Q1.

The following equation represents the oxidation of vanadium(IV) ions by manganate(VII) ions in acid solution.

$$5V^{4+} + MnO_4^{-} + 8H^{+} \longrightarrow 5V^{5+} + Mn^{2+} + 4H_2O$$

What volume of 0.020 mol dm^{-3} $KMnO_4$ solution is required to oxidise completely a solution containing 0.010 mol of vanadium(IV) ions?

A 10 cm^3 ☐

B 25 cm^3 ☐

C 50 cm^3 ☐

D 100 cm^3 ☐

(Total 1 mark)

Q2.

Magnesium reacts with hydrochloric acid according to the following equation.

$$Mg + 2HCl \longrightarrow MgCl_2 + H_2$$

A student calculated the minimum volume of 2.56 mol dm^{-3} hydrochloric acid required to react with an excess of magnesium to form 5.46 g of magnesium chloride (M_r = 95.3).

Which of the following uses the correct standard form and the appropriate number of significant figures to give the correct result of the calculation?

A 4.476×10^{-2} dm^3 ☐

B 4.48×10^{-2} dm^3 ☐

C 4.50×10^{-2} dm^3 ☐

D 44.8×10^{-3} dm^3 ☐

(Total 1 mark)

Q3.

This question is about the elements in Group 2.

(f) $Mg(OH)_2$ is used as an antacid to treat indigestion.
A student does an experiment to determine the percentage by mass of $Mg(OH)_2$ in an indigestion tablet.

40.0 cm^3 of 0.200 mol dm^{-3} HCl (an excess) is added to 0.200 g of a powdered tablet.
The mixture is swirled thoroughly.
All of the $Mg(OH)_2$ reacts with HCl as shown.

$$Mg(OH)_2 + 2\ HCl \rightarrow MgCl_2 + 2\ H_2O$$

The amount of HCl remaining after this reaction is determined by titration with 0.100 mol dm^{-3} NaOH

29.25 cm^3 of 0.100 mol dm^{-3} NaOH are needed.

Calculate the percentage by mass of $Mg(OH)_2$ in the indigestion tablet.

Percentage by mass ____________________

(6)

Q4.

Some airbags in cars contain sodium azide (NaN_3).

(a) Sodium azide is made by reacting dinitrogen monoxide gas with sodium amide ($NaNH_2$) as shown by the equation.

$$2NaNH_2 + N_2O \longrightarrow NaN_3 + NaOH + NH_3$$

Calculate the mass of sodium amide needed to obtain 550 g of sodium azide, assuming there is a 95.0% yield of sodium azide.
Give your answer to 3 significant figures.

(5)

(b) If a car is involved in a serious collision, the sodium azide decomposes to form sodium and nitrogen as shown in the equation.

$$2NaN_3(s) \longrightarrow 2Na(s) + 3N_2(g)$$

The nitrogen produced then inflates the airbag to a volume of 7.50×10^{-2} m^3 at a pressure of 150 kPa and temperature of 35 °C.

Calculate the minimum mass of sodium azide that must decompose.
(The gas constant $R = 8.31$ J K^{-1} mol^{-1})

(6)

(c) Sodium azide is toxic. It can be destroyed by reaction with an acidified solution of nitrous acid (HNO_2) as shown in the equation.

$$2NaN_3 + 2HNO_2 + 2HCl \longrightarrow 3N_2 + 2NO + 2NaCl + 2H_2O$$

(i) A 500 cm^3 volume of the nitrous acid solution was used to destroy completely 150 g of the sodium azide.

Calculate the concentration, in mol dm^{-3}, of the nitrous acid used.

(3)

(ii) Nitrous acid decomposes on heating.

Balance the following equation for this reaction.

........HNO_2 $\longrightarrow$ ....HNO_3 + ...NO + ...H_2O

(1)

Q5.

This question is about reactions of calcium compounds.

(a) A pure solid is thought to be calcium hydroxide. The solid can be identified from its relative formula mass.

The relative formula mass can be determined experimentally by reacting a measured mass of the pure solid with an excess of hydrochloric acid. The equation for this reaction is

$$Ca(OH)_2 + 2HCl \longrightarrow CaCl_2 + 2H_2O$$

The unreacted acid can then be determined by titration with a standard sodium hydroxide solution.

You are provided with 50.0 cm^3 of 0.200 mol dm^{-3} hydrochloric acid.
Outline, giving brief practical details, how you would conduct an experiment to calculate accurately the relative formula mass of the solid using this method.

(8)

(b) A 3.56 g sample of calcium chloride was dissolved in water and reacted with an excess of sulfuric acid to form a precipitate of calcium sulfate.

The percentage yield of calcium sulfate was 83.4%.

Calculate the mass of calcium sulfate formed.
Give your answer to an appropriate number of significant figures.

Mass of calcium sulfate formed = ____________ g

(3)

(Total 11 marks)

Q6.

This question is about hydrogen peroxide, H_2O_2

The half-equation for the oxidation of hydrogen peroxide is

$$H_2O_2 \longrightarrow O_2 + 2\,H^+ + 2e^-$$

Hair bleach solution contains hydrogen peroxide.

A sample of hair bleach solution is diluted with water.
The concentration of hydrogen peroxide in the diluted solution is 5.00% of that in the original solution.
A 25.0 cm^3 sample of the diluted hair bleach solution is acidified with dilute sulfuric acid.
This acidified sample is titrated with 0.0200 mol dm^{-3} potassium manganate(VII) solution.
The reaction is complete when 35.85 cm^3 of the potassium manganate(VII) solution are added.

(a) Give an ionic equation for the reaction between potassium manganate(VII) and acidified hydrogen peroxide.

Calculate the concentration, in mol dm^{-3}, of hydrogen peroxide in the original hair bleach solution.

(If you were unable to write an equation for the reaction you may assume that the mole ratio of potassium manganate(VII) to hydrogen peroxide is 3:4
This is **not** the correct mole ratio.)

Concentration ____________________ mol dm^{-3}

(5)

Q7.

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)

Q8.

This question is about ethanedioic acid ($H_2C_2O_4$) which is a dicarboxylic acid.

(c) Ethanedioic acid reacts with an excess of sodium hydroxide to form sodium ethanedioate.

$$H_2C_2O_4\,(aq) + 2\,NaOH\,(aq) \rightarrow Na_2C_2O_4\,(aq) + 2\,H_2O\,(l)$$

A student mixes 10.0 cm^3 of 0.400 mol dm^{-3} ethanedioic acid with 50.0 cm^3 of 0.200 mol dm^{-3} sodium hydroxide.

Show that the sodium hydroxide is in excess.

Calculate the mass, in mg, of sodium ethanedioate that can be formed in this reaction.

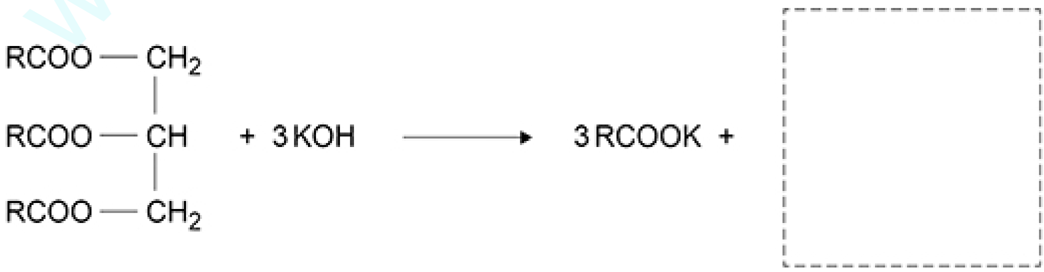
Mass of sodium ethanedioate ________________ mg

(5)

(Total 8 marks)

Q9.

Coconut oil contains a triester with three identical R groups.
This triester reacts with potassium hydroxide.



(a) Complete the equation by drawing the structure of the other product of this reaction in the box.

Name the type of compound shown by the formula RCOOK

Give **one** use for this type of compound.

Type of compound ____

Use ____

(3)

(b) The triester in coconut oil has a relative molecular mass, M_r = 638.0
In the equation shown at the start of this question, R represents an alkyl group that can be written as $CH_3(CH_2)_n$

Deduce the value of n in $CH_3(CH_2)_n$
Show your working.

n ________________

(3)

(c) A 1.450 g sample of coconut oil is heated with 0.421 g of KOH in aqueous ethanol until all of the triester is hydrolysed.
The mixture is cooled.
The remaining KOH is neutralised by exactly 15.65 cm^3 of 0.100 mol dm^{-3} HCl

Calculate the percentage by mass of the triester (M_r = 638.0) in the coconut oil.

Percentage by mass _______________

(6)

Q10.

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?

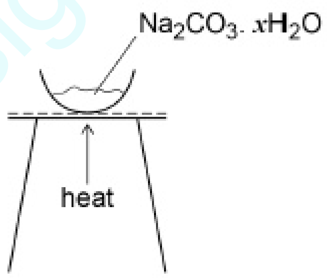
Tick (✓) **one** box.

0.45%	☐
0.90%	☐
1.34%	☐

(1)
(Total 8 marks)

Q11.

A student heated a solid sample of Na_2CO_3. $x$$H_2O$ for 1 minute to remove water and determine a value for x
The diagram shows the apparatus used. The table shows the results recorded.



Mass of empty evaporating basin	24.35 g
Mass of evaporating basin and solid before heating	25.47 g
Mass of evaporating basin and solid after heating for 1 minute	24.92 g

(a) Use the data in the table to calculate a value for x in the formula Na_2CO_3. $x$$H_2O$ Give your answer to 2 decimal places.

Value for *x* ____________________

(5)

(b) The correct value for *x* is 10.

Suggest a reason for the difference between the experimental value for *x* and the correct value.

(If you were unable to calculate an experimental value for *x* assume it was 8.05. This is **not** the correct experimental value.)

____

____

____

(1)

(c) Suggest how the procedure could be improved, using the same apparatus, to give a more accurate value for *x*

Justify your answer.

Suggestion ____

____

____

____

Justification ____

____

____

____

(2)

(Total 8 marks)

Q12.

(a) The manufacturer of vinegar buys concentrated ethanoic acid as a 15.0 mol dm^{-3} solution. In case of an accidental spillage of this ethanoic acid the manufacturer always has sodium carbonate readily available to neutralise the acid. The equation for this reaction is shown below.

$$2CH_3COOH + Na_2CO_3 \longrightarrow 2CH_3COONa + H_2O + CO_2$$

(i) Calculate the amount, in moles, of ethanoic acid in 10.0 cm^3 of a 15.0 mol dm^{-3} solution.

____

(1)

(ii) Use your answer from part (i) to calculate the amount, in moles, of sodium carbonate needed to react completely with this amount of ethanoic acid.

____

(1)

(iii) Use data from the Periodic Table to calculate the relative formula mass of sodium carbonate. Give your answer to the appropriate precision.

____

(1)

(iv) Use your answers from parts (ii) and (iii) to determine the minimum mass of sodium carbonate needed to react completely with 10.0 cm^3 of the 15.0 mol dm^{-3} solution of ethanoic acid.

____

(1)

(b) State **one** hazard when using concentrated ethanoic acid and **one** safety precaution you would take to minimise this hazard.

Hazard ____

Precaution ____

____

(1)

(Total 5 marks)

Q13.

(a) A student investigated the acid content of a different crater-lake solution. The student used a 50.0 cm^3 burette to measure out different volumes of this crater-lake solution. Each volume of crater-lake solution was titrated with a 0.100 mol dm^{-3} sodium hydroxide solution. Each titration was repeated. The results are shown below.

Volume of crater-lake solution / cm^3		10.0	20.0	30.0	40.0	50.0
Volume of sodium hydroxide solution / cm^3	Experiment 1	5.85	17.00	20.00	26.50	32.45
	Experiment 2	6.15	13.00	19.90	26.50	32.55
Average titre / cm^3		6.00	15.00	19.95	26.50	32.50

(i) On the graph paper below, plot a graph of average titre (*y*-axis) against volume of crater-lake solution. Both axes must start at zero.

(3)

(ii) Draw a line of best fit on the graph.

(1)

(iii) Use the graph to determine the titre that the student would have obtained using a 25.0 cm^3 sample of crater-lake solution.

____

(1)

(iv) Excluding any anomalous points, which average titre value would you expect to be the least accurate value? Give **one** reason for your choice.

Least accurate average titre ________________________________

Reason ____

(2)

(b) Another 100 cm^3 sample of crater-lake solution was reacted with an excess of powdered limestone. The gas produced was collected in a gas syringe. The equation for the reaction between the sulfuric(IV) acid in the crater-lake solution and the calcium carbonate in the powdered limestone is shown below.

$$H_2SO_3 + CaCO_3 \longrightarrow CaSO_3 + H_2O + CO_2$$

The volume of gas collected from the reaction of the sulfuric(IV) acid in 100 cm^3 of crater-lake solution with an excess of powdered limestone was 81.0 cm^3 at 298 K and 1.00×10^5 Pa.

(i) State the ideal gas equation.

(1)

(ii) Use the ideal gas equation to calculate the amount, in moles, of carbon dioxide formed.
Show your working.
(The gas constant R = 8.31 J K^{-1} mol^{-1})

(3)

(iii) Use the equation for the reaction and your answer from part (b)(ii) to calculate the minimum mass of calcium carbonate needed to neutralise the sulfuric(IV) acid in 1.00 dm^3 of crater-lake solution.
Show your working.

(If you could not complete the calculation in part (b)(ii) assume that the amount of carbon dioxide is 1.25×10^{-2} mol. This is **not** the correct value.)

(3)

(iv) The percentage by mass of calcium carbonate in the powdered limestone was 95.0%.
Calculate the minimum mass of this powdered limestone needed to neutralise the sulfuric(IV) acid in 1.00 dm^3 of this crater-lake solution.

(2)

(v) Give **one** reason, other than cost, why limestone rather than solid sodium hydroxide is often used to neutralise acidity in lakes.

(1)
(Total 17 marks)

Mark schemes

Q1.

D

[1]

Q2.

B

[1]

Q3.

(f) **M1** Amount of HCl added = 0.200 × 0.040 = 0.00800 mol

M2 Amount of NaOH = 0.100 × 0.02925 = 0.002925 mol

(Amount of HCl = 0.002925 mol)

M3 Amount of HCl reacted with $Mg(OH)_2$ = 0.00800 - 0.002925 = 0.005075 mol

M3 = M1 - M2

M4 Amount of $Mg(OH)_2$ = 0.005075 ÷ 2 = 0.0025375 mol

M4 = M3 ÷ 2

M5 Mass of $Mg(OH)_2$ = 58.3 × 0.0025375 = 0.148 g

M5 = M4 × 58.3

M6 % by mass = $\frac{0.148}{0.200}$ × 100 = 74.0 %

M6 = $\frac{M5}{0.200}$ *× 100*

Do not allow M6 if >100%

6

[19]

Q4.

(a) M1 550 × $\frac{100}{95}$ = 579 g would be 100% mass

Allow alternative methods.

There are 4 process marks:

1

M2 So $\frac{579}{65}$ = 8.91 moles NaN_3

or

M1 $\frac{550}{65}$ = 8.46 moles NaN_3 (this is 95%)

M2 So 100% would be $8.46 \times \frac{100}{95}$ = 8.91 moles NaN_3

1: mass ÷ 65

2: mass or moles × 100 / 95 or × 1.05

3: moles NaN_3 × 2

4: moles $NaNH_2$ × 39

1

Then M3 Moles $NaNH_2$ = 8.91 <u>× 2</u> = (17.8(2) moles)

1

M4 mass $NaNH_2$ = 17.8(2) <u>× 39</u>

1

M5 <u>693</u> or <u>694</u> or <u>695</u> (g)

If 693, 694 or 695 seen to 3 sig figs award 5 marks

1

(b) M1 308 K and 150 000 Pa

1

M2 $n = \frac{PV}{RT}$ or $\frac{150\ 000 \times 7.5 \times 10^{-2}}{8.31 \times 308}$

1

M3 = 4.4(0) or 4.395 moles N_2

Allow only this answer but allow to more than 3 sig figs

1

M4 Moles NaN_3 = 4.395 $\times \frac{2}{3}$ (= 2.93)

M4 is for M3 × $\frac{2}{3}$

1

M5 Mass NaN_3 = (2.93) <u>× 65</u>

M5 is for moles M4 × 65

1

M6 = 191 g

Allow 190 to 191 g allow answers to 2 sig figs or more

1

(c) (i) 150 / 65 = 2.31 moles NaN_3 or 2.31 moles nitrous acid

1

Conc = $2.31 \times \frac{1000}{500}$

M2 is for M1 × 1000 / 500

1

4.6(1) or 4.6(2) (mol dm^{-3})

Only this answer

1

(ii) $3HNO_2 \longrightarrow HNO_3 + 2NO + H_2O$

Can allow multiples

1

Q5.

(a) Stage 1: appreciation that the acid must be in excess and calculation of amount of solid that permits this

Statement that there must be an excess of acid

1

Moles of acid = 50.0 × 0.200 / 1000 = 1.00 × 10^{-2} mol

1

2 mol of acid react with 1 mol of calcium hydroxide therefore moles of solid weighed out must be less than half the moles of acid = 0.5 × 1.00 × 10^{-2} = 5.00 × 10^{-3} mol

1

Mass of solid must be $^{-3}$ × 74.1 =

1

Stage 2: Experimental method

Measure out 50 cm^3 of acid using a pipette and add the weighed amount of solid in a conical flask

1

Titrate against 0.100 (or 0.200) mol dm^{-3} NaOH added from a burette and record the volume (v) when an added indicator changes colour

1

Stage 3: How to calculate M_r from the experimental data

Moles of calcium hydroxide = 5.00 × 10^{-3} – (v/2 × conc NaOH) / 1000 = z mol

1

M_r = mass of solid / *z*

1

Extended response

Maximum of 7 marks for answers which do not show a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.

(b) Moles of calcium chloride = 3.56 / 111.1 = 3.204 × 10^{-2}

1

Moles of calcium sulfate = 3.204 × 10^{-2} × 83.4 / 100 = 2.672 × 10^{-2}

1

Mass of calcium sulfate = 2.672 × 10^{-2} × 136.2 = 3.6398 = 3.64 (g)

Answer must be to 3 significant figures

1

[11]

Q6.

(a) **M1** $2MnO_4^- + 6H^+ + 5H_2O_2 \rightarrow 2Mn^{2+} + 8H_2O + 5O_2$

ignore state symbols

1

M2 $n(MnO_4^-) = \frac{0.020 \times 35.85}{1000} = \underline{7.17 \times 10^{-4}}$ (mol)

1

M3 $n(H_2O_2) = 7.17 \times 10^{-4} \times 5/2 = 1.793 \times 10^{-3}$ (mol)

M3 = M2 × 5/2

1

M4 conc (H_2O_2 in sample) = $\frac{1.793 \times 10^{-3}}{25 \times 10^{-3}} = 0.0717$ (mol dm^{-3})

M4 = $\frac{M3 \times 100}{25}$

1

M5 original conc of H_2O_2 (= 0.0717 × $\underline{20}$ = 1.43 (mol dm^{-3})

M5 = $\frac{M4 \times 100}{5}$

allow 1.43−1.44

1

alternative answer using 3:4 ratio given on question paper

M3 = 7.17 × 10^{-4} × 4/3 = 9.56 × 10^{-4}

M4 = 0.0382 (mol dm^{-3})

M5 = 0.765 (mol dm^{-3})

Q7.

amount of CaS = $\frac{2.50}{72.2}$ = 0.0346 mol

M1: amount of CaS

1

amount of $CaSO_4$ = $\frac{9.85}{136.2}$ = 0.0723 mol

M2: amount of $CaSO_4$

1

3 mol of $CaSO_4$ needed for each mol of CaS, and n($CaSO_4$) is not 3 × n(CaO) (so $CaSO_4$ is the limiting reagent)

M3: limiting reagent justification

1

n(SO_2) = n($CaSO_4$) × $\frac{4}{3}$ = 0.0964 mol

M4: moles of $CaSO_4$ × 4/3

1

mass of SO_2 = n(SO_2) × 64.1 = 6.18g

M5: M4 × 64.1

If CaS used as limiting reagent then allow M4 and M5 ecf.

Must look for M1 and M3

1

[5]

Q8.

(c) **M1** amount of $H_2C_2O_4$ = $0.400 \times \frac{10}{1000}$ = 0.004 mol

1

NaOH in excess

M2 amount of NaOH = $0.200 \times \frac{50}{1000}$ = 0.010 mol

***NaOH in excess:** allow ECF from **M1/2** to **M3** as long as the amounts do have NaOH in excess*

1

M3 amount of NaOH needed for reaction = 0.008 mol or amount of left over NaOH needed for reaction = 0.002 mol or 0.005 mol of $H_2C_2O_4$ needed for all NaOH to react

***M3** Allow any reasoned justification using moles to show that NaOH is in excess (it must take into account the 2:1 ratio in some way)*

1

Yield

M4 amount of $Na_2C_2O_4$ formed = 0.004 mol

1

M5 mass of $Na_2C_2O_4$ = 134.0 x 0.004 = 0.536 g = 536 mg

Yield:** allow ECF from **M1** to **M4**, and from **M4** to **M5

*536 mg scores **M1,4,5***

*0.536 g scores **M1,4***

1

[8]

Q9.

(a) $CH_2OHCH(OH)CH_2OH$

1

(Potassium) Carboxylate salt

Allow fatty acid salt / salt

Salt of a carboxylic acid

1

Soap

Allow detergent / surfactant

1

(b) 638 = 173 + 3(15 + 14n)
M_r ester fragment = 173

M1

Show subtract 638 – (M1 + 45)

M2

Division of M2 by 42

n = 10

n must be an integer

M3

(c) Amount HCl = 0.100 × 0.01565 = 1.565 $\times 10^{-3}$ mol

M1

Initial amount KOH = $\frac{0.421}{56.1}$ = 7.50 $\times 10^{-3}$ mol

M2

Amount KOH used = M2 – M1 = 5.939 $\times 10^{-3}$ mol

M3

Amount ester = $\frac{5.935 \times 10^{-3}}{3}$ = 1.980 $\times 10^{-3}$ mol (M3 / 3)

M4

Mass ester = (1.980 $\times 10^{-3}$) × 638 = 1.263 g (M4 x 638)

M5

%age by mass = $\frac{1.263}{1.45}$ × 100 = 87.1 % ((M5 / 1.45) x 100)

Allow 87.0 to 87.1

Allow 2 sf

Don't allow M6 for an answer >100%

M6

Q10.

(a) **M1** n($S_2O_3^{2-}$) = 33.50 x 0.100 ÷1000 = <u>0.00335</u>

1

M2 n(I_2) = 0.00335 **÷ 2** = 0.001675 (from eqn 2)

***M2** = **M1**÷2*

1

M3 n(ClO^-) in 25 cm^3 pipette = 0.001675 (from eqn 1)

M3** = **M2

1

M4 n(ClO^-) in 100 cm^3 flask = 0.001675 **<u>x 4</u>** = 0.00670 = n(NaClO) in original 10 cm^3 sample

***M4** = **M3** x 4*

1

M5 mass (NaClO) = 0.00670 <u>x 74.5</u> = 0.499 g

***M5** = **M4** <u>x 74.5</u>*

1

M6 mass (bleach) = 10.0 x 1.20 = <u>12</u> g

***M6** = mass of bleach*

1

M7 % by mass of NaClO = $\frac{0.499}{12}$ = 4.16 %

*M7 = (**M5**÷**M6**) x 100 to 3 significant figures*
Allow 4.15% to 4.17%

1

(b) 0.45%

1

[8]

Q11.

(a) **M1**: Mass Na_2CO_3 = 0.57g AND Mass H_2O = 0.55g

If incorrect masses other than AE, lose M1 & M3

1

M2: Mol Na_2CO_3 $= \frac{0.57}{106}$ AND Mol H_2O = $\frac{0.55}{18}$

M2 = process

1

M3: = 0.0054 : 0.0306

M3 = these values only (at least 2sf)

1

M4: ÷ by smallest = 1 : 5.682

M4 = process mark

1

M5: Value of × = 5.68 (2dp)

Allow 5.67 – 5.74

1

OR

M1: Mass Na_2CO_3 = 0.57g AND Mass $Na_2CO_3.xH_2O$ = 1.12g

1

M2: Moles anhydrous Na_2CO_3 = $\frac{0.57}{106}$ = 5.377×10^{-3}

1

M3: Mr of hydrated Na_2CO_3 = $1.12/5.377 \times 10^{-3}$
= 208.3

1

M4: Mr of × H_2O = 102.3

1

M5: Value of × = 5.68 (2dp)

Allow 5.67 – 5.74

1

(b) Failure to drive off all the water
OR
Failure to heat for long enough
OR
Not heated to constant mass

Allow evaporate instead of drive off
Ignore incomplete reaction

1

(c) Heat to constant mass / heat for longer / use a smaller mass

1

You can be sure all / more of the water has been driven off
Ignore incomplete reaction
M2 dependent on M1

1

[8]

Q12.

(a) (i) 0.150
Accept 0.15

1

(ii) 0.0750
Accept 0.75
Accept consequential answer from (i)

1

(iii) 106.0
Must have M_r to 1 d.p. to score mark.
Only penalise once in paper
Do not penalise correct answer in g.
Ignore wrong units.

1

(iv) 7.95
Accept consequential answer from (ii) and (iii).

1

(b) Hazard: (acid) corrosive
Precaution: eye protection / gloves
Both hazard and appropriate precaution needed for 1 mark.
Do not accept 'toxic' as hazard.
Accept 'irritant vapour' and 'fume cupboard'.
Do not accept 'ingest'.

1

[5]

Q13.

(a) (i) Volume of crater-lake solution on x-axis
Do not penalise missing axes labels.
If axes unlabelled use data to decide.
Lose this mark if axes mis-labelled.

1

Sensible scales

*Lose this mark if **plotted points** do not cover at least half the paper or plot goes off the squared paper.*

1

All points plotted correctly +/– one square

1

(ii) Draws appropriate line of best fit, omitting point at 20 cm^3 / 15 cm^3

Lose this mark if the line deviated towards the anomalous result.

Lose this mark if the candidate's line is doubled or kinked.

Candidate does not have to extrapolate to the origin.

1

(iii) 16.5 cm^3 +/– 0.5 cm^3

Accept this answer only.

Do not mark consequentially on candidate's graph.

1

(iv) Value corresponding to 10 cm^3 crater-lake solution / 6.00 cm^3

Must have correct identity for explanation mark.

Accept results aren't concordant.

1

Greatest % error from use of burette

Accept difficult to be accurate with small volumes (owtte).

1

(b) (i) pV = nRT

Accept any correct rearrangement.

Ignore case.

1

(ii) $V = 81.0 \times 10^{-6}$ or 8.1×10^{-5}

1

$n = (1 \times 10^5 \times 81.0 \times 10^{-6}) / (8.31 \times 298)$

Mark consequentially on candidate's volume.

1

$n = 3.27 \times 10^{-3}$ (mol)

Correct answer without working scores one mark only.

Allow consequential mark using incorrect conversion.

Incorrect units lose this mark.

1

(iii) M_r $CaCO_3$ = 100.1 (M1)

Accept 100 (can score this mark in calculation for M2 and M3).

1

Moles $CaCO_3$ = $(3.27 \times 10^{-3} \times 10) = 3.27 \times 10^{-2}$ (M2)

Do not penalise lack of units.

Allow b(ii) × 10

Allow $1.25 \times 10^{-3} \times 10$

1

Mass $CaCO_3$ = M1 × M2 (= 3.27 g)

Correct mass without working scores one mark only.

Allow $1.25 \times 10^{-2} \times 10 \times 100.1 = 12.5$ g

1

(iv) (3.27 / 95) × 100

Accept (b(iii) / 95) × 100.

Do not penalise precision.

1

3.44 g

Do not penalise lack of units.

Using 12.5 g gives 13.2 g

Correct answer without working scores 2 marks.

1

(v) Abundant / readily available

Accept not caustic or alkaline.

Non-corrosive

Accept insoluble so safe to add in excess (owtte).

1

[17]