2021

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

Total marks: 100

Section I — 20 marks (pages 2-9)

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

Section II — 80 marks (pages 10-27)

- Attempt Questions 21– 35
- Allow about 2 hours and 25 minutes for this section

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

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1 Chemical systems can be open, closed or isolated depending on their features.

Which statement about systems is correct?

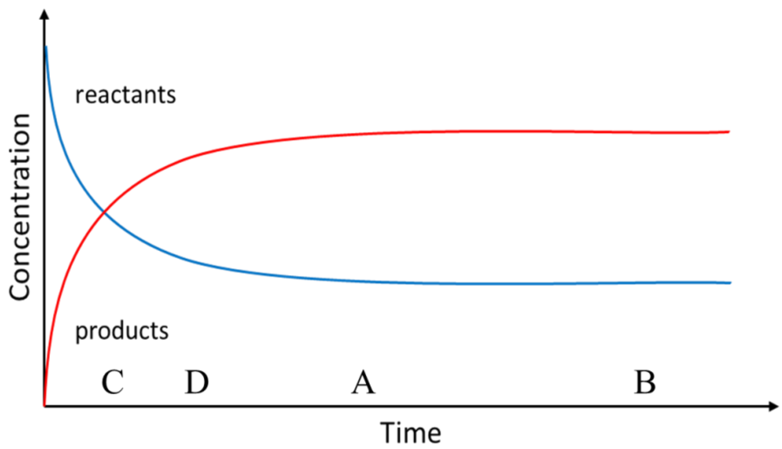
A. Only energy can move in and out of an isolated system.

B. Energy and matter can move in and out of an open system.

C. Energy can move in and out of the open system but matter cannot.

D. Energy and matter can move in and out of closed and isolated systems, but not an open system.

2 This graph shows how the concentration of reactants and products in a reaction change over time.



At which point on the graph has the reaction reached equilibrium?

A. A

B. B

C. C

D. D

3 What is the correct equilibrium expression for the reaction shown?

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

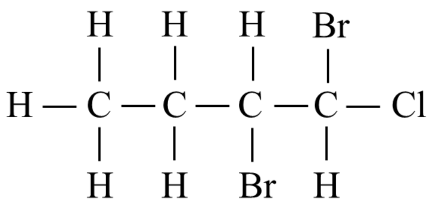
A. $\dfrac{[CaO][O_2]}{[CaCO_3]}$

B. $\dfrac{[O_2]}{[CaCO_3]}$

C. $[CaO][O_2]$

D. $[O_2]$

4 Look at the structural formula for the molecule shown.



What is the correct name for this haloalkane?

A. 1,2-bromo-1-chlorobutane

B. 1,2-dibromo-1-chlorobutane

C. 1-chloro-1,2-dibromobutane

D. 3, 4-dibromo-4-chlorobutane

5 The following equilibrium is set up in a sealed reaction vessel.

$$N_2O_4(g) \rightleftharpoons 2NO_2(g) \qquad \Delta H = +54.8 \text{ kJ mol}^{-1}$$

Which of the following would increase the yield of nitrogen dioxide?

A. Adding a catalyst to the reaction vessel

B. Decreasing the volume of the reaction vessel

C. Raising the temperature of the reaction vessel

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

6 How many isomers are there for C_6H_{14}?

A. Two

B. Three

C. Four

D. Five

7 Which reagent is required to synthesise butanol from butene?

A. Al_2O_3

B. H_2SO_4

C. Cl_2 and UV light

D. H_2O and H_3PO_4

8 The hydrogen sulfate ion, HSO_4^-, is commonly found in geothermal lakes.

Which of the following is the conjugate base of this ion?

A. H_2S

B. SO_3^{2-}

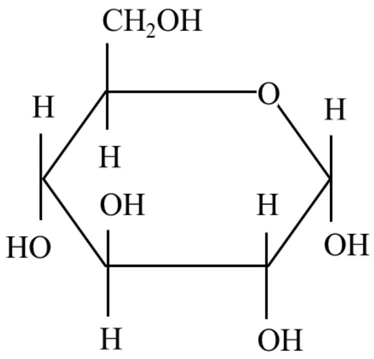
C. SO_4^{2-}

D. H_2SO_4

9 Which substance shows the correct indicator colour?

	Substance	*pH*	*Indicator*	*Colour*
A.	Toothpaste	9	Litmus	Red
B.	Lemon juice	2	Methyl orange	Red
C.	Seawater	8	Methyl orange	Red
D.	Soft drink	4	Litmus	Purple

10 Look at the monomer shown below.



What condensation polymer is formed using this monomer?

A. Nylon

B. Cellulose

C. Polyester

D. Polystyrene

11 The table shows the boiling point of several compounds.

Compound	*Type*	*Molar mass* ($g\ mol^{-1}$)	*Boiling point* (°C)
ethanoic acid	carboxylic acid	60	118
butane	alkane	58	-1
propan-1-ol	alcohol	60	97
propanal	aldehyde	58	49

The boiling point of ethanoic acid is much higher than other molecules of a similar size because

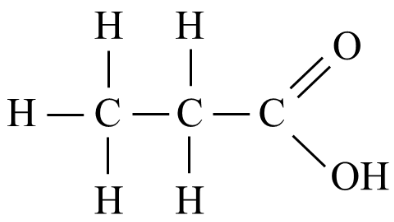
A. it has lower bond energies.

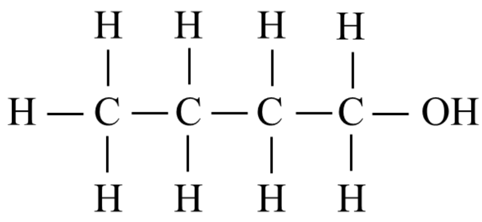
B. it has strong dipole-dipole interactions.

C. it has strong dispersion forces and hydrogen bonds.

D. it has fewer different types of atom in its molecular structure.

12 What ester would be formed through the reaction of the two reactants shown?





A. Propyl butanoate

B. Butyl butanoate

C. Propyl propanoate

D. Butyl propanoate

13 Which pK_a value represents the acid with the highest strength?

A. 2.54

B. 3.70

C. 4.76

D. 6.85

14 The solubility of iron(II) carbonate is 0.00067 g/100 g of water at 298 K.

What is the K_{sp} for iron(II) carbonate?

A. 3.16×10^{-9}

B. 3.16×10^{-11}

C. 3.34×10^{-9}

D. 3.34×10^{-11}

15 Nitrous acid, HNO_2, has a K_a of 7.2×10^{-4}.

What is the pH of a 0.40 M solution of the acid?

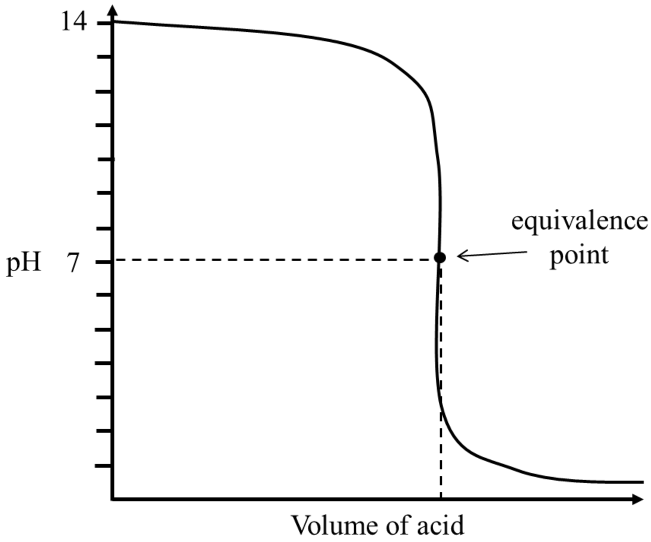
A. 1.02

B. 1.77

C. 2.14

D. 3.52

16 The titration curve below shows how the pH changes in a neutralisation reaction as more acid is added.



What are the two reactants?

A. HNO_3 and NH_3

B. H_3PO_4 and NH_3

C. HCl and NaOH

D. CH_3COOH and NaOH

17 A scientist collects a sample from a local river system and tests it for the presence of metal ions. They find during a flame test that the flame colour is a light blue-grey.

Based on this test, which ion is present in the water sample?

A. Lead

B. Barium

C. Calcium

D. Potassium

18 An alcohol is reacted with sodium metal, acidified potassium dichromate acidified potassium permanganate and zinc chloride in concentrated hydrochloric acid.

Reaction with:			
Na metal	$H^+/Cr_2O_7^{2-}$ solution	H^+/MnO_4^- solution	$ZnCl_2$/HCl mixture
production of hydrogen gas	colour change from orange to green	colour change from purple to colourless	slow reaction and the formation of a separate layer

Based on the results in the table, which alcohol was tested?

A. butan-2-ol

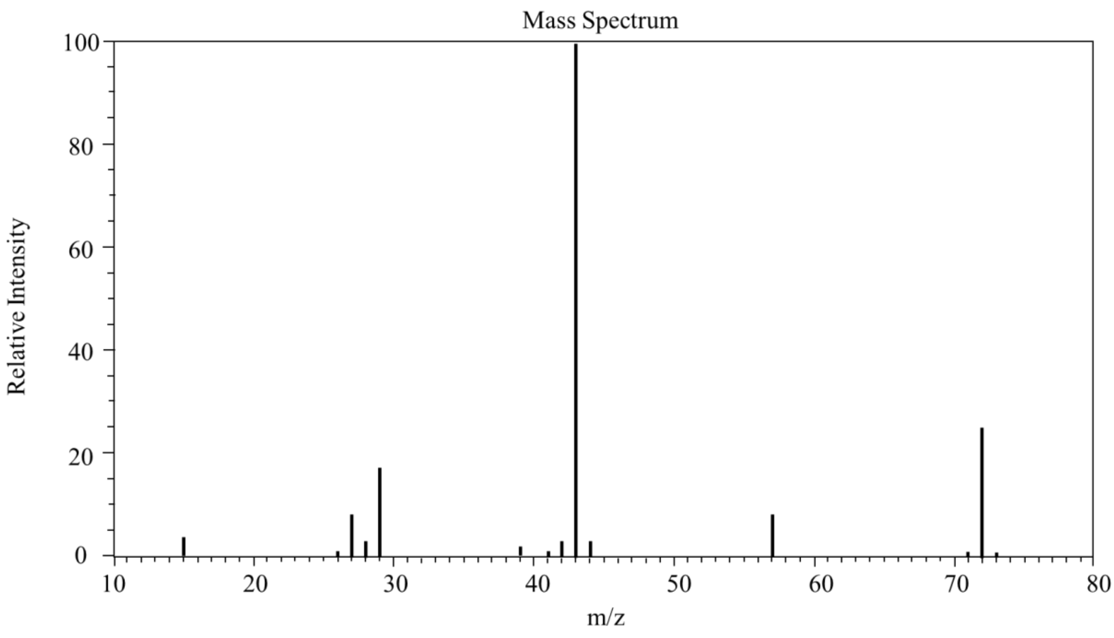
B. propan-1-ol

C. 2-methylbutan-2-ol

D. 2-methylpropan-1-ol

19 Mass spectroscopy can be used to identify unknown organic molecules.

The diagram shows the mass spectra of an unknown ketone.



According to this spectra, what would the molecular formula of the ketone be?

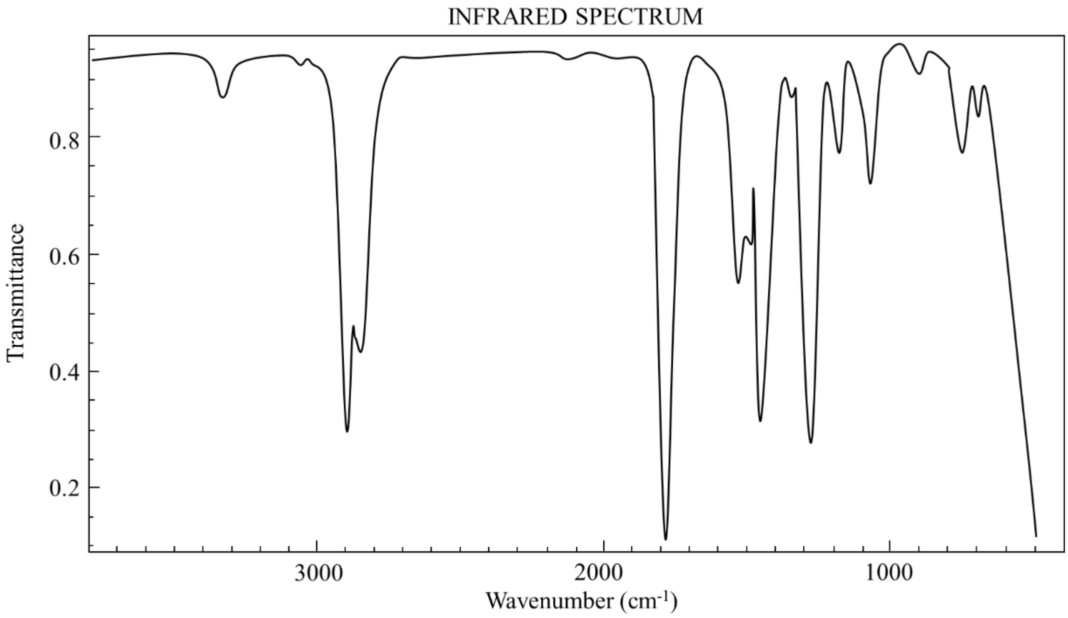
A. $C_6H_{12}O$

B. C_2H_4O

C. C_3H_6O

D. C_4H_8O

20 The diagram shows the infrared spectrum of a compound.



What is the compound?

A. Butene

B. Butanol

C. Butanone

D. Butanoic acid

Student ID: ______________________

2021 **HIGHER SCHOOL CERTIFICATE TRIAL EXAMINATION**

Chemistry

Section II
Answer Booklet

80 marks
Attempt Questions 21–35
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 (5 marks)

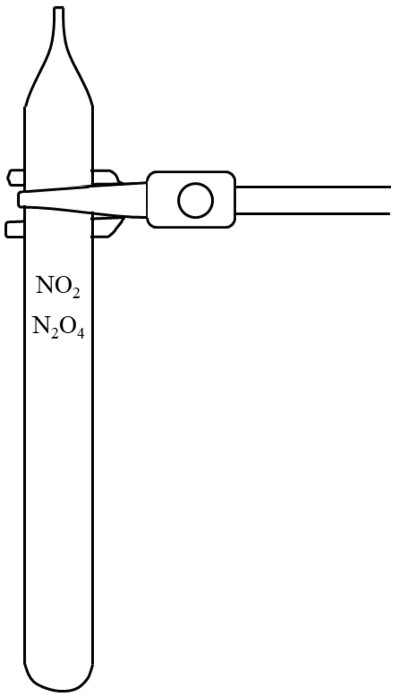
Quantitatively compare the solubility of barium fluoride in water and 0.03 mol L^{-1} NaF. **5**
K_{sp} for barium fluoride is 1.0×10^{-6} at 25°C.

Question 22 (8 marks)

At 25°C, nitrogen dioxide (NO_2) is a brown gas and dinitrogen tetroxide (N_2O_4) is a colourless gas. The two gases exist in a constant equilibrium according to the equation:

$$2NO_2(g) \rightleftharpoons N_2O_4(g) \qquad \Delta H = -58 \text{ kJ}$$

A 0.050 mol sample of NO_2 was placed in a 20 mL sealed glass tube. When equilibrium was achieved at 60°C, 0.002 mol of N_2O_4 was present.



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

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Question 22 continues on page 13

Question 22 (continued)

(b) Calculate the value of the equilibrium constant. **4**

(c) Use Le Chatelier's principle to explain any visible changes in the tube if it were to be placed into a beaker of ice water. **3**

End of Question 22

Question 23 (3 marks)

Explain how Aboriginal and Torres Strait Islander peoples used their knowledge of equilibrium systems to remove toxicity from food. **3**

Question 24 (5 marks)

Demi is given the solubility rules below and is asked to carry out an investigation to determine if a precipitate will form when a series of ionic solutions are mixed.

Soluble anions	*Exceptions*
NO_3^-	None
Cl^-	Ag^+ insoluble, Pb^{2+} slightly soluble
Br^-	Ag^+ insoluble, Pb^{2+} slightly soluble
I^-	Ag^+ and Pb^{2+} insoluble
SO_4^{2-}	Ba^{2+} and Pb^{2+} insoluble, Ca^{2+} and Ag^+ slightly soluble

(a) Identify the formulae of any precipitates that may form when potassium chloride is mixed with the following solutions. **1**

	potassium chloride
silver nitrate	
zinc nitrate	
sodium sulfate	

(b) The solubility of potassium chloride is 35.5 g/100 g of water at 25°C. Calculate the K_{sp} for potassium chloride. **4**

Question 25 (5 marks)

Rachel conducts a neutralisation reaction in which she reacts 25 mL of a 0.35 mol L^{-1} solution of potassium hydroxide with 30 mL of a 0.30 mol L^{-1} solution of hydrochloric acid.

Determine the pH of the final solution. **5**

Question 26 (2 marks)

Aboriginal and Torres Strait Islander peoples applied their knowledge of acid/base reactions in the treatments they used for bites and stings. Hop bush (*Dodonaea viscosa*) was used to treat stingray and stonefish stings, and Pigface (*Carpobrotus glaucescens*) was applied to jellyfish stings. The same knowledge and techniques are used in modern industrial chemistry.

Describe an example of how acid/base analytical techniques are used in industry. **2**

Question 27 (6 marks)

Jesse made 300 mL of primary standard using 2.35 g of sodium carbonate. He then conducted a titration to determine the concentration of his secondary standard, a sample of sulfuric acid.

His experimental results are in the table below.

	Trial 1	*Trial 2*	*Trial 3*	*Trial 4*	*Trial 5*
Volume of primary standard used (ml)	35.00	35.00	35.00	35.00	35.00
Initial burette reading	0.00	24.00	0.00	0.00	24.90
Final burette reading	24.70	48.85	24.80	24.90	47.95

(a) Determine the concentration of the secondary standard. **4**

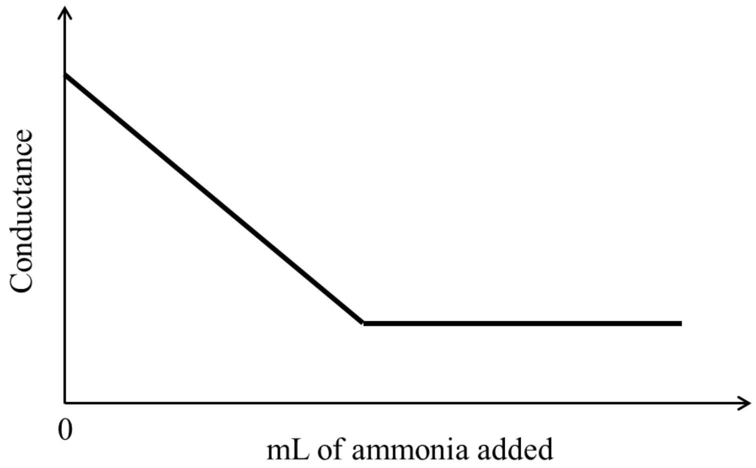
(b) Jesse used a methyl orange indicator to determine the end point in his titration. **2**

Explain why digital pH probes and meters are often preferred over indicators when carrying out a titration.

Question 28 (4 marks)

Conductivity curves show the change in conductivity during a titration.

The curve below was formed during the reaction of hydrochloric acid and ammonia.



(a) Mark the equivalence point on the curve. **1**

(b) Account for the shape of the curve. **3**

Question 29 (7 marks)

Ethene is an example of an unsaturated hydrocarbon. Unsaturated hydrocarbons will commonly undergo combustion and addition reactions to form a variety of new products.

(a) Write a word and structural formula equation for the reaction between ethene and bromine. **2**

(b) Many organic substances, including ethene, have properties that can make them hazardous to use. These properties include volatility, flammability and reactivity. Organic substances can travel through the blood stream to various organs where they can build up over time. **2**

Identify a strategy that can be applied to prevent or minimise exposure to these substances when using them in a laboratory.

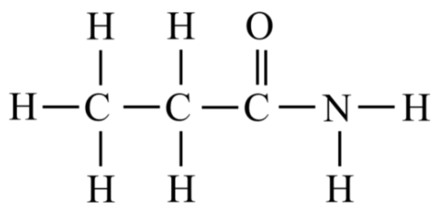
(c) Organic substances can also cause environmental issues if they are not disposed of correctly. **3**

Outline how scientists should correctly store and dispose of organic substances.

Question 30 (5 marks)

Amides are organic molecules that are used in the manufacture of many polymers, solvents and pharmaceutical drugs.

(a) Identify the amide shown in the diagram and circle the functional group that allows it to be placed in this category of molecule. **2**



(b) This table shows the boiling points of a variety of organic substances with similar molar masses. **3**

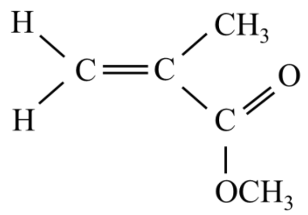
Compound	*Type*	*Molar mass* ($g\ mol^{-1}$)	*Boiling point* (°C)
propan-1-amine	amine	59	49
ethanamide	amide	59	210
ethanoic acid	carboxylic acid	60	118

Explain why the amide has a significantly higher boiling point than the amine.

Question 31 (5 marks)

Polymethyl methacrylate is an example of an addition polymer. Its monomer, properties and applications are shown in the table.

Complete the table with details of another named addition polymer that you have studied. **5**

Polymer name	*Monomer name and structural formula*	*Properties*	*Application*
polymethyl methacrylate	methyl-2-methylpropenoate 	• transparent • strong	shatter-proof glass substitute

Question 32 (7 marks)

Soaps are formed through a reaction known as saponification.

(a) Outline *saponification*. **3**

(b) Explain how soap works to clean surfaces. Include labelled diagrams to support your answer. **4**

Question 33 (8 marks)

This photograph shows the point in Wentworth, NSW where the Murray and Darling River systems join. From here, the system spreads across most of south-eastern Australia, feeding a multitude of smaller waterways and being home to a vast variety of aquatic flora and fauna.

At 28 sites along the length of the system, water samples are collected and tested. This allows scientists to monitor changes in environmental factors such as pH, temperature, and the levels of chemical substances such as phosphorus, nitrogen, sulfates and carbonates.

(a) Using THREE examples, analyse the need to monitor environmental factors in the Murray Darling River system. **6**

lines continue for Question 33 on page 24

Question 33 (continued)

(b) A scientist completes a series of precipitation reactions to determine the presence of particular ions in the river system. Some of his results are in this table. **2**

Reaction of water samples with sulfuric acid

Sample	*Observations*
1	X
2	forms white precipitate
3	forms white precipitate
4	X
5	X
6	X

From his observations he inferred that that Samples 2 and 3 must contain either Ba^{2+} or Ca^{2+} ions.

Suggest another test that could be undertaken to determine which of the two ions is present in the sample, and the expected results that would be used to make this determination.

Question 34 (4 marks)

The absorbance of a series of standard solutions of nickel(II) sulfate and a sample of lake water were determined using a colourimeter and are shown in the table.

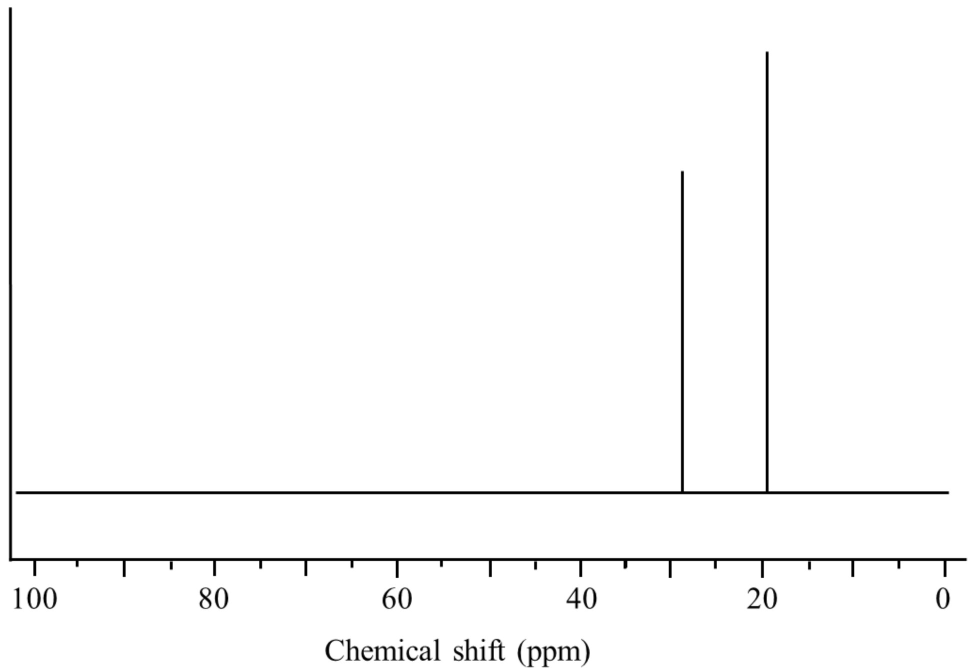
Concentration of Ni^{2+} (mg mL^{-1})	*Absorbance*
3.0	0.15
6.0	0.42
9.0	0.54
12.0	0.68
15.0	0.75
lake water sample	0.38

(a) Use the data in the table to draw a calibration curve on the grid below. **3**

(b) Determine the concentration of nickel in the sample. **1**

Question 35 (6 marks)

Jared carries out carbon-13 NMR testing on an unknown sample that was collected at an industrial work site. He uses the chemical shift information below to determine that the sample is a haloalkane.



(a) Justify his decision in determining that the sample was a haloalkane and suggest a name for the substance. **3**

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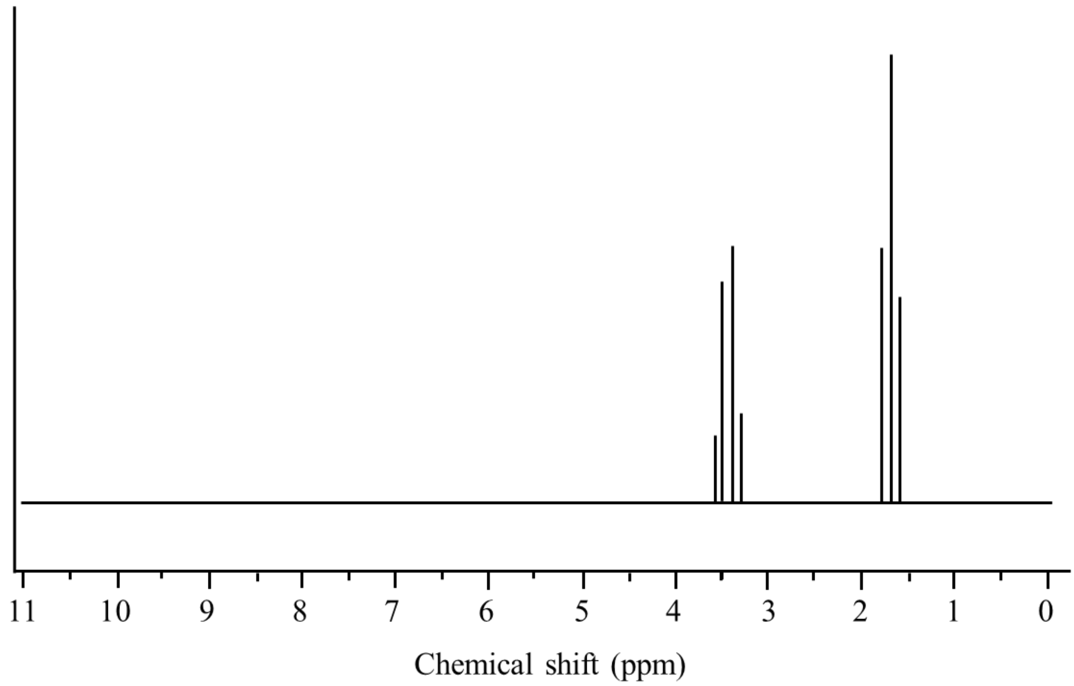
Question 35 continues on page 27

Question 35 (continued)

(b) Jared also carries out proton NMR testing and generates the spectrum below. He notices that there are multiple peaks where he expected to see single ones.



Explain why the splitting that can be seen in the spectrum has occurred. **3**

End of paper

Section I Part B extra writing space

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

Section I Part B extra writing space

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

2021 HSC TRIAL EXAMINATION

Chemistry

FORMULAE SHEET

$n = \dfrac{m}{MM}$	$c = \dfrac{n}{V}$	$PV = nRT$
$q = mc\Delta T$	$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$	$\mathrm{pH} = -\log_{10}[\mathrm{H}^+]$
$pK_a = -\log_{10}[K_a]$	$A = \varepsilon lc = \log_{10}\dfrac{I_o}{I}$	

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

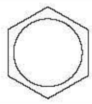
Compound	K_{sp}	*Compound*	K_{sp}
Barium carbonate	2.58×10^{-9}	Lead(II) bromide	6.60×10^{-6}
Barium hydroxide	2.55×10^{-4}	Lead(II) chloride	1.70×10^{-5}
Barium phosphate	1.3×10^{-29}	Lead(II) iodide	9.8×10^{-9}
Barium sulfate	1.08×10^{-10}	Lead(II) carbonate	7.40×10^{-14}
Calcium carbonate	3.36×10^{-9}	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
—C—C—		5–40
R—C—Cl or Br		10–70
R—C(═O)—C—		20–50
R—C—N		25–60
—C—O—	alcohols, ethers or esters	50–90
C═C		90–150
R—C≡N		110–125
		110–160
R—C(═O)—	esters or acids	160–185
R—C(═O)—	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
$\frac{1}{2}I_2(s) + e^-$	$\rightleftharpoons$	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

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: ______________________________

2021 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 ○

2021 HSC Chemistry
Marking Guidelines

Section I

Multiple-choice Answer Key

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

Section II

Question 21 (5 marks)

Criteria	Marks
• Provides balanced equation • Calculates solubility of BaF_2 in water • Calculates solubility of BaF_2 in NaF • Calculates difference in solubility between NaF and water • Makes a comparative statement about solubility in NaF and water	5
• Provides balanced equation • Calculates solubility of BaF_2 in water • Calculates solubility of BaF_2 in NaF	4
• Provides balanced equation • Calculates solubility of BaF_2 in water	3
• Provides balanced equation AND • Identifies molar ratio OR • Identifies common ion OR • Identifies correct equilibrium expression	2
• Provides some relevant information	1

Sample answer:

$BaF_2(s) \rightleftharpoons Ba^{2+}(aq) + 2F^-(aq)$
molar ratio 1 : 1 : 2

when dissolved in NaF, F^- is the common ion
reverse reaction is favoured
more precipitate forms

$[Ba^{2+}]$ = s mol L^{-1}
$[F^-]$ = 2s mol L^{-1}

$K_{sp} = [Ba^{2+}][F^-]^2$
$K_{sp} = s \times (2s)^2$
$K_{sp} = 4s^3$

$$s^3 = \frac{1.0 \times 10^{-6}}{4}$$

$$s = \sqrt[3]{\frac{1.0 \times 10^{-6}}{4}}$$

s = 0.0063 mol L^{-1}

Answer continued next page

[NaF] = $[F^-]$ = 0.03 mol L^{-1}
s<< 0.03 ∴ s + 0.03 ≈ 0.03 ∴ overall $[F^-]$ = 0.03 mol L^{-1}

K_{sp} = s x $(0.03)^2$
1.0 x 10^{-6} = s x 0.0009

$$s = \frac{1.0 \times 10^{-6}}{0.0009}$$

s = 0.0011 mol L^{-1}

compare: $\frac{\text{water}}{\text{NaF}}$ $\frac{0.0063}{0.0011}$ = 5.73

∴ BaF_2 is 5.73 times less soluble in NaF than it is in water

Question 22 (8 marks)

(a)

Criteria	Marks
• Identifies correct equilibrium expression	1

Sample answer:

$$\mathrm{K_{eq}} = \frac{[\mathrm{N_2O_4}]}{[\mathrm{NO_2}]^2}$$

(b)

Criteria	Marks
• Calculates concentration of NO_2 at equilibrium • Calculates concentration of N_2O_4 at equilibrium • Calculates K_{eq}	4
• Use ICE table to determine initial/equilibrium mole quantities • Calculates concentration of NO_2 at equilibrium • Calculates concentration of N_2O_4 at equilibrium	3
• Use ICE table to determine initial/equilibrium mole quantities • Calculates concentration of NO_2 or N_2O_4 at equilibrium	2
• Provides some relevant information	1

Sample answer:

	$2NO_2(g) \rightleftharpoons N_2O_4(g)$	
I	0.050	0
C	-2x	+x
E	0.046	0.002

Answer continued next page

$$[NO_2] = \frac{n}{V} = \frac{0.046}{0.02} = 2.3 \text{ mol L}^{-1}$$

$$[N_2O_4] = \frac{n}{V} = \frac{0.002}{0.02} = 0.1 \text{ mol L}^{-1}$$

$$K_{eq} = \frac{[N_2O_4]}{[NO_2]^2}$$

$$K_{eq} = \frac{0.1}{(2.3)^2}$$

$$K_{eq} = \frac{0.1}{5.29}$$

K_{eq} = 0.0189

(c)

Criteria	Marks
• Explains, with clear links to Le Chatelier's principle, how the reaction will adjust after the tube is placed in ice water • Makes explicit statement about colour change in tube	3
• Explains, with clear links to Le Chatelier's principle, how the reaction will adjust after the tube is placed in ice water	2
• Identifies that the forward reaction will be favoured OR • Identifies that more N_2O_4 would form	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. Placing the tube into ice water would decrease the temperature of the system. The reaction is exothermic so, according to Le Chatelier's principle, the forward reaction will be favoured in order to increase the temperature of the system. This would form more N_2O_4 and this would change the colour of the gas in the tube from brown to colourless.

Question 23 (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 24 (5 marks)

(a)

Criteria	Marks
• Identifies that precipitate formed will be silver chloride	1

Sample answer:

	potassium chloride
silver nitrate	AgCl
zinc nitrate	no ppt
sodium sulfate	no ppt

(b)

Criteria	Marks
• Provides balanced chemical equation • Identifies correct equilibrium expression • Calculates moles of KCl • Calculates K_{sp} for potassium chloride	4
• Provides balanced chemical equation • Identifies correct equilibrium expression • Calculates moles of KCl	3
• Provides balanced chemical equation • Identifies correct equilibrium expression	2
• Provides some relevant information	1

Sample answer:

$KCl(s) \rightleftharpoons K^+(aq) + Cl^-(aq)$

$[K^+] = s$
$[Cl^-] = s$
35.5 g/100 g = 355 g L^{-1}

MM(KCl) = 39.10 + 35.45
MM(KCl) = 74.55 g mol^{-1}

n(KCl) = $\frac{355}{74.55}$ = 4.76 mol

$K_{sp} = [K^+][Cl^-]$
K_{sp} = 4.76 x 4.76
K_{sp} = 22.68

Question 25 (5 marks)

Criteria	Marks
• Provides balanced chemical equation • Calculates moles of H_3PO_4 and KOH reacted • Calculates moles of H^+ and OH^- • Determines that H^+ is in excess and calculates excess concentration • Calculates pH	5
• Provides balanced chemical equation • Calculates moles of H_3PO_4 and KOH reacted • Calculates moles of H^+ and OH^- • Determines that H^+ is in excess and calculates excess concentration	4
• Provides balanced chemical equation • Calculates moles of H_3PO_4 and KOH reacted • Calculates moles of H^+ and OH^-	3
• Provides balanced chemical equation • Calculates moles of H_3PO_4 and KOH reacted	2
• Provides some relevant information	1

Sample answer:

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

n(HCl) = cV
n(HCl) = 0.30 x 0.03
n(HCl) = 0.009 mol

n(KOH) = cV
n(KOH) = 0.35 x 0.025
n(KOH) = 0.00875 mol

$n(H^+)$ = 0.009 mol

$n(OH^-)$ = 0.00875 mol

$n(H^+) - n(OH^-)$ = 0.009 – 0.00875
$n(H^+) - n(OH^-)$ = 0.00025 mol H^+ in excess

$[H^+] = \frac{n}{V}$
$[H^+] = \frac{0.00025}{0.055}$
$[H^+]$ = 0.0045 mol L^{-1}

pH = $-\log[H^+]$
pH = -log 0.0045

pH = 2.35

Question 26 (2 marks)

Criteria	Marks
• Describes an example of where acid/base analytical techniques are used in industry	2
• Identifies an example of where acid/base analytical techniques are used in industry	1

Sample answer:

Answers may vary.
During production, it is possible for wine to contain many different chemicals including tartaric, malic, citric and ethanoic acids. These acids can affect the taste of the wine and have role in the fermentation process. Winemakers can use titration to determine the acid content of wine as part of their quality control process. They titrate an aliquot of the wine against a standardised solution of sodium hydroxide.

Question 27 (6 marks)

(a)

Criteria	Marks
• Provides balanced chemical equation • Calculates moles of primary standard used • Calculates average volume of secondary standard used • Calculates concentration of secondary standard	4
• Provides balanced chemical equation • Calculates moles of primary standard produced OR used • Calculates average volume of secondary standard used	3
• Provides balanced chemical equation AND • Calculates moles or primary standard produced OR • Calculates average volume of secondary standard used	2
• Provides some relevant information	1

Sample answer:

n(primary made/Na_2CO_3) = $\frac{2.35}{105.9}$ = 0.022 mol
[primary made/Na_2CO_3] = $\frac{0.022}{0.300}$ = 0.074 mol L^{-1}
n(primary used/Na_2CO_3) = 0.074 x 0.035 = 0.0026 mol
$Na_2CO_3(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + H_2O(l) + CO_2(g)$
n(secondary/H_2SO_4) = 0.0026 mol as molar ratio 1:1
average volume of H_2SO_4 used = $\frac{24.70+24.85+24.80+24.90+24.80}{5}$ = 24.81 mL
[secondary/H_2SO_4] = $\frac{0.0026}{0.02481}$ = 0.105 mol L^{-1}

(b)

Criteria	Marks
• Explains why digital probes and meters are preferred over indicators	2
• Identifies issue with using an indicator	1

Sample answer:

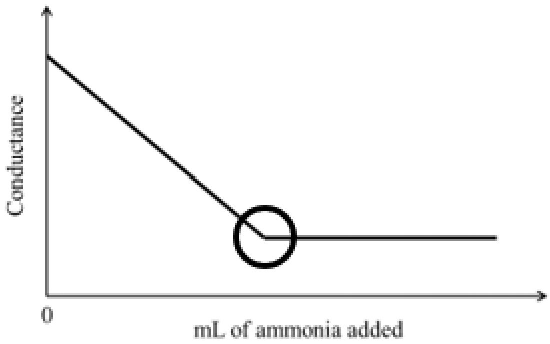
The use of an indicator is a destructive test and observing colour changes can be subjective. Using a probe or meter would remove these issues and provide a more accurate reading that cannot be misinterpreted.

Question 28 (4 marks)

(a)

Criteria	Marks
• Correctly identifies equivalence point on curve	1

Sample answer:



(b)

Criteria	Marks
• Accounts for the shape of a strong acid/weak base curve in terms of HCl and NH_3, referring to the change in H_+ ion levels	3
• Identifies that hydrochloric acid is a strong acid and that ammonia is a weak base • Describes some general aspects of the curve using appropriate scientific language	2
• Provides some relevant information	1

Sample answer:

Hydrochloric acid is a strong acid and ammonia is a weak base. Initially, there is a high conductivity due to presence of H^+ ions in the acid. Conductivity decreases as these H^+ ions react with ammonia molecules and are replaced by NH_4^+ ions, which have a lower conductivity. Once the equivalence point has been reached, conductivity does not change as more ammonia is added as it is a weak base and is only dissociated to a very small extent.

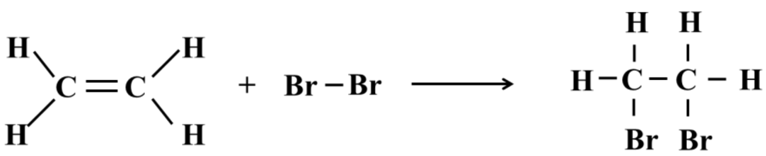
Question 29 (7 marks)

(a)

Criteria	Marks
• Provides word AND structural formula equation	2
• Provides word OR structural formula equation	1

Sample answer:

ethene + bromine → 1,2-dibromoethane



(b)

Criteria	Marks
• Identifies a strategy that can be applied to prevent or minimise exposure to organic substances in a laboratory • Describes how strategy reduces risk of harm	2
• Identifies a strategy that can be applied to prevent or minimise exposure to organic substances in a laboratory	1

Sample answer:

Answers may vary.

Using a labcoat, safety glasses and gloves would prevent any organic substances from having direct contact with the skin. This helps to minimise exposure.

(c)

Criteria	Marks
• Outlines how scientists should correctly store and dispose of organic substances	3
• Outlines how scientists should correctly store OR dispose of organic substances	2
• Provides some relevant information	1

Sample answer:

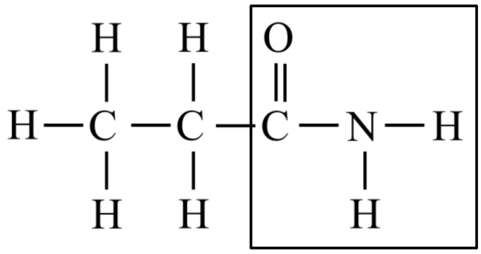
Organic substances should not be poured down the sink. They must be labelled correctly and different types of substance may need to be stored and disposed of separately. Some waste products may need to be treated first to remove acids or bases or filtered to remove solid materials. Waste must be collected, and then disposed of by chemical waste disposal companies.

Question 30 (5 marks)

(a)

Criteria	Marks
• Identifies name of compound AND correctly circles amide functional group	2
• Identifies name of compound OR correctly circles amide functional group	1

Sample answers:
propanamide



(b)

Criteria	Marks
• Describes the structure of amines and alcohols which results in the presence of hydrogen bonds • Compares the structure of amines and amides to explain differences in boiling point	3
• Describes the structure of amines and alcohols which results in the presence of hydrogen bonds	2
• Provides some relevant information	1

Sample answer:

The N-H bonds in amines and amides are highly polar, meaning that hydrogen bonds can form between the non-bonding pair of electrons on the nitrogen atom and the partially positive hydrogen atom on the other molecule.

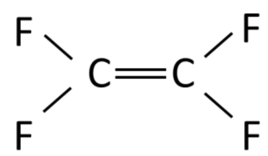
Amides have much higher boiling points than amines as they contain more atoms that can form hydrogen bonds. Hydrogen bonds also form between non-bonding electron pairs on the oxygen atom of one molecule and the partially positive hydrogen atom on a neighbouring molecule.

Question 31 (5 marks)

Criteria	Marks
• Identifies all of the features listed below	5
• Identifies four of the features listed below	4
• Identifies three of the features listed below	3
• Identifies two of the features listed below	2
• Identifies one of the following about an addition polymer: ○ polymer name ○ monomer name ○ monomer structural formula ○ properties ○ application	1

Sample answer:

Answers will vary.

Polymer	*Monomer*	*Properties*	*Application*
polytetrafluoroethene (PTFE)	tetrafluoroethene 	• non-stick • high melting point	• frying pan coatings • plumber's tape • waterproof fabrics

Question 32 (7 marks)

(a)

Criteria	Marks
• Identifies that saponification involves the hydrolysis of fats • Outlines the reaction • Provides word equation	3
• Identifies that saponification involves the hydrolysis of fats • Outlines the reaction OR provides word equation	2
• Identifies that saponification involves the hydrolysis of fats	1

Sample answer:

Saponification reactions involve the hydrolysis of fats. In these reactions, triglycerides are reacted with sodium or potassium hydroxide to form an alcohol and a salt of a fatty acid.

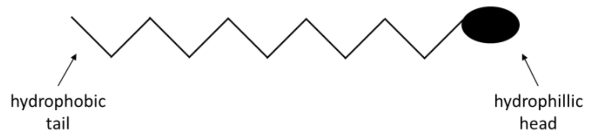
triglyceride + sodium hydroxide → alcohol + fatty acid salt

(b)

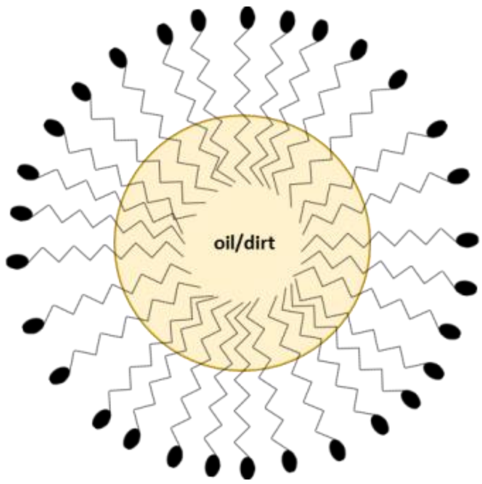
Criteria	Marks
• Provides two relevant, labelled diagrams • Explains how soaps can act as surfactants and emulsifiers • Explains the formation and role of a micelle	4
• Provides two relevant, labelled diagrams • Identifies that molecule has hydrophilic head and hydrophobic tail • Explains the formation and role of a micelle	3
• Provides one relevant, labelled diagram • Identifies that soaps can act as surfactants and emulsifiers OR • Identifies that molecule has hydrophilic head and hydrophobic tail	2
• Provides some relevant information	1

Sample answer:

Soaps and detergents can act as both surfactants and emulsifiers. Surfactants (or surface active agents) work to reduce surface tension. They do this by breaking the hydrogen bonds between water molecules, allowing the water to spread out onto a surface rather than remaining in a droplet. Emulsifiers allow immiscible liquids, such as water and oil, to mix and form an emulsion.
This occurs as the head of the molecule is hydrophillic and will bond with water, and the tail which is hydrophobic (and therefore lipophillic) will bond with the oil.



When water is agitated, the soap molecules are able to completely surround dirt and oil, forming a structure called a micelle.



As the water flows away, the micelles (and the dirt and oil they contain) are washed away.

Question 33 (8 marks)

(a)

Criteria	Marks
• Discusses THREE examples that demonstrate the need for monitoring environmental factors in the Murray Darling River system • Provides a link or shows the relationship between discussed examples	6
• Discusses THREE examples that demonstrate the need for monitoring environmental factors in the Murray Darling River system OR • Discusses TWO examples that demonstrate the need for monitoring environmental factors in the Murray Darling River system • Provides a link or shows the relationship between discussed examples	5
• Discusses TWO examples that demonstrate the need for monitoring environmental factors in the Murray Darling River system	4
• Discusses ONE example that demonstrates the need for monitoring environmental factors in the Murray Darling River system	3
• Any TWO of the following: ○ Identifies a reason for monitoring the river system ○ Identifies a problem that may occur if the river system is not monitored ○ Identifies a specific environmental factor that could be monitored ○ Identifies a specific technique that could be used to monitor a named environmental factor	2
• Identifies a reason for monitoring the river system OR • Identifies a problem that may occur if the river system is not monitored OR • Identifies a specific environmental factor that could be monitored OR • Identifies a specific technique that could be used to monitor a named environmental factor	1

Sample answer over page

Sample answer:

Answers will vary.

Many impurities, pollutants and components of manufactured products are ionic compounds and these will often ionise in solution. This means there is a need to test which, if any, cations or anions are present in the waterway. There needs to be multiple monitoring or test points as the Murray Darling River system covers a large amount of area and noting a contamination point or place with elevated levels may allow for the problem to be contained before it spread through the entire system.

Most pollutants that can enter the waterways can have a negative effect on the organisms living in an ecosystem (including humans). High levels of particular ions in our waterways can lead to problems such as heavy metal poisoning, bioaccumulation and eutrophication. Their levels must be frequently monitored to ensure they are within a safe range to prevent harm to people or other organisms.

There are rules and regulations that specify what chemical compounds can and cannot be released into the environment. Monitoring ensure that corporations can be held accountable if they are releasing inappropriate amounts of chemical compounds into the waterway.

Monitoring environmental factors in the Murray Darling River system is important as it allows for scientists and the local community to know have an understanding of what is happening in their waterways, it prevents corporations from contaminating the system, and helps keep the concentration of chemical compounds at an appropriate level.

(b)

Criteria	Marks
• Identifies an appropriate additional test that could be carried out • Identifies expected results	2
• Identifies an appropriate additional test that could be carried out	1

Sample answer:

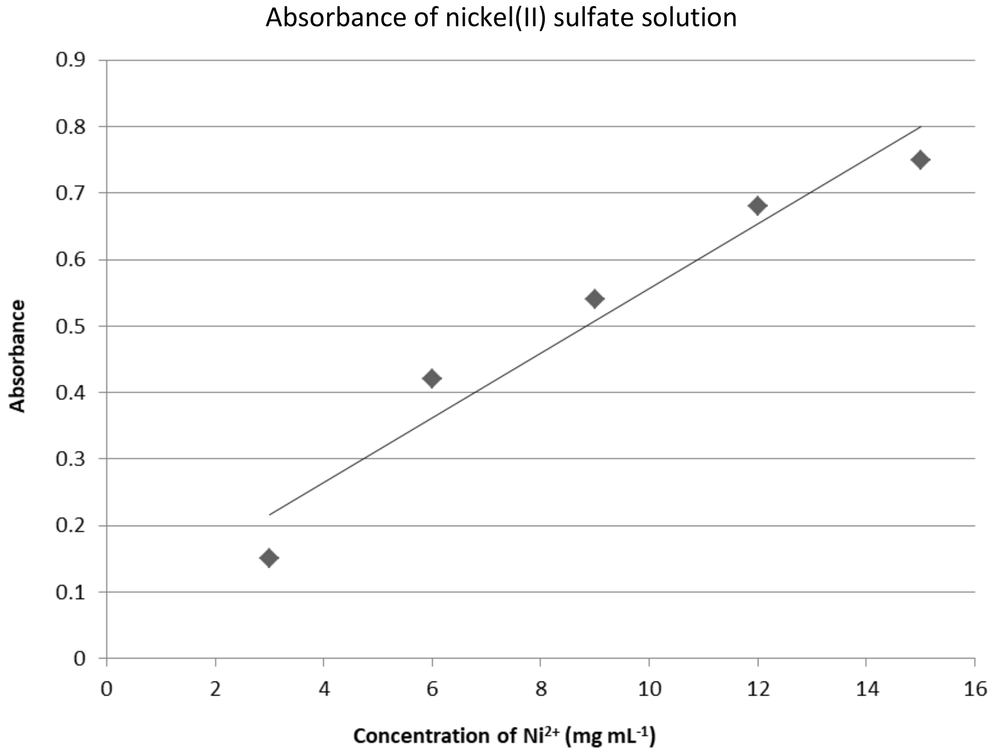
A flame test could be carried out by inserting a sample into a Bunsen burner flame. If the sample contained Ba^{2+} ions, the flame colour would change to a pale green. If the sample contained Ca^{2+} ions, the flame colour would change to a brick-red colour.

Question 34 (4 marks)

(a)

Criteria	Marks
• Graph has an appropriate title • Best fit line has been drawn • Uses an appropriate and even scale • Labels both axes, including appropriate units • Plots concentration on x-axis and absorbance on y-axis	3
• Provides a substantially correct graph	2
• Provides some basic feature of graph	1

Sample answer:



(b)

Criteria	Marks
• Identifies concentration of Ni^{2+} in water sample from calibration curve	1

Sample answer:

6.3 mg mL^{-1} (± 0.1 mg mL^{-1})

Question 35 (6 marks)

(a)

Criteria	Marks
• Justifies identification as haloalkane using chemical shift data for C-C group AND presence of halogen • Suggests a name for the substance • Justifies name/chain length using number of carbon environments	3
• Suggests a name for the substance AND • Justifies identification as haloalkane using chemical shift data for C-C group OR presence of halogen OR • Justifies name/chain length using number of carbon environments	2
• Provides some relevant information	1

Sample answer:

The sample may be a haloalkane such as bromoethane (or chloroethane) as:

- there is a peak with a chemical shift near 20 ppm, which suggest the presence of a C-C group
- there is a peak with a chemical shift near 30 ppm, which suggests the presence of a halogen (chlorine or bromine)
- there are two peaks on the spectra, which tells him that there are two different carbon environments

(b)

Criteria	Marks
• Identifies that splitting occurs due to the presence of neighbouring hydrogen atoms • Explains the presence of the triplet and quartet peaks	3
• Identifies that splitting occurs in high resolution proton NMR testing • Identifies that splitting occurs due to the presence of neighbouring hydrogen atoms	2
• Identifies that splitting occurs in high resolution proton NMR testing OR • Identifies that splitting occurs due to the presence of neighbouring hydrogen atoms	1

Sample answer:

Splitting occurs when using high resolution proton NMR testing. Signals are split into clusters of peaks due to the effect of neighbouring hydrogen atoms. The triplet between 1.5 and 2 ppm is likely caused by the $–CH_2–$ group found in the haloalkane where the halogen is attached. The quartet at 3.5 ppm is likely caused by the $–CH_3$ group found at one end of the haloalkane.

2021 HSC Chemistry Mapping Grid

Section I

Question	Marks	Module	Content	Syllabus outcomes
1	1	5	Static and Dynamic Equilibrium	CH12-12
2	1	5	Factors that Affect Equilibrium	CH12-4, CH12-12
3	1	5	Calculating the Equilibrium Constant (K_{eq})	CH12-6, CH12-12
4	1	7	Nomenclature	CH12-14
5	1	5	Factors that Affect Equilibrium	CH12-6, CH12-12
6	1	7	Alcohols	CH12-5, CH12-14
7	1	8	Chemical Synthesis and Design	CH12-15
8	1	6	Using Brønsted–Lowry Theory	CH12-13
9	1	6	Properties of Acids and Bases	CH12-5, CH12-13
10	1	7	Polymers	CH12-14
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13	1	6	Quantitative Analysis	CH12-6, CH12-13
14	1	5	Solution Equilibria	CH12-6, CH12-12
15	1	6	Using Brønsted–Lowry Theory	CH12-6, CH12-13
16	1	6	Quantitative Analysis	CH12-6, CH12-13
17	1	8	Analysis of Inorganic Substances	CH12-15
18	1	8	Analysis of Organic Substances	CH12-4, CH12-15
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Section II

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22 (b)	4	5	Calculating the Equilibrium Constant (K_{eq})	CH12-6, CH12-12
22 (c)	3	5	Factors that Affect Equilibrium	CH12-6, CH12-12
23	3	5	Solution Equilibria	CH12-12
24 (a)	1	8	Analysis of Inorganic Substances	CH12-5, CH12-12
24 (b)	4	5	Calculating the Equilibrium Constant (K_{eq})	CH12-6, CH12-12
25	5	6	Using Brønsted–Lowry Theory	CH12-6, CH12-13
26	2	6	Quantitative Analysis	CH12-13
27 (a)	4	6	Quantitative Analysis	CH12-6, CH12-13
27 (b)	2	6	Properties of Acids and Bases	CH12-13
28 (a)	1	6	Quantitative Analysis	CH12-13
28 (b)	3	6	Quantitative Analysis	CH12-5, CH12-13
29 (a)	2	7	Hydrocarbons	CH12-14
29 (b)	1	7	Hydrocarbons	CH12-14
29 (c)	3	7	Hydrocarbons	CH12-14
30 (a)	2	7	Nomenclature	CH12-14
30 (b)	3	7	Reactions of Organic Acids and Bases	CH12-5, CH12-14
31	5	7	Polymers	CH12-14
32 (a)	3	7	Reactions of Organic Acids and Bases	CH12-14
32 (b)	4	7	Reactions of Organic Acids and Bases	CH12-7, CH12-14
33 (a)	6	8	Analysis of Inorganic Substances	CH12-7, CH12-15
33 (b)	2	8	Analysis of Inorganic Substances	CH12-15
34 (a)	3	8	Analysis of Inorganic Substances	CH12-7, CH12-15
34 (b)	1	8	Analysis of Inorganic Substances	CH12-4, CH12-15
35 (a)	3	8	Analysis of Organic Substances	CH12-4, CH12-15
35 (b)	3	8	Analysis of Organic Substances	CH12-4, CH12-15