AQA Chemistry A-level

Mark Scheme for
Practical Skills Questions

Q1.

(a) Selects correct titres

If 3 or more titres used them MAX 1 for conseq M3

1

$$\text{mean titre} = \frac{9.75 + 9.65}{2}$$

$= 9.7(0)\ cm^3$

Calculates mean

1

mol HCL $= 0.102 \times 9.70/1000 = 9.89 \times 10^{-4}$

(allow 9.9 × 10-4 for M3 but check not via 4 titres in which case only 1 mark)

Calculates mol (working or result gains credit)

9.92×10^{-4} scores 1 if all 4 titres used

9.83×10^{-4} scores 1 if titres 1,2, and 3 used

1

(b) mol $MHCO_3$ = ANS 3.1 × 10 ($= 9.89 \times 10^{-3}$)

Use ecf if wrong mean calculated above

1

$$Mr = \frac{1464/1000}{M1}$$

1

Allow ecf following wrong mass conversion

1

(c) Suggestion: Use a larger mass of solid OR use a more concentrated solution of $MHCO_3$ OR less concentrated / more dilute solution of HCl OR more $MHCO_3$

1

Cannot score justification mark unless suggestion correct, but suggestion could be after justification

Justification: So a larger titre/reading will be needed OR larger volume of HCl

Assume reference to the solution means the $MHCO_3$

1

(d) This question is marked using levels of response.

Level 3

Must use volumetric flask to access level 3

Answer is communicated coherently and shows a logical progression from stage 1 to stage 2 then stage 3.

All stages are covered and the description of each stage is complete

6 marks

All stages are covered but up to 2 omissions/errors from different stages. If 2 omissions/errors from same stage only level 2 possible

5 marks

Level 2
Answer is mainly coherent and shows progression from stage 1 to stage 3

All stages are covered but 3 omissions/errors

4 marks

All stages are attempted

3 marks

Level 1
Answer includes isolated statements but these are not presented in a logical order or show confused reasoning.

2 stages attempted

2 marks

1 stage attempted

1 mark

Level 0
Insufficient correct chemistry to gain a mark.

0 marks

Indicative Chemistry content

***Stage 1**: transfers known mass of solid*

a) Weigh the sample bottle containing the solid on a (2 dp) balance

b) Transfer to beaker and reweigh sample bottle*

c) Record the difference in mass

Or

d) Place beaker on balance and tare*

e) Transfer solid into beaker

f) Record mass

Or

g) Known mass provided

*h) Transfers (known) mass into beaker**

i) Wash all remaining solid from sample bottle into beaker

Allow use of weighing boat

**Allow other suitable glassware including volumetric flask*

***Stage 2**: Dissolves in water*

a) Add distilled / deionised water

b) Stir (with a glass rod) or swirl

c) Until all solid has dissolved

***Stage 3**: Transfer, washing and agitation*

a) Transfer to volumetric / graduated flask. Allow if a clear description/diagram given eg long necked flask with 250 cm^3 mark

b) With washings

c) Make up to 250 cm^3 / mark with water

d) Shakes/inverts/mixes

6

[14]

Q2.

(a) 'Initial mass' must be the y-axis

If axis unlabelled, use data to decide that 'Initial mass' is on the y-axis.

1

Sensible scale

*Do not award this mark if **plotted points** do not cover at least half of the grid.*

Do not award this mark if any plotted point is outside the grid.

1

All points plotted correctly

Allow ± one small square.

1

Point at (0,0) is ringed

1

(b) Best-fit straight line that goes through the origin ± ½ small square

Mark consequentially to plotted points but the line must still go through the origin ± ½ small square.

Lose this mark if the line is doubled or kinked.

If the points are plotted correctly, lose this mark if the line deviates towards the anomalies.

(c) Students 3 and 5

Allow masses of 1.15 and 1.53 or 2.82 and 3.58

Mark consequentially to plot.

1

(d) Samples 3 or 5 have not lost all their water

Allow reaction / decomposition incomplete.

1

Sample not heated for enough time / larger masses will take a longer time to dehydrate / decompose

1

[8]

Q3.

(a) $[Fe(H_2O)_6]^{2+} + 2NH_3 \rightarrow Fe(H_2O)_4(OH)_2 + 2NH_4^+$

Allow equation with OH^- provided equation showing formation of OH^- from NH_3 given

1

Green precipitate

1

$[Fe(H_2O)_6]^{2+} + CO_3^{2-} \rightarrow FeCO_3 + 6H_2O$

1

Green precipitate

effervescence incorrect so loses M4

1

(b) (i) Colourless / (pale) green changes to pink / purple (solution)

Do not allow pale pink to purple

1

Just after the end−point MnO_4^- is in excess / present

1

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

1

Moles $KMnO_4 = 18.7 \times 0.0205 / 1000 = (3.8335 \times 10^{-4})$

Process mark

1

Moles $Fe^{2+} = 5 \times 3.8335 \times 10^{-4} = 1.91675 \times 10^{-3}$

Mark for M2 × 5

1

Moles Fe^{2+} in 250 $cm^3 = 10 \times 1.91675 \times 10^{-3} = 0.0191675$ moles in 50 cm^3

Process mark for moles of iron in titration (M3) × 10

1

Original conc $Fe^{2+} = 0.0191675 \times 1000 / 50 = 0.383$ $\underline{\text{mol dm}^{-3}}$

Answer for moles of iron (M4) × 1000 / 50

Answer must be to at least 2 sig. figs. (0.38)

1

[11]

Q4.

(a) 0.943 g water (M1)

If Mr of $NiSO_4$ wrong, can allow M1 and M3 from method 1 i.e. max 2

$NiSO_4$ H_2O

$\frac{1.344}{154.8}$ (M2) $\frac{0.943}{18}$ (M3)

(8.68×10^{-3} 0.052)

1 6 or $x = \underline{6}$ (M4)

Allow Mr = 155

Allow other methods e.g.

$M_r(NiSO_4) = 58.7 + 32.1 + 64.0 = 154.8$

$n(NiSO_4) = \frac{1.344}{154.8} = 0.008682$ mol (M1)

$M_r(NiSO_4.xH_2O) = \frac{2.287}{0.008682} = (263.4)$ (M2)

so $18x = 263.4 - 154.8 = (108.6)$ (M3)

so $x = \frac{108.6}{18} = \underline{6}$ (M4)

(b) re-heat

Heat to constant mass = 2 marks

1

check that mass is unchanged

M2 dependent on M1

Allow as alternative:

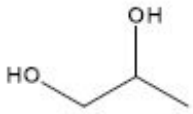
M1: record an IR spectrum

M2: peak between 3230 and 3550 (cm^{-1})

1

[6]

Q5.

(a) 

Any correct skeletal formula (both OH groups must be shown)

1

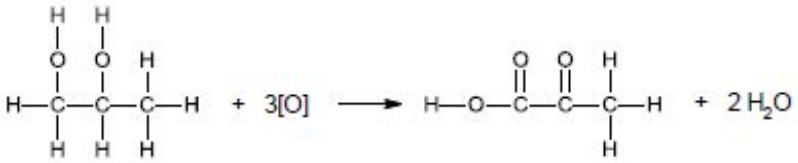
(b) M1 Displayed formula of correct product

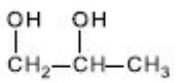
Incorrect organic product CE=0

Must be displayed formula but can be shown separately or in the equation

1

M2 Balanced equation





$CH_2OHCHOHCH_3$

$C_3H_8O_2$

Allow any correct structural formula (or molecular formula $C_3H_4O_3$) for product in balanced equation

Allow any correct formula of propane-1,2-diol (including its molecular formula $C_3H_8O_2$)

1

(c) M1 flask with condenser vertically above it (without gaps between flask and condenser)

Distillation diagram CE = 0

Condenser must have outer tube for water that is sealed at top and bottom; condenser must have two openings for water in/out (that are open, although these openings do not need to be labelled)

Penalise M1 if apparatus is sealed (a continuous line across

M2 flask and condenser labelled

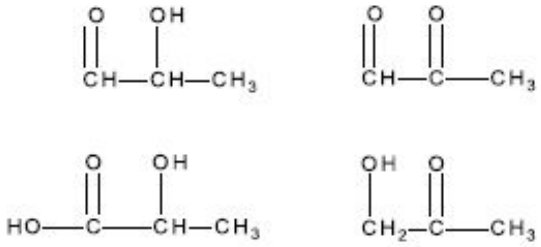
Allow condensing tube for condenser label

1

(d) Form small(er) bubbles or prevent large bubbles

1

(e) Any one of these four structures:



Allow any correct structural / displayed / skeletal formula

For reference:

Carbon 1	Carbon 2
aldehyde	alcohol
carboxylic acid	alcohol
aldehyde	ketone
alcohol	ketone

1

Q6.

(a) Over time / after storage meter does not give accurate readings

Do not allow 'to get an accurate reading' or 'reading drifts' on its own.

Allow 'temperature variations affect readings'.

1

(b) Any **five** from:

Ignore references to the use of the pipette, the filling of the burette and the calibration of the pH meter.

- Measure pH (of the acid)
- Add alkali in known small portions

  Allow 1 – 2cm³.
- Stir mixture
- Measure pH (after each addition)
- Repeat until alkali in excess

  Allow 27 – 50cm³.
- Add in smaller increments near endpoint

  Allow 0.1 – 0.5cm³.

  To score full marks, the sequence must follow a logical order.

5 max

[6]

(a) Compound 1

If M1 incorrect, CE = 0

M1
1

No visible change with H_2SO_4

M2
1

Gives white ppt with NaOH

M3
1

(b) $BaCO_3$

1

The carbonate ion releases CO_2

1

but the $BaSO_4$ formed is highly insoluble.

1

(c) Compound 4

1

$Sr(OH)_2 + H_2SO_4 \rightarrow SrSO_4 + 2H_2O$

Allow ionic equation; ignore state symbols

1

[8]

Q8.

(a) H_2SO_4

Allow H_3PO_4 or HCl

1

(b) Dichromate / Cr(VI) reduced or Cr(III) formed.

Allow Cr^{6+} and Cr^{3+}

1

(c) The alcohol is flammable

Allow enables temperature to be controlled

1

(d) Tollens'

1

Silver mirror
OR Fehling's
Red precipitate

Q9.

(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 = $50.0 \times 0.200 / 1000 = 1.00 \times 10^{-2}$ 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 = $0.5 \times 1.00 \times 10^{-2} = 5.00 \times 10^{-3}$ mol

1

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

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
Answer to 3 significant figures

M3

The correct answer only loses M1

1

(b) Take a known volume of the saturated solution

1

Evaporate the filtrate to dryness

Allow titrate with dilute HCl or HNO_3 .....

1

Weigh the residue

.....of known / specified concentration
Ignore any references to indicators

1

[6]

Q11.

(a) (i) Uses sensible scales.

*Lose this mark if the **plotted points** do not cover half of the paper.*
Lose this mark if the graph plot goes off the squared paper
Lose this mark if volume is plotted on the x-axis

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 = $3.204 \times 10^{-2} \times 83.4 / 100 = 2.672 \times 10^{-2}$

1

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

Answer must be to 3 significant figures

1

[11]

Q11.

(a) (i) Uses sensible scales.

*Lose this mark if the **plotted points** do not cover half of the paper.*

Lose this mark if the graph plot goes off the squared paper

Lose this mark if volume is plotted on the x-axis

1

All points plotted correctly

Allow ± one small square.

1

Smooth curve from 0 seconds to at least 135 seconds − the line must pass through or close to all points (± one small square).

Make some allowance for the difficulties of drawing a curve but do not allow very thick or doubled lines.

1

(ii) Any value in the range 91 to 105 s

Allow a range of times within this but not if 90 quoted.

1

(b) (i) Using pV = nRT

This mark can be gained in a correctly substituted equation.

1

$100\,000 \times 570 \times 10^{-6} = n \times 8.31 \times 293$

Correct answer with no working scores one mark only.

1

n = 0.0234 mol

Do not penalise precision of answer but must have a minimum of 2 significant figures.

1

(ii) Mol of $ZnCO_3$ = 0.0234

Mark consequentially on Q6

M1

1

Mass of $ZnCO_3$ = M1 × 125.4 = 2.9(3) or 2.9(4) g

If 0.0225 used then mass = 2.8(2) g

M2

1

(iii) Difference = (15.00 / 5) − Ans to b

If 2.87 g used then percentage is 4.3

M1

Percentage = (M1 / 3.00) × 100

Ignore precision beyond 2 significant figures in the final answer

If 2.82 g used from (ii) then percentage = 6.0

M2 1

(c) A reaction vessel which is clearly airtight round the bung 1

Gas collection over water or in a syringe

Collection vessel must be graduated by label or markings

Ignore any numbered volume markings. 1

[13]

Q12.

(a) **Wear plastic gloves:**

Essential – to prevent contamination from the hands to the plate 1

Add developing solvent to a depth of not more than 1 cm^3:

Essential – if the solvent is too deep it will dissolve the mixture from the plate 1

Allow the solvent to rise up the plate to the top:

Not essential – the R_f value can be calculated if the solvent front does not reach the top of the plate 1

Allow the plate to dry in a fume cupboard:

Essential – the solvent is toxic

Allow hazardous 1

(b) Spray with developing agent or use UV 1

Measure distances from initial pencil line to the spots (x) 1

Measure distance from initial pencil line to solvent front line (y) 1

R_f value = x / y 1

(c) Amino acids have different polarities 1

Therefore, have different retention on the stationary phase or different solubility in the developing solvent

1

[10]

Q13.

(a) Reheat the sample at least once.

Heat to constant mass gains both marks.

1

Mass of ash should not have changed.

Mark independently.

1

(b) Vacuum filtration is quicker / saves time

(c) Use indicator (paper) on a withdrawn sample / place a pH probe into the solution

If any indicator (including paper) is used directly on the solution lose this mark but then mark on.

1

Keep testing until paper shows acidity / until pH drops below 7.

Indicator does not need to be specified but if it is then correct colour must be quoted.

1

(d) $2I^- + H_2O_2 + 2H^+ \rightarrow I_2 + 2H_2O$

Do not accept $2I^- + H_2O_2 \rightarrow I_2 + 2OH^-$ as reaction conditions are acidic.

Accept multiples and fractions.

Ignore state symbols.

1

(e) Lower layer – as it will be the denser CCl_4

Mark is for correct identification and correct reasoning.

1

(f) Iodine in seaweed = 56.4 × (3/100) = 1.692 g

1

Iodine left in aqueous layer = 1.692 – 1.673 = 0.0190 g

1

K = (1.673/(253.8 × 0.05)) / (0.0190/(253.8 × 0.05)) = 88.1

(g) It would react with the iodine

*Allow (electrophilic) addition **OR** forms 1,2 –diiodocyclohexane **OR** addition across a double bond for **both** marks.*

1

It is unsaturated

1

(h) Solubility (of the iodine in the solvent) is high when hot and low when cold

1

(Therefore, on cooling a solution,) a significant quantity of crystals appear

1

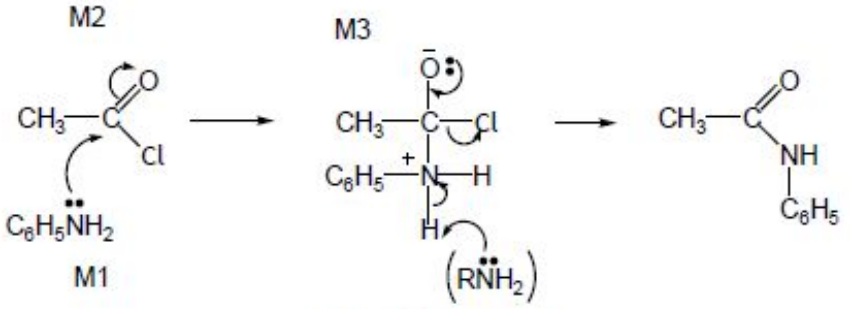
[14]

Q14.

(a) (nucleophilic) addition-elimination

Not electrophilic addition-elimination

1



M4 for 3 arrows and lp

Allow C_6H_5 or benzene ring

Allow attack by $:NH_2C_6H_5$

M2 not allowed independent of M1, but allow M1 for correct attack on C+

M3 for correct structure <u>with charges</u> but lone pair on O is part of M4

M4 (for three arrows and lone pair) can be shown in more than one structure

4

(b) **The minimum quantity of hot water was used:**

To ensure the hot solution would be saturated / crystals would form on cooling

1

The flask was left to cool before crystals were filtered off:

Yield lower if warm / solubility higher if warm

1

The crystals were compressed in the funnel:

Air passes through the sample not just round it

Allow better drying but not water squeezed out

1

A little cold water was poured through the crystals:

To wash away soluble impurities

1

(c) Water

Do not allow unreacted reagents

1

Press the sample of crystals between filter papers

Allow give the sample time to dry in air

1

(d) M_r product = 135.0

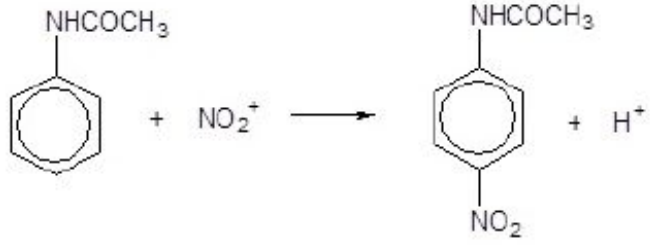
1

$$\text{Expected mass} = 5.05 \times \frac{135.0}{93.0} = 7.33 \text{ g}$$

1

$$\text{Percentage yield} = \frac{4.82}{7.33} \times 100 = 65.75 = 65.8(\%)$$

(e)



OR

$C_6H_5NHCOCH_3 + NO_2^+ \rightarrow C_6H_4(NHCOCH_3)NO_2 + H^+$

1

(f) Electrophilic substitution

1

(g) Hydrolysis

1

(h) Sn / HCl

Ignore acid concentration; allow Fe / HCl

1

[18]

Q15.

(a) Side-arm flask / side-arm test tube

Do not allow sealed side-arm flask.

Flat-bottomed filter funnel with filter paper clearly shown

Either Buchner or Hirsch versions are suitable.

Allow Hirsch funnel and horizontal filter paper.

Allow three-dimensional filter funnels.

Do not allow standard Y-shaped funnel.

Do not allow sealed funnel.

If it is not clearly air-tight between the funnel and the flask, maximum 1 mark.

1

(b) Heat melting point tube in an oil bath

Accept 'melting point apparatus' or Thiele tube.

Do not accept water bath.

1

slowly near the melting point

Ignore any additional correct details.

Apply list principle for additional incorrect details.

1

[4]

Q16.

(a) (i) M_r N−phenylethanamide = 135.0

1

Theoretical yield = 135.0 × 2 (1.15 / 284.1) = 1.09 g

1

Answer recorded to 3 significant figures.

1

(ii) $\frac{0.89}{\text{Ans to (a)}} \times 100$

= 81.4 %

Mark consequentially to (a)

Allow 81 to 82

1

(b) (i) Dissolve the product in the **minimum** volume of water / solvent (in a boiling tube / beaker)

If dissolving is not mentioned, CE = 0 / 4

1

Hot water / solvent

Steps must be in a logical order to score all 4 marks

1

Allow the solution to cool and allow crystals to form.

1

Filter off the pure product under reduced pressure / using a Buchner funnel and side arm flask

(ii) Measure the melting point

1

Use of melting point apparatus or oil bath

1

Sharp melting point / melting point matches data source value

1

(iii) Any **two** from:
Product left in the beaker or glassware
Sample was still wet
Sample lost during recrystallisation.
Do not allow "sample lost" without clarification.

2 Max

(c) An identified hazard of ethanoyl chloride
E.g. "Violent reaction", "harmful", "reacts violently with water"
Do not allow "toxic", "irritant" (unless linked with HCl gas).

1

HCl gas / fumes released / HCl not released when ethanoic anhydride used

1

[15]

Q17.

Minimum volume and hot water:

Any **two** from:

to obtain saturated solution

to increase yield / reduce amount left in solution

enable crystallisation (on cooling)
Do not allow 'because acid doesn't dissolve well in cold water'.

Max 2

Filtered hot: to remove insoluble impurities / to prevent crystals forming during filtration

1

Cooled in ice: to increase amount of crystals that are formed
Do not allow 'to cool quickly'.

1

Washed with cold water: to remove soluble impurities

Allow 'washing with hot water would dissolve some of the crystals'.

1

[5]

Q18.

(a) Weigh the spirit burner (alcohol) before and after combustion **M1**

Water in a calorimeter / beaker **M2**

1

Measure volume of water (or mass) **M3**

1

Burn the alcohol to heat the water **M4**

1

Measure temperature rise in water **M5**

1

(b) Incomplete combustion

Evaporation of alcohol

Heat capacity of / heat absorption by the apparatus

Inadequate stirring

Any two correct

1
1

(c) Acidified potassium dichromate / manganate(VII) (Heat)

Allow sodium in place of potassium with appropriate colour change)

If reagent incomplete lose M1 but mark on.

If reagent incorrect, CE = 0/3

1

butan-1-ol orange to green / purple to colourless

1

2-methylpropan-2-ol NVC / orange / purple

1

(d) $C_4H_9OH + 2O_2 \rightarrow 4C + 5H_2O$

OR

$C_4H_9OH + 4O_2 \rightarrow 4CO + 5H_2O$

Allow any correct balanced equations which include combinations of C, CO and/or CO_2 in the products but must be incomplete combustion.

1

Engine would not run as efficiently / would need to use more fuel / would release less energy

Allow build-up of carbon in engine costly to remove

1

CO / Particulates of carbon toxic

Allow global dimming if carbon given as product

1

[13]

Q19.

(a) $6S_2O_3^{2-} + BrO_3^- + 6H^+ \rightarrow 3S_4O_6^{2-} + Br^- + 3H_2O$

Check the formulae and charges carefully and penalise any transcription errors.
Allow multiples and fractions.
Ignore state symbols.

1

(b) Mol of thio = $25.0 \times 0.00100 / 1000 = 2.50 \times 10^{-5}$
and
Mol of bromate(V) = $(1/6) \times 2.5 \times 10^{-5} = 4.17 \times 10^{-6}$

If equation in Q5a is wrong, mark consequentially.

1

Vol of bromate(V) = $(4.17 \times 10^{-6} / 0.005) \times 1000 = 0.83$ cm^3

Lose this mark if (correct) unit of volume not given.
Do not penalise precision.

1

(c) Use a more dilute solution of sodium bromate

Allow 'use a bigger volume of sodium thiosulfate solution'.

1

[4]

Q20.

Filter

Must be in this order

1

Wash (the residue) with water

1

Dry by pressing between filter paper or in air

Allow other suitable methods for drying. If heat is mentioned, method of gentle heating must be specified. Heat, alone, is not sufficient

1

[3]

Q21.

(a) Mass of **X** = 0.270

Volume of **X** = 105.0

Both must be correct

1

(b) $pV = nRT$

$$\frac{100\,000 \times 105/1000000}{8.31 \times 370} = n$$

1

$n = 3.41 \times 10^{-3}$

1

$M_r = {}^{\text{mass}}/_{\text{mol}}$ or ${}^{0.270}/_{3.41 \times 10^{-3}}$

1

$M_r = 79.1$

If M_r = 52 used, allow CH_3Cl

1

(c) **M1** The volume of the gas in the syringe (V) is greater than the true volume (because some air leaked into the syringe)

If the M_r value of 52 is used and CH_3Cl is identified in 01.2:

1

M2 $M_r = m/n = m \times RT/PV$ so if V is too large, M_r is too small

OR

M1 The temperature measured (T) is less than the temperature of the gas in the syringe (because the syringe heated faster than the oven and the oven temperature was not constant)

M2 $M_r = m/n = m \times RT/PV$ so if T is too small, M_r is too small

OR

M1 The measured mass of liquid transferred to the syringe (m) is less than the actual mass transferred

M2 $M_r = m/n = m \times RT/PV$ so if m is too small, M_r is too small

M1 *The volume of the gas in the syringe (V) is less than the true volume (because not all the liquid vaporised in the syringe)*

M2 *M_r = m/n = m × RT/PV so if V is too small, M_r is too large*

OR

M1 *The temperature measured (T) is greater than the temperature of the gas in the syringe (because the syringe heated more slowly than the thermometer and the oven temperature was not constant)*

M2 *M_r = m/n = m × RT/PV so if T is too large, M_r is too large*

OR

M1 *The measured mass of liquid transferred to the syringe (m) is greater than the actual mass transferred*

M2 *M_r = m/n = m × RT/PV so if m is too large, M_r is too large*

1

(d) Carry out in a fume cupboard

Do not allow safety glasses / labcoat

1

To avoid toxic vapour

1

[10]

Q22.

(a) CO_2 gas escapes or is lost

(b) Mass CO_2 = 16.11 − 14.58 = 1.53 g

1

Mol CO_2 = 1.53 / 44.0 = 3.48×10^{-2}

1

Mol $SrCO_3$ = 3.48×10^{-2}

1

Mass $SrCO_3$ = mol × M_r = $3.48 \times 10^{-2} \times 147.6$

Mass $SrCO_3$ = 5.13 (g)

1 mark for the answer and 1 for 3 sf precision

Allow 5.14 g (as a result of rounding)

2

(c) Percentage error = $\frac{0.01}{6.26} \times 100$

= 0.160 (%)

1

(d) Original Mass SrO = 6.26 − 0.347 − 5.13

= 0.783 g (or 783 mg)

OR 6.26 − 0.347 − 4.85 = 1.063 g

*Allow 0.773 g or 773 mg (from rounding error in part **(b)***

1

Justification: All $SrCO_3$ reacted because heated to constant mass.

(e) $3SrO + 2Al \rightarrow Al_2O_3 + 3Sr$ 1

Al acts as a reducing agent 1

Sr is collected as a vapour because 1

Al_2O_3 is an ionic lattice and so has strong ionic attractions 1

Than Sr which is a metallic structure with (relatively) weaker bonding 1

[14]

Q23.

(a) Burette 1

Because it can deliver variable volumes 1

(b) The change in pH is gradual / not rapid at the end point 1

An indicator would change colour over a range of volumes of sodium hydroxide

(c) $[H^+] = 10^{-pH} = 1.58 \times 10^{-12}$ 1

$K_w = [H^+]\,[OH^-]$ therefore $[OH^-] = K_w / [H^+]$ 1

Therefore, $[OH^-] = 1 \times 10^{-14} / 1.58 \times 10^{-12} = 6.33 \times 10^{-3}$ (mol dm^{-3})

Allow 6.31–6.33 × 10^{-3} (mol dm^{-3}) 1

(d) At this point, $[NH_3] = [H^+]$

$$= \frac{[H^+]^2}{[NH_4^+]}$$

Therefore K_a 1

$[H^+] = 10^{-4.6} = 2.51 \times 10^{-5}$ 1

$K_a = (2.51 \times 10^{-5})^2 / 2 = 3.15 \times 10^{-10}$ (mol dm^{-3})

Allow 3.15 – 3.16 × 10^{-10} (mol dm^{-3}) 1

(e) When $[NH_3] = [NH_4^+]$, $K_a = [H^+]$ therefore $-\log K_a = -\log [H^+]$

Answer using alternative value

1

Therefore $pH = -\log_{10}(3.15 \times 10^{-10}) = 9.50$

M2 $pH = -\log_{10}(4.75 \times 10^{-9}) = 8.32$

Q24.

(a) Bromine (water)

1

Colour change from orange to colourless

1

(b) Add sodium hydrogencarbonate (or alternative named carbonate)

Allow suitable correct alternative test e.g.

Test the pH with named indicator (e.g. Universal Indicator)

1

Propanoic acid will produce effervescence / bubbles

Propanoic acid would turn Universal Indicator red

1

(c) Tollen's reagent

1

(Colourless solution to) silver mirror

1

OR

Fehling's solution

(Blue solution to) brick red precipitate

(d) Absorption at 1680–1750 cm^{-1} caused by C=O

1

No absorption at 1620−1680 cm^{-1} caused by C=C

1

No absorption at 3230–3550 cm^{-1} due to −OH (alcohol)

1

No absorption at 2500–3000 cm^{-1} due to −OH (acid)

1

[10]

Q25.

(a) (i) Flask with side arm

1

Buchner funnel and horizontal filter paper

Allow Hirsch funnel and horizontal filter paper.

Do not allow standard Y-shaped funnel.

If there is not a clear air-tight seal (labelled or drawn) between the funnel and the flask maximum 1 mark.

1

(ii) M_r $KMnO_4$ = 158(.0)

1

Mass = 0.225 × 158 / 3 = 11.9 (g)

Lose M2 if no working shown.

Allow consequential mark on an incorrect M_r for $KMnO_4$

1

Precision mark: three significant figures

Allow if mass incorrect.

1

(iii) (Unpleasant) taste

Ignore smell.

1

(b) Difficult to see meniscus / line on graduated flask

Do not allow reference to over filling.

1

[7]

Q26.

(a) $2NaBr + 2H_2SO_4 \longrightarrow Na_2SO_4 + Br_2 + SO_2 + 2H_2O$

Allow ionic equation

$2Br^- + 2H_2SO_4 \longrightarrow Br_2 + SO_4^{2-} + SO_2 + 2H_2O$

1

Br^- ions are bigger than Cl^- ions

1

Therefore Br^- ions more easily oxidised / lose an electron more easily (than Cl^- ions)

1

(b) This question is marked using levels of response. Refer to the Mark Scheme Instructions for Examiners for guidance on how to mark this question.

Level 3

All stages are covered and the explanation of each stage is generally correct and virtually complete. Stages 1 and 2 are supported by correct equations.

Answer communicates the whole process coherently and shows a logical progression from stage 1 to stage 2 and then stage 3. The steps in stage 3 are in a logical order.

5–6 marks

Level 2

All stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies OR two stages are covered and the explanations are generally correct and virtually complete.

Answer is mainly coherent and shows a progression through the stages. Some steps in each stage may be out of order and incomplete.

3–4 marks

Level 1

Two stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies, OR only one stage is covered but the explanation is generally correct and virtually complete.

Answer includes some isolated statements, but these are not presented in a logical order or show confused reasoning.

1–2 marks

Level 0

Insufficient correct chemistry to warrant a mark.

0 marks

Indicative chemistry content

***Stage 1**: formation of precipitates*

- *Add silver nitrate*
- *to form precipitates of AgCl and AgBr*
- $AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$
- $AgNO_3 + NaBr \rightarrow AgBr + NaNO_3$

***Stage 2**: selective dissolving of AgCl*

- *Add excess of dilute ammonia to the mixture of precipitates*
- *the silver chloride precipitate dissolves*
- $AgCl + 2NH_3 \rightarrow Ag(NH_3)_2^+ + Cl^-$

***Stage 3**: separation and purification of AgBr*

- *Filter off the remaining silver bromide precipitate*
- *Wash to remove soluble compounds*
- *Dry to remove water*

6

(c) $Cl_2 + 2HO^- \longrightarrow OCl^- + Cl^- + H_2O$

OCl^- is +1

Cl^- is –1

Both required for the mark

1

[11]

Q27.

(a) $Cr(OH)_3 + 3H_2O + 3H^+ \rightarrow [Cr(H_2O)_6]^{3+}$

Can start with $Cr(H_2O)_3(OH)_3$ for each equation

Ignore any unnecessary preliminary preparation of $Cr(OH)_3$

1

Green / grey−green solid

Mark colours independently from equations

Allow green ppt.

1

Forms green / purple / ruby / violet <u>solution</u>

ignore shades of colours

1

$Cr(OH)_3 + 2H_2O + OH^- \rightarrow [Cr(H_2O)_2(OH)_4]^-$

Allow with 5 or 6 OH^- provided complex has co−ordination number of 6

Penalise complex ions with incorrect charges overall or if shown on ligand.

1

Forms green <u>solution</u>

Note that for each equation final complex must be 6 co−ordinate

1

(b) $[Cu(H_2O)_6]^{2+} + 4NH_3 \rightarrow [Cu(H_2O)_2(NH_3)_4]^{2+} + 4H_2O$

Allow two correct equations via intermediate hydroxide in both cases even if first equation uses OH^- instead of NH_3

1

Blue (solution)

Mark colours independently from equations

1

Dark / deep / royal blue <u>solution</u>

1

$[Co(H_2O)_6]^{2+} + 6NH_3 \rightarrow [Co(NH_3)_6]^{2+} + 6H_2O$

1

pink / red (solution)

1

Brown / straw / yellow <u>solution</u>

Q28.

(a) q = 500 × 4.18 × 40

Do not penalise precision.

1

= 83600 J

Accept this answer only.
Ignore conversion to 83.6 kJ if 83600 J shown.
Unit not required but penalise if wrong unit given.
Ignore the sign of the heat change.
An answer of 83.6 with no working scores one mark only.
An answer of 83600 with no working scores both marks.

1

(b) Moles (= 83.6 / 51.2) = 1.63

Using 77400 alternative gives 1.51 mol
Allow (a) in kJ / 51.2
Do not penalise precision.

1

Mass = 1.63 × 40(.0) = 65.2 (g)

Allow 65.3 (g)
Using 77400 alternative gives 60.4 to 60.5
Allow consequential answer on M1.
1 mark for M_r (shown, not implied) and 1 for calculation.

(c) Molarity = 1.63 / 0.500 = 3.26 mol dm–3

Allow (b) M1 × 2
Using 1.51 gives 3.02

1

(d) Container splitting and releasing irritant / corrosive chemicals

Must have reference to both aspects; splitting or leaking (can be implied such as contact with body / hands) ***and*** *hazardous chemicals.*
Allow 'burns skin / hands' as covering both points
Ignore any reference to 'harmful'.
Do not allow 'toxic'.

1

(e) (i) $4Fe + 3O_2 \rightarrow 2Fe_2O_3$

Allow fractions / multiples in equation.
Ignore state symbols.

1

(ii) Iron powder particle size could be increased / surface area lessened

Decrease in particle size, chemical error = 0 / 3
Change in oxygen, chemical error = 0 / 3

1

(ii) Iron powder particle size could be increased / surface area lessened

Decrease in particle size, chemical error = 0 / 3

Change in oxygen, chemical error = 0 / 3

1

Not all the iron reacts / less reaction / not all energy released / slower release of energy / lower rate of reaction

Correct consequence of M2

An appropriate consequence, for example

- *too slow to warm the pouch effectively*
- *lower temperature reached*
- *waste of materials*

1

(f) (i) Conserves resources / fewer disposal problems / less use of landfill / fewer waste products

Must give a specific point.

Do not allow 'does not need to be thrown away' without qualification.

Do not accept 'no waste'.

1

(ii) Heat to / or above 80 °C (to allow thiosulfate to redissolve)

Accept 'heat in boiling water'.

If steps are transposed, max 1 mark.

1

Allow to cool before using again

Reference to crystallisation here loses this mark.

1

[14]

Q29.

(a) $Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$

*If equations reversed, allow **M1** only.*

1

$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$

Ignore state symbols.

1

(b) Moles of copper(II) reacted = (100 / 1000) × 0.5 = 0.05

1

Moles of zinc reacted = 0.05

1

Mass of zinc lost = 0.05 × 65.4 = 3.27 g

*Correct final answer without working scores **M3** only.*

1

(c) Allow cell to discharge until $[Cu^{2+}]$ is 0.5

Alternative: Allow cell to discharge completely.

1

Confirmed by colorimetric measurement or other suitable method

Solution colourless or use of chemical test to determine absence of copper(II)

1

Weigh the Zn electrode before and after the experiment

Weigh Zn electrodes before and after and halve the mass

Q30.

(a) Temperature on y-axis

If axes unlabelled use data to decide that temperature is on y-axis.

1

Uses sensible scales

*Lose this mark if the **plotted points** do not cover half of the paper.*

Lose this mark if the temperature axis starts at 0 °C.

1

Plots **all** of the points correctly ± one square

Lose this mark if the graph plot goes off the squared paper.

1

Draws two best-fit lines

*Candidate must draw **two** correct lines.*

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

1

Both extrapolations are correct to the 4th minute

Award this mark if the candidate's extrapolations are within one square of your extrapolations of the candidate's best-fit lines at the 4th minute.

1

(b) 19.5 (°C)

Accept this answer only.

1

(c) 26.5 ± 0.2 (°C)

Do not penalise precision.

1

(d) (c) – (b)

*Only award this mark if temperature rise is recorded to **1 d.p.***

1

(d) (c) – (b)

Only award this mark if temperature rise is recorded to ***1 d.p.***

1

(e) Uses $mc\Delta T$ equation

Allow use of this equation with symbols or values for M1 even if the mass is wrong.

1

Correct value using 25 × 4.18 × (d)

7.0 gives 732 J.

Correct answer with no working scores one mark only.

Do not penalise precision.

Allow answer in J or kJ.

Ignore sign of enthalpy change.

1

(f) $9.0(1) \times 10^{-3}$

Do not allow 0.01

Allow 9×10^{-3} or 0.009 in this case.

1

(g) If answer to (e) in J, then (e) / (1000 × (f))

or

If answer to (e) in kJ, then (e) / (f)

7.0 and 9.01×10^{-3} gives 81.2 kJ mol^{-1}

If answer to (e) is in J must convert to kJ mol^{-1} correctly to score mark.

1

Enthalpy change has negative sign

Award this mark independently, whatever the calculated value of the enthalpy change.

1

(h) The idea that this ensures that all of the solution is at the same temperature

Do not allow 'to get an accurate reading' without qualification.

1

(i) (i) Chlorine is <u>toxic / poisonous / corrosive</u>

(ii) Explosion risk / apparatus will fly apart / stopper will come out

Ignore 'gas can't escape' or 'gas can't enter the tube'.

1

[16]

Q31.

(a) (Biocide) reacts with bacteria / used up killing bacteria

Max two marks

Chlorine given off / evaporates

Do not allow "chlorine has reacted with water" alone.

Chlorine has reacted with water to form (HCl and) O_2

Do not allow products of HCl and HOCl alone

2

(b) the concentration of the remaining solution (after a sample has been removed) is unchanged.

1

(c) So that all chlorine was reacted / reduced

*Do **not** allow 'all of the iodide was oxidised'*

1

(d) The E° *value for the iodine half-equation is more positive than that for the thiosulfate*

(e) $S_2O_3^{2-} + \frac{1}{2} I_2 \rightarrow I^- + \frac{1}{2} S_4O_6^{2-}$

Allow multiples

1

[6]

Q32.

(a) Stoppered flask or similar with side arm

Allow gas outlet through stopper.

1

Calibrated container for collection eg gas syringe

Allow collection over water, but must use calibrated vessel for collection.

Lose 1 mark if apparatus is not gas tight.

1

(b) Plot a graph of 'volume (of gas)' against 'time'

1

Determine the slope (gradient) at the beginning

1

*(c) Repeat with same volume **or** concentration of hydrogen peroxide and at the same temperature*

Do not allow 'keep everything the same' or words to that effect. Must mention volume or concentration and temperature.

1

Add cobalt(II) chloride to one experiment

1

[6]

Q33.

(a) *Stage 1*

M_r *for* $Mg(NO_3)_2 = 148.3$

$$\text{Moles of } Mg(NO_3)_2 = \frac{3.74 \times 10^{-2}}{148.3} = 2.522 \times 10^{-4} \text{ mol}$$

Extended response calculation

1

Stage 2

Total moles of gas produced = 5/2 × moles of $Mg(NO_3)_2$

$= 5/2 \times 2.522 \times 10^{-4} = 6.305 \times 10^{-4}$

If ratio in stage 2 is incorrect, maximum marks for stage 3 is 2

1

$PV = nRT$ so volume of gas $V = nRT / P$

1

$$V = \frac{nRT}{P} = \frac{6.305 \times 10^{-4} \times 8.31 \times 333}{1.00 \times 10^{5}} = 1.745 \times 10^{-5} \text{ m}^3$$

1

$V = 1.745 \times 10^{-5} \times 1 \times 10^{6} = 17.45 \text{ cm}^3 = 17.5 \text{ (cm}^3\text{)}$

Answer must be to 3 significant figures (answer could be 17.4 cm³ dependent on intermediate values)

1

(b) Some of the solid is lost in weighing product / solid is blown away with the gas

1

[6]

Q34.

(a) $FeSO_4 + Na_2C_2O_4 \rightarrow FeC_2O_4 + Na_2SO_4$

Allow multiples, including fractions.

Allow $Fe^{2+} + C_2O_4^{2-} \rightarrow FeC_2O_4$

Allow correct equation which includes water of crystallisation.

1

(b) M_r $FeSO_4.7H_2O$ = 277.9

Allow if shown clearly in the calculation.

Allow 278

Moles = 6.95 / 277.9 = $2.5(0) \times 10^{-2}$

Do not penalise precision but must be to a minimum of two significant figures.

Allow correct calculation using incorrect M_r.

Correct answer without working scores this mark only.

1

(c) $3(.00) \times 10^{-2}$

1

(d) Theoretical mass = $2.50 \times 10^{-2} \times 179.8 = 4.50$g
as long as 2.50×10^{-2} is the smaller of parts (b) and (c) **(M1)**

Allow consequential answer from parts (b) and (c).

Allow theoretical mass = (smaller of parts (b) and (c)) × 179.8

*If larger of parts (b) and (c) used, lose **M1** but can score **M2**.*

Allow answers based on moles of reactant and product.

1

Yield = 3.31 × 100 / 4.50 = 73.6% **(M2)**

Award this mark only if answer given to 3 significant figures.

Correct answer without working scores this mark only, provided answer given to 3 significant figures.

1

(e) Some left in solution / some lost during filtration

(f) MnO_4^- will oxidise the iron(II) ion and the ethanedioate ion

1

MnO_4^- does not oxidise the Cu^{2+} ion / larger volume needed for iron(II) ethanedioate

1

[9]

Q35.

Acidified potassium dichromate

Accept words or formulae.

Accept acidified potassium permanganate.

Accept Lucas reagent (conc HCl, $ZnCl_2$) (cloudy in 5 mins for 2°, instantly for 3°).

Mark on for incomplete reagent.

Incorrect reagent CE = 0 / 3

Inclusion of Tollen's etc with acidified potassium dichromate is incorrect reagent.

Either

Obs with 2-methylpropan-2-ol

No visible change

1

or

Obs with 2-methylpropan-2-ol	orange
Obs with butan-2-ol	green

[3]