Mark schemes

Q1.

(a) H^+

1

(b) neutralisation

1

(c) $H_2SO_4 + 2\ KOH \rightarrow K_2SO_4 + 2\ H_2O$

allow multiples

1

(d) 14

1

(e) pipette

1

(f) add potassium hydroxide (solution) to the (conical) flask

1

add (a few drops of) indicator

1

add the (sulfuric) acid (from the burette)

1

until the colour (of the indicator) changes

1

read the volume from the burette

1

[10]

Q2.

(a) 48 (cm^3)

1

(b) (change in y =) 70 (cm^3)

1

(change in x =) 0.4 (g)

1

(gradient =) $\frac{70}{0.4}$

allow correct use of incorrectly derived values for change in y and / or change in x

1

= 175 (cm^3/g)

1

(c) hydrochloric acid

1

(d) carbon dioxide

1

(e) to evaporate water

1

(f) using a (boiling) water bath
or
using an electric heater

1

[9]

Q3.

(a) potassium chloride

allow KCl

1

(b) $H^+ + OH^- \rightarrow H_2O$

ignore state symbols

1

(c) copper carbonate and copper oxide only

1

(d) (Step 2) to speed up the reaction

1

(Step 5) to make sure all the (hydrochloric) acid reacts

1

(Step 6) to remove the excess magnesium oxide

ignore to remove impurities

1

(e) using a (boiling) water bath
or
using an electric heater

1

(f) (moles Fe = $\frac{14}{56}$ =) 0.25 (mol)

1

(moles Cl_2 = $\frac{3}{2}$ $_2$ × 0.25 =) 0.375 (mol)

allow correct use of an incorrectly calculated number of moles of Fe

1

(volume Cl_2 = 24 × 0.375) = 9.0 (dm^3)

allow correct use of an incorrectly calculated number of moles of Cl_2

1

[10]

Q4.

(a) a dilute solution of a strong acid

1

(b) 1.0 mol/dm^3 hydrogen chloride solution

1

(c) any **two** from:

- swirl (the solution)
- white tile (under the flask)
- add (ethanedioic) acid dropwise (near the endpoint)
- repeat **and** calculate mean

2

(d) (concentration = 90 × 0.0480 =)
4.32 (g/dm^3)

1

(mass = 4.32 × $\frac{250}{1000}$) = 1.08 (g)

allow correct use of an incorrectly calculated value of concentration in g/dm^3

1

alternative approach:

(moles = 0.0480 × $\frac{250}{1000}$ =)
0.012 (mol) (1)

(mass = 0.012 × 90)
= 1.08 (g) (1)

allow correct use of an incorrectly calculated value of number of moles

(e) (moles $H_2C_2O_4$ = $\frac{15.0}{1000}$ × 0.0480)
= 0.00072 (mol)

1

(moles NaOH =
moles $H_2C_2O_4$ × 2 =)
0.00144 (mol)

allow correct use of an incorrectly calculated value of number of moles of $H_2C_2O_4$

1

(concentration= $\frac{0.00144}{25.0}$ × 1000)
= 0.0576 (mol/dm^3)

allow 0.058 (mol/dm^3)

allow correct use of an incorrectly calculated value of number of moles of NaOH

1

alternative approach:

$$\frac{\text{volume} \times \text{conc (acid)}}{\text{volume} \times \text{conc (NaOH)}} = \frac{1}{2} \text{ (1)}$$

allow inverse

(conc NaOH =)

$$2 \times \frac{15.0 \times 0.0480}{25.0} \text{ (1)}$$

allow correct use of incorrect mole ratio

= 0.0576 (mol/dm^3) (1)

[9]

Q5.

(a) nitric acid

1

(b) zinc oxide

1

(c) magnesium bromide

1

(d) (from 0) to 20 cm^3 the pH increases (gradually)

allow a tolerance of 1 cm^3 on volumes
allow a tolerance of 0.2 on pH values

allow increase from pH 1 to pH 3

1

at 20 cm^3 the pH changes from pH 3 to pH 11

allow sudden / steep increase at 20 cm^3
allow sudden / steep increase from pH 3 to pH 11

1

from 20 cm^3 the pH increases (gradually)

allow (gradual) increase from pH 11

*if no other marks awarded allow **1** mark for a description of the three stages with no values used.*

1

(e) 20 (cm^3)

allow 20.0 (cm^3)

1

(f) red

1

(g)

$$\frac{0.06}{25(.0)} \times 100$$

1

= 0.24 (%)

1

(h) (pipette) measures volume more accurately
or
(pipette has a) smaller (percentage) uncertainty

allow (pipette is) more accurate

1

[11]

Q6.

(a) H^+

1

(b) hydrochloric (acid)

allow HCl

1

water

allow H_2O

1

(c) burette

*do **not** accept biuret*

1

(d) 27.6 (cm^3)

allow 27.60 (cm^3)

1

(e) **Level 3:** The design/plan would lead to the production of a valid outcome. All key steps are identified and logically sequenced.

5–6

Level 2: The design/plan would not necessarily lead to a valid outcome. Most steps are identified, but the plan is not fully logically sequenced.

3–4

Level 1: The design/plan would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.

1–2

No relevant content

0

Indicative content

allow converse using acid added to alkali

Key steps
- measure the volume of acid
- add indicator to the acid
- add sodium hydroxide solution
- until the colour changes
- record volume of sodium hydroxide solution added
- repeat procedure with the other acid

Use of results
- compare the two volumes of sodium hydroxide solution to find which sample **P** or **Q** is more concentrated

Other points

- pipette to measure volume of acid
- use a few drops of indicator
- swirl
- use a white tile
- rough titration to find approximate end point
- add dropwise near the endpoint
- read volume from bottom of meniscus
- repeat and take a mean

[11]

Q7.

(a) any **one** from:
- metal
- (metal) hydroxide

  allow ammonium hydroxide

- (metal) carbonate

  allow ammonium carbonate

- alkali

  allow soluble base
  allow ammonia

1

allow named example
allow correct formula
ignore base

(b) $Ca(NO_3)_2$

allow $Ca^{2+}(NO_3^-)_2$

1

(c) **Level 3:** The method would lead to the production of a valid outcome. All key steps are identified and logically sequenced.

5–6

Level 2: The method would not necessarily lead to a valid outcome. Most steps are identified, but the method is not fully logically sequenced.

3–4

Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.

1−2

No relevant content

0

Indicative content

- use magnesium oxide and sulfuric acid
- add sulfuric acid to a beaker
- warm sulfuric acid
- add magnesium oxide
- stir
- continue adding until magnesium oxide is in excess

- filter
- using a filter paper and funnel
- to remove excess magnesium oxide

- heat solution in an evaporating basin
- to crystallisation point
- leave to crystallise
- pat dry with filter paper

credit may be given for diagrams

[8]

Q8.

(a) (strong because) completely ionised (in aqueous solution)

ignore pH

allow dissociated for ionised

*do **not** accept hydrogen is ionising*
*do **not** accept H^+ are ionised*

1

(dilute because) small amount of acid per unit volume

ignore low concentration

1

(b) 5.0

allow 5

1

(c) (titre):
chooses titrations 3, 4, 5

1

average titre = 22.13 (cm^3)

allow average titre = 22.13(3…) (cm^3)
allow a correctly calculated average
from an incorrect choice of titrations

1

(calculation):
(moles NaOH =
$\frac{22.13}{1000} \times 0.105 = 0.002324)$

allow use of incorrect average titre from step 2

1

(moles H_2SO_4 =
½ × 0.002324 =) 0.001162

allow use of incorrect number of moles from step 3

1

(concentration =
$\frac{0.001162}{25} \times 1000)$

= 0.0465 (mol/dm^3)

allow use of incorrect number of moles from step 4

1

alternative approach for step 3, step 4 and step 5

$\frac{2}{1} = \frac{22.13 \times 0.105}{25.0 \times \text{conc. } H_2SO_4}$ *(1)*

(concentration H_2SO_4 =)
$\frac{22.13 \times 0.105}{25.0 \times 2}$

= 0.0465 (mol/dm^3) (1)

*an answer of 0.046473 **or** 0.04648 correctly rounded to at least 2 sig figs scores marking points 3, 4 and 5*

*an answer of 0.092946 **or** 0.09296 **or** 0.185892 **or** 0.18592 correctly rounded to at least 2 sig figs scores marking points 3 and 5*

*an incorrect answer for one step does **not** prevent allocation of marks for subsequent steps*

(d) pipette measures a fixed volume (accurately)

1

(but) burette measures variable volume

allow can measure drop by drop

1

(e) (moles =) $\frac{30}{1000} \times 0.105$

or 0.00315 (mol)

or

(mass per dm^3 =) 0.105 × 40
or 4.2 (g)

1

$$(\text{mass} = \frac{30}{1000} \times 0.105 \times 40)$$

= 0.126 (g)

1

*an answer of 0.126 (g) scores **2** marks*

*an answer of 126(g) scores **1** mark*

*an incorrect answer for one step does **not** prevent allocation of marks for subsequent steps*

[12]

Q9.

(a) $4\,Na + O_2 \longrightarrow 2Na_2O$

allow multiples

1

(b) (sodium) gains oxygen

1

(c) purple

1

(d) aluminium chloride

1

(e) **Level 2 (3-4 marks):**
Relevant reasons are identified, given in detail and logically linked to form a clear account.

Level 1 (1-2 marks):
Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.

Level 0
No relevant content

Indicative content

conclusion 1
- pH values above 7 are alkaline
- sodium oxide, calcium oxide and magnesium oxide do form alkaline solutions (so correct for those)
- not all metal oxides form solutions (so incorrect for zinc oxide)

conclusion 2
- pH values below 7 are acidic
- carbon dioxide, sulfur dioxide and phosphorus oxide do form acidic solutions (so correct for those)

- not all non-metal oxides form solutions (so incorrect for silicon oxide)]

4

(f) metal oxides produce alkaline solutions if they dissolve in water

*allow **1** mark for most metal oxides produce alkaline solutions*

2

[10]

Q10.

(a) fill burette with sodium hydroxide

1

add sodium hydroxide from the burette to the hydrochloric acid and indicator

1

stop when colour changes

1

measure volume used from burette

1

plus any **two** from:

- stand flask on white tile
- swirl
- add dropwise near the endpoint
- repeat

2

(b) filtration

1

(c) evaporate some of the solution and leave to cool

or

heat with an electric heater

1

[8]

Q11.

(a) heat with a water bath

or

heat with an electric heater

or

allow to evaporate / crystallise at room temperature

1

(b) to make sure that all the iodine reacts

allow so can see the reaction is complete

1

(as) excess iodine would remain in solution

1

(so) iodine could not be filtered off

allow (whereas) excess zinc could be filtered off

or

(so) the zinc iodide would not be pure

allow (so) would have to separate iodine from zinc iodide

1

(c) $\text{moles } I_2 = \frac{0.5(00)}{254} = (0.00197)$

allow moles I_2 = 0.00197

allow 65 g Zn: 254 g I_2

1

mass Zn = 0.00197 × 65 (g)

1

mass = 0.128 (g)

1

*allow an expression $\frac{0.5(00) \times 65}{254}$ (g) for the first **2** marks*

(d) $92.0 = \frac{12.5}{\text{maximum mass}} \times 100$

1

$(\text{maximum mass}=)\ \frac{100}{92.0} \times 12.5$

1

= 13.6 (g)

allow 13.5869... (g)

1

(e) some product lost on separation

allow incomplete reaction

1

(f) M_r ZnI_2 = 319

1

moles needed

$\left(= 0.1 \times \frac{250}{1000}\right) = 0.025$

or

mass per dm^3 = 31.9 (g)

1

(mass) = 7.98 (g)

allow 7.975 / 8.0 (g)

1

*an answer of 7.975, 7.98 or 8.0 (g) scores **3** marks*

[14]

Q12.

(a) produces H^+ / hydrogen ions in aqueous solution

1

(but is) only partially / slightly ionised

1

(b) indicator changes colour

1

from blue to yellow

allow from blue to green

1

(when) the acid and alkali are (exactly) neutralised
or
(when) no excess of either acid or alkali

1

(c) pipette measures one fixed volume (accurately)

1

(but) burette measures variable volumes (accurately)

1

(d) $\frac{12.10 + 12.15 + 12.15}{3}$

1

(mean titre =) 12.13(3) (cm^3)

1

(moles NaOH = conc × vol) = 0.00255

1

(moles citric acid = $\frac{1}{3}$ moles NaOH) = 0.00085

1

(conc acid = moles / vol) = 0.0701 (mol / dm^3)

allow ecf from steps 1, 2, 3 and / or 4

*allow an answer of 0.0701 (mol / dm^3) without working for **1** mark only*

1

[12]

Q13.

(a) 36 cm^3

1

(b) all points correct

± ½ small square

2

*allow **1** mark if 6 or 7 of the points are correct*

2 best fit lines drawn

must not deviate towards anomalous point

2

*allow **1** mark if 1 line correct*

(c) The bung was not pushed in firmly enough.

1

The measuring cylinder was not completely over the delivery tube.

1

(d) as mass of lithium carbonate increases volume of gas produced increases

1

linear / (directly) proportional

1

(e) A gas / carbon dioxide is produced.

allow because the air in the tube expands

1

(f) any **one** from:

- Potassium carbonate does not decompose to produce carbon dioxide / a gas.
- Potassium carbonate does not decompose at the temperature of the Bunsen
  burner **or** the Bunsen burner is not hot enough to decompose potassium carbonate.
- When potassium carbonate decomposes a gas is not formed.

1

[11]

Q14.

(a) s

1

l

*Answers **must** be in the correct order.*

1

(b) A gas was lost from the flask

1

(c) **Level 3 (5–6 marks):**
A coherent method is described with relevant detail, and in correct sequence which demonstrates a broad understanding of the relevant scientific techniques and procedures. The steps in the method are logically ordered. The method would lead to the production of valid results.

Level 2 (3–4 marks):
The bulk of the method is described with mostly relevant detail, which demonstrates a reasonable understanding of the relevant scientific

techniques and procedures. The method may not be in a completely logical sequence and may be missing some detail.

Level 1 (1–2 marks):
Simple statements are made which demonstrate some understanding of some of the relevant scientific techniques and procedures. The response may lack a logical structure and would not lead to the production of valid results.

0 marks:
No relevant content.

Indicative content

- sulfuric acid in beaker (or similar)
- add copper carbonate one spatula at a time
- until copper carbonate is in excess or until no more effervescence occurs *
- filter using filter paper and funnel
- filter excess copper carbonate
- pour solution into evaporating basin / dish
- heat using Bunsen burner
- leave to crystallise / leave for water to evaporate / boil off water
- decant solution
- pat dry (using filter paper)
- wear safety spectacles / goggles

*Students. may choose to use a named indicator until it turns a neutral colour, record the number of spatulas of copper carbonate added then repeat without the indicator.

6

(d) Total mass of reactants = 221.5

1

$\frac{159.5}{221.5}$

allow ecf from step 1

1

72.0 (%)

1

*allow 72.0 with no working shown for **3** marks*

(e) any **one** from:

- Important for sustainable development
- Economic reasons
- Waste products may be pollutants / greenhouse gases

1

[13]

Q15.

(a) add excess copper carbonate (to dilute hydrochloric acid) *accept alternatives to excess, such as 'until no more reacts'*

1

filter (to remove excess copper carbonate)

reject heat until dry

1

heat filtrate to evaporate some water **or** heat to point of crystallisation

accept leave to evaporate or leave in evaporating basin

1

leave to cool (so crystals form)

until crystals form

1

*must be in correct order to gain **4** marks*

(b) M_r $CuCl_2$ = 134.5

*correct answer scores **4** marks*

1

moles copper chloride = (mass / M_r = 11 / 134.5) = 0.0817843866

1

M_r $CuCO_3$= 123.5

1

Mass $CuCO_3$ (=moles × M_2= 0.08178 × 123.5) = 10.1(00)

1

*accept 10.1 with no working shown for **4** marks*

(c) $\frac{79.1}{100} \times 11.0$

or

11.0 × 0.791

1

8.70 (g)

1

*accept 8.70(g) with no working shown for **2** marks*

(d) Total mass of reactants = 152.5

1

$\frac{134.5}{152.5}$

allow ecf from step 1

1

88.20 (%)

1

*allow 88.20 with no working shown for **3** marks*

(e) atom economy using carbonate lower because an additional product is made **or** carbon dioxide is made as well

allow ecf

1

[14]

Q16.

(a) (delivery) tube sticks into the acid

1

the acid would go into the water **or** the acid would leave the flask or go up the delivery tube

ignore no gas collected

1

(b) any **one** from:

- bung not put in firmly / properly
- gas lost before bung put in
- leak from tube

1

(c) all of the acid has reacted

1

(d) take more readings in range 0.34 g to 0.54 g

1

take more readings is insufficient

ignore repeat

(e) $\frac{95}{24000}$

1

0.00396

or

3.96×10^{-3}

1

*accept 0.00396 or 3.96×10^{-3} with no working shown for **2** marks*

(f) use a pipette / burette to measure the acid

1

because it is more accurate volume than a measuring cylinder
or
greater precision than a measuring cylinder
or
use a gas syringe to collect the gas

so it will not dissolve in water

or
use a flask with a divider
accept description of tube suspended inside flask

so no gas escapes when bung removed
1

(g) they should be collected because carbon dioxide is left in flask at end
1

and it has the same volume as the air collected / displaced
1
[11]

Q17.

(a) (sulfuric acid is) completely / fully ionised
1

In aqueous solution **or** when dissolved in water
1

(b) $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$
allow multiples
***1** mark for equation*
***1** mark for state symbols*
2

(c) adds indicator, eg phenolpthalein / methyl orange / litmus added to the sodium hydroxide
(in the conical flask)
*do **not** accept universal indicator*
1

(adds the acid from a) burette
1

with swirling **or** dropwise towards the end point **or** until the indicator just changes colour
1

until the indicator changes from pink to colourless (for phenolphthalein) or yellow to red
(for methyl orange) or blue to red (for litmus)
1

(d) titrations 3, 4 and 5
or
$$\frac{27.05 + 27.15 + 27.15}{3}$$
1

27.12 cm^3
*accept 27.12 with no working shown for **2** marks*
1

*allow 27.1166 with no working shown for **2** marks*

(e) Moles H_2SO_4 = conc × vol = 0.00271

allow ecf from 8.4

1

Ratio H_2SO_4:NaOH is 1:2
or
Moles NaOH = Moles H_2SO_4 × 2 = 0.00542

1

Concentration NaOH = mol / vol = 0.00542 / 0.025 = 0.2168

1

0.217 (mol / dm^3)

*accept 0.217 with no working for **4** marks*

1

*accept 0.2168 with no working for **3** marks*

(f) $\frac{20}{1000}$ × 0.18 = no of moles

or

0.15 × 40 g

1

0.144 (g)

1

*accept 0.144g with no working for **2** marks*

[16]

Q18.

(a) $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$

2

*allow **1** mark for correct formulae*

(b) sensible scales, using at least half the grid for the points

1

all points correct

± ½ small square

*allow **1** mark if 8 or 9 of the points are correct*

2

best fit line

1

(c) steeper line to left of original

1

line finishes at same overall volume of gas collected

1

(d) acid particles used up

allow marble / reactant used up

1

so concentration decreases

allow surface area of marble decreases

1

so less frequent collisions / fewer collisions per second

*do **not** accept fewer collisions unqualified*

1

so rate decreases / reaction slows down

1

(e) mass lost of 2.2 (g)

1

time taken of
270 s

allow values in range 265 − 270

1

$\frac{2.2}{270} = 0.00814814$

allow ecf for values given for mass and time

1

0.00815 (g / s)

or

8.15×10^{-3}

*allow **1** mark for correct calculation of value to 3 sig figs*

*accept 0.00815 or 8.15×10^{-3} with no working shown for **4** marks*

1

(f) correct tangent

1

eg 0.35 / 50

1

0.007

allow values in range of 0.0065 − 0.0075

1

7×10^{-3}

1

*accept 7×10^{-3} with no working shown for **4** marks*

[20]

Q19.

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 apply a 'best-fit' approach to the marking.

Level 3 (5 – 6 marks)
There is a description of titrations that would allow a comparison to be made between the two solutions of hydrochloric acid.

Level 2 (3 – 4 marks)
There is a description of an experimental method including addition of acid to alkali which may include an indicator or colour change and may include a measurement of volume.

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

0 marks
No relevant content.

examples of chemistry points made in the response could include:

- acid in burette **or** flask
- alkali/sodium hydroxide **or** acid in burette **or** flask
- volume of acid **or** alkali measured using the pipette
- indicator in flask
- white tile under the flask
- slow addition
- swirling/mixing
- colour change of indicator
- burette volume measured

[6]