Student Number: …….

Ascham School

2019 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 21–32
- 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

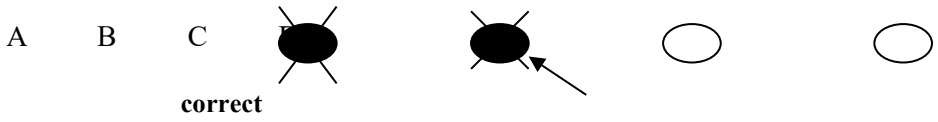
Use the multiple-choice answer sheet.

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

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

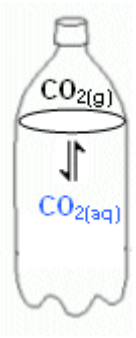
Part A – 20 marks

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 a strong base?
   (A) A substance that fully dissociates to produce H+ ions
   (B) A substance the partially dissociates to produce H+ ions
   (C) A substance that totally ionises to produce OH^- ions
   (D) A substance that partially dissociates to produce OH^- ions

2. Carbon dioxide is dissolved under pressure into a soft drink.

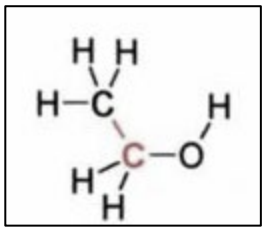


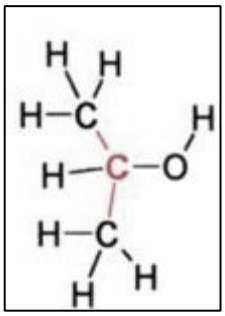
Which option correctly describes the equilibrium and the system?

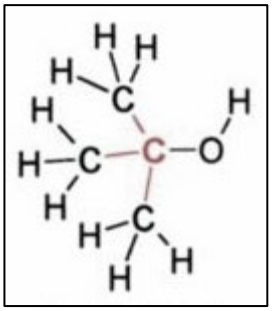
	Equilibrium	**System**
(A)	Dynamic	Closed
(B)	Static	Closed
(C)	Dynamic	Open
(D)	Static	Open

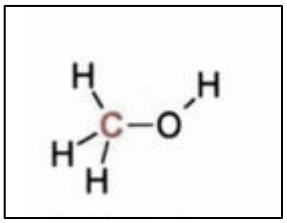
3. Why would a flame test be used?
   (A) To confirm the presence of a particular cation
   (B) To provide quantitative data on the ion in the compound
   (C) To determine the concentration of coloured compounds in a solution
   (D) To measure the light absorption at different wavelengths of the spectrum

4. Which structure shows a tertiary alcohol?

(A) 

(B) 

(C) 

(D) 

5. Which option outlines Arrhenius' theory of acids and bases?
   (A) Acids are proton acceptors.
   (B) Acids are electron pair acceptors.
   (C) Acids and bases form conjugate pairs
   (D) Acids produce H^+ ions when added to water.

6. A student conducted a gravimetric analysis to determine the mass of silver chloride precipitated in a particular reaction. However, the experimental value that the student measured was much less than the theoretical mass expected. How could the student have increased the accuracy of the experiment?
   (A) Repeated the experiment 5 times
   (B) Used a blank, distilled water control
   (C) Used filter paper with smaller hole size
   (D) Added the same volume of water in each repeat

7. What type of reaction is shown?

$$CH_3OH + PCl_5 \rightarrow CH_3Cl + POCl_3 + HCl$$

   (A) Combustion
   (B) Dehydration
   (C) Substitution
   (D) Oxidation

8. How would a student know if there were carbon-carbon double bonds in a molecule?
   (A) Limewater would turn milky
   (B) Brown bromine water would decolourise
   (C) Esterification would produce a “fruity” smell
   (D) Acidified potassium dichromate would change from yellow to green

9. A sulfate solution with an unknown cation was tested by adding chloride ions. No precipitate formed. Which cation was absent from the solution?
   (A) Copper (II) ion
   (B) Iron (II) ion
   (C) Lead (II) ion
   (D) Iron (III) ion

10. Which reaction is exothermic?
   (A) $H_2O_{(s)} \rightarrow H_2O_{(l)}$
   (B) $2H_2O_{(l)} \rightarrow H_{2\,(g)} + O_{2\,(g)}$
   (C) $6CO_{2\,(g)} + 6H_2O_{(l)} \rightarrow C_6H_{12}O_{6\,(aq)} + 6O_{2\,(g)}$
   (D) $2HNO_{3\,(aq)} + Ca(OH)_{2\,(aq)} \rightarrow Ca(NO_3)_{2\,(aq)} + 2H_2O_{(l)}$

11. A student boiled a red flower, filtered out the flower particles and used the filtrate. The student added 1mL of the filtrate to each of the following solutions and observed the colour produced:

Salt Solution	**Colour after flower solution is added**
NaF	Orange
KCN	Yellow
$CaCO_3$	Yellow
NH_4NO_3	Red

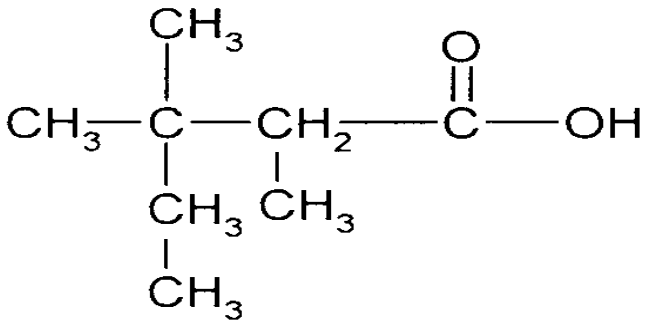
What do these colour changes represent?

	Orange	**Yellow**	**Red**
(A)	Base	Acid	Neutral
(B)	Acid	Base	Neutral
(C)	Neutral	Acid	Base
(D)	Neutral	Base	Acid

12. The following compounds all have similar molecular mass. Which compound has the highest boiling point?
    (A) CH_3CH_2CHO
    (B) $CH_3(CH_2)_2F$
    (C) CH_3CH_2COOH
    (D) $CH_3(CH_2)_2NH_2$

13. Which of the following will form a buffer solution if combined in appropriate ratios?
    (A) HCl and NaCl
    (B) NaOH and HCOONa
    (C) NaCl and H_2SO_4
    (D) NH_4Cl and NH_3

14. Identify the molecule shown.



(A) 3-ethyl-2,3-dimethylbutanoic acid
(B) 2,3-methyl-3-ethylbutanoic acid
(C) 2,3,3-trimethylpentanoic acid
(D) 3,3,4-trimethylpentanoic acid

15. What is the shape of an ethene molecule?

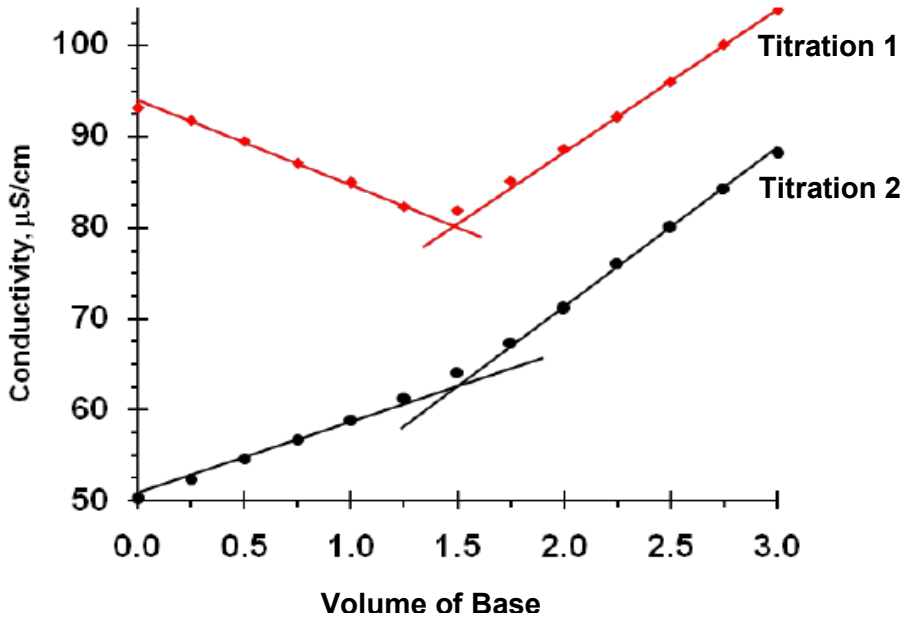
	Shape of the whole molecule	Shape of each carbon
(A)	Planar	Trigonal Planar
(B)	Planar	Tetrahedral
(C)	Linear	Linear
(D)	Linear	Trigonal Bipyramidal

16. 2.0 mol of $N_2(g)$, 2.0 mol of $H_2(g)$ and 2.0 mol of $NH_3(g)$ are placed in a 2.0L sealed flask and left to reach equilibrium. At equilibrium the concentration of $N_2(g)$ is 0.8 mol L^{-1}.

What are the equilibrium concentrations of $H_2(g)$ and $NH_3(g)$ in mol L^{-1}?

	Concentration of $H_2(g)$ (mol L^{-1})	Concentration of $NH_3(g)$ (mol L^{-1})
(A)	0.8	3.2
(B)	0.4	1.4
(C)	0.8	1.4
(D)	0.6	1.2

17. A student conducted two conductometric titrations, with different reagents. The student's results are graphed below.



What reagents did the student use?

	Titration 1	Titration 2
(A)	Strong Acid and Strong Base	Strong Acid and Weak Base
(B)	Strong Acid and Strong Base	Weak Acid and Strong Base
(C)	Weak Acid and Weak Base	Weak Acid and Strong Base
(D)	Weak Acid and Weak Base	Strong Acid and Weak Base

18. A student wanted to determine the percentage of magnesium hydroxide in a 1.24 g antacid tablet. The antacid tablet was added to 50.00mL of 0.100 mol L^{-1} hydrochloric acid. The excess hydrochloric acid required 20.80 mL of 0.1133 mol L^{-1} NaOH for neutralization.

    Calculate the percentage by mass of magnesium hydroxide in the 1.24 g antacid tablet

    (A) 1.32 %
    (B) 2.65 %
    (C) 6.23 %
    (D) 7.70%

19. Spectroscopy was used to determine the unknown concentration of copper (II) sulfate in a solution. The intensity of the light produced by the spectrophotometer was 10.6, but after being passed through a 1.0 cm cuvette, the recorded intensity was only 2.1. The molar absorptivity of the sample was known to be 49650 L cm^{-1} mol^{-1}. Using the Beer-Lambert Law, what is the concentration of copper (II) sulfate in the sample?

    (A) $1.6x10^{-3}$ mol L^{-1}
    (B) $1.7x10^{-4}$ mol L^{-1}
    (C) $1.2x10^{-4}$ mol L^{-1}
    (D) $1.4x10^{-5}$ mol L^{-1}

20. A variety of biofuels are being considered as alternatives to fossil fuels. Hydrogen fuel cell vehicles burn hydrogen and only produce water and heat as the by-products. Bio-Bug cars burn methane gas, and while they have more by-products, the methane can be produced from human waste, thus solving other environmental problems.

    A student researching these 2 types of vehicles found that the heat of combustion for hydrogen gas in 286kJ mol^{-1}, while it is 889kJ mol^{-1} for methane.

    What volume of hydrogen gas at 25°C and 100kPa produces the same amount of energy as 2.0 L of methane gas at the same temperature and pressure?

    (A) 0.08 L
    (B) 0.25 L
    (C) 6.22 L
    (D) 71.7 L

Part B – Extended Response Questions (80 marks)

Question 21 (7 marks)

A student wants to make an ester in a school laboratory.

(a) Identify the TWO types of compounds that react to make an ester (1 mark)

(b) Name an ester that can be produced in a school laboratory (1 mark)

(c) Describe the method used to produce the ester named in (b). (3 marks)

(d) Explain how you could increase the yield of ester produced. (2 marks)

Question 22 (4 marks)

(a) Draw the chemical structure of a soap (1 mark)

(b) How do soaps work to remove grease? (3 marks)

EXAMINATION CONTINUES ON THE NEXT PAGE

Question 23 (10 marks)

An unidentified substance was found in a sample of soup during a routine food safety inspection.

(a) Outline the need for monitoring of substances in food or the environment (2 marks)

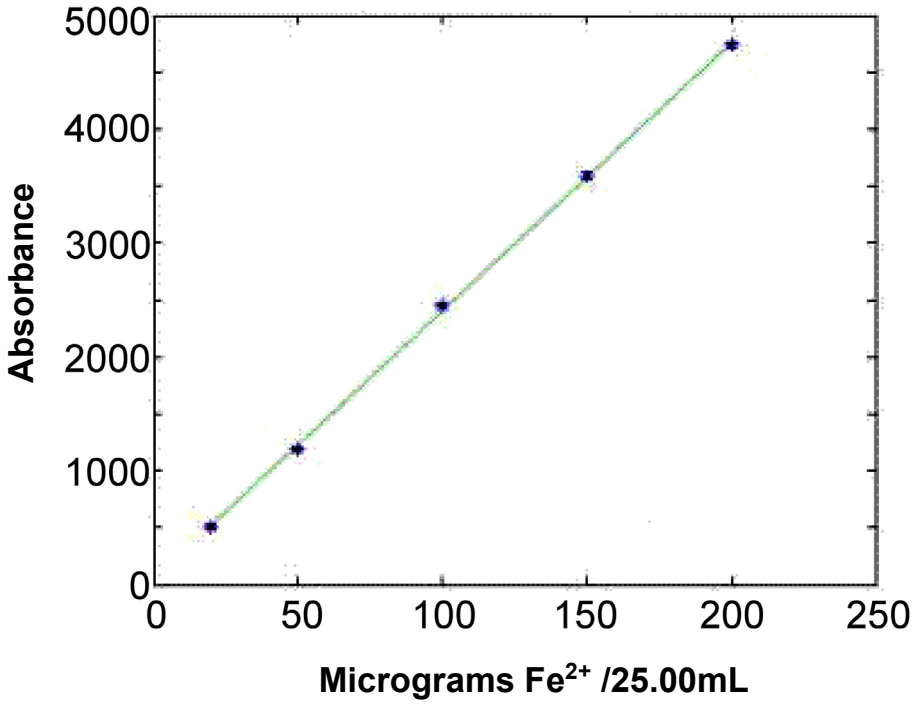
(b) The food safety inspector is concerned that there may be heavy metal contamination in the soup, with one of barium, lead (II), silver or copper (II) being present. Outline how the inspector could use precipitation or complexation reactions to determine if one of these ions is present. (4 marks)

QUESTION CONTINUES ON THE NEXT PAGE

(c) After further analysis, it was determined the unknown compound was iron. To determine the concentration of iron ions, AAS was used. Soup samples were prepared in the following manner:

- An excess of sodium carbonate solution was added to exactly 2.50 g of the soup sample.
- An iron precipitate formed. It was filtered, washed and then dissolved in a few drops of hydrochloric acid.
- The solution was then diluted to exactly 25.00 mL.
- This treated sample was analysed using atomic absorption spectrometry (AAS).

Iron (II) ion standard solutions were similarly prepared and then analysed with the AAS. Shown below is a calibration graph showing the absorbance values of the standard solutions.



The treated soup sample had an absorbance of 4500.

i. What is the concentration of Fe^{2+} in the treated soup sample in microgram/25.00mL? (1 mark)

……

ii. What is the Fe^{2+} concentration in the original soup sample in ppm? (3 marks)

……

……

……

……

……

……

Question 24 (5 marks)

(a) Describe how ionic compounds dissolve in water. (3 marks)

(b) Explain how Aboriginal and Torres Strait Islander People use solubility equilibria to remove toxins from food. (2 marks)

EXAMINATION CONTINUES ON THE NEXT PAGE

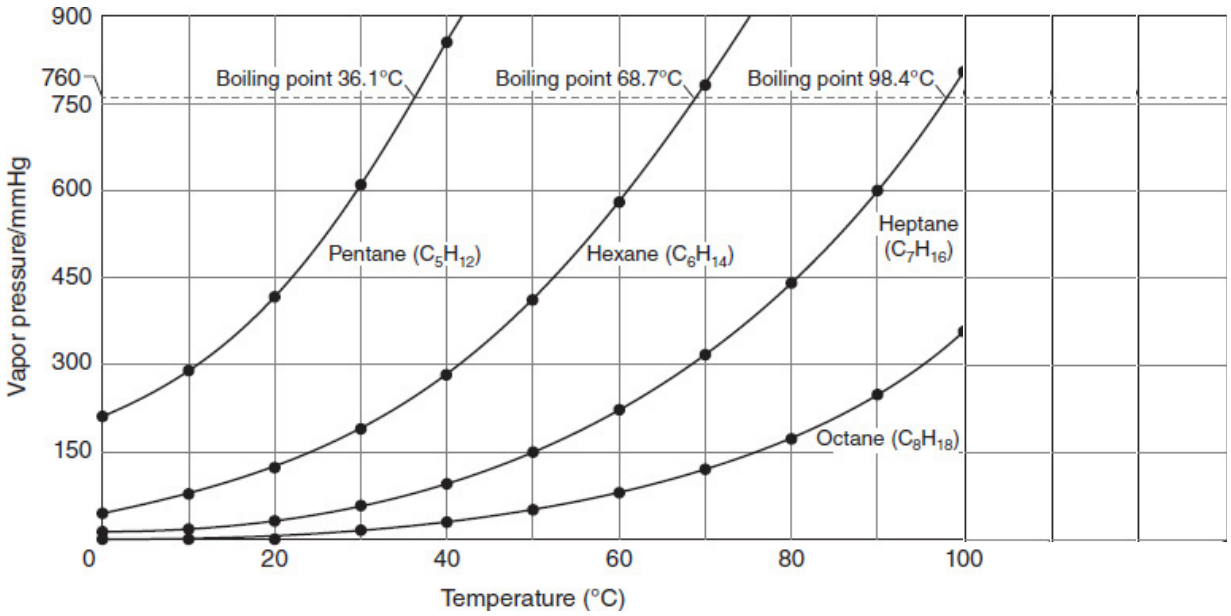
Question 25 (7 marks)

Ethanol is an important and widely used hydrocarbon. Describe how it can be produced, its properties and the reactions in which it is commonly involved. Include equations in your answer.

(7 marks)

Question 26 (7 marks)

The graph shown below compares four alkanes.

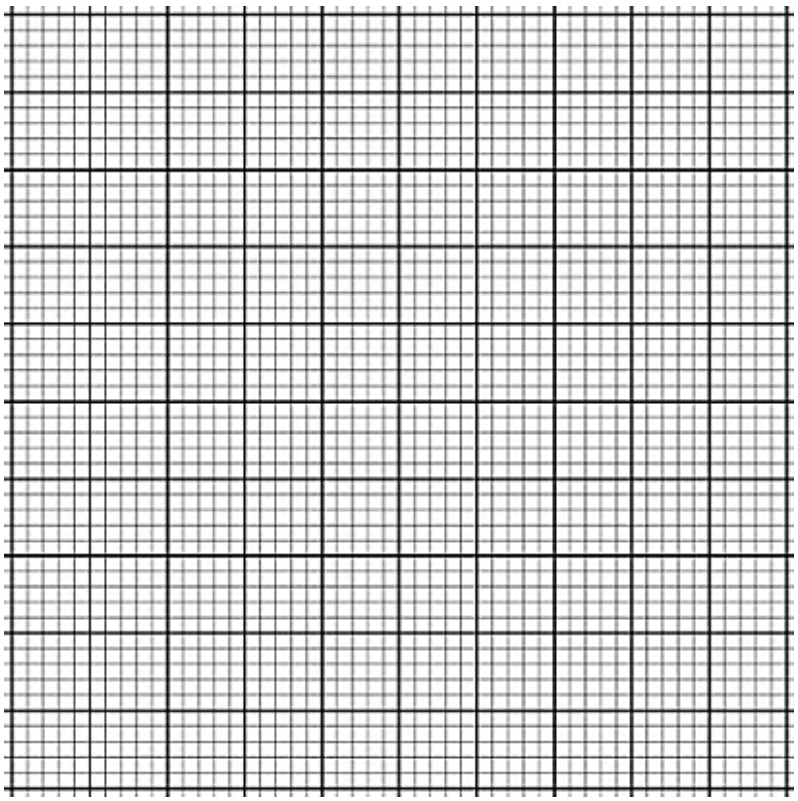


(a) Predict the boiling point of octane (1 mark)

……

(b) On the graph paper below, demonstrate the trend in boiling points for the alkanes C_5-C_8.

(3 marks)



QUESTION CONTINUES ON THE NEXT PAGE

(c) Explain this trend. (3 marks)

Question 27 (6 marks)

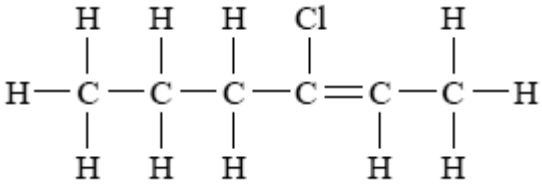
(a) Outline the method and results for a practical investigation to demonstrate an irreversible reaction. Include an equation in your answer (3 marks)

(b) The molar solubility of $Ba_3(PO_4)_2$ is 1.3 x 10^{-5} M in pure water at 30°C. Calculate the Ksp for $Ba_3(PO_4)_2$ at this temperature (3 marks)

Question 28 (5 marks)

Three important types of isomers are chain, position and functional group isomers.

(a) Draw 1 chain isomer and 1 position isomer of the molecule shown. (2 marks)



Chain Isomer:

Position Isomer

(b) Draw a new molecule and its functional group isomer. (1 mark)

Molecule:

Functional Group Isomer

(c) How can organic substances such as those shown above be safely handled and disposed of? (2 marks)

Question 29 (9 marks)

(a) Identify TWO conjugate acid-base pairs that would be involved in the reaction between hydrochloric acid and ammonia. Include identification of which is the acid and which is the base in each pair. (2 marks)

(b) A 25.0 mL aliquot of sodium carbonate solution is to be titrated with 1.0 M hydrochloric acid solution. What mass of dried anhydrous sodium carbonate must be dissolved in 250 mL of deionised water, so that the 25.0 mL aliquot of sodium carbonate solution will need a 20.0 mL titration of hydrochloric acid? Include a chemical equation in your answer. (4 marks)

(c) In a different acid-base experiment, 50mL of 0.50M H_2SO_4 was added to 100mL of 0.40M NaOH. What was the pH of the solution produced? (3 marks)

Question 30 (7 marks)

The balance between enthalpy change and entropy change determines the feasibility of a reaction. The table below contains enthalpy of formation and entropy data for some elements and compounds at 25°C.

	N_2 (g)	O_2 (g)	NO (g)	C (graphite)	C (diamond)
$\Delta H_f^{\ominus}$/kJ mol^{-1}	0	0	+90.4	0	+1.9
$S^{\ominus}$/J K^{-1} mol^{-1}	192.2	205.3	211.1	5.7	2.4

(a) Explain why the entropy value for the element nitrogen is much greater than the entropy value for the element carbon (graphite). (2 marks)

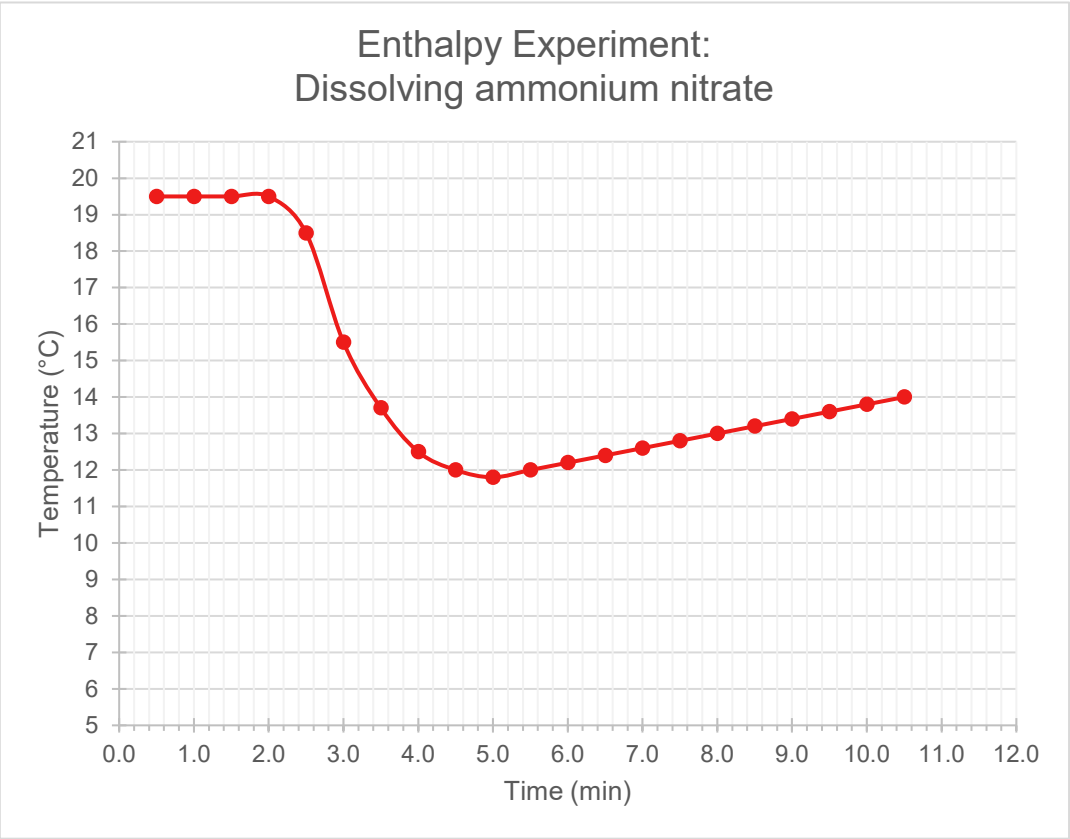
(b) Suggest the condition under which the element carbon (diamond) would have an entropy value of zero. (1 mark)

(c) Calculate ΔG for the reaction between nitrogen and oxygen to form nitric oxide (nitrogen monoxide). (3 marks)

(d) Is this a spontaneous reaction? Give a reason for your answer. (1 mark)

Question 31 (6 marks)

Using a simple polystyrene calorimeter 4.0 g of ammonium nitrate was dissolved in 50 mL of water.



(a) What is the temperature change for this reaction? (1 mark)

(b) Is this an exothermic or endothermic reaction? (1 mark)

(c) What is the enthalpy of dissolution for ammonium nitrate in kJ mol^{-1} (3 marks)

(d) Suggest a reason for why this value does not agree with the more accurate value found in the SI Data Book (1 mark)

Question 32 (7 marks)

K can be used to determine the equilibrium constant (Keq), the solubility product constant (Ksp) and the acid dissociation constant (Ka). It is sometimes compared to Q.

Evaluate the usefulness of K when examining, predicting and altering the conditions of certain chemical reactions. Include equations in your answer. (7 marks)

Student Number: .....

2019 | HIGHER SCHOOL CERTIFICATE EXAMINATION

Chemistry

FORMULAE SHEET

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

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

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

Avogadro constant, N_A ..... 6.022×10^{23} mol^{-1}

Volume of 1 mole ideal gas: at 100 kPa and

at 0°C (273.15 K) ..... 22.71 L

at 25°C (298.15 K) ..... 24.79 L

Gas constant ..... 8.314 J mol^{-1} K^{-1}

Ionisation constant for water at 25°C (298.15 K), K_w ..... 1.0×10^{-14}

Specific heat capacity of water ..... 4.18×10^3 J kg^{-1} K^{-1}

DATA SHEET

Solubility constants at 25°C

Compound	K_{sp}
Barium carbonate	2.58×10^{-9}
Barium hydroxide	2.55×10^{-4}
Barium phosphate	1.3×10^{-29}
Barium sulfate	1.08×10^{-10}
Calcium carbonate	3.36×10^{-9}
Calcium hydroxide	5.02×10^{-6}
Calcium phosphate	2.07×10^{-29}
Calcium sulfate	4.93×10^{-5}
Copper(II) carbonate	1.4×10^{-10}
Copper(II) hydroxide	2.2×10^{-20}
Copper(II) phosphate	1.40×10^{-37}
Iron(II) carbonate	3.13×10^{-11}
Iron(II) hydroxide	4.87×10^{-17}
Iron(III) hydroxide	2.79×10^{-39}
Iron(III) phosphate	9.91×10^{-16}

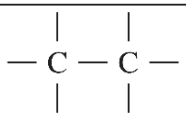
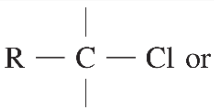
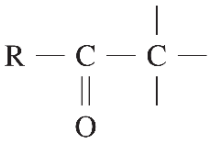
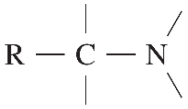
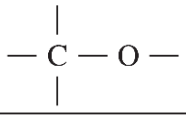
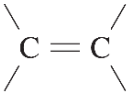
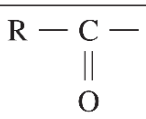
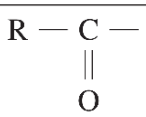
Compound	K_{sp}
Lead(II) bromide	6.60×10^{-6}
Lead(II) chloride	1.70×10^{-5}
Lead(II) iodide	9.8×10^{-9}
Lead(II) carbonate	7.40×10^{-14}
Lead(II) hydroxide	1.43×10^{-15}
Lead(II) phosphate	8.0×10^{-43}
Lead(II) sulfate	2.53×10^{-8}
Magnesium carbonate	6.82×10^{-6}
Magnesium hydroxide	5.61×10^{-12}
Magnesium phosphate	1.04×10^{-24}
Silver bromide	5.35×10^{-13}
Silver chloride	1.77×10^{-10}
Silver carbonate	8.46×10^{-12}
Silver hydroxide	2.0×10^{-8}
Silver iodide	8.52×10^{-17}
Silver phosphate	8.89×10^{-17}
Silver sulfate	1.20×10^{-5}

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

Infrared absorption data

Bond	Wavenumber/cm^{-1}
N—H (amines)	3300–3500
O—H (alcohols)	3230–3550 (broad)
C—H	2850–3300
O—H (acids)	2500–3000 (very broad)
C≡N	2220–2260
C=O	1680–1750
C=C	1620–1680
C—O	1000–1300
C—C	750–1100

^{13}C NMR chemical shift data

Type of carbon		δ/ppm
		5–40
		10–70
		20–50
		25–60
	alcohols, ethers or esters	50–90
		90–150
		110–125
		110–160
	esters or acids	160–185
	aldehydes or ketones	190–220

UV absorption

(This is not a definitive list and is approximate.)

Chromophore	λ_{max} (nm)
C—H	122
C—C	135
C=C	162

Chromophore	λ_{max} (nm)
C≡C	173 178 196 222
C—Cl	173
C—Br	208

Some standard potentials

$K^+ + e^-$	$\rightleftharpoons$	$K(s)$	–2.94 V
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	$Ba(s)$	–2.91 V
$Ca^{2+} + 2e^-$	$\rightleftharpoons$	$Ca(s)$	–2.87 V
$Na^+ + e^-$	$\rightleftharpoons$	$Na(s)$	–2.71 V
$Mg^{2+} + 2e^-$	$\rightleftharpoons$	$Mg(s)$	–2.36 V
$Al^{3+} + 3e^-$	$\rightleftharpoons$	$Al(s)$	–1.68 V
$Mn^{2+} + 2e^-$	$\rightleftharpoons$	$Mn(s)$	–1.18 V
$H_2O + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g) + OH^-$	–0.83 V
$Zn^{2+} + 2e^-$	$\rightleftharpoons$	$Zn(s)$	–0.76 V
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	$Fe(s)$	–0.44 V
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	$Ni(s)$	–0.24 V
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	$Sn(s)$	–0.14 V
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	$Pb(s)$	–0.13 V
$H^+ + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g)$	0.00 V
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_2(aq) + 2H_2O$	0.16 V
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	$Cu(s)$	0.34 V
$\frac{1}{2}O_2(g) + H_2O + 2e^-$	$\rightleftharpoons$	$2OH^-$	0.40 V
$Cu^+ + e^-$	$\rightleftharpoons$	$Cu(s)$	0.52 V
$\frac{1}{2}I_2(s) + e^-$	$\rightleftharpoons$	I^-	0.54 V
$\frac{1}{2}I_2(aq) + e^-$	$\rightleftharpoons$	I^-	0.62 V
$Fe^{3+} + e^-$	$\rightleftharpoons$	Fe^{2+}	0.77 V
$Ag^+ + e^-$	$\rightleftharpoons$	$Ag(s)$	0.80 V
$\frac{1}{2}Br_2(l) + e^-$	$\rightleftharpoons$	Br^-	1.08 V
$\frac{1}{2}Br_2(aq) + e^-$	$\rightleftharpoons$	Br^-	1.10 V
$\frac{1}{2}O_2(g) + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O	1.23 V
$\frac{1}{2}Cl_2(g) + e^-$	$\rightleftharpoons$	Cl^-	1.36 V
$\frac{1}{2}Cr_2O_7^{2-} + 7H^+ + 3e^-$	$\rightleftharpoons$	$Cr^{3+} + \frac{7}{2}H_2O$	1.36 V
$\frac{1}{2}Cl_2(aq) + e^-$	$\rightleftharpoons$	Cl^-	1.40 V
$MnO_4^- + 8H^+ + 5e^-$	$\rightleftharpoons$	$Mn^{2+} + 4H_2O$	1.51 V
$\frac{1}{2}F_2(g) + e^-$	$\rightleftharpoons$	F^-	2.89 V

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number	79
Symbol	Au
Standard Atomic Weight	197.0
Name	Gold

1 H 1.008 Hydrogen																	2 He 4.003 Helium
3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 22.99 Sodium	12 Mg 24.31 Magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.97 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.87 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.38 Zinc	31 Ga 69.72 Gallium	32 Ge 72.64 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.61 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.96 Molybdenum	43 Tc Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.9 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.9 Silver	48 Cd 112.4 Cadmium	49 In 114.8 Indium	50 Sn 118.7 Tin	51 Sb 121.8 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.3 Xenon
55 Cs 132.9 Caesium	56 Ba 137.3 Barium	57–71 Lanthanoids	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.9 Tungsten	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.2 Iridium	78 Pt 195.1 Platinum	79 Au 197.0 Gold	80 Hg 200.6 Mercury	81 Tl 204.4 Thallium	82 Pb 207.2 Lead	83 Bi 209.0 Bismuth	84 Po Polonium	85 At Astatine	86 Rn Radon
87 Fr Francium	88 Ra Radium	89–103 Actinoids	104 Rf Rutherfordium	105 Db Dubnium	106 Sg Seaborgium	107 Bh Bohrium	108 Hs Hassium	109 Mt Meitnerium	110 Ds Darmstadtium	111 Rg Roentgenium	112 Cn Copernicium	113 Nh Nihonium	114 Fl Flerovium	115 Mc Moscovium	116 Lv Livermorium	117 Ts Tennessine	118 Og Oganesson

Lanthanoids

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm Promethium	62 Sm 150.4 Samarium	63 Eu 152.0 Europium	64 Gd 157.3 Gadolinium	65 Tb 158.9 Terbium	66 Dy 162.5 Dysprosium	67 Ho 164.9 Holmium	68 Er 167.3 Erbium	69 Tm 168.9 Thulium	70 Yb 173.1 Ytterbium	71 Lu 175.0 Lutetium

Actinoids

89 Ac Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np Neptunium	94 Pu Plutonium	95 Am Americium	96 Cm Curium	97 Bk Berkelium	98 Cf Californium	99 Es Einsteinium	100 Fm Fermium	101 Md Mendelevium	102 No Nobelium	103 Lr Lawrencium

Standard atomic weights are abridged to four significant figures.

Elements with no reported values in the table have no stable nuclides.

Information on elements with atomic numbers 113 and above is sourced from the International Union of Pure and Applied Chemistry Periodic Table of the Elements (November 2016 version).

The International Union of Pure and Applied Chemistry Periodic Table of the Elements (February 2010 version) is the principal source of all other data. Some data may have been modified.

Student 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

2019 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 21–32

• 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

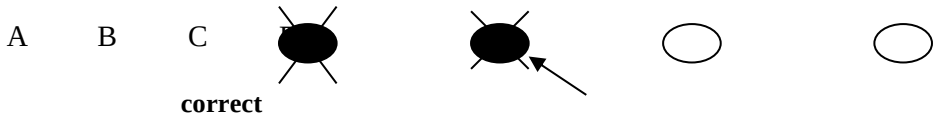
Use the multiple-choice answer sheet.

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

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 a strong base?
   (A) A substance that fully dissociates to produce H+ ions
   (B) A substance the partially dissociates to produce H+ ions
   (C) A substance that totally ionises to produce OH^- ions
   (D) A substance that partially dissociates to produce OH^- ions

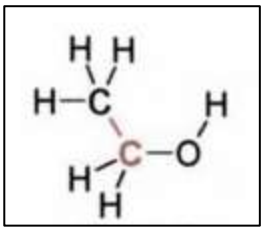
2. Carbon dioxide is dissolved under pressure into a soft drink.

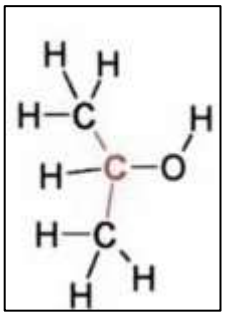
Which option correctly describes the equilibrium and the system?

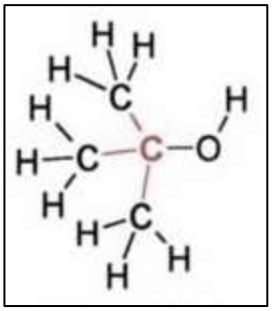
	Equilibrium	**System**
(A)	Dynamic	Closed
(B)	Static	Closed
(C)	Dynamic	Open
(D)	Static	Open

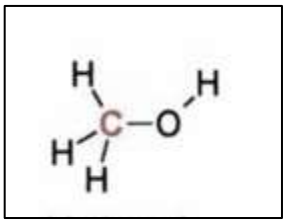
3. Why would a flame test be used?
   (A) To confirm the presence of a particular cation
   (B) To provide quantitative data on the ion in the compound
   (C) To determine the concentration of coloured compounds in a solution
   (D) To measure the light absorption at different wavelengths of the spectrum

4. Which structure shows a tertiary alcohol?

(A) 

(B) 

(C) 

(D) 

5. Which option outlines Arrhenius' theory of acids and bases?
   (A) Acids are proton acceptors.
   (B) Acids are electron pair acceptors.
   (C) Acids and bases form conjugate pairs
   (D) Acids produce H^+ ions when added to water.

6. A student conducted a gravimetric analysis to determine the mass of silver chloride precipitated in a particular reaction. However, the experimental value that the student measured was much less than the theoretical mass expected. How could the student have increased the accuracy of the experiment?
   (A) Repeated the experiment 5 times
   (B) Used a blank, distilled water control
   (C) Used filter paper with smaller hole size
   (D) Added the same volume of water in each repeat

7. What type of reaction is shown?

$$CH_3OH + PCl_5 \rightarrow CH_3Cl + POCl_3 + HCl$$

   (A) Combustion
   (B) Dehydration
   (C) Substitution
   (D) Oxidation

8. How would a student know if there were carbon-carbon double bonds in a molecule?
   (A) Limewater would turn milky
   (B) Brown bromine water would decolourise
   (C) Esterification would produce a "fruity" smell
   (D) Acidified potassium dichromate would change from yellow to green

9. A sulfate solution with an unknown cation was tested by adding chloride ions. No precipitate formed. Which cation was absent from the solution?
   (A) Copper (II) ion
   (B) Iron (II) ion
   (C) Lead (II) ion
   (D) Iron (III) ion

10. Which reaction is exothermic?
   (A) $H_2O_{(s)} \rightarrow H_2O_{(l)}$
   (B) $2H_2O_{(l)} \rightarrow H_{2\,(g)} + O_{2\,(g)}$
   (C) $6CO_{2\,(g)} + 6H_2O_{(l)} \rightarrow C_6H_{12}O_{6\,(aq)} + 6O_{2\,(g)}$
   (D) $2HNO_{3\,(aq)} + Ca(OH)_{2\,(aq)} \rightarrow Ca(NO_3)_{2\,(aq)} + 2H_2O_{(l)}$

11. A student boiled a red flower, filtered out the flower particles and used the filtrate. The student added 1mL of the filtrate to each of the following solutions and observed the colour produced:

Salt Solution	**Colour after flower solution is added**
NaF	Orange
KCN	Yellow
$CaCO_3$	Yellow
NH_4NO_3	Red

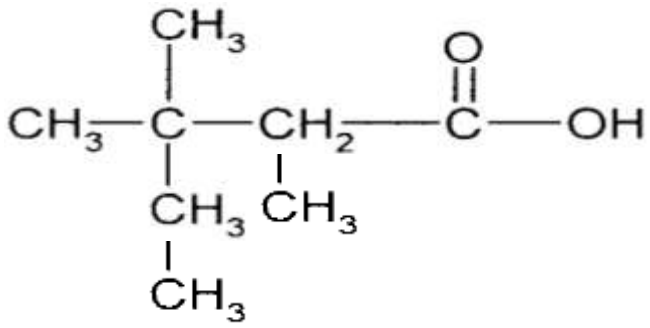
What do these colour changes represent?

	Orange	**Yellow**	**Red**
(A)	Base	Acid	Neutral
(B)	Acid	Base	Neutral
(C)	Neutral	Acid	Base
(D)	Neutral	Base	Acid

12. The following compounds all have similar molecular mass. Which compound has the highest boiling point?
    (A) CH_3CH_2CHO
    (B) $CH_3(CH_2)_2F$
    (C) CH_3CH_2COOH
    (D) $CH_3(CH_2)_2NH_2$

13. Which of the following will form a buffer solution if combined in appropriate ratios?
    (A) HCl and NaCl
    (B) NaOH and HCOONa
    (C) NaCl and H_2SO_4
    (D) NH_4Cl and NH_3

14. Identify the molecule shown.



(A) 3-ethyl-2,3-dimethylbutanoic acid
(B) 2,3-methyl-3-ethylbutanoic acid
(C) 2,3,3-trimethylpentanoic acid
(D) 3,3,4-trimethylpentanoic acid

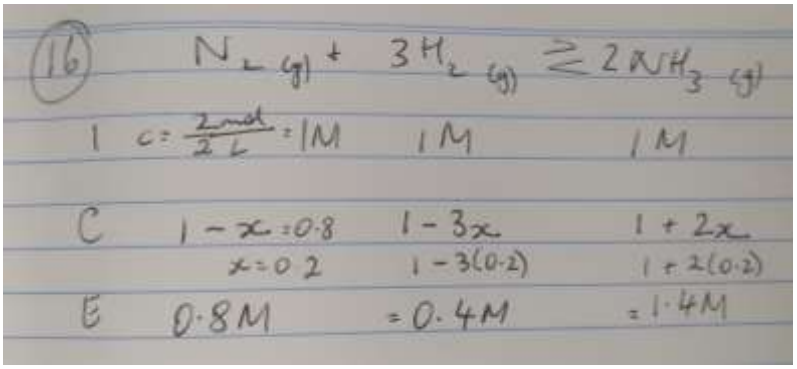
15. What is the shape of an ethene molecule?

	Shape of the whole molecule	Shape of each carbon
(A)	Planar	Trigonal Planar
(B)	Planar	Tetrahedral
(C)	Linear	Linear
(D)	Linear	Trigonal Bipyramidal

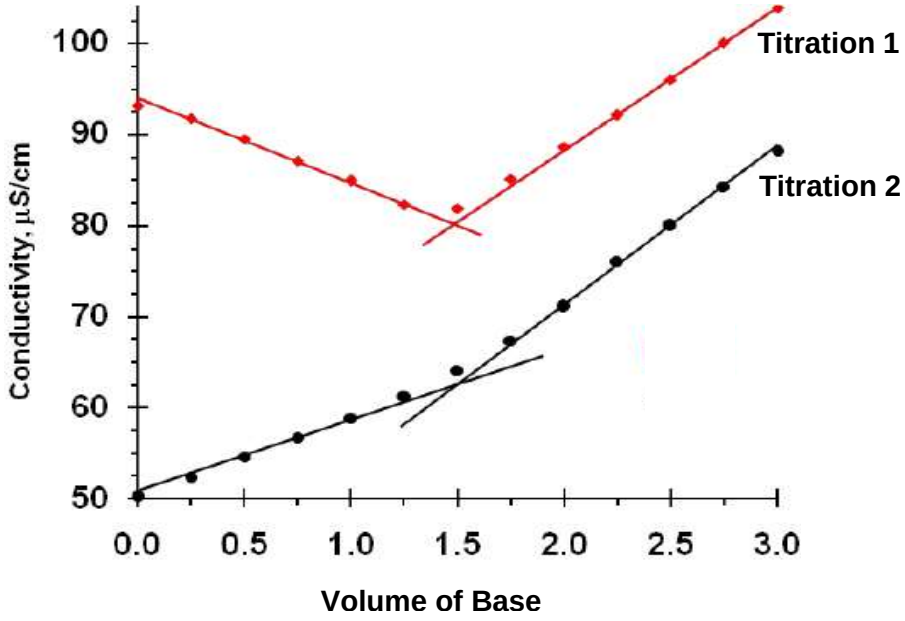
16. 2.0 mol of $N_2(g)$, 2.0 mol of $H_2(g)$ and 2.0 mol of $NH_3(g)$ are placed in a 2.0L sealed flask and left to reach equilibrium. At equilibrium the concentration of $N_2(g)$ is 0.8 mol L^{-1}.

What are the equilibrium concentrations of $H_2(g)$ and $NH_3(g)$ in mol L^{-1}?

	Concentration of $H_2(g)$ (mol L^{-1})	Concentration of $NH_3(g)$ (mol L^{-1})
(A)	0.8	3.2
(B)	0.4	1.4
(C)	0.8	1.4
(D)	0.6	1.2



17. A student conducted two conductometric titrations, with different reagents. The student's results are graphed below.



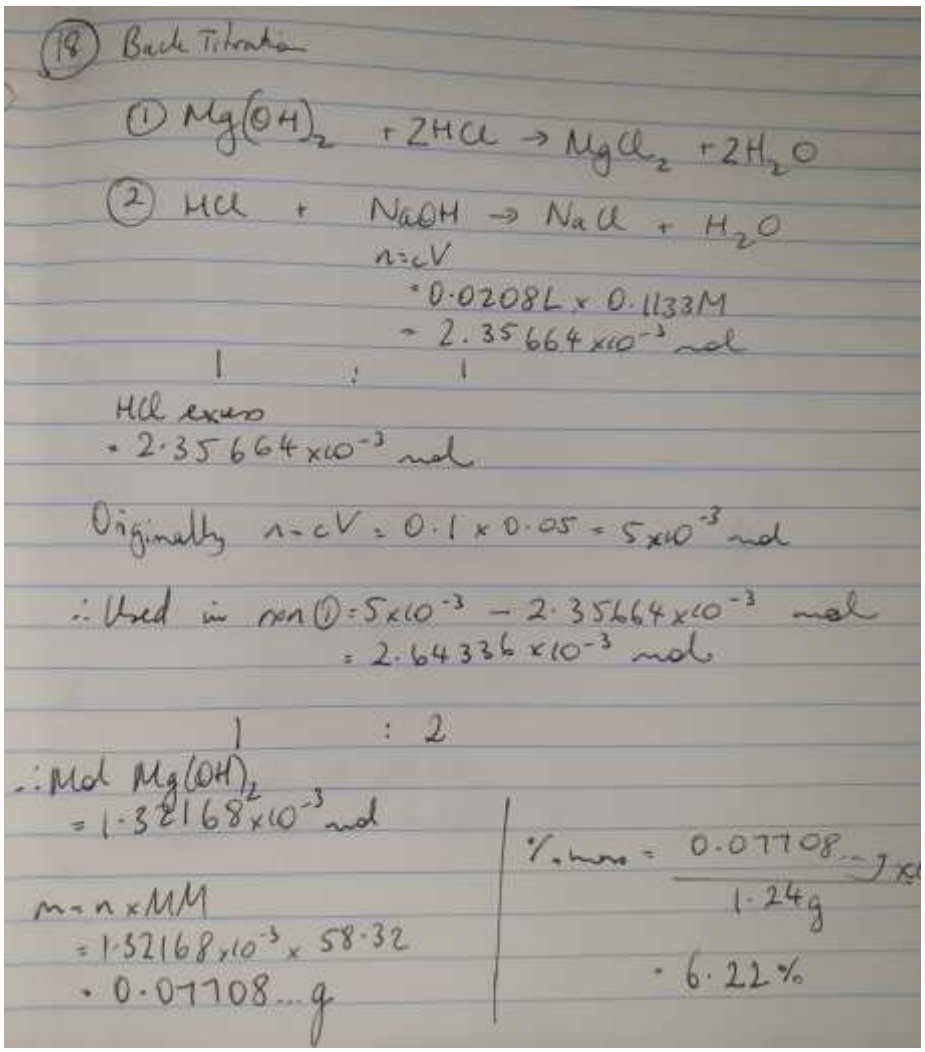
What reagents did the student use?

	Titration 1	Titration 2
(A)	Strong Acid and Strong Base	Strong Acid and Weak Base
(B)	Strong Acid and Strong Base	Weak Acid and Strong Base
(C)	Weak Acid and Weak Base	Weak Acid and Strong Base
(D)	Weak Acid and Weak Base	Strong Acid and Weak Base

18. A student wanted to determine the percentage of magnesium hydroxide in a 1.24 g antacid tablet. The antacid tablet was added to 50.00L of 0.100 mol L^{-1} hydrochloric acid. The excess hydrochloric acid required 20.80 mL of 0.1133 mol L^{-1} NaOH for neutralization.

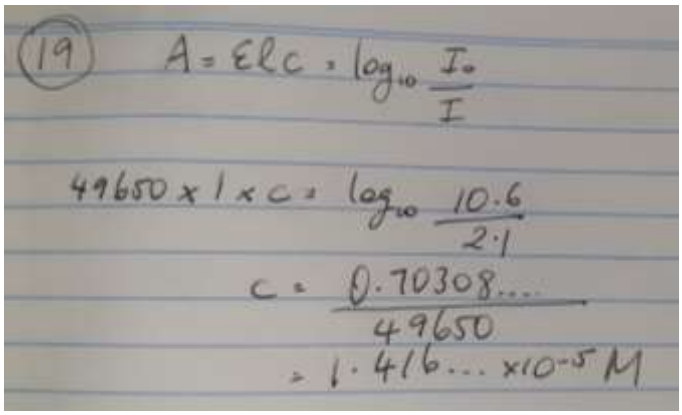
    Calculate the percentage by mass of magnesium hydroxide in the 1.24 g antacid tablet

    (A) 1.32 %
    (B) 2.65 %
    (C) 6.23 %
    (D) 7.70%



19. Spectroscopy was used to determine the unknown concentration of copper (II) sulfate in a solution. The intensity of the light produced by the spectrophotometer was 10.6, but after being passed through a 1.0 cm cuvette, the recorded intensity was only 2.1. The molar absorptivity of the sample was known to be 49650 L cm^{-1} mol^{-1}. Using the Beer-Lambert Law, what is the concentration of copper (II) sulfate in the sample?

(A) 1.6×10^{-3} mol L^{-1}
(B) 1.7×10^{-4} mol L^{-1}
(C) 1.2×10^{-4} mol L^{-1}
(D) 1.4×10^{-5} mol L^{-1}

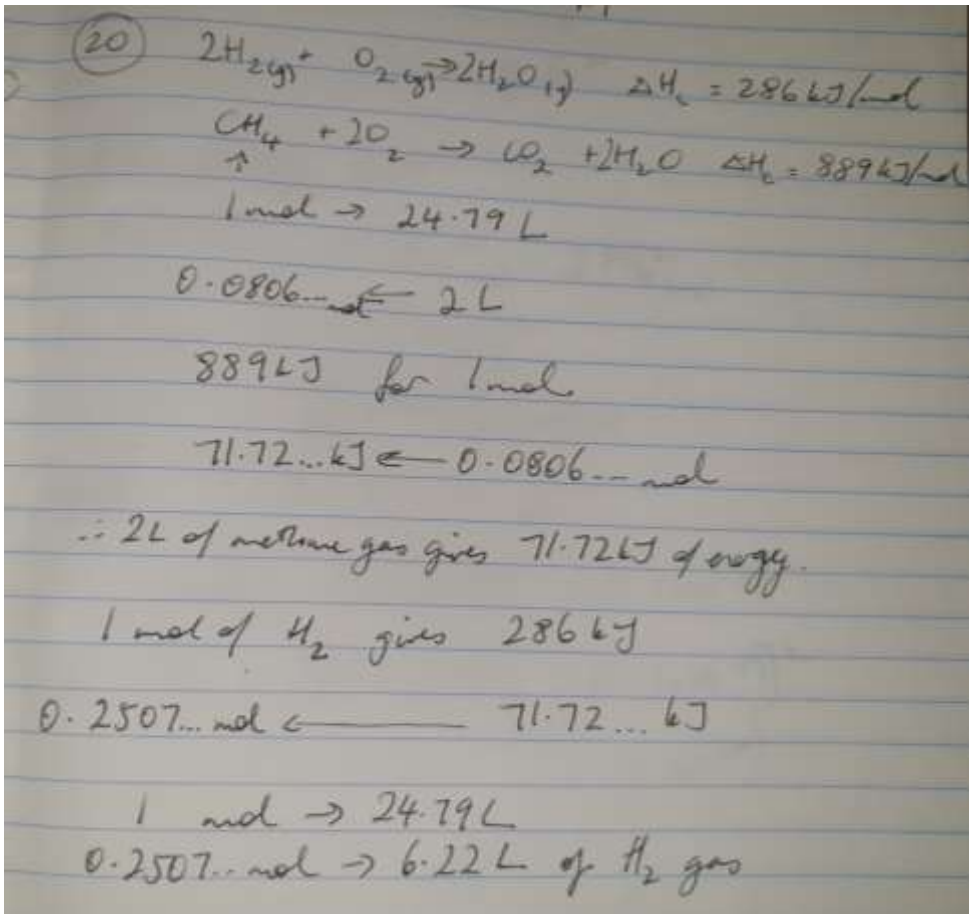


20. A variety of biofuels are being considered as alternatives to fossil fuels. Hydrogen fuel cell vehicles burn hydrogen and only produce water and heat as the by-products. Bio-Bug cars burn methane gas, and while they have more by-products, the methane can be produced from human waste, thus solving other environmental problems.

A student researching these 2 types of vehicles found that the heat of combustion for hydrogen gas in 286kJ mol^{-1}, while it is 889kJ mol^{-1} for methane.

What volume of hydrogen gas at 25°C and 100kPa produces the same amount of energy as 2.0 L of methane gas at the same temperature and pressure?

(A) 0.08 L
(B) 0.25 L
(C) 6.22 L
(D) 71.7 L



Part B – Extended Response Questions (80 marks)

Question 21 (7 marks)

A student wants to make an ester in a school laboratory.

(a) Identify the TWO types of compounds that react to make an ester (1 mark)

An alcohol and a carboxylic acid

Marking Guidelines	Marks
• Correctly identifies BOTH compounds	1

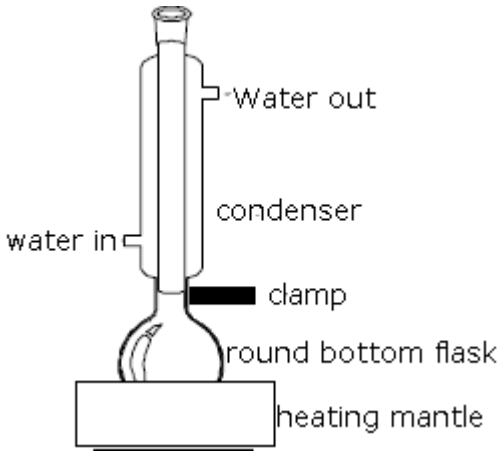
(b) Name an ester that can be produced in a school laboratory (1 mark)

Methyl ethanoate

Marking Guidelines	Marks
• Identifies, with correct IUPAC naming, an ester that could be safely made in a school	1

(c) Describe the method used to produce the ester named in (b). (3 marks)

1. Place safety goggles/glasses, gloves and lab coat on (since the glacial ethanoic acid and the concentrated sulfuric acid are corrosive and could cause burns.)
2. Add 15 mL of methanol and 10 mL glacial ethanoic (acetic) acid, to a 50 mL round bottom flask.
3. Slowly add about 1 mL of concentrated sulfuric acid and a few boiling chips which will prevent "bumping".
4. Set up the glassware as shown in the diagram.
5. Turn on the heating mantle to achieve a gentle boiling of the reaction mixture. (NOTE – a water bath can be used on a hot plate, but no flames should be near the equipment, since the organic substances are flammable)
6. Reflux the mixture for 30 minutes.
7. Turn off the heat and allow the mixture to cool.



Marking Guidelines	Marks
• Outlines an appropriate method, demonstrating consideration of at least TWO safety issues.	3
• Outlines a mostly appropriate method, demonstrating consideration of at least TWO safety issues. OR • Outlines an appropriate method.	2
• Any relevant information	1

(d) Explain how you could increase the yield of ester produced. (2 marks)

methanol + ethanoic acid ⇋ methyl ethanoate + water

By increasing the concentration of one of the reactants (either the methanol or the ethanoic acid). This will shift the equilibrium towards the RHS to try to minimise the increase in concentration (Le Chatelier's Principle), thus causing more products to be produced i.e. more ester/greater yield of ester.

OR

By removing water from the reaction mixture, the equilibrium shifts to the RHS to try to increase the amount of water (Le Chatelier's Principle), favouring the production of products ie. Ethanoic acid. Water can be removed from the reaction mixture by adding concentrated sulfuric acid, since it reacts with the water and removes it from the reaction mixture.

Marking Guidelines	**Marks**
• Identifies a method that could be used to increase yield • Provides reasons for why this would be successful including reference to Le Chatelier's Principle.	2
• Any relevant information	1

Markers comments

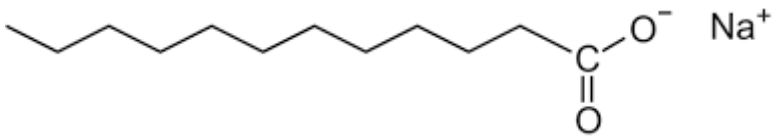
(a) and (b) done well by most. (c) also done well although a few did not mention refluxing.

(d) also done well by most but some did not make a link or reference to equilibrium. For the second mark.

(a)

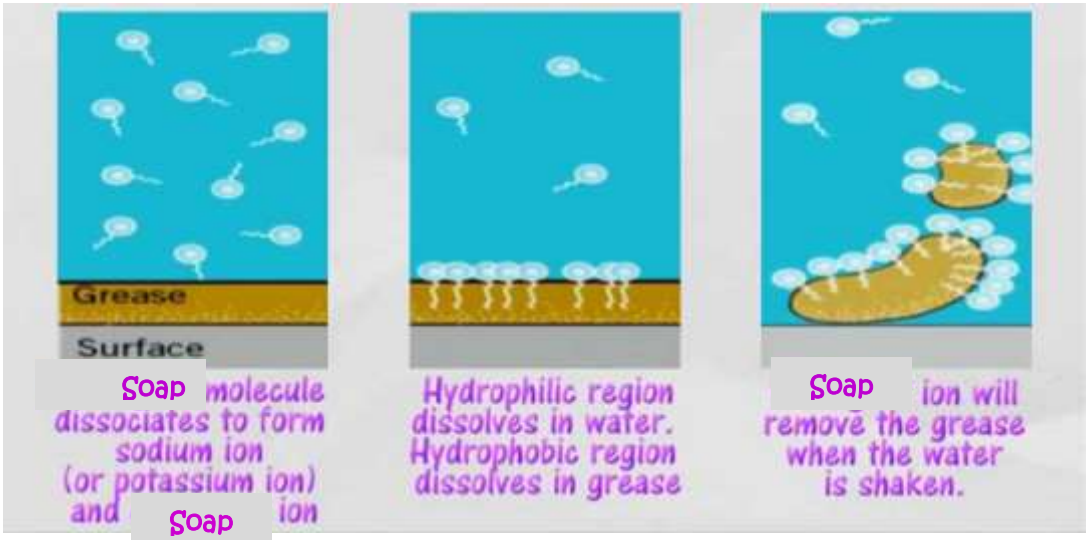
Question 22 (4 marks)

(a) Draw the chemical structure of a soap (1 mark)

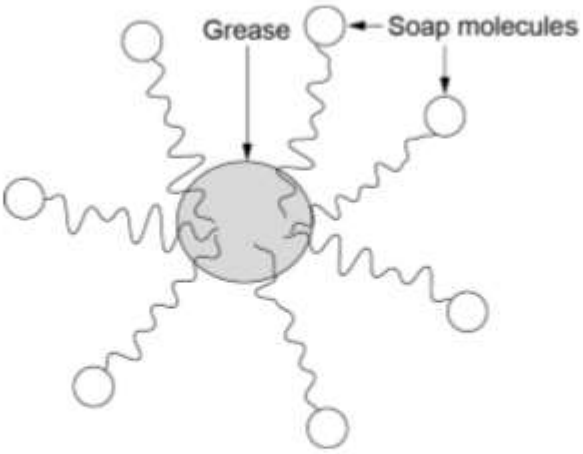


Marking Guidelines	Marks
• Provides a diagram showing a long carbon chain "tail" and a negative "head"	1

(b) How do soaps work to remove grease? (3 marks)



When a soap molecule is in water and meets a grease or oil particle, a micelle is formed.



This whole ball of soap and grease is a micelle. All the non-polar ends of the soap molecule are dissolved into the grease with dispersion forces (which is non-polar). The polar heads of the soap are soluble in the polar solvent, water, through attractive forces such as non-dipole forces and dipole-dipole/hydrogen bonding to form a micelle which can be lifted away by the water. The water and the grease form an emulsion.

Marking Guidelines	Marks
• Identifies components of the soap molecule that are soluble in grease/water • Identifies the forces that cause the "head"/"tail" to be soluble • Outlines the process of removing the grease from the substance	3
• Provides some features of how soaps function	2
• Any relevant information	1

Marker comments – this question was done well by most. Errors usually involved getting hydrophobic and hydrophilic confused

Question 23 (10 marks)

An unidentified substance was found in a sample of soup during a routine food safety inspection.

(a) Outline the need for monitoring of substances in food or the environment (2 marks)

Food/environment can become contaminated e.g foods can be contaminated with pathogenic bacteria/viruses, the environment can become contaminated with excess nutrients from fertilizer runoff or heavy metals from industry. If we do not monitor and check that these substances are not in high levels in our food/environment, then organisms, including humans, can become sick or even die.

Marking Guidelines	Marks
• Provides a reason for why food/water needs to be monitored • Demonstrates an understanding of what may occur if food/environment is not monitored	2
• Any relevant information	1

Marker comment – very well done. BUT to ensure full marks in an HSC it is advised that apart from a general comment (which was all that was needed in this exam) you should also include a specific example e.g monitoring food for mercury as this is a nerve toxin.

(b)The food safety inspector is concerned that there may be heavy metal contamination in the soup, with one of barium, lead (II), silver or copper (II) being present. Outline how the inspector could use precipitation or complexation reactions to determine if one of these ions is present. (4 marks)

The inspector could add NaOH and observe for precipitates:

1. Lead (II) - add NaOH to a sample and check for green precipitate of $Pb(OH)_2$
2. Copper – add NaOH to a sample and check for light blue precipitate of $Cu(OH)_2$
3. Silver – add NaOH to a sample and if a creamy/brown precipitate of AgOH forms, there is silver present.
4. Barium – add NaOH to a sample and check for a faint white precipitate of $Ba(OH)_2$ or no precipitate. This could be confirmed using a flame test, which would show green if there was Barium present.

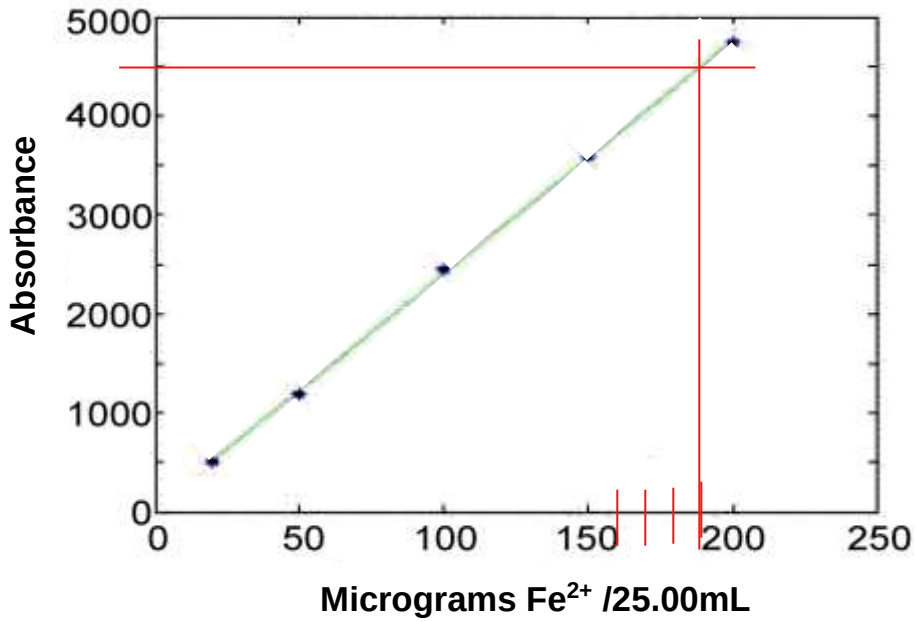
Marking Guidelines	Marks
• Provides an appropriate method to test for all 4 ions • Includes the expected outcome of the tests e.g. ppt, colour • Identifies the products produced in the tests	4
• Provides an appropriate method to test for all 4 ions • May include the expected outcome of the test e.g. ppt, colour OR identifies the products produced in the test OR • Provides a method to test for some of the ions • Includes the expected outcome of the tests e.g. ppt, colour • Identifies the products produced in the test	2-3
• Any relevant information	1

Marker comments – some done well. Needed to give tests specific for each ion. With precipitates better to include mention of colours. Some students included flame tests but the question did not ask for this

(b) After further analysis, it was determined the unknown compound was iron. To determine the concentration of iron ions, AAS was used. Soup samples were prepared in the following manner:

- An excess of sodium carbonate solution was added to exactly 2.50 g of the soup sample.
- An iron precipitate formed. It was filtered, washed and then dissolved in a few drops of hydrochloric acid.
- The solution was then diluted to exactly 25.00 mL.
- This treated sample was analysed using atomic absorption spectrometry (AAS).

Iron (II) ion standard solutions were similarly prepared and then analysed with the AAS. Shown below is a calibration graph showing the absorbance values of the standard solutions.



The treated soup sample had an absorbance of 4500.

i. What is the concentration of Fe^{2+} in the treated soup sample in microgram/25.00mL?

190micrograms per 25mL

Marking Guidelines	Marks
• Identifies correct concentration including units	1

ii. What is the Fe^{2+} concentration in the original soup sample in ppm? (3 marks)

190 µg in 25mL. All the iron came from the original sample, despite being dissolved/diluted, so there is 190 µg in 2.5g of soup.
Ppm = mg/L = **mg/kg**
So 190×10^{-3}mg in 2.5×10^{-3}kg
Thus for 1kg, there is 76mg
Hence, 76ppm of iron in the soup sample.

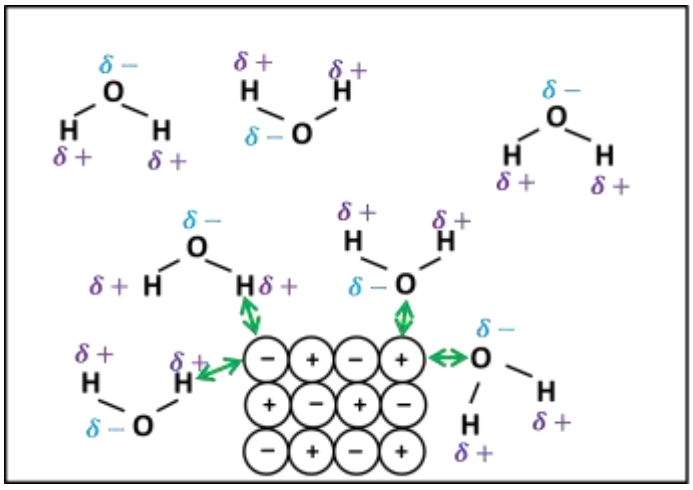
Marking Guidelines	Marks
• Calculation totally correct	3
• Calculation mostly correct	2
• Any relevant information	1

Marker comments – part (a) was fine. Part (b) poorly done. Most did not recognise that micrograms are ppm. (1 million micrograms in a gram)

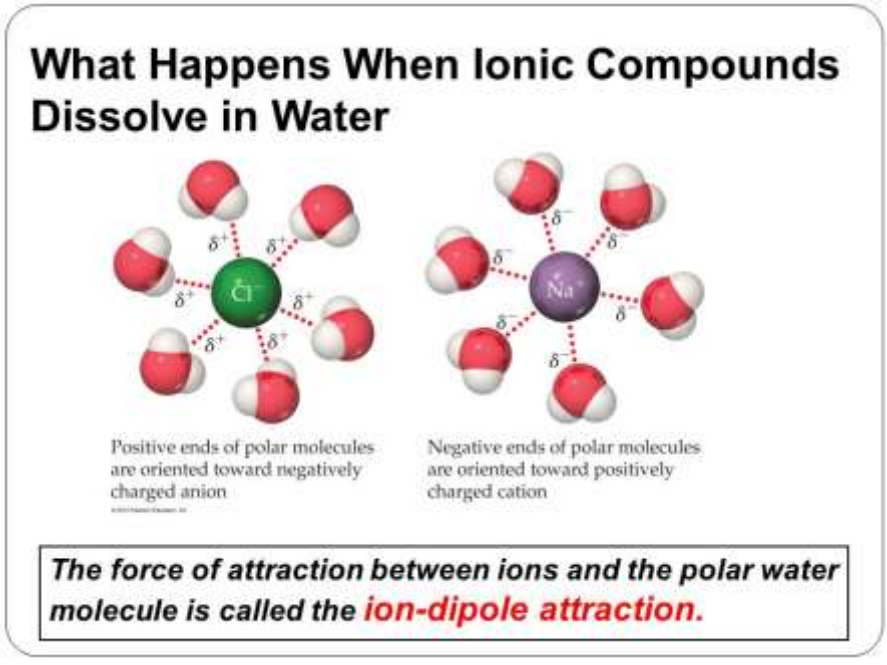
Question 24 (5 marks)

(a) Describe how ionic compounds dissolve in water. (3 marks)

Ionic compounds are composed of a crystal lattice of alternating positive and negative ions. When they come in contact with water, the positive ions are attracted to the negative polar end of the water molecules, and the negative ions are attracted to the positive polar end of the water molecules. Hence the water molecules surround the ion and remove it from the crystal lattice, allowing it to dissolve into the water.



↔ : represents the **forces** between the ions and the dipoles in the water molecule (ion-dipole interactions)



Marking Guidelines	Marks
• Identifies the composition of ionic compounds • Identifies the polar nature of water molecules • Identifies how the water molecules interact with the ions	3
• Outlines some features to demonstrate how ionic compounds dissolve	2
• Any relevant information	1

Marker comments – done well by many. Some confused terminology with e.g. mention of dipole-dipole bonds rather than ion-dipole forces.

(b) Explain how Aboriginal and Torres Strait Islander People use solubility equilibria to remove toxins from food. (2 marks)

The ATSI people commonly use solubility equilibria to remove toxins from cycad fruit, using prolonged leaching. The toxins in the fruit are soluble in water. The fruit are placed in running water eg. in a river/stream, and new, pure water keeps entering the system while water that has a higher concentration of the toxin constantly leaves the system. This produces an open equilibrium system. This also means that the aqueous toxin keeps being removed, so the equilibrium shifts towards the RHS to minimise the change and produce more aqueous toxin (Le Chatelier's Principle).

Toxin (s) ← → toxin (aq)

This is useful, since, if the cycad fruit are left long enough in running water, all of the toxin will be leached out, and the fruit will be safe to eat.

Marking Guidelines	**Marks**
• Outlines how and why ATSI people use solubility equilibria	2
• Any relevant information	1

Marker comments – done well by most with implied reference to equilibria. Better answers actually referred to flowing water removing leached toxins to equilibrium shift to right and have continued removal of toxins

EXAMINATION CONTINUES ON THE NEXT PAGE

Question 25 (7 marks)

Ethanol is an important and widely used hydrocarbon. Describe how it can be produced, its properties and the reactions in which it is commonly involved. Include equations in your answer.

(7 marks)

Answers could include:

Production – through fermentation using yeast, or through synthetic processes e.g. substitution reactions of halogenated compounds, addition/hydration reactions e.g. with ethene

Properties – polar end and non-polar end, so works well as a solvent, also has a reasonable enthalpy of combustion hence a good fuel, or mp/bp or acidity

Reactions – combustion, dehydration, substitution with HX, oxidation, esterification

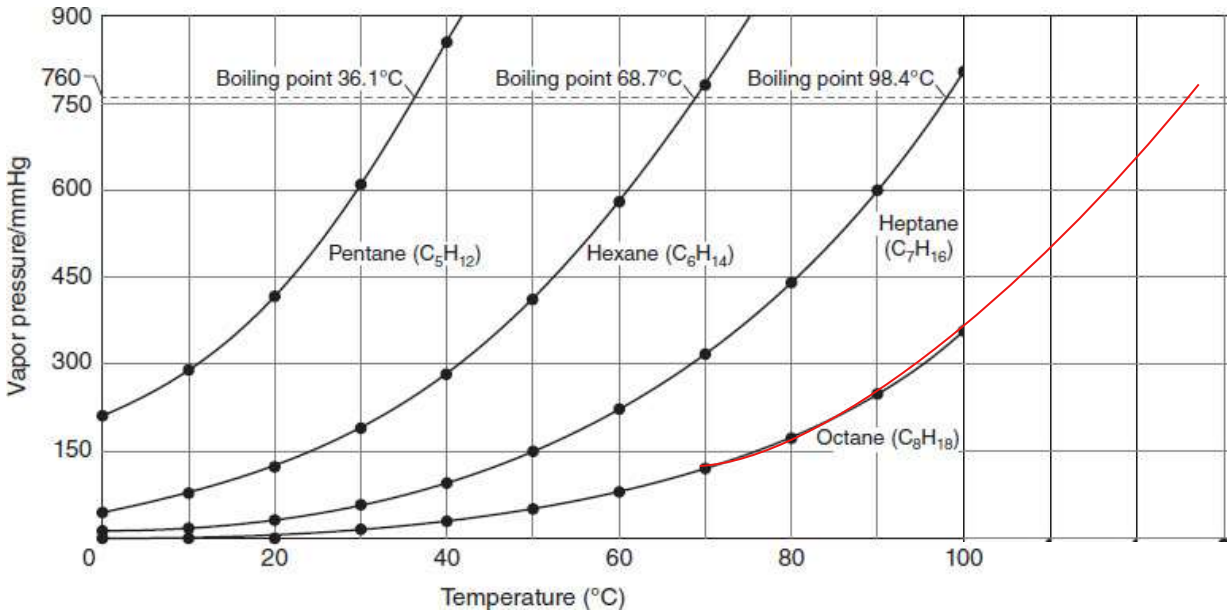
Marking Guidelines	Marks
• Describes how ethanol can be produced • Describes properties of ethanol • Outlines common reactions involving ethanol • Provides chemical equations and formulae • Demonstrates coherence and logical progression	7
• Outlines how ethanol can be produced • Describes properties of ethanol • Outlines common reactions involving ethanol • Provides some chemical equations and formulae OR • Describes how ethanol can be produced • Outlines properties of ethanol • Outlines common reactions involving ethanol • Provides some chemical equations and formulae OR • Describes how ethanol can be produced • Describes properties of ethanol • Identifies common reactions involving ethanol • Provides some chemical equations and formulae	5-6
• Outlines how ethanol can be produced • Outlines properties of ethanol • Identifies common reactions involving ethanol • Provides some chemical equations or formulae OR • Describes TWO of production/properties/reactions • Provides some chemical equations or formulae	3-4
• Outlines TWO of production/properties/reactions OR • Describes ONE of production/properties/reactions	2
• Any relevant information	1

Marker comments

- Some evidence of improved structuring of responses. Needed at least two examples of production, properties and uses as well as at least two correct equations. Word equations do NOT count!! – and avoid structural equations if possible. Marks were lost for not giving enough examples OR simply identifying e.g. a property without providing some information about the feature (the verb in the question is "describe")

Question 26 (7 marks)

The graph shown below compares four alkanes.

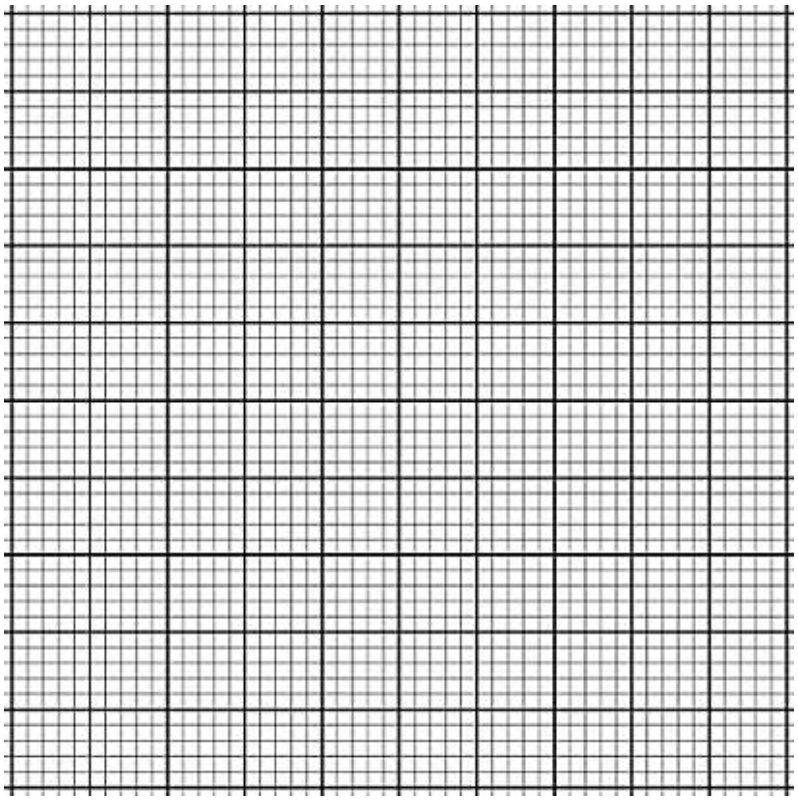


(a) Predict the boiling point of octane (1 mark)

125°C

Marking Guidelines	Marks
• Extrapolates and identifies boiling point	1

(b) On the graph paper below, demonstrate the trend in boiling points for the alkanes C_5-C_8. (3 marks)



Marking Guidelines	Marks
• Labels axes correctly including units • Uses appropriate scale • Plots points correctly • Provides appropriate line of best fit	3
• Provides a substantially correct graph	2
• Any relevant information	1

NOTE – most graphs showing tends in hydrocarbons use line graphs, since it makes trends clearer. However, since carbon number is actually discrete, a column graph is also acceptable.

(c) Explain this trend. (3 marks)

As the number of carbons in the chain increases (C5 to C8), the boiling point increases (≈ 36 - 125°C). This is because the molecular mass of each molecule has increased. This increases dispersion forces between the molecules, which means more energy is required to separate the molecules from each other in the liquid phase to form separated molecules in gas phase.

Marking Guidelines	Marks
• Identifies the trend, including reference to data in the graph • Provides reasons for the trend	3
• Identifies the trend and provides a reason OR • Provides reasons	2
• Any relevant information	1

Marker comments – this question was done well by many. Graphs were done well (few had axes wrong way round) and most had a straight line graph. Explanations were generally sound with correct reference to increase in number of dispersion forces

Question 27 (6 marks)

(a) Outline the method and results for a practical investigation to demonstrate an irreversible reaction. Include an equation in your answer (3 marks)

Combustion is an irreversible reaction. To observe combustion of an alcohol (methanol):

1. Obtain a spirit burner.
2. Weigh it
3. Light the wick, using match
4. Observe the flame produced and allow to burn for 5 min
5. Weight the spirit burner again.

Results – during combustion, a blue-white-orange flame was produced. After combustion, the spirit burner weighed less, indicating that some of the methanol was used during the combustion process.

This shows that it was an irreversible reaction, since the methanol that was used cannot be easily obtained again. The equation for the reaction is

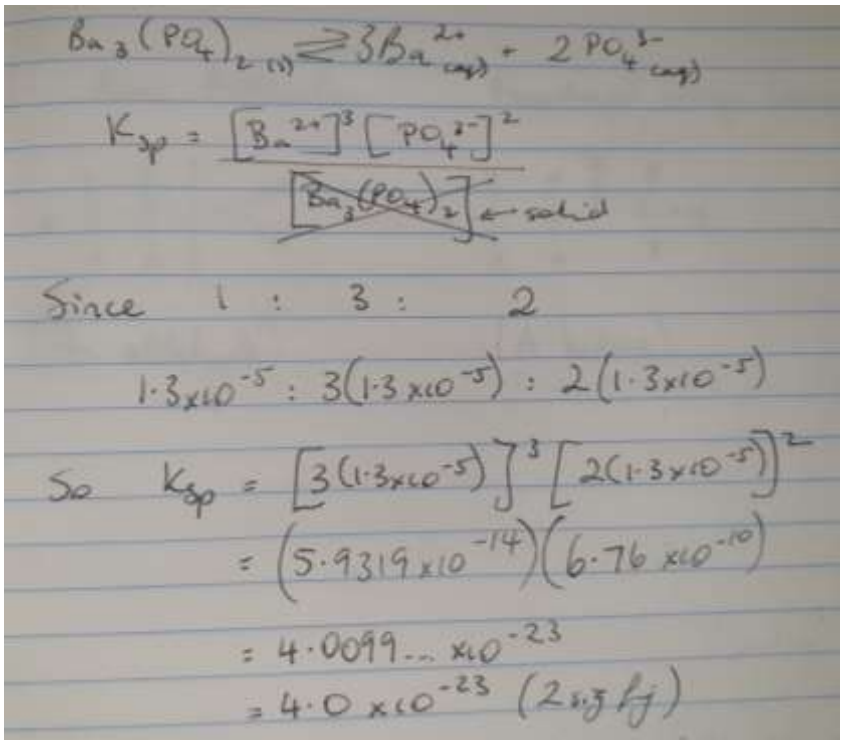
$$CH_3OH(l) + 3/2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$

Marking Guidelines	Marks
• Outlines an appropriate method • Outlines results • Includes an appropriate equation	3
• Provides TWO of method or results or equation	2
• Any relevant information	1

Markers comments

This was generally well answered

(b) The molar solubility of $Ba_3(PO_4)_2$ is 1.3 x 10^{-5} M in pure water at 30°C. Calculate the Ksp for $Ba_3(PO_4)_2$ at this temperature (3 marks)



Marking Guidelines	Marks
• Appropriate calculation including rounding	3
• Provides a substantially correct calculation	2
• Any relevant information	1

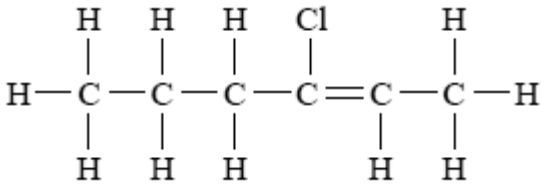
Markers comments

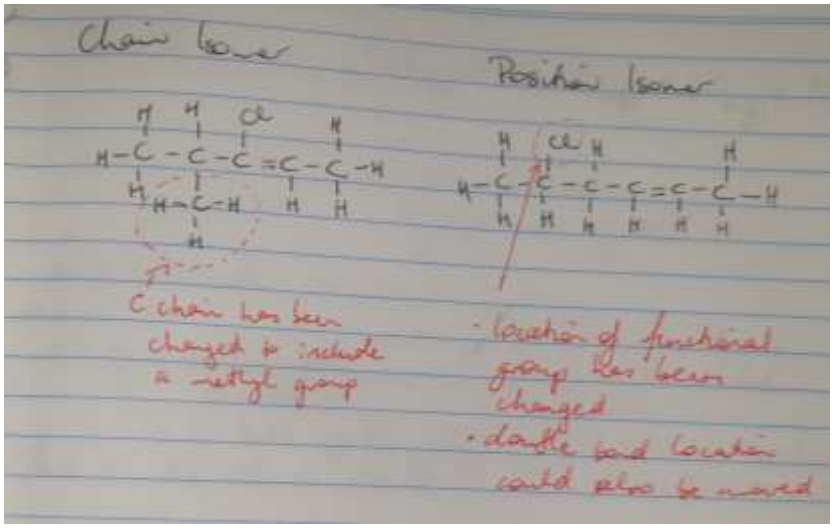
Few scored full marks – the first step is to write the dissociation equation so that the actually concentration of the ions can be determined by taking into account the co-efficients

Question 28 (5 marks)

Three important types of isomers are chain, position and functional group isomers.

(a) Draw 1 chain isomer and 1 position isomer of the molecule shown. (2 marks)



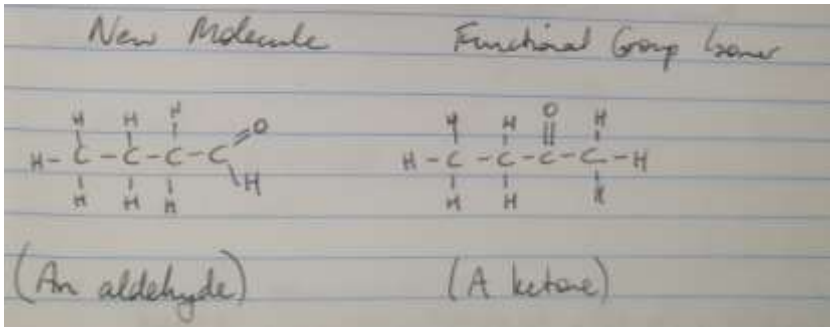


Marking Guidelines	Marks
• TWO appropriate molecules correctly drawn	2
• TWO substantially correct molecules drawn OR • ONE appropriate molecule correctly drawn	1

Markers comments

This was generally well answered

(b) Draw a new molecule and its functional group isomer. (1 mark)



Marking Guidelines	Marks
• TWO molecules correctly drawn, showing functional isomerism	1

Markers comments

Not well done – few knew of this type of isomer

(c) How can organic substances such as those shown above be safely handled and disposed of? (2 marks)

Safe handling – wear gloves and safety goggles (some are toxic, many are fat-soluble so are quickly absorbed through skin), never use near open flames (they are flammable), use in a fume hood (many have high volatility and toxicity)

Disposal – place in organic waste bottle, not to be poured down the sink.

Marking Guidelines	Marks
• Outlines safe handling and disposal procedures	2
• Any relevant information	1

Markers comments

Well answered- some students however confused handling with storage

Question 29 (9 marks)

(a) Identify TWO conjugate acid-base pairs that would be involved in the reaction between hydrochloric acid and ammonia. Include identification of which is the acid and which is the base in each pair. (2 marks)

$$HCl + NH_3 \rightarrow Cl^- + NH_4^+$$

Pair 1 – HCl (acid) and Cl^- (base)
Pair 2 – NH_3 (base) and NH_4^+ (acid)

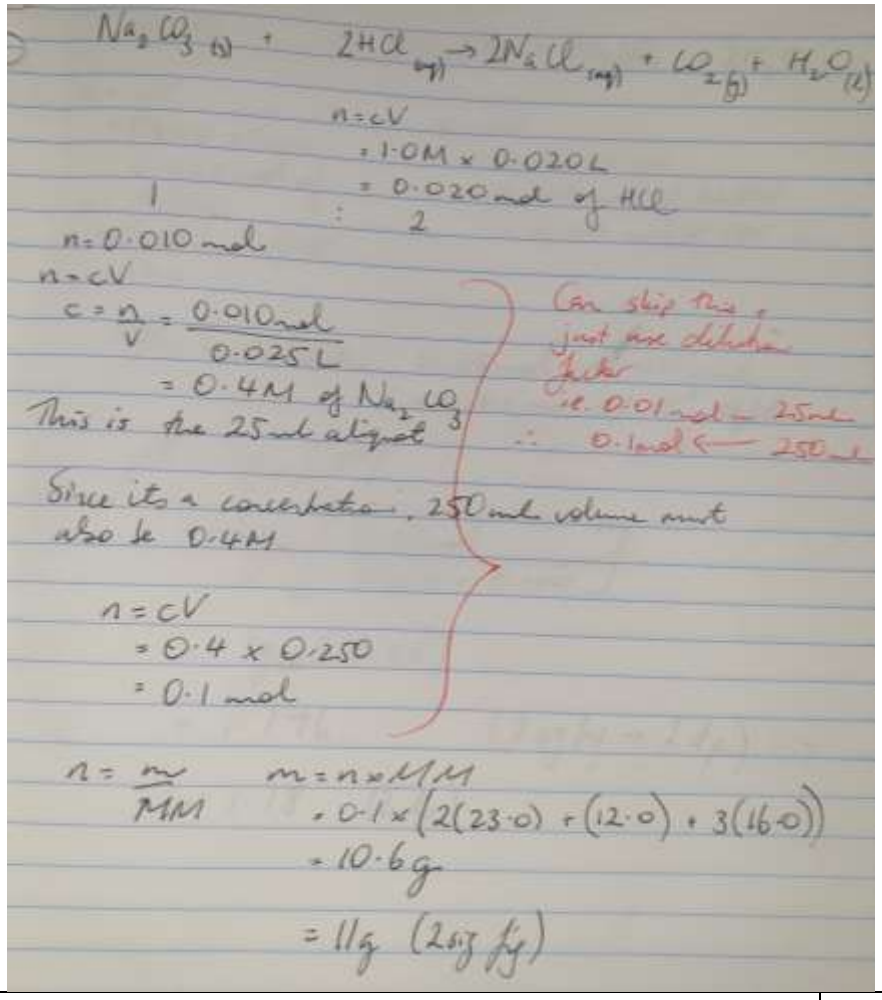
Marking Guidelines	Marks
• Correctly identifies TWO acid-base pairs	2
• Any relevant information	1

Markers comments

Well done but a suprising number of students make errors

(b) A 25.0 mL aliquot of sodium carbonate solution is to be titrated with 1.0 M hydrochloric acid solution. What mass of dried anhydrous sodium carbonate must be dissolved in 250 mL of deionised water, so that the 25.0 mL aliquot of sodium carbonate solution will need a 20.0 mL titration of hydrochloric acid? Include a chemical equation in your answer.

(4 marks)

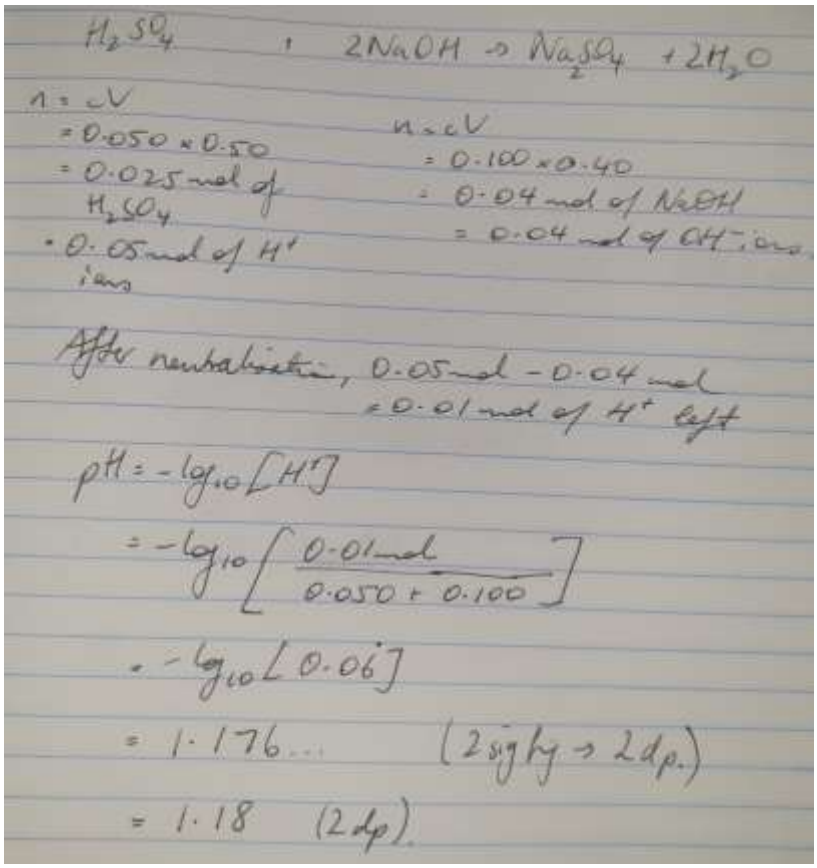


Marking Guidelines	Marks
• Correctly calculates mass required • Provides appropriate equation including states	4
• Provides a substantially correct method for calculating the mass • May provide an equation	2-3
• Any relevant information	1

Markers comments

Many good answers but a number of students found the amount of salt in the 25 ml sample but then didn't go on to calculate the mass in the original 250 ml sample

(c) In a different acid-base experiment, 50mL of 0.50M H_2SO_4 was added to 100mL of 0.40M NaOH. What was the pH of the solution produced? (3 marks)



Marking Guidelines	Marks
• Correctly calculates moles in resultant solution • Correctly calculates pH	3
• Provides a substantially correct method	2
• Any relevant information	1

Markers comments

Reasonably well done but many students did not take into account that the acid was diprotic and the [H+] is 2 x the concentration of the acid

Question 30 (7 marks)

The balance between enthalpy change and entropy change determines the feasibility of a reaction. The table below contains enthalpy of formation and entropy data for some elements and compounds at 25°C.

	N_2 (g)	O_2 (g)	NO (g)	C (graphite)	C (diamond)
$\Delta H_f^{\ominus}$/kJ mol^{-1}	0	0	+90.4	0	+1.9
$S^{\ominus}$/J K^{-1} mol^{-1}	192.2	205.3	211.1	5.7	2.4

(a) Explain why the entropy value for the element nitrogen is much greater than the entropy value for the element carbon (graphite). (2 marks)

Entropy is a measure of the randomness of a system/reaction. Since carbon is a solid, the particles are held tightly in a particular structure and cannot move very much, thus having low randomness/entropy. Nitrogen is a gas, and the molecules are moving randomly, thus it has a much higher entropy.

Marking Guidelines	Marks
• Provides reasons for why there is difference	2
• Any relevant information	1

Markers comments

Most gave a satisfactory answer

(b) Suggest the condition under which the element carbon (diamond) would have an entropy value of zero. (1 mark)

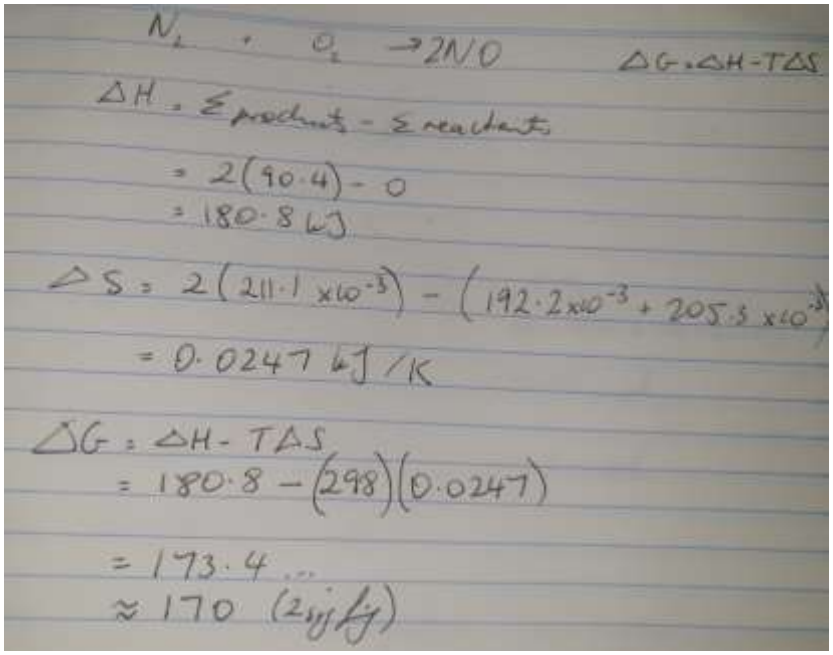
When it was at absolute zero (i.e. 0 K or -273°C)

Marking Guidelines	Marks
• Correct reason	1

Markers comments

Poorly answered

(c) Calculate ΔG for the reaction between nitrogen and oxygen to form nitric oxide (nitrogen monoxide). (3 marks)



Marking Guidelines	Marks
• Correctly ΔG	3
• Provides a substantially correct method	2
• Any relevant information	1

Markers Comments

Many students made a good attempt but few took notice of the coefficients to double the value of delta H f for the NO and few converted the entropy value to kj/mol and a number did not convert to degrees K

(d) Is this a spontaneous reaction? Give a reason for your answer. (1 mark)

No, not spontaneous, since delta G is positive.

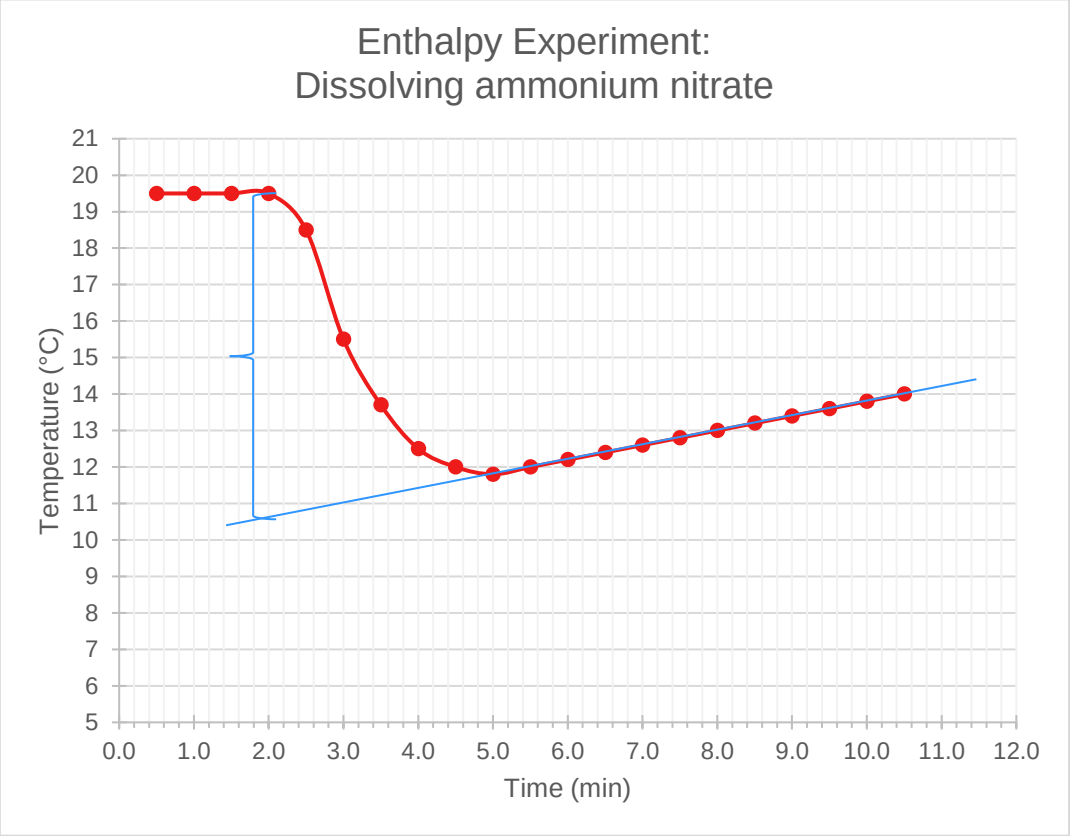
Marking Guidelines	Marks
• Correct answer and reason, allowing for error carried forward from (c)	1

Markers comments

Most gave a correct answer consistent with their answer to B

Question 31 (6 marks)

Using a simple polystyrene calorimeter 4.0 g of ammonium nitrate was dissolved in 50 mL of water.



(a) What is the temperature change for this reaction? (1 mark)

11.8 - 19.5 = -7.7°C (or if using error correction method taking into account heat lost/gained from the surrounding: 10.5 - 19.5-= -9°C)

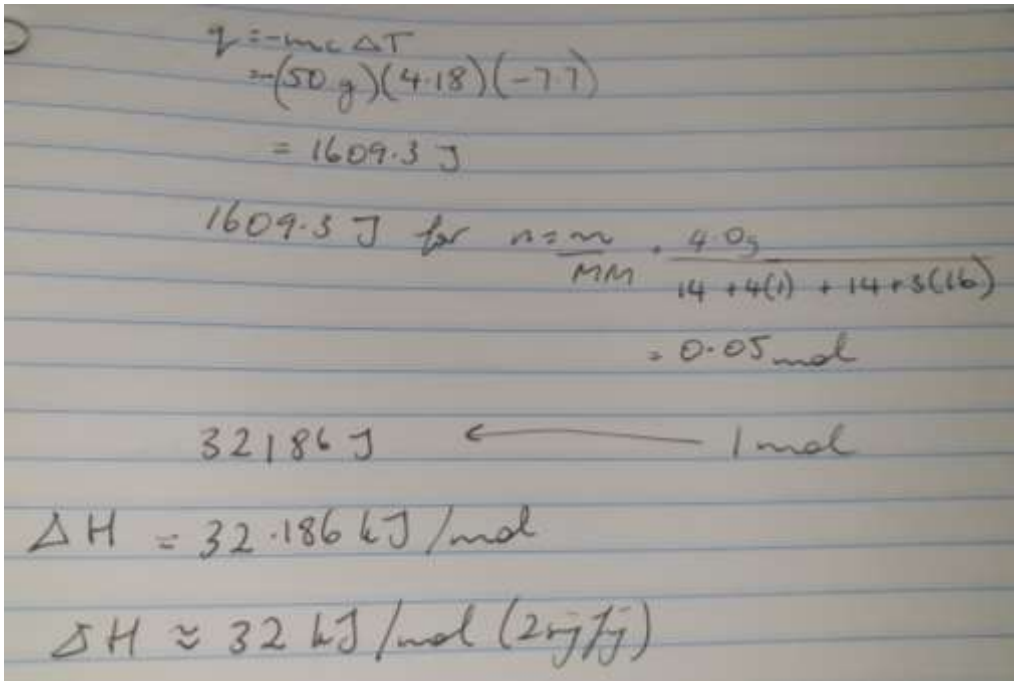
Marking Guidelines	Marks
• Correct answer	1

Markers comments
Some errors here that are avoidable
Some students used the last number on the graph not the minimum value reached
Change in temp is final minus initial so the value here should be negative

(b) Is this an exothermic or endothermic reaction? (1 mark)

endothermic

(c) What is the enthalpy of dissolution for ammonium nitrate in kJ mol^{-1} (3 marks)



Marking Guidelines	Marks
• Correctly calculates enthalpy of dissolution	3
• Provides a substantially correct method	2
• Any relevant information	1

Markers Comments

Well done . could have used 50 or 54 g for the mass of liquid in calorimeter

(d) Suggest a reason for why this value does not agree with the more accurate value found in the SI Data Book (1 mark)

During experiments in a school laboratory, it is hard to control heat gained from the surroundings, hence leading to inaccurate results. There may also be impurities in the ammonium nitrate used in the school laboratory.

Marking Guidelines	Marks
• An appropriate reason given	1

Markers Comments

Many gave reasons for heat being lost to environment which not relevant to this question because the reaction is endothermic and energy is absorbed

Question 32 (7 marks)

K can be used to determine the equilibrium constant (Keq), the solubility product constant (Ksp) and the acid dissociation constant (Ka). It is sometimes compared to Q.

Evaluate the usefulness of K when examining, predicting and altering the conditions of certain chemical reactions. Include equations in your answer. (7 marks)

Answers could include:

- Discussion of K_{eq} and concentrations of substances within an equilibrium system, and using these values to make predictions on the direction in which a reaction may proceed including the use of Q
- Discussion of the effect of temperature on the value of K_{eq}
- Include examples of investigations conducted to determine K_{eq} of a chemical equilibrium system

- Discussion of the use of K_{sp} for saturated solutions and the solubility of an ionic substance as determined by its K_{sp} value
- Discussion of how to predict the formation of a precipitate given the value for K_{sp}

- Discussion of how to apply the dissociation constant (K_a) and pK_a ($pK_a = -log_{10}(K_a)$) to determine the difference between strong and weak acids

Marking Guidelines	Marks
• Evaluates usefulness of K • Outlines examples to demonstrate the use of Keq, Ksp, Ka, and Q • Links examples to examining, predicting and altering the conditions of reactions • Provides relevant chemical equations and formulae • Demonstrates coherence and logical progression	7
• Outlines examples to demonstrate the use of most types of K identified in the stem • Some link to examining, predicting and altering the conditions of reactions • Provides some chemical equations and formulae	5-6
• Outlines examples to demonstrate the use of some types of K identified in the stem • May link to examining, predicting and altering the conditions of reactions • Provides some chemical equations or formulae	3-4
• Outlines TWO types of K OR • Outlines TWO uses of K for examining, OR predicting OR altering the conditions of reactions OR • Outlines ONE type of K and links it to ONE use of K	2
• Any relevant information	1

Markers comments
Many very good answers
Underline everything that needs to be addressed
Consider using subheadings
Avoid very general answer – be specific eg if Ksp give an indication of the solubility of the salt (general) the higher the value the more soluble (specific)