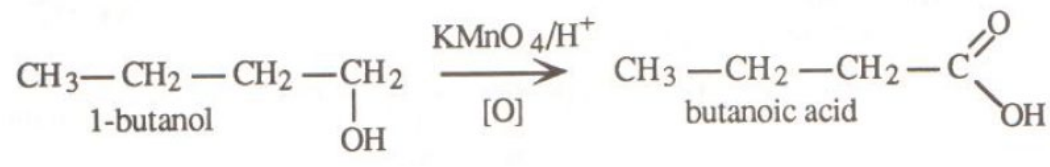
Suggested answer:



(c)

Marking Criteria	Marks
Correct chemical equation	1

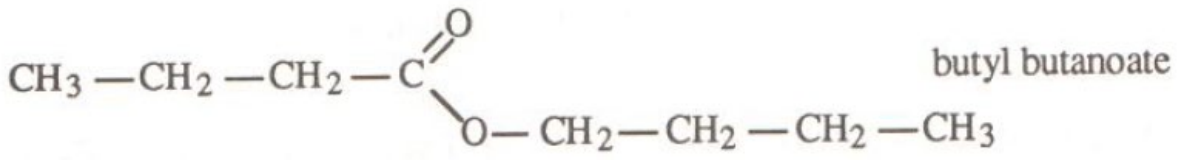
Suggested answer:



(d)

Marking Criteria	Marks
Correct structure and name	2
Correct structure or name	1

Suggested answer:



Question 32 (a)

Marking Criteria	Marks
Correct identification of D and E	2
Correct identification of D or E	1

Suggested answer:

(a) D = magnesium carbonate, E = carbon dioxide

Question 32 (b)

Marking Criteria	Marks
Write correct net ionic equations for the formation of precipitates F and G	2
Write correct net ionic equations for the formation of precipitates F or G	1

Suggested answer

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

G: $Pb^{2+}_{(aq)} + 2I^-_{(aq)} \rightarrow PbI_{2(s)}$

Question 32 (c)

Marking Criteria	Marks
Correctly describe a test and describes 2 observations to differentiate the compounds	2
Correctly describe a test or describes 2 observations to differentiate the compounds	1

Suggested answer

(c) Add sodium hydroxide solution to the compound. If a white precipitate forms it is calcium chloride, if a brown precipitate forms it is iron(III) chloride (other answers possible).

Question 33

Marking Criteria	Marks
Correctly describe the differences in strength of all 3 acids using appropriate equations. Distinguish that HCl is monoprotic and H_2SO_4 is diprotic. Correctly calculate pH of all three acids.	3
Any 2 from above	2
Any 1 from above	1

Suggested answer

HCl is a strong monoprotic acid which completely ionises in water:

$HCl_{(aq)} \rightarrow H^+_{(aq)} + Cl^-_{(aq)}$

Hence the concentration of H^+ in 0.1 M HCl will be 0.1 M and pH will be 1.

Acetic acid is a weak monoprotic acid which doesn't completely ionise in water: $CH_3COOH_{(aq)} \rightleftharpoons CH_3COO^-_{(aq)} + H^+_{(aq)}$

Hence the concentration of H^+ will be less than 0.1 M and pH will be > 1.

H_2SO_4 is a strong diprotic acid which completely ionises in water:

$H_2SO_{4(aq)} \rightarrow 2H^+_{(aq)} + SO_4^{2-}{}_{(aq)}$

Hence the concentration of H^+ will be 0.2 M and pH will be 0.7.