2019

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 2-8)

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

Section II — 80 marks (pages 9-27)

- Attempt Questions 21– 39
- Allow about 2 hour 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 equation would represent the greatest decrease in entropy?

A. $2O_{3(g)} \rightarrow 3O_{2(g)}$

B. $C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$

C. $2H_2O_{2(s)} \rightarrow 2H_2O_{(l)} + O_{2(g)}$

D. $HCl_{(g)} + NH_{3(g)} \rightarrow NH_4Cl_{(s)}$

2 Consider the two reactions at equilibrium shown below:

$$2NO_{2(g)} \rightleftharpoons N_2O_{4(g)} \quad \Delta H = -60 \text{ kJ mol}^{-1}$$

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)} \quad \Delta H = -92 \text{ kJ mol}^{-1}$$

Which action will drive BOTH reactions to form more product?

A. Reducing the overall pressure

B. Increasing the reaction temperature

C. Increasing the volume of the reaction vessel

D. Removing the product from the reaction vessel

3 Under what reaction conditions will the value of an equilibrium constant (K_{eq}) be changed?

A. Addition of a catalyst

B. Increased temperature

C. Increased concentration of reactants

D. Increased concentration of reactants and products

4 Which alternative most correctly represents the equilibrium expression for the following reaction?

$$Fe_2O_{3\,(s)} + 3CO_{(g)} \rightleftharpoons 2Fe_{(s)} + 3CO_{2(g)}$$

A. $\frac{[CO_2]^3}{[CO]^3}$

B. $\frac{[CO_2]^3}{[Fe_2O_3]\,[CO]^3}$

C. $\frac{[Fe_2O_3]\,[CO]^3}{[Fe]^2\,[CO]^3}$

D. $\frac{[Fe]^2\,[CO_2]^3}{[Fe_2O_3]\,[CO]^3}$

5 Which of the following reactions at equilibrium is closest to completion?

A. $2O_{3(g)} \rightleftharpoons 3O_{2(g)}$ $K_{eq} = 2.0 \times 10^{57}$

B. $2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$ $K_{eq} = 4.3$

C. $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$ $K_{eq} = 9.0$

D. $NH_{3(aq)} + H_2O_{(l)} \rightleftharpoons NH_4^+{}_{(aq)} + OH^-{}_{(aq)}$ $K_{eq} = 1.8 \times 10^{-5}$

6 What is the concentration of silver ions in a saturated solution of silver iodide?

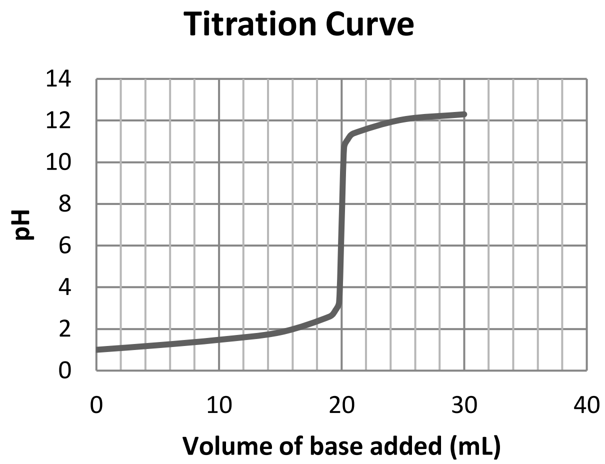
A. 4.26×10^{-9} mol L^{-1}

B. 9.23×10^{-9} mol L^{-1}

C. 8.52×10^{-17} mol L^{-1}

D. 9.23×10^{-18} mol L^{-1}

Use the following information for Questions 7 and 8.



7 Which statement about this titration is correct?

A. The acid was placed in the burette and the equivalence point was at pH 7.

B. The base was placed in the burette and the equivalence point was at pH 12.

C. The acid was placed in the conical flask and the equivalence point was at pH 7.

D. The acid was placed in the conical flask and the equivalence point was at pH 12.

8 Which pair of solutions would be most likely to produce this titration curve?

A. Acetic acid and ammonia solution

B. Citric acid and sodium hydroxide

C. Sulfuric acid and ammonia solution

D. Hydrochloric acid and sodium hydroxide

9 What is the concentration of H_3O^+ in a solution with a pH of 2.38?

A. 0.38 mol L^{-1}

B. 11.62 mol L^{-1}

C. 4.17×10^{-3} mol L^{-1}

D. 2.40×10^{-12} mol L^{-1}

10 Which alternative contains only amphiprotic substances?

A. SiO_2, SO_2, SnO

B. H_2CO_3, HCO_3^-, CO_3^{2-}

C. HS^-, H_3PO_4, HPO_4^{2-}

D. HCO_3^-, HSO_4^-, H_2O

11 25.00 mL of 0.02 M potassium hydroxide solution in a conical flask is neutralized by the gradual addition of 33.20 mL of nitric acid.

What is the concentration of the nitric acid?

A. 0.015 mol L^{-1}

B. 0.0265 mol L^{-1}

C. 5×10^{-4} mol L^{-1}

D. 1.66×10^{-5} mol L^{-1}

12 When a student added 25 mL of 0.10 mol L^{-1} NaOH to 25 mL of 0.10 mol L^{-1} HNO_3 the temperature increased by 0.66°C.

What is the enthalpy of neutralisation for this reaction?

A. -55.2 kJ mol^{-1}

B. -0.137 kJ mol^{-1}

C. 27.59 kJ mol^{-1}

D. 55.2 kJ mol^{-1}

13 Which equation represents esterification?

A. $C_6H_{12}O_{6(aq)} \rightarrow 2C_2H_5OH_{(aq)} + 2CO_{2(g)}$

B. $C_6H_{12}O_{6(aq)} + C_6H_{12}O_{6(aq)} \rightarrow C_{12}H_{22}O_{11(aq)} + H_2O_{(l)}$

C. $CH_3COOH_{(l)} + KOH_{(aq)} \rightarrow CH_3COONa_{(aq)} + H_2O_{(l)}$

D. $CH_3COOH_{(l)} + C_2H_5OH_{(l)} \rightarrow CH_3COO\ C_2H_{5(l)} + H_2O_{(l)}$

14 Which condensed formula represents a chain isomer for $C_4H_8F_2$?

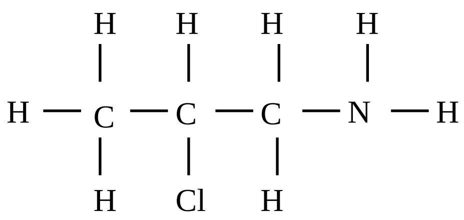
A. $(CH_3)_2CHFCHF$

B. $CH_3CHFCHFCH_3$

C. $CH_3CH_2CHFCHF$

D. $CH_2F\,CHCHFCH_3$

15 Consider the following structure.



What is the IUPAC name for this molecule?

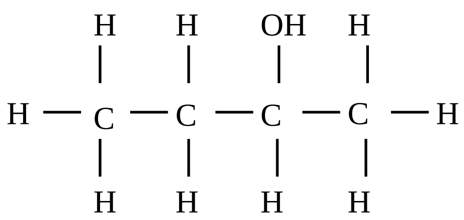
A. 2-chloropropanamide

B. 2-chloropropan-1-amine

C. 2-chloropropan-3-amine

D. 3-amino-2-chloropropane

16 Acidified potassium permanganate solution is a powerful oxidising agent. It is added to a substance with the following structural formula;



What is the name of the organic product of this reaction?

A. Butanol

B. Butanal

C. Butanone

D. Butanoic acid

17 Which anion will produce a precipitate when added to a barium nitrate solution?

A. Cl^-

B. Ag^+

C. Cu^{2+}

D. SO_4^{2-}

18 A colourless organic liquid compound is tested for the presence of functional groups. 2 mLs of the liquid are poured into three separate tests tubes. A reagent is added to each test tube then shaken.

Test	*Reagent added*	*Observation made after shaking*
1	2 drops of Bromine water	Yellowish-brown coloured solution
2	3 drops of acidified potassium dichromate	Yellowish-orange coloured solution
3	1 gram of sodium hydrogen carbonate	Colourless solution, small bubbles of colourless gas

What functional group(s) may be present in this compound?

A. Double bonds

B. Carboxylic acid

C. Double bonds and hydroxyl group

D. Hydroxyl group bonded to a secondary carbon

19 A student analysed the sodium chloride present in a 40.0 g sample of noodle soup. The chloride ion was precipitated by adding an excess of silver nitrate solution. The silver chloride was extracted, washed and dried. The mass of silver chloride was 0.752 g.

What percentage of sodium chloride was present in the soup?

A. 0.217%

B. 0.465%

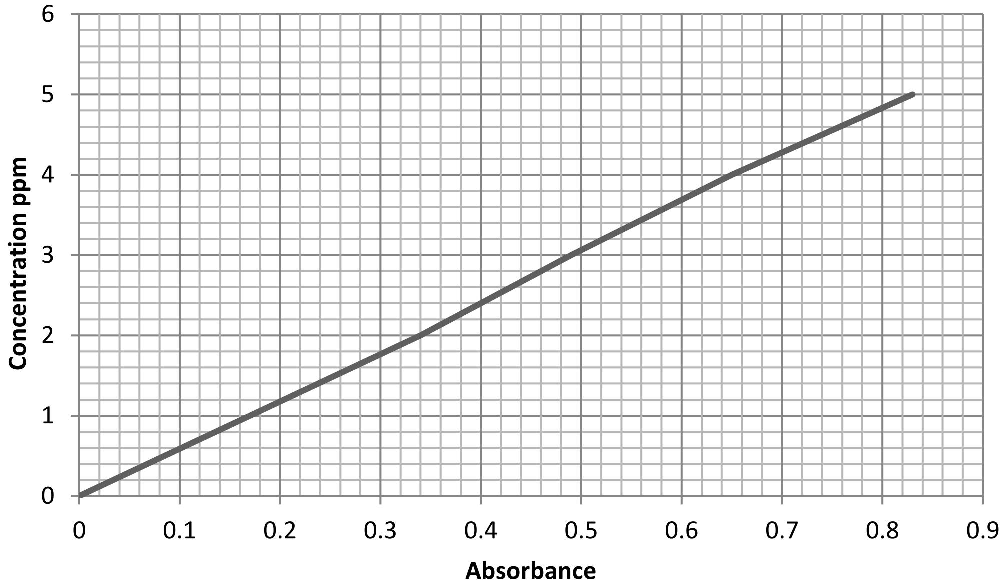
C. 0.767%

D. 1.89%

20 Soil from a playground was collected and a sample prepared for analysis using atomic absorption spectroscopy (AAS).

Five standard solutions of were also prepared. The sample and the standard solutions were tested, and the absorbance recorded. The calibration curve is shown below.

Concentration of Lead in Solution



The soil sample had an absorbance of 0.56.

What is the concentration of lead in the sample?

A. 0.0032 gL^{-1}

B. 3.4 mg L^{-1}

C. 3.4 x 10^{-2} gL^{-1}

D. 0.9 ppm

Student ID: ______________________________

2019 | **HIGHER SCHOOL CERTIFICATE TRIAL EXAMINATION**

Chemistry

Section II
Answer Booklet

80 marks
Attempt Questions 21–39
Allow about 2 hours and 25 minutes for this section

Instructions

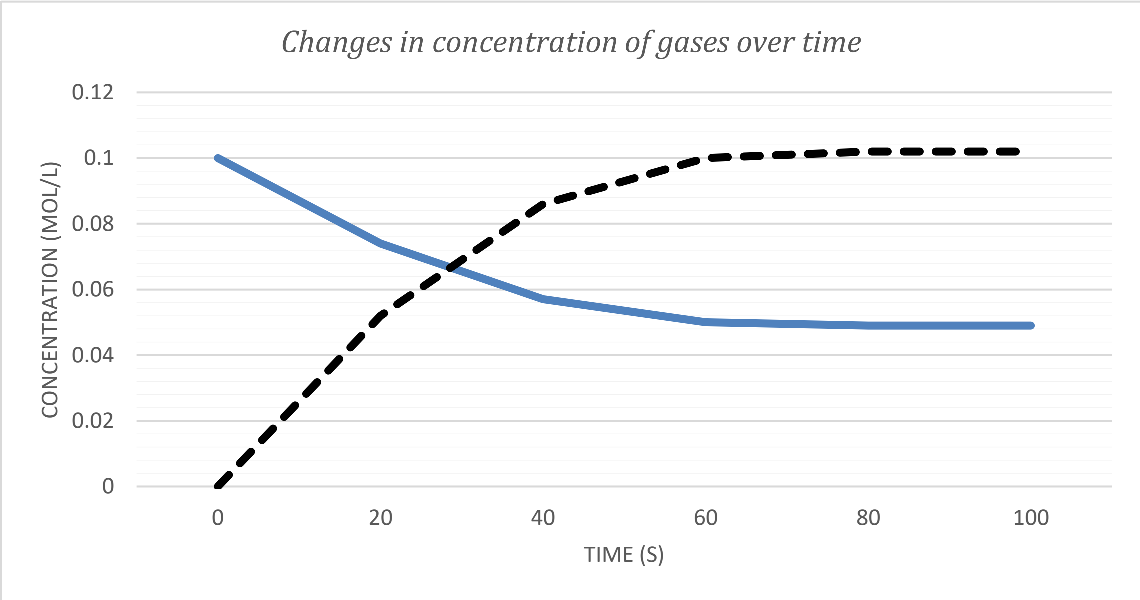
- Write your Student ID above
- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
- Show all relevant working in question involving calculations
- Extra writing space is provided at the back of this booklet. If you use this space, clearly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

Please turn over

Question 21 (4 marks)

A sealed glass flask originally contained colourless dinitrogen tetroxide gas with a concentration of 0.100 mol L^{-1} at a temperature of 100˚C. The dinitrogen tetroxide decomposed to form a dark brown gas.

$$N_2O_{4(g)} \rightleftharpoons 2NO_{2(g)}$$



(a) Describe the macroscopic appearance of the contents of the flask after 80 seconds. **1**

(b) Describe what happened at the molecular level to the contents of the flask after 80 seconds. **1**

(c) Explain the changes in reaction rate from 0 to 80 seconds. **2**

Question 22 (4 marks)

A student was provided with a beaker containing a violet coloured solution of cobalt (II) chloride and was asked to investigate the following equilibrium reaction:

$$Co(H_2O)_6^{2+}{}_{(aq)} + 4Cl^-{}_{(aq)} \rightleftharpoons CoCl_4^{2-}{}_{(aq)} + 6H_2O_{(l)} \quad \Delta H = +$$

(a) 5 mLs of cobalt (II) chloride solution were poured into a test tube with 5 drops of 4M HCl. **2**

Use Le Chatelier's principle to predict the impact on this reaction and describe its appearance.

(b) Outline a procedure the student could follow to investigate the impact of temperature changes on this reaction. **2**

Question 23 (3 marks)

Outline the processes used by Aboriginal and Torres Strait Islander Peoples to remove toxic chemicals from food. **3**

Question 24 (4 marks)

Carbon monoxide reacts with chlorine to produce carbon oxychloride as shown by the following equation.

$$CO_{(g)} + Cl_{2(g)} \rightleftharpoons COCl_{2(g)} \quad \Delta H = -5 kJ\ mol^{-1}$$

A 10 litre reaction vessel initially contained 2.0 moles carbon monoxide and 5.0 moles chlorine gas at 200°C. When the reaction reached equilibrium, there was 1.0 mole of carbon monoxide remaining.

(a) Calculate the equilibrium concentration of carbon monoxide, chlorine and carbon oxychloride. **2**

(b) Write the equilibrium expression for this reaction then calculate the value for K_{eq}. Show relevant working. **2**

Question 25 (3 marks)

Determine the solubility of copper (II) hydroxide at 25˚C and state the concentration of the copper and hydroxide ions. Show all working. **3**

Question 26 (3 marks)

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

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

(a) What would happen if a small volume of dilute acid or base was added to this solution? **2**

(b) Identify a buffer in a natural system. **1**

Question 27 (4 marks)

Discuss how theories about acids and bases have developed over time as new observations were made and existing ideas were shown to be too limited. **4**

Question 28 (7 marks)

A student was asked to determine the mass of $CaCO_3$ present in a 2.25 gram sample of chalk. The chalk reacted with 100 mL of a 1.00 M HCl solution. After the bubbling stopped, excess HCl remained. The excess HCl was titrated with 1.0 M NaOH. The average titre was 17.15 mLs.

(a) Calculate the number of moles of sodium hydroxide which reacted with the excess HCl. **1**

(b) Determine the number of moles of HCl added to the chalk sample and use this to calculate the actual number of moles of calcium carbonate present in the sample. **4**

(c) Calculate the mass of calcium carbonate present in the 2.25 g chalk sample. **2**

Question 29 (3 marks)

Acetic acid is placed in two beakers. In the first beaker, an equal volume of water is added. In the second beaker, sodium hydroxide solution is added.

(a) Write a balanced equation for the reaction between acetic acid and sodium hydroxide. **1**

(b) Account for the difference between the reactions taking place in the two beakers. **2**

Question 30 (3 marks)

Calculate the pH of a 0.10 M acetic acid solution given $K_a = 1.8 \times 10^{-5}$. Show all working. **3**

Question 31 (4 marks)

During your course of study, you carried out a first-hand investigation to compare the enthalpy of combustion of alcohols.

(a) Identify a risk present in this investigation and outline the safety precaution required to minimise this risk. **1**

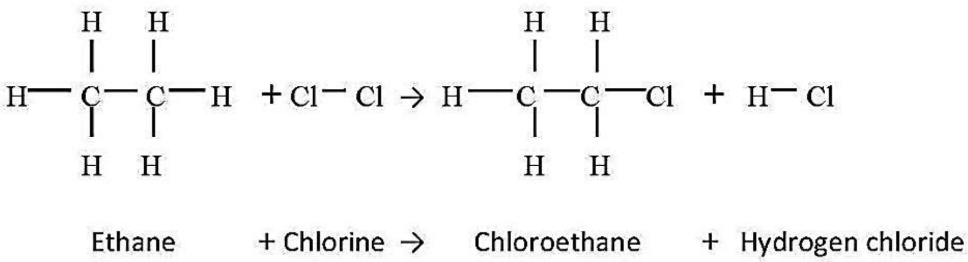
(b) A student recorded a temperature increase of 9.5˚C when 1.4 grams of methanol was combusted to heat 200 mL of water. **3**

Given that the theoretical enthalpy of combustion of methanol is 726 kJ mol^{-1}, calculate the efficiency of the apparatus at absorbing the heat released during the combustion.

Question 32 (4 marks)

Hydrocarbons undergo a variety of reactions.

(a) The structural equation shown below represents a reaction between a saturated hydrocarbon and a halogen. **1**



Draw a structural equation to show the reaction between an unsaturated hydrocarbon and a halogen.

(b) Explain why saturated and unsaturated hydrocarbons react differently with halogens. **3**

Question 33 (4 marks)

Polymers are long chained molecules consisting of repeating monomers.

(a) State a property and a use of a named addition polymer. **2**

(b) Name a condensation polymer and draw its monomer molecule. **2**

Question 34 (3 marks)

Draw and name THREE isomers with the molecular formula C_4H_8O. **3**

Question 35 (7 marks)

The properties of three compounds, **X**, **Y** and **Z** are given in the table.

Compound	*Carboxylic acid*	*Primary Amine*	*Amide*
Example	CH_3COOH	$CH_3CH_2CH_2NH_2$	CH_3CONH_2
Name	**X**	**Y**	**Z**
Molecular weight (g mol^{-1})	60.052	59.112	59.068
Boiling Point (°C)	118	48	221
pK_a	4.756	10.71	0.63

(a) Name the three compounds shown: **3**

X ____

Y ____

Z ____

(b) Write TWO equations to compare the reactions which occur when compound **X** is added to water, with compound **Y** added to water. **2**

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Question 35 continues on page 23

Question 35 (continued)

(c) Explain the variation in boiling points between the carboxylic acid and the amine or the amide given that all three compounds have very similar molecular weights. **2**

End of Question 35

Question 36 (5 marks)

A series of standard solutions of iron thiocyanate are prepared then placed in 1 cm sample tubes. The percent transmittance was measured at 505 nm in a colourimeter. The results were then converted to absorbance as shown below.

Solution	Blank	Standard 1	Standard 2	Standard 3	Standard 4
Concentration mol L^{-1}	0.00	0.15	0.30	0.45	0.60
Absorbance	0.00	0.24	0.50	0.72	0.99

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

(b) Calculate the molar absorptivity of this solution. **2**

Question 37 (5 marks)

River water is monitored to detect changes in the concentrations of various inorganic ions to assess water quality. Elevated concentrations of some ions can indicate a water pollution problem.

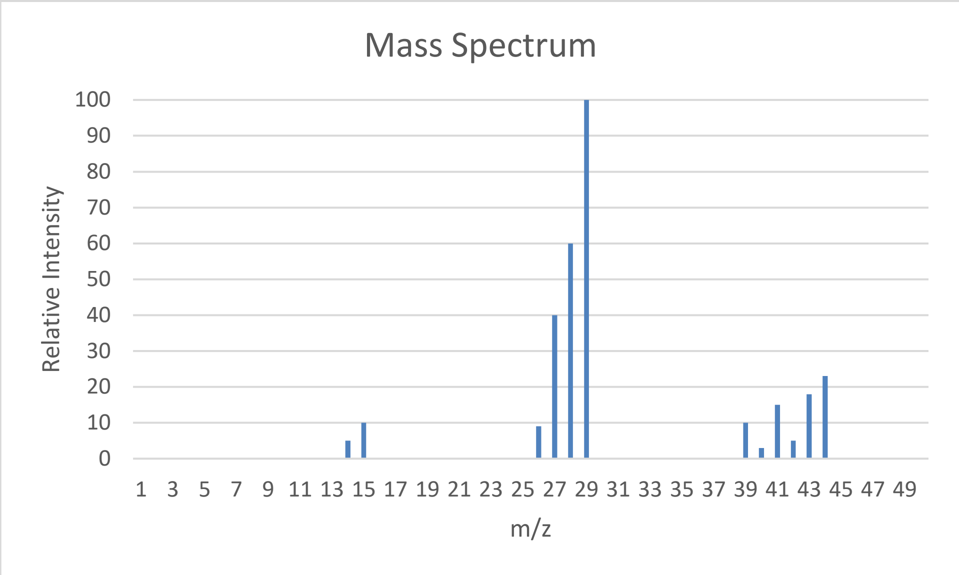
(a) Name ONE inorganic cation AND ONE inorganic anion which can cause a reduction in water quality. **1**

(b) For each named ion, explain what can cause increased concentrations in river water. **2**

(b) Describe the impact of elevated concentrations of each named ion. **2**

Question 38 (5 marks)

The mass spectrum of an alkane is shown below.



Typical m/z values for alkane fragments	
CH_3^+	15
$C_2H_5^+$	29
$C_3H_7^+$	43
$C_4H_9^+$	57
$C_5H_{11}^+$	71

(a) Outline how mass spectroscopy is used to analyse organic substances. **2**

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(b) Use the information provided to identify the alkane which could produce the mass spectrum shown and justify your choice. **3**

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Question 39 (5 marks)

Chemists must consider many factors when designing a chemical synthesis process.

Evaluate the need to consider environmental, social and economic issues for a named chemical synthesis you have studied.

End of paper

Section II extra writing space

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

Section II extra writing space

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

2019 HSC TRIAL EXAMINATION

Chemistry

FORMULAE SHEET

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

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

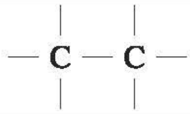
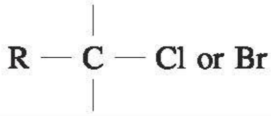
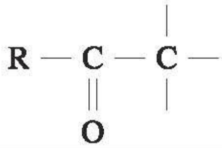
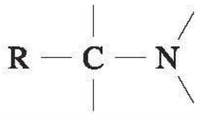
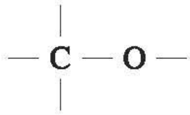
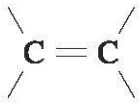
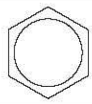
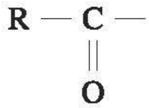
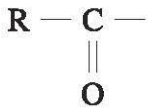
Compound	K_{sp}	*Compound*	K_{sp}
Barium carbonate	2.58×10^{-9}	Lead(II) bromide	6.60×10^{-6}
Barium hydroxide	2.55×10^{-4}	Lead(II) chloride	1.70×10^{-5}
Barium phosphate	1.3×10^{-29}	Lead(II) iodide	9.8×10^{-9}
Barium sulfate	1.08×10^{-10}	Lead(II) carbonate	7.40×10^{-14}
Calcium carbonate	3.36×10^{-9}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

2019 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 ○

2019 HSC Chemistry Marking Guidelines

Section I

Multiple-choice Answer Key

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

Section II

Question 21 (4 marks)

(a)

Criteria	Marks
• Correctly describes appearance of gas mixture at equilibrium	1

Sample answer:
The gas mixture inside the flask stays a light brown colour after 80 s.

(b)

Criteria	Marks
• Describes dynamic equilibrium	1

Sample answer:
Molecules of N_2O_4 decompose into NO_2 molecules at the same rate that NO_2 molecules collide to form N_2O_4.

(c)

Criteria	Marks
• Uses collision theory to explain changes in reaction rates	2
• Provides some relevant information	1

Sample answer:
At the start the concentration of reactant molecules (N_2O_4) is high but as the reactant molecules get used up, the forward reaction slows down. This is because fewer successful collisions will occur as the concentration of reactants decreases. The rate of the reverse reaction is very low at the start as there are few product molecules (NO_2). As more product is formed, the reverse reaction speeds up. This continues until dynamic equilibrium is established.

Question 22 (4 marks)

(a)

Criteria	Marks
• Uses le Chatelier's principle to predict impact of adding HCl • Correctly describes appearance of solution	2
• Uses le Chatelier's principle to predict impact of adding HCl OR • Correctly describes appearance of solution	1

Sample answer:
The addition of HCl raises the concentration of chloride ions causing the equilibrium to shift to the right to reduce the concentration of the additional chloride ions as predicted by Le Chatelier's principle. This solution would change from purple to blue in colour as more $CoCl_4^{2-}$ forms.

(b)

Criteria	Marks
• Outlines a valid procedure	2
• Provides some simple steps	1

Sample answer:

1. Pour 5 mL of violet coloured solution into three separate test tubes.
2. Label test tube 1 and keep at room temperature as a control.
3. Label test tube 2 and place in a hot water bath.
4. Label test tube 3 and place in an ice/water bath
5. Wait 5 minutes and record colour changes.

Question 23 (3 marks)

Criteria	Marks
• Demonstrates a comprehensive knowledge of the processes used by Aboriginal and Torres Strait Islander Peoples to remove toxic chemicals from food	3
• Demonstrates a sound knowledge of a process used by Aboriginal and Torres Strait Islander Peoples to remove toxic chemicals from food	2
• Demonstrates a basic knowledge of a process used by Aboriginal and Torres Strait Islander Peoples to remove toxic chemicals from food	1

Sample answer:

Aboriginal and Torres Strait Islander peoples used a variety of processes to prepare plant materials for food. Some of these foods contain toxic substances such as cycasin in cycad seeds. Processes which reduced the concentration of the toxic substances include leeching and fermentation. Cycad seeds were cracked open to extract the kernel. The kernels were ground into a paste then placed in a dilly-bag. The bag was then secured between rocks in a flowing stream. The soluble cycasin was leeched out of the paste over several days. Then the paste was dried and used as a flour.

Alternatively, the cycad seeds were dropped into a lined pit and covered with soil. Over a period of months, the seeds fermented in the anerobic conditions changing the chemical makeup of the kernels. The seeds are then dug-up and consumed.

Question 24 (4 marks)

(a)

Criteria	Marks
• Calculates correctly all initial concentrations and equilibrium concentrations of each species	2
• Calculates initial concentrations correctly with one error in equilibrium concentrations	1

Sample answer over page

Sample answer:
Volume of reaction vessel = 10 litres

species	Moles	initial conc. mol L^{-1}	equilibrium conc. mol L^{-1}
CO	2.0	0.20	0.10
Cl_2	5.0	0.50	$[Cl_2]$ - $[COCl_2]$ 0.50 - 0.10 = 0.40
$COCl_2$	1.0	0	0.20-0.10 =0.10

(b)

Criteria	Marks
• Shows correct equilibrium expression and working out showing correct equilibrium constant	2
• Shows correct equilibrium expression shown OR equilibrium constant	1

Sample answer:

$$k = \frac{[COCl_2]}{[CO]\,[Cl_2]} = \frac{0.1}{0.1 \times 0.40} = 2.5$$

Question 25 (3 marks)

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

Sample answer:
$Cu(OH)_{2(s)} \rightarrow Cu^{2+}_{(aq)} + 2OH^-_{(aq)}$

From data sheet $K_{sp} = 2.2 \times 10^{-20}$
Equilibrium expression $K_{sp} = [Cu^{2+}]\,[OH^-]^2$

Let X = concentration of Cu^{2+} then concentration of OH^- = 2X

$2.2 \times 10^{-20} = X \times 2X^2$
$2.2 \times 10^{-20} = 4X^3$
$5.5 \times 10^{-21} = X^3$
$X = 1.8 \times 10^{-7}$ mol L^{-1}

Concentration of copper (II) hydroxide is 1.8×10^{-7} mol L^{-1}
Concentration of copper ion is 1.8×10^{-7} mol L^{-1}
Concentration of hydroxide ion is 3.6×10^{-7} mol L^{-1}

Question 26 (3 marks)

(a)

Criteria	Marks
• Identifies the solution H_2CO_3/HCO_3^- as a buffer • States that the addition of a small amount of acid or base causes the equilibrium position to shift so that the pH remains the same	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 and the pH will remain constant.

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 and the pH will remain constant.

(b)

Criteria	Mark
• Identifies a buffer in a natural system	1

Sample answer: (Answers will vary)

Haemoglobin (a weak base) can act as a buffer in blood

Question 27 (4 marks)

Criteria	Marks
• Demonstrates thorough knowledge and understanding of changing theories about acids and bases • Identifies observations which lead to multiple modifications to theories • Names numerous chemists who proposed theories	4
• Demonstrates sound knowledge and understanding of changing theories about acids and bases • Identifies observations which lead to multiple to theories • Names numerous chemists who proposed theories	3
• Demonstrates some knowledge and understanding of changing theories about acids and bases • Identifies observations which lead to modifications to theories • Names chemists who proposed theories	2
• Provides some information about a theory of acids and bases • Names a chemist who proposed theory	1

Sample answer over page

Sample answer:

An early definition of acids was made by Lavosiser who said that acids were compounds which contained the element oxygen. When acids were discovered such as hydrochloric acid that did not contain oxygen the definition was adjusted by Davy to acids were compounds that contained the element hydrogen. It was then observed that both acids and bases conducted electricity.

Arrhenius improved on Davy's ideas by theorising that acids were compounds that produced hydrogen ions in water and bases produced hydroxide ions however it was shown that substances such as ammonia could behave like a base but did not contain hydroxide ions. The concept of acids and bases was further developed by two chemists, Brœnsted and Lowry, who said that acids are chemical species that transfer a proton to another species while bases were substances that received a proton.

Question 28 (7 marks)

(a)

Criteria	Marks
• Calculates the moles of sodium hydroxide which reacted with the excess HCl	1

Sample answer:

Moles of NaOH which react with excess HCl

n=C x V

n= 1.0 x 0.01715

n= 0.01715 moles of NaOH

(b)

Criteria	Marks
• Calculates the moles of HCl added to the chalk sample • Determines the actual number of moles of HCl which reacted with the $CaCO_3$ • Uses a balanced equation to determine the molar ratio for each reaction • Calculates the number of moles of $CaCO_3$ in the chalk sample	4
• Three of the above correct	3
• Two of the above correct	2
• One of the above correct	1

Sample answer:

Moles of HCl added to the chalk

n= C x V

n= 1.00 x 0.100

n= 0.10

Since NaOH reacts with HCl in a 1: 1 molar ratio number of moles of excess HCl = 0.01715

Therefore number of moles of HCl which reacted with $CaCO_3$ = 0.10 - 0.01715 = 0.08285

$$CaCO_{3(aq)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$$

Since $CaCO_3$ reacts with HCl in a 1: 2 molar ratio

number of moles of $CaCO_3$ in chalk sample is 0.08285/2 = 0.0207125

(c)

Criteria	Marks
• Calculates molar mass of $CaCO_3$ • Calculates mass of $CaCO_3$ in chalk sample	2
• Calculates molar mass of $CaCO_3$	1

Sample answer

Molar mass of $CaCO_3$ = 100.09g

Mass of $CaCO_3$ in chalk sample

m = n x M

m = 0.0207125 x100.09 = 2.07g

Question 29 (3 marks)

(a)

Criteria	Marks
• Provides correct equation	1

Sample answers: (Answers will vary)

$CH_3COOH_{(aq)} + NaOH_{(aq)} \rightarrow CH_3COO^-Na^+_{(aq)} + H_2O_{(l)}$

(b)

Criteria	Marks
• Accounts for the difference between two reactions	2
• Provides some relevant information	1

Sample answer: (Answers will vary)

Acetic acid is a weak acid, it ionises in water to a slight extent. The acetic acid molecules donate a proton to water molecules. As this is a reversible reaction the acetate ions receive the protons back from the hydronium ions. When acetic acid is mixed with sodium hydroxide a neutralisation reaction takes place. This reaction goes almost to completion. The products are sodium acetate and water.

Question 30 (3 marks)

Criteria	Marks
• Correctly calculates pH of a weak acid using *Ka* • Provides an equation	3
• Provides the main steps of the calculation	2
• Provides some relevant information	1

Sample answer:

$CH_3COOH_{(aq)} + H_2O_{(l)} \rightleftharpoons CH_3COO^-_{(aq)} + H_3O^+_{(aq)}$

	$CH_3COOH_{(aq)}$	$CH_3COO^-_{(aq)}$	$H_3O^+_{(aq)}$
initial	0.10	0	0
change	-x	x	x
equilibrium	0.10-x	x	x

$Ka = \frac{[CH_3COO^-][H_3O^+]}{[CH_3COOH]} = 1.8 \times 10^{-5}$

Since acetic acid is a weak acid, x is very small compared with 0.10 so (0.10 – x) is insignificant.

$1.8 \times 10^{-5} = \frac{x^2}{0.10}$

$x = 1.3 \times 10^{-3}$

$pH = -\log 1.3 \times 10^{-3} = 2.89$

Question 31 (4 marks)

(a)

Criteria	Marks
• Identifies one risk/hazard associated with investigation and provides a safety precaution	1

Sample answers: *(Answers will vary)*

Alkanols are highly flammable so long hair needs to be tied back.

OR

Alkanols are toxic so wipe up spills and wash hands promptly.

OR

Glassware and thermometers are brittle so set up away from edge of work space.

(b)

Criteria	Marks
• Correctly calculates the molar heat of combustion of methanol using experimental data • Calculates the efficiency of the apparatus by comparing the experimental and theoretical values	3
• Correctly calculates the molar heat of combustion of methanol using experimental data	2
• Calculates the energy released or the number of moles using the experimental data	1

Sample answer:

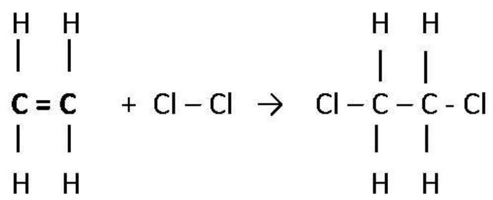
$q = -m \times C \times \Delta T$
$= -200 \times 4.18 \times 9.5$
$= -7942$ Joules
$n = 1.40 / 32.042$
$= 0.04369$
$\Delta H_{com} = -7942 / 0.04369$
$= 181769.6886$Joules per mole or -261.34 kJ mol^{-1}
Efficiency = 181.769/ 726 x 100
= 25.037
= 25%
(=0.25)

Question 32 (4 marks)

(a)

Criteria	Marks
• Draws a structural equation showing an addition reaction	1

Sample answer:



(b)

Criteria	Marks
• Provides a detailed comparison of a substitution reaction with an addition reaction • Provides equations showing reactions and names products	3
• Provides a sound explanation of why saturated hydrocarbons react differently to unsaturated hydrocarbons	2
• Provides some relevant information	1

Sample answer:

Alkanes are saturated hydrocarbons. Alkanes will not readily react with halogens in normal laboratory conditions. However, in the presence of UV light a substitution reaction may occur.

For example: ethane + bromine $\xrightarrow{uv}$ bromoethane + hydrogen bromide

In this substitution a bromine atom takes the place of a hydrogen atom. Further substitution can take place.

Alkenes and alkynes are unsaturated hydrocarbons. These hydrocarbons will react with halogens in an addition reaction.

For example: ethene + bromine → 1,2-dibromoethane

In this addition reaction the halogen is added across the double bond producing only a dihaloalkane product.

Question 33 (4 marks)

(a)

Criteria	Marks
• Names an addition polymer and correctly states a property and a use	2
• Names an addition polymer and correctly states a property OR a use	1

Sample answer: (Answers will vary)

Polyethylene (LDPE) is semi-rigid and is used to make plastic bottles.

(b)

Criteria	Marks
• Names a condensation polymer and correctly draws its monomer	2
• Names a condensation polymer or correctly draws its monomer	1

Sample answer: (Answers will vary)

A polyester $[CO(CH_2)_4CO\text{-}OCH_2CH_2O]_n$

Question 34 (3 marks)

Criteria	Marks
• Correctly names and gives the formula (condensed or structural) of three isomers of C_4H_8O	3
• Correctly names and gives the formula (condensed or structural) of two isomers of C_4H_8O	2
• Correctly names and gives the formula (condensed or structural) of one isomer of C_4H_8O	1

Sample answer: *(possible isomers)*

$CH_3CH_2CH_2\,CHO$	Butanal
$CH_3CH_2COCH_3$	Butanone
$CH_2{=}CHCH_2CH_2OH$ $CH_3CH_2\,CH{=}CHOH$ $CH_3CH{=}CHCH_2\,OH$ $CH_3CH{=}\,COHCH_3$	But-1-en-4-ol But-1-en-1-ol But-2-en-1-ol But-2-en-2-ol

Note: an ether is possible but beyond the range of the syllabus

Question 35 (7 marks)

(a)

Criteria	Marks
• Correctly names 3 compounds	3
• Correctly names 2 compounds	2
• Correctly names 1 compound	1

NB: NESA has said answers will be accepted in both formats - while may prefer IUPAC naming they accept marking centres will need to acknowledge both methods as they are still used in industry

Sample answer:

X = Ethanoic acid		X = Acetic acid
Y = Propan -1 - amine	OR	Y = Propylamine or n-Propylamine
Z = Ethanamide		Z = Aceta

(b)

Criteria	Marks
• Gives two correct equations showing acidic behaviour of X and basic behaviour of Y	2
• Gives one correct equation showing acidic behaviour of X OR basic behaviour of Y	1

Sample answer:

Acetic acid donates a proton to water

$CH_3COOH_{(l)} + H_2O_{(l)} \rightleftharpoons CH_3COO^-_{(aq)} + H_3O^+_{(aq)}$

Propylamine receives a proton from water

$CH_3CH_2CONH_{2(l)} + H_2O_{(l)} \rightleftharpoons CH_3CH_2CONH_3^+{}_{(aq)} + OH^-_{(aq)}$

(c)

Criteria	Marks
• Explains the variation in boiling points between carboxylic acid and amine or amide in terms of the strength of the intra-molecular forces involved due to different functional groups present	2
• Provides some relevant information	1

Sample answer:

The boiling points of the carboxylic acid (acetic acid) is higher than the amine (propylamine) due to the very polar -COOH functional group compared with the less polar $-NH_2$. While both functional groups produce hydrogen bonding the N-H bond is not as polar as the O-H bond. This is because nitrogen is less electronegative than oxygen.

OR

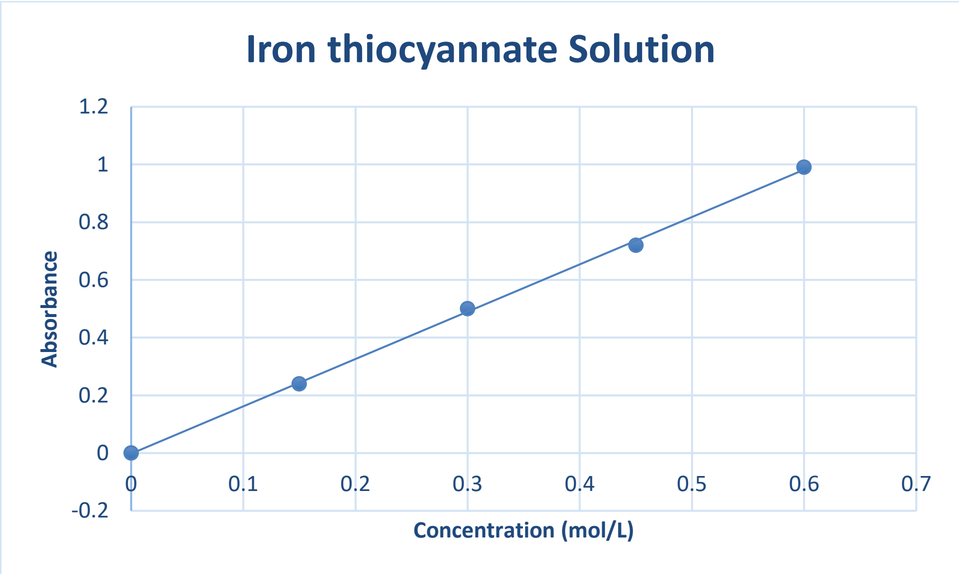
The boiling points of the amide (acetamide) is higher than the carboxylic acid (acetic acid) as the carbonyl functional group in the amide has two lone pairs of electrons giving a total of 4 locations where hydrogen bonds can form between neighboring molecules. Carboxylic acids have two locations where hydrogen bonding can occur.

Question 36 (5 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 calculates molar absorptivity of iron thiocyanate solution	2
• Provides main steps of calculation	1

Sample answer:

(Molar absorptivity or **molar extinction coefficient**, can be calculated from the slope of the line on the graph or by using formula from data sheet)

Using A= Ɛ *l c*

Since the sample length was 1 cm then Ɛ = A/*c*

using any pair of measurements from the table,

Ɛ = 0.24/0.15

= 1.6 L M^{-1} cm^{-1}

Question 37 (5 marks)

(a)

Criteria	Marks
• Provides both an inorganic cation and an anion which can reduce water quality	1

Sample answer: (Answers will vary)
Anion = Chloride ion
Cation = Phosphate ion

(b)

Criteria	Marks
• Explains how the concentration both ions can increase in river water	2
• Provides some relevant information on two ions	1

Sample answer:
The concentration of chloride ions can increase in river water due to irrigation. The water that is added to crops dissolves the natural salts present in the soil and raises the water table over time. The water will make its way back to the river carrying the dissolved ions. This is referred to as salinity.

The concentration of phosphate ions can increase in river water due to the addition of fertilisers such as super phosphate to crops. Excess fertiliser is washed into rivers through runoff or irrigation.

(c)

Criteria	Marks
• Describes the impact of elevated concentrations of both ions	2
• Provides some relevant information on two ions	1

Sample answer:
When chloride ion concentrations increase the water can no longer support freshwater organisms. River water can become so saline it cannot be used for human consumption or agriculture. When phosphate ion concentrations increase, algal blooms can block the light and cause other aquatic plants to die. The algal bloom eventually dies and decays, consuming the oxygen in the water thus killing aquatic animals.

Question 38 (5 marks)

(a)

Criteria	Marks
• Outlines how mass spectroscopy is used to analyse organic substances	2
• Provides some relevant information	1

Sample answer over page

Sample answer:

Firstly, a vaporized organic sample passes into the ionization chamber of a mass spectrometer where it is bombarded by a stream of electrons. These electrons have a high enough energy to knock an electron off an organic molecule to form a positive ion. The molecular ions are energetically unstable, and some of them will break up into smaller pieces or fragments. Positively charged fragments are then accelerated, deflected and detected by the mass spectrometer. Each fragment produces a line on the stick diagram. The pattern produced is interpreted to deduce the structure of the organic molecule.

(b)

Criteria	Marks
• Identifies alkane with correct justifications	3
• Identifies alkane with a correct justification	2
• Provides some relevant information	1

Sample answer:

The highest peak at 44 amu represents the cation of the molecule and its molecular mass. An alkane with a mass of 44 amu is propane C_3H_8. The base peak (highest intensity) occurs at 29 amu which fits an ethyl cation. This would form when a methyl radical is lost. The peak at 15 represents the methyl cation. Other peaks represent the loss of additional hydrogen radicals from the fragments.

Question 39 (5 marks)

Criteria	Marks
• Demonstrates thorough knowledge and understanding of a named chemical synthesis process • Makes a judgement about the need to consider environmental, social and economic issues	5
• Demonstrates a sound knowledge and understanding of a named chemical synthesis process • Makes a judgement about the need to consider environmental or social or economic issues	4
• Demonstrates some knowledge and understanding of a named chemical synthesis process • Identifies at least two issues that need to be considered	3
• Demonstrates a basic knowledge and understanding of a named chemical synthesis process • Identifies an issue that need to be considered	2
• Provides some information about a chemical synthesis process	1

Sample answer over page

Sample answer: (Answers will vary based on the chemical synthesis process studied)

Chemists must consider many factors when designing a chemical synthesis process. The product must be fit for purpose and meet a societal need at a reasonable price. Chemists must design safer chemicals that are neither toxic nor harmful to the environment. The chemical synthesis process should where ever possible use renewable biodegradable resources that do not pollute the environment. Also, chemists should design chemical synthesis processes that are energy efficient.

The process of synthesising soap starts with a supply of fats and oils. Often vegetable oils such as palm, coconut and soybean oil are used. The oils are hydrolysed under high temperature and pressure in the presence of steam and a zinc oxide catalyst. These conditions allow the triglyceride molecules to split to form fatty acids and glycerol. The waste glycerol produced is collected as a valuable by-product. The fatty acids are dried and mixed with a base to form soap.

Soap is a valuable product allowing better hygiene and reducing the spread of disease, which is of great benefit to society. However, poorly made soap can contain residual base which is too harsh on skin. This can lead to skin problems such as dermatitis and eczema.

While vegetable oils are both biodegradable and renewable raw materials, the use of palm oil can cause great pressure to clear rainforest habitat to increase its production. This has led to threatened species being pushed towards extinction. Vegetable oils are available in large quantities at a consistent price which allows soap to be economically produced.

Soap manufacturing does not produce any toxic by-products, but the energy required to make the soap adds to the greenhouse gases that are causing global warming.

2019 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	Factors that Affect Equilibrium	CH12-12, CH-4
3	1	5	Calculating the Equilibrium constant (K_{eq})	CH12-12
4	1	5	Calculating the Equilibrium constant (K_{eq})	CH12-12, CH-4
5	1	5	Calculating the Equilibrium constant (K_{eq})	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	Using Brønsted-Lowry Theory	CH12-13, CH-6
10	1	6	Using Brønsted-Lowry Theory	CH12-13
11	1	6	Quantitative Analysis	CH12-13, CH-6
12	1	6	Properties of Acids and Bases	CH12-13, CH-6
13	1	7	Reactions of Organic Acids and Bases	CH12-13
14	1	7	Nomenclature	CH12-14
15	1	7	Nomenclature	CH12-14
16	1	7	Alcohols	CH12-14
17	1	8	Analysis of Inorganic Substances	CH12-15
18	1	8	Analysis of Organic Substances	CH12-15
19	1	8	Analysis of Inorganic Substances	CH12-15, CH-6
20	1	8	Analysis of Inorganic Substances	CH12-15, CH-5

Section II

Question	Marks	Module	Content	Syllabus outcomes
21 (a)	1	5	Static and Dynamic Equilibrium	CH12-12
21 (b)	1	5	Factors that Affect Equilibrium	CH12-12
21 (c)	2	5	Factors that Affect Equilibrium	CH12-12, CH12-5
22 (a)	2	5	Factors that Affect Equilibrium	CH12-12
22 (b)	2	5	Factors that Affect Equilibrium	CH12-2
23	3	5	Solution Equilibria	CH12-12
24 (a)	2	5	Calculating the Equilibrium constant (K_{eq})	CH12-12, 12CH-6
24 (b)	2	5	Calculating the Equilibrium constant (K_{eq})	CH12-12, CH12-6
25	3	5	Solution Equilibria	CH12-12, CH12-6
26	3	6	Quantitative Analysis	CH12-13
27	4	6	Properties of Acids and Bases	CH12-13
28 (a)	1	6	Quantitative Analysis	CH12-13, CH12-6
28 (b)	4	6	Quantitative Analysis	CH12-13, CH-12-6

Question	Marks	Module	Content	Syllabus outcomes
28 (c)	2	6	Quantitative Analysis	CH12-13, CH12-6
29 (a)	2	6	Using Brønsted-Lowry Theory	CH12-13
29 (b)	1	6	Using Brønsted-Lowry Theory	CH12-13
30	3	6	Using Brønsted-Lowry Theory	CH12-13, CH12-6
31 (a)	1	7	Alcohols	CH12-2
31 (b)	3	7	Alcohols	CH12-14, CH12-6
32 (a)	1	7	Hydrocarbons	CH12-14, CH12-7
32 (b)	3	7	Hydrocarbons	CH12-14
33 (a)	2	7	Polymers	CH12-14
33 (b)	2	7	Polymers	CH12-14
34	3	7	Nomenclature	CH12-14, CH12-7
35 (a)	2	7	Reactions of Organic Acids and Bases	CH12-5
35 (b)	2	7	Reactions of Organic Acids and Bases	CH12-14
35 (c)	3	7	Reactions of Organic Acids and Bases	CH12-14
36 (a)	3	8	Analysis of Inorganic Substances	CH12-14
36 (b)	2	8	Analysis of Inorganic Substances	12CH-15, 12CH-4
37 (a)	1	8	Analysis of Inorganic Substances	12CH-15, 12CH-6
37 (b)	2	8	Analysis of Inorganic Substances	12CH-15
37 (c)	2	8	Analysis of Inorganic Substances	12CH-15
38 (a)	2	8	Analysis of Organic Substances	12CH-15
38 (b)	3	8	Analysis of Organic Substances	12CH-15, 12CH-5
39	5	8	Chemical Synthesis and Design	12CH-15