Student Number: .....

Ascham School

2020 SEMESTER II EXAMINATION

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 3hr
- Write using black pen
- Draw diagrams using pencil
- Board-approved calculators may be used
- A data sheet and a Periodic Table are provided at the back of this paper

Total marks – 100
This section has two parts, Part A and Part B

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

Part B – 80 marks
- Attempt Questions 21–29
- Allow about 2 hour and 25 minutes for this part

Student Number: .....

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

Use the multiple-choice answer sheet.

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

Sample: $2 + 4 =$ (A) 2 (B) 6 (C) 8 (D) 9

A B C D

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word **correct** and drawing an arrow as follows.

SECTION I

Part A – 20 marks

Multiple Choice
Attempt Questions 1-20
Allow about 35 minutes for this part

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

1. What is the equilibrium expression (K eq) for the reaction $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$?

(A) $\frac{[NO]}{[N_2][O_2]}$

(B) $\frac{[NO]^2}{[N_2][O_2]}$

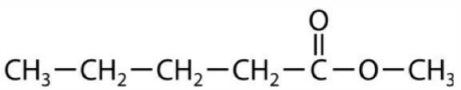
(C) $\frac{[N_2][O_2]}{[NO]^2}$

(D) $\frac{[N]^2[O]^2}{[2NO]}$

2. Which aqueous solution turns universal indicator blue-purple?

(A) H_2SO_4
(B) NaOH
(C) NH_4Cl
(D) CH_3COOH

3. What is the IUPAC name for this compound?



(A) 1-oxyhexan-2-one
(B) Pentyl methanoate
(C) Methyl pentanoate
(D) 1-methylpentanoic acid

4. The indigenous peoples of the Tiwi Islands in Northern Australia process yams (sweet potatoes) to make a food called Bitter Yam. Which of the following is an example of the use of solution equilibria to remove toxins from these yams?

(A) Fermenting
(B) Grinding
(C) Roasting
(D) Leaching

5. A sample of 1-bromoethane is heated under reflux with aqueous sodium hydroxide. What would be the most likely products of this reaction?

(A) Ethene and bromine
(B) Ethanol and bromine
(C) Ethanol and sodium bromide
(D) Ethene, water and sodium bromide

6. Which of the following pairs of compounds are positional isomers?

(A) pentan-2-one and pentanal
(B) pentan-2-one and pentan-3-one
(C) pentan-2-one and 3-methylbutanal
(D) pentan-2-one and 3-methylbutan-2-one

7. An unknown solution was tested. The following results were obtained.

Test	*Reaction*
Flame test	Apple green
Dilute HCl was added	No reaction
Na_2SO_4 was added	A white precipitate formed
$AgNO_3$ was added	A white precipitate formed

What compound was in the solution?

(A) Copper sulfate
(B) Copper carbonate
(C) Barium chloride
(D) Barium carbonate

8. Which equation demonstrates a limitation of the Bronsted-Lowry model of acids and bases?

(A) $BF_3 + NH_3 \rightarrow F_3BNH_3$
(B) $HCl + NaOH \rightarrow NaCl + H_2O$
(C) $PO_4^{3-} + HNO_2 \rightarrow NO_2^- + HPO_4^{2-}$
(D) $H_2SO_4 + H_2O \rightarrow HSO_4^- + H_3O^+$

9. Which row on the table ranks the compounds from lowest to highest pH?

	Lowest pH ----------> Highest pH			
(A)	trichloroethanoic acid	ethanoic acid	ethanamide	ethanamine
(B)	ethanoic acid	trichloroethanoic acid	ethanamine	ethanamide
(C)	ethanamine	ethanamide	trichloroethanoic acid	ethanoic acid
(D)	ethanamide	ethanamine	ethanoic acid	trichloroethanoic acid

10. Soaps and detergents have similar characteristics. Which set of criteria correctly identifies a detergent, but NOT a soap?

I. Ineffective in hard water
II. Only some are biodegradable
III. Always an ion
IV. Produced from natural fats or oils

(A) II
(B) II, IV
(C) I, III
(D) I, III, IV

11. At the end of a particular experiment, a chemist was left with several materials to be disposed of in a safe manner. These included:

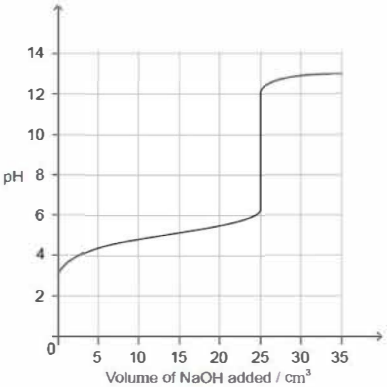
i. 120mL of cyclohexane
ii. 150mL unused 1M Na_2SO_4
iii. A solid compound of lead (produced during gravimetric analysis), dried and weighed on filter paper.

Which of the following describes an appropriate method of disposal for each of the above wastes?

	120mL cyclohexane	**150mL 1M Na_2SO_4**	**Solid lead compound**
(A)	Waste container labelled "Organic Liquids Only"	A stock bottle of Na_2SO_4 prepared for the experiment	In the rubbish bin
(B)	Waste container labelled "Organic Liquids Only"	Down the sink	Waste container labelled "Heavy Metals Only"
(C)	Waste container labelled "Aqueous Waste Only"	Waste container labelled "Aqueous Waste Only"	In the rubbish bin
(D)	Waste container labelled "Aqueous Waste Only"	A stock bottle of Na_2SO_4 prepared for the experiment	Waste container labelled "Heavy Metals Only"

The following information refers to questions 13 and 14.

A monoprotic acid, HA, was titrated with 0.100 mol L^{-1} NaOH. The following curve was obtained using a pH probe.



12. What was the strength of the acid?
    (A) Strong acid since the initial pH is low
    (B) Strong acid since the equivalence point is 9
    (C) Weak acid since the final pH is high
    (D) Weak acid since the equivalence point is 9

13. Which indicator would be appropriate to use?
    (A) Universal
    (B) Methyl orange
    (C) Phenolphthalein
    (D) Bromothymol blue

14. The acid H_3PO_4 dissociates in the following sequential way:

$$H_3PO_4(aq) \rightleftharpoons H^+(aq) + H_2PO_4^-(aq)$$
$$H_2PO_4^-(aq) \rightleftharpoons H^+(aq) + HPO_4^{2-}(aq$$
$$HPO_4^{2-}(aq) \rightleftharpoons H^+(aq) + PO_4^{3-}(aq)$$

Which of these compound(s) are amphiprotic?

    (A) HPO_4^{2-} only
    (B) $H_2PO_4^-$ and PO_4^{3-}
    (C) HPO_4^{2-} and PO_4^{3-}
    (D) $H_2PO_4^-$ and HPO_4^{2-}

The following information should be used to answer questions 15 and 16.

Coal is mostly composed of carbon solid, and is a major source for electricity. However, it is a limited resource and may run out in about 150 years. A student conducting research found the following information:

$$C(s) + CO_2(g) \rightleftharpoons 2CO(g)$$

$\Delta G < 0$ (in the forward direction) when $T > 1100K$

15. How could this equation be used to produce more coal in the school laboratory?

(A) Use a smaller container to decrease the volume of the vessel
(B) Use some dry ice to add more carbon dioxide to the vessel
(C) Use a larger container to decrease the pressure of the vessel
(D) Use a hot water bath to increase the temperature in the vessel

16. At a particular temperature, a mixture of 200g of coal and 0.70 moles of carbon monoxide were introduced into a 3.0L vessel. At equilibrium, 0.30 moles of carbon dioxide was present. What was the value of **K** at this temperature?

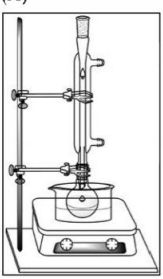
(A) 0.011
(B) 0.033
(C) 0.53
(D) 1.3

The following information should be used to answer questions 17 and 18.

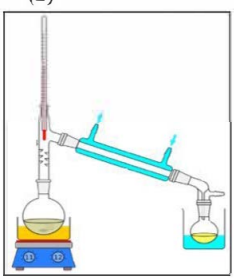
An ester was produced in the school laboratory.

17. Which set of equipment would have been used to produce the ester?

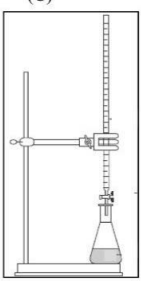
(A)



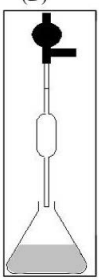
(B)



(C)



(D)



18. Gravimetric analysis of the ester gave a percentage composition by mass of C: 62.0% and H: 10.4% and a molar mass of approximately 116 $gmol^{-1}$. What is its molecular formula?

(A) C_8H_{16}
(B) C_8H_{20}
(C) C_3H_6O
(D) $C_6H_{12}O_2$

19. In an experiment, 4-hydroxybutanoic acid [$HO(CH_2)_3COOH$] forms a polymer containing 1000 monomer units.

Which of the following is closest to the approximate molar mass (in g mol^{-1}) of this polymer?

(A) 2.0×10^2
(B) 1.4×10^4
(C) 8.6×10^4
(D) 1.0×10^5

20. An antacid containing some magnesium oxide was tested. 40.6 g of antacid was dissolved in 500.0mL of water, then diluted to 1.00L. A 100mL aliquot was then removed and reacted with 100mL of 2.00 mol L^{-1} hydrochloric acid.

The excess acid required 19.7 mL of 0.200 mol L^{-1} sodium hydroxide for neutralisation.

What is the percentage of magnesium oxide in the antacid table?

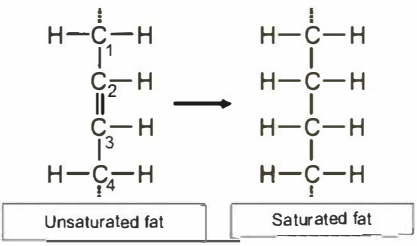
(A) 9.93%
(B) 19.5%
(C) 38.9%
(D) 97.3%

Part B – Extended Response Questions (80 marks)

Question 21 (10 marks)

(a) How does the structure of soap help it to remove fats? You may use a diagram in your answer (3 marks)

Two types of fats, unsaturated and saturated, are shown below. The carbons are numbered on the unsaturated fat.



(b) What shapes would the first and second carbons in the unsaturated fat display? (1 mark)

(c) Unsaturated fats are liquids at room temperature but can be hardened into solids by converting them to saturated fats. Other than their state, how could a fat be tested to ensure it was unsaturated? (2 marks)

QUESTION CONTINUES ON THE NEXT PAGE

(d) What type of reaction would be used to convert the unsaturated fat to a saturated fat?
(1 mark)

(e) Crude oil contains many unsaturated hydrocarbons and can be used to produce polymers.
Outline the structure and ONE property with its related use for an addition polymer.
(3 marks)

EXAMINATION CONTINUES ON THE NEXT PAGE

Question 22 (9 marks)

Pink Lake is a salt lake in Victoria that dries during the summer months leaving a bed of pink salt. Aboriginal Australians may have used the salt in their diet, and the salts are now commercially harvested during summer, before the rains turn the area back into a lake.

(a) Explain how pink salt dissolves in rainwater. Use diagrams to support your answer. (4 marks)

Analysis of the salt shows that as well as sodium chloride it contains traces of calcium, phosphate and copper.

(b) Using the information provided, why should the Pink Lake environment be monitored by chemists? (3 marks)

QUESTION CONTINUES ON THE NEXT PAGE

(c) How have Aboriginal Australians used acid/base analysis techniques? (2 marks)

EXAMINATION CONTINUES ON THE NEXT PAGE

Question 23 (6 marks)

A student conducting solubility tests mixed 10mL of 0.01M $AgNO_3$ with 10mL of 0.0001M NaCl.

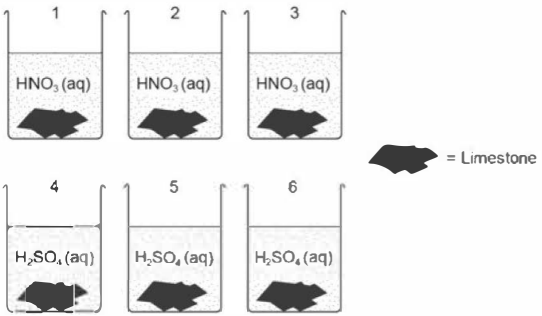
(a) Using calculations, demonstrate whether a precipitate would be produced. (4 marks)

(b) What mass of precipitate was produced? (2 marks)

EXAMINATION CONTINUES ON THE NEXT PAGE

Question 24 (9 marks)

A student investigated how acid affects limestone (a material mostly composed of calcium carbonate, but also containing small amounts of calcium sulfate). The student set up the experiment as shown below, using 200mL of 0.1 mol L^{-1} nitric acid in 3 beakers and 200mL of 0.1 mol L^{-1} sulfuric acid in the other 3 beakers.

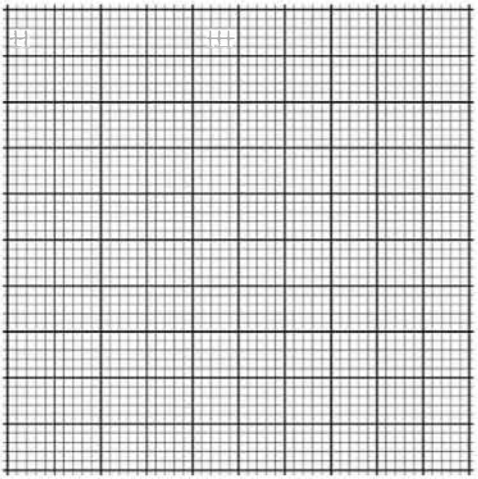


Each day the student removed the limestone from the acid, washed it and then dried it with paper towel. The student then weighed the limestone on electronic scales and replaced it in the beaker.

The student's results for nitric acid are shown below:

Time (days)	*Average mass of limestone sample (g)*
0	48.08
1	47.97
2	47.94
3	47.91
4	47.91
5	47.91

(a) Draw a graph of the results for the nitric acid experiment (3 marks)



(b) Explain why the rate of reaction decreases over the 5 days (2 marks)

(c) The student hypothesised that sulfuric acid would cause a larger mass loss than nitric acid. Justify this hypothesis (2 marks)

QUESTION CONTINUES ON THE NEXT PAGE

Unexpectedly, when the student compared the mass losses, she found that more mass was lost in the nitric acid than in the sulfuric acid.

(d) The student decided to examine the solubility rules and relevant Ksp data to see if this would help to explain the unexpected result.

Suggest an explanation for why there was greater mass loss in nitric acid than in sulfuric acid. Use equations to support your answer. (2 marks)

EXAMINATION CONTINUES ON THE NEXT PAGE

Question 25 (5 marks)

Fuels can be obtained from a variety of sources. Assess the benefits and limitations of using ethanol as a fuel compared to ONE other fuel source. (5 marks)

EXAMINATION CONTINUES ON THE NEXT PAGE

Question 26 (8 marks)

Gold mining often uses cyanide (CN^-) to help remove gold from ore. A scientist decided to test if the water in a river near a gold mine contained excessive levels of cyanide (the maximum allowable level for drinking water is 0.5 mg/L). The scientist used a variety of methods to determine the concentration of cyanide.

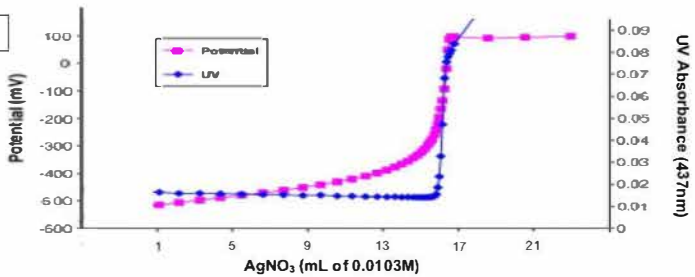
Test 1:

1. Took 200.00mL sample from river
2. Diluted sample up to 1000.00mL
3. Conducted a precipitation titration using silver nitrate (initially, the silver nitrate combines with CN^- to form $[Ag(CN)_2]^-$ (a colourless silver cyanide complex). Once all the CN^- is used up, the silver nitrate reacts with the $[Ag(CN)_2]^-$ and forms AgCN, a white precipitate. In the reaction, the scientist started with 0.0100M silver nitrate and filled the burette to a reading of 60.00mL. At the end of the reaction, the burette read 42.43mL. A blank titration caused precipitation to occur with 0.870mL of $AgNO_3$.

Test 2:

4. The scientist repeated the titration on a fresh, undiluted 200.00mL sample but used a conductivity (potential difference) titration and graphed the results to determine the endpoint of the titration (Figure 1).
5. The scientist repeated the titration on a fresh, undiluted 200.00mL sample but using UV absorbance to determine the endpoint of the titration (Figure 1).

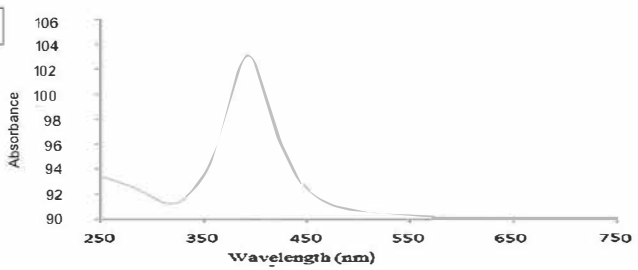
Figure 1



Test 3:

6. The scientist used UV-Vis spectroscopy to measure the concentration of CN- ions using the oxidation of cyanide with chlorine (Figure 2). The scientist used an undiluted 200.00mL sample in a 1.00cm cuvette and determined the molar absorptivity for cyanide was 5.87×10^4 mol^{-1} cm^{-1}.

Figure 2



Examine the results and concentrations the scientist obtained in each experiment. Evaluate the scientist's methods and results. (8 marks)

EXAMINATION CONTINUES ON THE NEXT PAGE

Question 27 (11 marks)

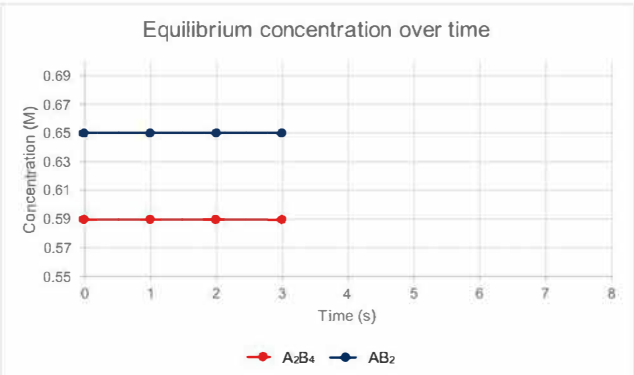
An equilibrium has the generalised equation:

$$2AB_2 \rightleftharpoons A_2B_4 \qquad \Delta H = -250 kJ\ mol^{-1}$$

At time t = 3s, the temperature was increased.

(a) Both Le Chatelier's Principle and collision theory state that the position of the equilibrium would change. Compare these TWO theories to explain the effect of the temperature change, including the effect of temperature change on activation energy and reaction rate. (4 marks)

(b) After the temperature was increased, the new equilibrium position was reached at 6s. Sketch the concentrations after t=3. (2 marks)



QUESTION CONTINUES ON THE NEXT PAGE

(c) What would be the effect of the increase in temperature on the value of Keq? (1 mark)

(d) Describe an investigation to determine the K_{eq} of a chemical equilibrium system. Include an equation and approximate results in your answer. (4 marks)

EXAMINATION CONTINUES ON THE NEXT PAGE

Question 28 (13 marks)

(a) 21mL of 0.210 mol L^{-1} hydrochloric acid was added to 31mL of 0.210 mol L^{-1} sodium hydroxide. What was the pH of the resulting solution? (4 marks)

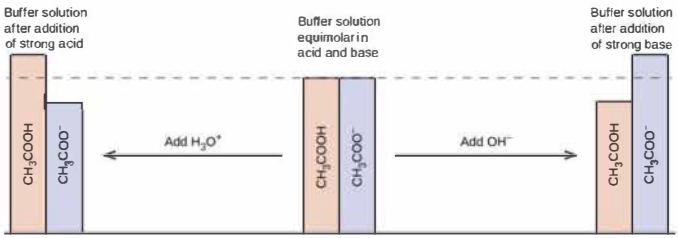
(b) (i) The pH of a 0.125 mol L^{-1} solution of benzoic acid (C_6H_5COOH) is 2.83. Calculate the Ka of the benzoic acid solution. (3 marks)

(ii) Calculate the pKa of the benzoic acid. (1 mark)

(iii) Calculate the percentage dissociation of the benzoic acid. (1 mark)

QUESTION CONTINUES ON THE NEXT PAGE

(c) A student found a model of a buffer system to help explain how an acetic acid/acetate ion buffer system works:



Assess the effectiveness of the model in explaining the chemistry of buffers. Include an equation in your answer. (4 marks)

EXAMINATION CONTINUES ON THE NEXT PAGE

Question 29 (9 marks)

Propene is an important starting material for many products.

A student wrote the following notes about propene and its products:

Reactions	C_3H_6 --> C_3H_7Cl --> C_3H_8O --> C_3H_6O Various reactants and conditions are needed to complete the above reactions
Molar Enthalpy of Combustion	C_3H_8O undergoes complete and incomplete combustion. In the classroom, 180mL of water was heated using 1.05g of C_3H_8O. This caused the water temperature to increase by 42°C. In the SI data book at 25.0°C, the standard molar entropy was 193 J mol^{-1} K^{-1} and the molar Gibbs free energy was -2078.5 kJ mol^{-1}.
Boiling Point	C_3H_8O has a higher boiling point than C_3H_6O

Explain the student's notes. Include equations in your answer. (9 marks)

END OF EXAMINATION PAPER

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Student Number: .....

2019 | HIGHER SCHOOL CERTIFICATE EXAMINATION

Chemistry

FORMULAE SHEET

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

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

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

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}

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
$\frac{1}{2}I_2(s) + c^-$	$\rightleftharpoons$	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

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

KEY

Atomic Number
Symbol
Standard Atomic Weight
Name

79 Au 197.0 Gold

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 Number: .....

Student Number: .....

HSC CHEMISTRY

S2 Examination

Multiple Choice Answer Sheet

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

Student Number: .....

Ascham School

2020 SEMESTER II EXAMINATION

MARKING GUIDELINES AND SAMPLE ANSWERS

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 3hr
- Write using black pen
- Draw diagrams using pencil
- Board-approved calculators may be used
- A data sheet and a Periodic Table are provided at the back of this paper

Total marks – 100
This section has two parts, Part A and Part B

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

Part B – 80 marks
- Attempt Questions 21–29
- Allow about 2 hour and 25 minutes for this part

Student Number: .....

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

Use the multiple-choice answer sheet.

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

Sample: $2 + 4 =$ (A) 2 (B) 6 (C) 8 (D) 9

A B C D

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word **correct** and drawing an arrow as follows.

SECTION I

Part A – 20 marks

Multiple Choice
Attempt Questions 1-20
Allow about 35 minutes for this part

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

1. What is the equilibrium expression (**K**eq) for the reaction $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$?

(A) $\frac{[NO]}{[N_2][O_2]}$

(B) $\frac{[NO]^2}{[N_2][O_2]}$

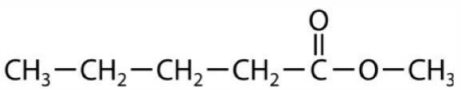
(C) $\frac{[N_2][O_2]}{[NO]^2}$

(D) $\frac{[N]^2[O]^2}{[2NO]}$

2. Which aqueous solution turns universal indicator blue-purple?

(A) H_2SO_4
(B) NaOH
(C) NH_4Cl
(D) CH_3COOH

3. What is the IUPAC name for this compound?



(A) 1-oxyhexan-2-one
(B) Pentyl methanoate
(C) Methyl pentanoate
(D) 1-methylpentanoic acid

4. The indigenous peoples of the Tiwi Islands in Northern Australia process yams (sweet potatoes) to make a food called Bitter Yam. Which of the following is an example of the use of solution equilibria to remove toxins from these yams?

(A) Fermenting
(B) Grinding
(C) Roasting
(D) Leaching

5. A sample of 1-bromoethane is heated under reflux with aqueous sodium hydroxide. What would be the most likely products of this reaction?

(A) Ethene and bromine
(B) Ethanol and bromine
(C) Ethanol and sodium bromide
(D) Ethene, water and sodium bromide

6. Which of the following pairs of compounds are positional isomers?

(A) pentan-2-one and pentanal
(B) pentan-2-one and pentan-3-one
(C) pentan-2-one and 3-methylbutanal
(D) pentan-2-one and 3-methylbutan-2-one

7. An unknown solution was tested. The following results were obtained.

Test	*Reaction*
Flame test	Apple green
Dilute HCl was added	No reaction
Na_2SO_4 was added	A white precipitate formed
$AgNO_3$ was added	A white precipitate formed

What compound was in the solution?

- Copper sulfate
- Copper carbonate
- Barium chloride
- Barium carbonate

8. Which equation demonstrates a limitation of the Bronsted-Lowry model of acids and bases?

(A) $BF_3 + NH_3 \rightarrow F_3BNH_3$
(B) $HCl + NaOH \rightarrow NaCl + H_2O$
(C) $PO_4^{3-} + HNO_2 \rightarrow NO_2^- + HPO_4^{2-}$
(D) $H_2SO_4 + H_2O \rightarrow HSO_4^- + H_3O^+$

9. Which row on the table ranks the compounds from lowest to highest pH?

	Lowest pH ----------> Highest pH			
(A)	trichloroethanoic acid	ethanoic acid	ethanamide	ethanamine
(B)	ethanoic acid	trichloroethanoic acid	ethanamine	ethanamide
(C)	ethanamine	ethanamide	trichloroethanoic acid	ethanoic acid
(D)	ethanamide	ethanamine	ethanoic acid	trichloroethanoic acid

10. Soaps and detergents have similar characteristics. Which set of criteria correctly identifies a detergent, but NOT a soap?

I. Ineffective in hard water
II. Only some are biodegradable
III. Always an ion
IV. Produced from natural fats or oils

(A) II
(B) II, IV
(C) I, III
(D) I, III, IV

11. At the end of a particular experiment, a chemist was left with several materials to be disposed of in a safe manner. These included:

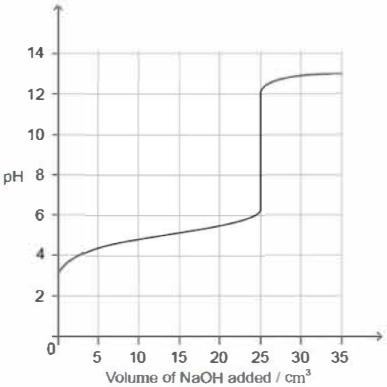
i. 120mL of cyclohexane
ii. 150mL unused 1M Na_2SO_4
iii. A solid compound of lead (produced during gravimetric analysis), dried and weighed on filter paper.

Which of the following describes an appropriate method of disposal for each of the above wastes?

	120mL cyclohexane	**150mL 1M Na_2SO_4**	**Solid lead compound**
(A)	Waste container labelled "Organic Liquids Only"	A stock bottle of Na_2SO_4 prepared for the experiment	In the rubbish bin
(B)	Waste container labelled "Organic Liquids Only"	Down the sink	Waste container labelled "Heavy Metals Only"
(C)	Waste container labelled "Aqueous Waste Only"	Waste container labelled "Aqueous Waste Only"	In the rubbish bin
(D)	Waste container labelled "Aqueous Waste Only"	A stock bottle of Na_2SO_4 prepared for the experiment	Waste container labelled "Heavy Metals Only"

The following information refers to questions 13 and 14.

A monoprotic acid, HA, was titrated with 0.100 mol L^{-1} NaOH. The following curve was obtained using a pH probe.



12. What was the strength of the acid?
    (A) Strong acid since the initial pH is low
    (B) Strong acid since the equivalence point is 9
    (C) Weak acid since the final pH is high
    (D) Weak acid since the equivalence point is 9

13. Which indicator would be appropriate to use?
    (A) Universal
    (B) Methyl orange
    (C) Phenolphthalein
    (D) Bromothymol blue

14. The acid H_3PO_4 dissociates in the following sequential way:

$$H_3PO_4(aq) \rightleftharpoons H^+(aq) + H_2PO_4^-(aq)$$
$$H_2PO_4^-(aq) \rightleftharpoons H^+(aq) + HPO_4^{2-}(aq)$$
$$HPO_4^{2-}(aq) \rightleftharpoons H^+(aq) + PO_4^{3-}(aq)$$

Which of these compound(s) are amphiprotic?

    (A) HPO_4^{2-} only
    (B) $H_2PO_4^-$ and PO_4^{3-}
    (C) HPO_4^{2-} and PO_4^{3-}
    (D) $H_2PO_4^-$ and HPO_4^{2-}

The following information should be used to answer questions 15 and 16.

Coal is mostly composed of carbon solid, and is a major source for electricity. However, it is a limited resource and may run out in about 150 years. A student conducting research found the following information:

$$C(s) + CO_2(g) \rightleftharpoons 2CO(g)$$

$\Delta G < 0$ (in the forward direction) when $T > 1100K$

15. How could this equation be used to produce more coal in the school laboratory?

(A) Use a smaller container to decrease the volume of the vessel
(B) Use some dry ice to add more carbon dioxide to the vessel
(C) Use a larger container to decrease the pressure of the vessel
(D) Use a hot water bath to increase the temperature in the vessel

16. At a particular temperature, a mixture of 200g of coal and 0.70 moles of carbon monoxide were introduced into a 3.0L vessel. At equilibrium, 0.30 moles of carbon dioxide was present. What was the value of K at this temperature?

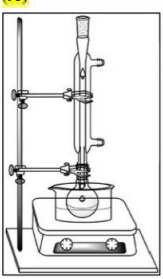
(A) 0.011
(B) 0.033
(C) 0.53
(D) 1.3

The following information should be used to answer questions 17 and 18.

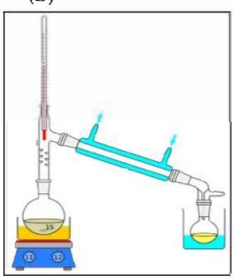
An ester was produced in the school laboratory.

17. Which set of equipment would have been used to produce the ester?

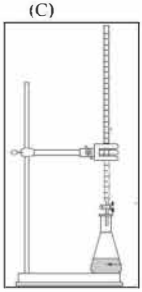
(A)



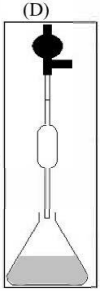
(B)



(C)



(D)



18. Gravimetric analysis of the ester gave a percentage composition by mass of C: 62.0% and H: 10.4% and a molar mass of approximately 116 $gmol^{-1}$. What is its molecular formula?

(A) C_8H_{16}
(B) C_8H_{20}
(C) C_3H_6O
(D) $C_6H_{12}O_2$

19. In an experiment, 4-hydroxybutanoic acid [$HO(CH_2)_3COOH$] forms a polymer containing 1000 monomer units.

Which of the following is closest to the approximate molar mass (in g mol^{-1}) of this polymer?

(A) 2.0×10^2
(B) 1.4×10^4
(C) 8.6×10^4
(D) 1.0×10^5

20. An antacid containing some magnesium oxide was tested. 40.6 g of antacid was dissolved in 500.0mL of water, then diluted to 1.00L. A 100mL aliquot was then removed and reacted with 100mL of 2.00 mol L^{-1} hydrochloric acid.

The excess acid required 19.7 mL of 0.200 mol L^{-1} sodium hydroxide for neutralisation.

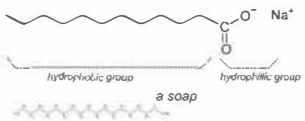
What is the percentage of magnesium oxide in the antacid table?

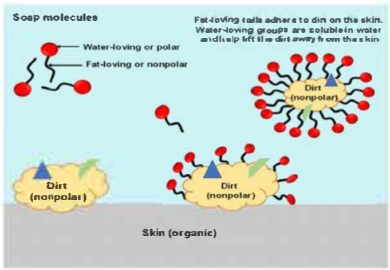
(A) 9.93%
(B) 19.5%
(C) 38.9%
(D) 97.3%

Part B – Extended Response Questions (80 marks)

Question 21 (10 marks)

(a) How does the structure of soap help it to remove fats? You may use a diagram in your answer (3 marks)



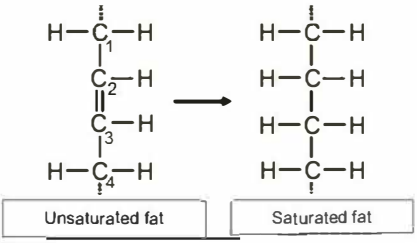


Since soap is composed of a long hydrocarbon "tail" that is hydrophobic/lipophilic, and like dissolves like (ie the dispersion forces in the non-polar "tail" are similar to the dispersion forces in the non-polar fats), the long hydrocarbon chain embeds in fat/lipid/grease/oil. The other end of the soap is polar, containing a negative "head". Since like dissolves like (ie the polar soap and the polar water molecules are attracted to each other), the negative head dissolves into the water. This creates a bridge between the lipid and the water and starts to lift the fat/lipid/grease/oil into the water. It forms micelles, with the negatively charged head around the outside of the micelle. This stops the micelles from joining together, since the negatively charged heads repel each other. The mixture can then be washed away, removing the oil micelles and the soap.

Marking Criteria	Mark
• Appropriately labelled diagram • Outlines structure • Relates structure to action	3
Any 2 of: • Appropriately labelled diagram • Outlines structure • Relates structure to action	2
• Any relevant information	1

Answers may include:
An extensively labelled diagram that outlines the structure and relates the structure to action can be sufficient.

Two types of fats, unsaturated and saturated, are shown below. The carbons are numbered on the unsaturated fat.



(b) What shapes would the first and second carbons in the unsaturated fat display? (1 mark)

Carbon 1 = tetrahedral

Carbon 2 = trigonal planar

Marking Criteria	Mark
• Appropriately names both shapes	1

(c) Unsaturated fats are liquids at room temperature but can be hardened into solids by converting them to saturated fats. Other than their state, how could a fat be tested to ensure it was unsaturated? (2 marks)

Add bromine water – if unsaturated, the bromine solution will change from brown to colourless/decolourise. If it were saturated, no colour change will occur ie it will remain brown.

$C_2H_4(g) + Br_2(aq) \dashrightarrow C_2H_4Br_2(aq)$

Ethene Bromine (brownish-red) 1,2-Dibromoethane (colourless)

Marking Criteria	Mark
• Identifies a test • Outlines the expected results of the test for both saturated and unsaturated fats	2
• Any relevant information	1

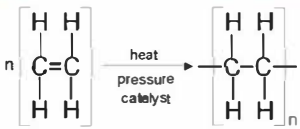
(d) What type of reaction would be used to convert the unsaturated fat to a saturated fat? (1 mark)

Addition reaction – hydrogenation

Marking Criteria	Mark
• Appropriately names the type of reaction	1

(e) Crude oil contains many unsaturated hydrocarbons and can be used to produce polymers. Outline the structure and ONE property with its related use for an addition polymer. (3 marks)

Polyethylene polymer is produced from the monomer ethene (ethylene) through an addition reaction.



LDPE (low density polyethylene) is flexible, chemically inert, fairly transparent. This allows it to be used for cling wrap and sandwich bags.

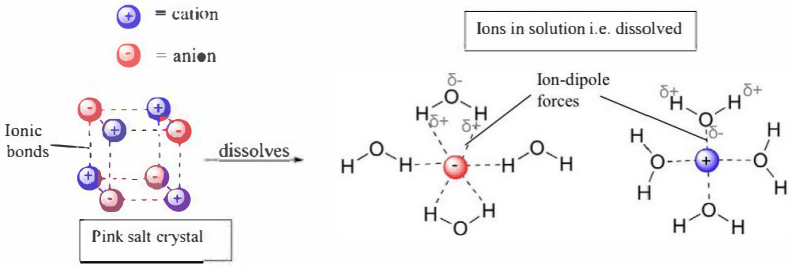
Marking Criteria	Mark
• Names an addition polymer • Draws or appropriately describes the structure of the polymer • Identifies a property of the polymer • Relates the property to its use	3
Any 2 of: • Names an addition polymer • Draws or appropriately describes the structure of the polymer • Identifies a property of the polymer • Relates the property to its use	2
• Any relevant information	1

EXAMINATION CONTINUES ON THE NEXT PAGE

Question 22 (9 marks)

Pink Lake is a salt lake in Victoria that dries during the summer months leaving a bed of pink salt. Aboriginal Australians may have used the salt in their diet, and the salts are now commercially harvested during summer, before the rains turn the area back into a lake.

(a) Explain how pink salt dissolves in rainwater. Use diagrams to support your answer. (4 marks)



Water is a very polar molecule so is able to form many ion-dipole interactions with both the sodium cation and the chloride anion. Thus the energy from this is enough to make up for the energy required to break up the ion-ion interactions in the salt crystal and some water-water hydrogen bonds. This results in individual sodium cations and chloride anions surrounded by water molecules with the appropriate pole of the water molecule arranged towards the oppositely charged ion (ie H which is δ+ is close to the negative ion, while the O which is δ- is close to the positive ion).

Marking Criteria	Mark
Includes all of: • Sketches appropriate, labelled diagrams • Identifies the intermolecular and intramolecular forces acting on the salt and the dissolved ions • Outlines the arrangement of the ions in the salt and when dissolved • Relates the amount of attractive forces/energy required to the effect ie dissolution	4
Includes some of: • Sketches appropriate, labelled diagrams • Identifies the intermolecular and intramolecular forces acting on the salt and the dissolved ions • Outlines the arrangement of the ions in the salt and when dissolved • Relates the amount of attractive forces/energy required to the effect ie dissolution	2-3
• Any relevant information	1

Answers may include:
An extensively labelled diagram may be sufficient.

Analysis of the salt shows that as well as sodium chloride it contains traces of calcium, phosphate and copper.

(b) Using the information provided, why should the Pink Lake environment be monitored by chemists? (3 marks)

Chemists need to be checking the lake to make sure that it is safe and at appropriate levels for the organisms living in the habitat and for those who use the salt in their diet.

If high levels of calcium are found in the salts/water of the lake, it will form hard water. If the lake water is being used as a water source, it may leave calcium carbonate deposits/limescale or form soap scum. However, it would not affect the health of the organisms in the area, thus close monitoring of this ion would not be necessary.

If high levels of phosphates are present in the water, it may cause algal blooms/eutrophication, which can be toxic to aquatic organisms. Thus, the level of phosphates needs to be carefully monitored to ensure it remains at safe levels.

If high levels of copper are present in the water, copper is toxic to aquatic organisms and also bioaccumulates to toxic levels for humans who eat the aquatic organisms. Thus, the level of copper needs to be carefully monitored to ensure it remains at safe levels.

Marking Criteria	Mark
• Identifies the need for monitoring to ensure safety/environmental protection • Relates the effects of the ions listed to safety issues/environmental protection	3
• Relates SOME of the effects of the ions listed to safety issues/environmental protection	2
• Any relevant information	1

(c) How have Aboriginal Australians used acid/base analysis techniques? (2 marks)

Analysis of acid content in the Kakadu plum (which contains high levels of ascorbic acid) was conducted using taste tests. It is much more sour (lower pH) when unripe, but becomes a little sweeter/less sour (higher pH) when ripe

Analysis of the effect of acids as cleaning substances was conducted by some Palawa women in Tasmania, where they discovered that Pyroligneous acid could be distilled from smoke and used to expose the iridescent nacre of some shells. Acetic acid is now used by some Palawa women.

Analysis of the effect of bases on the active components of some bush medicines led to some central Australian Aboriginal groups developing a medicine that assisted people in long, arduous journeys. To increase the effectiveness of the active component within this medicine, an alkali ash (quicklime/calcium oxide) was produced. This has the effect of raising the pH of the medicine, facilitating the release of the medicine from the plant source and increasing its absorption into the blood stream.

Marking Criteria	Mark
• Outlines TWO techniques	2
• Any relevant information	1

Question 23 (6 marks)

A student conducting solubility tests mixed 10mL of 0.01M $AgNO_3$ with 10mL of 0.0001 M NaCl.

(a) Using calculations, demonstrate whether a precipitate would be produced. (4 marks)

$$AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$$

$AgCl \rightleftarrows Ag^+ + Cl^-$

$n_{(Ag+)} = cV = (0.01)(0.010) = 1x10^{-4}$ mol in the new 20mL volume.

Therefore new Ag^+ concentration is $c = n/V = 1x10^{-4}$ mol / 0.020L = $5x10^{-3}$M

$n_{(Cl-)} = cV = (0.01)(0.0001) = 1x10^{-6}$ mol in the new 20mL volume

Therefore new Cl^- concentration is $c = n/V = 1x10^{-6}$ mol / 0.020L = $5x10^{-5}$M

$Q = [Ag^+][Cl^-] = (5x10^{-3}M)(5x10^{-5}M) = 2.5x10^{-7}$

Ksp (from data sheet) = $1.77x10^{-10}$

Since Q is greater than Ksp, a precipitate forms.

Marking Criteria	Mark
• Identifies the compound that will form a solid • Calculates molarity of each ion in new volume • Calculates Q • Compares Q to Ksp to determine if precipitate forms	4
Some of: • Identifies the compound that will form a solid • Calculates molarity of each ion in new volume • Calculates Q • Compares Q to Ksp to determine if precipitate forms	2-3
• Any relevant information	1

(b) What mass of precipitate was produced? (2 marks)

Since 1:1 ratio Ag^+:Cl^-, Cl^- must be limiting reagent.

$n_{Cl-} = 1x10^{-6}$ mol (from calculation in (a).

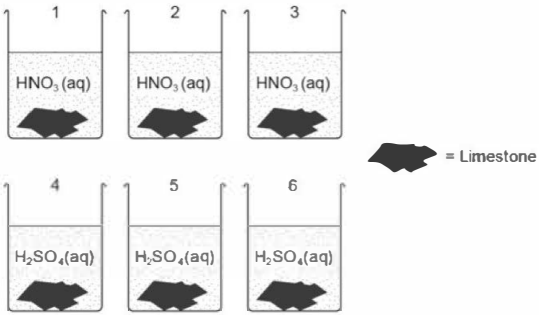
Since 1:1 ratio between Cl^-(aq):$AgCl^-$(s), there must be $1x10^{-6}$ mol of AgCl(s).

$m = n \times MM = 1x10^{-6}$ mol x (107.9 + 35.45) = $1.4335 \times 10^{-4} = 1.4 \times 10^{-4}$ g (2 sig fig)

Marking Criteria	Mark
• Appropriately calculated mass of precipitate	2
• Any relevant information	1

Question 24 (9 marks)

A student investigated how acid affects limestone (a material mostly composed of calcium carbonate, but also containing small amounts of calcium sulfate). The student set up the experiment as shown below, using 200mL of 0.1 mol L^{-1} nitric acid in 3 beakers and 200mL of 0.1 mol L^{-1} sulfuric acid in the other 3 beakers.

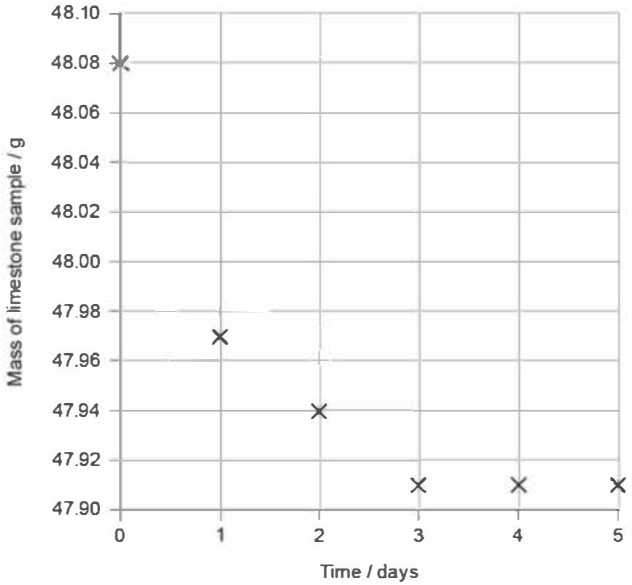


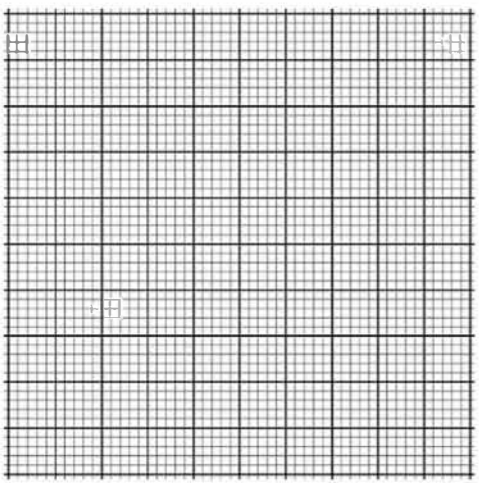
Each day the student removed the limestone from the acid, washed it and then dried it with paper towel. The student then weighed the limestone on electronic scales and replaced it in the beaker.

The student's results for nitric acid are shown below:

Time (days)	*Average mass of limestone sample (g)*
0	48.08
1	47.97
2	47.94
3	47.91
4	47.91
5	47.91

(a) Draw a graph of the results for the nitric acid experiment (3 mark)





(b) Explain why the rate of reaction decreases over the 5 days (2 mark)

Since acid is the limiting reactant, as the acid is used up/converted to water, the concentration of acid decreases. This means less frequent collisions between acid and limestone, leading to a decrease in the rate of the reaction.

Marking Criteria	Mark
• Identifies a cause for the decreased reaction rate • Relates the cause to its effect	2
• Any relevant information	1

(c) The student hypothesised that sulfuric acid would cause a larger mass loss than nitric acid. Justify this hypothesis (2 marks)

Sulfuric acid is diprotic/contains two H^+ while nitric acid contains only one H^+. This means each mole of H_2SO_4 releases almost double the H^+ compared to nitric acid, so reacts with more limestone, leading to a larger mass loss.

Marking Criteria	Mark
• Identifies sulfuric acid is diprotic while nitric acid is monoprotic • Relates the hydrogen ions to its effect on mass loss	2
• Any relevant information	1

Unexpectedly, when the student compared the mass losses, she found that more mass was lost in the nitric acid than in the sulfuric acid.

(d) The student decided to examine the solubility rules and relevant Ksp data to see if this would help to explain the unexpected result.

Suggest an explanation for why there was greater mass loss in nitric acid than in sulfuric acid. Use equations to support your answer. (2 marks)

In nitric acid: $2HNO_3(aq) + CaCO_3(s) \rightarrow Ca(NO_3)_2(aq) + H_2O(l) + CO_2(g)$

In sulfuric acid: $H_2SO_4(aq) + CaCO_3(s) \rightarrow CaSO_4(s) + H_2O(l) + CO_2(g)$

Calcium nitrate is soluble, calcium sulfate is insoluble with a Ksp of 4.93×10^{-5}

Thus, when sulfuric acid is used, the calcium sulfate will be forming a precipitate and may be depositing on the limestone. This may then prevent further hydrogen ions from reacting with the limestone. When nitric acid is used, no precipitate forms, thus the hydrogen ions can continue to react with the limestone for a longer time period resulting in greater mass loss.

Marking Criteria	Mark
• Provides TWO correct equations • Relates to solubility rules and Ksp data • Suggests a plausible reason for the increased mass loss in nitric acid compared to sulfuric acid	2
• Any relevant information	1

Question 25 (5 marks)

Fuels can be obtained from a variety of sources. Assess the benefits and limitations of using ethanol as a fuel compared to TWO other fuel sources. (5 marks)

May discuss some of the following:

Benefits of Petrol/Octane:

The use of fossil fuels in vehicles (mainly octane) saves time used in refueling as octane has a higher energy output per gram (and thus per mole) compared to ethanol, thus can travel a longer distance before the need for re-fuelling. The values are 46 kJ/g and 20.6 kJ/g respectively. Vehicles and infrastructure are already in place that make the use of petrol economically advantageous to both companies and the public.

Limitations of Petrol/Octane:

As the formation of fossil fuels takes millions of years, they are considered non-renewable. Therefore, it is not sustainable in the long term to meet the growing world population's demand for energy usage.

Furthermore, as quantity of fossil fuel decreases, the price of fossil fuels will rise which will become less affordable to consumers.

Petrol/octane burns less cleanly than biofuels such as ethanol as it requires more oxygen for one mole of octane to undergo complete combustion. This means that more toxic carbon monoxide will be produced as a product which can harmful to living organisms such as humans.

Benefits of Ethanol:

As crops can be grown at a large scale and broken down into glucose which can be subsequently fermented to produce ethanol, it is renewable. Therefore, it has the potential to sustain the growing world population's demand for energy usage in the long term

Biofuels like ethanol burns more cleanly (complete combustion) than from fossil fuels like octane as less oxygen is required per mole of ethanol as shown in the equations below:

$$C_2H_5OH(l) + 7/2\ O_2(g) \rightarrow 3H_2O(g) + 2CO_2(g)$$
$$C_8H_{18}(l) + 25/2\ O_2(g) \rightarrow 9H_2O(g) + 8CO_2(g)$$

Also, the plants grown to produce glucose will perform photosynthesis to consume carbon dioxide, which lowers the total carbon dioxide produced from combustion.

Benefits of Biodiesel:

There is current research into developing the use of photobioreactors in producing biodiesel from microalgae at a large scale. Microalgae provides many advantages over current plants that are currently used to produce biofuel (such as sugar cane to produce ethanol). This includes the fact that algae does not require to be grown on agricultural land so the arable land can be used to grow food for growing world population. Also, microalgae can grow during any time of the year as it can sustain harsh ambient conditions, reducing water and pesticides required (lowering cost) and higher yield per unit area (from 10 to 100 times more than conventional biofuel such as ethanol).

Another benefit of biodiesel is that it is compatible with existing diesel engines and distribution infrastructure. Biodiesel can be used alone or blended with petrodiesel in any proportions. Biodiesel blends can also be used as heating oil.

If ethanol or biodiesel biofuels are used by cars, factories, tractors to harvest and transport crops for processing, then there will be a greater net reduction in carbon dioxide greenhouse gas as seen in the equations above.

Limitations of ethanol:

The use of large amounts of land to grow crops for the purpose of fuel production reduces the land available for food production. With the increasing world population, both the demand for higher food and energy consumption (e.g. energy provided by biofuels) are both increasing and they both need to be both rather than just energy. Due to the limited land available on Earth, different food and biofuel production processes would be required.

The energy used by tractors to harvest the crops that would be used to produce ethanol is currently supplied by the burning of fossil fuels.

The energy used for the fermentation to produce alcohol and distillation to increase purity of alcohol currently derived from the burning fossil fuels.

The energy used by trucks to transport crops to to biofuel manufacturing plants and the ethanol product to relevant stores to sell to consumers are currently derived from the burning of fossil fuels.

Due to limited amount of land on Earth, the landfills are already burdened with the large amount of rubbish. There will be problems in the future in storing large volume of fermentation waste if a switch from fossil fuels to completely renewable biofuel production via fermentation in the future.

Not all vehicles' engines are currently compatible to use 100% ethanol and so some car engines may need to be modified to use 100% ethanol.

Limitations of Biodiesel

The limitation currently is that the cultivation cost of microalgae is greater than plants such as sugar cane in producing biofuel. Furthermore, there will be problem with producing microalgae arises when the availability of sunlight varies. Perhaps, with recombinant DNA technology (a form of biotechnology), a gene can be identified and inserted into microalgae that enhances its yield production during low sunlight conditions.

Biodiesel can solidify/form a gel in colder temperatures, so needs to be mixed with other chemicals to prevent forming a gel.

Biodiesel has about 10% higher NOx than other petroleum based fuels, which means that it contributes to the formation of smog and acid rain.

Therefore, overall, both ethanol and biodiesel have many long term benefits that outweigh the short term disadvantages such as initial production costs/modification of infrastructure/change in land use. However, while these make ethanol and biodiesel more beneficial than petrol/octane, they do not fully solve the problem of requiring fossil fuels for energy or of stopping the production of greenhouse gases. Thus, they are not without their limitations.

Marking Criteria	Mark
• Identifies TWO fuel sources • Outlines TWO benefits and TWO limitations for ethanol and each fuel chosen • Provides an assessment of the issues	5
• Identifies TWO fuel sources AND/OR • Outlines some benefits AND/OR limitations for each fuel AND/OR • May provide an assessment of the issues	2-4
• Any relevant information	1

Question 26 (8 marks)

Gold mining often uses cyanide (CN^-) to help remove gold from ore. A scientist decided to test if the water in a river near a gold mine contained excessive levels of cyanide (the maximum allowable level for drinking water is 0.5 mg/L). The scientist used a variety of methods to determine the concentration of cyanide.

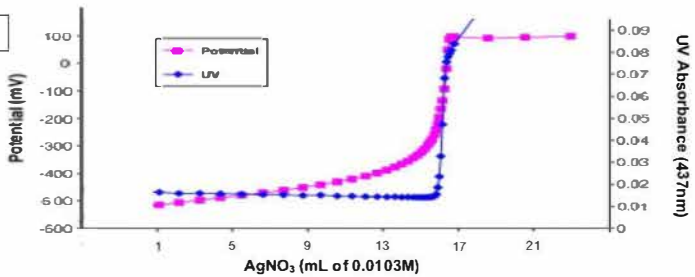
Test 1:

1. Took 200.00mL sample from river
2. Diluted sample up to 1000.00mL
3. Conducted a precipitation titration using silver nitrate (initially, the silver nitrate combines with CN^- to form $[Ag(CN)_2]^-$ (a colourless silver cyanide complex). Once all the CN^- is used up, the silver nitrate reacts with the $[Ag(CN)_2]^-$ and forms AgCN, a white precipitate. In the reaction, the scientist started with 0.0100M silver nitrate and filled the burette to a reading of 60.00mL. At the end of the reaction, the burette read 42.43mL. A blank titration caused precipitation to occur with 0.870mL of $AgNO_3$.

Test 2:

4. The scientist repeated the titration on a fresh, undiluted 200.00mL sample but used a conductivity (potential difference) titration and graphed the results to determine the endpoint of the titration (Figure 1).
5. The scientist repeated the titration on a fresh, undiluted 200.00mL sample but using UV absorbance to determine the endpoint of the titration (Figure 1).

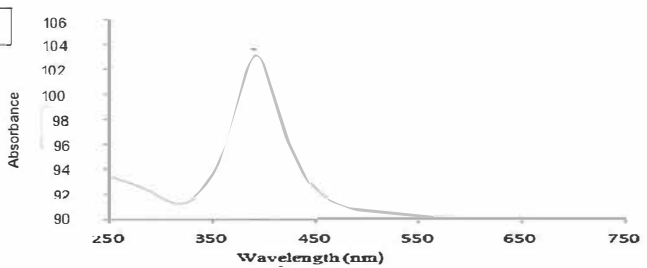
Figure 1



Test 3:

6. The scientist used UV-Vis spectroscopy to measure the concentration of CN- ions using the oxidation of cyanide with chlorine (Figure 2). The scientist used an undiluted 200.00mL sample in a 1.00cm cuvette and determined the molar absorptivity for cyanide was 5.87×10^4 mol^{-1} cm^{-1}.

Figure 2



Examine the results and concentrations the scientist obtained in each experiment. Evaluate the scientist's methods and results. (8 marks)

Scientist's results and concentrations:

Test 1

$AgNO_{3(aq)} + 2CN^-_{(aq)} \rightarrow [Ag(CN)_2]^-_{(aq)}$

$n_{AgNO_3} = cV = 0.010M \times ((17.57-0.87)\times10^{-3}) = 1.67\times10^{-4}$ mol of $AgNO_3$

Since 1:2 ratio for $AgNO_3 : 2CN^-$, $n_{CN^-} = 2(1.67\times10^{-4}) = 3.34\times10^{-4}$ mole of CN^-

$c=n/V = 3.34\times10^{-4} / 0.200 = 1.67\times10^{-3}$ mol /L of CN^-

$m_{CN^-} = n \times MM = (1.67\times10^{-3})(12+14) = 0.0434g = 43.4mg$ in 1 L (3 sig fig)

Therefore concentration of cyanide in water sample is 43.4mg/L, which is much greater than the maximum allowable of 0.5 mg/L.

Test 2

Examining the data, it shows that both methods have similar end points, suggesting the two different methods are fairly reliable, and therefore, may be accurate.

Reading from the graph, 16×10^{-3}L of 0.0103M $AgNO_3$ was used.

$n_{AgNO_3} = cV = 16\times10^{-3}L \times 0.0103M = 1.648\times10^{-4}$mol of $AgNO_3$

Since 1:2 ratio, $n_{CN^-} = 3.296\times10^{-4}$ mol CN^-

$c_{CN^-} = n/V = 3.296\times10^{-4} / 0.200 = 1.648\times10^{-3}$ mol/L of CN^-

$m_{CN^-} = n \times MM = (1.648\times10^{-3})(12+14) = 0.042848g$

Therefore concentration of CN^- is 42.848mg/L = 43mg/L of CN^- (2 sig fig)

This value is very similar to the result found in Test 1. It also agrees that the cyanide concentration is much higher than the allowable value.

Test 3

Reading from graph, Absorbance is 103

$A = \varepsilon l c$

$103 = 5.87\times10^4 \times 1.00 \times c$

$c = 1.754\times10^{-3}$ mol / L

$m = n \times MM = (1.754\times10^{-3})(12+14) = 0.0456g$ in 1 L

Therefore concentration of CN^- is 45.62 mg/L= 45.6mg/L (3 sig fig)

This value is fairly similar to the results found in Tests 1 and 2. It also agrees that the cyanide concentration is much higher than the allowable value.

Average concentration using the 3 methods = 44mg/L of cyanide in the water samples.

Evaluation of Methods and Results

Validity = testing what you mean to be testing. Three different types of tests were conducted, all seeking to find the concentration of cyanide in water samples. All three types of tests yielded similar results, hence, it is likely that the tests were actually determining the concentration of cyanide in the water samples, and hence, the method used was valid. Validity also requires a control

where appropriate, and controlling all other variables. In Test 1, a blank titration was used, which helps to act as a control. In Test 2, two different methods were used to check that the appropriate endpoint was being reached (and they both produced very similar results). In Test 2, it is hard to know what variables were controlled, as it does not state this in the question. This may lead to decreased validity for this Test.

Reliability = repeats with consistent results. No repeats were conducted with the same piece of equipment. Conducting at least 5 repeats with each type of equipment, and taking an average of each result (excluding outliers), would help to improve reliability. However, since 3 different methods were used, and all yielded similar results, it is likely the results are fairly reliable.

Accuracy = using appropriate equipment and being close to the true value. In each of the 3 tests, appropriate equipment was used, with a reasonable level of precision (2-3sig fig). These methods are known to be able to produce accurate results. However, it is hard to know what the "true" value is, as a comparison. Further testing of 100s of water samples would allow a larger data set, which help to produce a value that could be considered close to the "true value".

Thus, overall, the results obtained, using a variety of methods, appear to be fairly reliable, accurate and valid. They easily identify that the cyanide concentration is much greater than the acceptable value.

Marking Criteria	Mark
• Performs ALL calculations correctly to determine the concentrations produced by each of the 3 test methods • Demonstrates an extensive understanding of the results and methodology used • Critically analyses the methodology and results and provides a judgement • Logical sequence of thought, uses scientific terminology appropriately	8
Includes all of: • Performs MOST calculations to determine the concentrations produced • Demonstrates a thorough understanding of the results and methodology used • Analyses the methodology and results and may provide a judgement OR demonstrates extensive knowledge of two of the above points and a basic knowledge of the third point.	5-7
• Performs some calculations to determine the concentrations produced AND/OR • Demonstrates a basic understanding of the results and methodology used AND/OR • Examines the methodology and results and may provide a judgement	2-4
• Any relevant information	1

Question 27 (11 marks)

An equilibrium has the generalised equation:

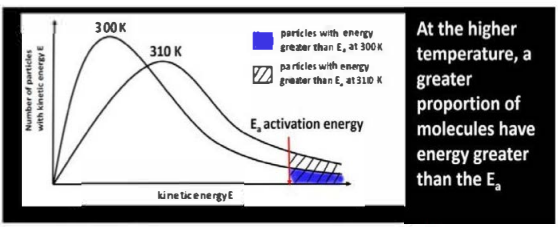
$$2AB_2 \rightleftharpoons A_2B_4 \qquad \Delta H = -250 kJ\ mol^{-1}$$

At time t = 3s, the temperature was increased.

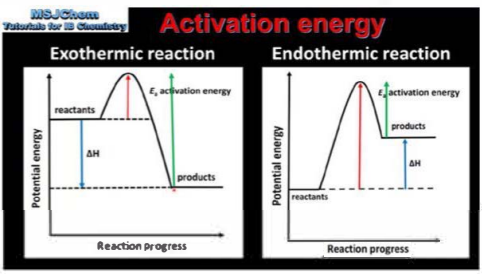
(a) Both Le Chatelier's Principle and collision theory state that the position of the equilibrium would change. Compare these TWO theories to explain the effect of the temperature change, including the effect of temperature change on activation energy and reaction rate. (4 marks)

Le Chatelier's Principle states that an equilibrium shifts to minimise the effect of any change imposed on the system. The above equation is exothermic which means heat is produced as a product. Thus, increasing the temperature/heat means an increase in the product side of the equation resulting in a shift towards the LHS (reactant side) of the equation, to try to use up the excess heat, thus minimising the change imposed on the system.

In comparison, collision theory states that all substances are composed of small particles and that, when they collide with the correct orientation and sufficient energy, these particles can react to form a product.
An increase in temperature leads to an increase in the movement of the particles, leading to an increase in collisions and therefore and increase in the reaction rates of both the forward and reverse reactions.
As temperature increases, the activation energy required for a reaction remains the same, however, with more energy from the increased heat, more particles have sufficient energy to react when they collide, hence, increasing the reaction rate.



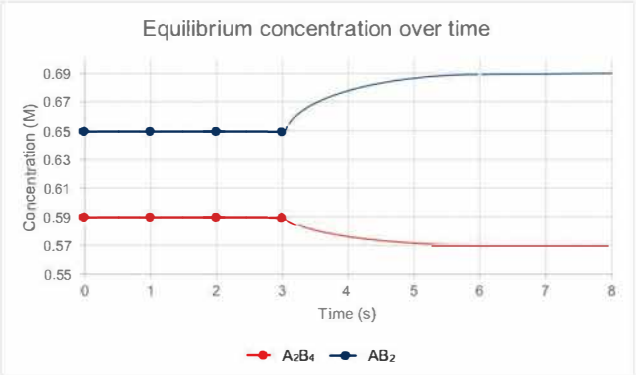
In equilibria, an increase in temperature favours the endothermic reaction. This is because, as temperature increases, a large amount of the particles in the exothermic reaction quickly reach activation energy. Any further increase in temperature does not significantly increase the number of particles with the required energy. However, with endothermic reactions, since they require a higher activation energy, as temperature continues to increase, a significantly larger proportion of particles now have the required activation energy and can therefore react, hence, favouring the endothermic reaction more significantly than the exothermic reaction.



Marking Criteria	Mark

• Outlines each theory • Outlines how the equilibrium position will change with an increase in temperature • Provides reasoning for this change, based on both theories • Explains how activation energy and reaction rate are affected by temperature	4
• Outlines each theory AND/OR • Outlines how the equilibrium position will change with an increase in temperature AND/OR • Provides reasoning for this change, based on both theories AND/OR • Explains how activation energy and reaction rate are affected by temperature	2–3
• Any relevant information	1

(b) After the temperature was increased, the new equilibrium position was reached at 6s. Sketch the concentrations after t=3. (2 marks)



Marking Criteria	Mark
• Sketches an increase on AB_2 and a decrease in A_2B_4 • Includes a 2:1 ratio for $2AB_2 : A_2B_4$ • Includes constant concentrations after 6s	2
• Any relevant information	1

(c) What would be the effect of the increase in temperature on the value of *Keq*? (1 mark)

An increase in temperature leads to increased reactants. Since K = [Products] / [Reactants], the a greater value in the denominator of the fraction leads to a decreased overall value, so Keq decreases.

Marking Criteria	Mark
• Correctly identifies the effect of an increase in temperature	1

(d) Describe an investigation to determine the K_{eq} of a chemical equilibrium system. Include an equation and approximate results in your answer. (4 marks)

An investigation was conducted using acetic acid to determine Keq/Ka:

$$CH_3COOH \rightleftharpoons CH_3COO^- + H^+$$

1. Added 1mL of 0.1M acetic acid to a test tube
2. Added 1 drop of universal indicator
3. Determined pH by comparing to universal indicator colourchart
4. Calculated Keq using ICE table and Keq equation (see below)
5. Repeated experiment 5 times and averaged the results, removing any outliers before averaging

Results:

	CH_3COOH (M)	CH_3COO^- (M)	H^+ (M)
I	0.1	0	0
C	-x	+x	+x
E	0.1-x	x	x

$[H^+] = 10^{-pH}$

$= 10^{-3}$

So $x = 1 \times 10^{-3}$

Since CH_3COO^- : H^+ is 1:1

$Keq = [CH_3COO^-][H^+] / [CH_3COOH]$

$= [1 \times 10^{-3}] \times [1 \times 10^{-3}] / [0.1 - 1 \times 10^{-3}]$

$= 1.01 \ldots \times 10^{-5}$

Marking Criteria	Mark
• Describes an appropriate investigation • Outlines results • Includes an equation	4
• Describes a partially appropriate investigation AND/OR • Provides a result AND/OR • Provides an equation	2-3
• Any relevant information	1

Question 28 (13 marks)

(a) 21mL of 0.210 mol L^{-1} hydrochloric acid was added to 31mL of 0.210 mol L^{-1} sodium hydroxide. What was the pH of the resulting solution? (4 marks)

$n_{HCl} = cV = (0.021)(0.210) = 4.41 \times 10^{-3}$ mol of H^+ (since 1:1 ratio HCl : H^+ ie. HCl → $H^+ + Cl^-$)

$n_{NaOH} = cV = (0.031)(0.210) = 6.51 \times 10^{-3}$ mol of OH^- (since 1:1 ratio NaOH : OH^- ie. NaOH → $Na^+ + OH^-$)

After neutralisation, 6.51×10^{-3} mol of OH^- - 4.41×10^{-3} mol of H^+ = 2.1×10^{-3} mol of OH^- remains in 21mL + 31mL = 52mL of solution

$c_{OH^-} = n/v = 2.1 \times 10^{-3} / 0.052 = 0.0403...M$

$pOH = -\log_{10}[OH^-] = -\log_{10}[0.0403...M] = 1.393...$

$pH = 14 - pOH = 14 - 1.393... = 12.606...$

2 sig fig → 2 dp, therefore, pH of resulting solution is 12.61 (2dp)

Marking Criteria	Mark
• All calculations correct, including correct decimal places	4
• Some of the following calculations correct: ○ Identification and calculation of mol of H+ and OH- in original and resultant volume ○ Calculation of mol of OH- remaining after neutralisation ○ Calculation of new concentration of OH- ○ Calculation of pOH and pH ○ Identification of correct rounding	2-3
• Any relevant information	1

(b) (i) The pH of a 0.125 mol L^{-1} solution of benzoic acid (C_6H_5COOH) is 2.83. Calculate the Ka of the benzoic acid solution. (3 marks)

$C_6H_5COOH(aq) \rightleftharpoons C_6H_5COO^-(aq) + H^+(aq)$

I	0.125M	0	0
C	-x	+x	+x
E	0.125 – x (assume -x is negligible compared to 0.125)	x	$[H^+] = 10^{-2.83} = 1.479...x10^{-3}$

Since $x = 1.479...x10^{-3}$,

$Ka = [C_6H_5COO^-][H^+] / [C_6H_5COOH] = (1.479..x10^{-3})(1.479..x10^{-3}) / 0.125 = 1.75x10^{-5}$ (3 sig fig)

Check assumption that x is negligible: $1.479..x10^{-3} / 0.125 \times 100 = 1.18\%$. Yes, assumption is valid since it is less than 5%.

Marking Criteria	Mark
• All equations/expressions/calculations correct	3
• Some of the following equations/expressions/calculations correct: ○ Correct equation ○ ICE table ○ Calculation of $[H^+]$ ○ Ka expression and calculation ○ Identification of assumption (or use of quadratic equation)	2
• Any relevant information	1

(ii) Calculate the pKa of the benzoic acid. (1 mark)

$Ka = 1.75 \times 10^{-5}$

$pKa = -\log_{10}(1.75 \times 10^{-5}) = 4.757$ (3 sig fig → 3 dec pl)

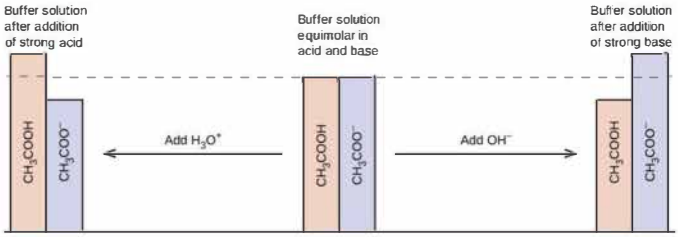
Marking Criteria	Mark
• Correct calculation	1

(iii) Calculate the percentage dissociation of the benzoic acid. (1 mark)

% dissociated = $[H^+] / [HA] \times 100 = 1.479 \times 10^{-3} / 0.125 \times 100 = 1.18\%$

Marking Criteria	Mark
• Correct calculation	1

(c) A student found a model of a buffer system to help explain how an acetic acid/acetate ion buffer system works:



Assess the effectiveness of the model in explaining the chemistry of buffers. Include an equation in your answer. (4 marks)

$$CH_3COOH(aq) + H_2O \rightleftharpoons CH_3COO^-(aq) + H_3O^+(aq)$$

Buffers are solutions that resist changes in pH when small quantities of acid or base are added to them. They are often composed of a weak acids and it conjugate base, as is the case with this model shown here. The model effectively shows that when acid is added (H_3O^+), this causes an increase in the concentration of acetic acid. However, the model does not explain the reason for this, or the effect of this on pH. According to Le Chatelier's Principle, an equilibrium system shifts to minimise any change to the system. Thus, the addition of the H_3O^+ causes the equilibrium to shift to the left, to decrease the higher H_3O^+ levels, thus converting them to $CH_3COOH(aq) + H_2O$. Since this removes the excess acid added, and converts it into neutral water and weak acid acetic acid (which stays mostly as the molecule, not the ion), the pH remains unaffected. This process works in reverse. As with previously, if OH^- is added, the model clearly shows that the amount of CH_3COO^- increases, but again, does not provide why and does not indicate the effect on pH i.e. the addition of base reacts with H_3O^+ to form water. This neutralises the base, but also uses up some of the H_3O^+. Hence, according to Le Chatelier's principle, the equilibrium shifts to minimise the change i.e. it shifts to the RHS to produce more H_3O^+ to replace that which was used up. This means that the H_3O^+ concentration remains fairly constant, leading to a fairly constant pH, despite the addition of the base.

The model is effective at providing a small snapshot of how buffers work (demonstrating changing concentrations of reactants/products based on what is added), but does not provide much detail as to the reasons or effects. Thus it is not a very effective model, and may lead to misconceptions as to how buffers function.

Marking Criteria	Mark
• Provides a correct equation that relates to the model • Explains how buffers work • Provides an assessment of the effectiveness of the model • Supports assessment with reasoning	4
• Provides a correct equation that relates to the model AND/OR • Outlines how buffers work AND/OR • Relates the model to the chemistry of buffers	2-3
• Any relevant information	1

Question 29 (9 marks)

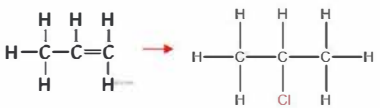
Propene is an important starting material for many products.

A student wrote the following notes about propene and its products:

Reactions	C_3H_6 --> C_3H_7Cl --> C_3H_8O --> C_3H_6O Various reactants and conditions are needed to complete the above reactions
Molar Enthalpy of Combustion	C_3H_8O undergoes complete and incomplete combustion. In the classroom, 180mL of water was heated using 1.05g of C_3H_8O. This caused the water temperature to increase by 42°C. In the SI data book at 25.0°C, the standard molar entropy was 193 J mol^{-1} K^{-1} and the molar Gibbs free energy was -2078.5 kJ mol^{-1}.
Boiling Point	C_3H_8O has a higher boiling point than C_3H_6O

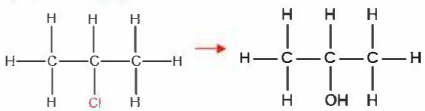
Explain the student's notes. Include equations in your answer. (9 marks)

C_3H_6 -----> C_3H_7Cl



Mix together hydrogen chloride gas (HCl gas) with propene gas at room temperature to produce 2-chloropropane. Note – this is the major product. The minor product (1-chloropropane) will also be produced in smaller quantities)

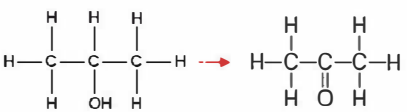
C_3H_7Cl --> C_3H_8O



Add dilute NaOH, heat in reflux. Use solvent mixture of water and ethanol. This produced 2-propanol.

(If 1-chloropropane was used, it would produce 1-propanol)

C_3H_8O --> C_3H_6O



Add acidified potassium dichromate, heat in reflux. Water is produced during the reaction. This produced propanone.

(If 1-propanol was used, acidified potassium dichromate would be added, then the mixture heated and distilled to remove the propanal as it forms)

Complete combustion of Propanol (excess oxygen)
$C_3H_7OH + 9/2O_2 \rightarrow 3CO + 4H_2O$

Incomplete combustion of Propanol (limited oxygen)
$C_3H_7OH + 3O_2 \rightarrow 3CO + 4H_2O$

Incomplete combustion of Propanol (extremely limited oxygen)
$C_3H_7OH + 3/2O_2 \rightarrow 3C + 4H_2O$

Classroom experiment:
$Q=mc\Delta T = 180 \times 4.18 \times 42 = 31600.8\ J = 31.6008\ kJ$ for 1.05g of propanol
n of propanol = m/MM = 1.05g / (3(12) + 8(1) + 16) = 0.0175 mol
$\Delta H = -q/n = -31.6008\ kJ / 0.0175\ mol = 1805.76\ kJ = 1800\ kJ/mol$ (2 sig fig)

SI Data book:
$\Delta G = \Delta H - T\Delta S$
$-2078.5\ kJ/mol = \Delta H - (298\ K)(193 \times 10^{-3}\ kJ\ mol^{-1}K^{-1})$
$\Delta H = -2078.5\ kJ/mol + (298\ K)(193 \times 10^{-3}\ kJ\ mol^{-1}K^{-1}) = -2020\ kJ/mol$

The SI Data book value was a little larger than that found experimentally in the classroom. This could be due to incomplete combustion in the classroom, but most likely due to loss of heat to the surroundings. There may also have been some impurities in the propanol.

Boiling Point
The boiling point of propan-2-ol is higher than the boiling point of propanone. This is because popan-2-ol has hydrogen bonding, as well as dispersion forces. Propanone does not have hydrogen bonding, it only had dipole-dipole forces and dispersion forces. Since Hydrogen bonding forces are stronger than dipole-dipole forces, more energy/heat is required to overcome these intermolecular forces and separate molecules from a liquid to gas, thus propan-2-ol has a higher boiling point.

Marking Criteria	Mark
• Explains, in detail, all pieces of information provided by the student • Demonstrates an extensive understanding of the information provided • Includes correct equations • Includes correct calculations • Logical sequence of thought, uses scientific terminology appropriately	9
Includes all of: • Explains, in some detail, all pieces of information provided by the student • Demonstrates a thorough understanding of the information provided • Includes mostly correct equation(s) • Includes mostly correct calculations OR • Demonstrates an extensive knowledge of at least 4 pieces of information that the student provided	6-8
• Explains some pieces of information provided by the student AND/OR • Demonstrates a basic understanding of the information provided AND/OR • Includes mostly correct equation(s) AND/OR • Includes mostly correct calculations	3-5
• Some relevant information	1-2

Student Number: .....

HSC CHEMISTRY

S2 Examination

Multiple Choice Answer Sheet

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