2020

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 10-29)

- Attempt Questions 21– 34
- 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 Which statement about dynamic equilibrium is correct?

A. At equilibrium, the forward and the reverse reactions cease to occur.

B. At equilibrium, the concentration of reactants and products will be the same.

C. The value of the equilibrium constant depends on the temperature at which the reaction occurs.

D. Increasing the temperature of the surroundings shifts the position of equilibrium in favour of exothermic reactions.

2 The table shows the results of some precipitation reactions.

Solutions	Silver nitrate	Calcium nitrate
Sodium chloride	white precipitate	red precipitate
Sodium carbonate	yellow precipitate	white precipitate

Which result is inconsistent with known solubility rules?

A. sodium chloride + silver nitrate

B. sodium carbonate + silver nitrate

C. sodium chloride + calcium nitrate

D. sodium carbonate + calcium nitrate

3 Which alternative most correctly represents the chemical reaction for the equilibrium expression shown below?

$$\frac{[Ni(CO)_4]}{[CO]^4}$$

A. $Ni(CO)_4(g) \rightleftharpoons 4CO(g)$

B. $Ni(CO)_4(g) \rightleftharpoons Ni(g) + 4CO(g)$

C. $Ni(s) + 4CO(g) \rightleftharpoons Ni(CO)_4(g)$

D. $4Ni(s) + 4CO(g) \rightleftharpoons 4\ Ni(CO)(g)$

4 A variety of spectroscopic tools can be used for identification and verification.

	Technique
1	Infrared spectrum
2	Mass spectrum
3	NMR ^{1}H and NMR ^{13}C spectrum

Which techniques are used to identify and verify an organic compound?

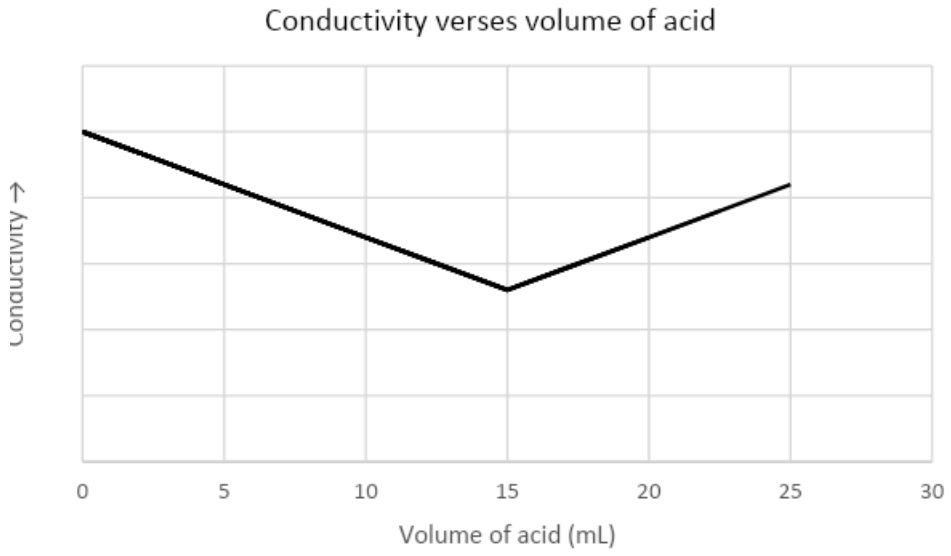
A. 1 and 2

B. 1 and 3

C. 2 and 3

D. 1, 2 and 3

The graph is used for Questions 5 and 6. It shows changes to conductivity as hydrochloric acid is added to 25 mL of sodium hydroxide.



5 Which statement about this titration is correct?

A. The equivalence point occurred when 15 mL of acid was added.

B. The equivalence point occurred when 25 mL of acid was added.

C. Neutralisation is incomplete as the conductivity has not reached zero.

D. The end point occurred when 15 mL of acid was added, and the equivalence point occurred when 25 mL of acid was added.

6 Given that the concentration of the sodium hydroxide was 0.12 M, what is the concentration of the hydrochloric acid solution?

A. 0.0072 M

B. 0.12 M

C. 0.20 M

D. 1.66 M

7 Which pair of compounds represents an acid and its conjugate base?

	Acid	*Conjugate base*
A.	HSO_4^-	H_2SO_4
B.	CH_3COO^-	CH_3COOH
C.	CH_3NH_2	$CH_3NH_3^+$
D.	$HCrO_4^-$	CrO_4^{2-}

8 Three solutions have been prepared.

Solution	*Concentration* (mol L^{-1})	*Formula*
P	0.05	Na_2CO_3
Q	0.005	NaOH
R	0.1	NH_3

Which statement is correct?

A. P is a weak acid and more dilute than R

B. P is a weak base and more dilute than R

C. R is a weak base and more dilute than Q

D. Q is a strong base and more concentrated than P

9 A three carbon carboxylic acid reacts with a four carbon alcohol in the presence of a catalyst.

What is the name of the main product?

A. Heptanoate

B. Propanoic acid

C. Propyl butanoate

D. Butyl propanoate

10 Which of the following metal hydroxides has the highest molar solubility?

A. $AgOH$

B. $Ba(OH)_2$

C. $Fe(OH)_2$

D. $Fe(OH)_3$

11 Which solution has the highest pH?

A. 0.001 M NH_3

B. 0.001 M KOH

C. 0.005 M H_2SO_4

D. 0.005 M CH_3COOH

12 Which equation represents the neutralisation of one reactant by the other?

A. $CH_3CH_2COH(l) + HI(g) \rightarrow CH_3CH_2Cl(l) + H_2O(l)$

B. $CH_3CH_2COH(l) \xrightarrow{Conc.H_2SO_4} CH_3CH_2CH_2(g) + H_2O(l)$

C. $CH_3CH_2CH_2NH_2(aq) + HNO_3(aq) \rightarrow CH_3CH_2CH_2NH_3NO_3(aq)$

D. $CH_3CH_2CH_2OH(l) + CH_3CH_2COOH(aq) \rightarrow CH_3CH_2CH_2OOCH_2CH_3(aq) + H_2O(l)$

13 Which compound below is NOT an isomer of the others?

A. 1-butene

B. 1-pentene

C. Cyclopentane

D. 2-methyl-2-butene

14 The information given concerns the equilibrium involving hydrogen, iodine and hydrogen iodide.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

Temperature (K)	K_{eq}
500	160
700	54

Which conclusion is correct?

A. The reaction favours the direction which gives out heat

B. The reaction favours the direction which produces fewer molecules

C. As the temperature increases, the value of K_{eq} decreases because the forward reaction is endothermic

D. As the temperature increases, the value of K_{eq} decreases because the forward reaction is exothermic

15 What is the concentration of barium ions in a saturated solution of barium carbonate?

A. 5.08×10^{-5} mol L^{-1}

B. 1.60×10^{-3} mol L^{-1}

C. 1.16×10^{-3} mol L^{-1}

D. 0.005 mol L^{-1}

16 One litre of buffer solution is made by combining which two substances?

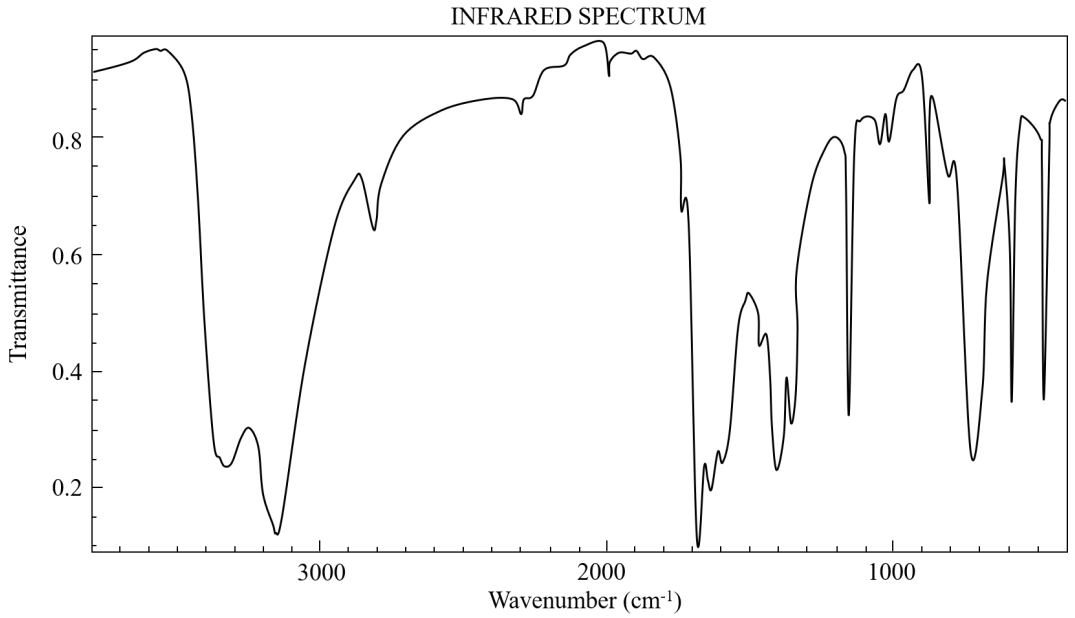
A. 0.2 mol acetic acid and 0.2 mol sodium acetate

B. 0.1 mol hydrofluoric acid and 1.0 mol sodium fluoride

C. 0.1 mol hydrochloric acid and 0.1 mol sodium chloride

D. 0.2 mol sodium hydrogen carbonate and 0.2 mol potassium hydrogen carbonate

17 The diagram shows the infrared spectrum of a compound.



What is the compound?

A. Ethene

B. Ethanol

C. Ethanamide

D. Ethanoic acid

18 A student set up a spirit burner containing an alcohol (molar mass 74.1 g mol^{-1}) to heat 200.0 g of water, at 23.0°C, in a conical flask. The initial mass of the spirit burner was 350.75 g.

After the water temperature reached 45.0°C, the spirit burner was extinguished, and its mass was found to be 350.01 g.

What is the molar heat of combustion of this alcohol?

A. 68.1 kJ mol^{-1}

B. 1841.7 kJ mol^{-1}

C. 6814.6 kJ mol^{-1}

D. 32254.9 kJ mol^{-1}

19 A sample of water collected from a cave was analysed and the results recorded.

Test	*Result*
Flame test	Red
Add HCl	Small bubbles
Add $AgNO_3$	White precipitate
Add $BaCl_2$	White precipitate

Which ions are mostly likely to be present in the water?

A. Ba^{2+} and CO_3^{2-}

B. Ca^{2+} and SO_4^{2-}

C. Ba^{2+} and SO_4^{2-}

D. Ca^{2+} and CO_3^{2-}

20 A solution of lead (II) nitrate was tested with the following

- KI solution
- NaOH solution
- NH_3 solution

Which alternative shows the expected observations?

	KI	NaOH	NH_3
A.	no reaction	yellow ppt.	white ppt.
B.	yellow ppt.	white ppt. dissolves in excess NaOH	white ppt. does not dissolve in excess
C.	no reaction	no reaction	blue ppt.
D.	white ppt.	white ppt. dissolves in excess NaOH	no reaction

Student ID: _____

2020

HIGHER SCHOOL CERTIFICATE
TRIAL EXAMINATION

Chemistry

Section II
Answer Booklet

80 marks
Attempt Questions 21–34
Allow about 2 hours 25 minutes for this section

Instructions

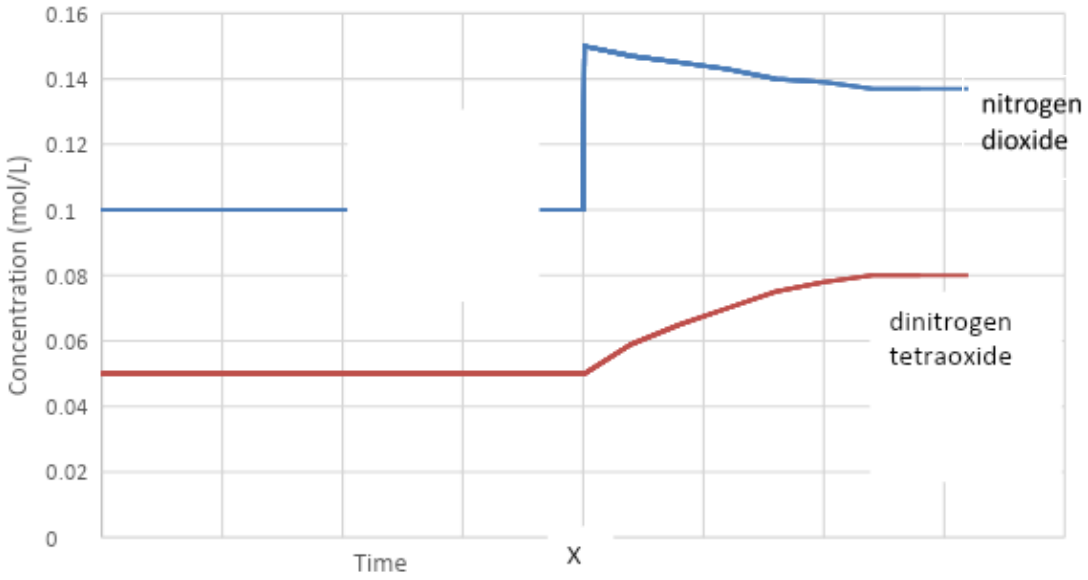
- Write your Student ID above
- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
- Show all relevant working in question involving calculations
- Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering.

Please turn over

Question 21 (4 marks)

A sealed glass flask contains the following gas reaction.

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$



(a) Describe what was happening inside the flask prior to time X. **1**

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(b) Predict the action which occurred at time X. **1**

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(c) Explain the changes which took place inside the flask after time X. **2**

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Question 22 (6 marks)

The reaction to produce hydrogen from carbon monoxide and steam is shown.

$$H_2O(g) + CO(g) \rightleftharpoons CO_2(g) + H_2(g)$$

Use the data supplied in the table to answer the following questions.

	ΔH_f^{ϕ} kJ mol^{-1}	S^{ϕ} J K^{-1} mol^{-1}
$CO_{(g)}$	-111	198
$H_2O_{(g)}$	-242	189
$CO_{2(g)}$	-393	214
$H_{2(g)}$	0	131

(a) Calculate the enthalpy change for this reaction. **1**

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(b) Calculate the entropy change for this reaction. **1**

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(c) Determine whether this reaction is spontaneous at 600K under standard conditions. **2**

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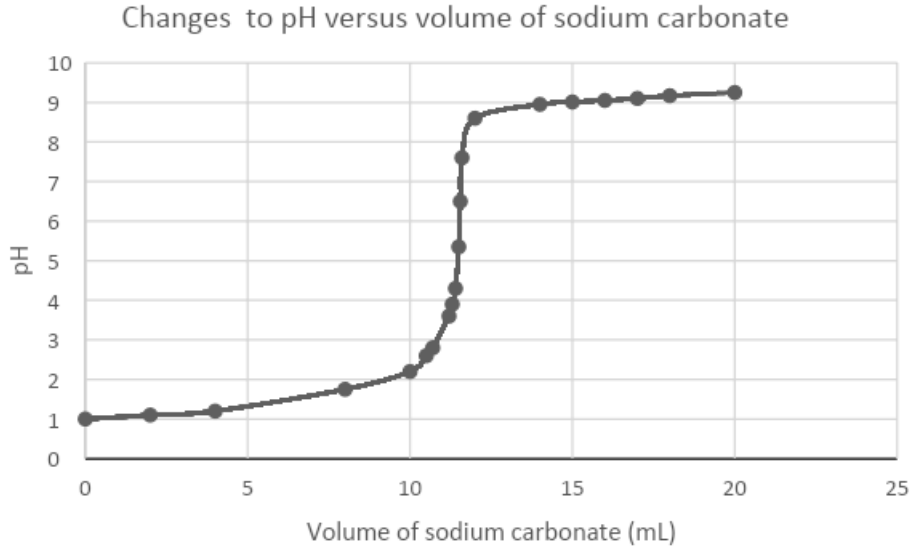
(d) Given that when a reaction has reached equilibrium $\Delta G = 0$, calculate the minimum temperature required for this reaction to reach equilibrium under standard conditions AND state when the reaction will be spontaneous. **2**

Question 23 (6 marks)

The graph shows the titration of 20 mL of hydrochloric acid with a standardised solution of 0.095 M sodium carbonate.



(a) Identify a suitable indicator for this titration and give a reason for selecting this indicator. **2**

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(b) What volume of sodium carbonate is required to neutralise the hydrochloric acid? **1**

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(c) Calculate the concentration of the hydrochloric acid solution. **3**

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Question 24 (7 marks)

Sodium acetate is dissolved in water to produce a 0.50 M acetate ion solution. The acetate ions then react with water molecules as shown.

$$CH_3COO^-(aq) + H_2O(l) \rightleftharpoons CH_3COOH\,(aq) + HO^-(aq)$$

(a) From the equation, describe the behaviour of the acetate ion. **2**

(b) Given that K_a for acetic acid is 1.75×10^{-5}, use the relationship $K_w = K_a \times K_b$ to calculate the K_b of the acetate ion. **2**

(c) Write the equilibrium expression for this reaction then calculate the hydroxide ion concentration. Show relevant working. **3**

Question 25 (4 marks)

Compare Arrhenius' theory of acids and bases with the Brønsted–Lowry theory. **4**

Question 26 (6 marks)

The table provides data regarding physical properties of alcohols.

Alcohol	*Molecular weight*	*Boiling point* (°C)	*Solubility* (g/100 mL at 25°C)
propan-1-ol	60.1	97.2	miscible
propan-2-ol	60.1	82.3	miscible
2-methyl propan-2-ol	74.1	82.6	miscible
butan-1-ol	74.1	117.7	7.3
butan-2-ol	74.1	99.5	2.9
pentan-1-ol	88.2	138	2.2
pentan-3-ol	88.2	115.9	5.9

(a) Draw the structural formula of the tertiary alcohol. **1**

(b) Name the intermolecular forces which occur in liquid alcohols. **1**

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Question 26 continues on page 17

Question 26 (continued)

(c) Explain the trends in boiling point and solubility with increasing molecular weight. **4**

Question 27 (4 marks)

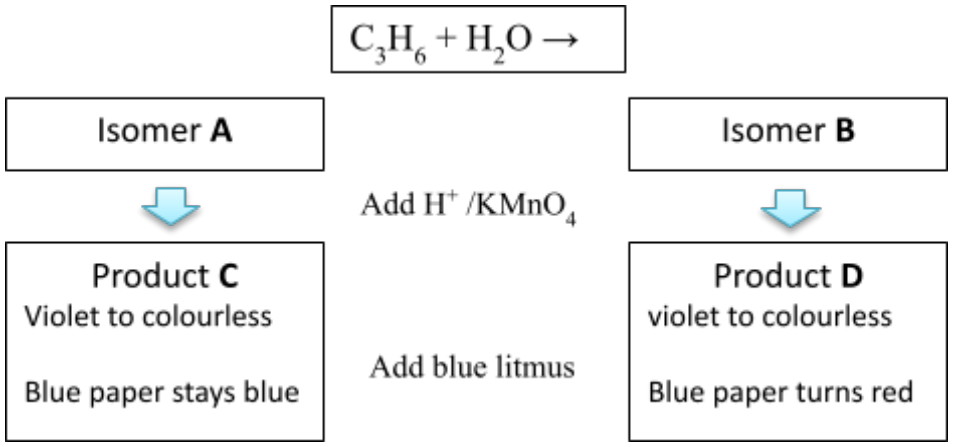
An equimolar solution of carbonic acid and hydrogen carbonate ions has reached equilibrium with a pH of 6.4. **4**

$$H_2CO_3(aq) + H_2O(l) \rightleftharpoons HCO_3^-(aq) + H_3O^+(l)$$

Explain how the addition of both a small volume of dilute acid and base can result in no change in the overall pH of this solution.

Question 28 (7 marks)

Propene is hydrated with a catalyst to produce two isomers, A and B. The isomers are then treated with a strong oxidant, acidified potassium permanganate solution. The products of each reaction, C and D, are then extracted and tested with blue litmus paper.



(a) Name the compounds A, B, C and D, justifying your answers for each with reference to the information provided. **5**

Question 28 continues on page 20

Question 28 (continued)

(b) Write balanced and net ionic equations for the reaction between acidified permanganate solution and ONE of the isomers. **2**

Question 29 (7 marks)

An investigation into the solubility product of silver bromate was conducted by reacting equal volumes of varying concentrations of two solutions, silver nitrate and sodium bromate. The solutions reacted at 25°C. The observations are recorded below.

Test	$[Ag^+]$ mol L^{-1}	$[BrO_3^-]$ mol L^{-1}	*Observations*
1	0.05	0.05	thick white precipitate
2	0.025	0.05	white precipitate
3	0.005	0.05	fine white precipitate settles on standing
4	0.0025	0.05	fine white precipitate settles on standing
5	0.00125	0.05	fine white precipitate settles on standing
6	0.0005	0.05	no precipitate
7	0.00025	0.05	no precipitate

7

Analyse the data to determine the range of values where the solubility product must lie.

Select a value within the range to estimate the K_{sp} and estimate the solubility of silver bromate at equilibrium.

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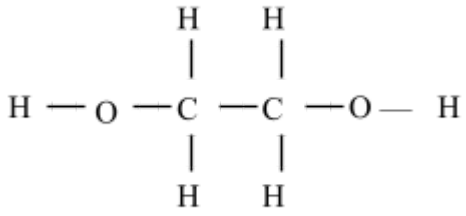
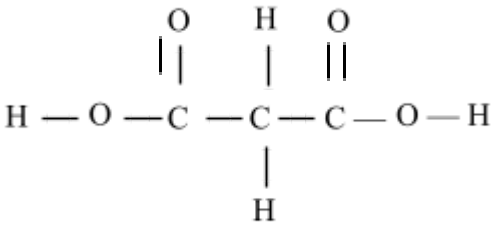
Question 30 (5 marks)

The two monomers shown below react to produce a useful polymer.



ethan-1,2diol



propanedioic acid

(a) Show using a diagram, how these monomers bond together to form a small segment of the polymer. **2**

(b) Describe the structure, properties and uses of this type of polymer. **3**

Question 31 (7 marks)

Alkanes, alkenes and alkynes vary in structure and reactivity.

(a) Use ethane, ethene and ethyne to illustrate how molecular shape is influenced by the type of bond present. **3**

(b) A hydrocarbon with empirical formula CH_2 has a molecular mass of 84.096 g. **4**

The hydrocarbon decolourises bromine water and reacts with hydrogen chloride to form two isomers.

Determine the name of the hydrocarbon using equations to support your answer.

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Question 32 (3 marks)

During the COVID-19 emergency, people were advised to wash hands with soap. Soap was found to be very effective at emulsifying the fatty coating surrounding the virus particles. **3**

Explain, using diagrams, how soap works.

Question 33 (6 marks)

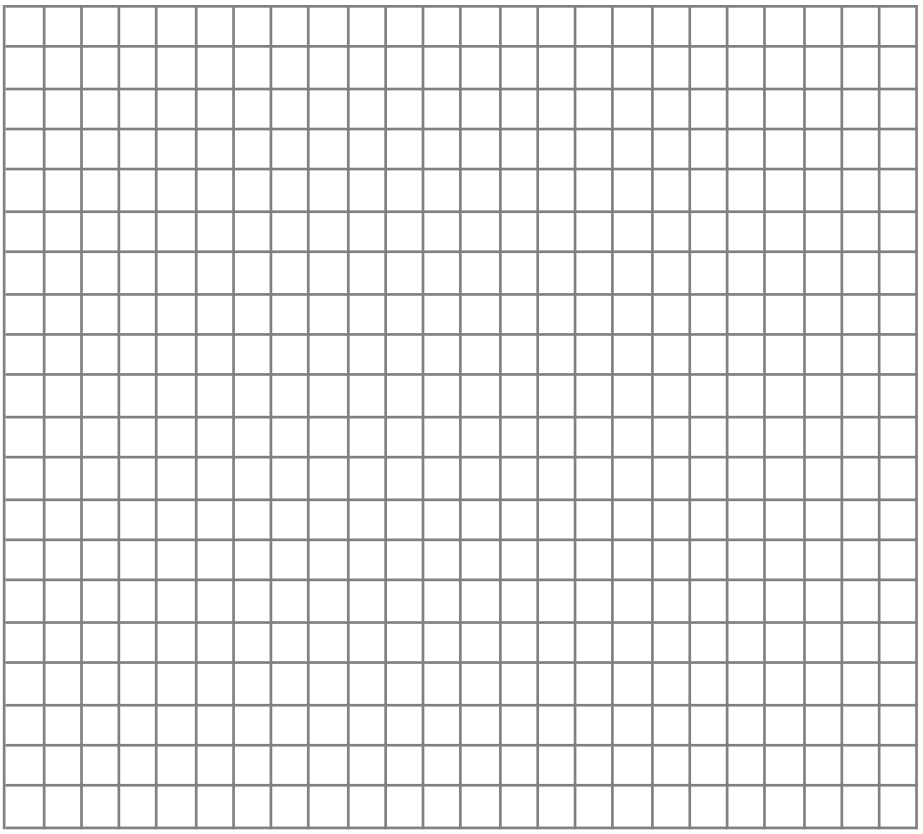
A water sample taken from a lagoon has been sent to an environmental chemist. Fish, crustaceans and other aquatic life were found dead in the lagoon.

The chemists observed that the water sample had a faint blue appearance. The chemists tested for the presence of Cu^{2+} which was found to be present. To determine the concentration, she decided to use colourimetry.

A series of standard solutions of copper sulfate are prepared then placed in 1 cm sample tubes. The percent transmittance was measured at 635 nm in a colourimeter. The results were then converted to absorbance as shown below.

Solution	Blank	Standard 1	Standard 2	Standard 3	Standard 4	Standard 5
Concentration mol L^{-1}	0.00	0.10	0.20	0.30	0.40	0.50
Absorbance	0.00	0.280	0.560	0.830	1.110	1.390

(a) Plot the data on the grid below. **3**



Question 33 continues on page 26

Question 33 (continued)

The lagoon water was then tested in the same way and its absorbance was 0.506.

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

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(c) A concentration of copper ions from 0.05 to 2.0 mg/L has been found to be toxic to various aquatic organisms. **2**

Is it possible that Cu^{2+} contamination is responsible for death of aquatic organisms in the lagoon? Support your answer with calculations.

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Question 34 (8 marks)

Examine the spectroscopy diagrams of an unknown organic molecule below and on page 28, then answer Question 34 on page 29.

Diagram A – Infrared spectrum

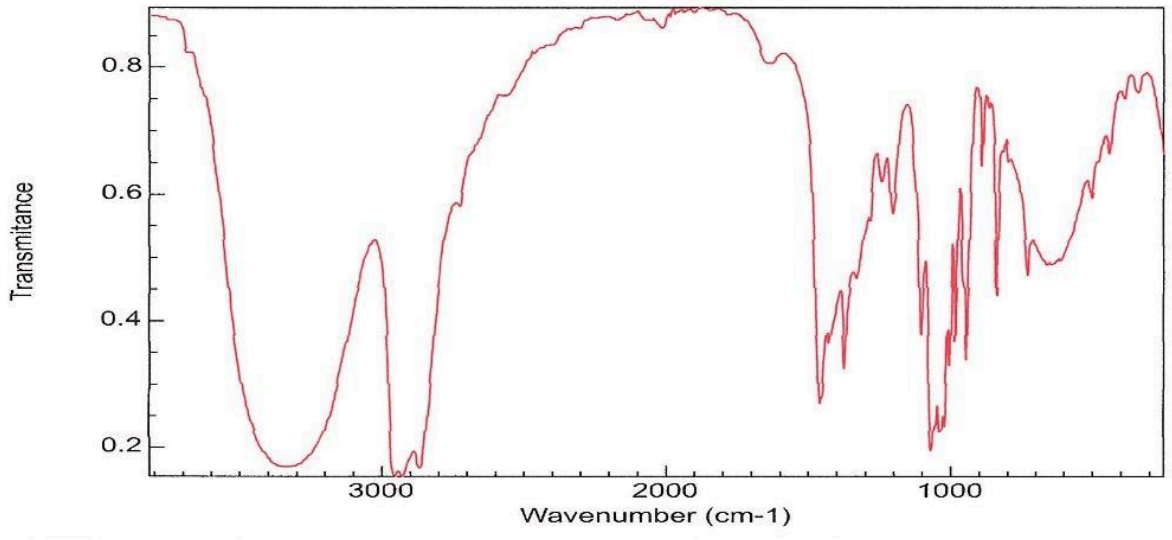
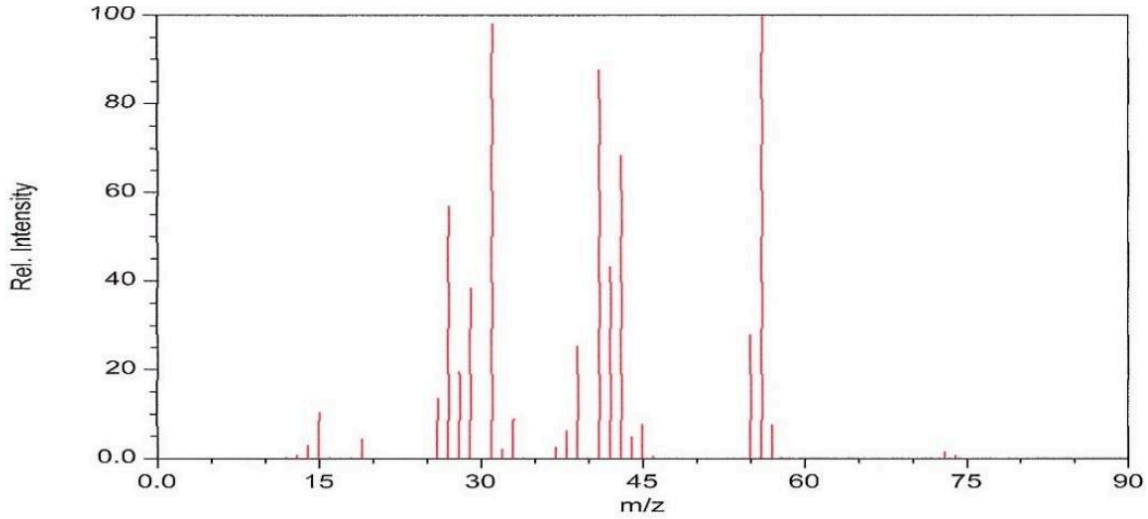


Diagram B – Mass spectrum



Question 34 continues on page 28

Question 34 (continued)

Diagram C – Proton NMR

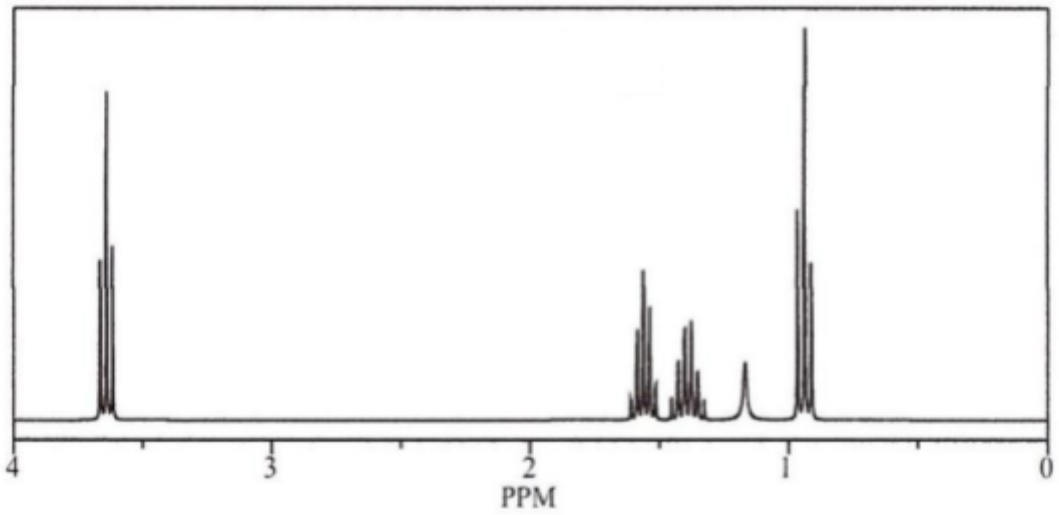
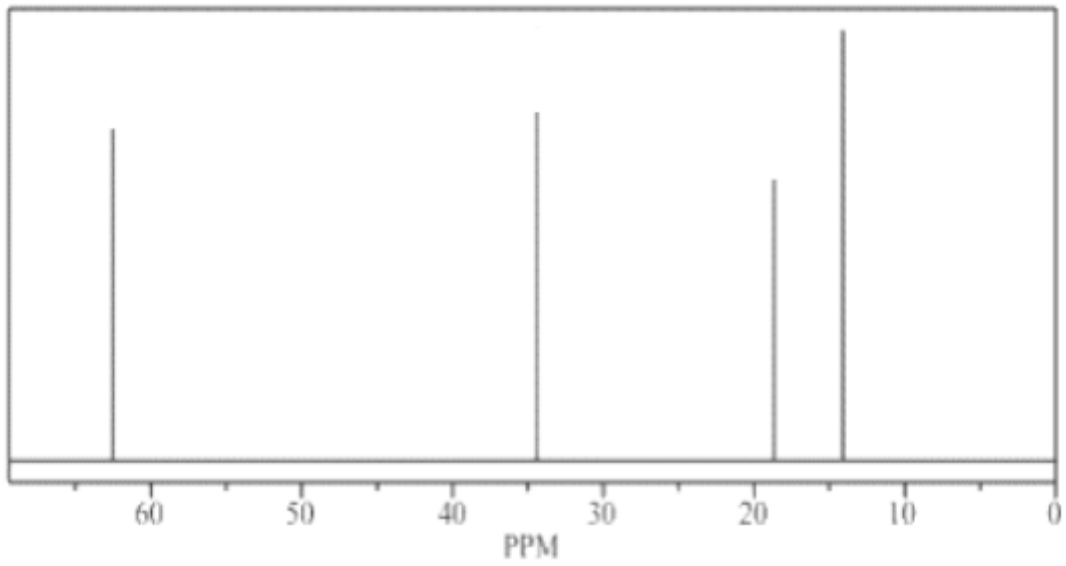


Diagram D – carbon-13 NMR



Question 34 continues on page 29

Question 34 (continued)

(a) Identify the THREE most significant characteristic functional groups for this organic molecule in the infrared spectrum. **3**

(b) Account for peaks at 74, 57, 43, and 31 in the mass spectrum to identify the number of carbons present and other main groups in the organic molecule. **2**

(c) Determine how many chemical environments there are for this organic compound using the carbon-13 NMR spectrum. **1**

(d) Identify the organic molecule which could produce the spectra shown and justify your choice. **2**

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.

2020 HSC TRIAL EXAMINATION

Chemistry

FORMULAE SHEET

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

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

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

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

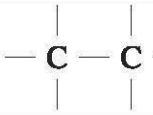
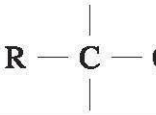
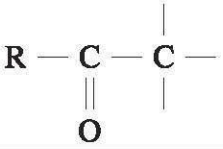
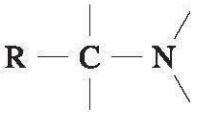
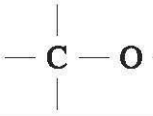
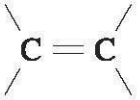
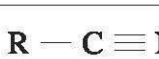
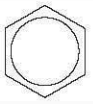
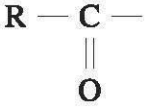
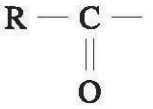
Compound	K_{sp}	*Compound*	K_{sp}
Barium carbonate	2.58×10^{-9}	Lead(II) bromide	6.60×10^{-6}
Barium hydroxide	2.55×10^{-4}	Lead(II) chloride	1.70×10^{-5}
Barium phosphate	1.3×10^{-29}	Lead(II) iodide	9.8×10^{-9}
Barium sulfate	1.08×10^{-10}	Lead(II) carbonate	7.40×10^{-14}
Calcium carbonate	3.36×10^{-9}	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
$\frac{1}{2}I_2(s) + e^-$	$\rightleftharpoons$	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: _____

2020 Chemistry HSC Trial Examination

Section I –Multiple Choice Answer Sheet

20 marks
Attempt Questions 1 –20
Allow about 30 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

2020 HSC Chemistry Marking Guidelines

Section I

Multiple-choice Answer Key

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

Section II

Question 21 (4 marks)

(a)

Criteria	Marks
● Correctly describes the reaction at equilibrium prior to time X	1

Sample answer:
The reaction is at dynamic equilibrium. Molecules of N_2O_4 decompose into NO_2 molecules at the same rate that NO_2 molecules collide to form N_2O_4.

(b)

Criteria	Marks
● Correctly predicts the action that occurred at time X based on the data shown graphically	1

Sample answer:
The concentration of only NO_2 has been increased by adding more NO_2 to the sealed flask.
(other possible changes such as volume, pressure or temperature alterations would have affected N_2O_4 simultaneously)

(c)

Criteria	Marks
● Explains how an equilibrium was disturbed and caused a new equilibrium to be established	2
● Provides some relevant information	1

Sample answer:
The addition of NO_2 at time X caused the concentration of NO_2 to increase. The higher concentration of NO_2 resulted in more successful collisions to form more N_2O_4. The concentration of NO_2 decreased at a decreasing rate and likewise the concentration of N_2O_4 increased at a decreasing rate until a new equilibrium position was established. This behaviour is consistent with Le Chatelier's Principle. A reaction will shift in a direction to oppose a change. This reaction shifted to the right to reduce the concentration of NO_2.

Question 22 (6 marks)

(a)

Criteria	Marks
● Calculates the enthalpy change correctly	1

Sample answer:
$\Delta H^{\emptyset} = (-393 + 0) - (-242 + -111) = -393 + 353$
$\Delta H^{\emptyset} = -40 \text{ kJ mol}^{-1}$

(b)

Criteria	Marks
● Calculates the entropy change correctly	1

Sample answer:

$\Delta S^{\emptyset}$ = (214 +131) – (198 + 189)

= -42 J K^{-1} mol^{-1}

(c)

Criteria	Marks
● Calculates ΔG correctly and states that the reaction is spontaneous at 600K with evidence	2
● Calculates ΔG correctly	1

Sample answer:

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

=–40 000 – (600 x –0.042)

= –14.8 kJ mol^{-1}

Yes, the reaction is spontaneous at 600 K as $\Delta G < 0$

(d)

Criteria	Marks
● Correctly calculates the minimum temperature for reaction to reach equilibrium ● States a criterion for the reaction to be spontaneous	2
● Correctly calculates the minimum temperature for reaction to reach equilibrium OR ● States a criterion for the reaction to be spontaneous	1

Sample answer:

When $\Delta G = 0$

$T = \Delta H / \Delta S$

T = –40 / – 0.042

= 952.38 K

The reaction will be spontaneous when the reaction temperature is above 953 K or when Gibbs Free energy change is negative.

Question 23 (6 marks)

(a)

Criteria	Marks
● Identifies a suitable indicator for titration of HCl and Na_2CO_3 ● Gives a logical reason for selection of indicator	2
● Identifies a suitable indicator for titration of HCl and Na_2CO_3	1

Sample answer:
Methyl orange is a suitable indicator in a titration between a strong acid and a weak base as the equivalence point is below 7 in this case approximately 6.5.

b)

Criteria	Marks
● Provides volume of sodium carbonate at equivalence point from graph	1

Sample answer:
Equivalence points is 11.5 mL (at mid-point of inflexion)

c)

Criteria	Marks
● Provides balanced equation ● Identifies molar ratio of acid to base as 2:1 and calculates number of moles of base reacted ● Calculates concentration of hydrochloric acid	3
● Provides balanced equation ● Identifies molar ratio of acid to base as 2:1 and calculates number of moles of base reacted	2
● Provides some relevant information	1

Sample answer:
$Na_2CO_{3(aq)} + 2HCl_{(aq)} \rightarrow 2NaCl_{(aq)} + H_2O_{(l)} + CO_{2(g)}$

Since Na_2CO_3 reacts with HCl in a 1: 2 molar ratio
number of moles of Na_2CO_3 required = 2 x 0.095 x 0.0115 = 0.002185
Concentration of HCl = 0.002185 / 0.02 = 0.11 $molL^{-1}$

Question 24 (7 marks)

(a)

Criteria	Marks
● Describes the behaviour of the acetate ion	2
● Provides some relevant information	1

Sample answer:

The acetate ion acts as a base as it accepts a proton from water to form its conjugate acid-acetic acid. The water is hydrolysed to produce hydroxide ions.

(b)

Criteria	Marks
● Uses $K_w = K_a.K_b$ to calculate the equilibrium constant for the acetate ion	2
● Provides some relevant information	1

Sample answer:

$K_w = 1 \times 10^{-14}$

$K_b = K_w / K_a$

$K_b = 1 \times 10^{-14} / 1.75 \times 10^{-5}$

$K_b = 5.71 \times 10^{-10}$

(c)

Criteria	Marks
● Writes correct equilibrium expression ● Calculates concentration of solution correctly ● States concentration of hydroxide ions correctly with unit	3
● Writes correct equilibrium expression ● Calculates concentration of solution correctly	2
● Provides some relevant information	1

Sample answer:

$K_b = \dfrac{[CH_3COOH]\,[OH^-]}{[CH_3COO^-]} = 5.71 \times 10^{-10}$

let $x = [OH^-]$ then $[CH_3COOH] = x$ and $[CH_3COO^-] = 0.50 - x$

assume x is very small compared with 0.50 so (0.50 – x) is insignificant, then

$5.71 \times 10^{-10} = \dfrac{x^2}{0.50}$

$x = 1.68967 \times 10^{-5}$

$x = 1.7 \times 10^{-5}$ molL^{-1}

Question 25 (4 marks)

Criteria	Marks
● Explains in detail similarities and differences between Arrhenius definition of acids and bases and Brønsted- Lowry ● Supports answer with clear, well-chosen examples	4
● Explains similarities and differences between Arrhenius definition of acids and bases and Brønsted- Lowry ● Supports answer with examples	3
● Explains at least one similarity and one difference between Arrhenius definition of acids and bases and Brønsted- Lowry	2
● Gives either a similarities OR differences between Arrhenius definition of acids and bases and Brønsted- Lowry	1

Suggested answer

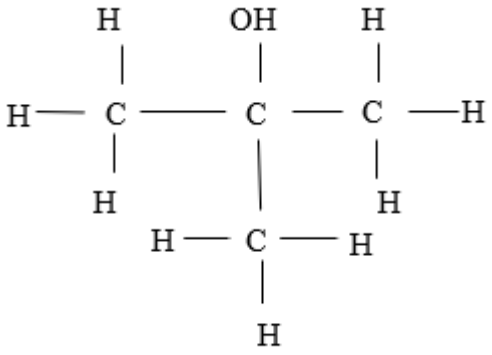
Svante Arrhenius theorised that acids were compounds that produced hydrogen ions in water. Strong acids ionised completely while weak acids only ionised slightly. He said bases were substances which produced hydroxide ions in solution. This definition failed to take into account the basic nature of metal oxides and ammonia. The concept of acid was further developed by two chemists, Johannes Brønsted and Thomas Lowry, who said that acids are chemical species that transferred a proton to another species. This included the same acid compounds as the Arrhenius definition. The Brønsted- Lowry definition of bases as species which accept protons included the basic compounds excluded by the Arrhenius definition

Question 26 (6 marks)

(a)

Criteria	Marks
● Draws correct structural diagram for tertiary alcohol	1

Sample answer:



(b)

Criteria	Marks
● Names two intramolecular forces present in alcohols	1

Sample answer:
Hydrogen bonds and dispersion forces are present

(c)

Criteria	Marks
● Describes the structure of alcohols which results in the intermolecular forces responsible for boiling point and solubility ● Compares similar M.W. isomers and explains variations in boiling points and solubilities ● Explains the link between molecular weight to changing influence of hydrogen bonds and dispersion forces ● States the trends shown with increasing molecular weight	4
● Describes the structure of alcohols which results in the intermolecular forces responsible for boiling point and solubility ● Explains the link between molecular weight to changing influence of hydrogen bonds and dispersion forces ● States the trends shown with increasing molecular weight	3
● Describes the structure of alcohols which results in the intermolecular forces responsible for boiling point and solubility ● States the trends shown with increasing molecular weight	2
● Provides some relevant information	1

Sample answer:
The structure of an alcohol consists of a hydroxyl functional group and a hydrocarbon chain. In general, as the molecular weight increases the boiling point increases and the solubility decreases. The larger the alcohol molecules, the greater the attraction between them due to the intermolecular forces present, therefore more heat energy is required to evaporate the liquid alcohol.

In alcohols, both dispersion forces and hydrogen bonding existing between molecules. In small short chain alcohols, the strong hydrogen bonds between hydrogen atoms and oxygen atoms on alcohol and water molecules are responsible for the good solubility. The hydrocarbon chain part of the alcohol produces weak dispersion forces between molecules. As the chain length (and molecular weight increases), the influence of the hydroxyl group deceases and the weak dispersion forces between the hydrocarbon chains are responsible for the reduced solubility.

When comparing alcohol isomers of similar molecular weight, other factors such as molecule shape, control how closely molecules can pack together. This impacts on the strength of the various intermolecular forces at work and the physical properties observed.

Question 27 (4 marks)

Criteria	Marks
● Identifies the solution H_2CO_3/HCO_3^- as a buffer ● Explains in detail how the addition of a small amount of acid or base can shift the equilibrium of the system to absorb the changes and maintain the pH ● Uses equation to illustrate equilibrium shifts	4
● Identifies the solution H_2CO_3/HCO_3^- as a buffer ● Explains how the addition of a small amount of acid or base can shift the equilibrium of the system to absorb the changes and maintain the pH	3
● Identifies the solution H_2CO_3/HCO_3^- as a buffer ● States that the addition of a small amount of acid or base increases the number of H^+ or OH^-	2
● Identifies the solution H_2CO_3/HCO_3^- as a buffer	1

Sample answer:

An equimolar solution of H_2CO_3/HCO_3^- is a buffer. This is a solution consisting of a weak acid and its conjugate base.

If a small amount of acid such as HCl is added to this buffer then the equilibrium will shift to the left as the increase in hydrogen ions will cause the reaction to shift in such a way as to counteract the change. The additional H^+ will react with the $HCO_3^-{}_{(aq)}$ to form $H_2CO_{3(aq)}$ and the pH will remain constant.

$$H_2CO_{3(aq)} + H_2O_{(l)} \leftarrow HCO_3^-{}_{(aq)} + H_3O^+_{(aq)}$$

If a small amount of base such as NaOH is added to this buffer then the equilibrium will shift to the right as the increase in hydroxide will cause the reaction to shift in such a way as to counteract the change. The additional OH^- will react with the H_3O^+ to form water and the H_2CO_3 will produce more $HCO_3^-{}_{(aq)}$ and the pH will remain constant.

$$H_2CO_{3(aq)} + H_2O_{(l)} \rightarrow HCO_3^-{}_{(aq)} + H_3O^+_{(aq)}$$

Question 28 (7 marks)

(a)

Criteria	Marks
● Correctly names the compounds A-D and provides a justification for each compound	5
● Correctly names most of the compounds A-D with relevant justifications	4
● Correctly names some of the compounds A-D with relevant justifications	3
● Identifies some of the compounds	2
● Provides some relevant information	1

Sample answer:

The hydration of propene produces two isomers of propanol. Primary alcohols are oxidised to alkanoic acids and secondary alcohols are oxidised to alkanones when a strong oxidising agent is used. Both isomers reduce the violet permanganate ion to colourless manganese ions. Since compound D turns blue litmus red it must be propanoic acid and isomer B is propan-1-ol, the primary alcohol. Since compound C does not affect litmus paper it must be propanone and isomer A is propan-2-ol, the secondary alcohol.

(b)

Criteria	Marks
● Provides oxidation and reduction half equations ● Provides balanced overall equation	2
● Provides oxidation and reduction half equations	1

Sample answer:

$MnO_4^-{}_{(aq)} + 8H^+_{(aq)} + 5e^- \rightarrow Mn^{2+}_{(aq)} + 4H_2O_{(l)}$

$C_3H_8O_{(aq)} \rightarrow C_3H_6O_{(aq)} + 2H^+ + 2e^-$

$(MnO_4^-{}_{(aq)} + 8H^+_{(aq)} + 5e^- \rightarrow Mn^{2+}_{(aq)} + 4H_2O_{(l)})$ x2

$(C_3H_8O_{(aq)} \rightarrow C_3H_8O_{(aq)} + 2H^+ + 2e^-)$ x5

$5\ C_3H_8O_{(aq)} + 2\ MnO_4^-{}_{(aq)} + 6H^+_{(aq)} \rightarrow 5C_3H_6O_{(aq)} + 2\ Mn^{2+}_{(aq)} + 8H_2O_{(l)}$

Question 29 (7 marks)

(a)

Criteria	Marks
● Analyses the observations to determine the relevant range of values ● Calculates the K_{sp} range using relevant values ● Estimates the solubility of $AgBrO_3$ at equilibrium using a suitable K_{sp}	7
● Analyses the observations to determine the relevant range of values ● Calculates the K_{sp} range using relevant values ● Mostly estimates the solubility of $AgBrO_3$ at equilibrium using a value of K_{sp}	6
● Analyses the observations to determine the relevant range of values ● Calculates a value for K_{sp} ● Attempts to estimates the solubility of $AgBrO_3$ at equilibrium using a value of K_{sp}	4-5
● Analyses the observations to determine the relevant range of values ● Attempts to calculates a value for K_{sp}	2-3
● Provides some relevant information	1

Sample answer:

From the observations the limits of solubility occur between test 5 and 6, using these values to calculate K_{sp} gives a range-

Upper range

$K_{sp} = [Ag^+]x\ [BrO_3^-]$

$= 0.00125 \times 0.05$

$= 6.25 \times 10^{-5}$

lower range

$K_{sp} = [Ag^+]x\ [BrO_3^-]$

$= 0.0005 \times 0.05$

$= 2.5 \times 10^{-5}$

Using a mid-value of 4.5×10^{-5} for the K_{sp} of $AgBrO_3$
then at equilibrium let the number of moles of $Ag^+ = X$ then the number of moles of BrO_3^- also = X so $K_{sp} = 4.5 \times 10^{-5} = X^2$ then $X = \sqrt{4.5 \times 10^{-5}} = 6.7 \times 10^{-3}$
therefore, the solubility of $AgBrO_3$ at equilibrium is estimated to be 6.7×10^{-3} mol L^{-1}

Question 30 (5 marks)

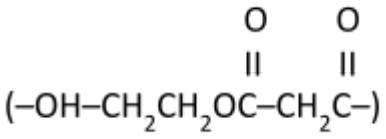
(a)

Criteria	Marks
● Draws a segment of polymer showing the bond between the monomers	2
● Draws a segment of polymer showing the bond between the monomers with minor omission	1

Sample answers:

$(–OHCH_2CH_2–OCOCH_2COOH–)$

OR



(b)

Criteria	Marks
● Describes structure, properties and uses of polyester, a condensation polymer	3
● Describes some features of polyester, a condensation polymer	2
● Provides some relevant information	1

Sample answer:

This polymer is a polyester formed by an ester bond between diol and dioic acid monomers. As a water molecule is produced by each ester bond it is also a condensation polymer. Polyesters are used to make fibres which are strong and elastic. This is why they are woven into fabrics by the textiles industry. Polyester fabrics have low water absorption and do not readily shrink when washed so are using to manufacture clothing.

Question 31 (7 marks)

(a)

Criteria	Marks
● Detailed description of bonding in hydrocarbons and molecular shape	3
● Some information linking bonding to shape in hydrocarbons	2
● Provides some relevant information	1

Sample answer:

Ethane C_2H_6 has single bonds between all atoms. All bonds angles are tetrahedral ($109^{)}$). The C-C form due to the interactions between sp^3 orbitals from each carbon atom.

Ethene C_2H_4 has a double bond between the carbon atoms with bond angles close to 120^0 due to interactions between sp^2 molecular orbitals arranged in a trigonal-planar shape.

Ethyne C_2H_2 has a triple bond between the carbon atoms arranged in a linear shape at 180^0 due to two sp molecular orbitals.

(b)

Criteria	Marks
● Deduces molecular formula ● Provides two correct equations to support answer ● Provides structural formulae or names of isomers and original hydrocarbon	4
● Deduces molecular formula ● Provides a correct equation to support answer ● Provides a structural formulae or name of an isomers and original hydrocarbon	3
● Deduces molecular formula ● Provides a correct equation to support answer	2
● Provides some relevant information	1

Sample answer:

Since the mass of CH_2 is 14.016g The molecular formula must be 84.096/ 14.016 = 6
6 x CH_2 = C_6H_{12}
The hydrocarbon decolourises bromine water so it must be saturated. The molecular formula suggests a double bond is present (not a cyclic alkane)

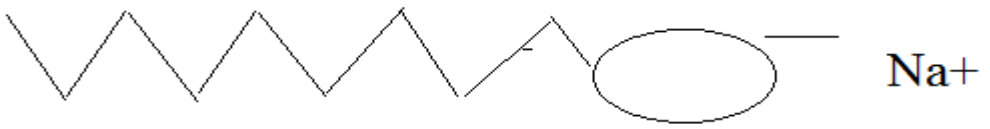
$C_6H_{12(l)} + Br_{2(aq)} \rightarrow C_6H_{12}Br_{2\ (l)}$ (dibromohexane)

When the hexene reacts with a hydrohalide HCl two isomers are produced so the hexene is not symmetrical. **It could therefore be hex-1ene or hex-2-ene**
$C_6H_{12(l)} + HCl_{(aq)} \rightarrow C_6H_{13}Cl_{(l)}$
Hex-1-ene would produce 1- chorohexane and 2-chlorohexane

Question 32 (3 marks)

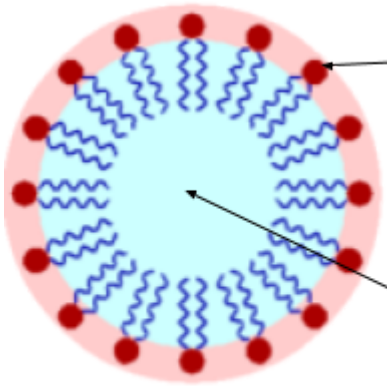
Criteria	Marks
• Draws at least two relevant diagrams • Indicates on the diagram the polar and non-polar ends and relates to solubility • Explains role of micelle	3
• Draws at least one relevant diagram • Indicates the polar and non-polar ends and relates to solubility OR • Explains role of micelle	2
• Draws a diagram that indicates some of the features of soap used to clean hands	1

Sample answer:



The tail is non polar and hydrophobic

Short ionic part is hydrophilic



http://en.wikipedia.org/wiki/File:Micelle.png#/media/File:Micelle.png

COO^- head hydrogen bonds with water

MICELLE
Micelle forms a water-soluble sheath around the fat/oil. When the surface is agitated it breaks away in the micelle, to form an emulsion with water.

Fat/oil dissolves in hydrophobic part of the micelle.

Soap molecules consist of a long hydrocarbon chain called the tail and a carboxylate end group called the head. The head is negatively charged due to the (COO^-) producing an anion which bonds with Na^+

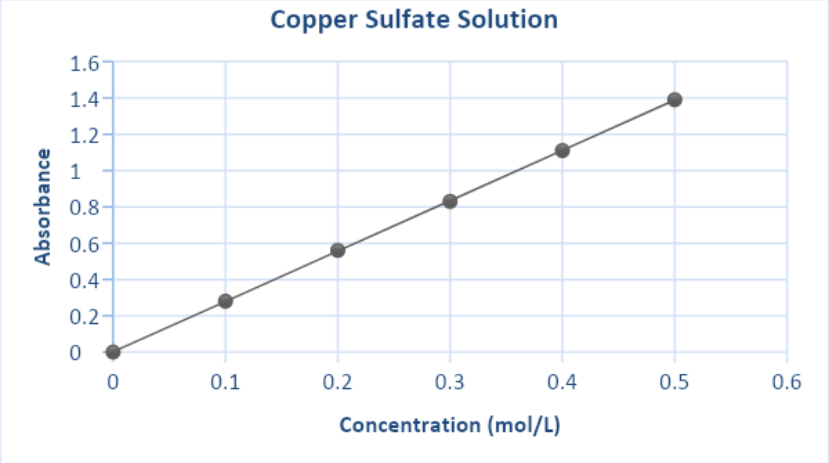
Soap is an effective handwash as it readily emulsified fats and oils by forming micelles. These allow the fats/oils to be washed away from the skin in running water.

Question 33 (6 marks)

(a)

Criteria	Marks
• Plots absorbance (vertical axis) against concentration (horizontal axis) accurately • Labels both axes including relevant units • Places even scale on each axis • Gives graph a title	3
• Provides a substantially correct graph	2
• Provides some basic features of the graph	1

Sample answer:



(b)

Criteria	Marks
• Correctly estimates the concentration of the unknown from graph	1

Sample answer:

Concentration of copper sulfate is 0.18 mol L^{-1}

(c)

Criteria	Marks
• Concentration of Cu^{2+} in lagoon compared to guidelines based on the same units	2
• Provides some calculations made to compare figures	1

Sample answer:

For every mole of $CuSO_4$ there is 1 mole of Cu^{2+} ions therefore if $[CuSO_4]$ = 0.18 $molL^{-1}$ then $[Cu^{2+}]$ = 0.18 $molL^{-1}$

mass of Cu^{2+} in one litre = 0.18 x 63.55 = 11.439 g

(The upper limit for copper toxicity was 2 mg/L)

The copper contamination is approximately 5 x 10^3 times greater than the safe limit, so it is possible that copper contamination is responsible for the death of aquatic species in the lagoon. Further testing could look for other contaminants being present in addition to the copper sulfate.

Question 34 (8 marks)

(a)

Criteria	Marks
● Provides three most relevant wavelength and characteristic stretches for O-H, C-H, and C-O	3
● Outlines relevant wavelength and characteristic stretches for O-H, C-H, and C-O	2
● Provides some relevant information	1

Sample answer:

1. The wavelength stretch of the bonds are at about 3500 which indicates an O-H bond.
2. There is another stretch at 3000 which is typical for a C-H bond.
3. The broad appearance of the spectra indicated an O-H of an alcohol group rather than from an acid O-H which is very broad and at a lower wavelength.

(The other important peaks are at about 1100 (C-O) and at about 800 indicating C-C bond.)

(b)

Criteria	Marks
● Identifies all the named peaks on the mass spectrograph to analyse organic substances	2
● Provides some relevant information	1

Sample answer:

The peak at 74 is the parent molecule, 57 will be $CH_3CH_2CH_2CH_2$- from the Infrared Spectra. The hydrocarbon has an -OH group (74 -16-1). The peak at 43 will be $CH_3CH_2CH_2$- The peak at 31 will be $HOCH_2$-.

(c)

Criteria	Marks
● Identifies four chemical environments	1

Sample answer:

There are four chemical environments, one for each carbon.

(d)

Criteria	Marks
● Identifies butanol and provides a valid reason	2
● Identifies butanol	1

Sample answer:

The compound is butanol (1-butanol). This because of the broad OH group in the infrared spectrum and the peak at 74 in the mass spectrum.

2020 HSC Chemistry Mapping Grid

Section I

Question	Marks	Module	Content	Syllabus outcomes
1	1	5	Static and Dynamic Equilibrium	CH12-12, CH11-11
2	1	5	Solution Equilibria	CH12-12, CH-4
3	1	5	Solution Equilibria	CH12-12
4	1	5	Calculating the Equilibrium constant (K_{eq})	CH12-12, CH-4
5	1	5	Factors that Affect Equilibrium	CH12-12, CH-6
6	1	5	Solution Equilibria	CH12-12, CH12-6
7	1	6	Quantitative Analysis	CH12-13, CH-5
8	1	6	Quantitative Analysis	CH12-13
9	1	6	Quantitative Analysis	CH12-13, CH-6
10	1	6	Properties of Acids and Bases	CH12-13
11	1	6	Using Brønsted-Lowry Theory	CH12-13, CH-6
12	1	6	Using Brønsted-Lowry Theory	CH12-13, CH-6
13	1	7	Reactions of Organic Acids and Bases	CH12-13
14	1	7	Nomenclature	CH12-14
15	1	7	Reactions of Organic Acids and Bases	CH12-14
16	1	7	Alcohols	CH12-14
17	1	8	Analysis of Inorganic Substances	CH12-15
18	1	8	Analysis of Inorganic Substances	CH12-15
19	1	8	Analysis of Organic Substances	12CH-15, 12CH-5
20	1	8	Analysis of Organic Substances	12CH-15, 12CH-5

Section II

Question	Marks	Module	Content	Syllabus outcomes
21 (a)	1	5	Static and Dynamic Equilibrium	CH12-12
21 (b)	1	5	Static and Dynamic Equilibrium	CH12-12
21 (c)	2	5	Factors that Affect Equilibrium	CH12-12, CH12-5
22 (a)	1	5	Static and Dynamic Equilibrium	CH12-12
22 (b)	1	5	Static and Dynamic Equilibrium	CH12-2
22 (c)	2	5	Factors that Affect Equilibrium	CH12-12
22 (d)	2	5	Calculating the Equilibrium constant (K_{eq})	CH12-12, 12CH-6
23 (a)	2	6	Quantitative Analysis	CH12-12, CH12-6
23 (b)	1	6	Quantitative Analysis	CH12-12, CH12-6
23 (c)	3	6	Quantitative Analysis	CH12-13
24 (a)	2	6	Using Brønsted-Lowry Theory	CH12-13
24 (b)	2	6	Quantitative Analysis	CH12-13, CH12-6
24 (c)	3	6	Using Brønsted-Lowry Theory	CH12-13, CH-12-6

Question	Marks	Module	Content	Syllabus outcomes
25	4	6	Properties of Acids and Bases	CH12-13, CH12-6
26 (a)	1	7	Alcohols	CH12-13
26 (b)	1	7	Alcohols	CH12-13
26 (c)	4	7	Alcohols	CH12-13, CH12-6
27	4	6	Quantitative Analysis	CH12-2
28 (a)	5	7	Alcohols	CH12-14, CH12-6
28 (b)	2	7	Alcohols	CH12-14, CH12-7
29	7	7	Solution Equilibria	CH12-14
30 (a)	2	7	Polymers	CH12-14
30 (b)	3	7	Polymers	CH12-14
31 (a)	3	7	Hydrocarbons	CH12-14, CH12-7
31 (b)	4	7	Hydrocarbons	CH12-5
32	3	7	Reactions of Organic Acids and Bases	CH12-14
33 (a)	3	8	Analysis of Inorganic Substances	CH12-14
33 (b)	1	8	Analysis of Inorganic Substances	CH12-14
33 (c)	2	8	Analysis of Inorganic Substances	12CH-15, 12CH-4
34 (a)	3	8	Analysis of Organic Substances	12CH-15, 12CH-5
34 (b)	2	8	Analysis of Organic Substances	12CH-15, 12CH-5
34 (c)	1	8	Analysis of Organic Substances	12CH-15, 12CH-5
34 (d)	2	8	Analysis of Organic Substances	12CH-15, 12CH-5