2022

HIGHER
SCHOOL
CERTIFICATE
TRIAL EXAMINATION

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 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
- Write your Student ID at the bottom of this page and at the top of page 12

Total marks:
100

Section I — 20 marks (pages 2-11)

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

Section II — 80 marks (pages 12-29)

- Attempt Questions 21– 37
- Allow about 2 hours and 25 minutes for this section

Student ID: _____

Section I

20 marks
Attempt Questions 1–20
Allow about 35 minutes for this part

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

---

1 The equilibrium expression shown can be written for which of the following equations?

$$K_{eq} = \frac{[H_3O^+][SO_4{}^{2-}]}{[HSO_4{}^-]}$$

A. $HSO_4^-(aq) \rightleftharpoons H_3O^+(aq) + SO_4^{2-}(aq)$

B. $H_3O^+(aq) + SO_4^{2-}(aq) \rightleftharpoons HSO_4^-(aq)$

C. $H_3O^+(aq) + SO_4^{2-}(aq) \rightleftharpoons HSO_4^-(aq) + H_2O(l)$

D. $HSO_4^-(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + SO_4^{2-}(aq)$

2 An equilibrium is set up in a sealed reaction vessel:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H = -198 \text{ kJ mol}^{-1}$$

Which would increase the yield of sulfur trioxide?

A. Adding a catalyst to the reaction vessel

B. Increasing the volume of the reaction vessel

C. Lowering the temperature of the reaction vessel

D. Increasing the pressure by adding argon to the reaction vessel

3 Look at these chemical equations.

I. $Cl_2(g) + H_2(g) \rightarrow 2HCl(g)$

II. $4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$

III. $2C_2H_6(g) + 7O_2(g) \rightarrow 4CO_2(g) + 6H_2O(g)$

IV. $CaCO_3(s) \rightleftharpoons CaO(s) + O_2(g)$

V. $2CrO_4^{2-}(aq) + 2H^+(aq) \rightleftharpoons Cr_2O_7^{2-}(aq) + H_2O(l)$

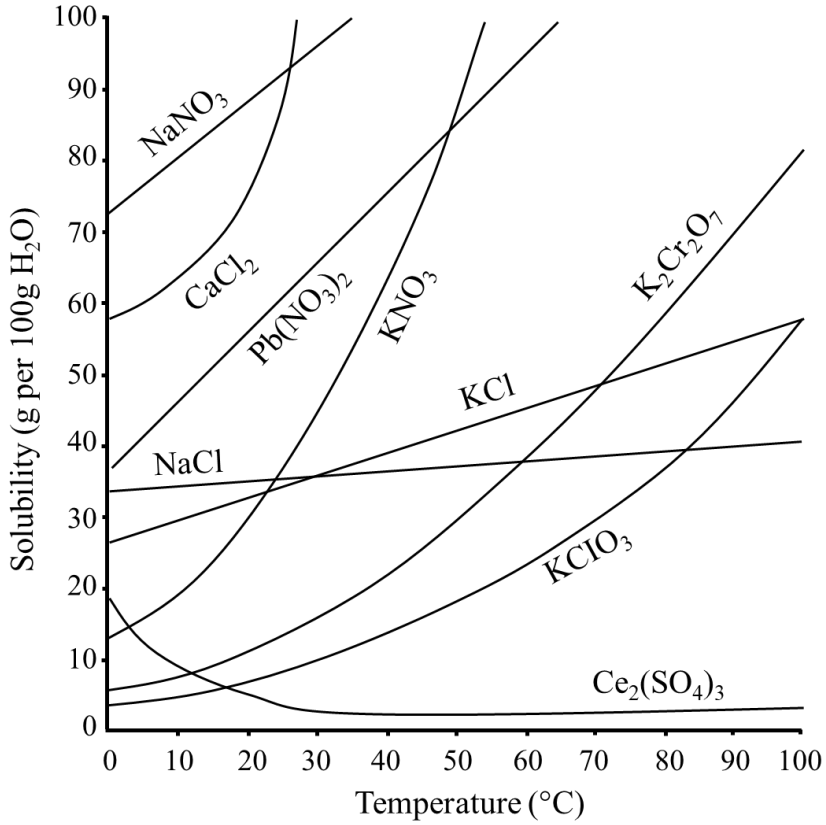
Which of these are examples of heterogeneous systems?

A. I and III
B. II, IV and V
C. I, II and IV
D. II, III and IV

4 Which of these substances would be considered a monoprotic acid?

A. HF
B. H_3PO_4
C. H_2SO_4
D. H_2CO_3

5 This graph shows solubility curves for ionic substances.



According to the graph, which substance will have a solubility of 65 g/100 g H_2O at a temperature of 40°C?

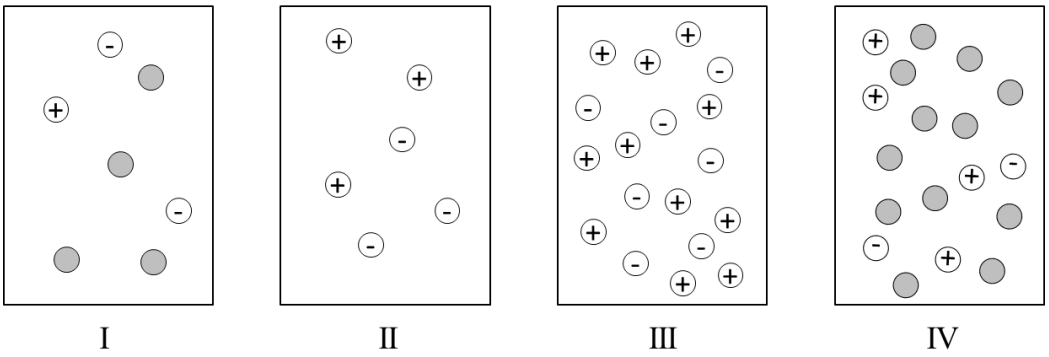
A. NaCl

B. KNO_3

C. $K_2Cr_2O_7$

D. $Pb(NO_3)_2$

6 A student models the difference between strong, weak, dilute and concentrated acids by placing different stickers onto sheets of paper.



⊕ positive ion
⊖ negative ion
● neutral molecule

Which model represents a concentrated strong acid?

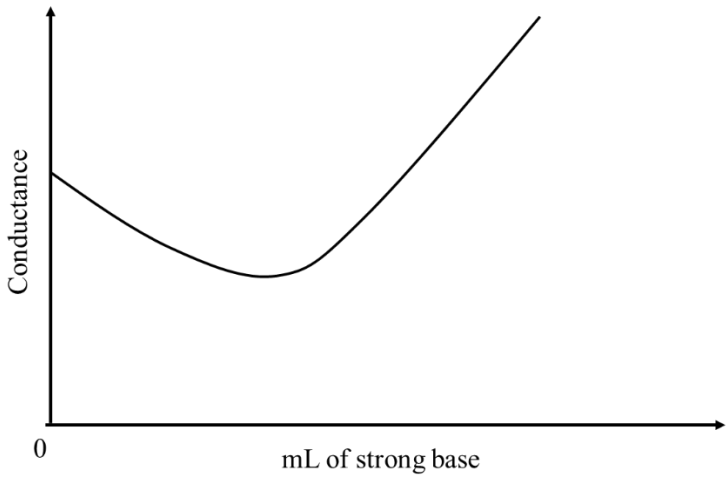
A. I

B. II

C. III

D. IV

7 This conductivity graph represents a reaction between two reactants.



What are the two reactants?

A. HNO_3 and NH_3

B. HCl and $Ca(OH)_2$

C. H_3PO_4 and $NaHCO_3$

D. CH_3COOH and KOH

8 Sodium hydrogen carbonate, $NaHCO_3$, is an example of an amphiprotic salt.

Which equation demonstrates how the hydrogen carbonate ion would react when added to a solution of sulfuric acid?

A. $HCO_3^-(aq) + OH^-(aq) \rightarrow CO_3^{2-}(aq) + H_2O(l)$

B. $HCO_3^-(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + CO_3^{2-}(aq)$

C. $HCO_3^-(aq) + H_2O(l) \rightleftharpoons H_2CO_3(aq) + OH^-(aq)$

D. $HCO_3^-(aq) + H_3O^+(aq) \rightarrow H_2CO_3(aq) + H_2O(l)$

9 Lactic acid, $HCH_3H_5O_3$, has a K_a of 1.38×10^{-4}.

What is the pH of a 0.25 mol L^{-1} solution of the acid?

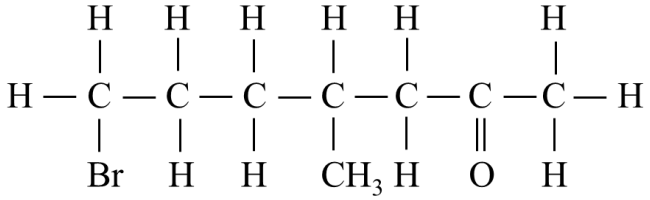
A. 2.20

B. 3.42

C. 5.49

D. 6.24

10 Look at the structural formula for the molecule shown.



What is the correct name for this molecule?

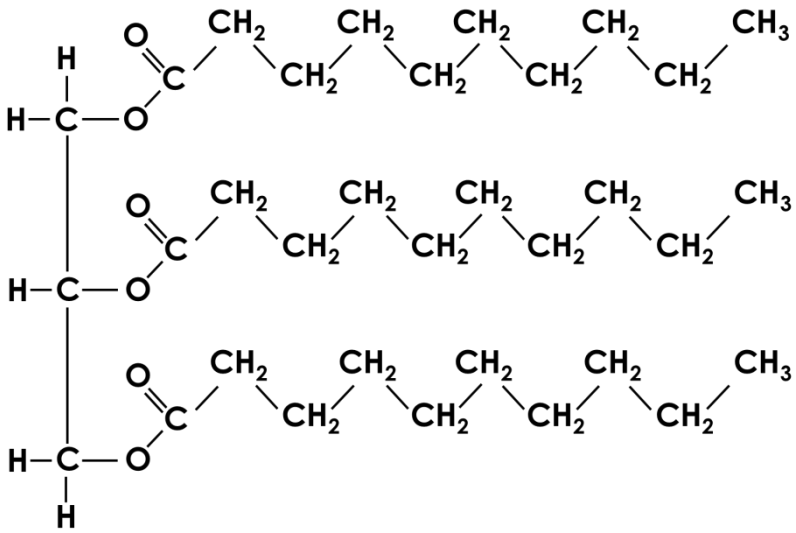
A. 1-bromo-4-methylheptanal

B. 1-bromo-4-methylheptan-6-one

C. 7-bromo-4-methylheptanal

D. 7-bromo-4-methylheptan-2-one

11 The diagram shows the structural formula of a triglyceride.



Triglycerides will react with sodium or potassium hydroxide to form an alcohol and a salt of a fatty acid.

What name is given to this type of reaction?

A. Substitution

B. Halogenation

C. Saponification

D. Hydrogenation

12 How many structural isomers are there for C_7H_{16}?

A. Ten

B. Nine

C. Eight

D. Seven

13 The solubility of lead(II) phosphate is 0.000014 g/100 g of water at 298 K.

Which would the K_{sp} for lead(II) phosphate be equal to?

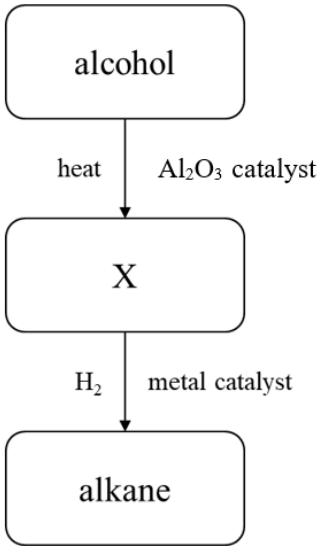
A. 1.10×10^{-32}

B. 1.10×10^{-37}

C. 1.65×10^{-32}

D. 1.65×10^{-37}

14 The diagram shows a series of synthesis pathways.



Which type of organic molecule is represented by X?

A. Alkene

B. Alkyne

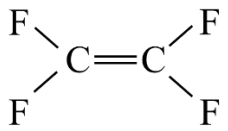
C. Aldehyde

D. Haloalkane

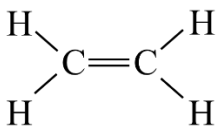
15 A monomer is commonly used to form an addition polymer as a frying pan coating due to its non-stick and high melting point properties.

Which monomer from those following is this most likely to be?

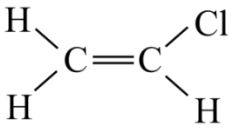
A.



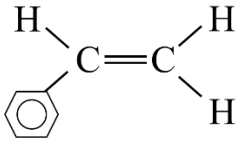
B.



C.



D.



The table shows the results of several complexation reactions and is used for Question 16.

	Fe^{2+}	Fe^{3+}	Co^{2+}	Cu^{2+}	Cr^{3+}
OH^-, dilute	$[Fe(H_2O)_4(OH_2]$ dark green precipitate	$[Fe(H_2O)_3(OH)_3]$ brown precipitate	$[Co(H_2O)_4(OH)_2]$ blue/green precipitate	$[Cu(H_2O)_4(OH)_2]$ blue precipitate	$[Cr(H_2O)_3(OH)_3]$ green precipitate
OH^-, concentrated	$[Fe(H_2O)_4(OH_2]$ dark green precipitate	$[Fe(H_2O)_3(OH)_3]$ brown precipitate	$[Co(H_2O)_4(OH)_2]$ blue/green precipitate	$[Cu(H_2O)_4(OH)_2]$ blue precipitate	$[Cr(OH)_6]^{3-}$ green solution
NH_3, dilute	$[Fe(H_2O)_4(OH_2]$ dark green precipitate	$[Fe(H_2O)_3(OH)_3]$ brown precipitate	$[Co(H_2O)_4(OH)_2]$ blue/green precipitate	$[Cu(H_2O)_4(OH)_2]$ blue precipitate	$[Cr(H_2O)_3(OH)_3]$ green precipitate
CO_3^{2-}	$FeCO_3$ dark green precipitate	$[Fe(H_2O)_3(OH)_3]$ brown precipitate bubbles	$CoCO_3$ pink precipitate	$CuCO_3$ blue/green precipitate	$[Cr(H_2O)_3(OH)_3]$ green precipitate bubbles

16 Which ligand would be best to use to distinguish between ions of cobalt and copper?

A. OH^-, dilute

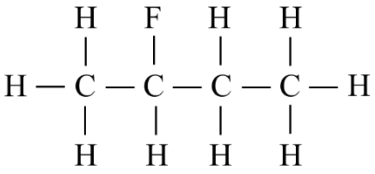
B. OH^-, concentrated

C. NH_3, dilute

D. CO_3^{2-}

17 Analysing a sample using carbon-13 NMR creates a spectrum based on chemical shift data that corresponds to the number of carbon chemical environments that are present in the molecule.

This is a structural formula of a haloalkane.



How many carbon chemical environments are found in this molecule?

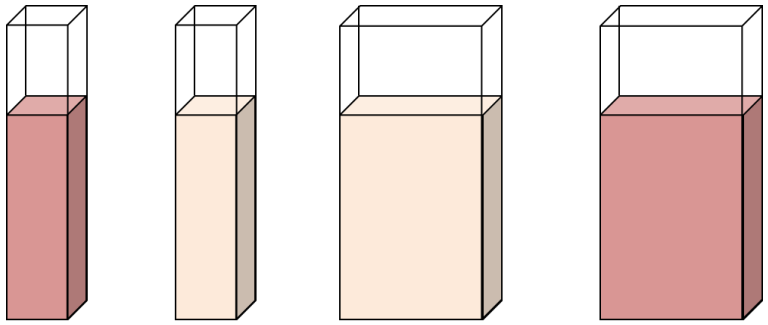
A. 1

B. 2

C. 3

D. 4

18 The diagram shows four types of sample cells that can be used in an ultraviolet-visible spectrophotometer.



Which sample cell would absorb the least light?

A. I

B. II

C. III

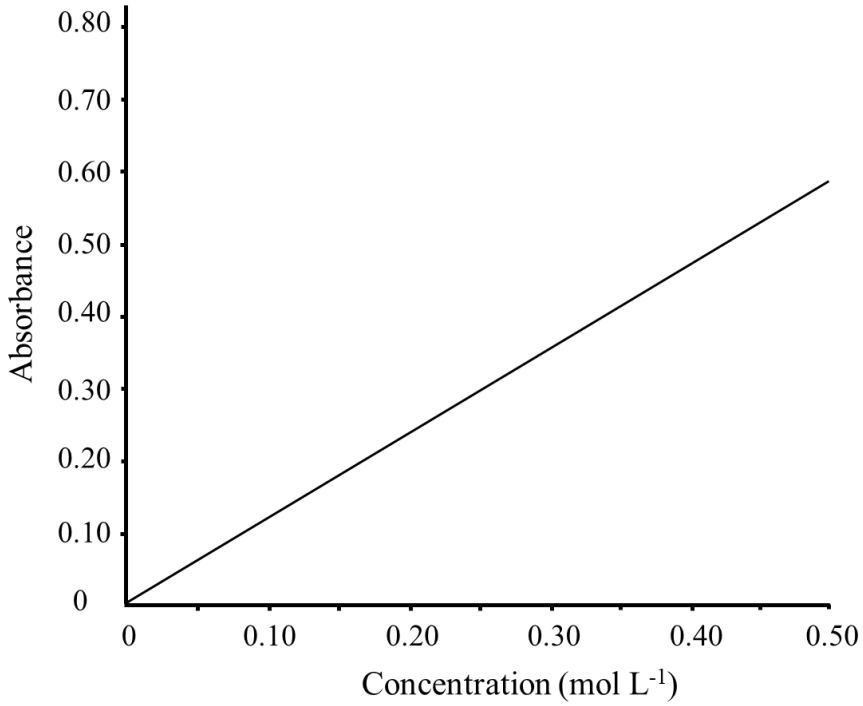
D. IV

19 Qualitative chemical tests can be used to determine the presence of certain functional groups.

Which response correctly outlines a chemical test that can be used to identify the presence of the hydroxyl functional group in a secondary alcohol?

	Functional group tested for	*Reaction with*	*Observations*
A.	hydroxyl	sodium metal	no reaction
B.	hydroxyl	limewater	colour change from clear to cloudy white
C.	hydroxyl	$H^+/Cr_2O_7^{2-}$ solution	colour change from orange to green
D.	hydroxyl	bromine water	colour change from orange-red to clear

20 This graph is a calibration curve produced by testing samples in a colourimeter.



What would be the concentration of a sample with an absorbance of 0.35?

A. 0.37 mol L^{-1}

B. 0.30 mol L^{-1}

C. 0.42 mol L^{-1}

D. 0.45 mol L^{-1}

Student ID: _____

2022

HIGHER SCHOOL CERTIFICATE
TRIAL EXAMINATION

Chemistry

Section II
Answer Booklet

80 marks
Attempt Questions 21–37
Allow about 2 hours 25 minutes for this section

Instructions

- Write your Student ID above
- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
- Show all relevant working in question 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 (3 marks)

Outline how Aboriginal and Torres Strait Islander Peoples used their knowledge of solubility equilibria to remove toxins from foods such as cycad fruit. **3**

Question 22 (4 marks)

Heptane is a clear, odourless liquid hydrocarbon. Its high flammability gives it properties necessary in many industries, including use as a fuel. **4**

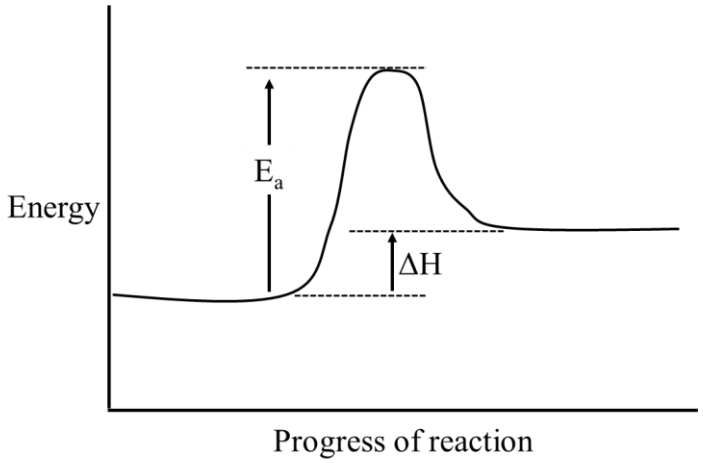
Species	$O_2(g)$	$CO_2(g)$	$H_2O(l)$	$C_7H_{16}(l)$
Enthalpy of Formation (kJ mol^{-1})	0	-393	-285	-224
Entropy (J K^{-1} mol^{-1})	+205	+214	+70	+329

Use the data in the table to determine whether the combustion of heptane at 298 K is spontaneous.

Question 23 (4 marks)

Calcium carbonate decomposes when heated to a high temperature according to the equation and energy profile diagram below.

$$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g) \qquad \Delta H = 177.8 \text{ kJ mol}^{-1}$$



(a) Identify whether the decomposition of calcium carbonate is an exothermic or endothermic reaction. Justify your answer. **1**

(b) Explain the effect that activation energy and collision theory have on the reversibility of a chemical reaction. **3**

Question 24 (8 marks)

The complex ion iron(III) thiocyanate can be formed according to the equation:

$$Fe^{3+}(aq) + SCN^{-}(aq) \rightleftharpoons FeSCN^{2+}(aq).$$

It has a very deep blood red colour whereas the two ions that are reacted to form it are both colourless.

During an investigation into this reaction, a scientist finds the equilibrium concentrations for the reactants and products to be as follows in the table.

Equilibrium concentrations (mol L^{-1})		
$Fe^{3+}(aq)$	$SCN^{-}(aq)$	$FeSCN^{2+}(aq)$
2.95×10^{-3}	7.96×10^{-5}	5.15×10^{-5}

(a) Determine the equilibrium expression for this reaction. **1**

(b) Calculate the value of the equilibrium constant. **3**

Question 24 continues on page 16

Question 24 (continued)

(c) Use Le Chatelier's principle to explain any visible changes in the tube if a solution of potassium thiocyanate was added to the system. **4**

End of Question 24

Question 25 (3 marks)

Hydrofluoric acid is an inorganic acid that can be used to make refrigerants, herbicides, pharmaceuticals and electrical components. **3**

Complete the table to show balanced chemical equations for hydrofluoric acid and the reactants provided.

Reactant	*Balanced chemical equation*
ammonia	
magnesium carbonate	
potassium	

Question 26 (4 marks)

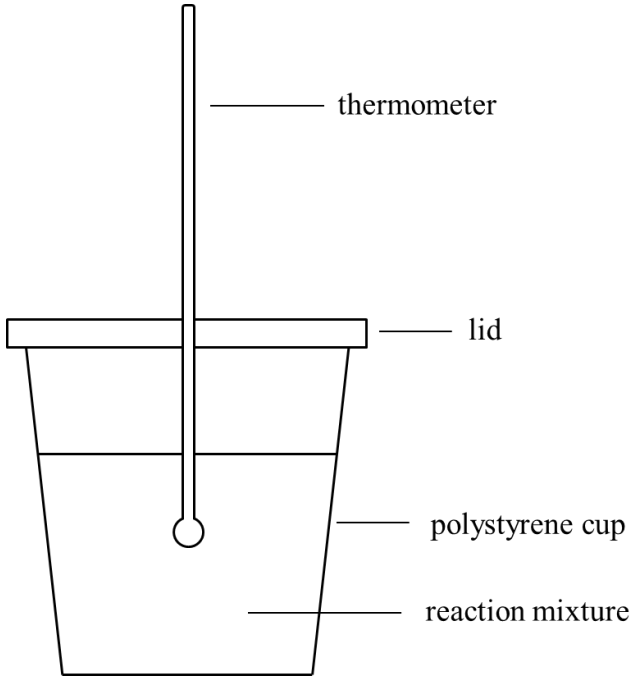
Chlorous acid, $HClO_2$, is a weak inorganic acid that has limited uses due to its instability.

(a) Identify the conjugate base of chlorous acid. **1**

(b) Determine the hydrogen ion concentration of a 0.20 mol L^{-1} solution of chlorous acid when $K_a = 1.1 \times 10^{-2}$. **3**

Question 27 (4 marks)

A student conducts an investigation to measure the enthalpy of neutralisation, setting up the apparatus as shown in the diagram. **4**



The reaction mixture consisted of 50.0 mL of diluted potassium hydroxide solution and 50.0 mL of a 1.5 mol L^{-1} solution of nitric acid. The student noticed that the temperature rose from 23°C to a maximum of 32°C.

Determine the enthalpy of neutralisation for this reaction.

Question 28 (6 marks)

Three students are attempting to produce a buffer solution as part of an investigation. However, they cannot agree on which substances should be used to prepare the solution.

Their suggestions can be seen in the table.

Student 1	*Student 2*	*Student 3*
H_2SO_4 and HSO_4^-	H_2CO_3 and HCO_3^-	H_3PO_4 and CH_3COO^-

(a) For each student's suggestion, state if it is correct and justify your answer. **3**

(b) Using an example, describe why buffer systems are important in natural systems. **3**

Question 29 (3 marks)

There have been several different definitions and models of an acid and a base. These models change over time as new discoveries are made and as technologies improve.

(a) Outline the Arrhenius theory of acids and bases. **2**

(b) Identify a limitation to Arrhenius's theory. **1**

Question 30 (5 marks)

Pentene is a colourless liquid hydrocarbon that can be used to produce pesticides and as an additive in plastic production.

(a) Draw the structural formula for the pent-2-ene isomer of pentene. **1**

(b) Write a balanced chemical equation for the reaction that occurs between pentene and hydrogen gas. **1**

(c) Use structural formula equations to outline the steps involved in synthesising pentanoic acid from pent-1-ene. **3**

Question 31 (6 marks)

The table shows the boiling points and molar masses of a variety of amines.

Compound	*Molar mass* (g mol^{-1})	*Boiling point* (°C)
ethanamine	45	17
propan-1-amine	59	47
butan-1-amine	73	77
pentan-1-amine	87	105
hexan-1-amine	101	132
heptan-1-amine	115	153
octan-1-amine	129	179

(a) Draw a graph that compares the molar mass of an amine to its boiling point. **4**

Question 31 continues on page 23

Question 31 (continued)

(b) Explain why the boiling points of amines increase as chain length increases. **2**

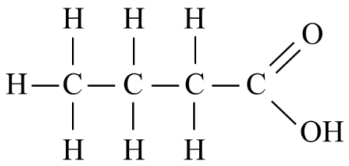
End of Question 31

Question 32 (5 marks)

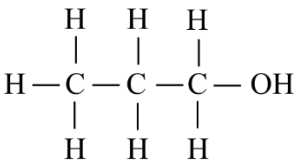
Esters are organic substances which often have pleasant, fruity odours and are responsible for the smell and flavour of many foods and drinks. They contain the ester functional group and are formed via an esterification reaction.

(a) Identify the ester formed through the reaction of the two reactants shown. **1**

Reactant 1



Reactant 2



(b) Explain the need for refluxing when carrying out an esterification reaction. **2**

(c) Identify ONE risk associated with carrying out an esterification reaction in a school laboratory and state how this risk can be minimised. **2**

Question 33 (4 marks)

Biofuels are fuels derived from biomass such as plant or algae material or animal waste. They are considered a source of renewable energy, unlike fossil fuels such as petroleum, coal, and natural gas which are non-renewable. **4**

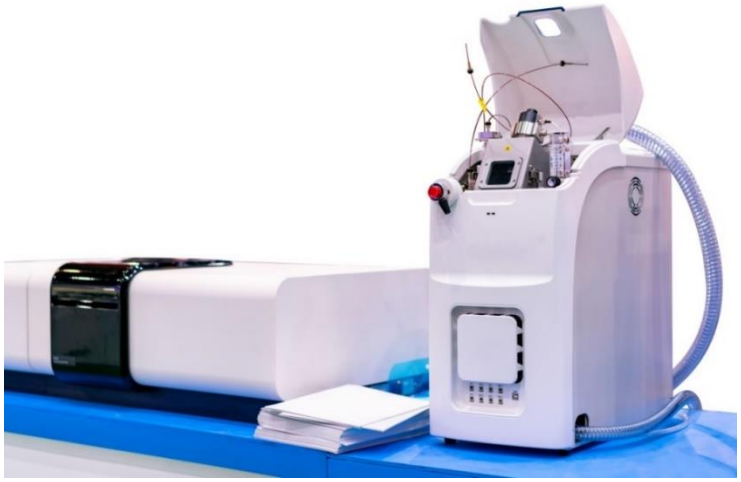
There are many factors of fuel types to be considered when investigating biofuels as an alternative to petrol and diesel in vehicles. Some of these include:

- Chemical composition
- Source
- Emission of CO_2
- Vehicle modification
- Running costs

Discuss the use of biofuels in vehicles as an alternative to petrol and diesel by comparing their properties and the implications of any change.

Question 34 (7 marks)

Mass spectroscopy is an analytical technique that identifies the elements or compounds present in a sample by converting them into positive ions.

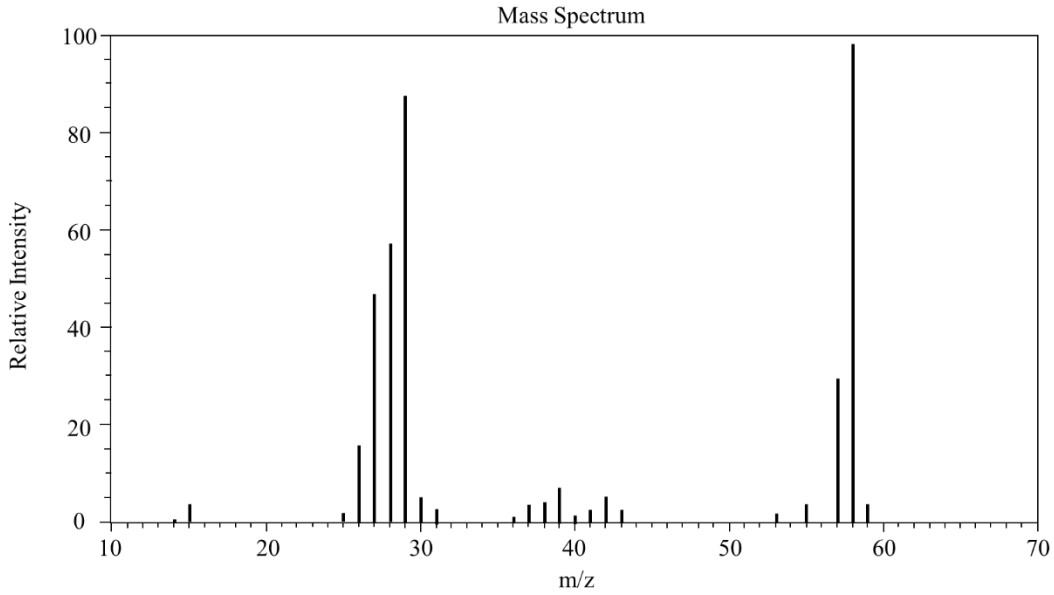


(a) Outline how a mass spectrometer works. **4**

Question 34 continues on page 26

Question 34 (continued)

(b) This spectrum was produced by analysing a sample of an unknown aldehyde.



Determine the molecular formula of the unknown aldehyde and suggest its name. Show all working out. **3**

End of Question 34

Question 35 (4 marks)

Gravimetric analysis is inexpensive and can identify many different inorganic substances. Therefore, it has many uses in industry, including determining the concentration of contaminants in ore samples and the presence of salts in foods.

A student mixed solutions of magnesium sulfate and calcium nitrate together and noticed that a white precipitate formed.

(a) Identify the white precipitate that was formed. **1**

(b) Calculate the mass of magnesium sulfate present in the solution if a mass of 2.15 g of precipitate was formed. **3**

Question 36 (4 marks)

Chemical cells or batteries are commonplace in most households. Many old car batteries are a type of lead acid cell. There are concerns that the incorrect disposable of lead acid cells may cause an increase in lead(II) ions in the environment. **4**

Outline TWO qualitative tests that could be carried out on a sample to determine the presence of lead(II) ions.

Question 37 (6 marks)

The Australian chemical industry employs over 60 000 people and contributes over $11.6 billion to the economy. Chemical industries can be large and expensive to build, and operate in very competitive markets. Because of this, it is important that these corporations consider all factors when designing any new chemical synthesis process. **6**

Analyse the factors that need to be considered when designing a chemical synthesis process.

End of exam

Section II extra writing space

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

Section II extra writing space

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

2022 HSC TRIAL EXAMINATION

Chemistry

FORMULAE SHEET

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

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

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

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

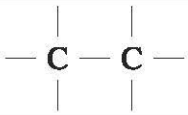
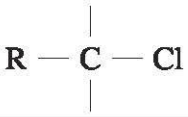
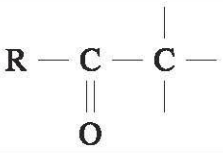
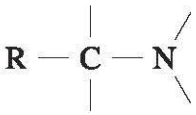
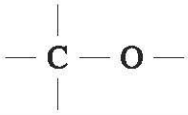
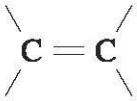
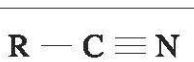
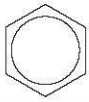
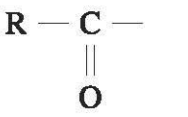
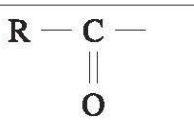
Compound	K_{sp}	*Compound*	K_{sp}
Barium carbonate	2.58×10^{-9}	Lead(II) bromide	6.60×10^{-6}
Barium hydroxide	2.55×10^{-4}	Lead(II) chloride	1.70×10^{-5}
Barium phosphate	1.3×10^{-29}	Lead(II) iodide	9.8×10^{-9}
Barium sulfate	1.08×10^{-10}	Lead(II) carbonate	7.40×10^{-14}
Calcium carbonate	3.36×10^{-9}	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

^{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	122
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
$\frac{1}{2}L_2(s) + e^-$	$\rightleftharpoons$	I^-	0.54 V
$\frac{1}{2}L_2(aq) + e^-$	$\rightleftharpoons$	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

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number	79
Symbol	Au
Standard Atomic Weight	197.0
Name	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.

STUDENT ID: _____

2022 Chemistry HSC Trial Examination

Section I –Multiple Choice Answer Sheet

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

Select the alternative A, B, C or D that best answers the question. Fill in the response circle completely.

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

2022 HSC Chemistry Marking Guidelines

Section I

Multiple-choice Answer Key

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

Section II

Question 21 (3 marks)

Criteria	Marks
• Explains how Aboriginal and Torres Strait Islander Peoples used leaching to remove toxins from food sources • Supports statement with reference to high solubility of toxins and the inability of the reaction to reach equilibrium	3
• Explains how Aboriginal and Torres Strait Islander Peoples used leaching to remove toxins from food sources	2
• Identifies that leaching is a process that was used to remove toxins from food sources	1

Sample answer:

Aboriginal and Torres Strait Islander Peoples used leaching to remove toxic substances from their food. This is a process where a substance can be removed from a solid by dissolving it in liquid. Parts of the plant (eg. cycads) were placed in a finely woven basket and placed in a flowing creek. Most toxins, such as cycasin, have a high solubility which means that minimal water was needed for them to dissolve.

After they dissolved, the toxins would dissolve and flow away with water. As the water was flowing and the toxins were carried away, the reaction never reached dynamic equilibrium and continued until all the toxins were removed. The process took from a few hours to a several days.

Question 22 (4 marks)

Criteria	Marks
• Provides balanced chemical equation for combustion of heptane • Converts ΔS to kJ K^{-1} mol^{-1} • Calculates ΔH, ΔS and ΔG • Writes statement about spontaneity	4
• Provides balanced chemical equation for combustion of heptane • Calculates ΔH, ΔS and ΔG • Writes statement about spontaneity OR • Provides balanced chemical equation for combustion of heptane • Converts ΔS to kJ K^{-1} mol^{-1} • Calculates ΔH, ΔS and ΔG	3
• Provides balanced chemical equation for combustion of heptane • Calculates ΔH and ΔS	2
• Provides some relevant calculation OR • Provides balanced chemical equation for combustion of heptane	1

Sample answer:

$C_7H_{16}(l) + 11O_2(g) \rightarrow 7CO_2(g) + 8H_2O(l)$

$\Delta H = [(7 \times -393) + (8 \times -285)] - [(1 \times -224) + [11 \times 0)]$
$\Delta H = (-2751 - 2280) - (-224)$
$\Delta H = -5031 + 224$
$\Delta H = -4807 \text{ kJ mol}^{-1}$

$\Delta S = [(7 \times 214) + (8 \times 70)] - [(1 \times 329) + (11 \times 205)]$
$\Delta S = (1498 + 560) - (329 + 2255)$
$\Delta S = 2058 - 2584$
$\Delta S = -526 \text{ J K}^{-1} \text{ mol}^{-1}$
$\Delta S = -0.526 \text{ kJ K}^{-1} \text{ mol}^{-1}$

$\Delta G = \Delta H - T\Delta S$
$\Delta G = -4807 - (298 \times -0.526)$
$\Delta G = -4807 - (-156.748)$
$\Delta G = -4650.25 \text{ kJ mol}^{-1}$

The reaction is spontaneous at 298 K as the value for ΔG is negative.

Question 23 (4 marks)

(a) 1 mark

Criteria	Marks
• Identifies that the decomposition of calcium carbonate is an endothermic reaction and justifies answer	1

Sample answer:

The decomposition of calcium carbonate is an endothermic reaction because the ΔH value is positive.

(b) 3 marks

Criteria	Marks
• Explains the effect that activation energy and collision theory have on the reversibility of a chemical reaction • Relates activation energy and collision theory to reversibility	3
• Explains the effect that activation energy and collision theory have on the reversibility of a chemical reaction • Relates activation energy or collision theory to reversibility	2
• Provides some relevant information	1

Sample answer:

The activation energy of both the forward and reverse reactions need to be considered when looking at the reversibility of a chemical reaction. If the activation energy of either of these is very high, then that reaction is unlikely to proceed because very few particles will have enough energy for a successful collision. For a reaction to be reversible, the activation energies of both the forward and reverse reactions must be low enough that sufficient particles will have enough energy for a successful collision.

Question 24 (8 marks)

(a) 1 mark

Criteria	Marks
• Determines correct equilibrium expression	1

Sample answer:

$$K_{eq} = \frac{[FeSCN^{2+}]}{[Fe^{3+}][SCN^{-}]}$$

(b) 3 marks

Criteria	Marks
• Correctly calculates K_{eq} using the expression from (a)	3
• Correctly provides most of the steps to calculate K_{eq} using the expression from (a)	2
• Provides some relevant calculation	1

Sample answer:

$$K_{eq} = \frac{[FeSCN^{2+}]}{[Fe^{3+}][SCN^{-}]}$$

$$K_{eq} = \frac{[5.15 \text{ x } 10^{-5}]}{[2.95 \text{ x } 10^{-3}][7.96 \text{ x } 10^{-5}]}$$

$$K_{eq} = \frac{5.15 \text{ x } 10^{-5}}{2.34 \text{ x } 10^{-7}}$$

$$K_{eq} = 219.31$$

(c) 4 marks

Criteria	Marks
• Explains, with clear links to Le Chatelier's principle, how the reaction will adjust after a solution of potassium thiocyanate is added • Makes explicit statement about colour change in tube	4
• Explains, with clear links to Le Chatelier's principle, how the reaction will adjust after a solution of potassium thiocyanate is added	3
• Identifies that the forward reaction will be favoured OR • Identifies that more $FeSCN^{2+}$ would form	2
• Provides some relevant information OR • Suggests that the solution will change colour to become a deeper red	1

Sample answer:

Le Chatelier's principle states that if a system at equilibrium is disturbed, then the system will adjust itself to minimise the disturbance and return to equilibrium. Adding a solution of potassium thiocyanate into the system would increase the concentration of SCN^- ions. According to Le Chatelier's principle, the forward reaction will be favoured in order to decrease the concentration of SCN^-. This change would also increase the concentration of $FeSCN^{2+}$ ions, and this would change the colour of the solution, turning it a deeper shade of red.

Question 25 (3 marks)

Criteria	Marks
• Provides three correct balanced chemical equations	3
• Provides two correct balanced chemical equations	2
• Provides one correct balanced chemical equation	1

Sample answer:

Reactant	*Balanced chemical equation*
ammonia	$HF(aq) + NH_3(aq) \rightarrow NH_4F(aq)$
magnesium carbonate	$2HF(aq) + MgCO_3(aq) \rightarrow MgF_2(aq) + H_2O(l) + CO_2(g)$
potassium	$2HF(aq) + 2K(s) \rightarrow 2KF(aq) + H_2(g)$

Question 26 (4 marks)

(a) 1 mark

Criteria	Marks
• Identifies conjugate base of chlorous acid	1

Sample answer:

ClO_2^-

(b) 3 marks

Criteria	Marks
• Provides correct balanced chemical equation • Correctly calculates hydrogen ion concentration	3
• Provides correct balanced chemical equation • Completes most steps to calculate hydrogen ion concentration	2
• Provides some relevant calculation OR • Provides correct balanced chemical equation	1

Sample answer:

$HClO_2(aq) + H_2O(l) \rightarrow H_3O^+(aq) + ClO_2^-(aq)$

$$K_a = \frac{[H_3O^+][ClO_2^-]}{[HClO_2]}$$

$$K_a = \frac{[H_3O^+]^2}{[HClO_2]}$$

$$1.1 \times 10^{-2} = \frac{[H_3O^+]^2}{0.20}$$

$[H_3O^+]^2 = 1.1 \times 10^{-2} \times 0.20$
$[H_3O^+]^2 = 0.0022$
$[H_3O^+] = \sqrt{0.0022}$
$[H_3O^+] = 0.047$ mol L^{-1}

Alternative method:
Students may use an ICE table.

	$HClO_2$ (aq) +	$H_2O(l) \rightarrow H_3O^+$ (aq) +	ClO_2^- (aq)
I	0.2	0	0
C	-x	+x	+x
E	0.2-x	+x	+x

$0.2-x \sim 0.2$

Question 27 (4 marks)

Criteria	Marks
• Calculates enthalpy of neutralisation (ΔH_{neut}) • Shows correct units throughout	4
• Calculates quantity of heat (q) • Calculates moles of nitric acid	3
• Calculates quantity of heat (q)	2
• Provides correct balanced chemical equation OR • Calculates temperature change (ΔT)	1

Sample answer:

$KOH(aq) + HNO_3(aq) \rightarrow KNO_3(aq) + H_2O(l)$

$\Delta T = 32 - 23$
$\Delta T = 9°C$

$q = mC\Delta T$
$q = 100 \times 4.18 \times 9$
$q = 3762\ J$
$q = 3.762\ kJ$

$n(HNO_3) = cV$

$n(HNO_3) = 1.5 \times 0.05$
$n(HNO_3) = 0.075\ mol$

$n(H_2O) = n(HNO_3)$ as 1:1 ratio
$n(H_2O) = 0.075\ mol$

$$\Delta H_{neut} = \frac{q}{n(H_2O)}$$

$$\Delta H_{neut} = \frac{3.762}{0.075}$$

$\Delta H_{neut} = 50.16\ kJ\ mol^{-1}$

Question 28 (6 marks)

(a) 3 marks

Criteria	Marks
• Correctly identifies correct student • Provides a justified statement about the suggestion of all three students	3
• Correctly identifies correct student • Provides a statement about the suggestion of all three students OR • Provides a justified statement about the suggestion of two of the three students	2
• Provides some relevant information	1

Sample answer:

- Student 1 is incorrect as although they have suggested an acid/conjugate base pair, the acid they have suggested is a strong acid.
- Student 2 is correct as they have suggested a weak acid and its corresponding conjugate base.
- Student 3 is incorrect as although they have suggested a weak acid, they have not suggested the correct conjugate base.

(b) 3 marks

Criteria	Marks
• Describes the importance of buffers in natural system • Refers to specific example • Includes relevant equation	3
• Describes the importance of buffers in natural system • Refers to specific example	2
• Provides some relevant information	1

Sample answer:

Buffers are important as they can maintain a constant pH even when significant amounts of acid or base are added. Freshwater lakes and rivers have buffer systems that involve carbon dioxide from the air and hydrogen carbonate formed through the breakdown of carbonate rocks. This system helps to maintain a pH of between 6.5 and 7.5 regardless of what may be introduced into the system. For example, according to the equation $H_2CO_3(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + HCO_3^-(aq)$, if more carbonate rocks were broken down, this would increase the amount of HCO3- available, making the water more alkaline. The system would shift in the reverse direction to produce more carbonic acid and counteract any change in pH.

Question 29 (3 marks)

(a) 2 marks

Criteria	Marks
• Outlines the Arrhenius theory of acids and bases	2
• Provides some relevant information	1

Sample answer:

Arrhenius defined an acid as a substance which ionises in solution to produce hydrogen ions and a base as a substance which ionises in solution to produce hydroxide ions. His theory also introduced the concept of 'strong' (if the substance ionises completely) and 'weak' (substance ionises only partially) acids and bases.

(b) 1 mark

Criteria	Marks
• Identifies a limitation to Arrhenius's theory	1

Sample answer:

Arrhenius's theory only applies to aqueous solutions.

Other suggested answers:

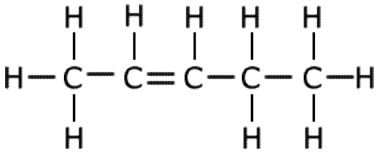
- does not give recognition to the role of the solvent (ionisation is a reaction between the acid and solvent)
- only accounts for substances which already have H^+ or OH^- in their structure (e.g. NH_3 is basic)
- does not explain why some salts act as acids or bases
- cannot explain how some substances can act as both an acid and a base (amphiprotic)

Question 30 (5 marks)

(a) 1 mark

Criteria	Marks
• Provides correct structural formula	1

Sample answer:



(b) 1 mark

Criteria	Marks
• Provides correct balanced chemical equation	1

Sample answer:

$C_5H_{10}(l) + H_2(g) \rightarrow C_5H_{12}(g)$

(c) 3 marks

Criteria	Marks

• Provides structural formula equations that show the synthesis of:
  ○ primary alcohol from alkene
  ○ aldehyde from primary alcohol
  ○ carboxylic acid from aldehyde
• Includes all relevant conditions
	3

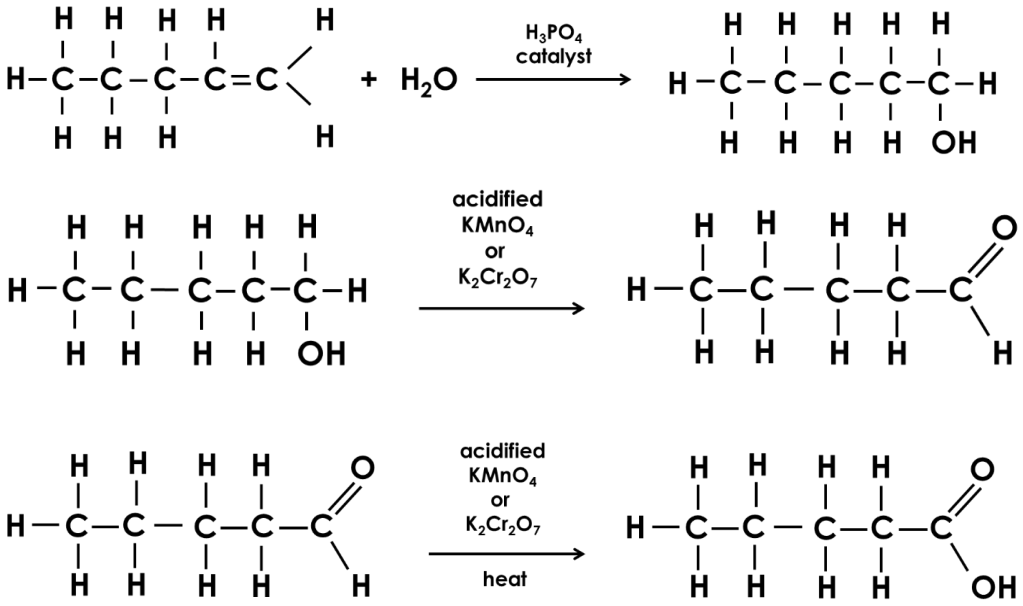
• Provides structural formula equations that show the synthesis of:
  ○ primary alcohol from alkene
  ○ aldehyde from primary alcohol
  ○ carboxylic acid from aldehyde
OR
• Provides structural formula equations that show the synthesis of two of the three substances, including relevant conditions
	2

• Provides balanced chemical equations OR • Provides some relevant information	1

Sample answer:

See over page

Question 30 c suggested answer continued

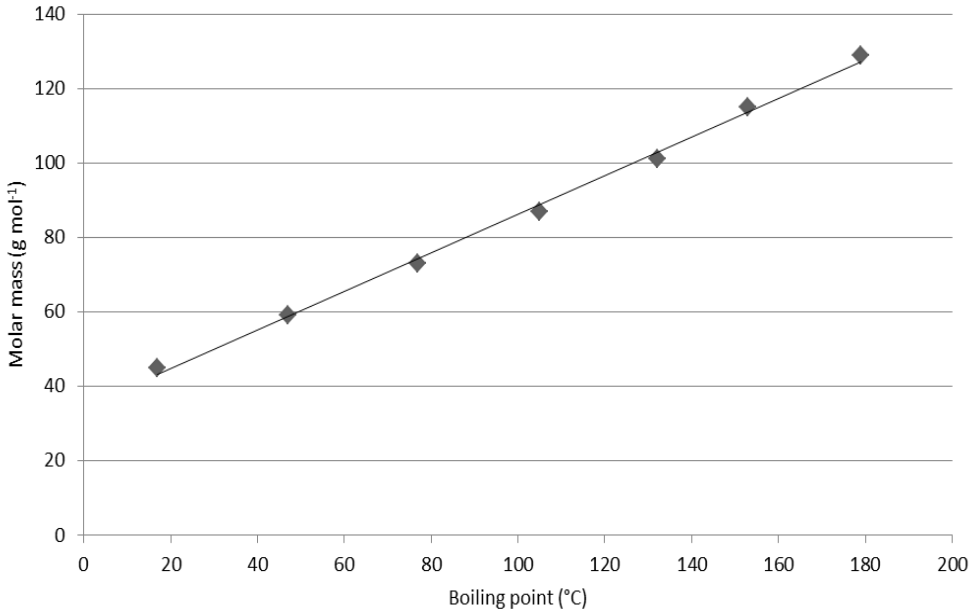


Question 31 (6 marks)

(a) 4 marks

Criteria	Marks
• Draws correct and clearly labelled graph with the key features: – Uses appropriate graph type – Plots molar mass (vertical axis) against boiling point (horizontal axis) accurately – Uses an even scale on each axis – Labels both axes including relevant units – Draws a line of best fit	4
• Draws a substantially correct and labelled graph	3
• Provides some correct features of the graph	2
• Provides basic aspects of the graph	1

Sample answer:



(b) 2 marks

Criteria	Marks
• Explains why the boiling points of amines increase as chain length increases • Relates chain length to increased number of hydrogen bonds	2
• Provides some relevant information	1

Sample answer:

The N-H bonds in amines are highly polar, meaning that hydrogen bonds can form between molecules, and hydrogen bonds require large amounts of energy to be broken. As chain length increases the dispersion forces between carbon atoms in the molecule also increases. Therefore, more energy is required to break those forces. Hence, the boiling point increases.

Question 32 (5 marks)

(a) 1 mark

Criteria	Marks
• Identifies correct ester	1

Sample answer:

Propyl butanoate

(b) 2 marks

Criteria	Marks
• Explains the need for refluxing in esterification • Relates refluxing to the minimised loss of volatile substances	2
• Provides some relevant information	1

Sample answer:

Esterification requires the addition of heat to speed up the reaction. Refluxing means that the mixture is heated, the volatile components evaporate and rise into the condenser. Here they are cooled and condensed by flowing water, and fall back into the reaction mixture rather than being lost to the atmosphere.

(c) 2 marks

Criteria	Marks
• Identifies an appropriate risk • Suggests how the risk can be minimised	2
• Identifies an appropriate risk OR • Suggests how risk can be minimised	1

Sample answer:

The vapours produced during esterification can be hazardous if breathed in. To minimise risk, the experiment could be completed in a fume cupboard or in a space with adequate ventilation.

Question 33 (4 marks)

Criteria	Marks
• Discusses advantages of using biofuels in vehicles as an alternative to petrol and diesel • Discusses disadvantages of using biofuels in vehicles as an alternative to petrol and diesel • Supports comments with accurate and varied evidence on properties and implications for the changeover	4
• Provides a combination of advantages or disadvantages of using biofuels in vehicles as an alternative to petrol and diesel • Supports comments with evidence on properties and implication(s) for the changeover	3
• Provides an advantage and a disadvantage of using biofuels in vehicles as an alternative to petrol and diesel with some reference to properties and/or implication(s)	2
• Provides some relevant information	1

Sample answer:

There are several advantages to using biofuels in place of petrol and diesel. Most biofuels are composed of renewable substances, for example, biodiesel is made from fats and oils. Using these substances would mean less environmental damage due to mining, and a lot less carbon dioxide being released into the atmosphere during their production. However, there are also some disadvantages to using biofuels, and these include the fact that most vehicles would require some sort of modification in order to use higher percentages of ethanol or biodiesel, and making these modifications could be expensive.

Question 34 (7 marks)

(a) 3 marks

Criteria	Marks
• Provides a comprehensive outline of how a mass spectrometer works • Shows a logical progression demonstrating how sample moves through device	4
• Provides a thorough outline of how a mass spectrometer works	3
• Provides a basic outline of how a mass spectrometer works	2
• Provides some relevant information	1

Sample answer:

- A vaporised sample is bombarded with electrons from a heated filament in a vacuum. This causes electrons to be knocked out of the molecule to form a positive molecular ion.
- Positive ions enter another chamber and are accelerated in a high voltage electric field that has been generated by charge plates.
- Narrow slits help to make sure a fine, focused beam of ions leave the chamber. Positive ions enter a magnetic field and are bent in a circular arc.
- Different ions are deflected by different amounts based on their mass and charge, and this leads to the formation of different, separate beams.
- In the detector the ions strike a metallic ion collector and causing them to gain an electron and become neutral. The small current generated is amplified, measured and recorded.
- The degree of deflection of each ion is measured and the mass-to-charge ratio (m/z) is calculated by a computer, and this information is then displayed on a chart called a mass spectrum.

(b) 3 marks

Criteria	Marks
• Determines the correct molecular formula • Identifies appropriate name for the substance	3
• Determines the correct molecular formula	2
• Provides some relevant information	1

Sample answer:

Molecular ion is located at m/Z = 58
General equation for an aldehyde = $C_nH_{2n}O$

(12 x n) + (1 x 2n) + 16 = 58
12n + 2n + 16 = 58
14n + 16 = 58
14n = 42
n = 3

∴ molecular formula = C_3H_6O
∴ possible name = propanal

Question 35 (4 marks)

(a) 1 mark

Criteria	Marks
• Identifies precipitate formed	1

Sample answer:

Calcium sulfate

(b) 3 marks

Criteria	Marks
• Provides correct balanced chemical equation • Identifies molar ratio • Calculates moles of precipitate • Calculates mass of magnesium sulfate	3
• Provides correct balanced chemical equation • Identifies molar ratio • Calculates moles of precipitate • Calculates mass of magnesium sulfate with error OR • Units are missing throughout	2
• Provides correct balanced chemical equation OR • Calculate molar mass of calcium sulfate OR • Calculates molar mass of magnesium sulfate	1

Sample answer:

$MgSO_4(aq) + Ca(NO_3)_2(aq) \rightarrow Mg(NO_3)_2(aq) + CaSO_4(s)$

$MM(CaSO_4) = 40.08 + 32.07 + (16.00 \times 4)$
$MM(CaSO_4) = 136.15 \text{ g mol}^{-1}$

$n(CaSO_4) = \frac{2.15}{136.15}$
$n(CaSO_4) = 0.016 \text{ mol}$

$n(MgSO_4) = n(CaSO_4)$ as molar ratio is 1:1
$n(MgSO_4) = 0.016 \text{ mol}$

$MM(MgSO_4) = 24.31 + 32.07 + (16.00 \times 4)$
$MM(MgSO_4) = 120.38 \text{ g mol}^{-1}$

$m(MgSO_4) = 0.016 \times 120.38$
$m(MgSO_4) = 1.90 \text{ g}$

Question 36 (4 marks)

Criteria	Marks
• Outlines two qualitative tests that could be carried out on a sample to determine the presence of lead(II) ions • Identifies criteria for positive test	4
• Outlines two qualitative tests that could be carried out on a sample to determine the presence of lead(II) ions OR • Outlines a qualitative test that could be carried out on a sample to determine the presence of lead(II) ions • Identifies criteria for positive test	3
• Outlines a qualitative test that could be carried out on a sample to determine the presence of lead(II) ions	2
• Provides some relevant information	1

Sample answer:

Precipitation reaction:

- Add dilute hydrochloric acid.
- Observe for a white precipitate.
- Add dilute ammonia to a second sample.
- Observe for a white precipitate.

Flame test:

- Place sample in blue Bunsen burner flame.
- Observe for a light blue/grey colour change.

Question 37 (6 marks)

Criteria	Marks
• Demonstrates a comprehensive understanding of the factors that need to be considered when designing a chemical synthesis process • Analyses at least three factors • Draws out and shows clear relationship between each factor	6
• Demonstrates a thorough understanding of the factors that need to be considered when designing a chemical synthesis process • Describes at least three factors • Shows some relationship between factors	4 - 5
• Demonstrates a sound understanding of the factors that need to be considered when designing a chemical synthesis process • Describes at least two factors	2 - 3
• Provides some relevant information	1

Sample answer:

There are several factors that should be considered when designing a chemical synthesis process. These include the availability of reagents, the conditions required for the reaction to occur, and any environmental, social and economic issues that might come about as a result of the process.

Some chemical reagents are inexpensive and easy to source, whereas others can be expensive, rare or are controlled substances. This may mean that acquiring them may be difficult or costly, particularly if they are needed in large amounts, at short notice or for long periods of time. Knowing what reagents are required and how easily they can be obtained needs prior investigation.

All chemical reactions have conditions that must be met for the reaction to occur. Some reactions will only occur at temperature and pressure conditions, and these conditions may be difficult to reach or expensive to maintain for long periods of time. When developing a new process, preference should be given to reactions that can be performed at STP, as this would make them less expensive, easier to maintain, and would likely require less monitoring.

The effect of the process on the environment should be considered, especially the disposal of waste products. Green Chemistry principles should be used by industries to determine how their processes can be carried out in an environmentally-friendly way. Economic viability needs to be considered and the process modified (if necessary) to ensure that the business can be sustained. Manufacturers could attempt to produce more than one useful product as a way to maximise their profit.

Each of these factors should be considered by a chemical manufacturer when designing a new chemical synthesis process to ensure that it meets the requirements of the community and is able to be sustained long term.

2022 HSC Chemistry Mapping Grid

Section I

Question	Marks	Module	Content	Syllabus outcomes
1	1	5	Calculating the Equilibrium Constant (K_{eq})	CH12-6
2	1	5	Factors that Affect Equilibrium	CH12-6, CH12-12
3	1	5	Static and Dynamic Equilibrium	CH12-12
4	1	6	Properties of Acids and Bases	CH12-5
5	1	5	Solution Equilibria	CH12-5, CH12-6
6	1	6	Using Bronsted-Lowry Theory	CH12-5, CH12-13
7	1	6	Quantitative Analysis	CH12-5, CH12-13
8	1	6	Using Bronsted-Lowry Theory	CH12-5
9	1	6	Quantitative Analysis	CH12-5
10	1	7	Nomenclature	CH12-6, CH12-14
11	1	7	Reactions of Organic Acids and Bases	CH12-14
12	1	7	Nomenclature	CH12-14
13	1	5	Solution Equilibria	CH12-6
14	1	7	Products of Reactions Involving Hydrocarbons	CH12-6, CH12-14
15	1	7	Polymers	CH12-14
16	1	8	Analysis of Inorganic Substances	CH12-4, CH12-15
17	1	8	Analysis of Organic Substances	CH12-4
18	1	8	Analysis of Inorganic Substances	CH12-4
19	1	8	Analysis of Organic Substances	CH12-2, CH12-15
20	1	8	Analysis of Inorganic Substances	CH12-4

Section II

Question	Marks	Module	Content	Syllabus outcomes
21	3	5	Solution Equilibria	CH12-12
22	4	5	Static and Dynamic Equilibrium	CH12-5, CH12-6
23(a)	1	5	Factors that Affect Equilibrium	CH12-5
23(b)	3	5	Factors that Affect Equilibrium	CH12-12
24(a)	1	5	Calculating the Equilibrium Constant (K_{eq})	CH12-6
24(b)	3	5	Calculating the Equilibrium Constant (K_{eq})	CH12-6
24(c)	4	5	Factors that Affect Equilibrium	CH12-5, CH12-12
25	3	6	Properties of Acids and Bases	CH12-5
26(a)	1	6	Using Bronsted-Lowry Theory	CH12-13
26(b)	3	6	Quantitative Analysis	CH12-5
27	4	6	Quantitative Analysis	CH12-2, CH12-3
28(a)	3	6	Quantitative Analysis	CH12-1, CH12-5
28(b)	3	6	Quantitative Analysis	CH12-13
29(a)	2	6	Properties of Acids and Bases	CH12-13
29(b)	1	6	Properties of Acids and Bases	CH12-13
30(a)	1	7	Nomenclature	CH12-14
30(b)	1	7	Products of Reactions Involving Hydrocarbons	CH12-14
30(c)	3	7	Reactions of Organic Acids and Bases	CH12-7, CH12-14
31(a)	4	7	Reactions of Organic Acids and Bases	CH12-6, CH12-7
31(b)	2	7	Reactions of Organic Acids and Bases	CH12-5
32(a)	1	7	Reactions of Organic Acids and Bases	CH12-6, CH12-14
32(b)	2	7	Reactions of Organic Acids and Bases	CH12-14
32(c)	2	7	Reactions of Organic Acids and Bases	CH12-14
33	4	7	Alcohols	CH12-5, CH12-7
34(a)	4	8	Analysis of Organic Substances	CH12-15
34(b)	3	8	Analysis of Organic Substances	CH12-4, CH12-15
35(a)	1	8	Analysis of Inorganic Substances	CH12-2, CH12-4
35(b)	3	8	Analysis of Inorganic Substances	CH12-2, CH12-4
36	4	8	Analysis of Inorganic Substances	CH12-2
37	6	8	Chemical Synthesis and Design	CH12-15