

2026 Mock HSC Chemistry Marking Guidelines

Section I

Multiple-choice Answer Key

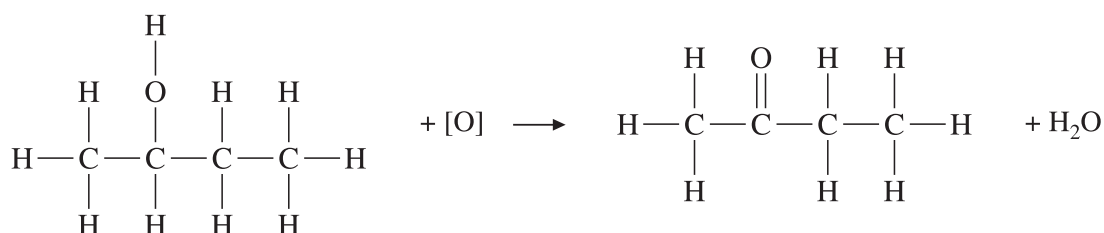
Question	Answer	Question	Answer
1	C	11	B
2	A	12	D
3	D	13	B
4	B	14	C
5	C	15	A
6	D	16	D
7	A	17	B
8	B	18	A
9	A	19	D
10	C	20	C

Section II

Question 21 (a)

Criteria	Marks
Provides a correct equation using structural formulae, including a suitable reagent and conditions	2
Provides some relevant information	1

Sample answer:



Reagent and conditions: acidified potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7/\text{H}^+$) or acidified potassium permanganate, heated.

Question 21 (b)

Criteria	Marks
Explains the boiling point of each compound in terms of its intermolecular forces, recognising that the molar masses (and so dispersion forces) are similar	3
Explains the boiling points of two compounds in terms of intermolecular forces OR Identifies the intermolecular forces in all three compounds	2
Provides some relevant information	1

Sample answer:

All three compounds have similar molar masses ($72\text{--}74\text{ g mol}^{-1}$), so their dispersion forces are of similar strength. The differences in boiling point are therefore due to the other intermolecular forces present.

Pentane is non-polar and has only dispersion forces between molecules, so it has the lowest boiling point (36°C).

Butanone contains a polar $\text{C}=\text{O}$ group, so it has dipole–dipole forces in addition to dispersion forces. More energy is needed to separate its molecules (80°C).

Butan-2-ol contains an $\text{O}-\text{H}$ group, so it forms hydrogen bonds between molecules. These are the strongest of the intermolecular forces here, so it has the highest boiling point (100°C).

Question 22 (a)

Criteria	Marks
Correctly identifies both species	1

Sample answer:

Conjugate acid: H_3PO_4 . Conjugate base: HPO_4^{2-} .

Question 22 (b)

Criteria	Marks
Explains why each solution is acidic or basic by comparing the K_a and K_b of each amphiprotic ion, supported by calculations and equations	3
Explains the observation for one solution, supported by a relevant calculation and equation OR Shows that both ions are amphiprotic, with relevant equations	2
Provides some relevant information	1

Sample answer:

Na^+ is a spectator ion. Both H_2PO_4^- and HPO_4^{2-} are amphiprotic, so the pH depends on whether each ion is a stronger acid or a stronger base. Use $K_b = K_w/K_a$ of the conjugate acid.

 H_2PO_4^-

as an acid: $\text{H}_2\text{PO}_4^-(aq) \rightleftharpoons \text{H}^+(aq) + \text{HPO}_4^{2-}(aq) \quad K_a = 6.3 \times 10^{-8}$

as a base: $\text{H}_2\text{PO}_4^-(aq) + \text{H}_2\text{O}(l) \rightleftharpoons \text{H}_3\text{PO}_4(aq) + \text{OH}^-(aq) \quad K_b = 1.0 \times 10^{-14}/7.1 \times 10^{-3} = 1.4 \times 10^{-12}$

$K_a > K_b$, so H_2PO_4^- donates protons to a greater extent than it accepts them, and the solution is acidic.

 HPO_4^{2-}

as an acid: $\text{HPO}_4^{2-}(aq) \rightleftharpoons \text{H}^+(aq) + \text{PO}_4^{3-}(aq) \quad K_a = 4.5 \times 10^{-13}$

as a base: $\text{HPO}_4^{2-}(aq) + \text{H}_2\text{O}(l) \rightleftharpoons \text{H}_2\text{PO}_4^-(aq) + \text{OH}^-(aq) \quad K_b = 1.0 \times 10^{-14}/6.3 \times 10^{-8} = 1.6 \times 10^{-7}$

$K_b > K_a$, so HPO_4^{2-} accepts protons to a greater extent, producing OH^- , and the solution is basic.

Question 23 (a)

Criteria	Marks
Correctly calculates the molar enthalpy of neutralisation, accounting for the limiting reagent and the calorimeter	3
Provides a substantially correct calculation with one error (eg ignores the calorimeter, uses the excess reagent, or omits the negative sign)	2
Provides some relevant steps	1

Sample answer:

$$n(\text{H}^+) = 2 \times 0.500 \times 0.0400 = 0.0400 \text{ mol} \quad n(\text{OH}^-) = 0.700 \times 0.0600 = 0.0420 \text{ mol}$$

H^+ is limiting, so 0.0400 mol of water forms.

$$q = mc\Delta T + C\Delta T = (0.1000 \text{ kg} \times 4.18 \times 10^3 \text{ J kg}^{-1} \text{ K}^{-1} \times 5.0 \text{ K}) + (41.0 \text{ J K}^{-1} \times 5.0 \text{ K}) = 2090 + 205 = 2295 \text{ J}$$

$$\Delta H = -q/n = -2295 \div 0.0400 = -5.74 \times 10^4 \text{ J mol}^{-1} = \mathbf{-57.4 \text{ kJ mol}^{-1}}$$

Question 23 (b)

Criteria	Marks
Predicts a smaller temperature rise and justifies the prediction with reference to the weak base	2
Makes a correct prediction OR identifies ammonia as a weak base	1

Sample answer:

The temperature rise would be smaller. Ammonia is a weak base and is only partially ionised in solution. As neutralisation proceeds, more NH_3 must react with the acid. Some of the energy released is absorbed in this process (the ionisation of a weak electrolyte is endothermic), so less heat is released overall per mole of acid neutralised.

Question 24 (a)

Criteria	Marks
Explains why a flame test cannot confirm both ions in the mixture	2
Provides some relevant information	1

Sample answer:

Ba^{2+} gives a pale (apple) green flame and Ca^{2+} gives an orange-red (brick-red) flame. When both ions are present, the colours are emitted together, and the intense orange-red can mask the green. The observed colour therefore cannot confirm that both ions are present.

Question 24 (b)

Criteria	Marks
Correctly calculates the percentage of barium ions remaining	3
Calculates the sulfate concentration at which CaSO_4 begins to precipitate and attempts to use it to find $[\text{Ba}^{2+}]$	2
Provides some relevant steps	1

Sample answer:

CaSO_4 begins to precipitate when $[\text{Ca}^{2+}][\text{SO}_4^{2-}] = K_{\text{sp}}(\text{CaSO}_4)$:

$$[\text{SO}_4^{2-}] = 4.93 \times 10^{-5} \div 0.010 = 4.93 \times 10^{-3} \text{ mol L}^{-1}$$

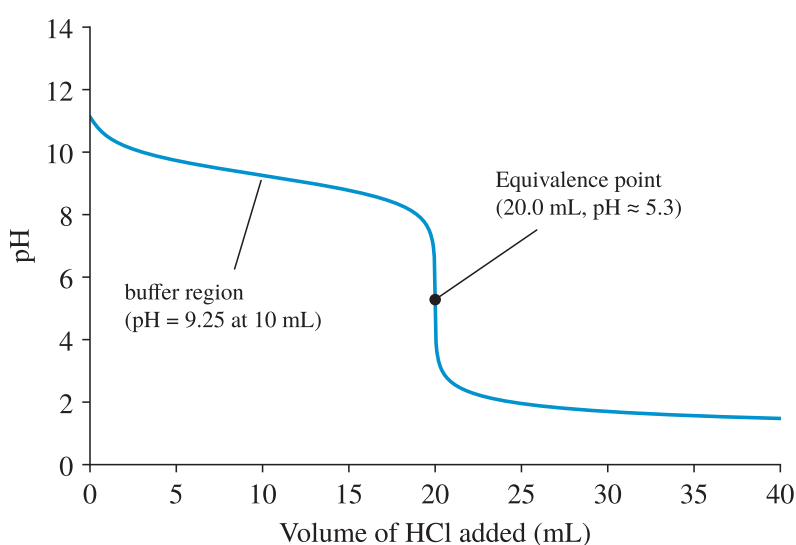
At this sulfate concentration, $[\text{Ba}^{2+}] = K_{\text{sp}}(\text{BaSO}_4)/[\text{SO}_4^{2-}] = 1.08 \times 10^{-10} \div 4.93 \times 10^{-3} = 2.19 \times 10^{-8} \text{ mol L}^{-1}$

% Ba^{2+} remaining = $(2.19 \times 10^{-8} \div 0.010) \times 100 = 2.2 \times 10^{-4} \%$ (effectively complete separation)

Question 25 (a)

Criteria	Marks
Sketches a correct curve: initial pH about 11, gradual decrease, sharp drop at 20 mL, equivalence point labelled at pH below 7, levelling off at low pH	2
Provides a curve with some correct features	1

Sample answer:

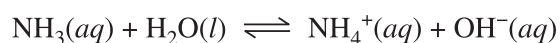


Initial pH ≈ 11.1 (weak base); equivalence point at 20.0 mL, pH ≈ 5.3 (acidic, NH_4^+ present); final pH ≈ 1.5 .

Question 25 (b)

Criteria	Marks
Explains how the buffer minimises pH change, with a relevant equation, AND correctly calculates the pH	4
Provides a correct explanation with an equation and a substantially correct calculation OR Correctly calculates the pH with a partial explanation	3
Provides a partial explanation OR a partially correct calculation	2
Provides some relevant information	1

Sample answer:



The buffer contains significant amounts of both the weak base NH_3 and its conjugate acid NH_4^+ . When a small amount of HCl is added, the H^+ ions are consumed by NH_3 ($\text{NH}_3 + \text{H}^+ \rightarrow \text{NH}_4^+$). Equivalently, H^+ removes OH^- and the equilibrium shifts right to replace it. Because $[\text{NH}_3]$ and $[\text{NH}_4^+]$ are both large, their ratio changes only slightly, so $[\text{OH}^-]$ and the pH change very little.

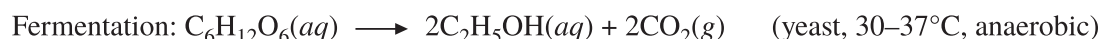
$$K_b = [\text{NH}_4^+][\text{OH}^-]/[\text{NH}_3] \Rightarrow [\text{OH}^-] = 1.8 \times 10^{-5} \times 0.250 \div 0.150 = 3.0 \times 10^{-5} \text{ mol L}^{-1}$$

$$\text{pOH} = -\log(3.0 \times 10^{-5}) = 4.52 \quad \text{pH} = 14.00 - 4.52 = \mathbf{9.48}$$

Question 26

Criteria	Marks
Makes an informed judgement about the suitability of BOTH methods for fuel ethanol Supports the judgement with advantages and disadvantages drawn from the data Includes correct equations for both methods	5
Makes a judgement about both methods, supported by relevant advantages and disadvantages, with at least one correct equation	4
Outlines advantages and/or disadvantages of both methods	3
Outlines some features of one or both methods	2
Provides some relevant information	1

Sample answer:



Fermentation uses a renewable feedstock. The CO_2 released during fermentation and combustion was absorbed by the sugar cane during photosynthesis, so the fuel is closer to carbon neutral. It operates at low temperature and atmospheric pressure. However, it is a slow batch process, and the product is only about 15% ethanol, so it must be fractionally distilled to fuel grade. This is energy intensive. Growing the crop also uses land and water that could produce food.

Hydration of ethene is fast and continuous, and gives high-purity ethanol with no distillation from water. Recycling unreacted ethene means little feedstock is wasted. However, ethene comes from crude oil, a non-renewable resource. The carbon released when this ethanol burns is fossil carbon, adding to atmospheric CO_2 . The high temperature and pressure also require large energy inputs.

Judgement: For fuel use, sustainability is the most important criterion, so fermentation is the more suitable method, provided the distillation energy comes from renewable sources (eg burning the bagasse). Hydration is more efficient for producing large volumes of pure ethanol, but it defeats the main purpose of an ethanol fuel by depending on fossil carbon.

Question 27 (a)

Criteria	Marks
Explains the use of reflux AND the use of excess ethanoic acid	2
Explains one of these	1

Sample answer:

Reflux allows the mixture to be heated for a long time to increase the rate of this slow reaction. Volatile reactants and the ester condense and return to the flask instead of escaping.

Esterification is an equilibrium. Using excess ethanoic acid shifts the equilibrium to the right (Le Chatelier's principle), so a greater proportion of the pentan-1-ol is converted to ester.

Question 27 (b)

Criteria	Marks
Correctly calculates the mass of pentan-1-ol	2
Provides some relevant steps	1

Sample answer:

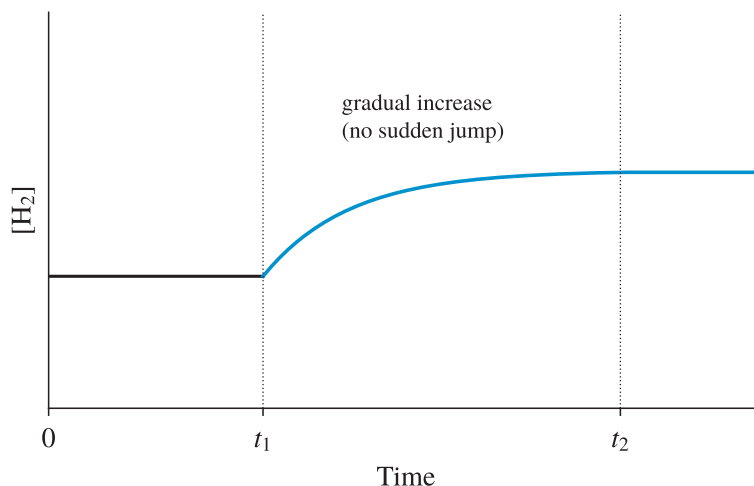
$n(\text{ester}) = 50.0 \div 130.18 = 0.3841 \text{ mol}$. Pentan-1-ol : ester = 1 : 1, and the yield is 70.0%, so $n(\text{pentan-1-ol}) = 0.3841 \div 0.700 = 0.5487 \text{ mol}$.

$m = 0.5487 \times 88.15 = \mathbf{48.4 \text{ g}}$

Question 28

Criteria	Marks
Sketches a correct graph AND uses collision theory to explain the changes in the forward and reverse rates, relating them to the endothermic forward reaction and the re-establishment of equilibrium	4
Sketches a correct graph and provides a substantially correct explanation	3
Sketches a correct graph OR provides a partial explanation using collision theory	2
Provides some relevant information	1

Sample answer:



Increasing the temperature increases the average kinetic energy of the particles. Collisions are more frequent, and a greater proportion of them have energy at least equal to the activation energy. Immediately after t_1 , both the forward and reverse rates increase.

The forward reaction is endothermic, so it has the higher activation energy and its rate increases by a greater proportion. The forward rate therefore exceeds the reverse rate, and $[H_2]$ increases. As CH_4 and H_2O are used up, the forward rate decreases; as CO and H_2 accumulate, the reverse rate increases. At t_2 the rates are equal again (both higher than before t_1), and $[H_2]$ is constant at a higher value.

Question 29

Criteria	Marks
Correctly calculates the pH of the diluted solution, including a relevant equation	4
Determines K_a and makes substantial progress towards the pH	3
Calculates $[H^+]$ and attempts to determine K_a OR Treats the acid as strong and correctly calculates a pH for the dilution	2
Provides some relevant information	1

Sample answer:



$$[H^+] = 10^{-2.85} = 1.41 \times 10^{-3} \text{ mol L}^{-1}$$

$$K_a = (1.41 \times 10^{-3})^2 \div (0.150 - 1.41 \times 10^{-3}) = 1.34 \times 10^{-5}$$

After dilution, $c = 0.150 \times 10.0/100.0 = 0.0150 \text{ mol L}^{-1}$. Let $[H^+] = x$: $x^2/(0.0150 - x) = 1.34 \times 10^{-5}$.

Assuming $x \ll 0.0150$, $x = \sqrt{(1.34 \times 10^{-5} \times 0.0150)} \approx 4.4 \times 10^{-4} \text{ mol L}^{-1}$ (3% ionised, so the assumption is valid)

$$\text{pH} = -\log(4.4 \times 10^{-4}) = \mathbf{3.35}$$

Question 30

Criteria	Marks
Correctly calculates the percentage of sodium chloride	3
Calculates $n(\text{AgCl})$ and sets up a correct relationship for the two chlorides	2
Provides some relevant steps	1

Sample answer:

$$n(\text{AgCl}) = 4.482 \div 143.35 = 0.03127 \text{ mol} = \text{total } n(\text{Cl}^-)$$

$$\text{Let } m = \text{mass of NaCl: } m/58.44 + (2.000 - m)/74.55 = 0.03127$$

$$0.017112m + 0.026828 - 0.013414m = 0.03127 \Rightarrow 0.003698m = 0.004438 \Rightarrow m = 1.200 \text{ g}$$

$$\% \text{ NaCl} = 1.200 \div 2.000 \times 100 = \mathbf{60.0\%}$$

Question 31 (a)

Criteria	Marks
Correctly calculates the molar solubility	2
Provides a correct K_{sp} expression in terms of s , or some relevant working	1

Sample answer:



$$s = (3.45 \times 10^{-11} \div 4)^{1/3} = \mathbf{2.05 \times 10^{-4} \text{ mol L}^{-1}}$$

Question 31 (b)

Criteria	Marks
Correctly calculates the maximum fluoride concentration in mg L^{-1}	2
Calculates $[\text{F}^-]$ in mol L^{-1} OR provides some relevant working	1

Sample answer:

$$[\text{F}^-]_{\text{max}} = \sqrt{(K_{\text{sp}}/[\text{Ca}^{2+}])} = \sqrt{(3.45 \times 10^{-11} \div 4.0 \times 10^{-3})} = 9.29 \times 10^{-5} \text{ mol L}^{-1}$$

$$9.29 \times 10^{-5} \times 19.00 = 1.76 \times 10^{-3} \text{ g L}^{-1} = \mathbf{1.8 \text{ mg L}^{-1}}$$

Question 32

Criteria	Marks
Calculates ΔG° correctly AND explains why photosynthesis is a non-equilibrium system	3
Calculates ΔG° correctly OR provides a correct explanation	2
Provides some relevant information	1

Sample answer:

$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ = 2803 - 298 \times (-0.262) = +2881 \text{ kJ mol}^{-1}$$

ΔG° is large and positive (and positive at every temperature, because $\Delta H > 0$ and $\Delta S < 0$), so the reaction is not spontaneous. It proceeds only because the leaf continuously absorbs energy from sunlight. The leaf is an open system: CO_2 and H_2O enter, and O_2 leaves while glucose is used or stored. The products are continuously removed and energy is continuously supplied, so the forward and reverse rates never become equal. The system never reaches equilibrium.

Question 33

Criteria	Marks
Correctly calculates the initial concentrations (allowing for dilution), $[\text{FeSCN}^{2+}]$ from $A = \epsilon l c$, the equilibrium concentrations, K_{eq} for all three mixtures, and the average	7
Provides a substantially correct calculation with one error	6
Uses a correct method with more than one error OR Correctly calculates K_{eq} for at least one mixture	4–5
Calculates $[\text{FeSCN}^{2+}]$ using the Beer–Lambert law and some initial or equilibrium concentrations	2–3
Provides some relevant information	1

Sample answer:

$[\text{FeSCN}^{2+}]_{\text{eq}} = A/\epsilon l = A \div (4.60 \times 10^3 \times 1.00)$. The total volume of each mixture is 10.00 mL, so initial concentration = $2.00 \times 10^{-3} \times V/10.00$.

Mixture	$[\text{Fe}^{3+}]_0$	$[\text{SCN}^-]_0$	$[\text{FeSCN}^{2+}]_{\text{eq}}$	$[\text{Fe}^{3+}]_{\text{eq}}$	$[\text{SCN}^-]_{\text{eq}}$	K_{eq}
1	1.00×10^{-3}	1.00×10^{-3}	1.076×10^{-4}	8.92×10^{-4}	8.92×10^{-4}	135
2	1.20×10^{-3}	6.00×10^{-4}	8.09×10^{-5}	1.119×10^{-3}	5.19×10^{-4}	139
3	6.00×10^{-4}	8.00×10^{-4}	5.57×10^{-5}	5.44×10^{-4}	7.44×10^{-4}	137

$$K_{\text{eq}} = [\text{FeSCN}^{2+}]/([\text{Fe}^{3+}][\text{SCN}^-]); \text{ eg mixture 1: } 1.076 \times 10^{-4} \div (8.92 \times 10^{-4})^2 = 135$$

$$\text{Average } K_{\text{eq}} = (135 + 139 + 137) \div 3 = \mathbf{137} \text{ (all concentrations in mol L}^{-1}\text{)}$$

Question 34 (a)

Criteria	Marks
Explains why a back titration is more appropriate	2
Provides some relevant information	1

Sample answer:

Aspirin is only slightly soluble in water. Its -COOH group is neutralised quickly, but the hydrolysis of its ester group by the second OH^- is slow at room temperature, so a direct titration would not reach the 1 : 2 stoichiometry and would not give a sharp, reliable end point. Adding a known excess of NaOH and heating ensures that all of the aspirin reacts completely. The unreacted NaOH can then be titrated quickly and accurately with HCl.

Question 34 (b)

Criteria	Marks
Correctly determines the mass of aspirin AND makes a correct judgement against the regulation, with all working shown	7
Provides a substantially correct calculation and judgement with one error	6
Calculates the moles of excess NaOH in the flask and the moles of NaOH that reacted, with some errors	4–5
Calculates the mean titre and moles of HCl, and makes some progress	2–3
Provides some relevant steps	1

Sample answer:

Mean of concordant titres (15.42 mL is an outlier): $(14.98 + 14.92 + 14.97) \div 3 = 14.96 \text{ mL}$

$n(\text{HCl}) = 0.02500 \times 0.01496 = 3.739 \times 10^{-4} \text{ mol} = n(\text{OH}^-) \text{ excess in each } 20.00 \text{ mL aliquot}$

$n(\text{OH}^-) \text{ excess in } 100.0 \text{ mL} = 3.739 \times 10^{-4} \times 100.0/20.00 = 1.870 \times 10^{-3} \text{ mol}$

$n(\text{OH}^-) \text{ initially} = 0.2000 \times 0.02500 = 5.000 \times 10^{-3} \text{ mol}$

$n(\text{OH}^-) \text{ reacted} = 5.000 \times 10^{-3} - 1.870 \times 10^{-3} = 3.130 \times 10^{-3} \text{ mol}$

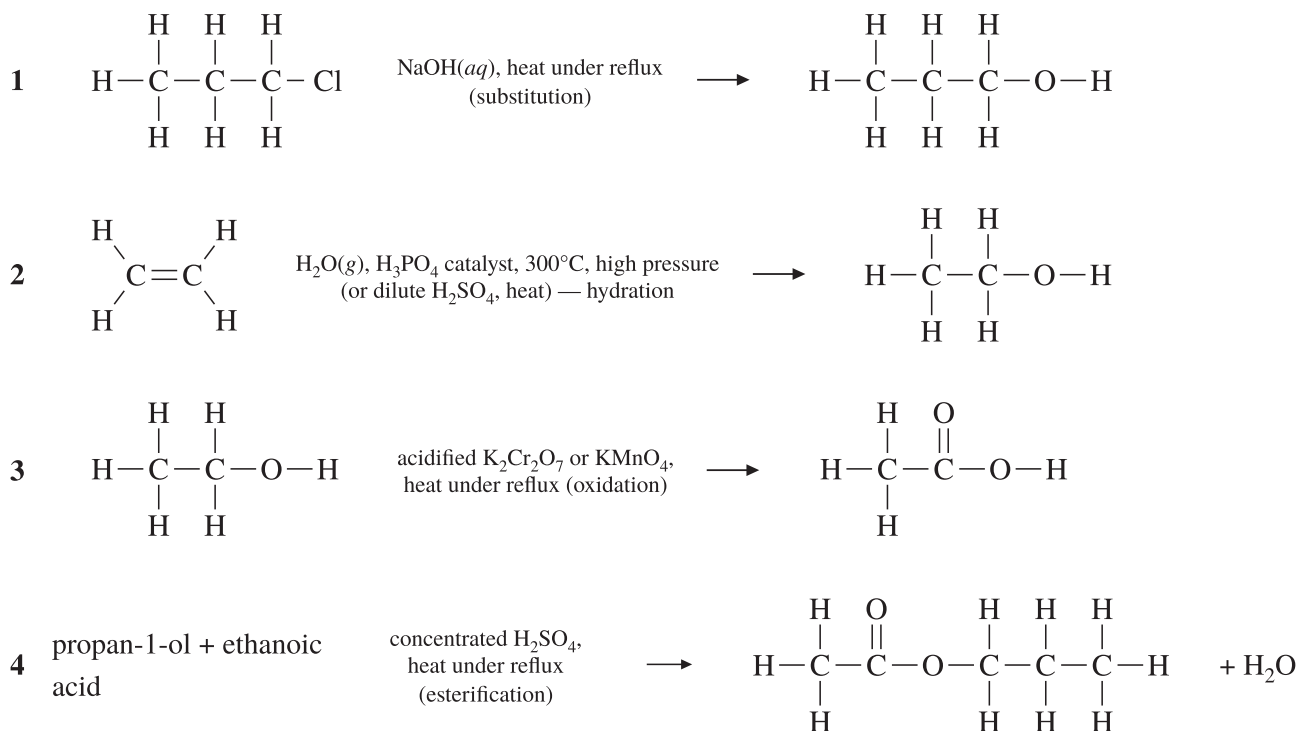
$n(\text{aspirin}) = \frac{1}{2} \times 3.130 \times 10^{-3} = 1.565 \times 10^{-3} \text{ mol} \quad m = 1.565 \times 10^{-3} \times 180.16 = 0.2820 \text{ g} = \mathbf{282 \text{ mg}}$

Allowed range: $300 \pm 5\% = 285\text{--}315 \text{ mg}$. The tablet contains 282 mg (6.0% below the stated mass), so it **does not meet** the regulation.

Question 35

Criteria	Marks
Outlines a complete and correct pathway, including structural formulae, reagents and conditions for each step	4
Outlines a correct pathway with one error or omission	3
Outlines some correct steps	2
Provides some relevant information	1

Sample answer:



Question 36 (a)

Criteria	Marks
Explains with reference to the IR spectrum and the information provided	2
Provides some relevant information	1

Sample answer:

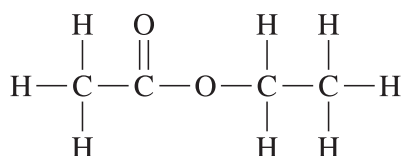
A carboxylic acid would show a very broad O–H absorption at 2500–3000 cm^{–1} (data sheet), which is absent; there is no alcohol O–H band at 3230–3550 cm^{–1} either. The strong absorption at 1742 cm^{–1} (C=O) and the absorptions at 1241 and 1047 cm^{–1} (C–O) are consistent with an ester. X also does not react with sodium carbonate, so it has no acidic –COOH group.

Question 36 (b)

Criteria	Marks
Correctly identifies X and Y with structural formulae, names the alcohol and acid for each, and justifies with reference to the NMR data and mass spectra of BOTH compounds	6
Correctly identifies X and Y with substantially correct justification	5
Identifies X and Y with a partial justification OR Identifies one compound with full justification	3–4
Identifies one compound OR provides some relevant analysis of the data	2
Provides some relevant information	1

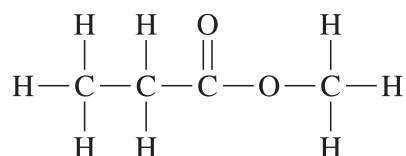
Sample answer:

X: ethyl ethanoate



Alcohol: ethanol Acid: ethanoic acid

Y: methyl propanoate



Alcohol: methanol Acid: propanoic acid

Both have a molecular ion at $m/z = 88$, consistent with $\text{C}_4\text{H}_8\text{O}_2$. Each ^{13}C spectrum has four signals (four carbon environments), including a short signal at about 170–175 ppm ($\text{C}=\text{O}$ of an ester or acid, 160–185 ppm). Neither has a signal at 8.0–8.2 ppm, so neither is a methanoate ester.

X: the singlet at 2.04 ppm (3H) is a $\text{CH}_3\text{--CO--}$ group with no neighbouring H. The quartet at 4.12 ppm (2H) is an $\text{--O--CH}_2\text{--}$ group next to a CH_3 ; the matching triplet at 1.26 ppm (3H) is that CH_3 . The ^{13}C signal at about 60 ppm is a carbon bonded to O (50–90 ppm on the data sheet). The base peak at 43 is CH_3CO^+ .

Y: the singlet at 3.67 ppm (3H) is an O--CH_3 group. The quartet at 2.32 ppm (2H) is a $\text{--CH}_2\text{--CO--}$ group next to a CH_3 (triplet at 1.14 ppm). The ^{13}C signal at about 52 ppm is the O--CH_3 carbon. The base peak at 57 is $\text{CH}_3\text{CH}_2\text{CO}^+$, and the peak at 29 is CH_3CH_2^+ .

2026 Mock HSC Chemistry

Mapping Grid

Section I

Question	Marks	Content	Syllabus outcomes
1	1	Mod 7 Nomenclature (7.1.1)	CH12-14
2	1	Mod 8 Analysis of inorganic substances (8.1.2)	CH12-5, CH12-15
3	1	Mod 7 Alcohols (7.4.5, 7.4.4)	CH12-14
4	1	Mod 7 / 8 Analysis of organic substances (8.2.1, 7.3.1)	CH12-5, CH12-14, CH12-15
5	1	Mod 6 Using Brønsted–Lowry theory (6.2.4)	CH12-13
6	1	Mod 7 Alcohols (7.4.4)	CH12-14
7	1	Mod 5 Factors that affect equilibrium (5.2.1)	CH12-6, CH12-12
8	1	Mod 8 Analysis of organic substances (8.2.2)	CH12-5, CH12-15
9	1	Mod 6 Quantitative analysis (6.3.1)	CH12-4, CH12-13
10	1	Mod 6 Quantitative analysis (6.3.2)	CH12-5, CH12-13
11	1	Mod 5 Static & dynamic equilibrium (5.1.3)	CH12-4, CH12-12
12	1	Mod 5 Factors that affect equilibrium (5.2.2)	CH12-6, CH12-12
13	1	Mod 8 Analysis of inorganic substances (8.1.4)	CH12-4, CH12-15
14	1	Mod 7 Alcohols (7.4.3)	CH12-4, CH12-14
15	1	Mod 6 Quantitative analysis (6.3.7)	CH12-6, CH12-13
16	1	Mod 5 Calculating K_{eq} (5.3.2)	CH12-4, CH12-12
17	1	Mod 7 Organic acids & bases (7.5.6, 7.5.3)	CH12-6, CH12-14
18	1	Mod 8 Analysis of organic substances (8.2.2)	CH12-5, CH12-15
19	1	Mod 5 Calculating K_{eq} (5.3.5, 5.4.4)	CH12-6, CH12-12
20	1	Mod 5 Solution equilibria (5.4.4, 5.4.5)	CH12-4, CH12-12

Section II

Question	Marks	Content	Syllabus outcomes
21 (a)	2	Mod 7 Alcohols (7.4.6)	CH12-7, CH12-14
21 (b)	3	Mod 7 Alcohols (7.4.2)	CH12-5, CH12-7, CH12-14
22 (a)	1	Mod 6 Using Brønsted–Lowry theory (6.2.4)	CH12-13
22 (b)	3	Mod 6 Using Brønsted–Lowry theory (6.2.4, 6.3.4)	CH12-6, CH12-7, CH12-13
23 (a)	3	Mod 6 Properties of acids & bases (6.1.5)	CH12-4, CH12-13
23 (b)	2	Mod 6 Properties of acids & bases (6.1.5)	CH12-6, CH12-13
24 (a)	2	Mod 8 Analysis of inorganic substances (8.1.2)	CH12-2, CH12-15
24 (b)	3	Mod 5 / 8 Solution equilibria (5.4.5, 8.1.3)	CH12-4, CH12-6, CH12-12, CH12-15
25 (a)	2	Mod 6 Quantitative analysis (6.3.2)	CH12-4, CH12-13
25 (b)	4	Mod 6 Quantitative analysis (6.3.7, 6.2.2)	CH12-6, CH12-7, CH12-13
26	5	Mod 7 Alcohols (7.4.5, 7.3.1)	CH12-5, CH12-7, CH12-14
27 (a)	2	Mod 7 Organic acids & bases (7.5.3)	CH12-2, CH12-14
27 (b)	2	Mod 7 Organic acids & bases (7.5.3)	CH12-4, CH12-14
28	4	Mod 5 Factors that affect equilibrium (5.2.1, 5.2.2)	CH12-4, CH12-6, CH12-12
29	4	Mod 6 Quantitative analysis (6.3.4, 6.2.2)	CH12-4, CH12-13
30	3	Mod 8 Analysis of inorganic substances (8.1.3)	CH12-4, CH12-15
31 (a)	2	Mod 5 Solution equilibria (5.4.4)	CH12-4, CH12-12
31 (b)	2	Mod 5 Solution equilibria (5.4.5)	CH12-6, CH12-12
32	3	Mod 5 Static & dynamic equilibrium (5.1.3)	CH12-6, CH12-12
33	7	Mod 5 / 8 Calculating K_{eq} (5.3.2, 8.1.4)	CH12-4, CH12-5, CH12-12, CH12-15
34 (a)	2	Mod 6 Quantitative analysis (6.3.6)	CH12-2, CH12-13
34 (b)	7	Mod 6 Quantitative analysis (6.3.6, 6.3.1)	CH12-4, CH12-5, CH12-13
35	4	Mod 7 / 8 Organic acids & bases (7.5.6, 8.3.1, 7.3.1)	CH12-6, CH12-7, CH12-14, CH12-15
36 (a)	2	Mod 8 Analysis of organic substances (8.2.2)	CH12-5, CH12-15
36 (b)	6	Mod 7 / 8 Analysis of organic substances (8.2.2, 7.5.3)	CH12-5, CH12-6, CH12-7, CH12-15

MOCK HSC CHEMISTRY WORKED SOLUTIONS

2026 MOCK HSC EXAMINATION • MARK IT, FIX IT, PRACTISE IT

1 • Mark

Mark your paper against each solution. In Section II every numbered step is worth one mark: tick the box when your answer has it.

2 • Fix

Tick *Got it*, *Revisit* or *Redo* for every question. Read “Where marks are lost” before you redo anything.

3 • Practise

Do the past HSC questions listed under each question (oldest first), and tick them off as you go.

SECTION I ANSWER KEY

tick the ones you got right

1	C ☐	2	A ☐	3	D ☐	4	B ☐	5	C ☐	6	D ☐	7	A ☐	8	B ☐	9	A ☐	10	C ☐
11	B ☐	12	D ☐	13	B ☐	14	C ☐	15	A ☐	16	D ☐	17	B ☐	18	A ☐	19	D ☐	20	C ☐

SCORE TRACKER

write your mark for each question

Sec I	Q21	Q22	Q23	Q24	Q25	Q26	Q27	Q28	Q29	Q30	Q31	Q32	Q33	Q34	Q35	Q36
/20	/5	/4	/5	/5	/6	/5	/4	/4	/4	/3	/4	/3	/7	/9	/4	/8

TOTAL _____ **/ 100**

SECTION I • MULTIPLE CHOICE

Each answer is boxed. “Why not the others?” explains every distractor: read it even when you got the question right.

1 Preferred IUPAC name of $\text{CH}_3\text{CH}(\text{Br})\text{CH}(\text{CH}_3)\text{COOH}$

C

The longest chain containing the -COOH carbon has four carbons (butanoic acid). Numbering from the carboxyl carbon (C1) places the methyl group on C2 and bromine on C3. Prefixes are listed alphabetically (bromo before methyl): **3-bromo-2-methylbutanoic acid**.

WHY NOT THE OTHERS? A reverses the locants. B lists the prefixes out of alphabetical order. D does not use the longest carbon chain, which has four carbons.

7.1.1 IUPAC naming (organic)

PRACTISE NEXT ☐ 2020 Q6 ☐ 2022 Q7 ☐ 2024 Q12

☐ GOT IT ☐ REVISIT ☐ REDO

2 Reagent to distinguish sodium carbonate solution from sodium sulfate solution

A

Dilute nitric acid reacts with carbonate ions to give effervescence of CO_2 : $\text{CO}_3^{2-}(\text{aq}) + 2\text{H}^+(\text{aq}) \longrightarrow \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$. Sulfate ions give no visible change.

WHY NOT THE OTHERS? B gives a white precipitate with both ions (BaCO_3 and BaSO_4). C and D produce no observable change with either solution.

8.1.2 Qualitative tests for cations & anions

PRACTISE NEXT ☐ 2022 Q5 ☐ 2023 Q30 ☐ 2025 Q4

☐ GOT IT ☐ REVISIT ☐ REDO

3 Reaction that gives propan-2-ol as the ONLY organic product

D

Nucleophilic substitution of 2-bromopropane by hydroxide gives only propan-2-ol (the bromine is on C2).

WHY NOT THE OTHERS? A gives a mixture of propan-2-ol (major) and propan-1-ol (minor). B gives propan-1-ol. C oxidises propanal to propanoic acid.

7.4.5 Producing alcohols, fermentation · 7.4.4 Dehydration, HX, combustion

PRACTISE NEXT ☐ 2021 Q7 ☐ 2021 Q13

☐ GOT IT ☐ REVISIT ☐ REDO

4 Liquid that rapidly decolourises bromine water and fizzes with Na_2CO_3

B

Rapid decolourisation of bromine water without UV light indicates a $\text{C}=\text{C}$ bond (addition). Effervescence with Na_2CO_3 indicates a -COOH group. Pent-4-enoic acid has both.

WHY NOT THE OTHERS? A has no $\text{C}=\text{C}$. C has a $\text{C}=\text{C}$ but an alcohol does not react with carbonate. D has no acidic group.

8.2.1 Chemical tests for functional groups · 7.3.1 Addition reactions (H_2 , X_2 , HX , H_2O)

PRACTISE NEXT ☐ 2020 Q9 ☐ 2021 Q21(b) ☐ 2024 Q35

☐ GOT IT ☐ REVISIT ☐ REDO

5 $\text{HSO}_3^- + \text{HS}^- \rightleftharpoons \text{SO}_3^{2-} + \text{H}_2\text{S}$: which pair are BOTH acting as acids?

C

In the forward reaction HSO_3^- donates a proton to HS^- . In the reverse reaction H_2S donates a proton to SO_3^{2-} . The proton donors (acids) are HSO_3^- and H_2S .

WHY NOT THE OTHERS? Each other option includes at least one species acting as a base (HS^- or SO_3^{2-}).

6.2.4 Conjugates & amphoteric species

PRACTISE NEXT ☐ 2019 Q18 ☐ 2022 Q10 ☐ 2022 Q22

☐ GOT IT ☐ REVISIT ☐ REDO

6

Alcohol that gives only ONE alkene when heated with concentrated H_2SO_4

D

Pentan-3-ol is symmetrical about C3: removing H from either C2 or C4 gives the same product, pent-2-ene.

WHY NOT THE OTHERS? Butan-2-ol gives but-1-ene and but-2-ene. 2-methylbutan-2-ol gives 2-methylbut-1-ene and 2-methylbut-2-ene. Pentan-2-ol gives pent-1-ene and pent-2-ene.

7.4.4 Dehydration, HX, combustion

PRACTISE NEXT ☐ 2020 Q29 ☐ 2022 Q11

☐ GOT IT ☐ REVISIT ☐ REDO

7

 $2\text{NO} + \text{Br}_2 \rightleftharpoons 2\text{NOBr}$ ($\Delta H < 0$): change that DECREASES the amount of NOBr

A

Adding argon at constant pressure increases the total volume, so the partial pressures (concentrations) of the reacting gases decrease. The system shifts to the side with more moles of gas (left: 3 mol vs 2 mol), decreasing NOBr.

WHY NOT THE OTHERS? B: at constant volume the partial pressures of the reacting gases are unchanged, so there is no shift. C: the forward reaction is exothermic, so cooling shifts the equilibrium right. D: adding a reactant shifts the equilibrium right.

5.2.1 Le Chatelier: T , conc., pressure

PRACTISE NEXT ☐ 2021 Q11 ☐ 2023 Q12 ☐ 2024 Q7

☐ GOT IT ☐ REVISIT ☐ REDO

8

Haloalkane with molecular ion peaks at m/z 122 and 124 in a 1 : 1 ratio

B

Two molecular ion peaks two units apart in a 1 : 1 ratio indicate one bromine atom. $\text{C}_3\text{H}_7^{79}\text{Br} = 3(12) + 7(1) + 79 = 122$ and $\text{C}_3\text{H}_7^{81}\text{Br} = 124$.

WHY NOT THE OTHERS? A would show peaks at 78 and 80 in a 3 : 1 ratio. C gives 108/110 and D gives 136/138.

8.2.2 Spectroscopy: ^1H & ^{13}C NMR, MS, IR

PRACTISE NEXT ☐ 2020 Q15 ☐ 2024 Q38

☐ GOT IT ☐ REVISIT ☐ REDO

9

Oxalic acid: 25.00 mL needs 22.40 mL of $0.1000 \text{ mol L}^{-1}$ NaOH. Concentration?

A

$n(\text{NaOH}) = 0.1000 \times 0.02240 = 2.240 \times 10^{-3} \text{ mol}$. $\text{H}_2\text{C}_2\text{O}_4 : \text{NaOH} = 1 : 2$, so $n(\text{acid}) = 1.120 \times 10^{-3} \text{ mol}$. $c = 1.120 \times 10^{-3} \div 0.02500 = 0.04480 \text{ mol L}^{-1}$.

WHY NOT THE OTHERS? C ignores the 1 : 2 ratio. B and D invert the volumes.

6.3.1 Titration for unknown concentration

PRACTISE NEXT ☐ 2020 Q25 ☐ 2022 Q32(a) ☐ 2023 Q14

☐ GOT IT ☐ REVISIT ☐ REDO

10

Conductivity graph for NaOH added to ethanoic acid

C

Ethanoic acid is weak, so the initial conductivity is low. As NaOH is added, the weak acid is converted to fully ionised sodium ethanoate, so conductivity rises gradually (after a slight initial dip as the few H^+ ions are removed). After equivalence (20.0 mL), excess highly mobile OH^- ions cause a steeper rise.

WHY NOT THE OTHERS? A is typical of a strong acid (high initial conductivity due to H^+). B ignores the ions formed before equivalence. D shows no increase after equivalence.

6.3.2 Titration & conductivity curves

PRACTISE NEXT ☐ 2019 Q24(a) ☐ 2022 Q15 ☐ 2024 Q34

☐ GOT IT ☐ REVISIT ☐ REDO

11 $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$ ($\Delta H^\circ = +178 \text{ kJ mol}^{-1}$, $\Delta S^\circ = +161 \text{ J K}^{-1} \text{ mol}^{-1}$): when spontaneous?**B**

Spontaneous when $\Delta G = \Delta H - T\Delta S < 0$, i.e. $T > \Delta H/\Delta S = 178\,000 \div 161 = 1106 \text{ K}$. Both terms are positive, so the reaction is spontaneous only above 1106 K.

WHY NOT THE OTHERS? C reverses the inequality. A and D would require ΔH and ΔS to have opposite signs.

5.1.3 Non-equilibrium systems (ΔH , ΔS , ΔG)

PRACTISE NEXT ☐ 2019 Q30 ☐ 2021 Q33(a) ☐ 2024 Q37

☐ GOT IT ☐ REVISIT ☐ REDO

12 $\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$, volume halved: rates immediately after**D**

Halving the volume doubles the concentration of every gas, so both rates increase. The forward reaction involves four reactant particles ($\text{N}_2 + 3\text{H}_2$) and the reverse only two (2NH_3), so the frequency of successful forward collisions increases more. Net forward reaction then occurs until the rates are equal again.

WHY NOT THE OTHERS? A would mean no shift in equilibrium. B: the reverse rate also increases because $[\text{NH}_3]$ doubles. C: concentration, not only temperature, affects rate.

5.2.2 Explaining shifts with collision theory

PRACTISE NEXT ☐ 2019 Q25(b) ☐ 2022 Q23(c) ☐ 2024 Q26(b)

☐ GOT IT ☐ REVISIT ☐ REDO

13 AAS for lead: 50.0 mL diluted to 250.0 mL, $A = 0.0750c$, $A = 0.0180$ **B**

Diluted sample: $c = 0.0180 \div 0.0750 = 0.240 \text{ mg L}^{-1}$. Original = $0.240 \times (250.0/50.0) = 1.20 \text{ mg L}^{-1} = 1.20 \times 10^{-3} \text{ g L}^{-1}$.
 $1.20 \times 10^{-3} \div 207.2 = 5.79 \times 10^{-6} \text{ mol L}^{-1}$.

WHY NOT THE OTHERS? A omits the dilution factor. C applies the dilution factor twice. D gives the concentration in g L^{-1} , not mol L^{-1} .

8.1.4 Colourimetry, UV-Vis & AAS

PRACTISE NEXT ☐ 2019 Q20 ☐ 2021 Q14 ☐ 2022 Q4

☐ GOT IT ☐ REVISIT ☐ REDO

14 Butan-1-ol spirit burner: percentage of heat absorbed by the water**C**

$q(\text{water}) = mc\Delta T = 250.0 \times 4.18 \times 15.6 = 1.630 \times 10^4 \text{ J} = 16.3 \text{ kJ}$. $n(\text{butan-1-ol}) = 0.740 \div 74.12 = 9.984 \times 10^{-3} \text{ mol}$, releasing $9.984 \times 10^{-3} \times 2676 = 26.7 \text{ kJ}$. Efficiency = $16.3 \div 26.7 \times 100 = 61\%$.

WHY NOT THE OTHERS? A mixes J and kJ. B is the percentage of heat lost. D does not follow from the data.

7.4.3 Enthalpy of combustion (prac)

PRACTISE NEXT ☐ 2019 Q23(a) ☐ 2023 Q25(a) ☐ 2024 Q13

☐ GOT IT ☐ REVISIT ☐ REDO

15 Most suitable acid/conjugate-base pair for a buffer of $\text{pH} \approx 9.2$ **A**

A buffer works best when $\text{pH} \approx \text{pK}_a$. The pK_a of NH_4^+ (9.25) is closest to 9.2.

WHY NOT THE OTHERS? B and C have pK_a values far below 9.2. D (10.33) would buffer around pH 10.3.

6.3.7 Buffers: preparation & properties

PRACTISE NEXT ☐ 2019 Q22 ☐ 2024 Q16 ☐ 2025 Q19

☐ GOT IT ☐ REVISIT ☐ REDO

16

0.400 mol Cl₂ + 0.400 mol F₂ in 2.00 L (K_{eq} = 16.0): equilibrium [ClF]

D

Initial [Cl₂] = [F₂] = 0.400 ÷ 2.00 = 0.200 mol L⁻¹. At equilibrium [Cl₂] = [F₂] = 0.200 - x, [ClF] = 2x. K_{eq} = (2x)² / (0.200 - x)² = 16.0, so 2x / (0.200 - x) = 4.00 and x = 0.1333. [ClF] = 2x = **0.267 mol L⁻¹**.

WHY NOT THE OTHERS? B gives x rather than 2x. A and C come from mishandling the square root or using moles instead of concentration.

5.3.2 K_{eq} calculations (ICE), Q vs KPRACTISE NEXT ☐ 2022 Q13 ☐ 2023 Q7 ☐ 2024 Q30☐ GOT IT ☐ REVISIT ☐ REDO

17

Molar mass of Z in the sequence starting from 1-chloropentane

B

X = pentan-1-ol (substitution); Y = pentanoic acid (oxidation of a primary alcohol); Z = pentyl pentanoate, C₁₀H₂₀O₂.

MM = 10(12.01) + 20(1.008) + 2(16.00) = **172.3 g mol⁻¹**.

WHY NOT THE OTHERS? A (C₉H₁₈O₂), C (C₁₁H₂₂O₂) and D (C₈H₁₆O₂) have the wrong number of carbon atoms.

7.5.6 Multi-step reaction pathways · 7.5.3 Esterification & reflux

PRACTISE NEXT ☐ 2019 Q34 ☐ 2021 Q26(a) ☐ 2025 Q15☐ GOT IT ☐ REVISIT ☐ REDO

18

¹H NMR of BrCH₂CH₂CH₂Cl: number of signals and splitting of the central CH₂

A

There are three hydrogen environments (BrCH₂, central CH₂, CH₂Cl). The central CH₂ has 2 + 2 = 4 neighbouring H atoms, so by the n + 1 rule its signal is a quintet.

WHY NOT THE OTHERS? B and D treat the two end CH₂ groups as equivalent, but they are attached to different halogens. A triplet (C, D) is the splitting of each end CH₂ signal.

8.2.2 Spectroscopy: ¹H & ¹³C NMR, MS, IRPRACTISE NEXT ☐ 2019 Q14 ☐ 2021 Q18 ☐ 2024 Q19☐ GOT IT ☐ REVISIT ☐ REDO

19

K for CaCO₃(s) + H⁺ ⇌ Ca²⁺ + HCO₃⁻, given K_a(HCO₃⁻) = 4.7 × 10⁻¹¹

D

Target reaction = CaCO₃(s) ⇌ Ca²⁺(aq) + CO₃²⁻(aq) (K_{sp} = 3.36 × 10⁻⁹) plus CO₃²⁻(aq) + H⁺(aq) ⇌ HCO₃⁻(aq) (K = 1/K_a). K = 3.36 × 10⁻⁹ ÷ 4.7 × 10⁻¹¹ = **71**.

WHY NOT THE OTHERS? A multiplies K_{sp} by K_a. B inverts the ratio. C is 1/(K_{sp} × K_a).

5.3.5 K for dissociation of salts, acids, bases · 5.4.4 K_{sp} expressions & solubilityPRACTISE NEXT ☐ 2019 Q27(a) ☐ 2021 Q36☐ GOT IT ☐ REVISIT ☐ REDO

20

[Cl⁻] after mixing 100.0 mL of 0.0400 mol L⁻¹ AgNO₃ with 100.0 mL of 0.0300 mol L⁻¹ NaCl

C

n(Ag⁺) = 4.00 × 10⁻³ mol; n(Cl⁻) = 3.00 × 10⁻³ mol. After precipitation, excess Ag⁺ = 1.00 × 10⁻³ mol in 0.2000 L = 5.00 × 10⁻³ mol L⁻¹. [Cl⁻] = K_{sp} / [Ag⁺] = 1.77 × 10⁻¹⁰ ÷ 5.00 × 10⁻³ = **3.54 × 10⁻⁸ mol L⁻¹**.

WHY NOT THE OTHERS? A is the solubility of AgCl in pure water (√K_{sp}), ignoring the excess Ag⁺. B and D use the wrong volume for the excess Ag⁺.

5.4.4 K_{sp} expressions & solubility · 5.4.5 Predicting precipitates (Q vs K_{sp})PRACTISE NEXT ☐ 2019 Q17 ☐ 2022 Q35 ☐ 2023 Q34☐ GOT IT ☐ REVISIT ☐ REDO

SECTION II

Every numbered step is one mark. Tick the box on the right if your answer has that step. Grey steps show set-up or a model sketch and carry no mark.

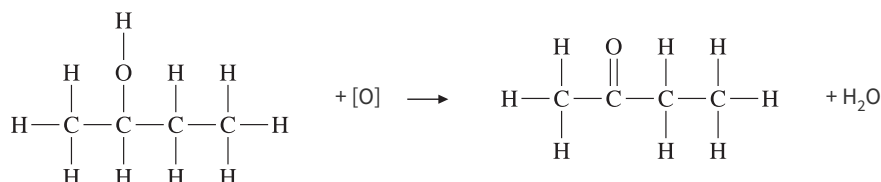
21(a)

Butan-2-ol → butanone: equation using structural formulae, with reagent and conditions

2

MARKS

1 EQUATION

☐


→ Every bond shown

2 REAGENT AND CONDITIONS

Acidified potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7/\text{H}^+$) or acidified KMnO_4 , heated

☐

WHERE MARKS ARE LOST

- Structural formulae must show every bond; a condensed formula alone does not meet the requirement.
- Butan-2-ol is a secondary alcohol, so oxidation stops at the ketone. It does not form a carboxylic acid.

7.4.6 Oxidation of 1° and 2° alcohols

PRACTISE NEXT ☐ 2019 Q21(c) ☐ 2022 Q27(c)

☐ GOT IT ☐ REVISIT ☐ REDO

21(b)

Boiling points: butan-2-ol 100°C, butanone 80°C, pentane 36°C (molar masses 72–74 g mol⁻¹)

3

MARKS

SET UP

The molar masses are almost the same, so dispersion forces are similar. The differences come from the other forces.

1 PENTANE

Non-polar: dispersion forces only, so the weakest attraction and the **lowest** boiling point (36°C)

☐

2 BUTANONE

Polar C=O group: dipole–dipole forces in addition to dispersion, so more energy is needed (80°C)

☐

3 BUTAN-2-OL

O–H group: **hydrogen bonding** between molecules, the strongest force here, so the **highest** boiling point (100°C)

☐

→ Forces between molecules, not bonds within them

WHERE MARKS ARE LOST

- Refer to forces *between* molecules; boiling does not break covalent bonds.
- Use the data. The near-equal molar masses are the reason dispersion forces can be treated as constant.

7.4.2 Alcohol properties & IMFs

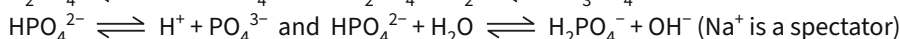
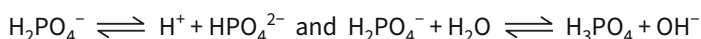
PRACTISE NEXT ☐ 2019 Q32 ☐ 2020 Q32 ☐ 2024 Q24(b)

☐ GOT IT ☐ REVISIT ☐ REDO

22 (a) Conjugate acid and conjugate base of H_2PO_4^- **1**
MARK**1 BOTH SPECIES**Conjugate acid H_3PO_4 ; conjugate base HPO_4^{2-} → Acid: one more H^+ ; base: one fewer☐**WHERE MARKS ARE LOST**

- The conjugate acid has one more H^+ ; the conjugate base has one fewer.

6.2.4 Conjugates & amphoteric species

PRACTISE NEXT ☐ 2022 Q22 ☐ 2023 Q24☐ GOT IT ☐ REVISIT ☐ REDO**22 (b)** Why $0.10 \text{ mol L}^{-1} \text{NaH}_2\text{PO}_4$ is acidic but $0.10 \text{ mol L}^{-1} \text{Na}_2\text{HPO}_4$ is basic**3**
MARKS**1 BOTH IONS ARE AMPHIPROTIC**☐**2 H_2PO_4^-** $K_b = K_w/K_{a1} = 1.0 \times 10^{-14} \div 7.1 \times 10^{-3} = 1.4 \times 10^{-12}$, less than $K_{a2} = 6.3 \times 10^{-8}$, so it is a stronger acid than base: **acidic**→ Use K_a of the conjugate acid☐**3 HPO_4^{2-}** $K_b = K_w/K_{a2} = 1.0 \times 10^{-14} \div 6.3 \times 10^{-8} = 1.6 \times 10^{-7}$, more than $K_{a3} = 4.5 \times 10^{-13}$, so it is a stronger base than acid: **basic**☐**WHERE MARKS ARE LOST**

- The K_b of an ion is found from the K_a of its *conjugate acid*. For H_2PO_4^- , that is K_{a1} , not K_{a2} .
- Comparing only the two acid dissociation constants does not answer the question; the competing base reaction must be considered.

6.2.4 Conjugates & amphoteric species · 6.3.4 K_a & pK_a calculationsPRACTISE NEXT ☐ 2020 Q10 ☐ 2020 Q18 ☐ 2021 Q23(b)☐ GOT IT ☐ REVISIT ☐ REDO**23 (a)** Molar enthalpy of neutralisation: $40.0 \text{ mL } 0.500 \text{ mol L}^{-1} \text{H}_2\text{SO}_4 + 60.0 \text{ mL } 0.700 \text{ mol L}^{-1} \text{KOH}$, $\Delta T = 5.0^\circ\text{C}$, calorimeter 41.0 J K^{-1} **3**
MARKS**1 LIMITING REAGENT**

$$n(\text{H}^+) = 2 \times 0.500 \times 0.0400 = 0.0400 \text{ mol}; n(\text{OH}^-) = 0.700 \times 0.0600 = 0.0420 \text{ mol. } \text{H}^+ \text{ is limiting: } \mathbf{0.0400 \text{ mol}}$$

 H_2O forms→ H_2SO_4 is diprotic☐**2 HEAT ABSORBED**

$$q = (0.1000 \times 4.18 \times 10^3 \times 5.0) + (41.0 \times 5.0) = 2090 + 205 = \mathbf{2295 \text{ J}}$$

→ Include the calorimeter; 100 g of solution

☐**3 MOLAR ENTHALPY**

$$\Delta H = -2295 \div 0.0400 = -5.74 \times 10^4 \text{ J mol}^{-1} = \mathbf{-57.4 \text{ kJ mol}^{-1}}$$

→ Negative sign

☐**WHERE MARKS ARE LOST**

- Sulfuric acid is diprotic: $0.0200 \text{ mol H}_2\text{SO}_4$ supplies 0.0400 mol H^+ .
- Ignoring the calorimeter gives $-52.3 \text{ kJ mol}^{-1}$; using the OH^- amount gives $-54.6 \text{ kJ mol}^{-1}$.
- The total mass of solution is 100 g (100.0 mL), not 40 g or 60 g .

6.1.5 Enthalpy of neutralisation

PRACTISE NEXT ☐ 2020 Q36 ☐ 2022 Q26(a)☐ GOT IT ☐ REVISIT ☐ REDO

23 (b) Temperature rise if 60.0 mL of 0.700 mol L⁻¹ aqueous ammonia replaces the KOH**2**
MARKS

- 1 PREDICTION** The temperature rise would be **smaller** ☐
- 2 JUSTIFICATION** NH₃ is a weak base, only partly ionised. Some of the energy released is used to ionise it (endothermic), so less heat is released per mole of acid neutralised ☐

WHERE MARKS ARE LOST

- The amount of acid is unchanged, so the same amount of product forms. The difference is in the energy released per mole.

6.1.5 Enthalpy of neutralisation

PRACTISE NEXT ☐ 2021 Q32 ☐ 2022 Q26(b)☐ GOT IT ☐ REVISIT ☐ REDO**24 (a)** Why a flame test cannot confirm both Ba²⁺ and Ca²⁺ in the same solution**2**
MARKS

- 1 COLOURS** Ba²⁺ gives a pale (apple) green flame; Ca²⁺ gives an orange-red (brick-red) flame ☐
- 2 PROBLEM IN A MIXTURE** Both colours appear together and the intense orange-red masks the green, so the colour cannot confirm both ions ☐

WHERE MARKS ARE LOST

- State both flame colours and explain the consequence for a mixture.

8.1.2 Qualitative tests for cations & anions

PRACTISE NEXT ☐ 2021 Q30 ☐ 2022 Q5 ☐ 2024 Q8☐ GOT IT ☐ REVISIT ☐ REDO**24 (b)** 0.010 mol L⁻¹ Ba²⁺ and Ca²⁺: % of Ba²⁺ left when CaSO₄ starts to precipitate**3**
MARKS

- 1 SULFATE NEEDED FOR CaSO₄** [SO₄²⁻] = K_{sp}(CaSO₄) ÷ [Ca²⁺] = 4.93 × 10⁻⁵ ÷ 0.010 = **4.93 × 10⁻³ mol L⁻¹** ☐
- 2 BA²⁺ LEFT AT THAT POINT** [Ba²⁺] = 1.08 × 10⁻¹⁰ ÷ 4.93 × 10⁻³ = **2.19 × 10⁻⁸ mol L⁻¹** ☐
→ BaSO₄ precipitates first
- 3 PERCENTAGE REMAINING** (2.19 × 10⁻⁸ ÷ 0.010) × 100 = **2.2 × 10⁻⁴ %** ☐

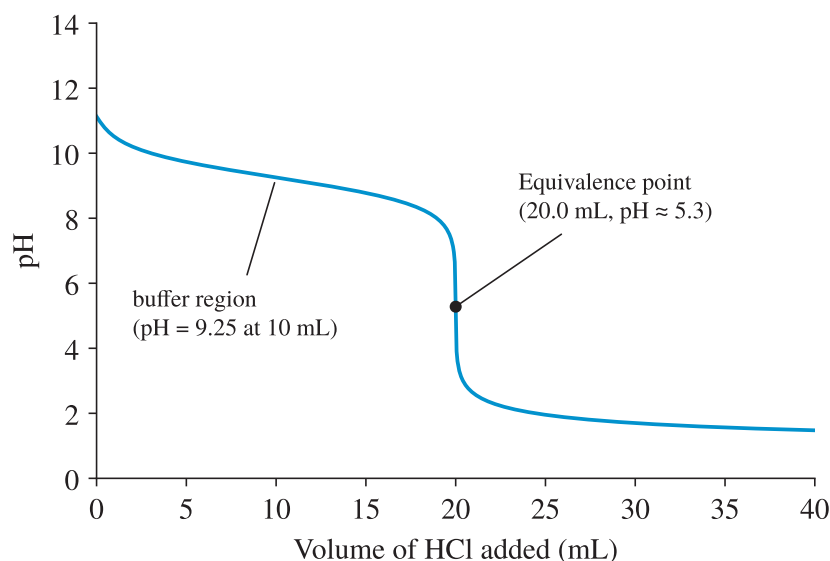
WHERE MARKS ARE LOST

- BaSO₄ precipitates first because its K_{sp} is much smaller. The question is how much Ba²⁺ is left by the time CaSO₄ starts to form.

5.4.5 Predicting precipitates (Q vs K_{sp}) · 8.1.3 Gravimetric & precipitation titrationsPRACTISE NEXT ☐ 2024 Q27 ☐ 2025 Q32☐ GOT IT ☐ REVISIT ☐ REDO

25 (a) Sketch the curve for 20.0 mL of 0.10 mol L⁻¹ NH₃ titrated with 0.10 mol L⁻¹ HCl**2**
MARKS

MODEL SKETCH



1 SHAPE	Starts near pH 11, decreases gradually through the buffer region, then drops sharply around 20 mL and levels off near pH 1.5	☐
2 EQUIVALENCE POINT	Labelled at 20.0 mL , at an acidic pH of about 5.3 (NH ₄ ⁺ is present) → Weak base + strong acid: below pH 7	☐

WHERE MARKS ARE LOST

- The equivalence point of a weak base / strong acid titration is below pH 7.
- Equal concentrations and 20.0 mL of base mean equivalence occurs at 20.0 mL of acid.

6.3.2 Titration & conductivity curves

PRACTISE NEXT ☐ 2019 Q6 ☐ 2020 Q8☐ GOT IT ☐ REVISIT ☐ REDO**25 (b)** Buffer of 0.250 mol L⁻¹ NH₃ and 0.150 mol L⁻¹ NH₄Cl ($K_b = 1.8 \times 10^{-5}$): how it works and its pH**4**
MARKS

1 BUFFER COMPONENTS	Large amounts of a weak base (NH ₃) and its conjugate acid (NH ₄ ⁺): NH ₃ + H ₂ O ⇌ NH ₄ ⁺ + OH ⁻	☐
2 RESPONSE TO ADDED ACID	Added H ⁺ is consumed (NH ₃ + H ⁺ → NH ₄ ⁺). The ratio [NH ₃]/[NH ₄ ⁺] barely changes, so the pH barely changes	☐
3 [OH⁻]	[OH ⁻] = $K_b \times [\text{NH}_3]/[\text{NH}_4^+] = 1.8 \times 10^{-5} \times 0.250/0.150 = 3.0 \times 10^{-5} \text{ mol L}^{-1}$ → Base on top	☐
4 PH	pOH = 4.52, so pH = 14.00 - 4.52 = 9.48	☐

WHERE MARKS ARE LOST

- Put the base concentration in the numerator for [OH⁻]. Inverting the ratio gives pH 9.03.
- Assume the equilibrium concentrations equal the initial concentrations; this is valid for a buffer.

6.3.7 Buffers: preparation & properties · 6.2.2 pH, pOH, [H⁺], [OH⁻] calculationsPRACTISE NEXT ☐ 2019 Q22 ☐ 2021 Q34 ☐ 2023 Q23☐ GOT IT ☐ REVISIT ☐ REDO

26

Evaluate fermentation of sugar cane and hydration of ethene for producing fuel ethanol

5
MARKS

1 FERMENTATION EQUATION	$C_6H_{12}O_6(aq) \longrightarrow 2C_2H_5OH(aq) + 2CO_2(g)$ (yeast, 30–37°C, anaerobic)	☐
2 HYDRATION EQUATION	$CH_2=CH_2(g) + H_2O(g) \longrightarrow CH_3CH_2OH(g)$ (H_3PO_4 , 300°C, 6–7 MPa)	☐
3 FERMENTATION: FOR AND AGAINST	Renewable feedstock; the CO_2 released was absorbed by the growing cane, so it is closer to carbon neutral; low-energy conditions. But it is slow and batch-based, and the 15% product must be distilled, which uses a lot of energy; it also competes with food for land	☐
4 HYDRATION: FOR AND AGAINST	Fast, continuous and high purity, with unreacted ethene recycled. But the feedstock is crude oil (non-renewable), so burning the ethanol adds fossil CO_2 ; high temperature and pressure use a lot of energy	☐
5 JUDGEMENT	For a fuel, sustainability matters most, so fermentation is more suitable , especially if the distillation energy comes from renewable sources (eg burning bagasse) → “Evaluate” needs a judgement	☐

WHERE MARKS ARE LOST

- “Evaluate” requires a judgement, not just a list of features.
- Use the information in the table, and include both equations: they carry marks.

7.4.5 Producing alcohols, fermentation · 7.3.1 Addition reactions (H_2 , X_2 , HX , H_2O)PRACTISE NEXT ☐ 2020 Q24(d) ☐ 2023 Q25(b) ☐ 2025 Q27(b)☐ GOT IT ☐ REVISIT ☐ REDO**27 (a)**

Pentyl ethanoate synthesis: why heat under reflux, and why use excess ethanoic acid

2
MARKS

1 REFLUX	Allows a long heating time to speed up this slow reaction; vapours of the volatile reactants and ester condense and return to the flask instead of escaping	☐
2 EXCESS ETHANOIC ACID	Esterification is an equilibrium. Excess acid shifts it to the right (Le Chatelier), converting more of the pentan-1-ol to ester → Excess raises yield, not rate	☐

WHERE MARKS ARE LOST

- Excess reagent increases the *yield*; it does not explain the faster rate.

7.5.3 Esterification & reflux

PRACTISE NEXT ☐ 2021 Q26(b) ☐ 2022 Q33☐ GOT IT ☐ REVISIT ☐ REDO**27 (b)**

Mass of pentan-1-ol needed for 50.0 g of pentyl ethanoate at 70.0% yield

2
MARKS

1 MOLES NEEDED	$n(\text{ester}) = 50.0 \div 130.18 = 0.3841 \text{ mol}$; with 70.0% yield, $n(\text{pentan-1-ol}) = 0.3841 \div 0.700 = 0.5487 \text{ mol}$ → Divide by the yield	☐
2 MASS	$m = 0.5487 \times 88.15 = \mathbf{48.4 \text{ g}}$	☐

WHERE MARKS ARE LOST

- Divide by the yield. Multiplying by 0.700 (23.7 g) would produce only 35.0 g of ester.

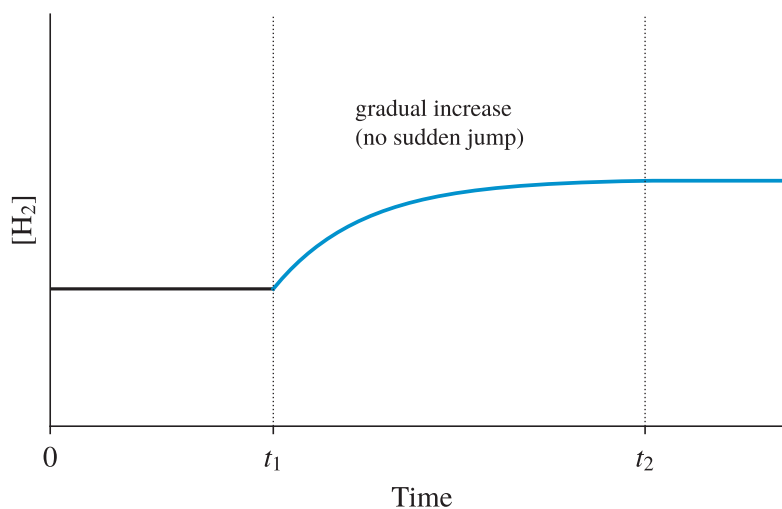
7.5.3 Esterification & reflux

PRACTISE NEXT ☐ 2025 Q25 ☐ 2025 Q27(c)☐ GOT IT ☐ REVISIT ☐ REDO

28

Steam reforming ($\Delta H = +206 \text{ kJ mol}^{-1}$): temperature raised at t_1 . Sketch $[\text{H}_2]$ and explain the rates4
MARKS

1 SKETCH

 $[\text{H}_2]$ rises gradually from t_1 (no jump) to a new, higher constant value by t_2

2 BOTH RATES INCREASE

Higher temperature means more frequent collisions, and more of them have energy $\geq E_a$. Both the forward and reverse rates increase
 → Say what happens to BOTH rates

3 FORWARD INCREASES MORE

The forward reaction is endothermic (higher E_a), so its rate increases more. Net forward reaction makes $[\text{H}_2]$ rise

4 NEW EQUILIBRIUM

As reactants are used up the forward rate falls and the reverse rate rises, until they are equal again at t_2 , both higher than before

WHERE MARKS ARE LOST

- Temperature changes do not produce a vertical jump in concentration: the change is gradual.
- Say what happens to BOTH rates; “the forward rate increases” alone is incomplete.

5.2.1 Le Chatelier: T , conc., pressure · 5.2.2 Explaining shifts with collision theoryPRACTISE NEXT ☐ 2019 Q25 ☐ 2024 Q26 ☐ 2025 Q29☐ GOT IT ☐ REVISIT ☐ REDO

290.150 mol L⁻¹ propanoic acid (pH 2.85) diluted from 10.0 mL to 100.0 mL: new pH**4**
MARKS

1 EQUATION AND [H⁺]	$\text{CH}_3\text{CH}_2\text{COOH} \rightleftharpoons \text{CH}_3\text{CH}_2\text{COO}^- + \text{H}^+$; $[\text{H}^+] = 10^{-2.85} = 1.41 \times 10^{-3} \text{ mol L}^{-1}$	☐
2 K_a	$K_a = (1.41 \times 10^{-3})^2 \div (0.150 - 1.41 \times 10^{-3}) = 1.34 \times 10^{-5}$ → Keep unrounded	☐
3 AFTER DILUTION	$c = 0.0150 \text{ mol L}^{-1}$; $x^2 / (0.0150 - x) = 1.34 \times 10^{-5}$. Assuming $x \ll 0.0150$: $x = \sqrt{(1.34 \times 10^{-5} \times 0.0150)} \approx 4.4 \times 10^{-4} \text{ mol L}^{-1}$ → State the assumption; it is valid (3% ionised)	☐
4 PH	$\text{pH} = -\log(4.4 \times 10^{-4}) = 3.35$ → Not 3.85: a weak acid ionises more when diluted	☐

WHERE MARKS ARE LOST

- A tenfold dilution of a weak acid raises the pH by only about 0.5, not 1. More of the acid ionises when it is diluted.
- State the assumption ($x \ll c$) when you use it, as NESA sample answers do. It is valid here because less than 5% of the acid ionises.
- Keep K_a unrounded until the final step.

6.3.4 K_a & $\text{p}K_a$ calculations · 6.2.2 pH, pOH, $[\text{H}^+]$, $[\text{OH}^-]$ calculationsPRACTISE NEXT ☐ 2021 Q6 ☐ 2023 Q35(a) ☐ 2024 Q28☐ GOT IT ☐ REVISIT ☐ REDO**30**

2.000 g of NaCl/KCl gives 4.482 g of AgCl: percentage of NaCl

3
MARKS

1 MOLES OF CHLORIDE	$n(\text{AgCl}) = 4.482 \div 143.35 = 0.03127 \text{ mol} = \text{total } n(\text{Cl}^-)$	☐
2 SET UP	Let m = mass of NaCl: $m/58.44 + (2.000 - m)/74.55 = 0.03127$ → Both chlorides precipitate	☐
3 SOLVE	$0.003698m = 0.004438$, so $m = 1.200 \text{ g}$; % NaCl = 60.0%	☐

WHERE MARKS ARE LOST

- Both chlorides contribute to the AgCl precipitate. This needs two unknowns linked by one total, not a single ratio.

8.1.3 Gravimetric & precipitation titrations

PRACTISE NEXT ☐ 2021 Q28 ☐ 2022 Q28(b) ☐ 2025 Q23☐ GOT IT ☐ REVISIT ☐ REDO**31(a)**Molar solubility of CaF₂ in pure water ($K_{sp} = 3.45 \times 10^{-11}$)**2**
MARKS

1 K_{sp} IN TERMS OF S	$\text{CaF}_2 \rightleftharpoons \text{Ca}^{2+} + 2\text{F}^-$; $K_{sp} = s(2s)^2 = 4s^3$ → $(2s)^2 = 4s^2$, not $2s^2$	☐
2 SOLVE	$s = (3.45 \times 10^{-11} \div 4)^{1/3} = 2.05 \times 10^{-4} \text{ mol L}^{-1}$	☐

WHERE MARKS ARE LOST

- $(2s)^2 = 4s^2$, not $2s^2$.

5.4.4 K_{sp} expressions & solubilityPRACTISE NEXT ☐ 2022 Q19 ☐ 2024 Q32☐ GOT IT ☐ REVISIT ☐ REDO

31(b)

Maximum $[F^-]$, in mg L^{-1} , in water containing $4.0 \times 10^{-3} \text{ mol L}^{-1} \text{ Ca}^{2+}$

2

MARKS

1	CONCENTRATION	$[F^-] = \sqrt{(K_{sp}/[Ca^{2+}])} = \sqrt{(3.45 \times 10^{-11} \div 4.0 \times 10^{-3})} = 9.29 \times 10^{-5} \text{ mol L}^{-1}$	☐
2	CONVERT TO MG L^{-1}	$9.29 \times 10^{-5} \times 19.00 = 1.76 \times 10^{-3} \text{ g L}^{-1} = \mathbf{1.8 \text{ mg L}^{-1}}$ → Use F (19.00), not F_2	☐

WHERE MARKS ARE LOST

- Use the molar mass of F (19.00), not F_2 .

5.4.5 Predicting precipitates (Q vs K_{sp})PRACTISE NEXT ☐ 2021 Q19 ☐ 2023 Q34☐ GOT IT ☐ REVISIT ☐ REDO

32

Photosynthesis ($\Delta H^\circ = +2803 \text{ kJ mol}^{-1}$, $\Delta S^\circ = -262 \text{ J K}^{-1} \text{ mol}^{-1}$) as a non-equilibrium system

3

MARKS

1	ΔG° AT 25°C	$\Delta G^\circ = 2803 - 298 \times (-0.262) = \mathbf{+2881 \text{ kJ mol}^{-1}}$ → Convert ΔS to kJ	☐
2	NOT SPONTANEOUS	$\Delta G > 0$ at every temperature ($\Delta H > 0$, $\Delta S < 0$), so it only proceeds while light energy is continuously supplied	☐
3	OPEN SYSTEM	CO_2 and H_2O enter and O_2 leaves; products are continuously removed and used, so the forward and reverse rates never become equal	☐

WHERE MARKS ARE LOST

- Convert ΔS to $\text{kJ K}^{-1} \text{ mol}^{-1}$ (-0.262) before combining with ΔH .
- Link the sign of ΔG to the need for a continuous energy input.

5.1.3 Non-equilibrium systems (ΔH , ΔS , ΔG)PRACTISE NEXT ☐ 2021 Q33(b) ☐ 2022 Q36 ☐ 2024 Q37☐ GOT IT ☐ REVISIT ☐ REDO

33

 FeSCN^{2+} colorimetry ($\epsilon = 4.60 \times 10^3 \text{ L mol}^{-1} \text{ cm}^{-1}$, 1.00 cm): average K_{eq} from three mixtures

7

MARKS

1	INITIAL CONCENTRATIONS	Each mixture is 10.00 mL, so $c = 2.00 \times 10^{-3} \times V/10.00$. Fe^{3+} : 1.00, 1.20, 0.600 ($\times 10^{-3}$); SCN^- : 1.00, 0.600, 0.800 ($\times 10^{-3}$) mol L^{-1} → Apply the dilution first	☐
2	$[\text{FeSCN}^{2+}]$ FROM $A = \epsilon LC$	$c = A/4600$: 1.076×10^{-4} , 8.09×10^{-5} , $5.57 \times 10^{-5} \text{ mol L}^{-1}$	☐
3	EQUILIBRIUM CONCENTRATIONS	Subtract $[\text{FeSCN}^{2+}]$ from both: Fe^{3+} 8.92×10^{-4} , 1.119×10^{-3} , 5.44×10^{-4} ; SCN^- 8.92×10^{-4} , 5.19×10^{-4} , 7.44×10^{-4} → Both reactants	☐
4	K_{eq} MIXTURE 1	$1.076 \times 10^{-4} \div (8.92 \times 10^{-4})^2 = \mathbf{135}$	☐
5	K_{eq} MIXTURE 2	$8.09 \times 10^{-5} \div (1.119 \times 10^{-3} \times 5.19 \times 10^{-4}) = \mathbf{139}$	☐
6	K_{eq} MIXTURE 3	$5.57 \times 10^{-5} \div (5.44 \times 10^{-4} \times 7.44 \times 10^{-4}) = \mathbf{137}$	☐
7	AVERAGE	$(135 + 139 + 137) \div 3 = \mathbf{K_{eq} = 137}$	☐

WHERE MARKS ARE LOST

- Each solution is diluted by mixing: apply the dilution before setting up the ICE table.
- Subtract $[\text{FeSCN}^{2+}]$ from the initial concentrations of BOTH reactants.

5.3.2 K_{eq} calculations (ICE), Q vs K · 8.1.4 Colourimetry, UV-Vis & AASPRACTISE NEXT ☐ 2022 Q31 ☐ 2023 Q31 ☐ 2024 Q25☐ GOT IT ☐ REVISIT ☐ REDO

34 (a) Why a back titration was used for aspirin**2**
MARKS

1 PROBLEM WITH A DIRECT TITRATION Aspirin is only slightly soluble, and although its -COOH reacts quickly, hydrolysis of its ester group (the second OH^-) is slow at room temperature, so a direct titration has no reliable end point ☐

2 WHAT THE BACK TITRATION DOES A known excess of NaOH with heating makes the reaction go to completion; the leftover NaOH is then titrated quickly and accurately with HCl ☐

WHERE MARKS ARE LOST

- Mention both the reaction stoichiometry (2 OH^- per aspirin, which requires heating) and the end-point problem.

6.3.6 Household substances, back titration

PRACTISE NEXT ☐ 2021 Q35 ☐ 2023 Q32☐ GOT IT ☐ REVISIT ☐ REDO**34 (b)** Does the 300 mg aspirin tablet meet the $\pm 5\%$ regulation? (excess 25.00 mL of 0.2000 M NaOH , made to 100.0 mL, 20.00 mL aliquots vs 0.02500 M HCl)**7**
MARKS

1 MEAN TITRE Reject 15.42 mL (outlier). $(14.98 + 14.92 + 14.97) \div 3 = 14.96 \text{ mL}$
→ Concordant titres only ☐

2 HCL IN EACH TITRE $n(\text{HCl}) = 0.02500 \times 0.01496 = 3.739 \times 10^{-4} \text{ mol} = \text{excess } \text{OH}^- \text{ in each aliquot}$ ☐

3 SCALE TO THE FLASK $3.739 \times 10^{-4} \times 100.0/20.00 = 1.870 \times 10^{-3} \text{ mol excess } \text{OH}^-$
→ The most commonly missed mark ☐

4 NAOH ADDED $n(\text{OH}^-) = 0.2000 \times 0.02500 = 5.000 \times 10^{-3} \text{ mol}$ ☐

5 OH⁻ USED BY ASPIRIN $5.000 \times 10^{-3} - 1.870 \times 10^{-3} = 3.130 \times 10^{-3} \text{ mol}$; $n(\text{aspirin}) = \frac{1}{2} \times \text{this} = 1.565 \times 10^{-3} \text{ mol}$
→ Aspirin : $\text{OH}^- = 1 : 2$ ☐

6 MASS OF ASPIRIN $m = 1.565 \times 10^{-3} \times 180.16 = 0.2820 \text{ g} = 282 \text{ mg}$ ☐

7 JUDGEMENT Allowed $300 \pm 15 \text{ mg} = 285\text{--}315 \text{ mg}$. 282 mg is 6.0% low, so the tablet **does not meet** the regulation
→ No conclusion, no mark ☐

WHERE MARKS ARE LOST

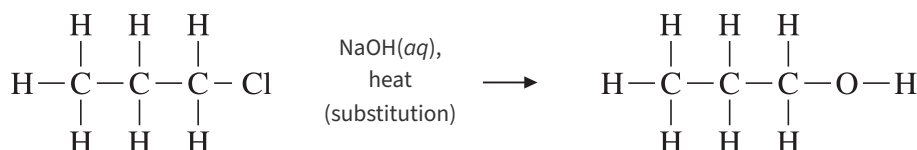
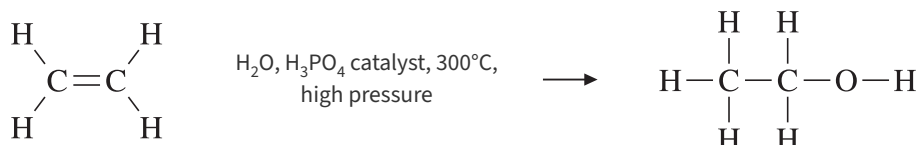
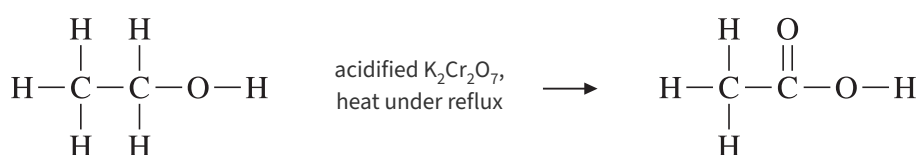
- Reject the rough/outlier titre before averaging.
- Scale the excess up from the 20.00 mL aliquot to the 100.0 mL flask ($\times 5$).
- Aspirin reacts with 2 OH^- . Using 1 : 1 gives 564 mg and the wrong conclusion.

6.3.6 Household substances, back titration · 6.3.1 Titration for unknown concentration

PRACTISE NEXT ☐ 2021 Q35 ☐ 2023 Q32 ☐ 2025 Q33☐ GOT IT ☐ REVISIT ☐ REDO

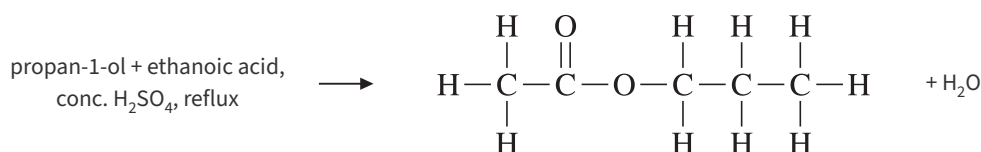
35

Synthesise propyl ethanoate using only 1-chloropropane and ethene as organic starting materials

4
MARKS1 1-
CHLOROPROPANE
→ PROPAN-1-OL2 ETHENE →
ETHANOL3 ETHANOL →
ETHANOIC ACID

→ Oxidise all the way to the acid

4 ESTERIFICATION



→ Ethene supplies the acid half

WHERE MARKS ARE LOST

- Ethene supplies the two-carbon acid part (via ethanol) and 1-chloropropane supplies the three-carbon alcohol part. Reversing these gives ethyl propanoate.
- The primary alcohol must be oxidised fully to the acid: use excess oxidant and reflux.

7.5.6 Multi-step reaction pathways · 8.3.1 Designing a synthesis process · 7.3.1 Addition reactions (H_2 , X_2 , HX , H_2O)PRACTISE NEXT ☐ 2019 Q34 ☐ 2021 Q26(a) ☐ 2025 Q37☐ GOT IT ☐ REVISIT ☐ REDO

36 (a)

Why X is an ester rather than a carboxylic acid

2
MARKS

1 NO O-H

There is no very broad O-H (acid) absorption at $2500\text{--}3000\text{ cm}^{-1}$ (data sheet), and X does not react with Na_2CO_3 , so there is no $-\text{COOH}$

2 ESTER ABSORPTIONS

Strong $\text{C}=\text{O}$ at 1742 cm^{-1} and $\text{C}-\text{O}$ at 1241 and 1047 cm^{-1} are consistent with an ester

→ $\text{C}=\text{O}$ alone doesn't distinguish them

WHERE MARKS ARE LOST

- The $\text{C}=\text{O}$ peak alone does not distinguish the two classes; the absence of the O-H band does.
- Quote the data-sheet ranges: O-H (acids) $2500\text{--}3000\text{ cm}^{-1}$, $\text{C}=\text{O}$ $1680\text{--}1750\text{ cm}^{-1}$, $\text{C}-\text{O}$ $1000\text{--}1300\text{ cm}^{-1}$.

8.2.2 Spectroscopy: ^1H & ^{13}C NMR, MS, IRPRACTISE NEXT ☐ 2020 Q30 ☐ 2024 Q4☐ GOT IT ☐ REVISIT ☐ REDO

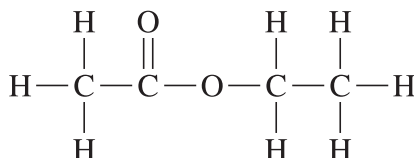
36 (b)

Identify X and Y ($C_4H_8O_2$), with the alcohol and acid for each, using the NMR data and mass spectra

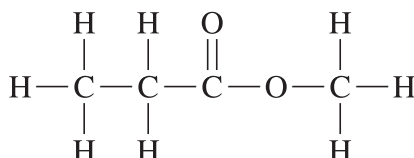
6

MARKS

1 X: ETHYL ETHANOATE

☐Made from **ethanol** and **ethanoic acid**

2 Y: METHYL PROPANOATE

☐Made from **methanol** and **propanoic acid**3 X: ^1H NMR2.04 singlet (3H) = CH_3-CO- ; 4.12 quartet (2H) = $-O-CH_2-$ next to CH_3 ; 1.26 triplet (3H) = that CH_3 → Shift of the CH_2 decides the side☐4 Y: ^1H NMR3.67 singlet (3H) = $O-CH_3$; 2.32 quartet (2H) = $-CH_2-CO-$ next to CH_3 ; 1.14 triplet (3H)☐

5 MASS SPECTRA

Both $M^+ = 88$ ($C_4H_8O_2$). X base peak 43 = CH_3CO^+ ; Y base peak 57 = $CH_3CH_2CO^+$, with 29 = $C_2H_5^+$ ☐6 ^{13}C AND RULING OUTFour signals each: a short $C=O$ signal near 170–175 ppm and a $C-O$ carbon near 60 ppm (X) or 52 ppm (Y), in the data-sheet ranges; no 8.0–8.2 ppm ^1H signal, so neither is a methanoate☐

→ Read the spectra against the data-sheet ranges

WHERE MARKS ARE LOST

- The chemical shift of the CH_2 quartet decides which side of the $-COO-$ group the ethyl group is on: about 4.1 ppm means it is bonded to O; about 2.3 ppm means it is bonded to $C=O$.
- Link each piece of evidence to a specific structural feature.

8.2.2 Spectroscopy: ^1H & ^{13}C NMR, MS, IR · 7.5.3 Esterification & refluxPRACTISE NEXT ☐ 2020 Q30 ☐ 2022 Q30 ☐ 2025 Q36☐ GOT IT ☐ REVISIT ☐ REDO