C3 Revision – Titrations and calculations

Q1. *In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.*

A student used the equipment shown to do a titration. **GRADE C QUESTION**

Describe how the student should use this equipment to find the volume of sodium hydroxide solution that reacts with a known volume of acid.
Include any measurements the student should make.

Do **not** describe how to do any calculations.

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(Total 6 marks)

Q2. A student investigated the rate of reaction of magnesium and hydrochloric acid.

$$Mg(s) + 2HCl(aq) \quad MgCl_2(aq) + H_2(g)$$

The student studied the effect of changing the concentration of the hydrochloric acid.

She measured the time for the magnesium to stop reacting.

	Concentration of hydrochloric acid in moles per dm^3	0.5	1.0	1.5	2.0

(a) The student changed the concentration of the hydrochloric acid.

Give **two** variables that the student should control.

1 .....

2 ..... **(2)**

(b) (i) The rate of reaction increased as the concentration of hydrochloric acid increased.

Explain why.

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..... .**(2)**

(ii) Explain why increasing the temperature would increase the rate of reaction.

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(3)

(c) (i) The student had a solution of sodium hydroxide with a concentration of 0.100 moles per dm^3.

She wanted to check the concentration of a solution of hydrochloric acid.

She used a pipette to transfer 5.00 cm^3 of the hydrochloric acid into a conical flask.

She filled a burette with the 0.100 moles per dm^3 sodium hydroxide solution.

Describe how she should use titration to obtain accurate results.

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.....**(4)**

(ii) Sodium hydroxide neutralises hydrochloric acid as shown in the equation:

$$NaOH(aq) + HCl(aq) \quad NaCl(aq) + H_2O(l)$$

The student found that 27.20 cm^3 of 0.100 moles per dm^3 sodium hydroxide neutralised 5.00 cm^3 of hydrochloric acid.

Calculate the concentration of the hydrochloric acid in moles per dm^3.

Give your answer to three significant figures.

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Concentration of hydrochloric acid = ... moles per dm^3

(3)
(Total 14 marks)

Q3.(a) A student had a colourless solution.

The student thought the solution was dilute hydrochloric acid.

(i) The student added universal indicator to this solution.

What colour would the universal indicator change to if the solution is hydrochloric acid?

..... **(1)**

(ii) Describe how the student could show that there are chloride ions in this solution.

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..... **(2)**

(b) The results of a titration can be used to find the concentration of an acid.

Describe how to use the apparatus to do a titration using 25 cm^3 of dilute hydrochloric acid.

In your answer you should include:

- how you will determine the end point of the titration
- how you will make sure the result obtained is accurate.

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..... **(4)**

(c) Hydrochloric acid is a strong acid.

Ethanoic acid is a *weak acid*.

What is meant by the term *weak acid*?

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..... **(1) (Total 8 marks)**

Q4. A student carried out a titration to find the concentration of a solution of sulphuric acid. 25.0 cm^3 of the sulphuric acid solution was neutralised exactly by 34.0 cm^3 of a potassium hydroxide solution of concentration 2.0 mol/dm^3. The equation for the reaction is:

$2KOH(aq) + H_2SO_4(aq) \rightarrow K_2SO_4(aq) + 2H_2O(l)$

(a) Describe the experimental procedure for the titration carried out by the student.

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..... **(4)**

(b) Calculate the number of moles of potassium hydroxide used.

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Number of moles = ... **(2)**

(c) Calculate the concentration of the sulphuric acid in mol/dm^3.

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Concentration = ... mol/dm^3 **(3) (Total 9 marks)**

Q5. Some students were titrating sodium hydroxide solution against 0.100 mol/dm^3 sulfuric acid using the apparatus shown in the diagram.

(a) (i) A student first carried out a trial titration to find the approximate volume of 0.100 mol/dm^3 sulfuric acid needed to neutralise 25.0 cm^3 of sodium hydroxide solution.

Describe how the student would use the same apparatus to obtain an accurate value for the volume required to neutralise the sodium hydroxide.

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(6)

(ii) Give **one** safety precaution the student should use when doing the titration.

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(1)

(b) The diagrams show the level of the sulfuric acid in the burette at the start and the end of one titration.

Use the diagrams to work out the volume of sulfuric acid added in the titration.

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..... cm^3 **(3)**

(c) The table shows the colours of some indicators that could be used in the titration.

	Name of indicator	Colour in acid	Colour in alkali	Colour at end point
	litmus	red	blue	purple
	phenolphthalein	colourless	red	colourless
	bromothymol blue	yellow	green	blue

Litmus is **not** a good choice for this titration.

Suggest why.

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(1)

(d) Another student obtained the following results.

	end reading in cm^3	26.85	28.15	26.90	24.95
	start reading in cm^3	1.75	4.85	3.65	1.65
	volume added in cm^3	25.10	23.30	23.25	23.30

(i) Which results should the student use to calculate the mean volume of acid added?

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.....**(1)**

(ii) Calculate the mean from the results. Give your answer to 2 decimal places.

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Mean = ... cm^3 **(2)**

(e) One student found that 25.0 cm^3 of sodium hydroxide solution was neutralised by exactly 22.30 cm^3 of 0.100 mol/dm^3 sulfuric acid solution.

(i) Calculate the number of moles of sulfuric acid that this student used in the titration.

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number of moles = ...

(2)

(ii) The equation for the reaction of sulfuric acid with sodium hydroxide solution is:

$$H_2SO_4(aq) + 2\ NaOH(aq) \quad Na_2SO_4(aq) + 2\ H_2O(l)$$

Use your answer to (e)(i) and the equation to calculate the number of moles of sodium hydroxide that must have been used.

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number of moles = ...

(1)

(iii) Calculate the concentration, in mol/dm^3, of the sodium hydroxide solution used. Give your answer to 3 decimal places.

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Concentration = ... mol/dm^3

(2)
(Total 19 marks)

Q6. In 1916, during the First World War, a German U-boat sank a Swedish ship which was carrying a cargo of champagne. The wreck was discovered in 1997 and the champagne was brought to the surface and analysed.

(a) 25.0 cm^3 of the champagne were placed in a conical flask.

Describe how the volume of sodium hydroxide solution needed to react completely with the weak acids in 25.0 cm^3 of this champagne can be found by titration, using phenolphthalein indicator.

Name any other apparatus used.

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(4)

(b) The acid in 25.0 cm^3 of the champagne reacted completely with 13.5 cm^3 of sodium hydroxide of concentration 0.10 moles per cubic decimetre.

Calculate the concentration in moles per cubic decimetre of acid in the champagne.

Assume that 1 mole of sodium hydroxide reacts completely with 1 mole of acid.

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Concentration = ... moles per cubic decimetre

(2)

(c) Is analysis by titration enough to decide whether this champagne is safe to drink?

Explain your answer.

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(1)
(Total 7 marks)

Q7. This label has been taken from a bottle of household ammonia solution.

Household ammonia is a dilute solution of ammonia in water. It is commonly used to remove grease from ovens and windows.

(a) The amount of ammonia in household ammonia can be found by titration.

25.0 cm^3 of household ammonia is placed in a conical flask. Describe how the volume of dilute nitric acid required to neutralise this amount of household ammonia can be found accurately by titration. Name any other apparatus and materials used.

To gain full marks you should write down your ideas in good English. Put them into a sensible order and use correct scientific words.

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(4)

(b) In an experiment, it was found that 25.0 cm^3 of household ammonia was neutralised by 20.0 cm^3 of dilute nitric acid with a concentration of 0.25 moles per cubic decimetre.

The balanced symbol equation which represents this reaction is

$$NH_3(aq) + HNO_3(aq) \rightarrow NH_4NO_3(aq)$$

Calculate the concentration of the ammonia in this household ammonia in moles per cubic decimetre.

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Concentration = ... moles per cubic decimetre

(2)

(c) The salt, ammonium nitrate, is formed in this reaction.

Describe, and give the result of, a chemical test which shows that ammonium nitrate contains ammonium ions.

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(2)

(Total 8 marks)

M1. Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information in the Marking guidance.

0 marks No relevant content.

Level 1 (1-2 marks) There is a simple description of using some of the equipment.

Level 2 (3-4 marks) There is a description of an experimental method involving a measurement, **or** including addition of alkali to acid (or vice versa).

Level 3 (5-6 marks) There is a description of a titration that would allow a successful result to be obtained.

Examples of chemistry points made in the response could include:

- acid in (conical) flask
- volume of acid measured using pipette
- indicator in (conical) flask
- sodium hydroxide in burette
- white tile under flask
- slow addition
- swirling
- colour change
- volume of sodium hydroxide added

Extra information

- allow acid in the burette to be added to sodium hydroxide in the (conical) flask
- allow any specified indicator

colour change need not be specified

[6]

M2.(a) any **two** from:

- temperature (of the HCl)
- mass or length of the magnesium
- surface area of the magnesium
- volume of HCl

2

(b) (i) (a greater concentration has) more particles per unit volume

allow particles are closer together

1

therefore more collisions per unit time **or** more frequent collisions.

1

(ii) particles move faster

allow particles have more (kinetic) energy

1

therefore more collisions per unit time **or** more frequent collisions

1

collisions more energetic (therefore more collisions have energy greater than the activation energy) **or** more productive collisions

1

(c) (i) add (a few drops) of indicator to the acid in the conical flask

allow any named indicator

1

add NaOH (from the burette) until the indicator changes colour **or** add the NaOH dropwise

candidate does not have to state a colour change but penalise an incorrect colour change.

1

repeat the titration

1

calculate the **average** volume of NaOH **or** repeat until concordant results are obtained

1

(ii) **moles of NaOH**

$0.10 \times 0.0272 = 0.00272$ moles

*correct answer with or without working gains **3** marks*

1

Concentration of HCl

0.00272 / 0.005 = 0.544

allow ecf from mp1 to mp2

1

correct number of significant figures

1

[14]

M3.(a) (i) red

ignore pink

1

(ii) add silver nitrate (solution)

1

white precipitate

dependent on addition of silver nitrate
ignore addition of another acid
*if hydrochloric acid added max **1** mark*

1

(b) suitable named alkali / sodium hydroxide solution in burette

1

add alkali solution until (indicator) becomes pink / red

1

*if acid to acid titration described, first two marking points **not** available*

any **two** from:

- wash / rinse equipment
- add dropwise or slowly (near end point)
- swirl / mix
- read (meniscus) at eye level
- white background
- read start and final burette levels / calculate the volume needed
- repeat

2

(c) does not ionise / dissociate completely

allow <u>for acids of the same concentration</u>, weak acids have a higher pH or fewer hydrogen ions

1

(d) (i) ring round COOH

1

(ii)

*if not fully correct, allow **1** mark for correct ester group − minimum*

2

[11]

M4. (a) any four from:

- sulphuric acid measure by pipette
  ***or** diagram*
- potassium hydroxide in burette
  ***or** diagram*
- if solutions reversed, award
- note initial reading
- use of indicator
- note final reading **or** amount used

4

(b)

1

= 0.068

1

(c) ½ or 0.5 moles H_2SO_4 react with 1 mole KOH

1

moles H_2SO_4 in 25.0 cm^3 = 0.068 × 0.5

1

moles H_2SO_4 in 1 dm^3 = = 1.36 mol/dm^3

1

[9]

M5. (a) (i) read meniscus (on burette) at eye level

1

add acid dropwise (near previous endpoint) to the flask

1

with swirling / mixing

1

flask to be stood on white tile (or similar)

1

stop adding acid when colour of indicator changed by one drop

1

repeat to get concordant results

1

(ii) any sensible precaution eg eye protection, gloves
*do **not** accept tie hair back*

1

(b) 24.50
trailing zero required

1

2.35

1

22.15
allow ecf

1

(c) hard to detect change of colour (blue to purple)

accept blue and purple are (too) similar / hard to tell apart

1

(d) (i) 23.30, 23.25 **and** 23.30

all 3 values required

*allow word description eg 'the last 3 values' **or** 'every value except the first one'*

1

(ii) (23.30 + 23.25 + 23.30) / 3

1

23.28

*correct answer to 2 decimal places with or without working gains **2** marks*

*allow ecf from (d)(i) to 2 decimal places for **1** mark*

1

(e) (i) (22.30 × 0.100) / 1000

1

0.00223

*correct answer with or without working gains **2** marks*

*failure to /1000, (= 2.23) gains **1** mark*

1

(ii) 0.00446

allow their (e)(i) × 2

1

(iii) 0.00446 / (25 / 1000)

1

0.178

*correct answer with or without working gains **2** marks*

*if no /1000 max **1** mark*

*allow their (e)(ii) / (25 / 1000) for **1** mark*

1

[19]

M6. (a) **must** be description of a titration no titration = no marks

NaOH in <u>burette</u>

*do **not** accept biuret etc*

1

add NaOH until (indicator) changes colour

*if specific colour change mentioned, must be correct – colourless to pink / red **or** 'goes pink / red'*

*do **not** accept 'clear' for colourless*

1

note (burette) volume used **or** final reading

accept 'work out the volume'

1

one other point: eg repeat

accept:
*(white) tile **or** add dropwise / slowly **or** white background **or** swirling / mix **or** read meniscus at eye level **or** wash apparatus*

1

(b) 0.054

*for **2** marks*

*(0.1 × 13.5)/25 for **1** mark*

(c) don't know – insufficient evidence to decide

owtte

any sensible answer

or

depends on whether acid level is considered safe or unsafe

yes, safe – acid level low / weak acids / low compared with stomach acid

owtte

any sensible answer

2

no, unsafe – acid level (too) high / other substances or bacteria may be present / insufficient evidence to decide

owtte

any sensible answer

1

(d) (methyl orange) would have changed colour (well) before the end-point / pH7 / neutral

owtte

1

weak acid present

weak acid-strong base (titration)

allow methyl orange used for strong acid-weak base titration

1

[9]

M7. (a)

***must** be a description of a titration no titration = **0** marks*

Quality of written communication

*for correct sequencing of 2 of first 3 bullet points i.e. 1 + 2 **or** 2 + 3 **or** 1 + 3*

1

any **three** from:

- nitric acid in burette

  *do **not** accept biuret*
  can be inferred from 3rd point

- add nitric acid until indicator changes (colour)

  can be named acid-base indicator
  colour change does not have to be correct

- note (burette) volume used **or** final reading

- accuracy: e.g. repeat

  *accept white tile **or** dropwise near end **or** white background **or** swirling the flask **or** read meniscus at eye level*

3

(b) e.g. formula method:

$25 \times M_{NH3} = 0.25 \times 20$

1

$M_{NH3} = 0.2$

*correct answer alone = **2***

OR

moles NH_3 = moles HNO_3

= × 0.25 = 0.005 moles (1)

concentration NH3

= = 0.2 (1)

1

(c) sodium hydroxide **or** potassium hydroxide **or** lithium hydroxide **or** calcium hydroxide

ignore mention of alkali

1

ammonia produced

accept gas produced turns (damp) (red) litmus blue (not blue litmus) ***or*** *<u>alkaline</u> gas produced*

any suitable named indicator e.g. UI with consequential marking white fumes / smoke with (concentrated) HCl

do ***not*** *accept white gas wrong test =* ***0*** *marks*

1

[8]