Strathfield Girls
High School

Student Number

Chemistry

2020

HIGHER SCHOOL CERTIFICATE

Trial Examination

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 formulae sheet, data sheets and Periodic Table are provided at the back of this paper and can be detached
- A Multiple-Choice Answer Sheet is provided at the back of this paper and should be detached

Total marks – 100

Section I – Pages 2–8
20 marks

- Attempt Questions 1–20
- Allow about 30 minutes for this section

Section II – Pages 9–20
80 marks

This section has two parts:

Part A – Questions 21–24
Part B – Questions 25–33

- Attempt Questions 21–33
- Allow about 2 hours and 30 minutes for this section

This paper MUST NOT be removed from the examination room

Section I

20 marks

Attempt Questions 1–20
Allow about 30 minutes for this section

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

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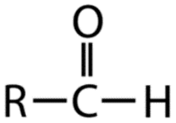
1 Which of the following is NOT a consideration in the *chemical synthesis and design* process?

(A) Yield and purity
(B) Availability of reagents
(C) Reaction conditions
(D) Employability of chemists

2 Which class of organic compound is represented by this general formula?



(A) Carboxylic acid
(B) Aldehyde
(C) Ketone
(D) Amide

3 A reagent that could distinguish hex-2-ene from cyclohexane is:

(A) Acidified dichromate
(B) Bromine water
(C) Sodium carbonate
(D) Universal indicator

4 The K_a of hydrofluoric acid is 6.6×10^{-4} at 25°C.

Given that $K_a \times K_b = K_w$, the K_b of hydrofluoric acid at 25°C is calculated to be:

(A) 1.5×10^{-11}
(B) 6.6×10^{-18}
(C) 7.4×10^{-9}
(D) 2.1×10^{-10}

5 The concentration of hydroxide ions (in mol L^{-1}) in a solution that has a pH of 9.54 is:

(A) 2.9×10^{-10}
(B) 3.5×10^{-5}
(C) 3.5×10^{9}
(D) 2.9×10^{4}

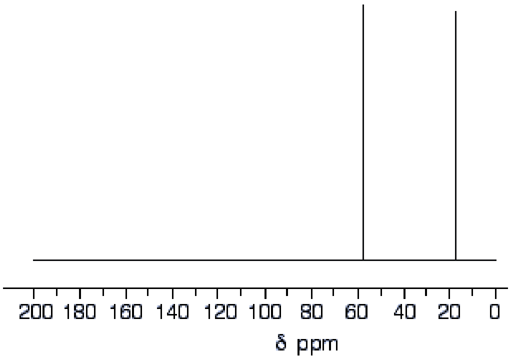
6 A *buffer* could be made by mixing which of the following chemicals?

(A) carbonic acid and sodium phosphate
(B) sodium nitrate and nitric acid
(C) ethanoic acid and potassium ethanoate
(D) hydrochloric acid and sodium chloride

7 Which of the following is the *conjugate base* of the hydrogen sulfite ion (HSO_3^-)?

(A) SO_3^{2-}
(B) HSO_3^-
(C) H_2SO_3
(D) $H_3SO_3^+$

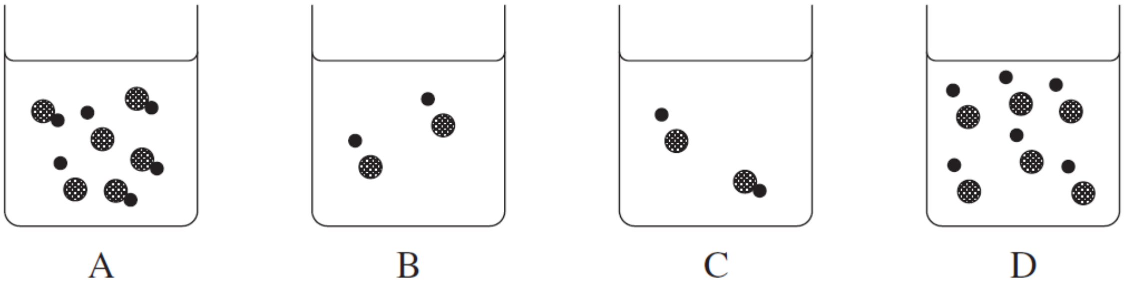
8 The *^{13}C NMR spectrum* of an organic compound is shown.



A compound that could produce this spectrum is:

(A) propan-1-ol
(B) butan-2-ol
(C) 2-methylpropan-2-ol
(D) 2-methylbutan-2-ol

9 Which beaker contains a strong, relatively dilute acid?



(A) Beaker A

(B) Beaker B

(C) Beaker C

(D) Beaker D

10 The chart below shows the pH range and colour changes for a number of pH indicators.

Indicator	**Colour Change From**	**pH Range of Colour Change**	**Colour Change To**
thymol blue	red	1.2 – 2.8	yellow
2,4-dinitrophenol	colourless	2.8 – 4.0	yellow
methyl yellow	red	2.9 – 4.0	yellow
bromophenol blue	yellow	3.0 – 4.6	blue-violet
congo red	blue-violet	3.0 – 5.0	red
methyl red	red	4.8 – 6.0	yellow
4-nitrophenol	colourless	5.4 – 6.6	yellow
bromothymol blue	yellow	6.0 – 7.6	blue
phenol red	yellow	6.4 – 8.0	red
phenolphthalein	colourless	8.3 – 10.0	dark pink
alizarin yellow R	yellow	10.0 – 12.0	red
methyl blue	blue	10.6 – 13.4	pale violet
1,3,5-trinitrobenzene	colourless	12.0 – 14.0	orange

The indicators 1,3,5-trinitrobenzene, phenolphthalein, phenol red and congo red were mixed together with a solution of unknown pH to produce a red solution.

The unknown solution's pH must be in the range:

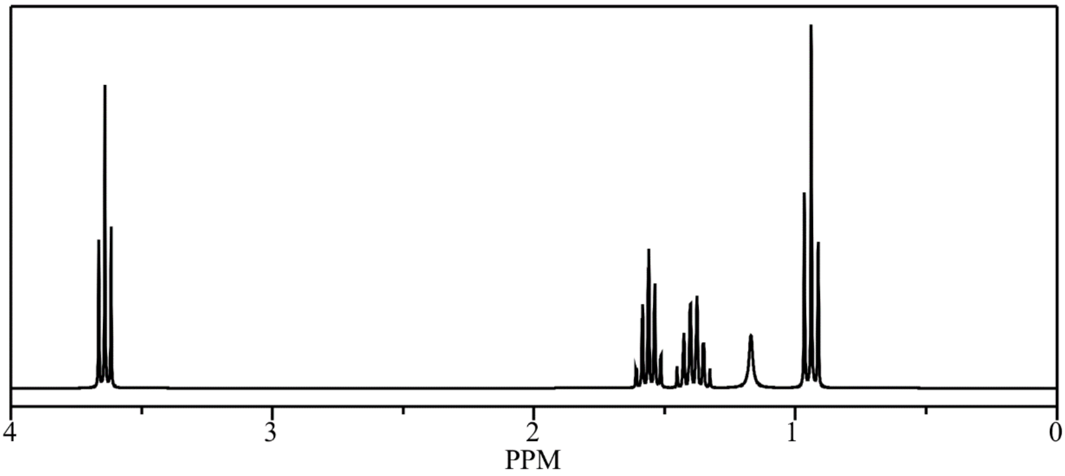
(A) 10.0 to 12.0

(B) 8.3 to 10.0

(C) 8.0 to 8.3

(D) 5.0 to 8.0

11 The complete *^1H NMR spectrum* of an organic compound is shown.



Which compound would produce this spectrum?

(A) Butan-1-ol
(B) Butan-2-one
(C) Butanoic acid
(D) Butanal

12 Equal volumes of four different acids are titrated with the same base at 25°C.

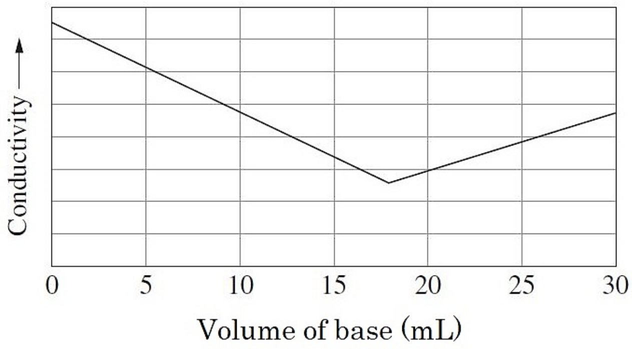
Information about these acids is given in the table below.

Acid	*Concentration (mol L^{-1})*	*pH*
H_2SO_4	0.1	0.96
H_3PO_4	0.1	1.6
HF	0.1	2.1
HCN	0.1	5.1

Which acid requires the greatest volume of base for complete *neutralisation*?

(A) H_2SO_4
(B) H_3PO_4
(C) HF
(D) HCN

13 A graph from a *conductometric titration* between an acid and base is shown.



Which type of acid-base titration does this graph represent?

(A) Strong acid and strong base
(B) Strong acid and weak base
(C) Weak acid and strong base
(D) Weak acid and weak base

14 Which of the following options correctly classifies the two techniques stated below?

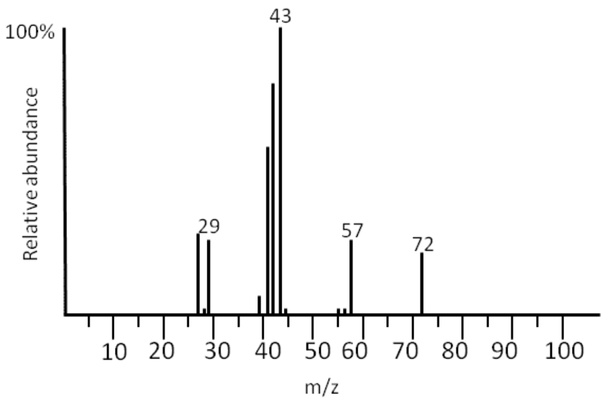
	Flame Tests	*Atomic Absorption Spectroscopy*
(A)	Qualitative	Qualitative
(B)	Quantitative	Quantitative
(C)	Quantitative	Qualitative
(D)	Qualitative	Quantitative

15 56 mL of 0.089 mol L^{-1} sulfuric acid solution was added to 250 mL of 0.15 mol L^{-1} sodium hydroxide solution. The volume of the resulting solution was then made up to 500 mL by the addition of water.

What is the pH of the final solution?

(A) 1.19
(B) 1.26
(C) 12.74
(D) 12.81

16 The *mass spectrum* of an organic compound is shown.



Which compound was analysed?

(A) Butan-1-ol
(B) Methyl ethanoate
(C) Pentane
(D) Propanamide

17 The *heat of combustion* of butan-1-ol is 2,670 kJ mol^{-1}.

When a student burns 1.85 g of butan-1-ol to measure the heat of combustion in an experiment, 35% of the heat produced is lost to the atmosphere.

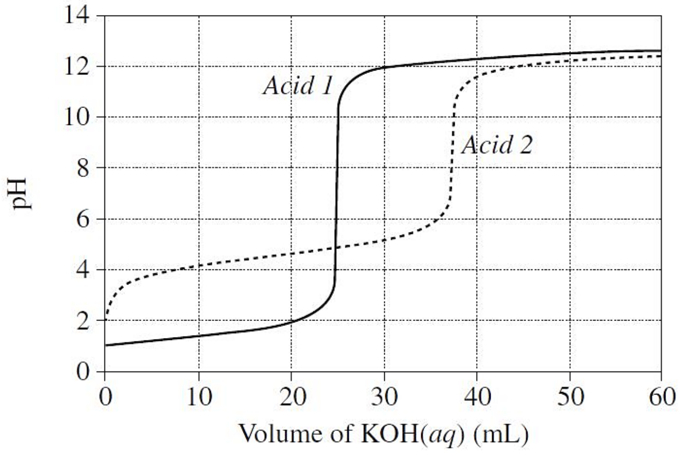
The temperature change of the 200 mL volume of water would therefore be:

(A) 27.9°C
(B) 51.8°C
(C) 66.6°C
(D) 79.7°C

18 Which of the following pairs of compounds are *isomers* of each other?

(A) cyclohexane and cyclohexene
(B) 2-methylhexane and 2-methylheptane
(C) butanoic acid and butanal
(D) ethyl methanoate and propanoic acid

19 The graph shows changes in pH during the titrations of equal volumes of two monoprotic acids, *Acid 1* and *Acid 2*.



Which of the following statements is correct?

(A) Acid 1 is stronger and more concentrated than Acid 2

(B) Acid 2 is stronger and more concentrated than Acid 1

(C) Acid 1 is stronger and less concentrated than Acid 2

(D) Acid 2 is stronger and less concentrated than Acid 1

20 The pK_a of chlorous acid ($HClO_2$) is 1.96. Nitrous acid (HNO_2) has a pK_a of 3.39.

When comparing these two acids and their conjugate bases, the relative strength of each acid and its conjugate base can be identified as:

	Stronger Acid	*Stronger Conjugate Base*
(A)	$HClO_2$	ClO_2^-
(B)	$HClO_2$	NO_2^-
(C)	HNO_2	NO_2^-
(D)	HNO_2	ClO_2^-

Section II

80 marks

Attempt Questions 21–33 (Parts A and B)
Part A – Questions 21-24
Part B – Questions 25-33

Allow about 2 hours and 30 minutes for this section

Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response. Show all relevant working in questions involving calculations.

Extra writing space is provided on pages 21 and 22. If you use this space, clearly indicate which question you are answering and indicate the use of this extra space with the question on the examination paper.

Question 21 (5 marks)

The pH of a 0.05 mol L^{-1} solution of unknown monoprotic, water-soluble acid, **HX**, was measured using a pH meter. The solution was found to have a pH of 3.035.

(a) Explain why acid **HX** must be a *weak* acid. **2**

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(b) Write a chemical equation to show the ionisation of acid **HX** in aqueous solution. **1**

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(c) Calculate the percentage (%) dissociation of acid **HX**. **2**

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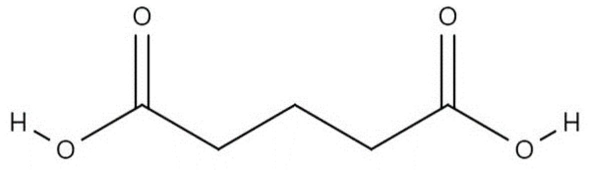
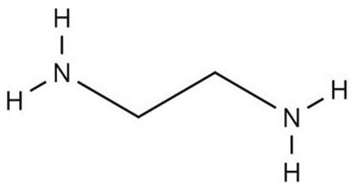
Question 22 (7 marks)

A chemist reacted the **dicarboxylic acid A** with **diamine B** to obtain the *nylon* product.



Dicarboxylic acid A



Diamine B

(a) Using a skeletal or condensed structural formula, draw the structure of the *polymer* that would be produced from the reaction of 'n' units of **dicarboxylic acid A** with 'n' units of **diamine B**. **2**

(b) Identify the process by which nylon is formed and explain why nylon is considered a *polyamide*. **2**

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(c) Calculate the expected molecular mass of the polymer produced from the reaction of 1,000 molecules of each *monomer* to give the polymer product. Assume a single chain is produced. **3**

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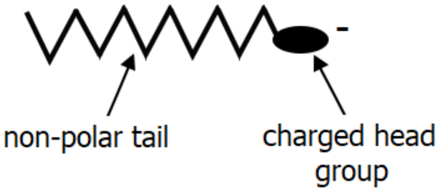
Question 23 (4 marks)

A Chemistry student added 10 g of NaOH solid to 750 mL of 0.100 mol L^{-1} H_3PO_4 solution.

Calculate the pH of the resulting solution which has a final volume of 750 mL. **4**

Question 24 (3 marks)

A simple diagram that represents a soap particle is shown.



With reference to the structural features indicated in this diagram, describe how soap is able to remove oil or grease from a surface during cleaning with soap and water. **3**

This examination continues in Section II Part B – Questions 25-33 on pages 12-20

Strathfield Girls High School

Student Number

Section II Part B

Questions 25-33

Pages 12-20

Attempt all Questions

Chemistry

2020

HIGHER SCHOOL CERTIFICATE

Trial Examination

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Question 25 (6 marks)

A 0.01 mol L^{-1} solution of ammonia has a pH of 10.62.

(a) Write a balanced chemical equation for the ionisation of ammonia in water. **1**

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(b) Calculate the K_b and pK_b for this base. **5**

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Question 26 (3 marks)

The phosphate *buffer* is an important component of intracellular fluid in living organisms. It consists of two main species, the dihydrogen phosphate ion ($H_2PO_4^-$) and the hydrogen phosphate ion (HPO_4^{2-}).

Explain the role of the phosphate buffer. Include at least ONE chemical equation in the response. **3**

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Question 27 (8 marks)

A chemist needed to determine the identity of two different ionic solutions, *Unknown A* and *Unknown B*, found in the laboratory.

The solutions were known to be *pure*, with each containing ONE cation and ONE anion, but could contain any of the ions from the following list: Ba^{2+}, Ca^{2+}, Cu^{2+}, Fe^{3+}, Cl^-, CO_3^{2-}, SO_4^{2-}, OH^- and PO_4^{3-}.

The chemist performed some chemical tests and flame tests to determine the identity of the solutions. The results of these tests are provided below.

Cation Identification Tests	**Addition of CO_3^{2-}**	**Addition of SO_4^{2-}**	**Addition of PO_4^{3-}**	**Flame Test**
Unknown A	white precipitate	white precipitate	white precipitate	green
Unknown B	white precipitate	no precipitate	white precipitate	red

Anion Identification Tests	**Addition of Ag^+**	**Addition of Ba^{2+}**	**Addition of Ca^{2+}**	**Addition of H^+**
Unknown A	brown precipitate	no precipitate	no precipitate	no bubbles
Unknown B	white precipitate	no precipitate	no precipitate	no bubbles

Use the results of ALL the tests to eliminate ions and thereby deduce the identity of the cation and anion in the two solutions, *Unknown A* and *Unknown B*. **8**

Ion Identity	***Justification for Identity***
Cation A:	
Cation B:	
Anion A:	
Anion B:	

Question 28 (6 marks)

A Chemistry student was required to determine the concentration of the purple permanganate ion (MnO_4^-) in unknown **solution X** in the school laboratory. The solution's concentration was believed to be approximately 30 mg/L.

The student selected a colorimeter for this analysis. She also realised the analysis would require the preparation of some *standard solutions*.

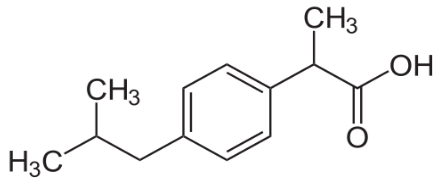
Describe the procedure the student should use to accurately determine the permanganate ion concentration of **solution X**. Include all steps, the required chemical and laboratory equipment. **6**

Question 29 (8 marks)

A chemist needed to check the composition of Nurofen® tablets which contain the active ingredient, ibuprofen.

A Nurofen® tablet, weighing 256 mg, was crushed to a fine powder and then dissolved in 125 mL of an aqueous solution. Four 25.0 mL aliquots of this solution were then *titrated* against 0.00502 mol L^{-1} sodium hydroxide solution to a phenolphthalein end point. The titration results are shown below.

Titration Run	*Titre (mL)*
1	39.65
2	38.60
3	38.55
4	38.65



Ibuprofen
$C_{13}H_{18}O_2$

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

(b) Determine the percentage composition (%w/w) of ibuprofen in the Nurofen® tablet. **5**

(c) Explain why phenolphthalein was chosen as the pH indicator for this analysis. **2**

Question 30 (10 marks)

A Chemistry student wanted to investigate the concentration of lead (Pb) in the soil from her front garden. She prepared five *standard solutions* of lead nitrate and measured the absorbance of each solution. The results are shown below.

Concentration of Lead Standard Solution (mg/L)	*Absorbance*
0.00	0.00
1.00	0.15
2.50	0.37
4.25	0.64
6.00	0.91
7.00	1.06

(a) Construct a line graph of these data. **4**

Question 30 continues on page 17

(b) The student collected a sample of soil from her front garden. The soil sample weighed 12.2 g.

To prepare a solution from the soil sample, she added 50 mL of nitric acid to the sample and filtered it. The 50 mL filtrate was then diluted to 800 mL with distilled water. A 15 mL sample of this solution was measured for its lead concentration. The absorbance obtained was 0.72.

Use the graph from part (a) to determine the lead concentration of the final solution prepared from the soil sample. **1**

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(c) The Australian maximum acceptable level of lead in the soil of residential areas is 300 mg/kg.

Determine whether the soil obtained from the student's garden is below the accepted level. **3**

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(d) Explain the purpose of preparing the *standard solutions* in part (a). **2**

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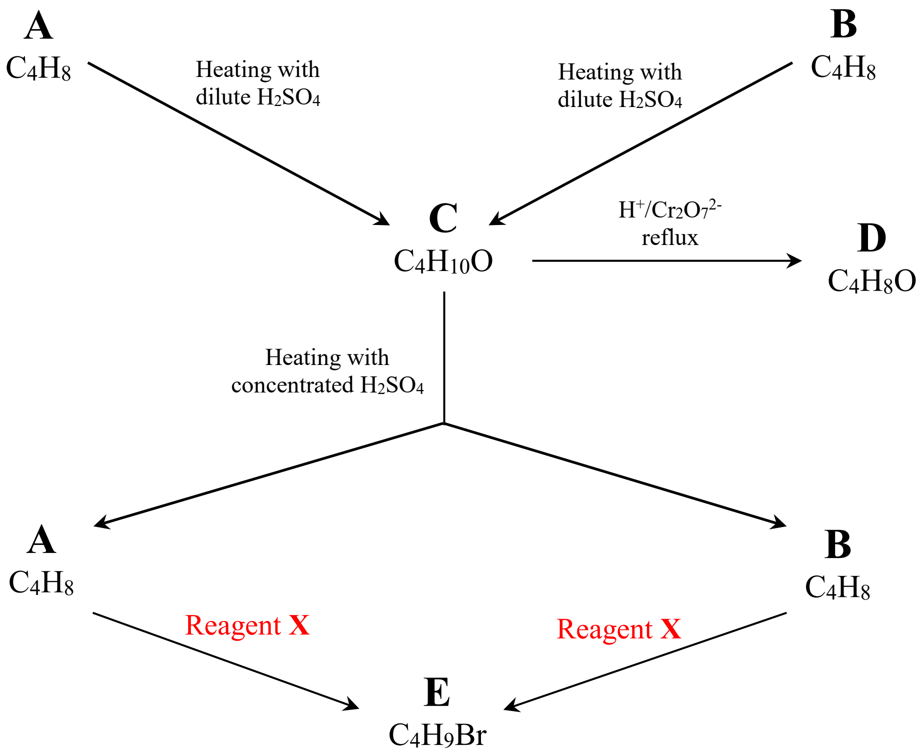
End of Question 30

Question 31 (10 marks)

The flow chart shows *reaction pathways* involving organic compounds **A** to **E**.



(a) Given that **compounds A** and **B** are *isomers*, suggest possible structures for these two compounds by drawing the structural formula of each in the space below. **3**

Compound A	**Compound B**

(b) Identify **compounds C** and **D** by providing their systematic (IUPAC) names. **2**

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Question 31 continues on page 19

Question 31 (continued)

(c) **Compound E** is synthesised by a reaction with **reagent X**. Isomers **A** and **B** give the same product in a reaction with this reagent.

Identify **reagent X** and **compound E**, and explain why the same compound is produced from these two reactions. **5**

Question 32 (3 marks)

When carbon dioxide gas is bubbled through sodium hydroxide solution, a *neutralisation* reaction occurs. Carbon dioxide acts as an acid to neutralise the hydroxide ion, producing the bicarbonate ion.

(a) Write the net ionic equation for this acid-base reaction. **1**

(b) Explain why this acid-base reaction is not a *Brønsted-Lowry* reaction. **2**

Question 33 (7 marks)

Scientists have a number of techniques available to them for the *effective monitoring of ions* in the environment. For the monitoring of metal ions, the methods a chemist may choose to use include:

- gravimetric analysis;
- precipitation titration; and
- atomic absorption spectroscopy.

As part of ongoing environmental monitoring, a chemist is required to accurately measure the concentration of silver ions (Ag^+) in water samples taken from a river located near a silver refining industrial site on the outskirts of a town. The maximum acceptable level for silver in water is 50 ppb.

Evaluate the THREE methods stated above for the analysis of silver in the samples by the chemist. In your response, consider the requirements of EACH technique and its suitability in this application where there are many samples to analyse accurately and efficiently. **7**

End of paper

Student Number: ______________________________

Section II Part A and B extra writing space. Clearly indicate which question you are answering. Please note the use of this extra space with the question in the examination paper.

Student Number: ________________________________

Section II Part A and B extra writing space. Clearly indicate which question you are answering. Please note the use of this extra space with the question in the examination paper.

2019 HIGHER SCHOOL CERTIFICATE EXAMINATION

Chemistry

FORMULAE SHEET

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

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

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

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

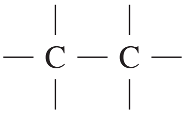
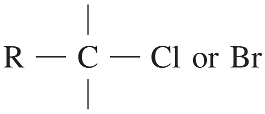
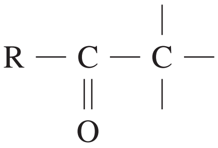
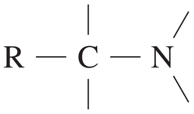
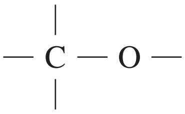
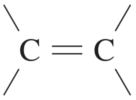
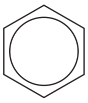
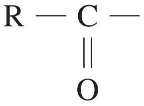
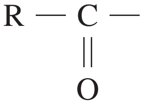
Solubility constants at 25°C

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}

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
 $-\overset{\vert}{\underset{\vert}{C}}-\overset{\vert}{\underset{\vert}{C}}-$		5–40
 $R-\overset{\vert}{\underset{\vert}{C}}-$Cl or Br		10–70
 $R-\underset{\underset{O}{\Vert}}{C}-\overset{\vert}{\underset{\vert}{C}}-$		20–50
		25–60
 $-\overset{\vert}{\underset{\vert}{C}}-O-$	alcohols, ethers or esters	50–90
		90–150
$R-C\equiv N$		110–125
		110–160
 $R-\underset{\underset{O}{\Vert}}{C}-$	esters or acids	160–185
 $R-\underset{\underset{O}{\Vert}}{C}-$	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

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

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number	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.

Strathfield Girls High School

Student Number

HSC Chemistry Trial Examination 2020

Multiple Choice Answer Sheet

Select the alternative A, B, C or D that best answers the question and indicate your choice with a cross (X) in the appropriate space on the grid below.

	A	B	C	D
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

	A	B	C	D
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

HSC Chemistry Trial Examination 2020
Marking Guidelines and Sample Answers

SECTION I (20 marks)

Multiple Choice Q1-20

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

SECTION II (80 marks)

Q21 (5 marks)

(a)

Criteria	Marks
• Uses a calculation to show that **HX** cannot be a strong acid – relates pH to $[H^+]$ • Relates to hydrogen ion concentration to explain why **HX** must be a weak acid	2
• Provides ONE of the above criteria or equivalent information	1

Sample answer: The pH of HX is 3.035, therefore, the H^+ concentration must be 9.23×10^{-4} M which does not equal 0.05 M. This means only some of the molecules are ionising to produce H^+ so HX is a weak acid.

(b)

Criteria	Marks
• Provides an equation to show the ionisation of **HX** in aqueous solution • Includes an equilibrium arrow and states of matter for all molecular species	1

Sample answer: $HX_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + X^-_{(aq)}$

(c)

Criteria	Marks
• Calculates the percentage dissociation of **HX** • All working is shown	2
• Calculates the percentage dissociation of **HX** without working	1

Sample answer: $[H^+] = 9.23 \times 10^{-4}$ M

% dissociation = $[X^-]/[HX] \times 100\% = (9.23 \times 10^{-4}\ \text{M}/0.05\ \text{M}) \times 100\% = 1.85\%$

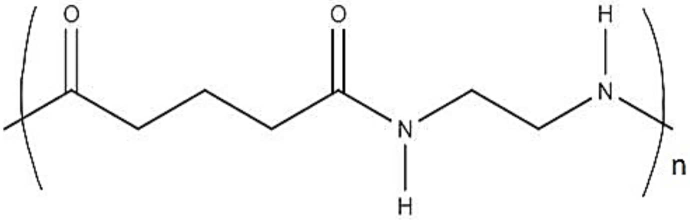
Note: % dissociation uses the conjugate base concentration (at equilibrium) and the initial acid concentration.

Q22 (7marks)

(a)

Criteria	**Marks**
• Draws the polyamide structure of two monomers with an amide linkage • The structure is representing a polymer with 'n' units shown	2
• Draws a substantially correct structure to represent the polymer	1

Sample answer:



(b)

Criteria	**Marks**
• Explains that the polymer contains many amide bonds which hold the monomers together • Identifies the process of nylon formation as condensation polymerisation	2
• Any information relevant to the above criteria	1

Sample answer: Nylon is formed through the process of condensation polymerisation. The polymer contains many amide bonds which hold the two different monomers together. The amide bond is part of the repeating unit of the polymer making it a 'polyamide'.

(c)

Criteria	**Marks**
• Calculates the molar mass of each molecule or monomer unit (as part of the polymer) • Calculates the mass of the polymer comprising 1,000 units of each monomer • Accounts for the two ends of the single chain polymer in the calculation	3
• Provides any TWO of the above criteria or equivalent combination	2
• Calculates the molar mass of any one molecule or monomer unit OR multiplies an incorrectly calculated molar mass by 1000 (or equivalent information)	1

Sample answer: The molar mass of the dicarboxylic acid monomer ($C_5H_6O_2$) is 98.098 g mol^{-1} (in polymer). The molar mass of the diamine monomer ($C_2H_6N_2$) is 58.088 g mol^{-1} (in polymer). The mass of the polymer when 1000 units of each monomer are reacted together:

= [(1000 x 98.098) + (1000 x 58.088) + 17.008 + 1.008] g/mol = 156,204 g mol^{-1}

Q23 (4 marks)

Criteria	**Marks**
• Calculates the moles of H^+ ions provided by the H_3PO_4 • Calculates the moles of OH^- ions provided by the solid NaOH • Calculates the moles of excess OH^- ions in the solution • Calculates the concentration of excess OH^- ions in 750 mL solution • Calculates the pOH of the solution • Calculates the pH of the solution	4

- Provides any FIVE of the above criteria (or equivalent)	3
- Provides any THREE of the above criteria (or equivalent)	2
- Provides any ONE correct calculation	1

Sample answer: mol H^+ = 0.1 M x 0.75 L x 3 = 0.225 mol H^+
MM NaOH = (22.99 + 16.0 + 1.008) g mol^{-1} = 39.998 g mol^{-1}
mol OH^- = 10 g/39.998 g mol^{-1} = 0.250 mol OH^-
Mol excess OH^- = 0.250 mol OH^- - 0.225 mol H^+ = 0.0250 mol OH^-
Conc. OH^- = 0.0250 mol/0.750 L = 0.03335 M
pOH = - log 0.03335 = 1.4769 $\therefore$ pH = 14 - 1.4769 = 12.5

Q24 (3 marks)

Criteria	Marks
- Identifies that the non-polar tail of a soap particle interacts with the oil/grease - Identifies that the charged head group of a soap particle interacts with water - Explains how the oil/grease is lifted from the surface to form micelles that are carried away	3
Any TWO of the following criteria (or equivalent combination): - Identifies that the non-polar tail interacts with the oil/grease - Identifies that the charged head group interacts with water - Describes the micelle structure of soap and oil/grease OR how the oil/grease is lifted off the surface to form micelles	2
- Any relevant information relating to the above criteria	1

Sample answer: The non-polar tail of soap particles dissolves in the oil/grease and the charged head group interacts with water. After many non-polar tails dissolve in the oil/grease, the stain is lifted from the surface and forms 3D micelles where the oil/grease is at the centre and the charged head groups are at the outer edge with the non-polar tails in between. The micelles of oil/grease are then carried away in the water.

Q25 (6 marks)
(a)

Criteria	Marks
- Provides a balanced chemical equation for the ionisation of ammonia in water - Includes an equilibrium arrow in the equation and states of matter for all molecular species	1

Sample answer: $NH_{3(aq)} + H_2O_{(l)} \rightleftharpoons NH_4{}^+{}_{(aq)} + OH^-{}_{(aq)}$

(b)

Criteria	Marks
- Calculates the $[OH^-]$ from ammonia ionisation in water - Provides an expression for the K_b of ammonia - Constructs an ICE chart or equivalent to calculate concentrations - Calculates the K_b using concentrations - Calculates the pK_b of ammonia	5
- Provides any FOUR of the above criteria (or equivalent)	4

- Provides any THREE of the above criteria (or equivalent)	3
- Provides any TWO of the above criteria (or equivalent)	2
- Provides the K_b expression or any ONE correct calculation	1

Sample answer:

pOH = 14 - pH = 14 - 10.62 = 3.38

$[OH^-] = 10^{-3.38} = 4.1687 \times 10^{-4}$ M

$K_b = [NH_4^+][OH^-]/[NH_3]$

	$[NH_3]$	**$[NH_4^+]$**	**$[OH^-]$**
I	0.01	0	0
C	$- 4.1687 \times 10^{-4}$	$+ 4.1687 \times 10^{-4}$	$+ 4.1687 \times 10^{-4}$
E	9.5831×10^{-3}	4.1687×10^{-4}	4.1687×10^{-4}

Using ICE chart concentrations:

$K_b = (4.1687 \times 10^{-4})^2/(9.5831 \times 10^{-3}) = 1.81 \times 10^{-5}$

$pK_b = -\log K_b = -\log 1.81 \times 10^{-5} = 4.74$

Q26 (3 marks)

Criteria	**Marks**
- Explains that the phosphate buffer regulates pH or maintains the $[H_3O^+]$ - Provides at least one equation to show how the buffer maintains the pH - Relates to the equation(s) to explain how the buffer manages excess acid and base	3
- Provides any TWO of the above criteria or equivalent combination	2
- Any relevant information relating to the above criteria	1

Sample answer: The phosphate buffer regulates pH by maintaining the $[H_3O^+]$, as shown by the following equation: $H_2PO_4^-{}_{(aq)} + H_2O_{(l)} \rightleftharpoons HPO_4^{2-}{}_{(aq)} + H_3O^+{}_{(aq)}$

When excess acid enters the buffer system, the backward reaction is favoured to reduce the $[H_3O^+]$. When excess base enters the buffer, the forward reaction is favoured to release H_3O^+ that will neutralise the base.

Q27 (8 marks)

Criteria	**Marks**
- Identifies the ions in unknown **A** as Ba^{2+} and OH^- - Identifies the ions in unknown **B** as Ca^{2+} and Cl^- - Eliminates ions to deduce the identity of cations **A** & **B** with the results of all cation tests - Eliminates ions to deduce the identity of anions **A** & **B** with the results of all anion tests - All other possible cations & anions are eliminated - No incorrect and/or irrelevant information is included in the response	8
- Provides the above information with ONE error in justification or some missing information	7
- Identifies the ions in unknown **A** as Ba^{2+} and OH^- - Identifies the ions in unknown **B** as Ca^{2+} and Cl^- *And provides any THREE of the following criteria:* - Eliminates ions to deduce the identity of cation **A** with key precipitation & flame tests - Eliminates ions to deduce the identity of cation **B** with key precipitation & flame tests - Eliminates ions to deduce the identity of anion **A** with key precipitation & H^+ tests - Eliminates ions to deduce the identity of anion **B** with key precipitation & H^+ tests	6

• Identifies any TWO of the four ions in the unknown **A** and/or **B** *And provides any THREE of the following criteria or equivalent combination:* • Identifies the remaining TWO of the four ions in unknown **A** and/or **B** • Eliminates ions to deduce the identity of cation **A** with key precipitation & flame tests • Eliminates ions to deduce the identity of cation **B** with key precipitation & flame tests • Eliminates ions to deduce the identity of anion **A** with key precipitation & H^+ tests • Eliminates ions to deduce the identity of anion **B** with key precipitation & H^+ tests	5
• Identifies any TWO of the four ions in unknown **A** and/or **B** • Eliminates ions to deduce the identity of these identified ions with key cation/anion tests **OR** *Provides any THREE of the following criteria or equivalent combination:* • Identifies any TWO of the four ions in unknown **A** and/or **B** • Identifies the remaining TWO of the four ions in unknown **A** and/or **B** • Supports the identity of any TWO ions with the results of some cation/anion tests • Supports the identity of the remaining TWO ions with the results of some cation/anion tests	4
• Provides any TWO of the above criteria or equivalent combination	3
• Identifies any ONE ion and supports the identity with the results of cation/anion tests **OR** • Any TWO ions are identified correctly	2
• Any ONE ion is correctly identified or provides some relevant information	1

Sample answer:

Ion Identity	***Justification for Identity***
Cation A: Ba^{2+}	• White ppt with SO_4^{2-} eliminates Ca^{2+} (slightly insoluble*), Cu^{2+} (soluble) and Fe^{3+} (soluble). White ppt with PO_4^{3-} eliminates Cu^{2+} (blue ppt). • Green flame test indicates Ba^{2+}, eliminates Ca^{2+} (brick red) and Fe^{3+} (gold). • White ppt with CO_3^{2-} confirms Ba^{2+}. Therefore, **cation A** must be **Ba^{2+}**.
Cation B: Ca^{2+}	• No ppt with SO_4^{2-} eliminates Ba^{2+} (white ppt). White ppt with PO_4^{3-} eliminates Cu^{2+} (blue ppt). • Red flame test indicates Ca^{2+}, eliminates Ba^{2+} (green), Cu^{2+} (green) and Fe^{3+} (gold). • White ppt with CO_3^{2-} confirms Ca^{2+}. Therefore, **cation B** must be **Ca^{2+}**.
Anion A: OH^-	• Brown ppt with Ag^+ eliminates Cl^- (white ppt), CO_3^{2-} (white ppt), SO_4^{2-} (slightly insoluble*), and PO_4^{3-} (yellow ppt). Soluble with Ba^{2+} and Ca^{2+}, indicating OH^-. • No bubbles with H^+ eliminating CO_3^{2-} • Therefore, **anion A** must be **OH^-**.
Anion B: Cl^-	• White ppt with Ag^+ eliminates SO_4^{2-} (very slightly insoluble*), OH^- (brown ppt) and PO_4^{3-} (yellow ppt). Soluble with Ba^{2+} and Ca^{2+}, indicating Cl^-. • No bubbles with H^+ eliminating CO_3^{2-}. • Therefore, **anion B** must be **Cl^-**.

***Note:** Sulfate does not precipitate significantly with calcium and silver. Precipitation requires quite high concentrations. Note also that $Ba(OH)_2$ and $Ca(OH)_2$ are quite soluble and would not appear as precipitates at low concentrations.

Q28 (6 marks)

Criteria	Marks
• Describes the preparation of a *standard solution* • Describes the technique used to perform a serial dilution • Identifies the chemical required ($KMnO_4$) and all equipment • Explains how the absorbance of all solutions (incl. **X**) is measured using the colorimeter • Describes the construction of a calibration curve using the absorbance and concentration data • Explains how the concentration of solution **X** is determined using the calibration curve	6
• Provides all of the above information but with minor errors and/or some detail missing	5
Any FOUR of the following (or equivalent combination): • Outlines the preparation of a *standard solution* • Outlines the technique used to perform a serial dilution • Identifies the chemical required ($KMnO_4$) and <u>most</u> equipment • Outlines how the absorbance of all solutions (incl. **X**) is measured using the colorimeter • Outlines the construction of a calibration curve using the absorbance and concentration data • Identifies that the concentration of solution **X** is determined using the calibration curve	4
• Provides any THREE of the above criteria or equivalent combination	3
• Provides any TWO of the above criteria or equivalent combination **OR** • Provides an overview of the process required	2
• Provides any ONE of the above criteria or equivalent relevant information	1

Sample answer: Determining the concentration of solution **X** requires the use of a calibration curve, which is constructed from standard solutions. First, we need to weigh out the required amount of $KMnO_4$ solid on an electronic balance to prepare the first standard solution in a 250 mL volumetric flask. The solid is dissolved in a small beaker and then poured into a clean volumetric flask. The solution is fully washed into the flask with water and the solution level made up to the calibration line with water. The lid is fitted and the solution is mixed thoroughly.

We then need to perform a serial dilution to make the set of standard solutions across a range of concentrations. To do this we need to measure 25 mL of the solution with a bulb pipette and transfer this to another clean 250 mL volumetric flask. The choice of flask size depends on the dilution required. The pipette should be washed with water and then the solution to be measured before using it to measure the solution volume to be transferred. The second standard solution is made up to the calibration line and mixed thoroughly before the process is completed again to obtain the third and fourth standard solutions.

The absorbance of all standard solutions is then measured using the colorimeter. As the solution is purple, the solution's absorbance in the opposite colour is measured (green). The colorimeter is set to the colour required and calibrated to zero with distilled water in a cuvette. Then a small volume of the first standard solution is poured into a clean cuvette and the absorbance measured by the colorimeter. The absorbance is recorded in a table. This process is repeated for each standard solution. The absorbance of solution **X** is also measured.

The absorbance data is then graphed against the known concentrations to obtain a calibration curve. The recorded absorbance of solution **X** is then used to determine its concentration from the graph. Straight lines are drawn from the Y axis to the graphed line and then to the x axis to read off the concentration for solution **X**.

Q29 (8 marks)

(a)

Criteria	**Marks**
• Provides a balanced chemical equation for the reaction between Ibuprofen and NaOH • The equation shows that Ibuprofen loses a proton and includes all states of matter	1

Sample answer: $C_{13}H_{18}O_{2(aq)} + NaOH_{(aq)} \rightarrow C_{13}H_{17}O_2Na_{(aq)} + H_2O_{(l)}$

Note: The Ibuprofen reactant may be written with the solid state of matter.

(b)

Criteria	**Marks**
• Calculates the average titre using titration runs 2, 3 and 4 only • Calculates the moles of NaOH used • Applies the mole ratio to calculate the moles of Ibuprofen in the tablet (125 mL solution) • Calculates the mass of Ibuprofen in the tablet • Calculates the percentage composition (%w/w) of Ibuprofen in the tablet	5
• Provides the above information with ONE error only	4
Any THREE of the following criteria (or equivalent combination): • Calculates the average titre using titration runs 2, 3 and 4 only • Calculates the moles of NaOH used • Applies the mole ratio to calculate the moles of Ibuprofen in the tablet (125 mL solution) • Calculates the mass of ibuprofen in the tablet • Calculates the percentage composition (%w/w) of Ibuprofen in the tablet	3
• Provides any TWO of the above criteria or equivalent combination	2
• Provides any ONE correct calculation	1

Sample answer: Average titration volume = (38.60 + 38.55 + 38.65)/3 = 38.6 mL (don't include the outlier)
Moles of NaOH used: n = cV = 0.00502 M x 0.0386 L = 0.000193772 mol
Reaction mole ratio of Ibuprofen to NaOH is 1:1 $\therefore$Moles Ibuprofen = 0.000193772 mol (in 25 mL aliquot)
Moles Ibuprofen in 125 mL (entire tablet) = 5 x moles in 25 mL = 5 x 0.000193772 mol = 0.0009689 mol
MM Ibuprofen ($C_{13}H_{18}O_2$) = [(12.01 x 13) + (1.008 x 18) + (16.0 x 2)] g mol^{-1} = 206.274 g mol^{-1}
Mass Ibuprofen in the tablet = n x MM = 0.0009689 mol x 206.274 g mol^{-1} = 0.19985 g
% composition = (0.19985 g/0.256 g) x 100% = 78.1%

(c)

Criteria	**Marks**
• Identifies that the titration involves a weak acid and strong base • Identifies that the equivalence point of the titration will be > pH 7 • Explains that phenolphthalein changes colour in the pH range of the equivalence point	2
• Provides any ONE of the above criteria	1

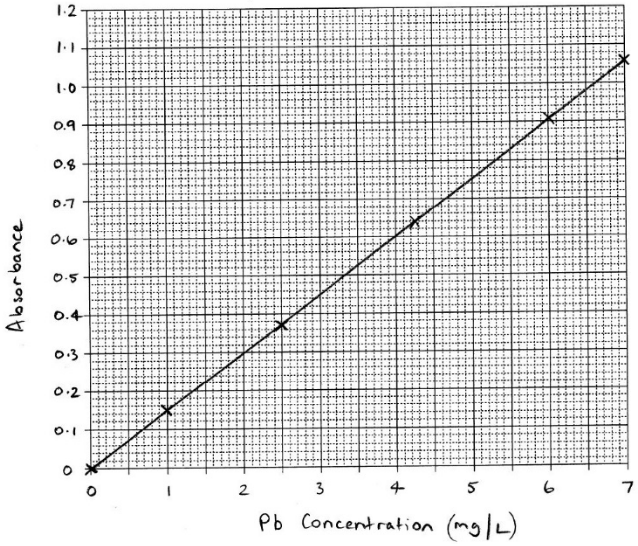
Sample answer: The titration involves a weak acid and strong base, which means the pH of the equivalence point will be above pH 7. Phenolphthalein is suitable as it changes colour in the pH range of the equivalence point.

Q30 (10 marks)

(a)

Criteria	**Marks**
• Labels both axes correctly with units on the X axis only (absorbance has no units) • Draws consistent numerical scales • Correctly plots all data points • Draws a straight line of best fit through the data points • Places the independent variable on the X axis	4
Any THREE of the following criteria: • Labels both axes correctly with units on the X axis only (absorbance has no units) • Draws consistent numerical scales • Correctly plots all data points • Draws a straight line of best fit through the data points	3
Any TWO of the following criteria: • Labels both axes correctly with units on the X axis only (absorbance has no units) • Draws consistent numerical scales • Correctly plots all data points • Draws a straight line of best fit through the data points	2
• Provides a correct numerical scale relevant to the graph	1

Sample answer:



(b)

Criteria	**Marks**
• Provides an estimate of Pb concentration based on the graph drawn and given absorbance	1

Sample answer: 4.75 mg/L

Note: Units were not required to obtain the mark.

(c)

Criteria	**Marks**
• Uses the concentration to calculate the total mass of Pb in the soil sample • Calculates the concentration of Pb in the soil sample (mg/kg) • Provides a relevant statement on the calculated level of Pb in the soil	3
• Uses the concentration to calculate the total mass of Pb in the soil sample • Calculates the concentration of Pb in the soil sample (mg/kg)	2

- Provides any ONE correct and relevant calculation	1

Sample answer: The concentration of Pb in the diluted sample is 4.75 mg/L

Mass Pb in the 800 mL sample = 0.8 L x 4.75 mg/L = 3.8 mg

∴ The mass of Pb in the 12.2 g soil sample is 3.8 mg

Concentration of Pb in the 12.2 g soil sample = 3.8 mg/0.0122 kg = 311 mg/kg

∴ The Pb concentration in the soil is above the acceptable level.

(d)

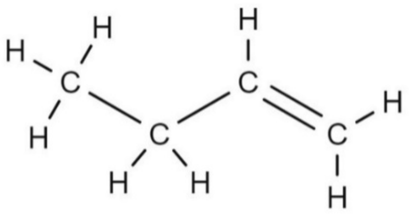
Criteria	Marks
- States that the standard solutions have a known concentration - Explains that the standards are used to construct a calibration curve to show how absorbance relates to concentration - Identifies that the graph enables the concentration of the Pb sample to be determined	2
- Provides any ONE of the above criteria or equivalent information	1

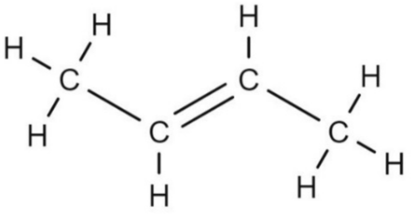
Sample answer: The standard solutions have a known concentration of Pb. The solutions are measured in order to construct a calibration curve to show the relationship between absorbance and concentration. This graph is then used to determine the concentration of the Pb sample.

Q31 (10 marks)

Criteria	Marks
- Draws the structures of compounds **A** and **B** - Provides the structural formula for each compound	3
- Draws the structures of compounds **A** and **B** in any format **OR** - Draws the structural formula of compound **A** or **B**	2
- Draws a correct structure for compound **A** or **B** in any format	1

Sample answer: Compounds **A** and **B** (but-1-ene and but-2-ene)





(b)

Criteria	Marks
- Provides the IUPAC names for compounds **C** and **D**	2
- Provides the IUPAC name for compound **C** or **D** **OR** - Provides the IUPAC name of the aldehyde **D** where **C** is identified as the primary alcohol	1

Sample answer: Compound **C** is butan-2-ol. Compound **D** is butan-2-one (or butanone).

Note: Where compound **C** was incorrectly identified as butan-1-ol, a mark was awarded for identifying compound **D** as butanal, which is the oxidation product of butan-1-ol and has the chemical formula indicated in the question.

(c)

Criteria	Marks
• Identifies reagent **X** as HBr • Identifies compound **E** as 2-bromobutane • Describes the formation of <u>one</u> addition product from but-1-ene • Uses Markovnikov's rule to explain the formation of only 2-bromobutane from but-1-ene • Explains the formation of only <u>one</u> addition product from the symmetrical but-2-ene	5
• Provides any FOUR of the above criteria (or equivalent combination)	4
• Provides any THREE of the above criteria (or equivalent combination)	3
• Provides any TWO of the above criteria (or equivalent combination)	2
• Provides any ONE of the above criteria or equivalent information	1

Sample answer: Reagent **X** is HBr. Compound **E** is 2-bromobutane. When but-1-ene reacts, there is only one possible product from the reaction due to Markovnikov's rule which ensures that the H atom attaches to the terminal carbon and the Br atom attaches to the second carbon. When but-2-ene reacts, the H and Br can add to either carbon in the double bond, but each reaction gives the same compound as the alkene is symmetrical – the product is always 2-bromobutane, which is the same compound produced from the reaction with the other alkene isomer.

Q32 (3 marks)

(a)

Criteria	Marks
• Provides a balanced net ionic equation for the neutralisation reaction	1

Sample answer: $CO_{2(g)} + OH^-_{(aq)} \rightarrow HCO_3^-{}_{(aq)}$

Note: CO_2 may be written with the aqueous state.

(b)

Criteria	Marks
• Defines the Brønsted-Lowry acid-base theory as involving proton transfer (acid to base) • States that the reaction of CO_2 with OH^- does not involve any proton transfer	2
• Provides any ONE of the above criteria or equivalent information **OR** • Describes the reaction as a Lewis acid-base reaction involving electron pair transfer from the base to acid	1

Sample answer: Brønsted-Lowry acid-base reactions involve the transfer of protons from the acid to the base. In this reaction, there is no transfer of protons so the acid-base reaction is not a Brønsted-Lowry reaction.

Q33 (7 marks)

Criteria	Marks
• Describes the features of *gravimetric analysis* relating to accuracy and time requirement • Summarises the *gravimetric analysis process* that could be used to analyse for Ag^+ • Describes the features of *precipitation titration* relating to accuracy and time requirement • Summarises the *precipitation titration process* that could be used to analyse for Ag^+ • Describes the features of *AAS* relating to accuracy and time requirement • Summarises the *AAS process* that could be used to analyse for Ag^+ • Provides a supported judgement on the most suitable technique for the analysis to ppb levels	7
• Provides the above criteria with minor errors or missing some information	6
Any FIVE of the following (or equivalent combination): • Describes the features of *gravimetric analysis* relating to accuracy and time requirement • Outlines the *gravimetric analysis process* that could be used to analyse for Ag^+ • Describes the features of *precipitation titration* relating to accuracy and time requirement • Outlines the *precipitation titration process* that could be used to analyse for Ag^+ • Describes the features of *AAS* relating to accuracy and time requirement • Outlines the *AAS process* that could be used to analyse for Ag^+ • Provides a judgement on the most suitable technique for the analysis	5
• Provides any FOUR of the above criteria or equivalent combination	4
• Provides any THREE of the above criteria or equivalent combination	3
• Provides any TWO of the above criteria or equivalent combination	2
• Any relevant information relating to the above criteria	1

Sample answer: When choosing which method to use, the chemist needs to consider the concentration range to be measured and how easily the analysis can be performed, as many samples will need to be analysed for the monitoring of silver to be effective.

For gravimetric analysis to be used, this would involve precipitating out the silver by the addition of a suitable anion (eg Cl^-) and then filtering and drying the solid before weighing it to determine the amount of silver that had been present in the sample. This method is time consuming and would require higher concentrations than ppb levels for the precipitate to be easily collected from the sample. The gravimetric analysis of such a low concentration sample is likely to be unreliable and inaccurate. Additionally, the samples may have other ions present that also precipitate with the anion used, leading to an inaccurate result.

Alternatively, the chemist might choose the precipitation titration technique as this would give a more accurate result for a low concentration sample. The chemist would need to obtain a suitable standard solution (eg Cl^-) and an indicator (eg chromate ions) which could indicate the equivalence point in order to use this method. The silver sample is titrated against the standard solution to form a precipitate. The equivalence point of the titration is indicated by the formation of a coloured complex with silver, which only forms when all the chloride has been precipitated. While the result is likely to be much more accurate, though the problem of sample impurity is still an issue, the analysis would require that a titration is performed on every sample and this would be time consuming where there are multiple samples to analyse.

If AAS is selected, the chemist would be choosing a technique which is both accurate to ppb concentrations and relatively fast, ensuring that multiple samples could be analysed with ease. AAS is a very sensitive technique that can selectively measure concentrations of metal ions to the ppb level. For AAS to be used, the chemist would need to have prepared standard solutions for silver and measured the absorbance of these solutions on an atomic absorption spectrometer. However, once this has been completed, many samples could be analysed for the concentration of silver relatively quickly and easily. The spectrometer uses a hollow cathode lamp which selects for silver in the sample, eliminating the issue of sample impurity. The measured absorbance can be attributed to the silver in the sample and compared against the calibration curve to determine concentration.

Therefore, the chemist should choose AAS for the ongoing effective monitoring of silver in the water samples. While analysis by AAS does require access to a spectrometer, this technique is the most suitable as it allows for very low concentrations to be analysed accurately, and is the least time consuming of the three techniques.