Neap

Trial Examination 2023

HSC Year 12 Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- Calculators approved by NESA may be used
- A formulae sheet, data sheet and Periodic Table are provided at the back of this paper

Total Marks: 100

Section I – 20 marks (pages 2–10)

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

Section II – 80 marks (pages 11–34)

- Attempt Questions 21– 33
- Allow about 2 hours and 25 minutes for this section

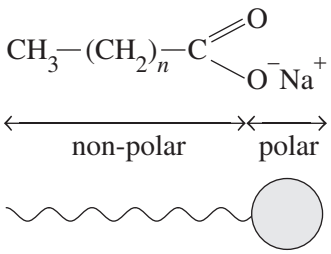
Students are advised that this is a trial examination only and cannot in any way guarantee the content or the format of the 2023 HSC Year 12 Chemistry examination.

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 Consider the diagram.



The diagram represents the structure of a

A. detergent molecule.
B. soap molecule.
C. hydrocarbon.
D. polymer.

2 Which of the following statements about activation energy, E_a, and equilibrium is correct?

A. Lowering the E_a will cause a reaction to reach equilibrium faster.
B. Lowering the E_a will shift the position of equilibrium to increase product yield.
C. E_a affects only exothermic equilibrium reactions.
D. E_a does not apply to equilibrium reactions.

3 Which row of the table correctly describes dynamic equilibrium and static equilibrium?

	Dynamic equilibrium	*Static equilibrium*
A.	It is reversible in nature.	It is reversible in nature.
B.	No further chemical reaction occurs in the system.	The reactants and the products are still participating in chemical reactions.
C.	The forward and backward reaction rates are zero.	The forward and backward reaction rates are zero.
D.	It occurs in only closed systems.	It occurs in both open and closed systems.

4 Phosphoric acid (H_3PO_4) is a tribasic acid.

An aqueous solution of H_3PO_4 is used to neutralise a sample of powdered potassium hydroxide (KOH).

Which of the following equations represents this reaction?

A. $H_3PO_4(aq) + 3KOH(s) \rightarrow K_3PO_4(aq) + 3H_2O(l)$

B. $H_3PO_4(s) + 3KOH(s) \rightarrow K_3PO_4(aq) + 3H_2O(l)$

C. $3H_3PO_4(s) + KOH(s) \rightarrow K_3PO_4(aq) + H_2O(l)$

D. $H_3PO_4(aq) + 3KOH(s) \rightarrow K_3PO_4(s) + 3H_2O(l)$

5 Which of the following could be used as a buffer?

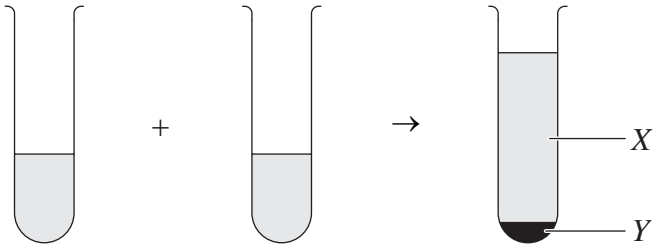
A. distilled water

B. a solution containing only sodium chloride

C. a solution containing a strong acid and a strong base

D. a solution containing a weak acid and its salt

6 The diagram shows two solutions being mixed.



lead(II) nitrate ($Pb(NO_3)_2(aq)$) potassium iodide ($KI(aq)$)

Which row of the table identifies *X* and *Y*?

	X	*Y*
A.	$PbI_2(aq)$	$KNO_3(s)$
B.	$KNO_3(aq)$	$PbI_2(s)$
C.	$PbI_2(s)$	$KNO_3(aq)$
D.	$KNO_3(s)$	$PbI_2(aq)$

7 The enthalpy change, ΔH, of a reaction is –30 kJ, and the entropy change, ΔS, is –90 J K^{-1}.

At what temperature will this reaction change from spontaneous to non-spontaneous?

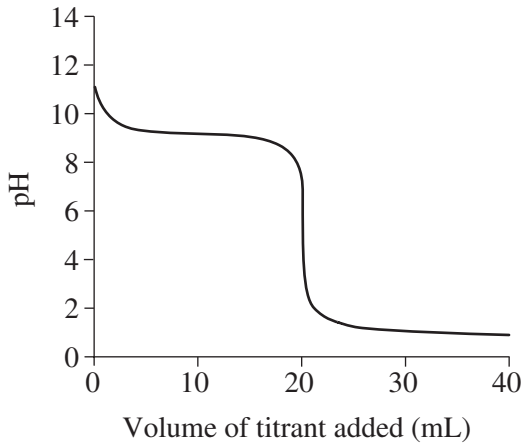
A. 30°C

B. 333°C

C. 333 K

D. 670 K

8 Consider the titration curve.



Based on the curve, what can be concluded about the titration?

A. A strong acid was added to a strong base.

B. A strong acid was added to a weak base.

C. A strong base was added to a strong acid.

D. A weak acid was added to a weak base.

9 If the pH of a solution is 3.5, what is the solution's hydroxide ion concentration, $[OH^-]$?

A. $1 \times 10^{-10.5}$ mol L^{-1}

B. $1 \times 10^{-3.5}$ mol L^{-1}

C. $1 \times 10^{3.5}$ mol L^{-1}

D. $1 \times 10^{10.5}$ mol L^{-1}

10 Which of the following best describes a Brønsted–Lowry base?

A. When dissolved in water, it increases the concentration of hydrogen ions, $[H^+]$.

B. When dissolved in water, it increases the concentration of hydroxide ions, $[OH^-]$.

C. It donates protons to another species.

D. It accepts protons from another species.

11 Which of the following reactions is most likely to occur?

A. $C_2H_6(g) + H_2O(l) \rightarrow C_2H_5OH(l) + H_2(g)$

B. $C_6H_{14}(g) + H_2(g) \rightarrow C_6H_{16}(g)$

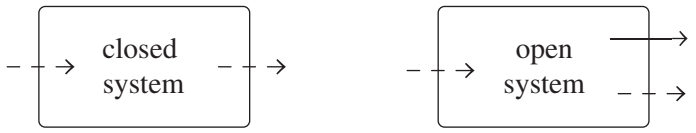
C. $C_6H_{12}(g) + HCl(aq) \rightarrow C_6H_{13}Cl(g)$

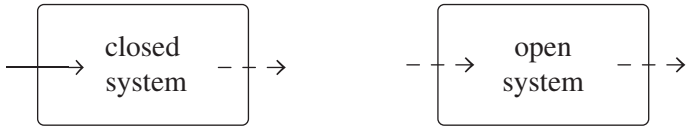
D. $C_8H_{18}(l) + Cl_2(g) \rightarrow C_6H_{14}Cl_2(l)$

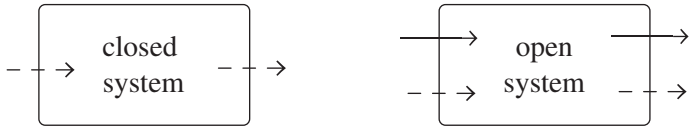
12 A student drew a diagram that illustrated the flow of matter and energy in closed and open systems. They used the following key.

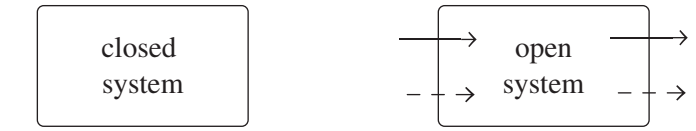
KEY
⟶ exchange of matter with the surroundings
- - → exchange of energy with the surroundings

Which of the following could be the student's diagram?

A 

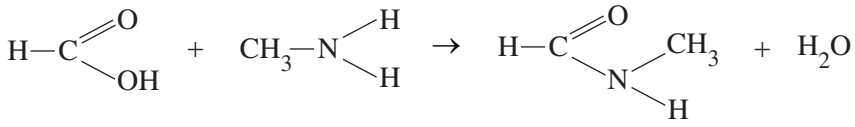
B. 

C. 

D. 

13 The diagram shows molecules *P* and *Q* reacting to form molecule *R* and water.

P *Q* *R*

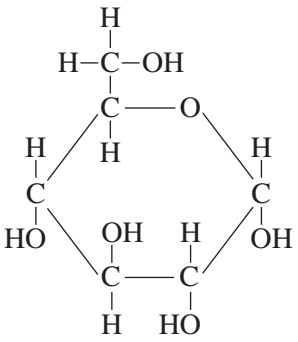


Which row of the table identifies the molecule types?

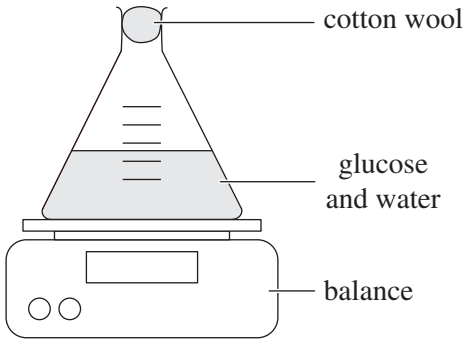
	P	*Q*	*R*
A.	carboxylic acid	amine	amide
B.	carboxylic acid	amide	amine
C.	alcohol	amine	ester
D.	aldehyde	amide	ketone

Use the following information to answer Questions 14 and 15.

Consider the structural formula of glucose ($C_6H_{12}O_6$).

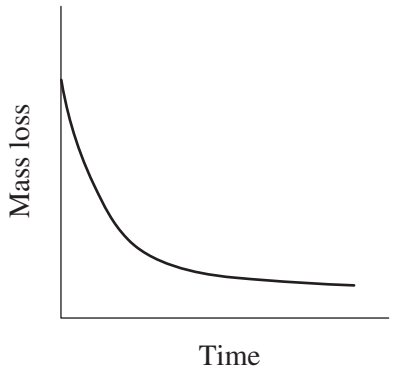


A student conducted an experiment using the apparatus shown below to investigate the fermentation of $C_6H_{12}O_6$. The fermentation of $C_6H_{12}O_6$ produces ethanol (C_2H_5OH) and carbon dioxide (CO_2). The student dissolved 5.0 g of $C_6H_{12}O_6$ in 50 mL of water in a conical flask, then added 1.0 g of yeast. They used cotton wool to plug the neck of the flask. The initial total mass of the flask and its contents was recorded. The flask and its contents were weighed at regular intervals until fermentation had ceased, and the results were recorded.

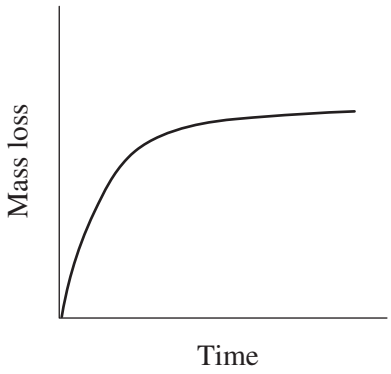


14 The student plotted a graph showing the progress of the reaction.
Which graph could be the student's graph?

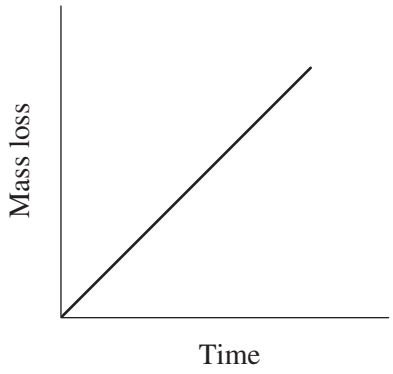
A.



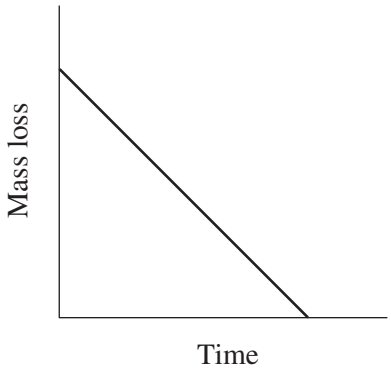
B.



C.



D.



15 Which of the following statements is correct?

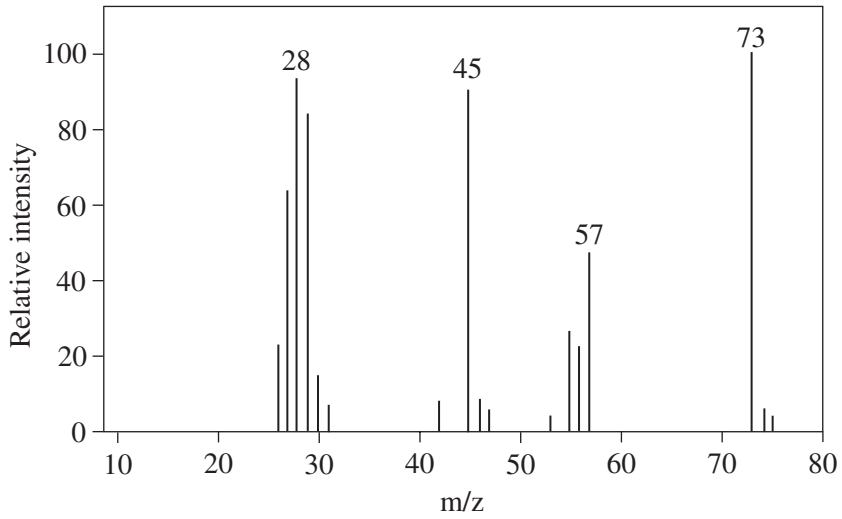
A. The initial concentration of the glucose was 1 m/v%.

B. The yeast was used up in the reaction.

C. The stoichiometry of the reaction shows that 2 mol of CO_2 was produced for every 1 mol of $C_6H_{12}O_6$ initially present.

D. C_2H_5OH is only used in beverages.

16 A simplified mass spectrum of butanoic acid is shown.



The peak with the mass-to-charge ratio, m/z, of 73

A. has the greatest mass-to-charge ratio.

B. represents the species $CH_2CH_2COOH^-$.

C. represents the species CH_2CH_2COOH.

D. represents the species $CH_2CH_2COOH^+$.

17 Five steps that are commonly followed in a gravimetric analysis are listed in an incorrect order.

I Calculate the amount of the isolated constituent using its mass.

II Separate the desired constituent.

III Prepare a solution containing a known mass of the substance being investigated.

IV Obtain a pure sample of the substance being investigated.

V Determine the mass of the isolated constituent.

Which is the correct order of the steps?

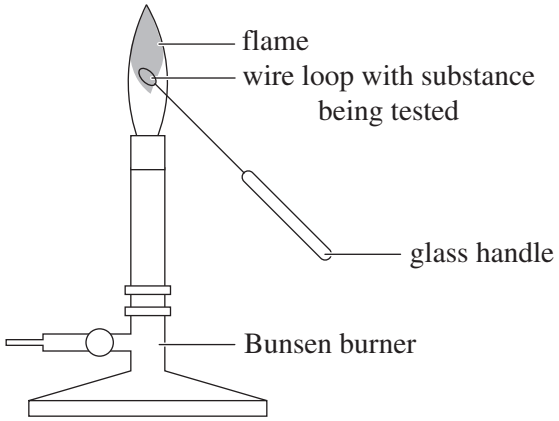
A. III, II, I, V, IV

B. III, IV, II, V, I

C. IV, III, V, II, I

D. IV, III, II, V, I

18 The diagram shows a test being carried out.



This type of test is used to identify

A. cations.

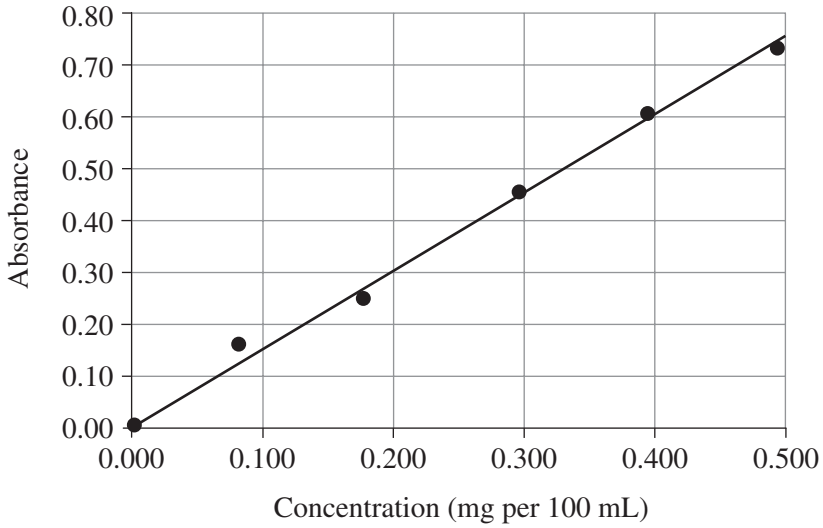
B. anions.

C. organic compounds.

D. mineral acids.

19 A mining company tested a sample of ore to determine the lead concentration. A 10 g sample of the ore was treated with a mixture of nitric and hydrochloric acids to dissolve all the lead in the sample. The resulting solution was diluted to 1.0 L, and the concentration of lead was determined using atomic absorption spectroscopy.

The absorbances of a series of lead standard solutions were then measured and the results plotted to produce the calibration curve shown.



Using the curve, the company was able to determine that the absorbance of the 1.00 L sample solution was 0.53.

What is the percentage by mass of lead in the original ore sample?

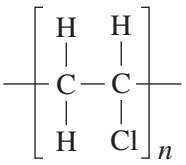
A. 0.0035%

B. 0.0053%

C. 0.035%

D. 0.35%

20 A researcher was examining a sample of the polymer polyvinyl chloride (PVC) to determine its chain length. The sample was found to have a molar mass of 623 800 g mol^{-1}. A section of the chain is shown.



What is the value of n?

A. 789.8

B. 2494

C. 9982

D. 155 950

HSC Year 12 Chemistry

Section II Answer Booklet

80 marks
Attempt Questions 21–33
Allow about 2 hours and 25 minutes for this section

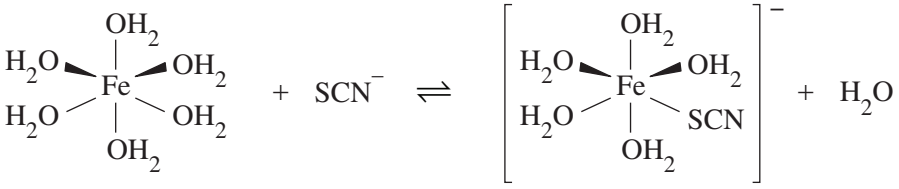
Instructions

- 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.

Please turn over

Question 21 (4 marks)

The equilibrium reaction between hydrated Fe^{3+} ions and SCN^- ions is shown.



(a) At equilibrium, how do the rates of the forward and backward reactions compare? **1**

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(b) Write the equilibrium expression for this reaction. **1**

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(c) The reaction's equilibrium constant, K_{eq}, under a particular set of conditions was found to be 2.7×10^2. **2**

Explain what this indicates about the equilibrium position.

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Question 22 (7 marks)

Ammonia gas (NH_3) reacts with carbon monoxide gas (CO) to produce the highly toxic gas hydrogen cyanide (HCN), as well as carbon dioxide (CO_2) and hydrogen (H_2). This is an endothermic equilibrium reaction. A student attempted to write the chemical equation for the reaction; their equation is shown.

$$NH_3 + CO \rightleftharpoons HCN + CO_2 + H_2$$

(a) Write the complete balanced chemical equation. **1**

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(b) In the table, state the effect of each of the changes on the system's equilibrium position. **4**

Change	*Effect*
adding a catalyst	
increasing the pressure	
increasing the temperature	
adding a quantity of an inert gas	

(c) HCN dissolves in water (H_2O) to form conjugate acid/base pairs. **2**

Label the conjugate acid/base pairs in the equation below. Use appropriate scientific notation.

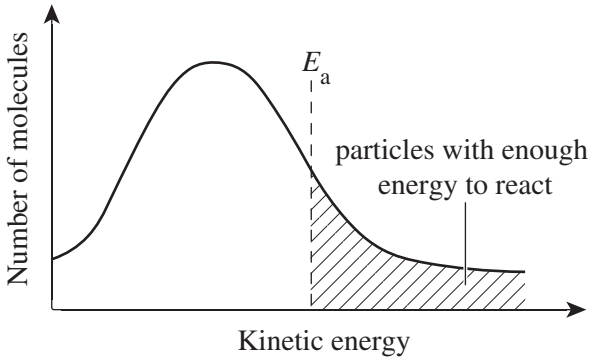
$$HCN(aq) \quad + \quad H_2O(l) \quad \rightleftharpoons \quad CN^-(aq) \quad + \quad H_3O^+(aq)$$

Question 23 (5 marks)

A student was studying chemical equilibrium reactions. As part of their studies, they wrote a report to analyse the relationship between collision theory and the rate of reactions. An extract from their report is shown. **5**

Collision theory

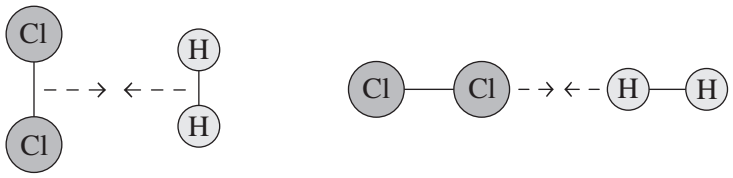
There are several factors involved in collision theory. Reactant molecules must collide successfully for a chemical reaction to occur. Only collisions with sufficient kinetic energy are successful. The maximum kinetic energy required for a reaction to occur is called the activation energy, E_a.



Only particles with kinetic energy to the left of the dashed line have the required amount of kinetic energy.

Also, how molecules line up affects how successful a collision will be. This example shows the stages of the reaction between chlorine and hydrogen: $Cl_2(g) + H_2(g) \rightarrow 2HCl(g)$.

Successful collision likely *Successful collision unlikely*



A collision will only result in a reaction if the molecules are lined up in the right way. The more successful collisions there are in a system, the faster the reactants and products will reach equilibrium.

Evaluate how well the student analysed the relationship between collision theory and reaction rate in terms of how it relates to chemical equilibrium reactions.

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Question 24 (6 marks)

An aqueous solution containing silver nitrate ($AgNO_3$) was mixed with an aqueous solution of sodium chloride (NaCl). A precipitate, *X*, was formed and found to have a solubility product constant, K_{sp}, of 1.77×10^{-10}.

(a) Write the name and molecular formula of *X*. **1**

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(b) What information about a substance does its K_{sp} provide? **1**

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(c) Determine the equilibrium expression for *X* and calculate the solubility, in grams per litre, of *X*. **4**

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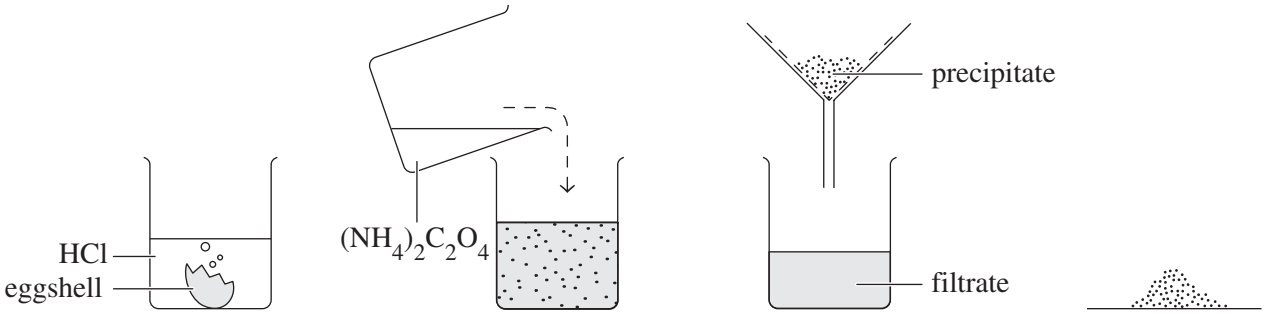
Question 25 (6 marks)

A commercial producer of chicken eggs conducted a quality control check of their eggs to ensure that they were suitable for transport. They tested the strength of the eggshells by measuring the calcium carbonate ($CaCO_3$) content of the shells. The percentage by mass of $CaCO_3$ in the shells was determined using a multi-stage process. Part of the laboratory technician's report for the test is shown.

> A sample of clean, dry eggshell with a mass of 0.391 g was completely reacted with a minimum volume of dilute hydrochloric acid (HCl). A solution of ammonium oxalate ($(NH_4)_2C_2O_4$) was then added in excess to form crystals of calcium oxalate monohydrate ($CaC_2O_4.H_2O$). The resulting suspension was filtered and the insoluble residue was dried to a constant mass. A mass of 0.497 g of $CaC_2O_4.H_2O$ was collected.

Some details of the process are illustrated in the diagram.



Step 1
The reaction occurs.

Step 2
A precipitate is formed.

Step 3
The precipitate is filtered.

Step 4
The precipitate is dried.

(a) How would the technician have known when all the $CaCo_3$ in the eggshell had reacted with the HCl? **1**

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Question 25 continues on page 18

Question 25 (continued)

(b) Determine the percentage by mass of $CaCO_3$ in the eggshell. Include all relevant chemical equations in your answer. **4**

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(c) Identify ONE assumption that was made in accepting that the mass of $CaC_2O_4.H_2O$ obtained was accurate. **1**

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End of Question 25

Question 26 (7 marks)

As part of the Chemistry course, you have carried out an investigation to demonstrate the use of pH to indicate the differences between the strengths of acids and bases. **7**

Explain how you carried out your investigation. In your answer, refer to how pH relates to acid and base strength, the conclusions reached and any safety precautions taken.

Question 27 (5 marks)

A Chemistry class was instructed to find the concentration of a sample of sodium hydroxide (NaOH) solution using 1.07 mol L^{-1} HCl. The class determined that an average titre of 23.45 mL of acid was required to neutralise a 20.00 mL aliquot of the base.

(a) Calculate the concentration of the NaOH solution. **3**

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(b) A group of students in the class did not rinse one of the pieces of glassware with the appropriate solution; they rinsed the 20.00 mL pipette with water rather than the base. **2**

Explain the effect that this had on the figure that the class obtained for the titre.

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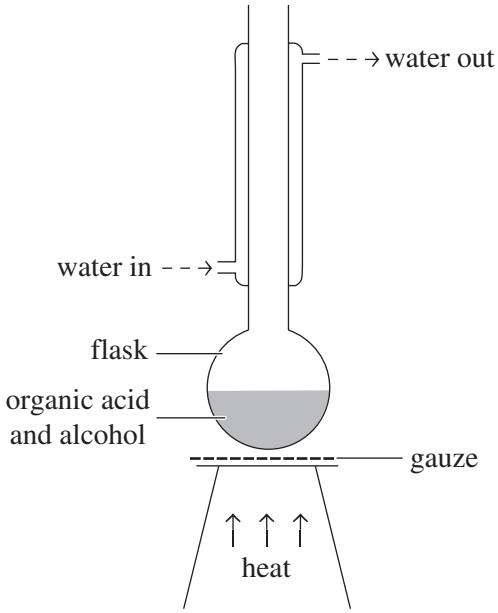
Question 28 (10 marks)

Alcohols can be used to make different compounds. The diagram shows the apparatus used to react an organic acid with an alcohol.



(a) Identify the technique illustrated in the diagram. **1**

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(b) Provide ONE reason why this technique was used for the reaction. **1**

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(c) What is the general name of the type of compound produced by this reaction? **1**

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Question 28 continues on page 22

Question 28 (continued)

The table shows the solubility of a series of alcohols.

Alcohol	*Solubility in water (g L^{-1})*
butan-1-ol	73
hexan-1-ol	5.9
heptan-1-ol	1.7
octan-1-ol	0.3

(d) Plot the number of carbon atoms against solubility. **3**

(e) Estimate the solubility of pentan-1-ol in grams per litre. **1**

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Question 28 continues on page 23

Question 28 (continued)

(f) Explain the trend in the solubilities of these alcohols. **3**

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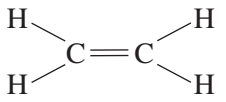
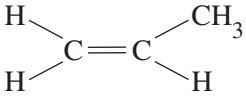
End of Question 28

Question 29 (4 marks)

The table shows the reactants of two reactions involving unsaturated hydrocarbons. **4**

Complete the table with the structural formulae and names of the products.

Reactants		*Structural formula of product*	*Name of product*
	→		
	→		

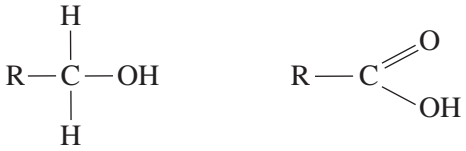
Question 30 (7 marks)

Discuss the implications of the extraction and use of hydrocarbons obtained from Earth. **7**

Question 31 (6 marks)

The general structural formulae of two types of organic compounds, *A* and *B*, are shown. **6**

Compound A *Compound B*



Using examples, explain how qualitative tests could be used to differentiate these compound types.

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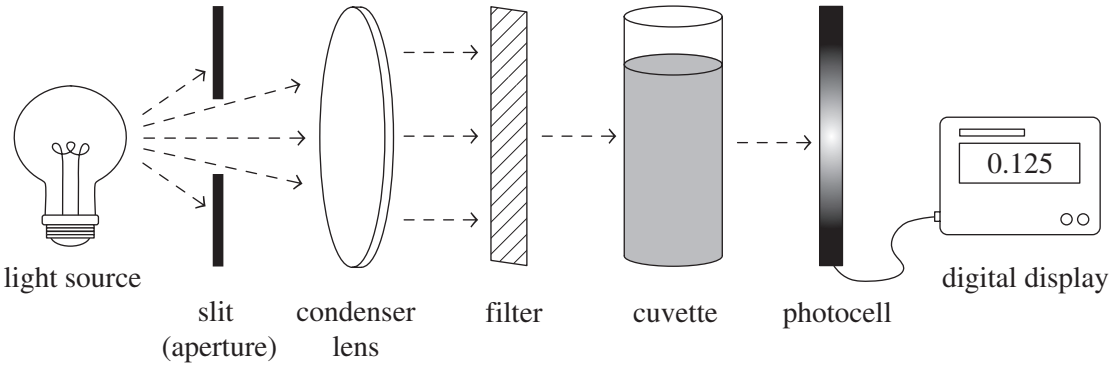
Question 32 (6 marks)

The diagram shows the major components of a colourimeter. **6**



Explain the purpose of and principle behind colourimetry and, with reference to the diagram, explain how a colourimeter works.

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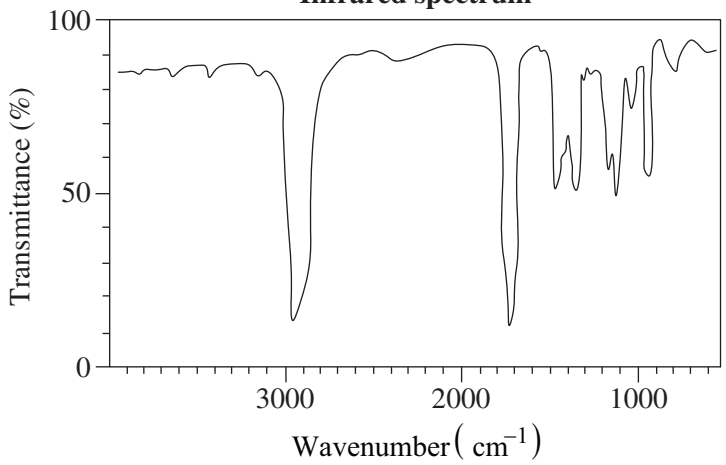
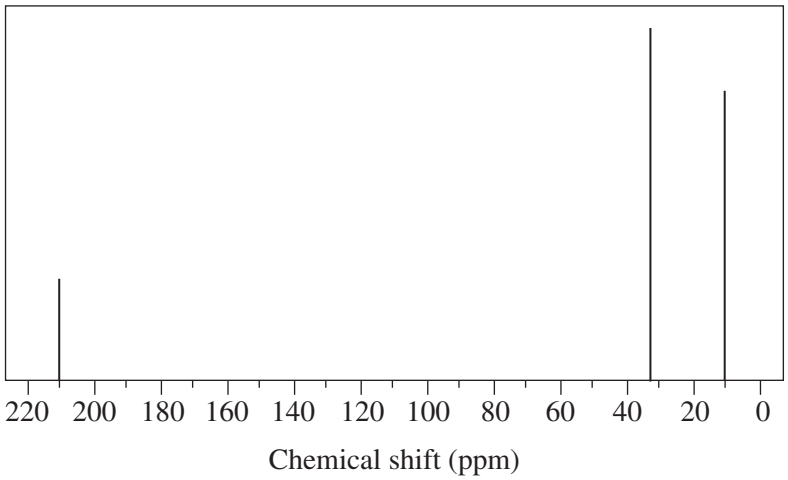
Question 33 (7 marks)

A laboratory technician came across a bottle containing an unknown organic compound. There was an incomplete label on the bottle that only indicated the empirical formula of the bottle's contents: $C_5H_{10}O$. The technician carried out several tests on the bottle's contents. The results of the tests are shown. The molar mass of the compound is 86.13 g mol^{-1}.

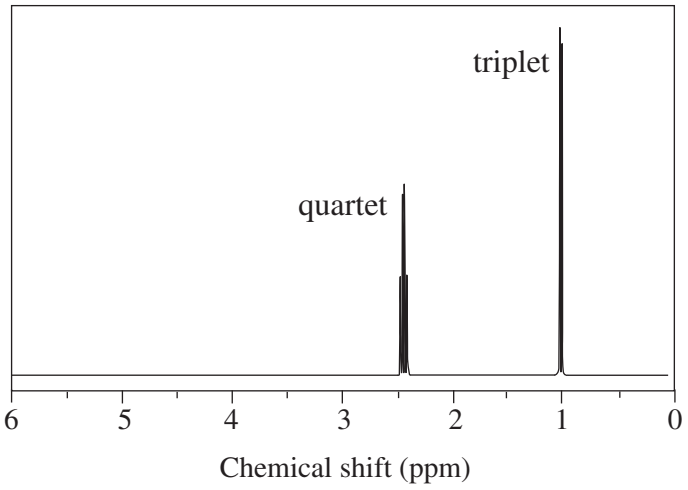
Infrared spectrum



Carbon-13 NMR spectrum



Proton NMR



Question 33 continued on page 29

Question 33 (continued)

(a) Determine the molecular formula of the compound. Justify your answer. **2**

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(b) Draw and name the compound. Justify your answer with reference to the information provided. **5**
Structure:

Question 33 continues on page 30

Question 33 (continued)

Name:.....

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Section II extra writing space

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If you use this space, clearly indicate which question you are answering.

FORMULAE SHEET

$$n = \frac{m}{MM} \qquad c = \frac{n}{V} \qquad PV = nRT$$

$$q = mc\Delta T \qquad \Delta G^\circ = \Delta H^\circ - T\Delta S^\circ \qquad \text{pH} = -\log_{10}\left[\text{H}^+\right]$$

$$pK_a = -\log_{10}\left[K_a\right] \qquad A = \varepsilon lc = \log_{10}\frac{I_o}{I}$$

Avogadro constant, N_A		6.022×10^{23} 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 J mol^{-1} K^{-1}
Ionisation constant for water at 25°C (298.15 K), K_w		1.0×10^{-14}
Specific heat capacity of water		4.18×10^3 J kg^{-1} K^{-1}

DATA SHEET

Solubility constants at 25°C

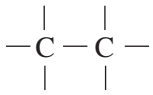
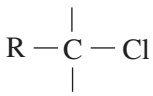
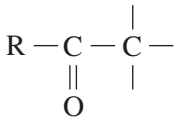
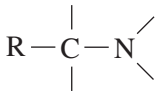
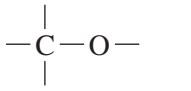
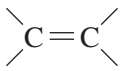
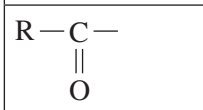
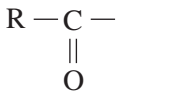
Compound	K_{sp}
Barium carbonate	2.58×10^{-9}
Barium hydroxide	2.55×10^{-4}
Barium phosphate	1.3×10^{-29}
Barium sulfate	1.08×10^{-10}
Calcium carbonate	3.36×10^{-9}
Calcium hydroxide	5.02×10^{-6}
Calcium phosphate	2.07×10^{-29}
Calcium sulfate	4.93×10^{-5}
Copper(II) carbonate	1.4×10^{-10}
Copper(II) hydroxide	2.2×10^{-20}
Copper(II) phosphate	1.40×10^{-37}
Iron(II) carbonate	3.13×10^{-11}
Iron(II) hydroxide	4.87×10^{-17}
Iron(III) hydroxide	2.79×10^{-39}
Iron(III) phosphate	9.91×10^{-16}

Compound	K_{sp}
Lead(II) bromide	6.60×10^{-6}
Lead(II) chloride	1.70×10^{-5}
Lead(II) iodide	9.8×10^{-9}
Lead(II) carbonate	7.40×10^{-14}
Lead(II) hydroxide	1.43×10^{-15}
Lead(II) phosphate	8.0×10^{-43}
Lead(II) sulfate	2.53×10^{-8}
Magnesium carbonate	6.82×10^{-6}
Magnesium hydroxide	5.61×10^{-12}
Magnesium phosphate	1.04×10^{-24}
Silver bromide	5.35×10^{-13}
Silver chloride	1.77×10^{-10}
Silver carbonate	8.46×10^{-12}
Silver hydroxide	2.0×10^{-8}
Silver iodide	8.52×10^{-17}
Silver phosphate	8.89×10^{-17}
Silver sulfate	1.20×10^{-5}

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

^{13}C NMR chemical shift data

Type of carbon	δ/ppm
	5–40
	10–70
	20–50
	25–60
 alcohols, ethers or esters	50–90
	90–150
	110–125
	110–160
 esters or acids	160–185
 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

$K^+ + e^-$	$\rightleftharpoons$	$K(s)$	–2.94 V
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	$Ba(s)$	–2.91 V
$Ca^{2+} + 2e^-$	$\rightleftharpoons$	$Ca(s)$	–2.87 V
$Na^+ + e^-$	$\rightleftharpoons$	$Na(s)$	–2.71 V
$Mg^{2+} + 2e^-$	$\rightleftharpoons$	$Mg(s)$	–2.36 V
$Al^{3+} + 3e^-$	$\rightleftharpoons$	$Al(s)$	–1.68 V
$Mn^{2+} + 2e^-$	$\rightleftharpoons$	$Mn(s)$	–1.18 V
$H_2O + e^-$	$\rightleftharpoons$	$\frac{1}{2} H_2(g) + OH^-$	–0.83 V
$Zn^{2+} + 2e^-$	$\rightleftharpoons$	$Zn(s)$	–0.76 V
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	$Fe(s)$	–0.44 V
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	$Ni(s)$	–0.24 V
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	$Sn(s)$	–0.14 V
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	$Pb(s)$	–0.13 V
$H^+ + e^-$	$\rightleftharpoons$	$\frac{1}{2} H_2(g)$	0.00 V
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_2(aq) + 2H_2O$	0.16 V
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	$Cu(s)$	0.34 V
$\frac{1}{2} O_2(g) + H_2O + 2e^-$	$\rightleftharpoons$	$2OH^-$	0.40 V
$Cu^+ + e^-$	$\rightleftharpoons$	$Cu(s)$	0.52 V
$\frac{1}{2} I_2(s) + e^-$	$\rightleftharpoons$	I^-	0.54 V
$\frac{1}{2} I_2(aq) + e^-$	$\rightleftharpoons$	I^-	0.62 V
$Fe^{3+} + e$	$\rightleftharpoons$	Fe^{2+}	0.77 V
$Ag^+ + e^-$	$\rightleftharpoons$	$Ag(s)$	0.80 V
$\frac{1}{2} Br_2(l) + e^-$	$\rightleftharpoons$	Br^-	1.08 V
$\frac{1}{2} Br_2(aq) + e^-$	$\rightleftharpoons$	Br^-	1.10 V
$\frac{1}{2} O_2(g) + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O	1.23 V
$\frac{1}{2} Cl_2(g) + e^-$	$\rightleftharpoons$	Cl^-	1.36 V
$\frac{1}{2} Cr_2O_7^{2-} + 7H^+ + 3e^-$	$\rightleftharpoons$	$Cr^{3+} + \frac{7}{2} H_2O$	1.36 V
$\frac{1}{2} Cl_2(aq) + e^-$	$\rightleftharpoons$	Cl^-	1.40 V
$MnO_4^- + 8H^+ + 5e^-$	$\rightleftharpoons$	$Mn^{2+} + 4H_2O$	1.51 V
$\frac{1}{2} F_2(g) + e^-$	$\rightleftharpoons$	F^-	2.89 V

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

PERIODIC TABLE OF THE ELEMENTS

KEY

atomic number
symbol
standard atomic weight
name

79 Au 197.0 gold

1 H 1.008 hydrogen																	**2 He** 4.003 helium
3 Li 6.941 lithium	**4 Be** 9.012 beryllium											**5 B** 10.81 boron	**6 C** 12.01 carbon	**7 N** 14.01 nitrogen	**8 O** 16.00 oxygen	**9 F** 19.00 fluorine	**10 Ne** 20.18 neon
11 Na 22.99 sodium	**12 Mg** 24.31 magnesium											**13 Al** 26.98 aluminium	**14 Si** 28.09 silicon	**15 P** 30.97 phosphorus	**16 S** 32.07 sulfur	**17 Cl** 35.45 chlorine	**18 Ar** 39.95 argon
19 K 39.10 potassium	**20 Ca** 40.08 calcium	**21 Sc** 44.96 scandium	**22 Ti** 47.87 titanium	**23 V** 50.94 vanadium	**24 Cr** 52.00 chromium	**25 Mn** 54.94 manganese	**26 Fe** 55.85 iron	**27 Co** 58.93 cobalt	**28 Ni** 58.69 nickel	**29 Cu** 63.55 copper	**30 Zn** 65.38 zinc	**31 Ga** 69.72 gallium	**32 Ge** 72.64 germanium	**33 As** 74.92 arsenic	**34 Se** 78.96 selenium	**35 Br** 79.90 bromine	**36 Kr** 83.80 krypton
37 Rb 85.47 rubidium	**38 Sr** 87.61 strontium	**39 Y** 88.91 yttrium	**40 Zr** 91.22 zirconium	**41 Nb** 92.91 niobium	**42 Mo** 95.96 molybdenum	**43 Tc** technetium	**44 Ru** 101.1 ruthenium	**45 Rh** 102.9 rhodium	**46 Pd** 106.4 palladium	**47 Ag** 107.9 silver	**48 Cd** 112.4 cadmium	**49 In** 114.8 indium	**50 Sn** 118.7 tin	**51 Sb** 121.8 antimony	**52 Te** 127.6 tellurium	**53 I** 126.9 iodine	**54 Xe** 131.3 xenon
55 Cs 132.9 caesium	**56 Ba** 137.3 barium	**57–71** lanthanoids	**72 Hf** 178.5 hafnium	**73 Ta** 180.9 tantalum	**74 W** 183.9 tungsten	**75 Re** 186.2 rhenium	**76 Os** 190.2 osmium	**77 Ir** 192.2 iridium	**78 Pt** 195.1 platinum	**79 Au** 197.0 gold	**80 Hg** 200.6 mercury	**81 Tl** 204.4 thallium	**82 Pb** 207.2 lead	**83 Bi** 209.0 bismuth	**84 Po** polonium	**85 At** astatine	**86 Rn** radon
87 Fr francium	**88 Ra** radium	**89–103** actinoids	**104 Rf** rutherfordium	**105 Db** dubnium	**106 Sg** seaborgium	**107 Bh** bohrium	**108 Hs** hassium	**109 Mt** meitnerium	**110 Ds** darmstadtium	**111 Rg** roentgenium	**112 Cn** copernicium	**113 Nh** nihonium	**114 Fl** flerovium	**115 Mc** moscovium	**116 Lv** livermorium	**117 Ts** tennessine	**118 Og** oganesson

Lanthanoids

57 La 138.9 lanthanum	**58 Ce** 140.1 cerium	**59 Pr** 140.9 praseodymium	**60 Nd** 144.2 neodymium	**61 Pm** promethium	**62 Sm** 150.4 samarium	**63 Eu** 152.0 europium	**64 Gd** 157.3 gadolinium	**65 Tb** 158.9 terbium	**66 Dy** 162.5 dysprosium	**67 Ho** 164.9 holmium	**68 Er** 167.3 erbium	**69 Tm** 168.9 thulium	**70 Yb** 173.1 ytterbium	**71 Lu** 175.0 lutetium

Actinoids

89 Ac actinium	**90 Th** 232.0 thorium	**91 Pa** 231.0 protactinium	**92 U** 238.0 uranium	**93 Np** neptunium	**94 Pu** plutonium	**95 Am** americium	**96 Cm** curium	**97 Bk** berkelium	**98 Cf** californium	**99 Es** einsteinium	**100 Fm** fermium	**101 Md** mendelevium	**102 No** nobelium	**103 Lr** lawrencium

Standard atomic weights are abridged to four significant figures.
Elements with no reported values in the table have no stable nuclides.
Information on elements with atomic numbers 113 and above is sourced from the International Union of Pure and Applied Chemistry Periodic Table of the Elements (November 2016 version).
The International Union of Pure and Applied Chemistry Periodic Table of the Elements (February 2010 version) is the principal source of all other data. Some data may have been modified.

Neap

Trial Examination 2023

HSC Year 12 Chemistry

Solutions and Marking Guidelines

SECTION I

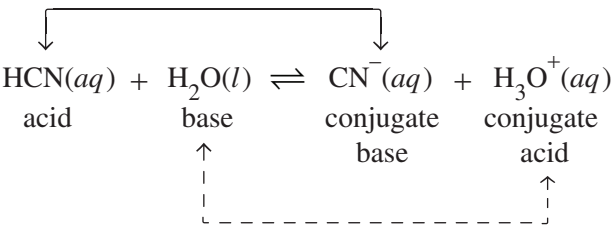
Answer and explanation	Syllabus content, outcomes and targeted performance bands
Question 1 B **B** is correct. The diagram shows the non-polar and polar components found in a soap molecule. An example of a soap molecule is sodium stearate. **A** is incorrect. A detergent molecule has a non-polar component similar to that shown in the diagram, but the polar end is different. An example of a detergent molecule is sodium lauryl sulfate. **C** is incorrect. A hydrocarbon contains carbon and hydrogen atoms only. **D** is incorrect. A polymer comprises many monomers joined together, but soap has separate molecules.	Mod 7 Organic Chemistry CH12–14 Bands 1–2
Question 2 A **A** is correct. Lowering the activation energy, E_a, enables a reaction to reach equilibrium faster. This is because a lower E_a means that more reactant molecules will have sufficient energy to overcome the E_a and react. **B** is incorrect. E_a has no effect on equilibrium position. **C** is incorrect. E_a affects both exothermic and endothermic reactions. **D** is incorrect. E_a applies to both equilibrium and non-equilibrium reactions.	Mod 5 Equilibrium and Acid Reactions CH12–12 Bands 2–3
Question 3 D **D** is correct. Dynamic equilibrium occurs in only closed systems where energy but not matter can be exchanged with the surroundings. Static equilibrium can occur in both open systems (where matter and energy can be exchanged with the surroundings) and closed systems. **A** and **B** are incorrect. Dynamic equilibrium is reversible in nature because the reactants and products are still participating in chemical reactions. On the other hand, static equilibrium is irreversible as no chemical reactions are occurring. **C** is incorrect. In dynamic equilibrium, the forward and backward reaction rates are equal. In static equilibrium, the reaction rates are zero because no reactions are occurring.	Mod 5 Equilibrium and Acid Reactions CH12–12 Bands 2–3
Question 4 A **A** is correct. This option is the only balanced equation with the correct states. **B** and **D** are incorrect. These options do not show the correct states. **C** is incorrect. This option is unbalanced.	Mod 6 Acid/Base Reactions CH12–6 Bands 2–3

Answer and explanation	Syllabus content, outcomes and targeted performance bands
Question 5 D A buffer should contain a mixture of a weak acid and its salt or a weak base and its salt. Only option **D** meets these criteria.	Mod 6 Acid/Base Reactions CH12–13 Bands 2–3
Question 6 B The equation for this reaction is as follows. $Pb(NO_3)_2(aq) + 2KI(aq) \rightarrow PbI_2(s) + 2KNO_3(aq)$ Solution X is $KNO_3(aq)$ and precipitate Y is $PbI_2(s)$.	Mod 5 Equilibrium and Acid Reactions CH12–6 Bands 4–5
Question 7 C A reaction proceeds spontaneously when $\Delta G^\circ < 0$ and non-spontaneously when $\Delta G^\circ > 0$. Letting $\Delta G^\circ = 0$ and solving $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$ for T gives: $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$ $0 = -30\,000 - (T \times -90)$ $30\,000 = 90T$ $T = 333$ K	Mod 5 Equilibrium and Acid Reactions CH12–6 Bands 5–6
Question 8 B The initial pH is 11, which implies that the initial solution was a weak base. The final pH is 1, which implies that a strong acid was added.	Mod 6 Acid/Base Reactions CH12–6, 12–13 Bands 3–4
Question 9 A $pOH + pH = 14$ $pOH = 14 - pH$ $14 - 3.5 = 10.5$ Hence, $[OH^-] = 1 \times 10^{-10.5}$ mol L^{-1}.	Mod 6 Acid/Base Reactions CH12–5, 12–13 Bands 4–5
Question 10 D **D** is correct. A Brønsted–Lowry base is defined as a substance that can accept a donated proton. **A** is incorrect. This option defines an Arrhenius acid. **B** is incorrect. This option defines an Arrhenius base. **C** is incorrect. This option defines a Brønsted–Lowry acid.	Mod 6 Acid/Base Reactions CH12–13 Bands 3–4
Question 11 C **C** is correct. This equation represents the addition reaction of an unsaturated hydrocarbon and is balanced. **A**, **B** and **D** are incorrect. In these equations, the hydrocarbons are saturated and will not undergo addition reactions. Option **D** is also an unbalanced equation.	Mod 7 Organic Chemistry CH12–14 Bands 3–4
Question 12 C An open system allows the flow of matter and energy in and out of a system. A closed system allows the flow of only energy.	Mod 5 Equilibrium and Acid Reactions CH12–2, 12–6 Bands 3–4

Answer and explanation	Syllabus content, outcomes and targeted performance bands
Question 13 A Molecule *P* has a carboxyl group (COOH) and so is a carboxylic acid. Molecule *Q* has an amino group (NH_2) and so is an amine. Molecule *R* has an amide group (carbonyl group (C=O) attached to an N) and so is an amide.	Mod 7 Organic Chemistry CH12–14 Bands 4–5
Question 14 B The mass loss occurs due to the evolution of carbon dioxide (CO_2). It starts at zero, initially increases quickly and then settles to a steady value.	Mod 7 Organic Chemistry CH12–6, 12–14 Bands 3–4
Question 15 C **C** is correct. The reaction occurs according to the following equation. $C_6H_{12}O_6(aq) \xrightarrow{\text{yeast}} 2C_2H_5OH(aq) + 2CO_2(g)$ Stoichiometry shows that 2 mol of CO_2 was produced per mole of $C_6H_{12}O_6$. **A** is incorrect. The initial concentration was $\frac{5}{50} \times 100 = 10$ m/v%. **B** is incorrect. More yeast would have been formed during fermentation. **D** is incorrect. C_2H_5OH is also used as a solvent and a biofuel.	Mod 7 Organic Chemistry CH12–4, 12–14 Bands 4–5
Question 16 D **D** is correct. In mass spectra, the species have positive charges. **A** is incorrect. The species with the greatest mass-to-charge ratio is at m/z = 75. **B** is incorrect. This option shows a negative charge. **C** is incorrect. This option shows no charge.	Mod 8 Applying Chemical Ideas CH12–6, 12–14 Bands 3–4
Question 17 D The correct order is as follows. 1. Obtain a pure sample of the substance being investigated. (IV) 2. Prepare a solution containing a known mass of the substance being investigated. (III) 3. Separate the desired constituent. (II) 4. Determine the mass of the isolated constituent. (V) 5. Calculate the amount of the isolated constituent using its mass. (I)	Mod 8 Applying Chemical Ideas CH12–6, 12–15 Bands 3–4

Answer and explanation	Syllabus content, outcomes and targeted performance bands
Question 18 **A** **A** is correct. A flame test is used to identify metallic ions (positive cations); the different cations produce different colours in the flames. **B** is incorrect. Anions can be identified using, for example, a precipitation reaction. **C** is incorrect. Organic compounds can be identified using, for example, chromatography, mass spectrometry and infrared spectroscopy. **D** is incorrect. Mineral acids can be identified using, for example, mass spectrometry.	Mod 8 Applying Chemical Ideas CH12–3, 12–15 Bands 3–4
Question 19 **C** Reading from the curve, an absorbance of 0.53 corresponds to a concentration of 0.350 mg per 100 mL. Therefore, 1.0 L of solution (and hence 10 g of ore) contains 3.5 mg of lead. $\%(\text{Pb}) = \frac{m(\text{Pb})}{m(\text{sample})} \times 100$ $= \frac{3.5 \times 10^{-3}}{10} \times 100$ $= 0.035\%$	Mod 8 Applying Chemical Ideas CH12–6, 12–15 Bands 5–6
Question 20 **C** The monomer has the formula C_2H_3Cl and a molar mass of 62.494 g mol^{-1}. n is the number of monomers in the chain. value of $n = \frac{MM(\text{sample})}{MM(\text{monomer})}$ $= \frac{623\,800}{62.494}$ $= 9982$	Mod 7 Organic Chemistry CH12–6, 12–14 Bands 4–5

SECTION II

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 21	
(a) They are the same.	Mod 5 Equilibrium and Acid Reactions CH12– 6, 12–12 Bands 1–2 • States that the reaction rates are the same 1
(b) The equation is $Fe^{3+} + SCN^- \rightleftharpoons FeSCN^{2+}$. The equilibrium expression is: $K_{eq} = \frac{[\text{products}]}{[\text{reactants}]} = \frac{[FeSCN^{2+}]}{[Fe^{3+}][SCN^-]}$	Mod 5 Equilibrium and Acid Reactions CH12–6, 12–12 Bands 3–4 • Provides the correct equilibrium expression 1
(c) The equilibrium constant, K_{eq}, is a relatively large number, which suggests that at equilibrium there are significantly more products than reactants. This indicates that the equilibrium position lies to the right.	Mod 5 Equilibrium and Acid Reactions CH12–6, 12–12 Bands 2–3 • Provides a detailed explanation . . . . 2 • Provides some relevant information 1
Question 22	
(a) $NH_3(g) + 2CO(g) \rightleftharpoons HCN(g) + CO_2(g) + H_2(g)$ $\Delta H > 0$ *Note: The enthalpy change is not required to obtain the mark.*	Mod 5 Equilibrium and Acid Reactions CH12–12 Bands 1–2 • Provides the correct balanced equation 1
(b) *Change* / *Effect* adding a catalyst — no effect *(A catalyst enables the reaction to reach the equilibrium position faster but does not affect the position.)* increasing the pressure — no effect *(Volumes are equal on both the left-hand side and right-hand side.)* increasing the temperature — shifts the equilibrium to the right *(The reaction is endothermic.)* adding a quantity of an inert gas — no effect *(Volumes are equal on both the left-hand side and right-hand side.)*	Mod 5 Equilibrium and Acid Reactions CH12–12 Bands 2–3 • States all FOUR effects . . . . . 4 • States THREE effects . . . . . 3 • States TWO effects . . . . . 2 • States ONE effect OR • Provides some relevant information 1
(c) 	Mod 6 Acid/Base Reactions CH12–13 Bands 3–4 • Labels BOTH pairs . . . . . 2 • Labels ONE pair 1

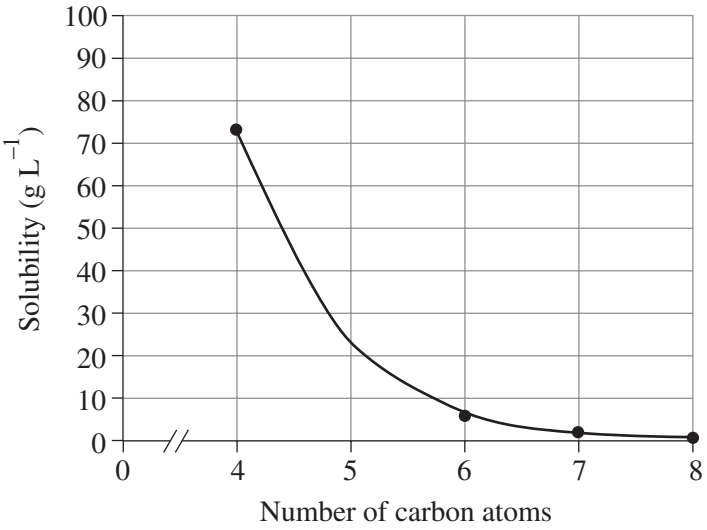
Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 23	
The student explained some aspects of collision theory and reaction rate more successfully than others. Although the basic principles of the student's report are sound, the student incorrectly stated that activation energy is the maximum amount of energy required for a reaction to occur; however, it is the minimum amount. They used some appropriate language and terms, such as kinetic energy and activation energy, which are part of collision theory. However, they used poor terminology to address orientation. The student included accurate diagrams and an example to illustrate the theory. However, they did not accurately cross-reference the graph and the example reaction is not an equilibrium reaction. Overall, the student's report did not provide an in-depth analysis and described the relationship between collision theory and reaction rate with errors.	Mod 5 Equilibrium and Acid Reactions CH12–7, 12–12 Bands 4–6 • Provides a detailed evaluation. AND • Explains the strengths of the report. AND • Explains the weaknesses of the report. AND • Provides a judgement of the report . . . . . .5 • Explains the strengths of the report. AND • Explains the weaknesses of the report . . . . . .4 • Identifies the strengths of the report. AND • Identifies the weaknesses of the report . . . . . .3 • Identifies the strengths of the report. OR • Identifies the weaknesses of the report . . . . . .2 • Provides some relevant information 1

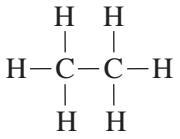
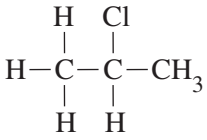
Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 24	
(a) silver chloride, AgCl	Mod 5 Equilibrium and Acid Reactions CH12–6, 12–15 Bands 2–3 • Provides the correct name and molecular formula. 1
(b) the level of the substance's solubility in water *Note: The lower the K_{sp} value, the lower the solubility; the higher the K_{sp} value, the higher the solubility.*	Mod 5 Equilibrium and Acid Reactions CH12–5, 12–12 Bands 1–2 • Identifies the information provided by K_{sp} 1
(c) $K_{sp} = [Ag^+][Cl^-]$ $= 1.77 \times 10^{-10}$ $[Ag^+] = [Cl^-]$, hence $[Ag^+]^2 = 1.77 \times 10^{-10}$ mol L^{-1}. $[Ag^+] = \sqrt{1.77 \times 10^{-10}}$ $= 1.3304 \times 10^{-5}$ mol L^{-1} $MM(AgCl) = 143.35$ g mol^{-1} $m(AgCl)$ in 1 L $= MM \times c$ $= 143.35 \times 1.3304 \times 10^{-5}$ $= 1.91 \times 10^{-3}$ g L^{-1}	Mod 5 Equilibrium and Acid Reactions CH12–6, 12–12 Bands 5–6 • Determines the correct equilibrium expression. AND • Calculates the concentration of Ag^+. AND • Calculates the solubility. . . . . 4 --- • Determines the correct equilibrium expression. AND • Calculates the concentration of Ag^+ with some minor errors. AND • Calculates the solubility. . . . . 3 --- • Determines the correct equilibrium expression. AND • Calculates the solubility. OR • Determines the correct equilibrium expression. AND • Shows some relevant working. . . . . 2 --- • Provides some relevant information 1

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 25	
(a) when the addition of dilute hydrochloric acid (HCl) did not cause more evolution of the carbon dioxide (CO_2) gas	Mod 6 Acid/Base Reactions CH12–13, 12–15 Bands 2–3 • Provides an appropriate reason 1
(b) Reaction of egg shell: $CaCO_3(s) + 2H^+(aq) \rightarrow Ca^{2+}(aq) + CO_2(g) + H_2O(l)$ Stoichiometry shows that 1 mol of Ca^{2+} is produced per mole of calcium carbonate ($CaCO_3$). Precipitation: $Ca^{2+}(aq) + C_2O_4{}^{2-}(aq) + H_2O(l) \rightarrow CaC_2O_4.H_2O(s)$ Stoichiometry shows that 1 mol of Ca^{2+} is present in 1 mol of calcium oxalate monohydrate ($CaC_2O_4.H_2O(s)$). $n(CaC_2O_4.H_2O) = \frac{m}{MM}$ $= \frac{0.497}{146.116}$ $= 3.4014 \times 10^{-3}$ mol Hence, the number of moles of Ca^{2+} present in the initial mass of $CaCO_3$ is 3.4014×10^{-3} mol. $m(CaCO_3) = n \times MM$ $= 3.4014 \times 10^{-3} \times 100.09$ $= 0.3404$ g $\%(CaCO_3) = \frac{m(CaCO_3)}{m(\text{egg shell})} \times 100$ $= \frac{0.3404}{0.391} \times 100$ $= 87.1\%$	Mod 6 Acid/Base Reactions CH12–6, 12–13 Bands 5–6 • Shows all relevant chemical equations. AND • Calculates the amount of $CaC_2O_4.H_2O$. AND • Calculates the mass of $CaCO_3$. AND • Determines the percentage by mass . . . . 4 • Shows some relevant chemical equations. AND • Shows some relevant working. AND • Determines the percentage by mass . . . . 3 • Determines the percentage by mass. AND • Shows some relevant working. OR • Shows some relevant chemical equations . . . . 2 • Provides some relevant information 1
(c) *For example, any one of:* • No undissolved solid remained after the initial reaction between eggshell and HCl. • All of the $CaC_2O_4.H_2O$ was precipitated out; that is, it was totally insoluble. • No mass was lost when the $CaC_2O_4.H_2O$ was allowed to dry to a constant mass.	Mod 6 Acid/Base Reactions CH12–5, 12–13 Bands 5–6 • Identifies ONE assumption 1

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 26	
For example: The strength of an acid or base is a measure of how completely ionised the molecules become when dissolved in water. Strong acids and bases are completely (or nearly completely) ionised in aqueous solutions. Weak acids and bases are only partially ionised. This means that when comparing a strong acid with a weak acid of the same concentration, the strong acid will have more hydrogen ions (H^+) in the solution and thus a lower pH. Similarly, when comparing a strong base with a weak base of the same concentration, the strong base will have more hydroxide ions (OH^-) in solution and thus a higher pH. To investigate this in the laboratory, a range of aqueous solutions of various acids and bases were made. These were made to various concentrations; for example, 1 mol L^{-1}, 0.1 mol L^{-1} and 0.01 mol L^{-1}. A pH meter was calibrated using a buffer of known pH and was used to record the pH of each acidic solution. The meter's electrode was rinsed with distilled water between each test. The meter was re-calibrated for use with the basic solutions and the pH of each of these solutions were recorded in the same manner as the acidic solutions. It was found that acids with a low pH could be classified as strong (for example, hydrochloric, nitric and sulfuric) and acids with a higher pH could be classified as weak (for example, citric, ethanoic and phosphoric). Similarly, bases with a high pH could be classified as strong (for example, sodium hydroxide and potassium hydroxide) and bases with a lower pH could be classified as weak (for example, aqueous ammonia and magnesium hydroxide). Safety precautions taken included wearing safety glasses, ensuring all glassware was free from cracks and sharp edges, ensuring all electrical items had a current safety tag and working on a bench free from clutter.	Mod 6 Acid/Base Reactions CH12–7, 12–13 Bands 5–6 • Explains the investigation in detail. AND • Refers to how pH relates to acid and base strength. AND • Refers to the conclusions reached. AND • Refers to any safety precautions taken . . . . . 6–7 --- • Explains the investigation. AND • Refers to how pH relates to acid and base strength. AND • Refers to the conclusions reached. AND • Refers to any safety precautions taken . . . . . 4–5 --- • Describes the investigation with limited detail. AND • Refers to at least ONE conclusion reached. AND • Refers to at least ONE safety precaution taken . . . . . 2–3 --- • Provides some relevant information 1

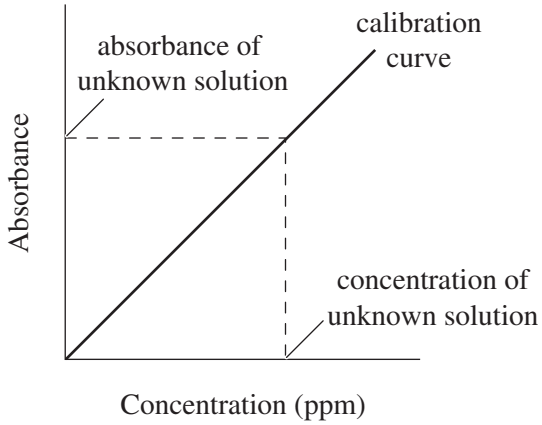
Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 27	
(a) Reaction: $HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$ stoichiometry = 1 : 1 Hence: $V(HCl) \times c(HCl) = V(NaOH) \times c(NaOH)$ $23.45 \times 1.07 = 20.00 \times c(NaOH)$ $c(NaOH) = \frac{23.45 \times 1.07}{20.00}$ $= 1.25 \text{ mol L}^{-1}$	Module 6 Acid/Base Reactions CH12–6, 12–13 Bands 4–5 • Determines a 1 : 1 ratio. AND • Shows relevant working. AND • Calculates the concentration . . . . . 3 • Shows some relevant working. AND • Calculates the concentration . . . . . 2 • Shows some relevant working. OR • Calculates the concentration 1
(b) As the pipette was rinsed with water instead of the NaOH solution, residual traces of water would have caused there to be less NaOH in the 20.00 mL aliquot. Hence, less HCl would have been required to neutralise the NaOH, meaning that the titre obtained is lower than would be expected.	Mod 6 Acid/Base Reactions CH12–6, 12–13 Bands 4–5 • Explains the effect . . . . . 2 • Identifies the effect 1

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 28	
(a) refluxing	Mod 7 Organic Chemistry CH12–7, 12–14 Bands 1–2 • Identifies the technique 1
(b) *Any one of:* • The reactants and products are flammable/ noxious and could be dangerous if they were to escape from the reaction vessel; the technique ensures that these reactants and products are kept in the reaction vessel and not lost. • The reaction is an equilibrium reaction that takes some time to reach equilibrium; the technique increases the percentage yield of products by ensuring that they are kept in the reaction vessel and not lost.	Mod 7 Organic Chemistry CH12–12, 12–14 Bands 3–4 • Provides ONE appropriate reason. 1
(c) ester	Mod 7 Organic Chemistry CH12–14 Bands 1–2 • Provides the general name. 1
(d) 	Mod 7 Organic Chemistry CH12–4 Bands 2–3 • Plots the correct data points. AND • Uses appropriate scales. AND • Draws a line of best fit. AND • Labels axes . . . . . 3 • Any THREE of the above points. . . 2 • Any TWO of the above points. 1
(e) 22 g L^{-1} *Note: Accept responses consistent with the line of best fit. Consequential on answer to* ***Question 28(d)****.*	Mod 7 Organic Chemistry CH12–6 Bands 2–3 • Estimates the solubility 1

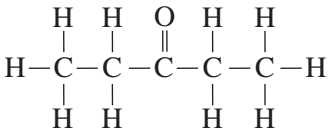
	Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
(f)	The solubility of the alcohols decreases with increasing hydrocarbon chain length. For an alcohol to be soluble in water, the energy released when new intermolecular bonds form between the alcohol molecules and water molecules must be greater than the energy required to break the bonds between the alcohol molecules and the bonds between the water molecules. The alcohols have a covalent component (the hydrocarbon chain) and a polar component (the hydroxyl (OH) group). The hydroxyl group is hydrophilic and forms hydrogen bonds with water molecules but, as a result, the hydrocarbon chain becomes longer as the number of carbons increases. Consequently, the effect of the hydrogen bonding becomes proportionately less and solubility decreases.	Mod 7 Organic Chemistry CH12–7,12–14 Bands 5–6 • Identifies the trend. AND • Explains the energy changes involved. AND • Explains the bonding involved . . . . 3 --- • Identifies the trend. AND • Identifies the energy changes involved. OR • Identifies the bonding involved . . . . 2 --- • Identifies the trend. OR • Identifies the energy changes involved. OR • Identifies the bonding involved 1
Question 29		
	<table><tr><th>Structural formula of product</th><th>Name of product</th></tr><tr><td>  </td><td>ethane</td></tr><tr><td>  </td><td>2-chloropropane</td></tr></table>	Mod 7 Organic Chemistry CH12–14 Bands 2–4 • Identifies ethane. AND • Draws the structural formula of ethane. AND • Identifies 2-chloropropane. AND • Draws the structural formula of 2-chloropropane . . . . . 4 --- • Any THREE of the above points . . . 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 30	
Hydrocarbons, which are often referred to as petrochemicals, are compounds that contain only hydrogen and carbon. They can be gases (for example, methane) or liquids (for example, crude oil) and have many uses. They tend to be used as fossil fuels and the raw materials for the production of more complex compounds (for example, as monomers for the production of polymers). The use of hydrocarbons has many environmental implications. They are extracted from the ground and this physical removal can damage sensitive environments as well as release toxic chemicals and greenhouse gases. Some companies that extract hydrocarbons claim that they have become more aware of their environmental impact and are putting practices into place that reduce damage to the environment. Additionally, burning hydrocarbons releases vast quantities of carbon dioxide, a greenhouse gas, into the atmosphere. Some vehicles that use hydrocarbon fuels such as diesel and petrol have become more fuel efficient and thus have less of a negative effect on the environment. Hydrocarbons are very useful chemicals, and the technology to extract and use them is well proven. Their use has implications for many economies. It has been estimated that in 2023 the petrochemical industry will be worth around a trillion Australian dollars annually. Many countries are financially dependent on exporting hydrocarbons and many people are employed in hydrocarbon-related industries. A large number of countries are reliant on hydrocarbons for heating and power stations. From a sociocultural perspective, the use of hydrocarbons has provided benefits such as the invention of durable polymers, including PVC and polystyrene. However, in recent years, many people have become concerned about the negative impacts of hydrocarbons on the environment and their contribution to global warming. Despite the many negative aspects of using hydrocarbons, they will most likely continue to play an important industrial role for many years. This is due to the benefits of using them, familiarity, the quantity of existing infrastructure and the absence of alternative materials. *Note: Responses may refer to environmental, economic and sociocultural implications. Students can obtain full marks by referring to only one of these areas provided that sufficient detail is given.*	Mod 7 Organic Chemistry CH12–7, 12–14 Bands 5–6 • Refers to a wide range of implications. AND • Discusses the implications in detail . . . . . .6–7 • Refers to a range of implications. AND • Discusses the implications adequately . . . . . .4–5 • Refers to at least TWO implications. AND • Outlines the implications . . . . . .3 • Refers to at least TWO implications . . . . . .2 • Provides some relevant information 1

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 31	
For example: A qualitative test is designed to identify the type of species present. Both compounds have a hydroxyl (OH) group, but they have different functional groups. Compound *A* is an alcohol and compound *B* is a carboxylic acid. An organic acid could be added to compound *A* and gently heated; this would produce the sweet smell of an ester. Alternatively, ceric ammonium nitrate solution, which has an orange-yellow colour, could be added; this would cause the mixture to turn red. Sodium hydrogen carbonate ($NaHCO_3$) could be added to compound *B*; this would effervesce, evolving bubbles of CO_2. Alternatively, an alcohol could added to compound *B* and gently heated; this would produce the sweet smell of an ester.	Mod 8 Applying Chemical Ideas CH12–14 Bands 4–5 • Outlines qualitative tests. AND • Identifies compound *A*. AND • Identifies compound *B*. AND • Explains at least TWO tests that could be used to differentiate the compounds . . . .5–6 --- • Identifies compound *A*. AND • Identifies compound *B*. AND • Outlines at least TWO tests that could be used to differentiate the compounds . . . . . .4 --- • Identifies compound *A*. AND • Identifies compound *B*. OR • Outlines at least TWO tests that could be used to differentiate the compounds . . . . . .3 --- • Identifies at least ONE test that could be used to differentiate the compounds . . . . . .2 --- • Provides some relevant information 1

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 32	
Colourimetry is a technique used to measure the concentration of a particular compound in a coloured solution. A colourimeter is a device that measures how much light of a particular frequency is absorbed by a liquid. The technique is based on the principle that the concentration of a coloured solute is proportional to the light absorbance of that solute, according to the Beer–Lambert law. Simply, this means that, if a light is shone through a coloured solution, a more concentrated solution will allow less light to pass through it. In the colourimeter shown, polychromatic light is passed through a slit, which controls the amount of light that passes into a condenser lens. The condenser lens focuses this light onto a filter. The filter passes monochromatic light of a frequency that will be absorbed by the sample solution being tested. The cuvette contains the sample; some light is absorbed by the sample as the light passes through the sample. The light that is not absorbed is then collected by the photocell and electricity is generated. The lower the concentration, the greater the amount of light that passes through the sample, and the greater the amount of electricity that is generated. Conversely, the higher the concentration, the lesser the amount of light and the lesser the amount of electricity. The electrical signal is translated into a number or reading on a digital scale. Before a colourimeter can be used for testing a particular solution, it needs to be calibrated. This involves making up standard solutions of known concentration of the substance under investigation. These should be in the approximate range of the concentration of the sample. The absorbances of these solutions are determined and the values plotted as a calibration curve, as shown in the diagram. The absorbance of the sample is compared to the calibration curve and its concentration calculated.  *Note: Responses are not required to include a diagram to obtain full marks.*	Mod 8 Applying Chemical Ideas CH12–7, 12–15 Bands 5–6 • Explains the purpose of colourimetry. AND • Explains the principle behind colourimetry. AND • Explains how a colourimeter works with reference to ALL the components in the diagram. AND • Explains colourimetry calibration . . . . . .5–6 • Outlines the purpose of colourimetry. AND • Outlines the principle behind colourimetry. AND • Explains how a colourimeter works with reference to some of the components in the diagram . . . . . .3–4 • Outlines the purpose of colourimetry. OR • Outlines the principle behind colourimetry. AND • Outlines how a colourimeter works with reference to some of the components in the diagram . . . . . .2–3 • Provides some relevant information 1

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 33	
(a) The molecular formula is $C_5H_{10}O$. The empirical formula is $C_5H_{10}O$, so the molecular formula is determined using $n \times (C_5H_{10}O)$. The molar mass of the compound is 86.13 g mol^{-1}. $12.01 \times 5 + 1.008 \times 10 + 16.00 = 86.13$ g mol^{-1}; therefore, $n = 1$, so the molecular formula is the same as the empirical formula.	Mod 7 Organic Chemistry CH12–6, 12–14 Bands 2–3 • Determines the correct molecular formula. AND • Justifies the answer . . . . . 2 • Determines the correct molecular formula 1

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
(b) **Structure:**  **Name:** pentan-3-one The molecular formula is $C_5H_{10}O$, which means that oxygen is present. This cannot be present in a hydroxyl group (OH) because OH does not fit the formula, and the infrared spectrum does not show absorption at the corresponding frequency (3230–3550 cm^{-1}). There is strong absorption at 1700 cm^{-1}; this corresponds to a carbonyl group (C=O), which indicates an aldehyde or ketone. The carbon-13 NMR spectrum shows peaks at 10 ppm and 33 ppm, which indicate carbon–carbon single bonds. The peak at 215 ppm corresponds to C=O, again indicating an aldehyde or ketone. The proton NMR shows two groups/environments. The triplet at 1 ppm and the quartet at 2.5 ppm show that there are CH_2 and CH_3 groups next to each other. As there are only two major groups, this indicates a symmetry where there are two groups of CH_3–CH_2–. This information points to a molecule with the C=O group in a central position, thus the compound is a ketone and not an aldehyde as C=O is chain-ending in an aldehyde. Therefore, the chemical formula of the compound is $CH_3CH_2COCH_2CH_3$ and the name is pentan-3-one.	Mod 8 Applying Chemical Ideas CH12–6, 12–14 Bands 5–6 • Draws the structure of the compound. AND • Names the compound. AND • Provides detailed justification. AND • Refers to ALL spectra . . . . . 5 --- • Draws the structure of the compound. AND • Names the compound. AND • Provides justification. AND • Refers to at least TWO spectra . . . . 4 --- • Draws the structure of the compound. AND • Names the compound. AND • Provides adequate justification. AND • Refers to at least ONE spectra . . . . . 3 --- • Draws the structure of the compound. AND • Names the compound. AND • Provides some justification . . . . . 2 --- • Provides some relevant information 1

