Q7.

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.

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(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.

___

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(1)
(Total 8 marks)

Q8.

Propanedioic acid contains two carboxylic acid groups. It is a solid organic acid that is soluble in water.

(a) Draw the skeletal formula of propanedioic acid.

(1)

(b) Describe how to prepare 250 cm^3 of an aqueous standard solution of propanedioic acid containing an accurately measured mass of the acid.
Include essential practical details in your answer.

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(6)

(c) Calculate the mass, in mg, of propanedioic acid (M_r = 104.0) needed to prepare 250 cm^3 of a 0.00500 mol dm^{-3} solution.

Mass of propanedioic acid ____________________________________mg

(Total 9 marks)

Q9.

Propanal can be prepared by the oxidation of propan-1-ol with acidified potassium dichromate(VI).

An ionic equation for this reaction is

$$3\ CH_3CH_2CH_2OH + Cr_2O_7^{2-} + 8\ H^+ \rightarrow 3\ CH_3CH_2CHO + 2\ Cr^{3+} + 7\ H_2O$$

(a) Calculate the minimum volume, in cm^3, of 0.40 mol dm^{-3} potassium dichromate(VI) solution needed to oxidise 6.0 cm^3 of propan-1-ol to propanal.

M_r of propan-1-ol = 60.0
Density of propan-1-ol = 0.80 g cm^{-3}

Minimum volume ___________________________ cm^3

(b) The reaction is done in a pear-shaped flask.

Complete the diagram to show the assembled apparatus needed to prepare propanal from propan-1-ol in this way.

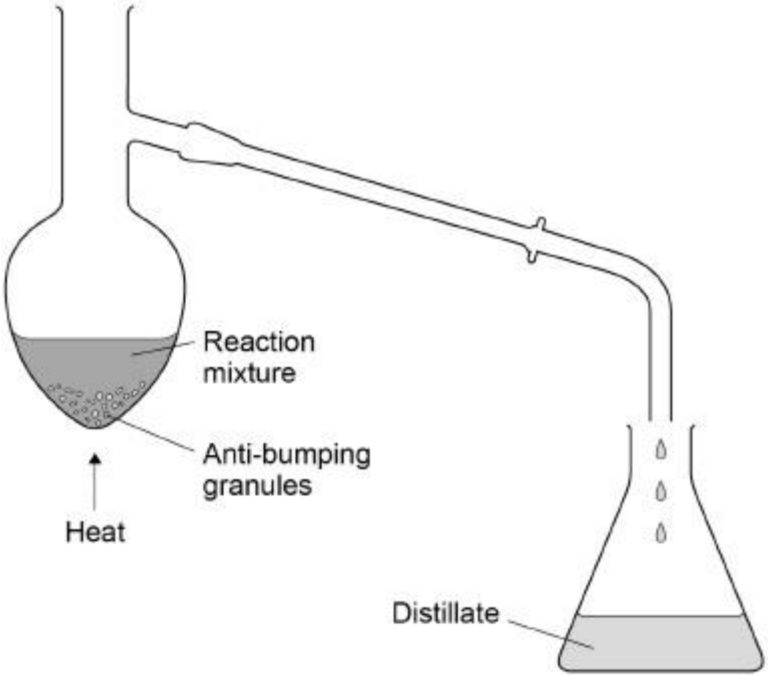
Label the diagram.

(3)
(Total 6 marks)

Q10.

A student prepared cyclohexene by heating cyclohexanol with concentrated phosphoric acid. The cyclohexene produced was distilled off from the reaction mixture.

(a) Complete the diagram of the apparatus used to distil the cyclohexene from the reaction mixture at 83 °C.



(2)

(b) The distillate was shaken with saturated sodium chloride solution. The cyclohexene was separated from the aqueous solution using a separating funnel.

State why cyclohexene can be separated from the aqueous solution using the separating funnel.

____

____

(1)

(c) The cyclohexene separated in part **(b)** was obtained as a cloudy liquid.
The student dried this cyclohexene by adding a few lumps of anhydrous calcium chloride and allowing the mixture to stand.

Give **one** observation that the student made to confirm that the cyclohexene was dry.

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(1)

(d) In this preparation, the student added an excess of concentrated phosphoric acid to 14.4 g of cyclohexanol (M_r = 100.0).
The student obtained 4.15 cm^3 of cyclohexene (M_r = 82.0).
Density of cyclohexene = 0.810 g cm^{-3}

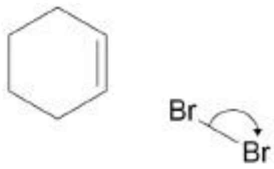
Calculate the percentage yield of cyclohexene obtained.
Give your answer to the appropriate number of significant figures.

% yield ____________________________

(5)

(e) Cyclohexene reacts with bromine.

Complete the mechanism for this reaction.



(3)
(Total 12 marks)

Q11.

The percentage by mass of iron in a steel wire is determined by a student.

The student

- reacts 680 mg of the wire with an excess of sulfuric acid, so that all of the iron in the wire forms Fe^{2+}(aq)
- makes up the volume of the Fe^{2+}(aq) solution to exactly 100 cm^3
- takes 25.0 cm^3 portions of the Fe^{2+}(aq) solution
- titrates each portion with 0.0200 mol dm^{-3} potassium manganate(VII) solution.

(a) Give the equation for the reaction between iron and sulfuric acid.

____

(1)

(b) The titration results are shown in the table.

	1	2	3
Final volume / cm^3	22.90	45.60	22.60
Initial volume / cm^3	0.00	22.90	0.00
Titre / cm^3	22.90	22.70	22.60

Calculate the mean titre.

Mean titre ______________________________ cm^3

(1)

(c) Give the overall ionic equation for the oxidation of Fe^{2+} by manganate(VII) ions, in acidic conditions.

____

(1)

(d) State the colour change seen at the end point of the titration.

____

(1)

(e) Name the piece of apparatus used for these stages of the method.

Taking the 25.0 cm^3 portions ____

Adding the
potassium manganate(VII) solution ____

(1)

(f) The balance used to weigh the 680 mg of iron wire has an uncertainty of ±0.005 g

A container was weighed and its mass was subtracted from the total mass of the container and wire.

Calculate the percentage uncertainty in using the balance.

% uncertainty ________________________

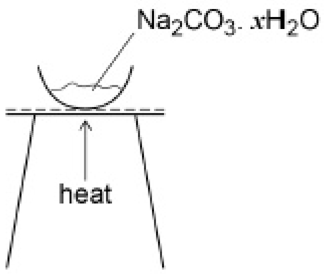
(1)

(Total 6 marks)

Q12.

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)

Q13.

Separate unlabelled solid samples of three anhydrous sodium compounds are provided for a student to identify.
These compounds are known to be sodium carbonate, sodium fluoride and sodium chloride but it is not known which sample is which.

Outline a logical sequence of test-tube reactions that the student could carry out to identify each of these compounds.
Include the observations the student would expect to make.
Give equations, including **state symbols**, for any reactions that would take place.

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(Total 6 marks)

Q14.

Citric acid, $C_3H_5O(COOH)_3$, occurs naturally in many fruits and can also be synthesised in the laboratory for use as a food flavouring. A student analysed a sample of citric acid to determine its percentage purity.

The student dissolved 784 mg of impure citric acid in water to prepare 250 cm^3 of solution in a volumetric flask.

The student titrated 25.0 cm^3 samples of this solution with 0.0500 mol dm^{-3} sodium hydroxide solution using phenolphthalein as the indicator.

$$C_3H_5O(COOH)_3(aq) + 3NaOH(aq) \rightarrow C_3H_5O(COO)_3Na_3(aq) + 3H_2O(l)$$

(a) The student rinsed the burette before filling it with the sodium hydroxide solution.

State why the student should use sodium hydroxide solution rather than water for the final rinse of the burette.

___

___

___

(1)

(b) The student carried out several titrations. The results are shown in the table.

Complete the table to show the titre in each titration.

Titration	**Rough**	**1**	**2**	**3**
Final reading / cm^3	25.2	23.95	47.65	24.10
Start reading / cm^3	0.0	0.05	23.95	0.10
Titre / cm^3				

(1)

(c) Calculate the mean titre using the concordant results.

Give your answer to the appropriate number of significant figures.

Mean titre ____________________ cm^3

(2)

(d) The total uncertainty when using the burette is ± 0.15 cm^3. This is the combination of uncertainties in the start reading, final reading and the determination of the end point.

Use your answer to part (c) to calculate the percentage uncertainty for the use of the burette in this experiment.

Percentage uncertainty ____________________ %

(1)

(e) Use your answer to part (c) to find the mass, in mg, of citric acid dissolved in 250 cm^3 of the solution.

The relative molecular mass (M_r) of citric acid is 192.0

mass ____________________ mg

(3)

(f) Calculate the percentage purity of this sample of citric acid.

Percentage purity ____________________ %

(1)

(Total 9 marks)

Mark Scheme

Q7.

(a) Average titre = 26.45 cm^3

M1 = average of concordant titres

1

$n(NaOH) = (25 \times 0.112 / 1000) = 2.80 \times 10^{-3}$ mol

M2 – this value only

1

n(acid in titre) = $2.80 \times 10^{-3} / 2 = 1.40 \times 10^{-3}$ mol

M3 = M2/2

1

n(acid in 250 cm^3) = $1.40 \times 10^{-3} \times 250/26.45 = 0.0132$ mol

M4 = M3 × 250/M1

1

M_r = mass / moles = 1.300/0.0132 = 98.2-98.5

M5 = (1.300/M4) = answer

Mr must be given to at least 1dp

1

Alternatives:

98.6 – scores 4

92.9 – scores 4

87.8 – scores 3

49.3 – scores 3

49.1 – scores 4

(b) % uncertainty = 0.06/25.0 × 100 = 0.24 %

1

(c) Some solution/acid replaces air bubble /
Solution/acid fills below the tap /
Air bubble takes up volume that would be filled by solution/acid

Score for the idea that:

Acid/solution replaces air/bubble/fills jet space

Allow acid/solution fills the bubble/gap

'The final reading is higher than the volume added' is not enough.

1

(d) Does not react (with the alkali) / does not change the number of moles (of alkali)

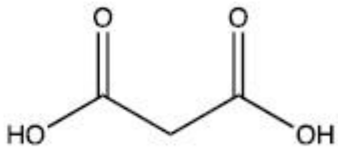
Allow water is a product / water is not a reagent

1

[8]

Q8.

(a)



Must be a skeletal formula

Need to show the H atoms of OH groups

1

(b)

This is an extended response question and there is a requirement for shaking right at the end. (M6 requires idea of mixing at the end.)

M1 weigh out sample in bottle / boat / container

*Penalise **M1** for weighing out wrong substance or using the acid as a liquid or solution (for **M1**, acid must be a solid that is being weighed). For **M1**, ignore any reference to a specific mass.*

1

M2 transfer to (conical) flask / beaker (or suitable container) and wash all sample in or re-weigh bottle / boat / container or re weigh bottle / boat / container

1

M3 dissolve sample in (deionised / distilled) water (if volume of water is specified, must be less than 250 cm^3)

For dissolving, ignore any reference to warming.

Maximum of 4 marks for candidates who add any substance other than water.

1

M4 add into volumetric flask with washings

Allow graduated flask for volumetric flask

1

M5 make up to mark / 250 cm^3 in volumetric flask

1

M6 shake / invert (this should be to give a homogenous solution rather than to dissolve; must be after made up to mark; ignore any earlier shaking)

1

Candidates may dissolve sample directly in volumetric flask. Mark scheme for this method:

***M1** weigh out sample in bottle / boat / container*

***M2** add into volumetric flask*

***M3** wash all sample in or re-weigh bottle / boat / container or re-weigh bottle / boat / container or re-weigh bottle / boat / container*

***M4** dissolve sample in (deionised / distilled) water (if volume of water is specified, must be less than 250 cm^3)*

***M5** make up to mark / 250 cm^3 in volumetric flask*

M6 shake / invert (this should be to give a homogenous solution rather than to dissolve; must be after made up to mark; ignore any earlier shaking)

(c) **M1** moles of acid = 0.00500 × $\frac{250}{1000}$ (= 0.00125)

130 scores 2 marks

Final answer must be at least 2sf

1

M2 mass of acid (= 0.00125 x 104(.0) = 0.130 g) = 130 (mg)

*Allow ECF from **M1** to **M2***

0.13(0) scores 1 mark

2080 (mg) scores 1 mark

1

[9]

Q9.

(a) **M1** moles of propan-1-ol = $\frac{6.0 \times 0.80}{60.0}$ (= 0.080)

67 cm³ scores 3 marks

1

M2 moles of $K_2Cr_2O_7$ = $\frac{M1}{3}$ (= 0.0267)

*Allow ECF for **M2** and **M3***

1

M3 volume of $K_2Cr_2O_7$ = $\frac{M2}{0.40} \times 1000$ = 67 (cm^3)

(allow 66.666…. to 68)

final answer to at least 2 sf

200 (cm^3) scores 2 marks;

66.6 (cm^3) is outside range and scores 2 marks;

66.·6 (cm^3) (i.e. 66.6 dot scores 3 marks)

1

(b) **M1** an attempt to draw apparatus that is clearly for (fractional) distillation

On this occasion, the apparatus does not need a thermometer or a collection container

1

M2 suitable drawing of distillation apparatus with condenser attached to side of distillation head

- condenser must have outer tube for water that is sealed at the ends but have two openings for water in/out (that are open)
- condenser must have downwards slope
- condenser must be open at each end
- as this is a cross-section, there should be a continuous flow through the diagram from the flask to the end of

the open condenser (there should be no lines drawn across implying a seal of any sort)

- there must be no gaps at joints between apparatus where vapour could escape
- there must be some opening to the system at the collection end

*Ignore any fractionating column in **M1** and **M2** between the flask and condenser.*

1

M3 condenser labelled including labels for water in and water out (water must come in at lower end)

*For **M3**, if water in and out clearly stated, ignore direction of any arrows drawn. Allow 'condensing tube' or 'condensing column' or similar for name of condenser.*

1

If a reflux diagram is drawn (any diagram with a condenser attached vertically into the flask is a reflux set up, even with a downwards tube from the top of the condenser):

- *cannot score **M1** or **M2***
- *could score **M3** for condenser labelled including labels for water in and water out (water must come in at the lower end)*

[6]

Q10.

(a) Thermometer and bung in flask with bulb level with side arm.

Must be cross section diagram with no gaps at joints

1

Condenser jacket with water in at bottom and out at top.

1

(b) Liquids are immiscible

Allow don't mix, forms two layers (stated or implied)

Allow it is insoluble

Ignore density or reference to solutions

1

(c) Liquid goes clear / not cloudy

Ignore colourless

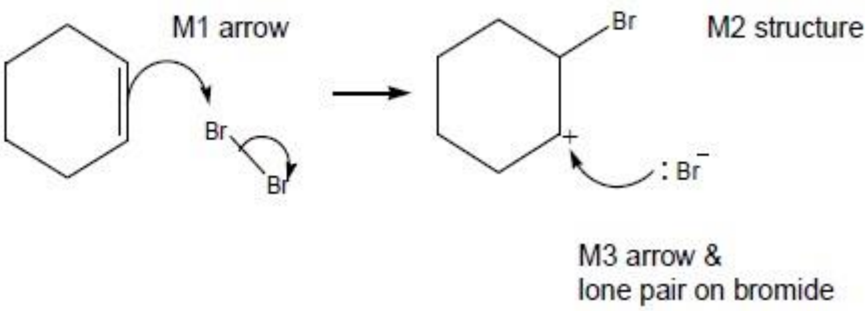
1

(d)

Via moles Amount cyclohexanol (= 14.4/100) = 0.144 mol	*Via mass* Amount cyclohexanol (= 14.4/100) = 0.144 mol	*Via volume* Amount cyclohexanol (= 14.4/100) = 0.144 mol	**M1**
Mass cyclohexene formed = 4.15 x 0.81 = 3.36 g	Mass cyclohexene formed = 4.15 x 0.81 = 3.36 g	Mass of cyclohexene expected (= 0.144 × 82.0 = 11.808 g) OR M1 × 82	**M2**
amount cyclohexene	mass of cyclohexene	volume of cyclohexene	**M3**

obtained (= 3.36/82.0 = 0.0410 mol) OR M2/82.0	expected (= 0.144 × 82.0 = 11.808 g) OR = M1 × 82.0	expected (= 11.808/0.810 = 14.577cm³) OR M2/0.810	
%Yield = $\frac{0.0410}{0.144}$ x 100 OR $\frac{M3}{M1}$ x 100	%Yield = $\frac{3.36}{11.808}$ x 100 OR $\frac{M2}{M3}$ x 100	%Yield = $\frac{4.15}{14.577}$ x 100 OR $\frac{4.15}{M3}$ x 100	**M4**
= 28.5% (must be 3 sf)	= 28.5% (must be 3 sf)	= 28.5% (must be 3 sf)	
Only award M5 if answer is to 3sf and follows some attempt at % yield calculation in M4			**M5**

(e)



*Lose **M1** if*

Full charges on Br−Br

OR

Wrong partial charges on Br−Br

OR

Arrow is to Br^+ ion (formed in a preliminary step)

*Any C shown in the ring must have the correct number of hydrogens attached to score **M2***

3

[12]

Q11.

(a) $Fe + H_2SO_4 \rightarrow FeSO_4 + H_2$

Allow $Fe + 2H^+ \rightarrow Fe^{2+} + H_2$

Allow $Fe + 2H^+ + SO_4^{2-} \rightarrow Fe^{2+} + SO_4^{2-} + H_2$

Allow $Fe + H_2SO_4 \rightarrow Fe^{2+} + SO_4^{2-} + H_2$

Allow $Fe + 2H^+ + SO_4^{2-} \rightarrow FeSO_4 + H_2$

Allow multiples

Ignore state symbols

1

(b) 22.65 (cm^3)

1

(c) $5 Fe^{2+} + MnO_4^- + 8 H^+ \rightarrow 5 Fe^{3+} + Mn^{2+} + 4 H_2O$

Allow multiples
Ignore state symbols
NOT if electrons shown

1

(d) colourless / (pale) green to (hint of) pink
NOT …. to purple
Allow …. to pale / hint of purple

1

(e) pipette

burette
both needed
Allow (graduated/volumetric) pipette
Allow (graduated/volumetric) burette
NOT dropping pipette

1

(f) 1.47(%)
Allow 1.5(%)

1

[6]

Q12.

(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 × 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]

Q13.

Marks awarded for this answer will be determined by the quality of written communication as well as the standard of the scientific response. Examiners should apply a 'best-fit' approach to the marking. **Additional tests limits to lower mark within a level.** This would include, for example, adding silver nitrate to the already identified sodium carbonate. Use of hydrochloric acid with silver nitrate also limits to lower mark within a level as this would not be a logical sequence/method that would work.	
Level 3 5-6 marks	All stages are covered and each stage is generally correct and virtually complete. Answer is communicated coherently and shows a logical progression from Stage 1 to Stages 2 and 3 to identify all three compounds in a logical sequence with results and equations for all compounds stated. **Covers 2 tests with matching observations, conclusions and equations**
Level 2 3-4 marks	All stages are covered but stage(s) may be incomplete or may contain inaccuracies OR two stages are covered and are generally correct and

	virtually complete. Answer is communicated mainly coherently and shows a logical progression from Stage 1 to Stages 2 and 3. **Covers 2 compounds** Isolated tests on named compounds – max LEVEL 2
Level 1 1-2 marks	Two stages are covered but stage(s) may be incomplete or may contain inaccuracies OR only one stage is covered but is generally correct and virtually complete. Answer includes isolated statements but these are not presented in a logical order.

Indicative Chemistry Content

Stage 1 Suggested tests
1a Add named acid to all 3
1b Add water / make into a solution
1c Add $AgNO_3$
Ignore addition of NH_3 / Ignore additional test for CO_2 produced

Stage 2 Expected observations - conclusions
2a Na_2CO_3 will fizz with acid
2b NaCl gives white ppt with $AgNO_3$
2c NaF shows no (visible) change / no ppt
Additional incorrect observations loses point

Stage 3 Equations – state symbols must match method
3a $Na_2CO_3 + 2HNO_3 \rightarrow 2NaNO_3 + CO_2 + H_2O$ … or ionic
3b $AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$
… or ionic
3c correct state symbols

[6]

Q14.

(a) use of water would dilute the NaOH OR
use of water would change the concentration of NaOH OR
to ensure the concentration of the NaOH is not changed OR

Ignore reference to weakening the solution, watering down the solution, contaminate

Allow

it would gives a titre value that is larger

it would decrease the pH of the NaOH

(any additional qualifying reason given must be correct)

1

(b) Rough = 25.2, 1= 23.90, 2 = 23.70, 3 = 24.00.

Need all four (with rough to 1dp and the other three to 2dp)

1

(c) **M1** use of titrations 1 & 3 only

***M1** is for choosing correct titres*

1

M2 23.95 (cm^3)

__M2__ is for calculating the mean to 2dp for their chosen titres

24.0 cm^3 = 1 mark (wrong number of decimal places)

24 cm^3 = 1 mark (only if it is clear that titration 2 is not included)

23.86 cm^3 = 1 mark (used all three titrations)

23.9 cm^3 = 0 marks (used all three titrations and wrong number of decimal places)

If error(s) made in 2.2, allow ECF from 2.2, where they choose concordant titres and find the mean (can score M1 and M2)

1

(d) $(\frac{0.15}{23.95} \times 100) = 0.63\%$

(0.6263%)

Allow any correct value with at least 2 significant figures based on their answer to 2.3. Rounding must be correct.

1

(e) **M1** moles NaOH = $\frac{23.95}{1000} \times 0.0500$ (=0.001198)

1

M2 moles acid in flask = $\frac{M1}{3} \times 10$ (= 0.003992)

1

M3 mass acid (= 0.003992 x 192.0 = 0.766 g) = 766 (mg)

Correct answer to at least 2sf = 3 marks (allow 760-770 mg)

Correct value in grams (lose M3) = 2 marks (allow 0.76-0.77 g)

Allow ECF at each stage (including those based on value from 2.3)

Incorrect answers that are a factor of 10 too small lose M2 (76-77 mg = 2 marks, 0.076-0.077 g = 1 mark)

(if use 25 cm^3 for volume of NaOH, then max 2 marks (__M2__ and __M3__ for 800 mg)

1

(f) $(\frac{\text{Answer to Q (e)}}{784} \times 100) = 97.7$ or 97.8%

Allow any correct value to at least 2 significant figures based on their answer to Q(e)

(values may be over 100% if 2.5 is incorrect)

1

[9]