A-Level Chemistry

Balanced Equations

Question Paper

Time available: 65 minutes
Marks available: 57 marks

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1. Calcium sulfide reacts with calcium sulfate as shown.

$$CaS + 3\ CaSO_4 \rightarrow 4\ CaO + 4\ SO_2$$

2.50 g of calcium sulfide are heated with 9.85 g of calcium sulfate until there is no further reaction.

Show that calcium sulfate is the limiting reagent in this reaction.

Calculate the mass, in g, of sulfur dioxide formed.

M_r (CaS) = 72.2
M_r ($CaSO_4$) = 136.2

Mass of sulfur dioxide _____ g

(Total 5 marks)

2. A student is provided with a 5.60 g sample of ethanoic acid (CH_3COOH) contaminated with sodium ethanoate (CH_3COONa).

The student dissolves the sample in deionised water and makes the volume up to 200 cm^3

The student removes 25.0 cm^3 samples of the solution and titrates them with 0.350 mol dm^{-3} sodium hydroxide solution.

The table below shows the results of these titrations.

	Rough	**1**	**2**	**3**
Final volume / cm^3	20.85	41.10	20.50	40.80
Initial volume / cm^3	0.00	20.85	0.00	20.50
Titre / cm^3	20.85	20.25	20.50	20.30

(a) Use the results in the table above to calculate the mean titre value.

Use the mean titre to calculate the percentage by mass of sodium ethanoate in the original sample.

Mean titre value _____ cm^3

Percentage by mass _____

(6)

(b) The student rinses the burette with deionised water before filling with sodium hydroxide solution.

State and explain the effect, if any, that this rinsing will have on the value of the titre.

_____

_____

_____

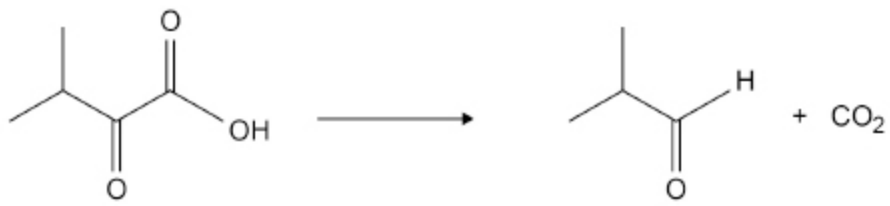
_____

(2)

(Total 8 marks)

3. A student investigates two experimental methods of making methylpropanal. The equations for these two methods are shown.

Method 1



M_r = 116.0 M_r = 72.0

Method 2

M_r = 74.0 M_r = 72.0

In each method, the student uses 1.00 g of organic starting material.

The yield of methylpropanal obtained using each method and other data are included in the table.

	Method 1	**Method 2**
Yield of methylpropanal / mg	552	778
Percentage yield		80.0%
Percentage atom economy	62.1%	

Calculate the percentage yield for Method 1.

Calculate the percentage atom economy for Method 2.

State the importance of percentage yield and percentage atom economy when choosing the method used to make a compound.

% yield _____

Importance of percentage yield _____

_____

_____

_____

_____

% atom economy _____

Importance of percentage atom economy _____

_____

_____

_____

_____

(Total 6 marks)

4. A student does an experiment to determine the percentage by mass of sodium chlorate(I), NaClO, in a sample of bleach solution.

Method:

- Dilute a 10.0 cm^3 sample of bleach solution to 100 cm^3 with distilled water.
- Transfer 25.0 cm^3 of the diluted bleach solution to a conical flask and acidify using sulfuric acid.
- Add excess potassium iodide to the conical flask to form a brown solution containing $I_2(aq)$.
- Add 0.100 mol dm^{-3} sodium thiosulfate solution ($Na_2S_2O_3$) to the conical flask from a burette until the brown solution containing $I_2(aq)$ becomes a colourless solution containing $I^-(aq)$.

The student uses 33.50 cm^3 of sodium thiosulfate solution.

The density of the original bleach solution is 1.20 g cm^{-3}

The equations for the reactions in this experiment are

$$ClO^-(aq) + 2\ H^+(aq) + 2\ I^-(aq) \rightarrow Cl^-(aq) + H_2O(l) + I_2(aq)$$

$$2\ S_2O_3^{2-}(aq) + I_2(aq) \rightarrow 2\ I^-(aq) + S_4O_6^{2-}(aq)$$

(a) Use all the information given to calculate the percentage by mass of NaClO in the original bleach solution.

Give your answer to 3 significant figures.

Percentage by mass _____

(7)

(b) The total uncertainty from two readings and an end point error in using a burette is ± 0.15 cm^3

What is the total percentage uncertainty in using the burette in this experiment?

Tick (✓) **one** box.

0.45% ☐

0.90% ☐

1.34% ☐

(1)

(Total 8 marks)

5. A student does an investigation to determine the relative formula mass, M_r, of a solid unknown diprotic acid, H_2A

$$H_2A + 2\ NaOH \rightarrow Na_2A + 2\ H_2O$$

- 250 cm^3 of aqueous solution are prepared using 1300 mg of H_2A
- A pipette is used to add 25.0 cm^3 of 0.112 mol dm^{-3} aqueous sodium hydroxide to a conical flask.
- This aqueous sodium hydroxide is titrated with the acid solution.

The titration results are shown in the table.

	Rough	**1**	**2**	**3**
Final volume / cm^3	27.35	26.75	38.90	35.70
Initial volume / cm^3	0.00	0.35	12.15	9.20
Titre / cm^3	27.35	26.40	26.75	26.50

(a) Use the results to calculate the M_r of H_2A

M_r of H_2A _____

(5)

(b) The uncertainty in using the pipette in this experiment is ±0.06 cm^3

Calculate the percentage uncertainty in using the pipette.

% uncertainty _____

(1)

(c) Before adding the solution from the burette in the rough titration, there was an air bubble below the tap.
At the end of this titration the air bubble was not there.

Explain why this air bubble increases the final burette reading of the rough titration.

_____

_____

_____

(1)

(d) During the titration the student washed the inside of the conical flask with some distilled water.

Suggest why this washing does not give an incorrect result.

_____

_____

(1)

(Total 8 marks)

6. This question is about the reactions of magnesium and its compounds.

(a) Magnesium is used in one of the stages in the extraction of titanium.

Give an equation for the reaction between titanium(IV) chloride and magnesium.
State the role of magnesium in this reaction.

Equation

_____

Role of magnesium _____

(2)

(b) A mixture of magnesium oxide and magnesium hydroxide has a mass of 3200 mg

This mixture is reacted with carbon dioxide to form magnesium carbonate and water. The mass of water produced is 210 mg

$$Mg(OH)_2 + CO_2 \rightarrow MgCO_3 + H_2O$$

$$MgO + CO_2 \rightarrow MgCO_3$$

Calculate the percentage by mass of magnesium oxide in this mixture.

% of magnesium oxide _____

(4)

(Total 6 marks)

7. A student does an experiment to determine the percentage of copper in an alloy.

The student

- reacts 985 mg of the alloy with concentrated nitric acid to form a solution (all of the copper in the alloy reacts to form aqueous copper(II) ions)
- pours the solution into a volumetric flask and makes the volume up to 250 cm^3 with distilled water
- shakes the flask thoroughly
- transfers 25.0 cm^3 of the solution into a conical flask and adds an excess of potassium iodide
- uses exactly 9.00 cm^3 of 0.0800 mol dm^{-3} sodium thiosulfate ($Na_2S_2O_3$) solution to react with all the iodine produced.

The equations for the reactions are

$$2\ Cu^{2+} + 4\ I^- \rightarrow 2\ CuI + I_2$$

$$2\ S_2O_3^{2-} + I_2 \rightarrow 2\ I^- + S_4O_6^{2-}$$

(a) Calculate the percentage of copper by mass in the alloy.

Give your answer to the appropriate number of significant figures.

% copper _____

(6)

(b) Suggest **two** ways that the student could reduce the percentage uncertainty in the measurement of the volume of sodium thiosulfate solution, using the same apparatus as this experiment.

1 _____

_____

2 _____

_____

3 _____

_____

(2)

(c) State the role of iodine in the reaction with sodium thiosulfate.

_____

(1)

(d) Give the full electron configuration of a copper(II) ion.

_____

(1)

(e) Copper(I) iodide is a white solid.

Explain why copper(I) iodide is white.

_____

_____

_____

_____

_____

_____

(2)

(f) Iodine vaporises easily.

Calculate the volume, in cm^3, that 5.00 g of iodine vapour occupies at 185 °C and 100 kPa

The gas constant $R = 8.31\ J\ K^{-1}\ mol^{-1}$

Give your answer to 3 significant figures.

Volume _____ cm^3

(4)

(Total 16 marks)