

HSC Trial Examination 2019

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- NESA approved calculators may be used
- A formulae sheet, data sheet and Periodic Table are provided at the back of this paper
- For questions in Section II, show all relevant working in questions involving calculations

Total marks: 100

Section I – 20 marks (pages 2–7)

- Attempt Questions 1–20
- Allow about 35 minutes for this section

Section II – 80 marks (pages 8–27)

- Attempt Questions 21–38
- Allow about 2 hours and 25 minutes for this section

Students are advised that this is a trial examination only and cannot in any way guarantee the content or the format of the 2019 HSC Chemistry Examination.

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Section I

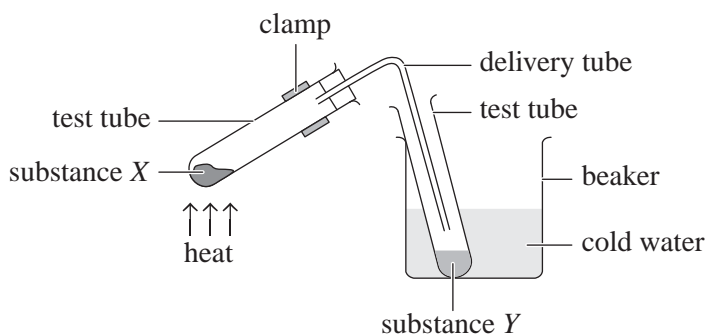
20 marks

Attempt Questions 1–20

Allow about 35 minutes for this section

Use the multiple-choice answer sheet for Questions 1–20.

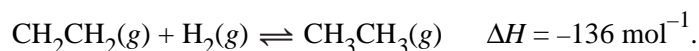
1. Which of the following statements about systems is correct?
- (A) An open system can transfer matter but not energy with its surroundings.
(B) An open system can transfer energy but not matter with its surroundings.
(C) A closed system can transfer energy but not matter with its surroundings.
(D) A closed system can transfer neither energy nor matter with its surroundings.
2. The diagram shows hydrated cobalt(II) chloride after it has been heated and all signs of a reaction have ceased.



Which row of the table correctly shows the most likely identities of the substances X and Y?

	<i>Substance X</i>	<i>Substance Y</i>
(A)	water	dehydrated cobalt(II) chloride
(B)	dehydrated cobalt(II) chloride	water
(C)	dehydrated cobalt(II) chloride	chlorine
(D)	cobalt(II) oxide	water

3. Consider the equilibrium process



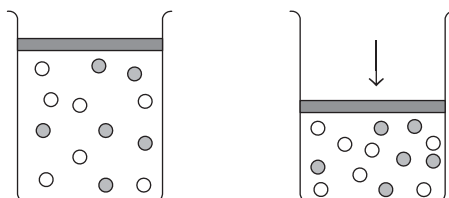
Which of the following changes would cause the magnitude of the equilibrium constant for this reaction to increase?

- (A) The temperature is decreased.
(B) The pressure is decreased.
(C) The concentration of H_2 in the equilibrium mixture is increased.
(D) The concentration of CH_3CH_3 in the equilibrium mixture is increased.

4. Which of the following aqueous solutions of ionic compounds would form a precipitate when mixed?

- (A) potassium chloride and sodium hydroxide
- (B) magnesium sulfate and sodium chloride
- (C) sodium iodide and ammonium nitrate
- (D) sodium sulfate and barium nitrate

5. The diagram shows a mixture of gases in a sealed container where the volume is decreased.



Which of the following statements most accurately describes this system?

- (A) As volume increases, the gas molecules move faster.
 - (B) As volume decreases, the gas molecules move further before colliding.
 - (C) As volume decreases, the gas molecules can have more collisions.
 - (D) Changing the volume has no effect on the movement of molecules.
6. The pH of an alkaline solution is 8.
- Which of the following expressions could represent this solution?

- (A) $[\text{OH}^-] = 10^{-8}$
- (B) $-\log_{10}[\text{H}^+] = 8$
- (C) $\log_{10}[\text{OH}^-] = 8$
- (D) $\log_{10}[\text{H}^+] = 8$

7. Magnesium reacts with dilute hydrochloric acid to liberate hydrogen.

What is the volume of hydrogen produced at 298.1 K and 100 kPa when 1.22 g of magnesium is reacted with excess dilute acid?

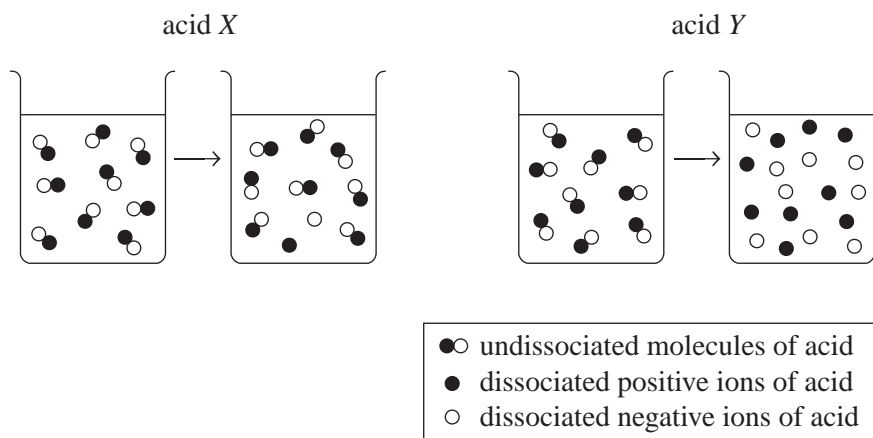
- (A) 1140 mL
- (B) 1240 mL
- (C) 2270 mL
- (D) 2450 mL

8. Nitric acid completely dissociates in aqueous solutions. 1.0 mL of 10 mol L⁻¹ solution was diluted to 1 L with distilled water. 100 mL of this resulting solution was then further diluted to 1 L using distilled water.

What pH is the final solution closest to?

- (A) 1
(B) 2
(C) 3
(D) 4

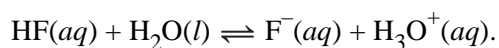
9. The diagram shows the behaviour of two different acids when they are dissolved in distilled water.



Which row of the table correctly describes the two acids?

	<i>Acid X</i>	<i>Acid Y</i>
(A)	concentrated	dilute
(B)	dilute	concentrated
(C)	strong	weak
(D)	weak	strong

- 10.** Consider the system



Which of the following represents a conjugate acid–base pair present in this system?

- (A) $\text{HF}(aq)/\text{F}^-(aq)$
 (B) $\text{HF}(aq)/\text{H}_3\text{O}^+(aq)$
 (C) $\text{HF}(aq)/\text{H}_2\text{O}(l)$
 (D) $\text{F}^-(aq)/\text{H}_3\text{O}^+(aq)$

11. In an experiment, 4-hydroxybutanoic acid $[\text{HO}(\text{CH}_2)_3\text{COOH}]$ forms a polymer containing 1000 monomer units.

Which of the following is closest to the approximate molar mass (in g mol^{-1}) of this polymer?

- (A) 2.0×10^2
(B) 1.4×10^4
(C) 8.6×10^4
(D) 1.0×10^5
12. How many hydrogen atoms are there in one molecule of 2,2-dimethylbutan-1-ol?
- (A) 8
(B) 10
(C) 12
(D) 14
13. Separate samples of hex-1-ene and hex-2-ene are reacted with bromine in the absence of light.
- Which of the following statements about these reactions is correct?
- (A) The product will be 1,2-dibromohexane.
(B) The products will be structural isomers of each other.
(C) The products will be isomeric dihaloalkenes.
(D) The products will be isomeric unsaturated compounds.
14. What type of reaction is represented by the conversion of hexan-3-ol to hexan-3-one?
- (A) addition
(B) substitution
(C) elimination
(D) oxidation
15. The infrared spectrum of a pure compound showed a broad band between 3000 and 3200 cm^{-1} ; a series of moderate bands at 2900 , 2990 and 3200 cm^{-1} ; an intense band at 1725 cm^{-1} ; and numerous bands between 1640 and 750 cm^{-1} .
- Which of the following compounds matches these absorbances?
- (A) ethene
(B) ethanol
(C) ethyl ethanoate
(D) ethanoic acid
16. Which type of bonding forms between the monomers that react together to form nylon polymers?
- (A) amide bonds
(B) ester bonds
(C) ionic bonds
(D) hydrogen bonds

17. Which of the following pairs of compounds are NOT isomers?

- (A) hexan-2-ol and 2,2-dimethylbutan-1-ol
- (B) methyl ethanoate and propanoic acid
- (C) butane and cyclobutane
- (D) butan-2-one and 2-methylpropanal

18. How many peaks would appear in the ^{13}C NMR spectra of pentan-3-one?

- (A) 2
- (B) 3
- (C) 4
- (D) 5

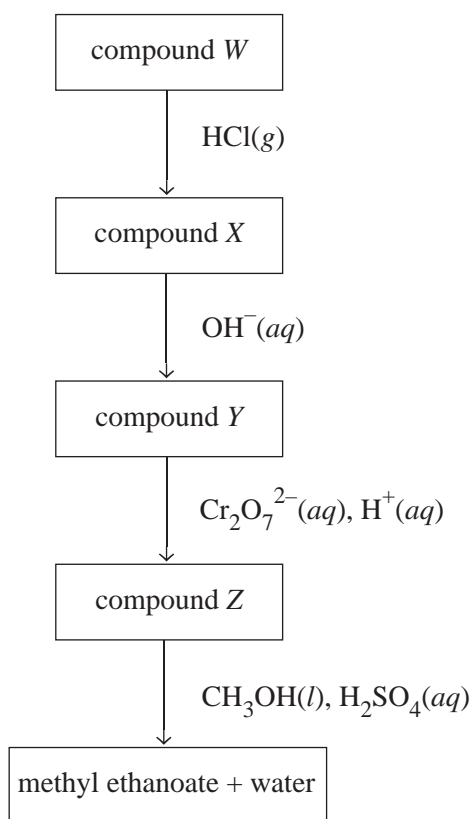
19. A solution was prepared by dissolving a pure compound in water. The solution was subjected to a series of tests. The results are shown in the table.

<i>Test</i>	<i>Reaction</i>
flame test	The flame turns lilac/pink.
adding $\text{BaCl}_2(\text{aq})$	A precipitate forms.
adding $\text{HCl}(\text{aq})$	Bubbles of gas form.

Which of the following compounds was dissolved into the water?

- (A) calcium carbonate
- (B) potassium carbonate
- (C) sodium sulfate
- (D) potassium sulfate

20. The flow chart shows a sequence of reactions that result in the formation of methyl ethanoate.



Which row of the table correctly identifies the compounds labelled W, X, Y and Z?

	<i>Compound W</i>	<i>Compound X</i>	<i>Compound Y</i>	<i>Compound Z</i>
(A)	ethane	chloroethane	ethanol	methanoic acid
(B)	methane	chloromethane	methanol	methanoic acid
(C)	ethane	chloroethane	ethanol	ethanoic acid
(D)	ethene	chloroethane	ethanol	ethanoic acid

Section II

80 marks

Attempt Questions 21–38

Allow about 2 hours and 25 minutes for this section

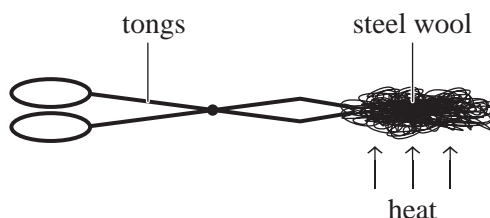
Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.

Show all relevant working in questions involving calculations.

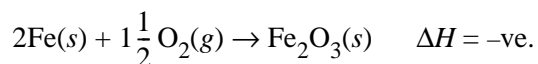
Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering.

Question 21 (5 marks)

The diagram shows heat applied to steel wool.



Steel wool is a mass of fine wire made of iron. When a flame is applied, the iron strands start to burn in air to produce iron(III) oxide according to the equation



- (a) What is the type of energy supplied by the flame to start the reaction? 1
-
- (b) What is the overall energy exchange with the surroundings for this reaction? Explain your answer. 1
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Question 21 continues on page 9

Question 21 (continued)

- (c) At the completion of the reaction it is said to be in static equilibrium. **1**

What is meant by the term 'static equilibrium'?

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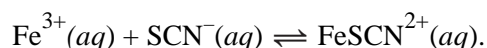
- (d) Describe how entropy changes in this reaction. **2**

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End of Question 21

Question 22 (5 marks)

Solutions of iron(III) nitrate and potassium thiocyanate react according to the equation



The iron thiocyanate ion has a blood-red colour, whereas other ions present have little or no colour.

Equimolar solutions of iron(III) nitrate and potassium thiocyanate were mixed. The concentrations of the various ions at equilibrium are shown in the table.

<i>Ion</i>	Fe^{3+}	SCN^{-}	FeSCN^{2+}
<i>Concentration at equilibrium (mol L⁻¹)</i>	0.0184	0.0184	0.0932

- (a) Calculate the equilibrium constant (K_{eq}) for the reaction.

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- (b) What does the calculated value of the equilibrium constant for this reaction indicate?

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- (c) Explain what would happen to the colour of this equilibrium mixture if an aqueous solution of sodium hydroxide was added.

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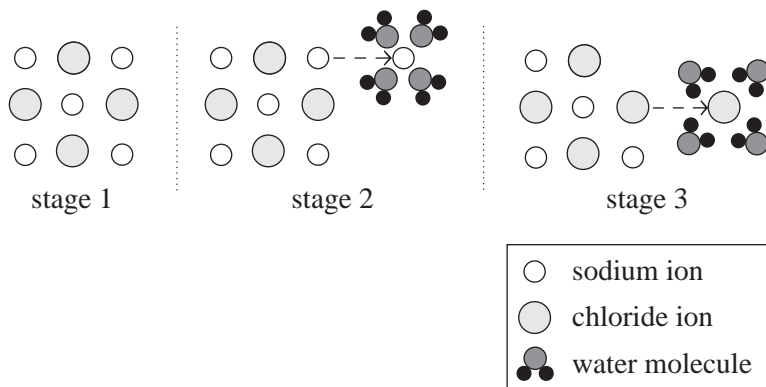
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Question 23 (5 marks)

The diagram shows sodium chloride (common salt) dissolving in water.



- (a) A saturated solution of sodium chloride in water was found to have a concentration of 359 g L^{-1} .

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With reference to the diagram, describe the dissociation of sodium chloride.

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- (b) Calculate the value of K_{sp} for this system.

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Question 24 (4 marks)

Consider the reaction



- (a) Using the reaction, outline how activation energy (E_a) varies for the forward and the reverse reactions in equilibrium reactions. **2**

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- (b) How would increasing the temperature affect this reaction? Explain your answer. **2**

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Question 25 (5 marks)

Carbonic acid is formed when carbon dioxide dissolves in water. Carbonic acid plays a major part in the buffering of human blood, which has a typical pH of 7.40. One way to show the ionisation of carbonic acid is



- (a) Write an expression for the equilibrium constant (K_{eq}) for this reaction. **1**

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- (b) Buffers play a role in many natural systems. **3**

Using human blood, or another relevant example, explain why buffers are important.

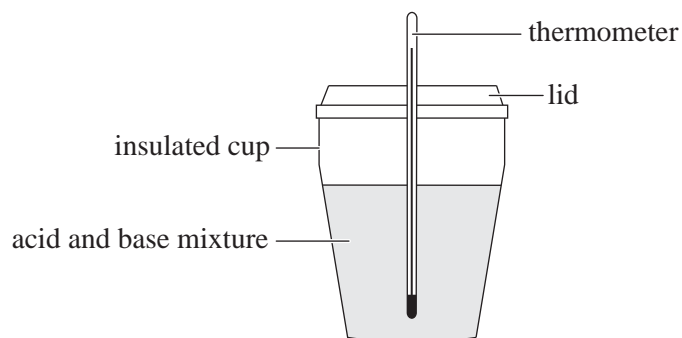
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- (c) What is the typical hydrogen ion concentration in human blood? Show your working. **1**

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Question 26 (8 marks)

The diagram shows a coffee cup calorimeter used by a student to measure the enthalpy of neutralisation of an acid–base reaction.



120 mL of 0.500 mol L^{-1} sodium hydroxide was added to 60.0 mL of 0.500 mol L^{-1} sulfuric acid. Both solutions were at a temperature of 24.2°C . After mixing, the final temperature was 26.3°C .

- (a) Calculate the enthalpy change per mole of water formed in this reaction.

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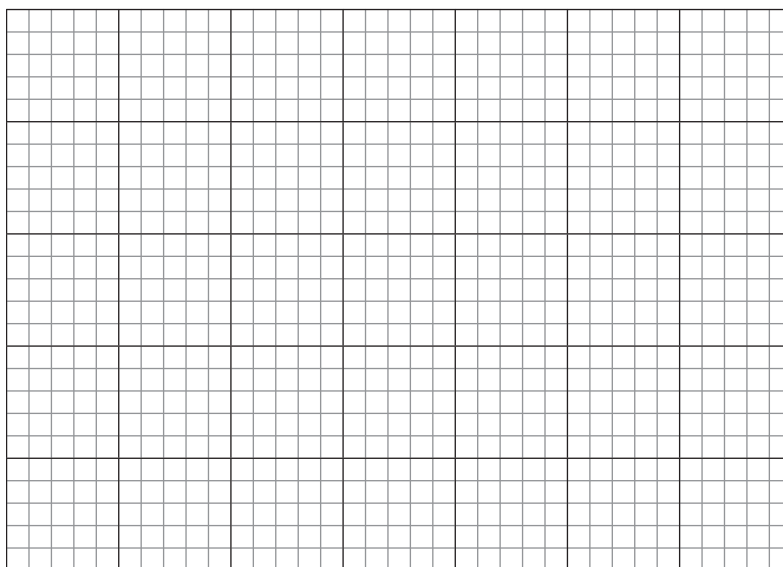
Question 26 continues on page 15

Question 26 (continued)

- (b) The heat of combustion of a number of alcohols was measured. The results are shown in the table. 3

<i>Alcohol</i>	<i>Enthalpy of combustion (kJ mol^{-1})</i>
methanol	-726
propan-1-ol	-2021
butan-1-ol	-2676
pentan-1-ol	-3331
hexan-1-ol	-3984

Using the data provided, construct a graph that shows the relationship between chain length (number of carbon atoms) and enthalpy of combustion for these alcohols.



- (c) Using the graph constructed in part (b), predict the value of the enthalpy of combustion of ethanol in kJ per gram of ethanol. 2

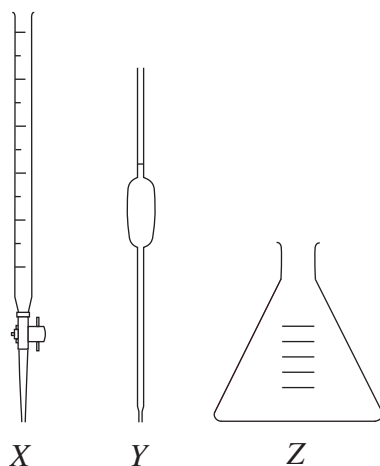
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End of Question 26

Question 27 (3 marks)

The diagram shows three pieces of glassware (*X*, *Y* and *Z*) used in conventional acid–base titrations (indicator colour change).

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Identify each piece of equipment and outline its role in a titration.

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Question 28 (4 marks)

Various models of acids and bases have been used over time.

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Compare the theories of Arrhenius and Brønsted–Lowry.

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Question 29 (6 marks)

A class was set the task of conducting a chemical analysis of a common household substance for its acidity or basicity.

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Describe TWO different methods of how this analysis could be conducted. In your answer, include any advantages and disadvantages of the methods.

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Question 30 (5 marks)

Complete the table by drawing the structural formulae for the products and naming the catalyst, if required.

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<i>Reactants</i>		<i>Products</i>	<i>Catalyst</i>
propene + H ₂	→		
but-2-ene + HCl	→		no catalyst
hex-3-ene + H ₂ O	→		

Question 31 (3 marks)

Describe how to prepare an ester in the school laboratory. Include a specific safety precaution in your answer.

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Question 32 (3 marks)

A 50.00 g sample contaminated with a small amount of potassium permanganate was dissolved into sufficient water to give 2.00 L of solution. The molar absorptivity, ϵ , of sodium permanganate at 526 nm is known to be $22\,400\text{ L mol}^{-1}\text{ cm}^{-1}$.

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Light of 526 nm was passed through a 1.00 cm wide sample of this solution. The absorbance was measured and found to be 0.398.

Determine the concentration, in parts per million (ppm), of potassium permanganate in the original 50.0 g sample.

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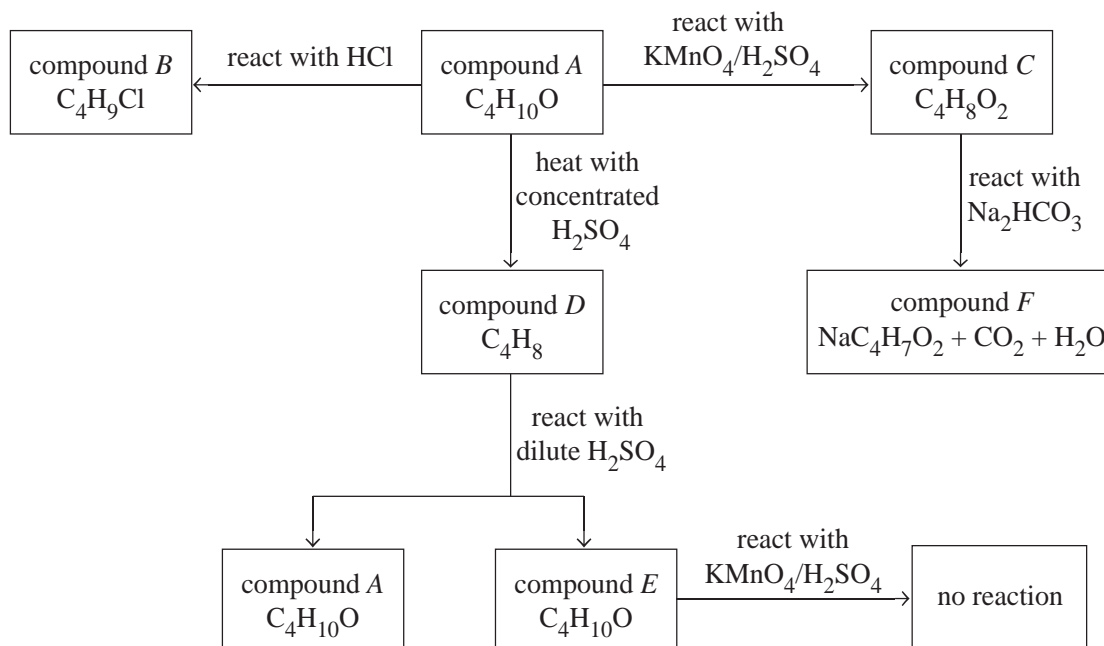
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Question 33 (6 marks)

The flow chart shows the reactions of six different organic compounds.

6

Complete the table by drawing the structural formulae for the compounds and justifying your answers with reference to the information provided.

Compound	Structural formula	Justification
Compound A C ₄ H ₁₀ O		
Compound B C ₄ H ₉ Cl		

Question 33 continues on page 21

Question 33 (continued)

<i>Compound</i>	<i>Structural formula</i>	<i>Justification</i>
Compound <i>C</i> $C_4H_8O_2$		
Compound <i>D</i> C_4H_8		
Compound <i>E</i> $C_4H_{10}O$		
Compound <i>F</i> $NaC_4H_7O_2$		

End of Question 33

Question 34 (3 marks)

Many people wash their dirty dishes with soapy water.

- (a) Describe how soapy water is able to clean dishes covered with grease or fat while fresh water is not. **2**

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- (b) Draw a diagram to show how soaps form micelles in water. **1**

Question 35 (3 marks)

A student collected a 50.0 mL sample of river water. He determined the concentration of chloride ions in the water by adding excess silver nitrate solution, filtering to collect the resulting precipitate, drying the precipitate overnight and weighing the dried precipitate. The mass of dried precipitate obtained was 1.05 g.

- (a) Write a balanced net ionic equation to account for the formation of the precipitate. **1**

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- (b) Calculate the percentage mass of chloride ion in the water sample. **2**

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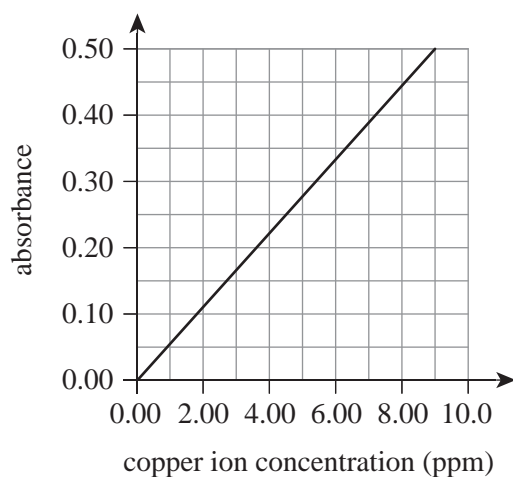
Question 36 (3 marks)

A copper mine was monitoring copper concentration in a stream. Five samples were collected from the stream and the absorbance of each sample was measured. The results are shown in the table.

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<i>Sample</i>	<i>Absorbance</i>
1	0.37
2	0.39
3	0.40
4	0.13
5	0.44

The absorbance of a series of standard $\text{Cu}(\text{NO}_3)_2$ solutions was then prepared. The measurements were graphed to obtain the standard curve shown.



Using the absorbance data and standard curve provided, determine a reliable value for the concentration of copper in the stream.

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Question 37 (4 marks)

Methanamide, HCONH_2 , is used in both drug manufacture and as an industrial solvent.

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Compare the factors that need to be considered when synthesising methanamide for these two purposes.

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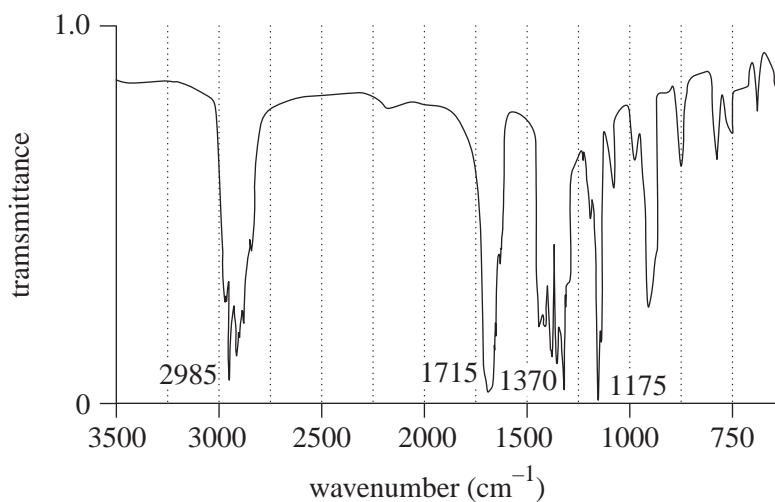
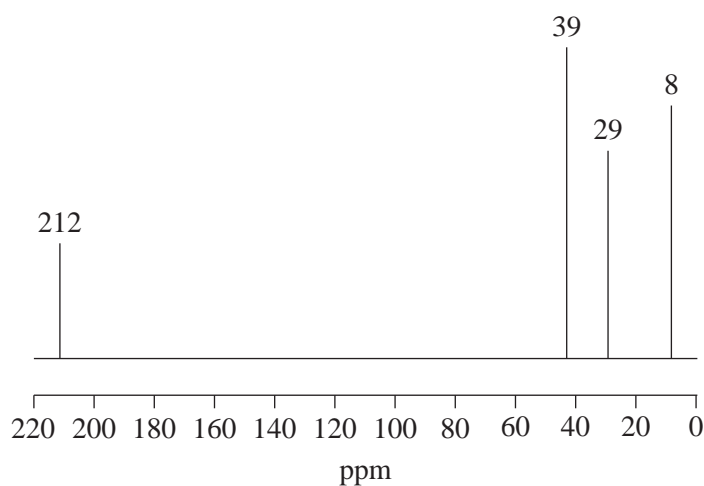
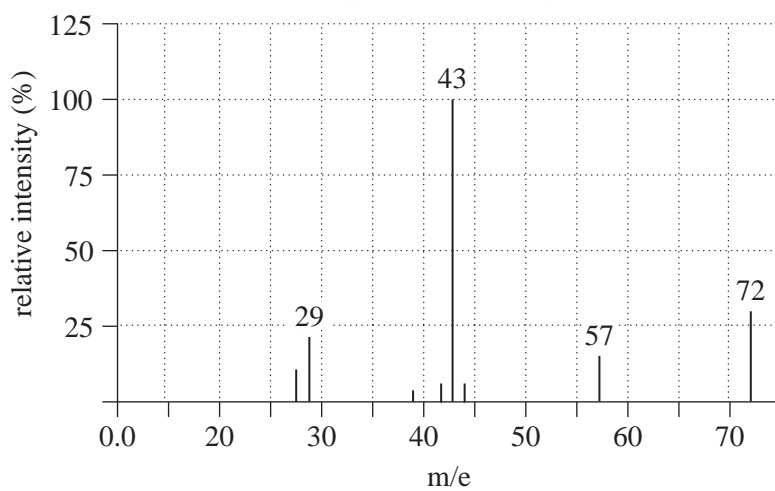
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Question 38 (5 marks)

A student investigating the identity of compound *X* examined the following spectroscopic data.

5**Infrared spectrum of compound *X*** **^{13}C NMR spectra of compound *X*****Mass spectrum of compound *X***

Question 38 continues on page 27

Question 38 (continued)

After narrowing down the identity of compound *X* to one of two possibilities, the student conducted a final chemical test to identify the compound. The student tested the reaction of compound *X* with acidified potassium permanganate and no colour change was observed.

Identify compound *X*. Support your answer with an analysis of the evidence provided.

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End of paper

FORMULAE SHEET

$$n = \frac{m}{MM}$$

$$c = \frac{n}{V}$$

$$PV = nRT$$

$$q = mc\Delta T$$

$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$$

$$\text{pH} = -\log_{10}[\text{H}^+]$$

$$\text{p}K_a = -\log_{10}[K_a]$$

$$A = \epsilon lc = \log_{10} \frac{I_o}{I}$$

Avogadro constant, N_A $6.022 \times 10^{23} \text{ mol}^{-1}$

Volume of 1 mole ideal gas: at 100 kPa and

at 0°C (273.15 K) 22.71 L

at 25°C (298.15 K) 24.79 L

Gas constant $8.314 \text{ J mol}^{-1} \text{ K}^{-1}$

Ionisation constant for water at 25°C (298.15 K), K_w 1.0×10^{-14}

Specific heat capacity of water $4.18 \times 10^3 \text{ J kg}^{-1} \text{ K}^{-1}$

DATA SHEET

Solubility constants at 25°C

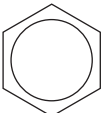
Compound	K_{sp}	Compound	K_{sp}
Barium carbonate	2.58×10^{-9}	Lead(II) bromide	6.60×10^{-6}
Barium hydroxide	2.55×10^{-4}	Lead(II) chloride	1.70×10^{-5}
Barium phosphate	1.3×10^{-29}	Lead(II) iodide	9.8×10^{-9}
Barium sulfate	1.08×10^{-10}	Lead(II) carbonate	7.40×10^{-14}
Calcium carbonate	3.36×10^{-9}	Lead(II) hydroxide	1.43×10^{-15}
Calcium hydroxide	5.02×10^{-6}	Lead(II) phosphate	8.0×10^{-43}
Calcium phosphate	2.07×10^{-29}	Lead(II) sulfate	2.53×10^{-8}
Calcium sulfate	4.93×10^{-5}	Magnesium carbonate	6.82×10^{-6}
Copper(II) carbonate	1.4×10^{-10}	Magnesium hydroxide	5.61×10^{-12}
Copper(II) hydroxide	2.2×10^{-20}	Magnesium phosphate	1.04×10^{-24}
Copper(II) phosphate	1.40×10^{-37}	Silver bromide	5.35×10^{-13}
Iron(II) carbonate	3.13×10^{-11}	Silver chloride	1.77×10^{-10}
Iron(II) hydroxide	4.87×10^{-17}	Silver carbonate	8.46×10^{-12}
Iron(III) hydroxide	2.79×10^{-39}	Silver hydroxide	2.0×10^{-8}
Iron(III) phosphate	9.91×10^{-16}	Silver iodide	8.52×10^{-17}
		Silver phosphate	8.89×10^{-17}
		Silver sulfate	1.20×10^{-5}

Aylward and Findlay, *SI Chemical Data* (5th Edition) is the principal source of data for this examination paper. Some data may have been modified for examination purposes.

Infrared absorption data

Bond	Wavenumber/cm ⁻¹
N—H (amines)	3300–3500
O—H (alcohols)	3230–3550 (broad)
C—H	2850–3300
O—H (acids)	2500–3000 (very broad)
C≡N	2220–2260
C=O	1680–1750
C=C	1620–1680
C—O	1000–1300
C—C	750–1100

¹³C NMR chemical shift data

Type of carbon	δ/ppm
$\begin{array}{c} \quad \\ -C - C- \\ \quad \end{array}$	5–40
$\begin{array}{c} \\ R - C - Cl \text{ or } Br \\ \end{array}$	10–70
$\begin{array}{c} \\ R - C - C - \\ \quad \\ O \end{array}$	20–50
$\begin{array}{c} \\ R - C - N \diagup \diagdown \\ \end{array}$	25–60
$\begin{array}{c} \\ -C - O - \\ \end{array}$ alcohols, ethers or esters	50–90
$\begin{array}{c} \diagdown \quad \diagup \\ C = C \\ \diagup \quad \diagdown \end{array}$	90–150
R—C≡N	110–125
	110–160
$\begin{array}{c} R - C - \\ \\ O \end{array}$ esters or acids	160–185
$\begin{array}{c} R - C - \\ \\ O \end{array}$ aldehydes or ketones	190–220

UV absorption*(This is not a definitive list and is approximate.)*

Chromophore	λ_{max} (nm)
C—H	112
C—C	135
C=C	162

Chromophore	λ_{max} (nm)
C≡C	173 178 196 222
C—Cl	173
C—Br	208

Some standard potentials

$\text{K}^+ + \text{e}^-$	\rightleftharpoons	K(s)	-2.94 V
$\text{Ba}^{2+} + 2\text{e}^-$	\rightleftharpoons	Ba(s)	-2.91 V
$\text{Ca}^{2+} + 2\text{e}^-$	\rightleftharpoons	Ca(s)	-2.87 V
$\text{Na}^+ + \text{e}^-$	\rightleftharpoons	Na(s)	-2.71 V
$\text{Mg}^{2+} + 2\text{e}^-$	\rightleftharpoons	Mg(s)	-2.36 V
$\text{Al}^{3+} + 3\text{e}^-$	\rightleftharpoons	Al(s)	-1.68 V
$\text{Mn}^{2+} + 2\text{e}^-$	\rightleftharpoons	Mn(s)	-1.18 V
$\text{H}_2\text{O} + \text{e}^-$	\rightleftharpoons	$\frac{1}{2}\text{H}_2(\text{g}) + \text{OH}^-$	-0.83 V
$\text{Zn}^{2+} + 2\text{e}^-$	\rightleftharpoons	Zn(s)	-0.76 V
$\text{Fe}^{2+} + 2\text{e}^-$	\rightleftharpoons	Fe(s)	-0.44 V
$\text{Ni}^{2+} + 2\text{e}^-$	\rightleftharpoons	Ni(s)	-0.24 V
$\text{Sn}^{2+} + 2\text{e}^-$	\rightleftharpoons	Sn(s)	-0.14 V
$\text{Pb}^{2+} + 2\text{e}^-$	\rightleftharpoons	Pb(s)	-0.13 V
$\text{H}^+ + \text{e}^-$	\rightleftharpoons	$\frac{1}{2}\text{H}_2(\text{g})$	0.00 V
$\text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^-$	\rightleftharpoons	$\text{SO}_2(\text{aq}) + 2\text{H}_2\text{O}$	0.16 V
$\text{Cu}^{2+} + 2\text{e}^-$	\rightleftharpoons	Cu(s)	0.34 V
$\frac{1}{2}\text{O}_2(\text{g}) + \text{H}_2\text{O} + 2\text{e}^-$	\rightleftharpoons	2OH^-	0.40 V
$\text{Cu}^+ + \text{e}^-$	\rightleftharpoons	Cu(s)	0.52 V
$\frac{1}{2}\text{I}_2(\text{s}) + \text{e}^-$	\rightleftharpoons	I^-	0.54 V
$\frac{1}{2}\text{I}_2(\text{aq}) + \text{e}^-$	\rightleftharpoons	I^-	0.62 V
$\text{Fe}^{3+} + \text{e}^-$	\rightleftharpoons	Fe^{2+}	0.77 V
$\text{Ag}^+ + \text{e}^-$	\rightleftharpoons	Ag(s)	0.80 V
$\frac{1}{2}\text{Br}_2(\text{l}) + \text{e}^-$	\rightleftharpoons	Br^-	1.08 V
$\frac{1}{2}\text{Br}_2(\text{aq}) + \text{e}^-$	\rightleftharpoons	Br^-	1.10 V
$\frac{1}{2}\text{O}_2(\text{g}) + 2\text{H}^+ + 2\text{e}^-$	\rightleftharpoons	H_2O	1.23 V
$\frac{1}{2}\text{Cl}_2(\text{g}) + \text{e}^-$	\rightleftharpoons	Cl^-	1.36 V
$\frac{1}{2}\text{Cr}_2\text{O}_7^{2-} + 7\text{H}^+ + 3\text{e}^-$	\rightleftharpoons	$\text{Cr}^{3+} + \frac{7}{2}\text{H}_2\text{O}$	1.36 V
$\frac{1}{2}\text{Cl}_2(\text{aq}) + \text{e}^-$	\rightleftharpoons	Cl^-	1.40 V
$\text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^-$	\rightleftharpoons	$\text{Mn}^{2+} + 4\text{H}_2\text{O}$	1.51 V
$\frac{1}{2}\text{F}_2(\text{g}) + \text{e}^-$	\rightleftharpoons	F^-	2.89 V



HSC Trial Examination 2019

Chemistry

Solutions and marking guidelines

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Section I

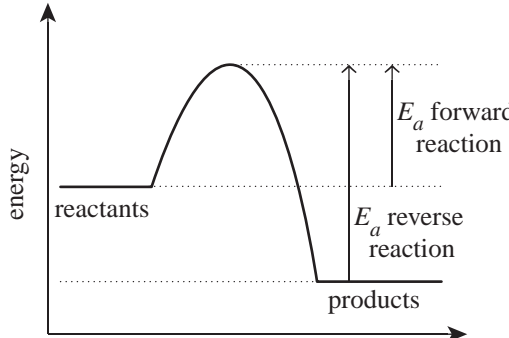
Answer and explanation	Syllabus content, outcomes and targeted performance bands
Question 1 C A closed system can transfer energy but not matter with its surroundings. An open system can transfer both energy and matter with its surroundings.	Mod 5 Static and Dynamic Equilibrium CH12–5 Band 2
Question 2 B Heating hydrated cobalt(II) chloride gives dehydrated cobalt(II) chloride, X, and water, Y.	Mod 5 Static and Dynamic Equilibrium CH12–5 Bands 3–4
Question 3 A Equilibrium constants are constant if the temperature is constant. Changing the temperature changes the equilibrium constant. Changing other variables does not change the value of the equilibrium constant.	Mod 5 Factors that Affect Equilibrium CH12–5, CH12–12 Bands 3
Question 4 D Precipitation reactions occur when (positive) cations and (negative) anions in aqueous solution combine to form an insoluble ionic solid called a precipitate. These insoluble solids will have a low solubility product (K_{sp}). Examining the solubility constants on the data sheet, the only substance with a very low solubility constant is barium sulfate ($K_{sp} = 1.08 \times 10^{-10}$), so this solution will precipitate.	Mod 5 Solution Equilibria CH12–6 Bands 3–4
Question 5 C Volume has no effect on the speed of particles. When volume is decreased the particles travel shorter distances before a collision takes place, so more collisions take place in a given time.	Mod 5 Static and Dynamic Equilibrium CH12–6 Bands 3–4
Question 6 B B is the only expression that corresponds to the definition $\text{pH} = -\log_{10}[\text{H}^+]$.	Mod 6 Using Brønsted–Lowry Theory CH12–6, CH12–13 Bands 3–4
Question 7 B $\text{Mg(s)} + 2\text{HCl(aq)} \rightarrow \text{H}_2\text{(g)} + \text{MgCl}_2\text{(aq)}$ $n(\text{Mg}) = \frac{\text{mass (Mg)}}{\text{atomic mass (Mg)}} = \frac{1.22}{24.31} = 0.05019 \text{ mol}$ $n(\text{H}_2) = n(\text{Mg}) = 0.05019 = \frac{\text{volume H}_2}{\text{molar volume}}$ $V(\text{H}_2) = 0.05019 \times 24.79 = 1.24 \text{ L} = 1240 \text{ mL}$	Mod 6 Properties of Acids and Bases CH12–6, CH12–13 Band 4
Question 8 C first dilution: $1 \text{ mL} \rightarrow 1000 \text{ mL} (\times 1000)$ second dilution: $100 \text{ mL} \rightarrow 1000 \text{ mL} (\times 10)$ total dilutions: $1000 \times 10 = 10\,000$ $\therefore \text{final } [\text{H}^+] = \frac{10}{10\,000} = 10^{-3} \text{ mol}$ $\therefore \text{pH} = -\log_{10}[\text{H}^+] = -\log_{10}[10^{-3}] = 3.00$	Mod 6 Using Brønsted–Lowry Theory CH12–6, CH12–13 Bands 4–5

Answer and explanation	Syllabus content, outcomes and targeted performance bands
Question 9 D The diagrams for both acids show nine molecules in the same volume, hence both acid solutions have the same initial concentration. Only one of the nine molecules of acid X dissociates, so X is a weak acid. All nine molecules of acid Y dissociate (dissociates completely), so Y is a strong acid. <i>Note: The terms 'concentrated' and 'dilute' describe the amount of acid in the solution, NOT the degree of dissociation of the acids themselves.</i>	Mod 6 Using Brønsted–Lowry Theory CH12–6, CH12–13 Band 3
Question 10 A Conjugate acid–base pairs only differ by a proton (H^+). Only the pair $\text{HF}(\text{aq})/\text{F}^-(\text{aq})$ meets this criterion.	Mod 6 Using Brønsted–Lowry Theory CH12–6, CH12–13 Band 3
Question 11 C The molar mass of 4-hydroxybutanoic acid, $\text{HO}(\text{CH}_2)_3\text{COOH}$, is 104.11 amu. It will form a condensation polymer according to the reaction $(n + 2)\text{HO}(\text{CH}_2)_3\text{COOH} \rightarrow$ $\text{HO}(\text{CH}_2)_3\text{CO}(\text{O}(\text{CH}_2)_3\text{CO})_n\text{O}(\text{CH}_2)_3\text{COOH} + n\text{H}_2\text{O}.$ molar mass of polymer = $(1000 \times 104.11) - (998 \times 18.106)$ $= 85\,986 \text{ amu}$ The closest approximate molar mass is $8.6 \times 10^4 \text{ g mol}^{-1}$.	Mod 7 Polymers CH12–6, CH12–13 Band 3
Question 12 D 2,2-dimethylbutan-1-ol has the condensed structural formula of $(\text{CH}_3)_3\text{CH}_2\text{CH}_2\text{OH}$, giving a total of 14 hydrogen in each molecule.	Mod 7 Nomenclature CH12–6, CH12–14 Bands 4–5
Question 13 B Hex-1-ene will add bromine to give 1,2-dibromohexane. Hex-2-ene adds bromine to give the isomeric 2,3-dibromohexane.	Mod 7 Products of Reactions Involving Hydrocarbons CH12–14 Bands 3–4
Question 14 D The CHOH of hexan-3-ol is oxidised to C=O in hexan-3-one.	Mod 7 Alcohols CH12–4, CH12–14 Band 3
Question 15 D The presence of a broad band between 3000 and 3500 cm^{-1} indicates the presence of an OH group. The strong absorbance at 1725 cm^{-1} indicates the presence of a carbonyl group (C=O). Ethanoic acid is the only option that would produce these absorbance bands.	Mod 8 Analysis of Organic Substances CH12–14 Band 3
Question 16 A Nylon is a polyamide and is held together by amide bonds.	Mod 7 Polymers CH12–14 Band 2
Question 17 C Isomers have different structural formulae but the same molecular formula. Cyclobutane has a molecular formula of C_4H_8 while butane has a molecular formula of C_4H_{10} . Therefore these two compounds are not isomeric.	Mod 7 Nomenclature CH12–13, CH12–14 Band 2

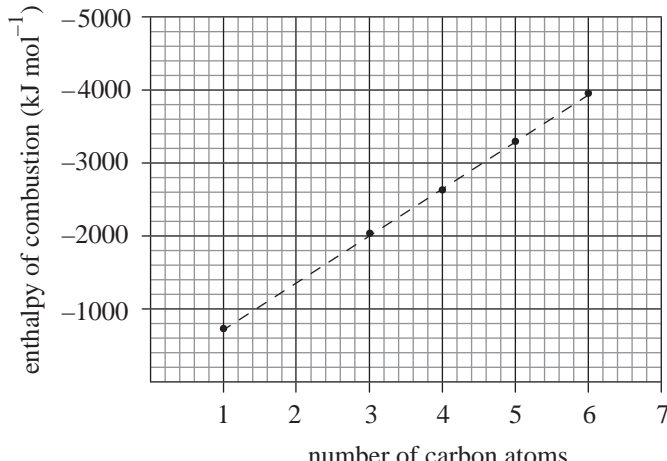
Answer and explanation	Syllabus content, outcomes and targeted performance bands
<p>Question 18 B</p> <p>Pentan-3-one can be represented by the condensed formula $(\text{CH}_3\text{CH}_2)_2\text{C}=\text{O}$.</p> <p>There are only three different chemical environments in pentan-3-one, so three peaks will appear in its mass spectrum.</p>	<p>Mod 7 Analysis of Organic Substances CH12–14 Band 3</p>
<p>Question 19 B</p> <p>The lilac/pink flame test eliminates sodium compounds because they have a yellow flame test. A number of anions precipitate with barium ions. The formation of a gas with acid indicates the presence of a carbonate. Calcium carbonate is not soluble; since this compound dissolves in water, it is not calcium carbonate. This leaves potassium carbonate as the only possible answer.</p>	<p>Mod 7 Analysis of Inorganic Substances CH12–15 Bands 4–5</p>
<p>Question 20 D</p> <p>Methyl ethanoate results when ethanoic acid reacts with methanol, so <i>Z</i> must be ethanoic acid. This is produced by the oxidation of ethanol, so <i>Y</i> must be ethanol. Ethanol was produced by a substitution reaction involving chloroethane, so <i>X</i> must be chloroethane. Chloroethane was produced by the addition of HCl to ethene, so <i>W</i> must be ethene.</p>	<p>Mod 7 Analysis of Organic Substances CH12–14, CH12–15 Bands 4–6</p>

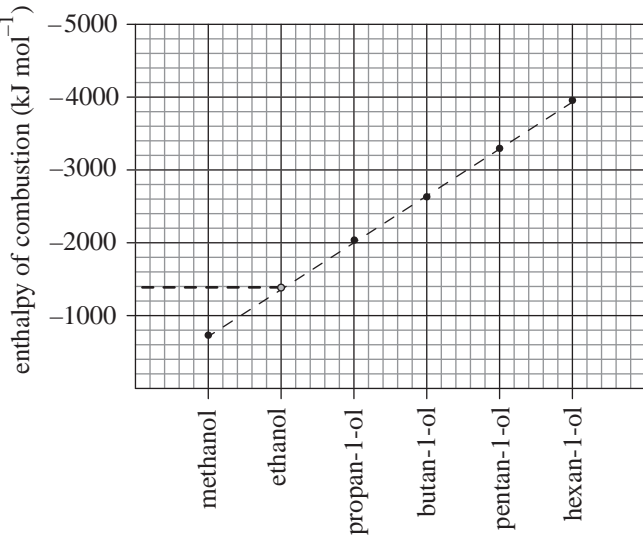
Section II

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 21	
(a) activation energy	Mod 5 Static and Dynamic Equilibrium CH12–15 Band 2 • Identifies the type of energy 1
(b) Energy is given to the surroundings ($\Delta H = -ve$).	Mod 5 Static and Dynamic Equilibrium CH12–15 Band 2 • Gives energy change AND explanation. . 1
(c) Static equilibrium occurs when the reaction is complete and there is no reversible reaction occurring between reactants and products.	Mod 5 Static and Dynamic Equilibrium CH12–6, CH12–13 Bands 3–4 • Gives correct meaning 1
(d) The reaction goes from 2 moles of a solid and 1.5 moles of a gas to 1 mole of a solid. Entropy decreases; there are now fewer moles of solids present and fewer moles of gases present.	Mod 5 Static and Dynamic Equilibrium CH12–6, CH12–12 Bands 3–4 • Describes how entropy changes. AND • Gives quantities and physical states of reactants and products 2 • Describes how entropy changes. 1
Question 22	
(a) $K_{eq} = \frac{[FeSCN^{2+}]}{[Fe^{3+}][SCN^{-}]} = \frac{[0.0932]}{[0.0184][0.0184]}$ $= \frac{0.0932}{0.000338}$ $= 275 \text{ or } 2.275 \times 10^2$	Mod 5 Calculating the Equilibrium Constant CH12–6, CH12–12 Bands 4–5 • Derives correct equilibrium expression. AND • Calculates equilibrium constant. 2 • Derives correct equilibrium expression. . 1
(b) K_{eq} is a large value and hence the position of equilibrium will lie to the right (more products than reactants).	Mod 5 Calculating the Equilibrium Constant CH12–6, CH12–12 Bands 2–3 • Describes what the value of equilibrium constant indicates. 1
(c) Iron(III) hydroxide would precipitate out (the data sheet gives $K_{sp} = 2.79 \times 10^{-39}$), decreasing $[Fe^{3+}]$ ions. Le Châtelier's principle tells us that the system will react to minimise this change – that is, form more Fe^{3+} ions. This will drive the reaction to the left and remove $FeSCN^{2+}$ ions, hence the blood-red colour would fade.	Mod 5 Factors that Affect Equilibrium CH12–7, CH12–12 Bands 5–6 • Gives colour change AND gives an explanation. AND • Refers to Le Châtelier's principle 2 • Gives colour change AND gives an explanation. OR • Refers to Le Châtelier's principle 1

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 23	
<p>(a) The sodium chloride crystal lattice is composed of alternating positive (Na^+) and negative (Cl^-) ions. Water is polar and has both a relatively positive (δ^+) and a relatively negative (δ^-) end. Water molecules are in continuous motion and collide with the crystal lattice. The positively charged sodium ions in the crystal attract the relatively negative (δ^-) ends of the water molecules. The negatively charged chloride ions in the crystal attract the relatively positive (δ^+) ends of the water molecules. The action of the polar water molecules takes the crystal lattice apart, forming individual (solvated) sodium ions and chloride ions that are surrounded by water molecules. The opposite of this is association, where the solvated ions return to the lattice. When the rate of dissociation equals the rate of association, an equilibrium state occurs:</p> $\text{NaCl}(s) \rightleftharpoons \text{Na}^+(aq) + \text{Cl}^-(aq)$	<p>Mod 5 Solution Equilibria CH12–7 Bands 2–5</p> <ul style="list-style-type: none"> Describes the dissociation. <p>AND</p> <ul style="list-style-type: none"> Refers to the diagram. <p>AND</p> <ul style="list-style-type: none"> Makes at least THREE additional relevant points. 3 <hr/> <ul style="list-style-type: none"> Describes the dissociation. <p>AND</p> <ul style="list-style-type: none"> Refers to the diagram. <p>AND</p> <ul style="list-style-type: none"> Makes at least TWO additional relevant points. 2 <hr/> <ul style="list-style-type: none"> Describes the dissociation. 1
<p>(b) The formula is NaCl.</p> <p>The formula mass is $22.99 + 35.45 = 58.44 \text{ g mol}^{-1}$.</p> $\text{moles of NaCl} = \frac{359}{58.44} = 6.14$ $\text{NaCl}(s) \rightleftharpoons \text{Na}^+(aq) + \text{Cl}^-(aq)$ $K_{sp} = [\text{Na}^+][\text{Cl}^-] = [6.14][6.14] = 37.7 \text{ (to three significant figures)}$	<p>Mod 5 Solution Equilibria CH12–12 Bands 3–4</p> <ul style="list-style-type: none"> Derives correct expression for solubility constant. <p>AND</p> <ul style="list-style-type: none"> Calculates value accurately. 2 <hr/> <ul style="list-style-type: none"> Derives correct expression for solubility constant. 1
Question 24	
<p>(a) For an exothermic reaction, the activation energy of the forward reaction must be less than the activation energy of the reverse reaction. This is an exothermic reaction; hence the E_a for the forward reaction (forming dinitrogen tetroxide) is less than the E_a for the reverse reaction (forming nitrogen dioxide).</p>  <p style="text-align: center;">reaction profile</p> <p><i>Note: A diagram is not required for full marks. It has been included for clarification.</i></p>	<p>Mod 5 Static and Dynamic Equilibrium CH12–6, CH12–12 Bands 4–6</p> <ul style="list-style-type: none"> Outlines forward reaction. <p>AND</p> <ul style="list-style-type: none"> Outlines reverse reaction 2 <hr/> <ul style="list-style-type: none"> Outlines forward reaction. <p>OR</p> <ul style="list-style-type: none"> Outlines reverse reaction 1

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
(b) Increasing the temperature would drive the position of equilibrium to the left (formation of nitrogen dioxide). Le Châtelier's principle states that the addition of heat to a reaction will favour the endothermic direction of a reaction as this minimises the increase in heat content of the system when the temperature is increased.	Mod 5 Static and Dynamic Equilibrium CH12–6, CH12–12 Bands 3–4 • Describes how increasing the temperature would affect the reaction. AND • Provides correct explanation 2 OR • Describes how increasing the temperature would affect the reaction. OR • Provides correct explanation 1
Question 25	
(a) $K_{eq} = \frac{[\text{HCO}_3^-][\text{H}^+]}{[\text{H}_2\text{CO}_3]}$	Mod 6 Qualitative Analysis CH12–5, CH12–12 Band 2 • Writes a correct expression 1
(b) A buffer is usually a mixture of a weak acid and its salt. Buffering resists changes in the pH of blood (or other natural systems) when acids or bases are added. It does this because added H^+ ion reacts with the weak base (and hence is removed by reaction) and added OH^- reacts with the weak acid (and hence is removed by reaction). Therefore the change in concentration of H^+ is minimised by the buffer and pH change is also minimised. Many processes of natural systems will only take place within a narrow pH range. If the pH deviates too far from the optimum, then the system will not work as well as it should. In the case of human blood, illness will occur.	Mod 6 Qualitative Analysis CH12–7, CH12–12 Bands 3–4 • Defines buffering. AND • Relates buffering to blood or other relevant natural system. AND • Makes at least ONE additional relevant point 3 OR • Defines buffering. AND • Relates buffering to blood 2 OR • Defines buffering. OR • Relates buffering to blood 1
(c) $\text{pH} = -\log_{10}[\text{H}^+] \therefore [\text{H}^+] = 10^{-\text{pH}}$ $\text{pH} = 7.4 \therefore [\text{H}^+] = 10^{-7.4} = 3.98 \times 10^{-8} \text{ mol L}^{-1}$	Mod 6 Qualitative Analysis, Mod 6 Calculating the Equilibrium Constant CH12–6, CH12–12 Bands 3–4 • Calculates correct value AND shows working 1

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 26	
<p>(a) $\text{H}_2\text{SO}_4(\text{aq}) + 2\text{NaOH}(\text{aq}) \rightarrow \text{Na}_2\text{SO}_4(\text{aq}) + 2\text{H}_2\text{O}(\text{l})$ 1 mole of sulfuric acid (a diprotic acid) reacts with 2 moles of alkali to form 2 moles of water. $2\text{H}^+(\text{aq}) + 2\text{OH}^-(\text{aq}) \rightarrow 2\text{H}_2\text{O}(\text{l})$ moles of water formed = moles of sodium hydroxide $= \frac{120}{1000} \times 0.500$ $= 0.0600 \text{ mol}$ heat change (q) = $mc\Delta T$ $= \frac{(120 + 60)}{1000} \times 4.18 \times 10^3 \times (26.3 - 24.2)$ $= 0.8 \times 4.18 \times 2.1 = 1.58 \text{ kJ}$ $\therefore \Delta H = \frac{-q}{n(\text{water})} = \frac{-1.58 \text{ kJ}}{0.06 \text{ mol}} = -26.3 \text{ kJ mol}^{-1} \text{ (exothermic)}$</p>	<p>Mod 6 Qualitative Analysis, Mod 7 Alcohols CH12-5, CH12-12 Band 2</p> <ul style="list-style-type: none"> • Gives balanced equation. <p>AND</p> <ul style="list-style-type: none"> • Performs the calculation. <p>AND</p> <ul style="list-style-type: none"> • Gives the correct answer. 3 <hr/> <ul style="list-style-type: none"> • Gives balanced equation. <p>AND</p> <ul style="list-style-type: none"> • Performs the calculation OR gives the correct answer. 2 <hr/> <ul style="list-style-type: none"> • Shows some understanding of the calculation. 1
<p>(b)</p> 	<p>Mod 6 Qualitative Analysis, Mod 7 Alcohols CH12-3, CH12-5, CH12-7 Bands 3-4</p> <ul style="list-style-type: none"> • Labels axes. <p>AND</p> <ul style="list-style-type: none"> • Accurately plots points. <p>AND</p> <ul style="list-style-type: none"> • Draws a line of best fit 3 <hr/> <ul style="list-style-type: none"> • Any TWO of the above points 2 <hr/> <ul style="list-style-type: none"> • Any ONE of the above points. 1

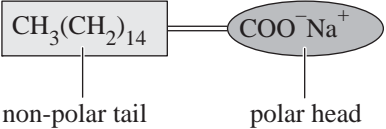
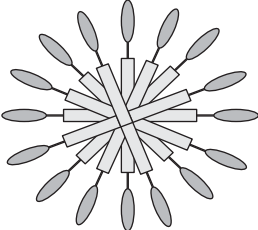
Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
<p>(c) The interpolated value for ethanol is shown on the graph below.</p>  <p>The enthalpy of combustion of ethanol is approximately $-1400 \text{ kJ mol}^{-1}$. The molar mass of ethanol ($\text{CH}_3\text{CH}_2\text{OH}$) is $46.068 \text{ g mol}^{-1}$. The enthalpy of combustion of ethanol will equal approximately $-\frac{1400}{46.068} = -30.4 \text{ kJ g}^{-1}$.</p>	<p>Mod 6 Quantitative Analysis Mod 7 Alcohols CH12–1, 2, 6, 7, 12 Bands 3–4</p> <ul style="list-style-type: none"> Interpolates a value of between 1300 and 1400 kJ mol^{-1} as the correct molar enthalpy change from the graph. <p>AND</p> <ul style="list-style-type: none"> Converts kJ mol^{-1} to kJ g^{-1} 2 Any ONE of the above points 1
<p>Question 27</p>	
<p>X is a burette, Y is a pipette and Z is a conical flask.</p> <p>The burette's role in a titration is to deliver a variable volume of a liquid. The pipette's role in a titration is to deliver a fixed volume of a liquid. The conical flask's role in a titration is to contain the indicator and the liquids from the pipette and burette.</p>	<p>Mod 6 Qualitative Analysis CH12–13 Bands 2–4</p> <ul style="list-style-type: none"> Identifies all THREE pieces of equipment. <p>AND</p> <ul style="list-style-type: none"> Outlines the role of each 3 <ul style="list-style-type: none"> Identifies TWO pieces of equipment. <p>AND</p> <ul style="list-style-type: none"> Outlines the role of each 2 <ul style="list-style-type: none"> Identifies ONE piece of equipment AND outlines its role. <p>OR</p> <ul style="list-style-type: none"> Identifies TWO or more pieces of equipment 1

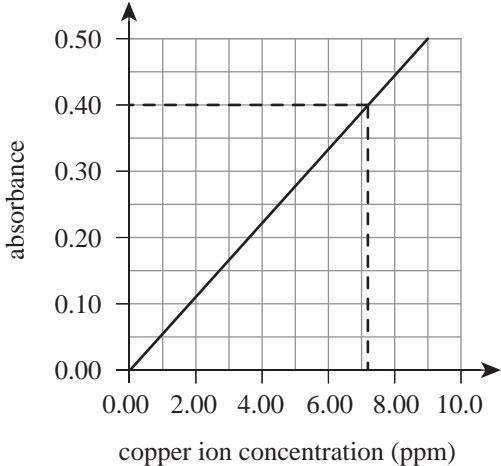
Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 28	
<p>In 1887, Arrhenius suggested that all aqueous solutions of acids contained an excess of hydrogen (H^+) ions and all aqueous solutions of bases (alkalis) contained an excess of hydroxide (OH^- ions). His proposal was that H^+ and OH^- ions are formed when the acid or base ionises as it dissolves in water.</p> <p>In 1923, Brønsted and Lowry independently proposed that an acid is a proton donor and a base is a proton acceptor. Water need not be present using their definition and a base does not have to contain a hydroxide.</p> <p>All Arrhenius acids will also be Brønsted–Lowry acids. Not all Brønsted–Lowry acids will be Arrhenius acids.</p>	<p>Mod 6 Using Brønsted–Lowry Theory CH12–7, CH12–13 Bands 2–5</p> <ul style="list-style-type: none"> Gives details of the Arrhenius model. <p>AND</p> <ul style="list-style-type: none"> Gives details of the Brønsted–Lowry model. <p>AND</p> <ul style="list-style-type: none"> Makes a comparison 3–4 <hr/> <ul style="list-style-type: none"> Gives details of the Arrhenius model. <p>AND</p> <ul style="list-style-type: none"> Gives details of the Brønsted–Lowry model 2 <hr/> <ul style="list-style-type: none"> Gives details of the Arrhenius model. <p>OR</p> <ul style="list-style-type: none"> Gives details of the Brønsted–Lowry model 1
Question 29	
<p>The sample must be in aqueous solution. If supplied as a solid, it must be mixed with distilled/deionised water.</p> <p>One method is to use indicators. Indicators are chemicals that change colour over a specific pH range to help identify if a substance is acidic, neutral or basic. The advantage of using indicators is that they are relatively cheap and easy to use. A disadvantage is that one must use an indicator with a colour change that matches the actual pH of the substance. If the substance being tested is itself coloured, this can obscure the result.</p> <p>The second method is to use electronic means such as pH metres, a pH probe or data loggers. The advantage of using these is that they are much more accurate and work over a larger pH range. A disadvantage is that they are more costly and more complex to operate. They have to be calibrated (set to an accurate value) using buffer solutions of known pH.</p>	<p>Mod 6 Using Brønsted–Lowry Theory CH12–7, CH12–13 Bands 2–6</p> <ul style="list-style-type: none"> Describes TWO methods in detail. <p>AND</p> <ul style="list-style-type: none"> Identifies the advantages of the TWO methods. <p>AND</p> <ul style="list-style-type: none"> Identifies the disadvantages of the TWO methods. 6 <hr/> <ul style="list-style-type: none"> Describes TWO methods. <p>AND</p> <ul style="list-style-type: none"> Identifies the advantages of the TWO methods. <p>OR</p> <ul style="list-style-type: none"> Identifies the disadvantages of the TWO methods. 4–5 <hr/> <ul style="list-style-type: none"> Describes TWO methods. <p>AND</p> <ul style="list-style-type: none"> Identifies the advantages OR disadvantages of ONE method 3 <hr/> <ul style="list-style-type: none"> Describes TWO methods 2 <hr/> <ul style="list-style-type: none"> Provides some relevant details 1

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide								
Question 30									
<table border="1"> <thead> <tr> <th>Products</th><th>Catalyst</th></tr> </thead> <tbody> <tr> <td> $\begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{H} \\ \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \end{array}$ </td><td>Pt or Pd or Ni</td></tr> <tr> <td> $\begin{array}{c} \text{H} \quad \text{H} \quad \text{Cl} \quad \text{H} \\ \quad \quad \quad \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{C}-\text{H} \\ \quad \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \end{array}$ </td><td>no catalyst</td></tr> <tr> <td> $\begin{array}{c} \text{H} \quad \text{H} \quad \text{OH} \quad \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \quad \quad \quad \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{H} \\ \quad \quad \quad \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \end{array}$ </td><td>H_2SO_4 or H_3PO_4</td></tr> </tbody> </table> <p><i>Note: The addition of hydrogen to propene will result in the formation of propane. The catalyst needed is nickel metal (or platinum or palladium). The addition of hydrogen chloride gas to but-2-ene will result in the formation of 2-chlorobutane. The addition of water to hex-3-ene will result in the formation of hexan-3-ol. The addition of water to an alkene requires an acid catalyst (H_2SO_4 or H_3PO_4).</i></p>	Products	Catalyst	$ \begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{H} \\ \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \end{array} $	Pt or Pd or Ni	$ \begin{array}{c} \text{H} \quad \text{H} \quad \text{Cl} \quad \text{H} \\ \quad \quad \quad \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{C}-\text{H} \\ \quad \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \end{array} $	no catalyst	$ \begin{array}{c} \text{H} \quad \text{H} \quad \text{OH} \quad \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \quad \quad \quad \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{H} \\ \quad \quad \quad \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \end{array} $	H_2SO_4 or H_3PO_4	<p>Mod 7 Products of Reactions Involving Hydrocarbons CH12–7, CH12–14 Bands 3–5</p> <ul style="list-style-type: none"> Correctly completes all FIVE cells of the table. 5 Correctly completes FOUR cells of the table. 4 Correctly completes THREE cells of the table. 3 Correctly completes TWO cells of the table. 2 Correctly completes ONE cell of the table. 1
Products	Catalyst								
$ \begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{H} \\ \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \end{array} $	Pt or Pd or Ni								
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Question 31									
<p>Esters are produced by refluxing the starting reagents – a carboxylic acid and alcohol – in the presence of a sulphuric acid catalyst.</p> <p>Safety precautions include heating under reflux conditions to minimise risk of exposure to toxic chemicals, adding boiling chips and choosing a heating source to minimise the risk of fire.</p>	<p>Mod 7 Reactions of Organic Acids and Bases CH12–2, CH12–3, CH12–14 Bands 2–6</p> <ul style="list-style-type: none"> Identifies both reagents. AND Identifies the catalyst. AND Identifies a safe experimental procedure 3 Any TWO of the above points 2 Any ONE of the above points 1 								
Question 32									
<p>$A = \epsilon lc$</p> <p>formulae weight of $\text{KMnO}_4 = 158.04 \text{ g mol}^{-1}$</p> <p>$\therefore c = [\text{KMnO}_4] = \frac{A}{\epsilon l} = \frac{0.398}{22\,400} \times 1 = 1.78 \times 10^{-5} \text{ mol L}^{-1}$</p> <p>$\therefore \text{moles of KMnO}_4 = 1.78 \times 10^{-5} \times 2.00 = 3.56 \times 10^{-5} \text{ mol}$</p> <p>$\therefore \text{mass of KMnO}_4 = 1.78 \times 10^{-5} \times 158.04 = 0.00563 \text{ g}$</p> <p>$\text{ppm of KMnO}_4 = \frac{\text{mass of KMnO}_4}{\text{mass of sample}} \times 10^6$</p> <p>$= \frac{0.00563}{50.00} \times 10^6 = 112 \text{ ppm}$</p>	<p>Mod 8 Analysis of Inorganic Substances CH12–6, CH12–15 Bands 4–5</p> <ul style="list-style-type: none"> Calculates concentration. AND Calculates mass of pure KMnO_4. AND Calculates ppm of KMnO_4 3 Any TWO of the above points 2 Any ONE of the above points 1 								

Sample answer			Syllabus content, outcomes, targeted performance bands and marking guide
Question 33			
	<p><i>Structural formula</i></p>	<p><i>Justification</i></p>	<p>Mod 7 Reactions of Organic Acids and Bases CH12–5, CH12–7, CH12–14 Bands 5–6</p>
A	$ \begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{OH} \\ \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \\ \quad \\ \text{H}-\text{C}-\text{H} \\ \\ \text{H} \end{array} $ <p>2-methylpropan-1-ol</p>	<p>Compound A is a primary alcohol as oxidation of compound A produces an acid, compound C. The branched structure is indicated by the formation of the tertiary alcohol, compound E.</p>	<p>Correctly draws the structures of all of the compounds.</p> <p>AND</p> <p>Provides justification for all of the structures. 6</p>
B	$ \begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{Cl} \\ \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \\ \quad \\ \text{H}-\text{C}-\text{H} \\ \\ \text{H} \end{array} $ <p>1-chloro-2-methylpropane</p>	<p>Compound B is a chloroalkane formed by the replacement of OH with Cl in compound A.</p>	<p>Correctly draws most of the structures of the compounds.</p> <p>AND</p> <p>Provides justification for most of the structures. 4–5</p>
C	$ \begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{OH} \\ \quad \quad \\ \text{H} \quad \text{H} \quad \text{O} \\ \quad \\ \text{H}-\text{C}-\text{H} \\ \\ \text{H} \end{array} $ <p>2-methylpropanoic acid</p>	<p>Compound C is the acid produced by the oxidation of compound A. This is confirmed by the production of CO₂ when reacted with carbonate ion.</p>	<p>Identifies some characteristics (functional groups) of some structures . . . 2</p>
D	$ \begin{array}{c} \text{H} \quad \quad \text{H} \\ \quad \quad \\ \text{H}-\text{C}-\text{C}=\text{C} \\ \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \\ \quad \\ \text{H}-\text{C}-\text{H} \\ \\ \text{H} \end{array} $ <p>2-methylpropene</p>	<p>Compound D is the alkene produced from compound A through the dehydration reaction, which removes the OH and another H atom to form the double bond.</p>	<p>Provides some relevant information 1</p>
E	$ \begin{array}{c} \text{H} \quad \text{OH} \quad \text{H} \\ \quad \quad \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{H} \\ \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \\ \quad \\ \text{H}-\text{C}-\text{H} \\ \\ \text{H} \end{array} $ <p>2-methylpropan-2-ol</p>	<p>Compound E is a tertiary alcohol as compound E is not oxidised with strong oxidants.</p>	
F	$ \begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{O}^-\text{Na}^+ \\ \quad \quad \\ \text{H} \quad \text{H} \quad \text{O} \\ \quad \\ \text{H}-\text{C}-\text{H} \\ \\ \text{H} \end{array} $ <p>sodium 2-methylpropanoate</p>	<p>Compound F is the sodium salt of the acid.</p>	

Note: The names of the compounds are not required. They have been included as a guide.

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 34	
<p>(a) Water can only dissolve polar compounds like alcohols and some ionic compounds like sodium chloride. The addition of soap allows the resulting mixture to dissolve many non-polar substances.</p> <p>Soaps are the sodium or potassium salts of long-chain alkanolic acids. The carbon chain forms a non-polar tail and the carboxylate salt forms a polar head. Soaps form micelles in water with polar heads on the outside and non-polar tails on the inside.</p> <p>A micelle forms with the polar head groups on the outside of the micelle and the non-polar groups on the inside of the micelle. Fat and grease can dissolve into the non-polar interior of the micelle and form colloidal suspensions because of the polar head groups on the outside of the micelle.</p>	<p>Mod 7 Reactions of Organic Acids and Bases CH12–7, CH12–14 Bands 4–5</p> <ul style="list-style-type: none"> Describes the structure of soap. <p>AND</p> <ul style="list-style-type: none"> Explains how micelles dissolve greasy substances in water. 2 <hr/> <ul style="list-style-type: none"> Any ONE of the above points 1
<p>(b) For example, sodium stearate:</p> <div style="text-align: center;">  </div> <p>Micelle formed with polar heads on the outside:</p> <div style="text-align: center;">  </div>	<p>Mod 7 Reactions of Organic Acids and Bases CH12–7, CH12–14 Bands 4–5</p> <ul style="list-style-type: none"> Draws a diagram to represent a micelle. 1
Question 35	
<p>(a) $\text{Ag}^+(\text{aq}) + \text{Cl}^-(\text{aq}) \rightarrow \text{AgCl}(\text{s})$</p>	<p>Mod 8 Analysis of Inorganic Substances CH12–6, CH12–15 Bands 2–3</p> <ul style="list-style-type: none"> Gives correct ionic equation with solid state shown 1
<p>(b) moles of $\text{AgCl} = \frac{\text{mass}}{\text{molar mass}}$</p> $= \frac{1.05}{(107.9 + 35.45)}$ $= 7.325 \times 10^{-3} \text{ mol}$ <p>mass of $\text{Cl}^- = 7.325 \times 10^{-3} \times 35.45 = 0.260 \text{ g}$</p> <p>% of $\text{Cl}^- = \frac{\text{mass of Cl}^-}{\text{mass of sample}} \times 100$</p> $= \frac{0.260}{50.0} \times 100$ $= 0.520\%$	<p>Mod 8 Analysis of Inorganic Substances CH12–6, CH12–15 Bands 2–3</p> <ul style="list-style-type: none"> Calculates moles of silver chloride. <p>AND</p> <ul style="list-style-type: none"> Calculates % mass of chloride ion in the sample 2 <hr/> <ul style="list-style-type: none"> Calculates moles of silver chloride 1

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
<p>Question 36</p> <p>The fourth absorbance value is not concordant with the other values and should not be included in determining the average value.</p> <p>average absorbance: $\frac{(0.37 + 0.39 + 0.40 + 0.34)}{4} = 0.40$</p> <p>The graph is used to determine the concentration by interpolation as shown below.</p>  <p>The concentration of copper ions is 7.20 ppm.</p>	<p>Mod 8 Analysis of Inorganic Substances CH12–4, 5, 6, 15 Bands 2–3</p> <ul style="list-style-type: none"> Calculates the correct average value in the range 7.00 to 7.40. <p>AND</p> <ul style="list-style-type: none"> Interpolates a value from the graph. <p>AND</p> <ul style="list-style-type: none"> Gives a final answer including units. 3 <hr/> <ul style="list-style-type: none"> Any TWO of the above points 2 <hr/> <ul style="list-style-type: none"> Any ONE of the above points. 1
<p>Question 37</p> <p>The manufacture of compounds for use in the drug industry requires care be taken to ensure the final product is 100% pure. The final step in the manufacturing process should be an analysis to ensure purity. The purity of the final product may be the most important consideration when methanamide is produced for drug manufacture. Methanamide that is produced as an industrial solvent may not need to be 100% pure.</p> <p>Industrial solvents need to be economically competitive and the cost of production may be the most important consideration in this case. The cost of the sequence, while an important consideration when methanamide is used in drug manufacture, is not an overriding consideration for industrial solvents.</p> <p>An important consideration in both cases is the yield of the reactions involved in the manufacture. A high-yielding process is preferable to a low-yielding process.</p> <p>In both cases, the environmental impacts of the synthetic process must be taken into consideration. A process that does not affect the environment would be preferred to one that produces toxic by-products that are then released into the environment.</p>	<p>Mod 8 Analysis of Inorganic Substances CH12–4, CH12–7, CH12–14 Bands 4–6</p> <ul style="list-style-type: none"> Comprehensively compares a range of factors 4 <hr/> <ul style="list-style-type: none"> Compares some factors. 3 <hr/> <ul style="list-style-type: none"> Identifies some factors 2 <hr/> <ul style="list-style-type: none"> Provides some relevant information 1

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 38	
<p>The ^{13}C NMR indicates four different types of carbon. The 212 ppm peak is indicative of one carbonyl carbon, with the carbonyl being either an aldehyde or ketone. The peaks at 29 and 39 ppm are associated with carbons next to a carbonyl. The peak at 8 ppm is associated with a carbon adjacent to another unfunctionalised carbon.</p> <p>From this information, the compound is most likely either butanal or butanone.</p> <p>The highest peak in the mass spectrum occurs at an m/e of 72. If the compound contains only one oxygen, then $72 - 16 = 56$ amu remains to be accounted for by carbons and hydrogens. The maximum number of CH_2 units can be determined by dividing through by 14 $\rightarrow \frac{56}{14} = 4$.</p> <p>From this information, the compound could be either butanone (a ketone) or butanal (an aldehyde).</p> <p>The peak at 57 represents a loss of 15 amu from the molecular ion and is due to a CH_3 group being cleaved from the molecular ion. The peak at 29 is almost certainly due to C_2H_5 (an ethyl group) and the peak at 57 is due to a $[\text{CH}_3\text{CH}_2\text{CO}]$ fragmentation pattern. This strongly suggests that the compound is butanone.</p> <p>The infrared spectrum supports that the compound is a ketone or aldehyde, as the absorption at 1715 cm^{-1} in the infrared spectrum is also associated with a carbonyl group. The absence of any broad band between 2500 to 3000 cm^{-1} eliminates the possibility of NH or OH-containing compounds.</p> <p>The peak at 2985 cm^{-1} is expected for any compound containing C–H bonds. The peaks below 1500 cm^{-1} are in the fingerprint region of the infrared and provide less information about the functional group, or groups, in the molecule.</p> <p>Butanal would be easily oxidised by acidified permanganate. As no colour change was observed in the final chemical test, the compound is not butanal.</p> <p>The identity of compound X is therefore butanone.</p>	<p>Mod 8 Analysis of Inorganic Substances CH12–4, 5, 6, 15 Bands 4–6</p> <ul style="list-style-type: none"> Analyses all the spectra to produce evidence regarding the identity of compound X. <p>AND</p> <ul style="list-style-type: none"> Determines the importance of the results of the chemical test. <p>AND</p> <ul style="list-style-type: none"> Correctly identifies compound X as butanone. 5 <hr/> <ul style="list-style-type: none"> Analyses some spectra to produce evidence regarding the identity of compound X. <p>AND</p> <ul style="list-style-type: none"> Determines the importance of the results of the chemical test. <p>AND</p> <ul style="list-style-type: none"> Correctly identifies compound X as butanone 3–4 <hr/> <ul style="list-style-type: none"> Correctly identifies compound X as butanone 2 <hr/> <ul style="list-style-type: none"> Provides some relevant information 1