2025 HSC Chemistry Marking Guidelines

Section I

Multiple-choice Answer Key

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

Section II

Question 21

Criteria	Marks
• Correctly identifies both the reaction condition AND product	2
• Correctly identifies either the reaction condition OR product	1

Sample answer:

Reaction condition X	*IUPAC name of organic product*
UV light	2-bromobutane

Question 22

Criteria	Marks
• Outlines the need for both analysis types	2
• Provides some relevant information	1

Sample answer:

Qualitative analysis allows the identification of a pollutant present in the water. Quantitative analysis allows for the amount of the pollutant present to be determined.

Question 23

Criteria	Marks
• Justifies TWO appropriate changes with justifications of both related to accuracy	3
• Justifies ONE appropriate change OR • Identifies TWO appropriate changes	2
• Provides some relevant information	1

Sample answer:

Filter out any insoluble components before step 4, or else these will contribute to the mass of the precipitate.

Weigh the filter paper, or else the mass of the precipitate will be inaccurate.

Answers could include:

- Dry to constant mass (step 6) else water will contribute to the mass of precipitate.
- Rinse the precipitate with distilled water during step 5 to prevent soluble salts from crystallising on the precipitate.
- Add more $BaCl_2$ solution to the filtrate after step 5 to ensure all sulfate has precipitated.
- Use finer filter paper and a Buchner funnel, to ensure solid is captured.

Question 24 (a)

Criteria	Marks
• Correctly draws the structural formula AND correctly identifies the shape	2
• Correctly draws the structural formula OR correctly identifies the shape	1

Sample answer:

Structural formula	*Shape of molecule*
H — C ≡ C — H	Linear

Question 24 (b)

Criteria	Marks
• Calculates the correct mass of chloroethene AND provides a correct chemical equation	3
• Provides the main steps of the calculation OR • Provides some steps of the calculation AND a correct chemical equation	2
• Provides some relevant information	1

Sample answer:

$C_2H_2 + HCl \longrightarrow C_2H_3Cl$

$$\text{Moles of } C_2H_2 = \frac{65.0}{26.04} = 2.50 \text{ mol}$$

$$n\ C_2H_3Cl = nC_2H_2$$
$$= 2.50 \text{ mol}$$
$$m\ C_2H_3Cl = 2.50 \times 62.50 = 156.25 \text{ g}$$
$$= 156 \text{ g}$$

Question 25

Criteria	Marks
• Provides the correct calculations, with correct significant figures	3
• Provides substantially correct calculations OR • Provides the correct calculations with incorrect significant figures	2
• Provides some relevant information	1

Sample answer:

Mass of ester $= 12.2 \times 0.873 = 10.65$ g

Moles of ester $= \dfrac{10.65}{130.2} = 0.0818$ moles

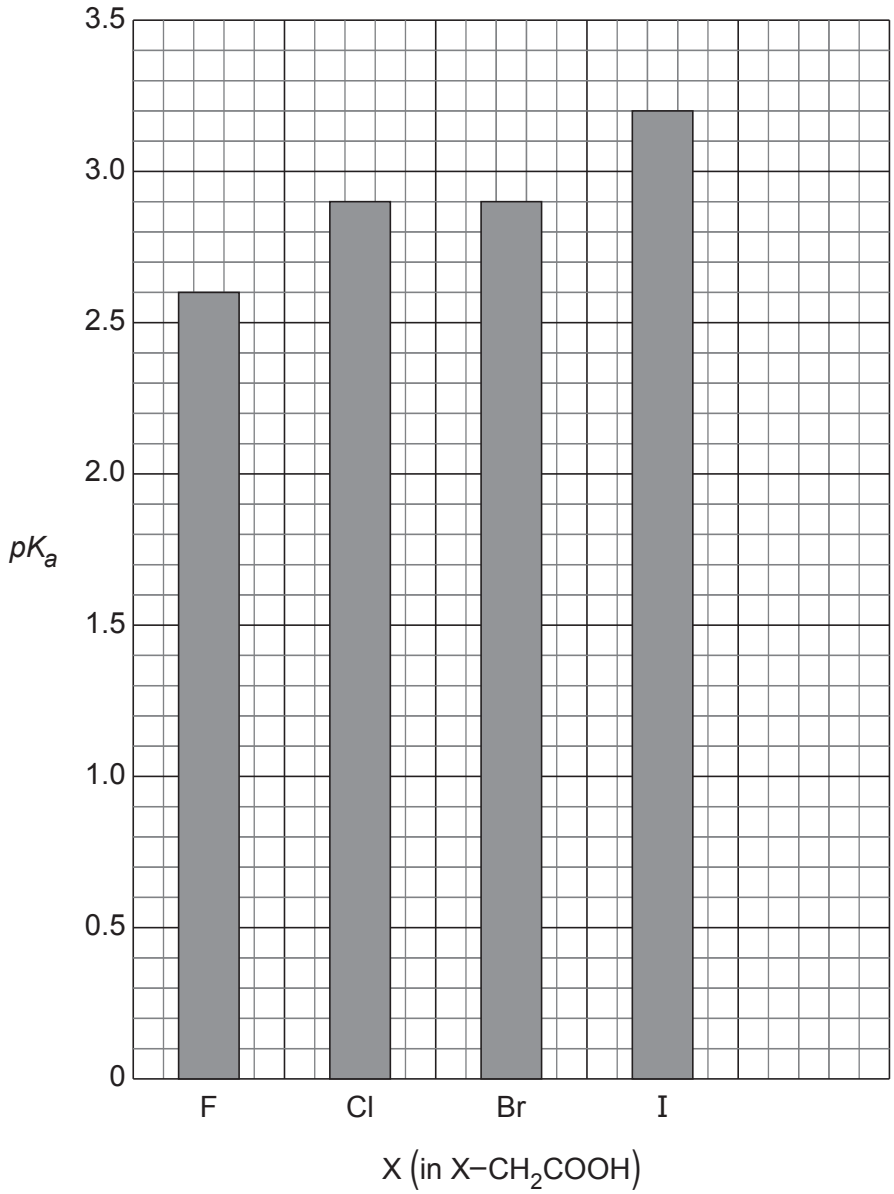
From the data provided, butanoic acid was in excess, propan-1-ol was limiting, so the theoretical yield is 0.267 moles.

Actual yield $= \dfrac{0.0818}{0.267} \times 100\% = 30.6\%$ (3 significant figures)

Question 26 (a)

Criteria	Marks
• Draws a column graph with accurate scales, axes labels and column heights	3
• Draws a substantially correct graph	2
• Provides a relevant graphical feature	1

Sample answer:



Question 26 (b)

Criteria	Marks
• Correctly describes the trend between acid strength and the identity of the halogen X	2
• Provides some relevant information	1

Sample answer:

From the graph, as the halogen changes going down the group, the strength of the haloethanoic acid decreases.

Question 27 (a)

Criteria	Marks
• Outlines the use AND environmental impact of a named hydrocarbon mixture	2
• Outlines the use OR environmental impact of a named hydrocarbon mixture	1

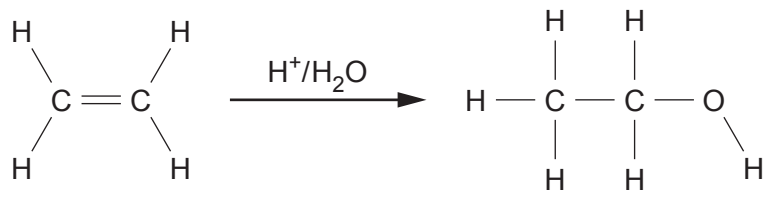
Sample answer:

Combustion of petrol used in vehicle engines produces CO_2. This leads to increased levels of CO_2 in the atmosphere which contributes to climate change.

Question 27 (b)

Criteria	Marks
• Provides a chemical equation with correct structural formulae of organic reactants and product, which includes aqueous acidic conditions	3
• Provides a chemical equation with correct structural formulae of organic reactants and product OR • Provides a chemical equation with correct formulae of organic reactants OR products, which includes aqueous acidic conditions	2
• Provides some relevant information	1

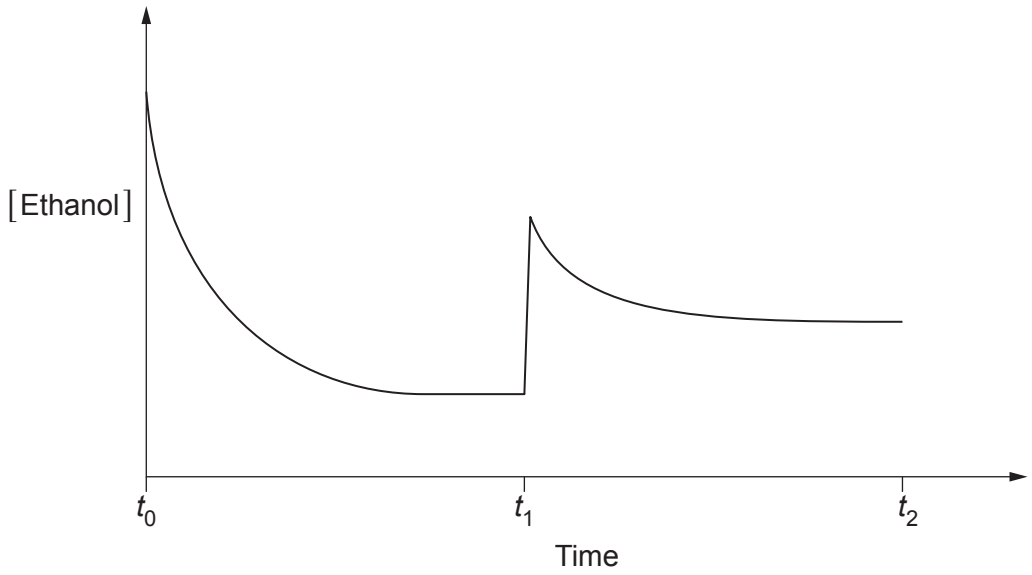
Sample answer:



Question 27 (c)

Criteria	Marks
• Sketches a graph showing the correct changes to the concentration of ethanol	3
• Sketches a graph showing most of the correct changes to the concentration of ethanol	2
• Provides a relevant graphical feature	1

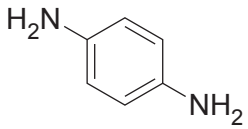
Sample answer:



Question 28 (a)

Criteria	Marks
• Correctly identifies the structure of the monomer	1

Sample answer:



Question 28 (b)

Criteria	Marks
• Explains the intermolecular forces in both polystyrene and Kevlar and relates these forces to the physical properties of the polymers	3
• Identifies the correct intermolecular forces in both polystyrene and Kevlar	2
• Provides some relevant information	1

Sample answer:

Polystyrene only has dispersion forces between individual chains.

Kevlar has hydrogen bonding between individual chains, as well as dispersion forces.

As H-bonds are stronger than dispersion forces for similarly sized molecules, it is harder to pull apart Kevlar polymer chains as compared to polystyrene.

Question 29

Criteria	Marks
• Provides a thorough explanation of the impact on the temperature of this system	4
• Provides an explanation that shows a sound understanding of equilibrium systems	3
• Provides a description of an impact on the system	2
• Provides some relevant information	1

Sample answer:

Addition of argon gas does not change the amount of NO_2 or N_2O_4 present. As the volume of the system remains consistent, the concentrations of NO_2 and N_2O_4 are unchanged. Therefore $Q = K_{eq}$ and the system remains at equilibrium. Accordingly, the temperature remains constant.

Answers could include:

The rates of the forward and reverse reaction remain equal, and the system remains at equilibrium.

The system is undisturbed and remains at equilibrium, in accordance with Le Châtelier's Principle.

The partial pressures of NO_2 and N_2O_4 are unchanged.

Question 30 (a)

Criteria	Marks
• Justifies a named precaution	2
• Provides any relevant information	1

Sample answer:

Phosgene is dangerous to the environment because it is toxic. Therefore, it is important to ensure it does not leak from the reaction vessel, which requires constant monitoring.

Answers could include:

– Regular maintenance of reaction vessels
– Sufficient training of industry staff
– Correct PPE for all staff
– Ensuring gas pressures stay below safe limits

Question 30 (b)

Criteria	Marks
• Explains the use of a catalyst AND • Explains the use of a large excess of CO	3
• Describes how BOTH features affect the reaction but does NOT link cause and effect OR • Explains how one feature affects the reaction	2
• Provides any relevant information	1

Sample answer:

The use of a catalyst saves time and money because it increases the rate of reaction by lowering the activation energy. The use of a large excess of CO causes the equilibrium to shift to the products side, therefore improving the yield of phosgene.

Question 31 (a)

Criteria	Marks
• Confirms the molecular formula using a substantially correct chemical equation	2
• Provides a partially correct chemical equation OR • Provides some relevant reasoning	1

Sample answer:

Stoichiometry implies that a hydrazine molecule contains 2 nitrogen atoms and 4 hydrogen atoms.

$$N_xH_y(g) + 3O_2(g) \longrightarrow 2NO_2(g) + 2H_2O(g)$$

2 N atoms; 4 H atoms

Answers could include:

Given the volumes, the stoichiometry of the reaction is:

$$1N_xH_y(g) + 3O_2(g) \longrightarrow 2NO_2(g) + 2H_2O(g)$$

This only balances if $x = 2,\ y = 4$

$\therefore$ N_2H_4 is correct.

Question 31 (b)

Criteria	Marks
• Correctly calculates the pH • Provides a correct chemical equation	4
• Provides the main steps of the calculation	3
• Provides some steps of the calculation OR • Provides a correct chemical equation	2
• Provides some relevant information	1

Sample answer:

Hydrazinium ion, $N_2H_5^+$, reacts with water to produce an acidic solution in the following way:

$$N_2H_5^+(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + N_2H_4(aq)$$

R	$N_2H_5^+(aq)$	$H_2O(l)$	$H_3O^+(aq)$	$N_2H_4(aq)$
I	0.20	–	0	0
C	$-x$	–	$+x$	$+x$
E	$(0.20 - x)$	–	x	x

$$K_a = \frac{K_w}{K_b} = \frac{1.0 \times 10^{-14}}{1.7 \times 10^{-6}} = 5.88 \times 10^{-9}$$

Assume equilibrium concentration of $N_2H_5^+ = 0.20$ mol L^{-1} (ie, x is very small)

$$K_a = \frac{\left[H_3O^+\right]\left[N_2H_4\right]}{\left[N_2H_5^+\right]} = 5.88 \times 10^{-9}$$

$$\frac{x^2}{0.20} = 5.88 \times 10^{-9}$$

$$x = \sqrt{(5.88 \times 10^{-9} \times 0.20)}$$

$$x = 3.43 \times 10^{-5} = \left[H_3O^+\right]$$

$$\text{pH} = -\log_{10}(3.43 \times 10^{-5})$$

$$= 4.46$$

Question 32

Criteria	Marks
• Identifies the correct precipitate, with justification using correct calculations	5
• Identifies the correct precipitate, with justification using substantially correct calculations OR • Identifies the order of precipitation supported by substantially correct calculations	4
• Identifies the correct precipitate, supported by some relevant calculations OR • Identifies the incorrect precipitate(s), supported by substantially correct calculations	3
• Demonstrates some understanding of solubility constants and/or solubility products	2
• Provides some relevant information	1

Sample answer:

$[Mg^{2+}] = 6 \times 10^{-3}$ $[OH^-] = 1 \times 10^{-2}$ $\left[CO_3^{2-}\right] = 2 \times 10^{-3}$

$[Mg^{2+}][OH^-]^2 = 6 \times 10^{-7}$ $K_{sp} = 5.61 \times 10^{-12}$

$[Mg^{2+}]\left[CO_3^{2-}\right] = 1.2 \times 10^{-5}$ $K_{sp} = 6.82 \times 10^{-6}$

$Mg(OH)_2$ is a lot less soluble than $MgCO_3$.

$Mg(OH)_2$ will precipitate. The Mg^{2+} is in excess. Its concentration will drop to approximately $6 \times 10^{-3} - \frac{1 \times 10^{-2}}{2} = 1 \times 10^{-3}$.

$[Mg^{2+}]\left[CO_3^{2-}\right]$ becomes 2×10^{-6} which is less than K_{sp}.

$MgCO_3$ won't precipitate.

Question 33

Criteria	Marks
• Correctly identifies the brand • Provides all correct calculations • Provides a balanced chemical equation including states	7
• Provides substantially correct calculations • Provides a balanced chemical equation	6
• Provides the main steps in the calculation • Provides a balanced chemical equation	4–5
• Provides some steps in the calculation	2–3
• Provides some relevant information	1

Sample answer:

Exclude the outlier.

Average volume KOH used excluding Trial 1 $= \dfrac{7.10 + 7.20 + 7.15}{3} = 0.00715$ L

$HCl(aq) + KOH(aq) \longrightarrow KCl(aq) + H_2O(l)$

moles KOH $= 0.10 \times 0.00715 = 0.000715$ mol KOH

Ratio HCl : KOH = 1 : 1 $\quad \therefore$ 0.000715 mol HCl for each sample

$\therefore$ $0.000715 \times 5 = 0.003575$ mol total in sampled solution

Initial nHCl $= 0.550 \times 0.1000 = 0.0550$ mol HCl

nHCl that reacted with $CaCO_3 = 0.0550 - 0.003575$

$= 0.051425$ mol HCl

$2HCl(aq) + CaCO_3(s) \longrightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$

Ratio HCl : $CaCO_3$ = 2 : 1 $\quad \therefore \dfrac{0.051425}{2} = 0.0257125$ mol $CaCO_3$

Mass $CaCO_3 = 0.0257125 \times MM\ CaCO_3\ (100.09)$

$= 2.5735641$ g

$\%\ CaCO_3 = \dfrac{2.5735641}{3.00} \times 100 = 85.7854\% \approx 85.8\%$

Chalk sample has to be Brand X.

Question 34 (a)

Criteria	Marks
• Correctly calculates the K_a of the acid	3
• Provides a substantially correct calculation	2
• Provides some relevant information	1

Sample answer:

From the shape of the titration curve, the acid was weak.

Halfway to the equivalent point, at 0.012 L, $[HA] = [A^-]$

Here the pH is approximately 4.4, or $[H^+]$ is 4.0×10^{-5}.

$$K_a = [H^+] \times \frac{[A^-]}{[HA]}$$

At this pH, $[A^-] = [HA]$ so $K_a = 4.0 \times 10^{-5}$.

Answers could include:

Equivalence point is at 0.024 L NaOH added.

Shape of curve shows acid is monoprotic.

$[HA] \times 0.010 = 0.1 \times 0.024$

$[HA] = 0.24 \text{ mol L}^{-1}$

pH at start is approximately 2.5

So, $[H^+] = 3.16 \times 10^{-3}$

$$K_a = \frac{[H^+][A^-]}{[HA]} \qquad [A^-] = [H^+]$$

$[HA] = 0.24 - 3.16 \times 10^{-3}$

$= 0.237$

$$K_a = \frac{(3.16 \times 10^{-3})^2}{0.237} = 4.2 \times 10^{-5}$$

Question 34 (b)

Criteria	Marks
• Provides a valid explanation	2
• Provides some relevant information	1

Sample answer:

Some of the hydroxide was neutralised by the acid.

The 10 mL of acid also diluted the NaOH.

So the NaOH concentration of the mixture will be less than 0.1 mol L^{-1} and the pH will be less than 13.

Question 35

Criteria	Marks
• Shows how both Le Chatelier's principle AND collision theory account for the colour change, with reference to the energy profile	5
• Demonstrates a sound understanding of how both collision theory AND Le Chatelier's principle account for the colour change	4
• Demonstrates a sound understanding of how collision theory OR Le Chatelier's principle accounts for the colour change	3
• Demonstrates some understanding of collision theory OR Le Chatelier's principle	2
• Provides some relevant information	1

Sample answer:

The energy profile diagram shows that the forward reaction is exothermic.

Le Chatelier's principle considers heat as a 'substance' that the system seeks to replace when lost. As this system is cooled, it responds in a way as to minimise the disturbance. Consequently, the forward reaction is favoured so the solution turns pink.

Collision theory considers the proportion of molecules above a particular activation energy. Decreasing the temperature slows the rates of both forward and reverse reactions, due to a drop in the average kinetic energy of all particles. However, the rate of the reverse reaction decreases more than the forward reaction. This is due to a greater proportion of particles falling below the relatively higher activation energy of the reverse reaction, E_{a2}, as shown in the reaction profile. Since the forward reaction is faster, $\left[CoCl_4^{2-}\right]$ will decrease, and $\left[Co(H_2O)_6^{2+}\right]$ will increase, and the colour changes to pink.

Question 36

Criteria	Marks
• Predicts the expected spectroscopic observations of ALL four techniques showing an extensive understanding of the relationship between molecular features and spectroscopic outcomes for these techniques	7
• Predicts the expected spectroscopic observations of ALL four techniques showing a thorough understanding of the relationship between molecular features and spectroscopic outcomes for these techniques	6
• Predicts the expected spectroscopic outcomes of most techniques showing a sound understanding of the relationship between molecular features and spectroscopic outcomes for these techniques	4–5
• Relates the expected spectroscopic outcomes of some techniques showing a basic understanding of the relationship between molecular features and spectroscopic outcomes for these techniques	2–3
• Provides some relevant information	1

Answers could include:

IR

- Strong broad OH signal at approximately 2750 cm^{-1}
- Strong sharp CO signal at approximately 1700 cm^{-1}

^{13}C NMR

- 3 chemical environments (either outright stated or through inference)
- 1 signal at 5−40 ppm (CH_3)
- 1 signal at 20−50 ppm (CH_2)
- 1 signal at 160−185 ppm (acid CO)

^{1}H NMR

- 3 chemical environments (either outright stated or through inference)
- 1 signal at 0.7−2.1 ppm (CH_3), triplet splitting pattern, integration of 3
- 1 signal at 2.1−4.5 ppm (CH_2), quartet splitting pattern, integration of 2
- 1 signal at 9.0−13.0 ppm (COOH), singlet, integration of 1

MS

- Molecular ion at 74 m/z

Question 37

Criteria	Marks
• Correctly determines the structure of compound A • Correctly justifies the structure using all the data provided	4
• Correctly determines the structure of compound A AND justifies the structure using some of the data provided OR • Correctly interprets all of the data provided	3
• Correctly interprets some of the data provided	2
• Provides some relevant information	1

Sample answer:

Compounds B and C are alkanols.

Compound B cannot be oxidised – so B must be a tertiary alkanol, therefore there must be branching.

Compound C can be oxidised but not to a carboxylic acid (no reaction with carbonate) – so the oxidation product is a ketone, so compound C is a secondary alkanol.

To explain the alkanols produced above, the C$=$C in compound A is not in the terminal position.

Therefore compound A is 2-methylbut-2-ene $\left(C_5H_{10}\right)$.

2025 HSC Chemistry Mapping Grid

Section I

Question	Marks	Content	Syllabus outcomes
1	1	Mod 6 Properties of Acids and Bases	12-13
2	1	Mod 7 Alcohols	12-14
3	1	Mod 7 Nomenclature	12-14
4	1	Mod 8 Analysis of Inorganic Substances	12-13
5	1	Mod 5 Static and Dynamic Equilibrium	12-12
6	1	Mod 6 Using Brønsted–Lowry Theory	12-4, 12-13
7	1	Mod 8 Analysis of Inorganic Substances	12-2, 12-15
8	1	Mod 8 Analysis of Organic Substances	12-15
9	1	Mod 7 Reactions of Organic Acids and Bases	12-12
10	1	Mod 7 Reactions of Organic Acids and Bases	12-14
11	1	Mod 6 Using Brønsted–Lowry Theory	12-13
12	1	Mod 5 Calculating the Equilibrium Constant	12-4, 12-12
13	1	Mod 5 Static and Dynamic Equilibrium	12-12
14	1	Mod 5 Factors that Affect Equilibrium	12-4, 12-5, 12-12
15	1	Mod 7 Products of Reactions Involving Hydrocarbons	12-5, 12-14
16	1	Mod 7 Polymers	12-4, 12-14
17	1	Mod 8 Analysis of Organic Substances	12-15
18	1	Mod 8 Analysis of Inorganic Substances	12-6, 12-15
19	1	Mod 6 Quantitative Analysis	12-4, 12-13
20	1	Mod 5 Solution Equilibria	12-4, 12-12

Section II

Question	Marks	Content	Syllabus outcomes
21	2	Mod 7 Products of Reactions Involving Hydrocarbons	12-14
22	2	Mod 8 Analysis of Inorganic Substances	12-2, 12-15
23	3	Mod 8 Chemical Synthesis and Design	12-2, 12-15
24 (a)	2	Mod 7 Hydrocarbons	12-14
24 (b)	3	Mod 7 Products of Reactions Involving Hydrocarbons	12-14
25	3	Mod 7 Reactions of Organic Acids and Bases	12-4, 12-14
26 (a)	3	Mod 6 Properties of Acids and Bases	12-4, 12-13
26 (b)	2	Mod 6 Using Brønsted–Lowry Theory	12-5, 12-13
27 (a)	2	Mod 7 Hydrocarbons	12-14
27 (b)	3	Mod 7 Products of Reactions Involving Hydrocarbons	12-14
27 (c)	3	Mod 5 Static and Dynamic Equilibrium	12-4, 12-12
28 (a)	1	Mod 7 Polymers	12-7, 12-14
28 (b)	3	Mod 7 Polymers	12-14

Question	Marks	Content	Syllabus outcomes
29	4	Mod 5 Factors that Affect Equilibrium	12-6, 12-12
30 (a)	2	Mod 8 Chemical Synthesis and Design	12-2, 12-15
30 (b)	3	Mod 8 Chemical Synthesis and Design	12-7, 12-15
31 (a)	2	Mod 8 Analysis of Inorganic Substances	12-15
31 (b)	4	Mod 6 Quantitative Analysis	12-4, 12-13
32	5	Mod 5 Solution Equilibria	12-4, 12-6, 12-12
33	7	Mod 6 Quantitative Analysis	12-4, 12-13
34 (a)	3	Mod 6 Quantitative Analysis	12-13
34 (b)	2	Mod 6 Quantitative Analysis	12-4, 12-13
35	5	Mod 5 Factors that Affect Equilibrium	12-5, 12-7, 12-12
36	7	Mod 8 Analysis of Organic Substances	12-7, 12-15
37	4	Mod 8 Analysis of Organic Substances	12-15