IQM3012 A1 Teacher reference commentary

Chemistry Assessment 1: Reflective/lab log portfolio

TEACHER STANDARDISATION | Selected extracts | Subject review required before distribution

These selected synthetic responses support discussion of how to apply the marking guidance. They do not form a complete assessment response. Use the approved question paper and marking scheme alongside this document. Use this proposed commentary after the independent marking exercise. The reference judgements require subject confirmation.

Compare the evidence against the holistic AO2 and AO3 descriptors. Do not assign a separate practical or extract mark, or infer a whole-portfolio grade from these extracts. All experimental data and claims are simulated; no teacher observation has occurred.

Selected task P1-method

Shows repeated-mass processing, mole ratio and evaluation across profiles.

Example X

Simulated standardisation entry; not a real practical or personal observation. Purpose: estimate water of crystallisation. I would tare a crucible, weigh the hydrate, heat using the approved method, cool fully with tongs and reweigh to constant mass; eye protection and copper-waste controls are required. The fictional record is empty vessel 18.4 g, vessel plus hydrate 20.0 g, final masses 19.4, 19.4, 19.4 g. Thus sample 1.6 g, residue 1.0 g, water loss 0.6 g. n($CuSO_4$)=1.0/159.6=.00627 mol; water=.6/18=.0333 mol; ratio 5.31:1, giving an approximate x of 5. The rounded readings limit confidence. If some water remained, x would be too low; if solid was lost, x could be too high. Cooling may allow water uptake. Repeat to a tighter balance tolerance and prevent loss. These numbers and interpretation are fictional and cannot prove practical skill.

reading	mass (g)
empty vessel	18.4
vessel + hydrated sample	20.0
after heat cycle 1	19.4
after heat cycle 2	19.4
after heat cycle 3	19.4

Reference commentary: The route to a mole ratio is valid, but the one-decimal-place readings and limited uncertainty discussion weaken precision. Credit the chemistry already demonstrated; do not treat fewer decimals alone as a fixed mark deduction.

Example Y

Purpose: find the water in $CuSO_4 \cdot xH_2O$. In this simulated run I heat the sample, let it cool and weigh it again. Goggles, tongs and a heatproof surface are needed; copper waste goes in the designated container. The table records all three cycles.

Hydrated sample = 20.0 − 18.4 = 1.6 g. Residue = 19.4 − 18.4 = 1.0 g. Water lost = 0.6 g. I used x = 0.6/1.0 = 0.6 and rounded this to 1, giving $CuSO_4 \cdot H_2O$. I think the water-to-salt mass ratio is the number in the formula. The final pair of readings is the same, so I think all the water is certainly gone and the white residue must be pure $CuSO_4$.

If it is not heated long enough, less mass is lost. Some powder might also fall out. I am unsure whether either makes x larger. I would repeat the weighing more carefully and use more decimal places. The first heating changes the mass most, so repeating the cycle matters. I have not worked out a balance uncertainty or converted masses into moles; my formula is therefore tentative.

reading	mass (g)
empty vessel	18.4
vessel + hydrated sample	20.0
after heat cycle 1	19.5
after heat cycle 2	19.4
after heat cycle 3	19.4

Reference commentary: Mass differences are correct, but the mass ratio is incorrectly treated as the formula mole ratio. Constant mass is overinterpreted as proof. Credit recorded data and awareness of possible loss; the central chemical inference is not secure.

Example Z

Simulated standardisation entry only: no real laboratory session occurred and these are not my observations. Purpose: estimate x in $CuSO_4 \cdot xH_2O$. Method planned from the centre heating/cooling/weighing protocol: tare dry crucible, weigh hydrated sample, heat gently, cool on a heatproof mat, weigh, repeat to constant mass; use tongs and eye protection, avoid dust, place copper residue in designated waste. This text cannot evidence that I performed the technique.

The fictional readings below represent a plausible run. Empty crucible 18.42 g; crucible + hydrate 20.00 g; repeated final assembly masses are 19.44, 19.43, 19.43 g. Hydrate = 1.58 g; anhydrous $CuSO_4$ = 1.01 g; water lost = 0.57 g. $n(CuSO_4)=1.01/159.6=0.00633$ mol; $n(H_2O)=0.57/18.0=0.0317$ mol; ratio water:salt=5.01:1, so $x \approx 5$ and formula $CuSO_4 \cdot 5H_2O$. The plateau supports constant mass, not residue identity. Incomplete dehydration would make water loss too small and x low; spitting/lost solid would lower final residue mass and can make x too high. Reabsorption during cooling can raise final mass and lower apparent water loss. A ±0.01 g balance uncertainty is substantial relative to the 0.57 g loss; a lidded crucible used as instructed and more heating-cooling cycles to a predefined tolerance would help. Conclusion is consistent with the pentahydrate but simulated evidence only.

reading	mass (g)
empty vessel	18.42
vessel + hydrated sample	20.00
after heat cycle 1	19.44
after heat cycle 2	19.43
after heat cycle 3	19.43

Reference commentary: Strong AO2 processing: distinguishes water mass from salt mass and converts both to moles before choosing x. AO3 evaluation explains why incomplete dehydration, solid loss and reabsorption can bias x differently. Constant mass is correctly treated as evidence, not proof of chemical identity.

Selected task P2-titration

Shows concordance, stoichiometry, uncertainty and an unresolved criterion issue.

Example X

Simulated example only. Aim: estimate H_2SO_4 concentration using 25.0 cm^3 aliquot and 0.100 mol dm^{-3} NaOH. Use pipette filler, secured burette, indicator, swirl and add drops near endpoint; wear goggles and follow spill rules. Fictional rough titre 25.0 cm^3; accurate titres 24.8, 24.7, 24.9 cm^3, mean 24.8. They span 0.2 cm^3; concordance should be checked against local criterion. $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$. c acid=$0.100 \times 0.0248/(2 \times 0.0250)=0.0496$ mol dm^{-3}. Reading uncertainty affects the titre from both burette readings; endpoint colour is a possible systematic source. One extra careful repeat and consistent endpoint would improve it. This is fictional evidence, not an actual titration.

trial	initial (cm^3)	final (cm^3)	titre (cm^3)
rough	0.0	25.0	25.0
1	0.0	24.8	24.8
2	0.0	24.7	24.7
3	0.0	24.9	24.9

Reference commentary: The mean and stoichiometric calculation are sound. Concordance is appropriately left dependent on the agreed criterion, but a numerical uncertainty estimate and a clearer systematic-error analysis are missing.

Example Y

Purpose: calculate the acid concentration. Simulation conditions are a 25 cm^3 H_2SO_4 aliquot and 0.100 mol dm^{-3} NaOH in the burette. I use a filler, goggles, a secured burette and indicator, and swirl while adding base. The rough trial and three later trials are in the table.

I excluded the rough result of 25 cm^3. Mean of 24, 25 and 24 cm^3 = 24.3 cm^3. I used all three because all are near 25; I have not checked a concordance rule. The equation is $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$. NaOH amount = 0.100 × 0.0243 = 0.00243 mol. I treated this as the acid amount, so acid concentration = 0.00243/0.025 = 0.0972 mol dm^{-3}.

The endpoint was judged by a permanent colour change. If I added too much base, the reading would be larger, so I would add smaller drops next time. The burette scale is hard to read, but I have not calculated the uncertainty or considered both readings. I would repeat the titration to see whether it agrees. I need to check why the equation has a 2 before NaOH before trusting my answer.

trial	initial (cm^3)	final (cm^3)	titre (cm^3)
rough	0	25	25
1	0	24	24
2	0	25	25
3	0	24	24

Reference commentary: The balanced equation is correct but its factor of two is not used: the proposed acid concentration is doubled. The rough trial is excluded, but agreement of the later titres is inadequately justified. Credit the valid NaOH calculation without crediting the resulting acid value.

Example Z

Simulated standardisation evidence only. Purpose: find centre acid concentration by titration. Planned method: pipette 25.00 cm^3 acid with filler into flask, add specified indicator, titrate 0.1000 mol dm^{-3} NaOH from a rinsed/fixed burette, swirl and approach endpoint dropwise; record rough separately, repeat to concordance. Fictional concordant titres 24.52, 24.51, 24.53 cm^3 (mean 24.52); rough 24.70 excluded as exploratory. Equation $H_2SO_4+2NaOH \rightarrow Na_2SO_4+2H_2O$. $n(NaOH)=0.1000\times0.02452=0.002452$ mol; $n(H_2SO_4)=0.001226$ mol; $c=0.001226/0.02500=0.04904$ mol dm^{-3}. With ±0.05 cm^3 per burette reading, titre tolerance ±0.10 cm^3, relative ±0.41%; pipette tolerance ±0.06 cm^3 adds ±0.24%, giving worst-case sum about ±0.65% before standard-solution uncertainty. Overshooting endpoint biases titre high and calculated acid concentration high. A pale persistent endpoint agreed with the supplied indicator; white tile and same endpoint rule improve repeatability. Simulated data do not demonstrate rinsing or endpoint competence.

trial	initial (cm^3)	final (cm^3)	titre (cm^3)
rough	0.10	24.80	24.70
1	0.10	24.62	24.52
2	0.10	24.61	24.51
3	0.10	24.63	24.53

Reference commentary: Accurate 1:2 stoichiometry, mean titre and uncertainty reasoning support strong application. The rough trial is separately identified and the endpoint-bias direction is explained. Actual apparatus use is not established by this written account.

Selected task P7-curves

Optional extract showing graph and interpretation quality; not included in the C01–C05 portfolio calibration.

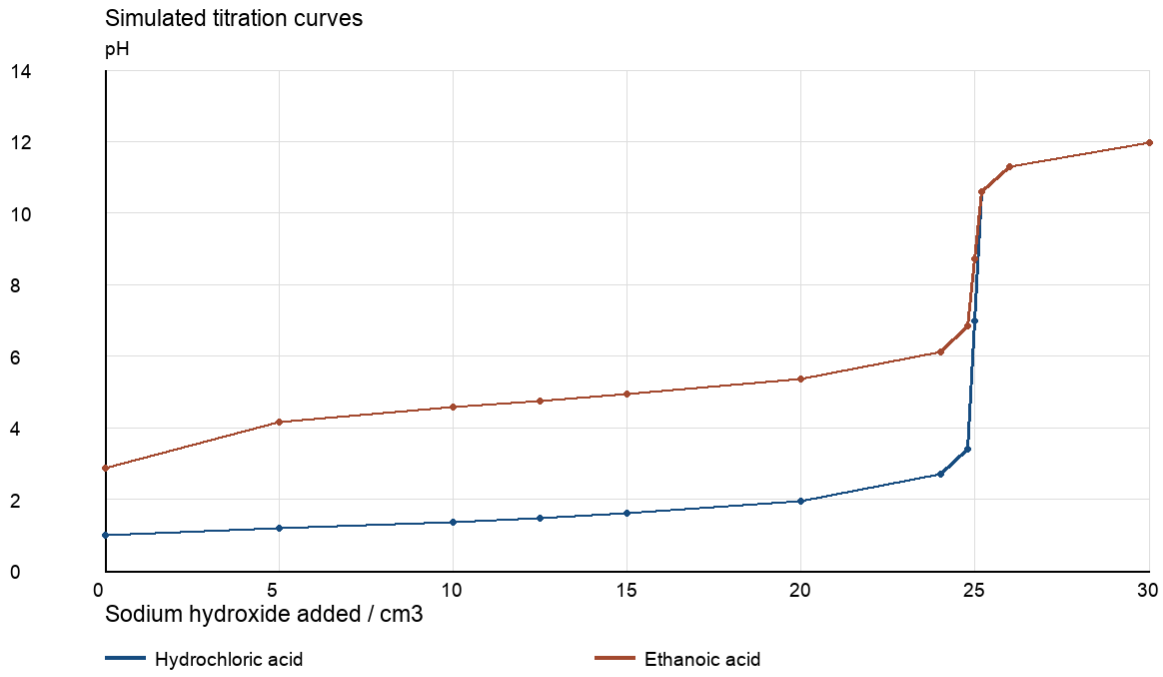
Example X

Simulation conditions: separate 25.00 cm^3 samples of 0.100 mol dm^{-3} hydrochloric acid and ethanoic acid, titrated with 0.100 mol dm^{-3} NaOH at 25 °C. Use a calibrated probe, rinse between samples, mix and wait for a stable reading; smaller additions are used near the rapid change. The table and graph are simulated pH measurements.

Both curves change rapidly near 25 cm^3. HCl starts at lower pH; ethanoic acid has a gentler buffer section and reaches a pH above 7 at equivalence. At 12.5 cm^3 its pH is 4.75, giving pKa about 4.75. Bromothymol blue, with range 6.0–7.6, should work for HCl. Phenolphthalein, 8.2–10.0, changes in the rapid part of the weak-acid curve.

The endpoint is where the indicator changes colour, whereas equivalence concerns the reacting amounts. I would add less NaOH near the jump and wait for stable pH. Probe calibration could shift readings, although I have not estimated an uncertainty in equivalence volume. The graph shows the difference between the acid systems more clearly than the initial pH alone.

NaOH added cm³	HCl pH	Ethanoic acid pH
0	1.00	2.88
5	1.18	4.15
10	1.37	4.57
12.5	1.48	4.75
15	1.60	4.93
20	1.95	5.35
24	2.69	6.13
24.8	3.40	6.84
25	7.00	8.72
25.2	10.60	10.60
26	11.29	11.29
30	11.96	11.96



Reference commentary: Correct broad interpretation and pKa estimate with relevant indicator ranges. Evaluation is brief and equivalence uncertainty is not explored. It is an optional extract and cannot receive a separate portfolio submark.

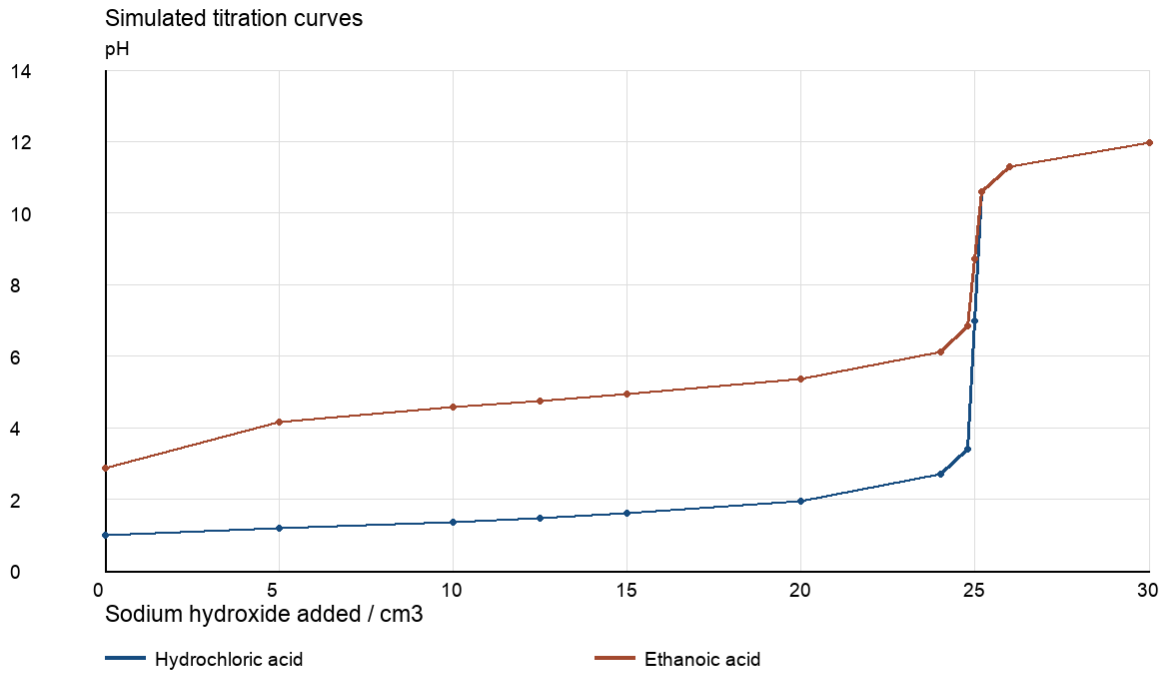
Example Y

Simulation conditions: separate 25.00 cm³ samples of 0.100 mol dm⁻³ hydrochloric acid and ethanoic acid, titrated with 0.100 mol dm⁻³ NaOH at 25 °C. Use a calibrated probe, rinse between samples, mix and wait for a stable reading; smaller additions are used near the rapid change. The table and graph are simulated pH measurements.

The curves both rise sharply near 25 cm³. HCl starts lower and ethanoic acid has a flatter middle section. I think equivalence must be pH 7 for both acids, so I would choose the volume where each curve crosses pH 7. I would use bromothymol blue, range 6.0–7.6, for both because it shows neutral pH.

At 12.5 cm³ the ethanoic reading is 4.75. I think this is Ka = 4.75 rather than pKa. The steep jump makes volume hard to judge, so smaller additions would help. I have not explained the alkaline equivalence reading or distinguished the colour endpoint from equivalence. The shapes look different, but I need to connect them to acid dissociation.

NaOH added cm³	HCl pH	Ethanoic acid pH
0	1.00	2.88
5	1.18	4.15
10	1.37	4.57
12.5	1.48	4.75
15	1.60	4.93
20	1.95	5.35
24	2.69	6.13
24.8	3.40	6.84
25	7.00	8.72
25.2	10.60	10.60
26	11.29	11.29
30	11.96	11.96



Reference commentary: Correctly notices the different curve shapes but assumes all equivalence points have pH 7 and confuses pKa with Ka. These conceptual errors matter more than neat presentation. This optional extract has no standalone numeric mark.

Example Z

Simulation conditions: separate 25.00 cm³ samples of 0.100 mol dm⁻³ hydrochloric acid and ethanoic acid, titrated with 0.100 mol dm⁻³ NaOH at 25 °C. Use a calibrated probe, rinse between samples, mix and wait for a stable reading; smaller additions are used near the rapid change. The table and graph are simulated pH measurements.

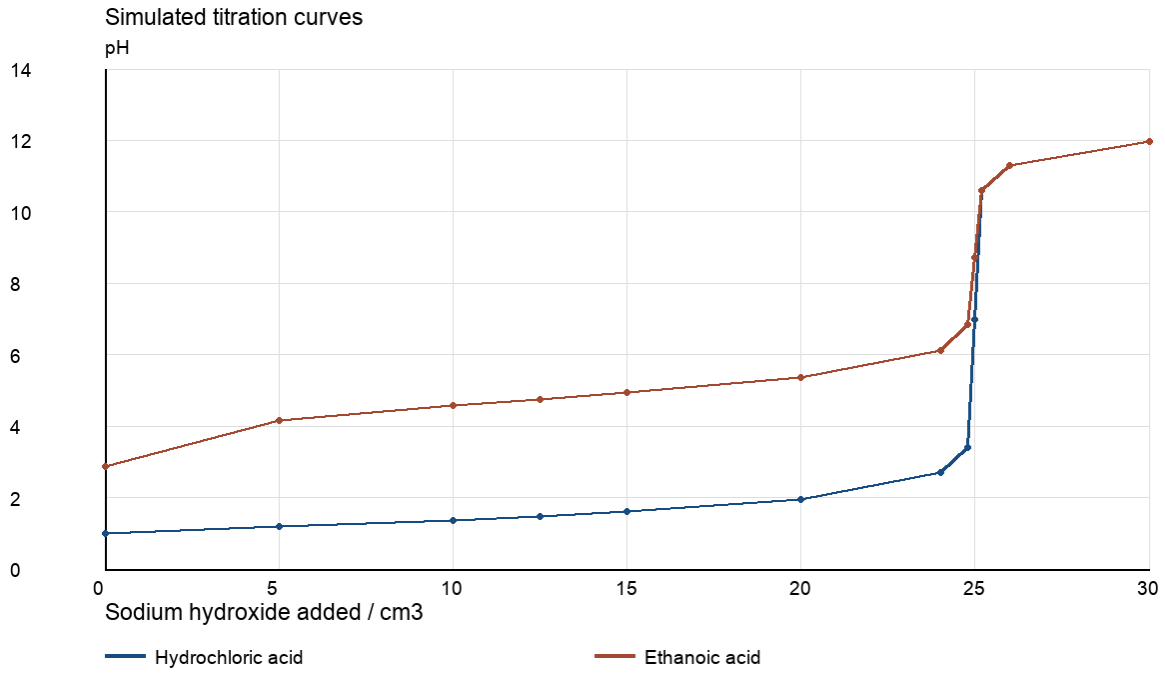
Both equivalence volumes are about 25.00 cm³, matching equal starting acid amounts. The HCl curve begins at pH 1.00 and passes through pH 7.00 at equivalence. The ethanoic curve begins at 2.88, changes more

gradually through a buffer region and reaches about 8.72 at equivalence because acetate reacts with water to produce hydroxide. At 12.50 cm³, half-equivalence, its pH is 4.75, so pKa ≈ 4.75.

For this simulation, indicator ranges are bromothymol blue 6.0–7.6 and phenolphthalein 8.2–10.0. Bromothymol blue changes within the steep HCl region. Phenolphthalein suits the weak-acid titration because it changes within its steep alkaline region. An indicator endpoint is the observed colour change; equivalence is a stoichiometric condition, so the two need not coincide exactly.

The 0.2 cm³ steps near equivalence narrow its location, but calibration error, mixing and probe response still affect the result. Closer additions and a replicate curve would improve confidence. The pH model uses concentration in place of activity; comparisons assume the same temperature. Comparing the curves helped me see why equivalence does not always mean pH 7.

NaOH added cm³	HCl pH	Ethanoic acid pH
0	1.00	2.88
5	1.18	4.15
10	1.37	4.57
12.5	1.48	4.75
15	1.60	4.93
20	1.95	5.35
24	2.69	6.13
24.8	3.40	6.84
25	7.00	8.72
25.2	10.60	10.60
26	11.29	11.29
30	11.96	11.96



Reference commentary: The interpretation uses both curves, the 12.5 cm³ half-equivalence reading and the alkaline weak-acid equivalence point. Indicator choices are justified by the measured steep regions. This is an optional extract, not evidence included in the C01–C05 score.