Mark schemes

Q1.

(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]

Q2.

(a) didn't stir (the solution enough)

allow measured the temperature before the temperature stopped falling
allow measured the temperature too soon

1

(b) the temperature decreases (initially) because energy is taken in (by the reaction from the solution)

allow temperature decreases (initially) because the reaction is endothermic

when 1.5 g (of citric acid) is added the sodium hydrogencarbonate has all reacted

allow when the temperature reaches 11.6 °C the sodium hydrogencarbonate has all reacted

or

from 1.5 g the citric acid is in excess

allow after the temperature reaches 11.6 °C the citric acid is in excess

or

when 1.5 g (of citric acid) is added the reaction is complete

allow when the temperature reaches 11.6 °C the reaction is complete

(so) the temperature increases as energy is transferred from the room to the solution

allow (so) the temperature increases as energy is transferred from the excess

citric acid to the solution

1

(c) less steep line starting at 16.8 °C **and** reaching 1.00 g (of citric acid)

ignore any part of the line drawn beyond 1.00 g

1

(as) metal is a better conductor

allow (as) polystyrene is a better insulator

1

(so) more energy is absorbed (from the surroundings)

allow (so) more heat is absorbed (from the surroundings)

1

(d) (M_r citric acid =) 192

(moles = $\frac{250}{1000}$ × 0.0500) = 0.0125

(mass = 0.0125 × 192 =) 2.4 (g)

1

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

1

alternative approach:

(M_r citric acid =) 192 (1)

(concentration = 0.0500 × 192)
= 9.6 (g/dm^3) (1)

allow correct use of an incorrectly calculated M_r

(mass = $\frac{250}{1000}$ × 9.6 =) 2.4 (g) (1)

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

(e) add the citric acid (to the flask) until there is a (permanent) colour change

ignore colours of indicator

1

measure / record the volume (of citric acid) added

allow take the final (and initial) burette reading

1

any **one** from:
- swirl
- use a white tile
- add the citric acid dropwise (near the end-point)
- repeat **and** calculate a mean

allow add the citric acid slowly (near the end-point)

1

(f) any **two** from:
- can add (the citric acid) in small increments

allow can add (the citric acid) drop by drop

allow can add (the citric acid) slowly

- can measure variable volumes

allow has a scale 2

- more accurate than a measuring cylinder

2

(g) (moles citric acid = $\frac{13.3}{1000}$ × 0.0500) = 0.000665

1

(moles NaOH = 3 × 0.000665) = 0.001995

allow correct use of an incorrectly calculated number of moles of citric acid

1

(conc = $\frac{1000}{25}$ × 0.001995) = 0.0798 (mol/dm^3)

allow 0.08 or 0.080 (mol/dm^3)

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

1

alternative approach:

$\frac{25.0 \times \text{conc NaOH}}{13.3 \times 0.0500} = \frac{3}{1}$ (1)

allow $\frac{13.3 \times 0.0500}{25.0 \times \text{conc NaOH}} = \frac{1}{3}$

(conc NaOH =) 3 × $\frac{13.3 \times 0.0500}{25.0}$ (1)

= 0.0798 (mol/dm^3) (1)

allow 0.08 or 0.080 (mol/dm^3)

[18]

Q3.

(a) polystyrene is a better (thermal) insulator
allow polystyrene is a poorer (thermal) conductor

1

(so) reduces energy exchange (with the surroundings)
allow (so) reduces energy / heat loss (to the surroundings)

1

(b) all six points plotted correctly
allow a tolerance of ± ½ a small square
*allow **1** mark for at least 3 points plotted correctly*

2

line of best fit through points plotted from the table

1

both lines of best fit extrapolated correctly until they cross

1

(c) 11 (cm^3)
allow ecf from part (b)
allow answers in the range 10.75 to 11.25 (cm^3)
allow a tolerance of ± ½ a small square

1

(d) (27.5 − 18.9) = 8.6 (°C)
allow ecf from part (b)
allow answers in the range 8.5 to 8.7 (°C)
allow a tolerance of ± ½ a small square

1

(e)
*an answer of 0.62 (mol/dm^3) for concentration in mol/dm^3 scores **4** marks*
*an answer of 0.31 (mol/dm^3) for concentration in mol/dm^3 scores **3** marks*

(moles H_2SO_4 = 0.500 × $\frac{15.5}{1000}$) = 0.00775

1

(moles KOH = 2 x moles H_2SO_4 = 2 x 0.00775) = 0.0155
allow correct calculation using incorrectly calculated value of moles of H_2SO_4

1

(conc KOH = moles KOH x $\frac{1000}{25.0}$) = 0.0155 x $\frac{1000}{25.0}$)

allow correct calculation using incorrectly calculated value of moles of KOH

1

= 0.62 (mol/dm^3)

allow correct answer using incorrectly calculated value of moles of KOH

1

(M_r KOH =) 56

1

(conc = M_r x conc in mol/dm^3 = 56 x 0.62) = 34.7 (g/dm^3)

allow 35 or 34.72 (g/dm^3)

allow correct answer using incorrectly calculated value of concentration in mol/dm^3 and/or incorrect M_r

1

alternative approach for step 1 to step 4

$\frac{2}{1} = \frac{25 \times \text{conc KOH}}{15.5 \times 0.500}$ (2)

$(\text{conc KOH}) = \frac{2 \times 15.5 \times 0.500}{25.0}$ (1)

= 0.62 (mol/dm^3) (1)

allow 1 mark if mole ratio is incorrect

1

[14]

Q4.

(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

$\frac{2}{1} = \frac{22.13 \times 0.105}{25.0 \times conc.\ H_2SO_4}$ *(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) $(\text{moles} =) \frac{30}{1000} \times 0.105$

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]

Q5.

(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]

Q6.

(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]