Killara HIGH SCHOOL

2016
TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

Chemistry

INSTRUCTIONS

- Reading time – 5 minutes
- Working time – 3 hours
- Write using blue or 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
- Use the Multiple Choice Grid provided for your answers to Part A
- Write your answers for Part B in the spaces provided
- Write your answers to Section II in the booklet provided
- Your Student Number **must** be used.

This paper comprises two sections:

Section I - 75 marks
This section has two parts, Part A and Part B
Part A – 20 marks
Part B – 55 marks

Section II
Option – 25 marks

Total marks – 100

Student Number: _____

Multiple Choice Answer Sheet:

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

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

Student Number: _____

Section 1 (75 marks)

Part A – 20 marks
Multiple choice. Attempt questions 1-20.
Allow about 30 minutes for this part. Use the Multiple Choice Answer Sheet for Questions 1-20.

---

1. The standard cell potential for the reaction between 1 $molL^{-1}$ potassium permanganate ($KMnO_4$) and 1 $molL^{-1}$ iron II nitrate is:

   (A) +3.28
   (B) +1.07
   (C) +0.74
   (D) -0.74

2. In which of the following reactions is the metal species reduced?

   (A) $2FeCl_2(aq) + Cl_2(g) \rightarrow 2FeCl_3(aq)$
   (B) $CuS(s) + O_2(g) \rightarrow Cu(s) + SO_2(g)$
   (C) $2Al(OH)_3(aq) \rightarrow Al_2O_3(s) + 3H_2O(l)$
   (D) $Ca(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2(g)$

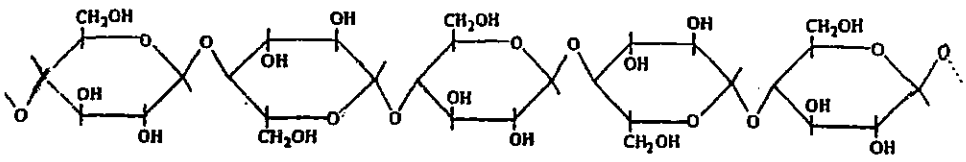
3. Most of the world's ethylene is currently produced from the

   (A) dehydration of ethanol
   (B) fermentation of sugars
   (C) treatment of biomass
   (D) cracking of crude oil

4. Which of the following chemical formulae could **not** represent a monomer for addition polymerisation:

   (A) C_6H_{12}
   (B) C_6H_{14}
   (C) C_6H_{10}
   (D) C_5H_{10}

5. The diagram below represents an important polymer. Choose the statement that is most accurate about this polymer.



   (A) This polymer is an important petrochemical product
   (B) The monomer from which this polymer is made is starch
   (C) This polymer is a major component of biomass
   (D) This polymer is a naturally occurring addition polymer

6. In an experiment 6.0 g of propan-1-ol underwent complete combustion to produce carbon dioxide and water.

What volume of carbon dioxide was produced at 25°C and 100 kPa?

(A) 2.5 L
(B) 3.4 L
(C) 3.8 L
(D) 7.4 L

7. The fuel E10 consists of 10% ethanol blended with petrol consisting mainly of octane. Which of the following statements best explains the solubility of ethanol in petrol?

(A) Ethanol undergoes hydrogen bonding with petrol which increases its solubility.
(B) Ethanol contains a polar –OH group improving its solubility in hydrocarbons.
(C) Ethanol and petrol are both non-polar molecules and soluble in each other.
(D) Ethanol contains a short hydrocarbon chain which allows it to be soluble in petrol.

8. The following table shows the colour of universal indicator over a range of pH.

pH	1-4	5	6	7	8	9	10-11
Colour	Red	Orange	Yellow	Green	Blue	Purple	Violet

Aqueous solutions of four different solids were tested with universal indicator. The results appear below:

Solution	**Colour**
Sugar	Green
Ammonium chloride	Orange
Sodium hydroxide	Violet
Potassium acetate	Purple

The solution that is most acidic is:

(A) Sugar
(B) Ammonium chloride
(C) Sodium hydroxide
(D) Potassium acetate

Student Number: _____

9. Americium-241 is produced according to the reaction

$$^{239}_{94}Pu + 2X \rightarrow {}^{241}_{95}\text{Am} + {}^{0}_{-1}\text{e}$$

What is the identity of X?

(A) A neutron
(B) A proton
(C) A beta particle
(D) An alpha particle

10. A chemist adds 990 mL of distilled water to 10 mL of hydrochloric acid solution with an original pH of 1.5. The pH of the diluted solution will be:

(A) 2.5
(B) 3.5
(C) 3.9
(D) 4.5

11. What flame colour is produced by calcium ions in a flame test?

(A) Brick red
(B) Blue green
(C) Apple green
(D) Yellow

12. Which alternative best fits the properties of gaseous oxygen and the oxygen free radical?

	Gaseous oxygen		*Oxygen free radical*	
(A)	More reactive	Monatomic	Less reactive	Molecular
(B)	Less reactive	Molecular	More reactive	Monatomic
(C)	Less reactive	Monatomic	More reactive	Molecular
(D)	More reactive	Molecular	Less reactive	Monatomic

13. Which of the following contains a coordinate covalent bond?

(A) NH_3
(B) OH^-
(C) H_2O
(D) H_3O^+

14. Which of the following salts in aqueous solution will have a pH greater than 7?

(A) sodium carbonate
(B) ammonium chloride
(B) potassium nitrate
(B) sodium chloride

Student Number: _____

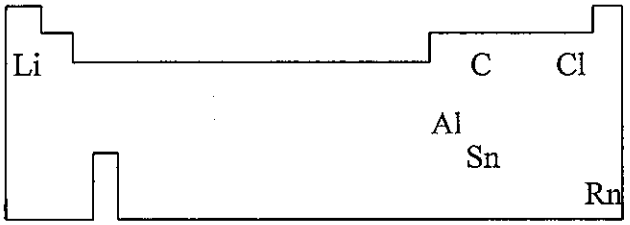
15. Which of the following solutions has the lowest pH?

(A) 0.1 $molL^{-1}$ ethanoic acid
(B) 0.1 $molL^{-1}$ hydrochloric acid
(C) 0.2 $molL^{-1}$ sodium hydroxide
(D) 0.2 $molL^{-1}$ nitric acid

16. The chemical formula for citric acid is:

(A) $C_6H_6O_6$
(B) $C_5H_9O_6$
(C) $C_6H_8O_7$
(D) $C_6H_8O_6$

17. The diagram below is a representation of the Periodic Table. The positions of six different elements are shown.



The oxides of which of these elements react only with acids, only with bases or with acids and with bases?

	Oxide reacts with acid	*Oxide reacts with base*	*Oxide reacts with acid and with base*
(A)	Cl	Li	C
(B)	Li	C	Sn
(C)	Ra	Sn	Cl
(D)	C	Cl	Ra

18. Which pair of equations correctly describes the behaviour of the oxides of lithium and carbon when placed with water?

(A) $Li_2O_{(s)} + H_2O_{(l)} \rightarrow 2\ LiOH_{(aq)}$
$2\ CO_{2(g)} + H_2O_{(l)} \rightarrow HCO_{3(aq)} + HCO_{2(aq)}$

(B) $Li_2O_{(l)} + H_2O_{(l)} \rightarrow 2\ LiOH_{(aq)}$
$CO_{2(g)} + H_2O_{(l)} \rightarrow H_2CO_{3(aq)}$

(C) $2\ Li_2O_{(s)} + H_2O_{(l)} \rightarrow HLiO_{3(aq)} + HLiO_{2(aq)}$
$C_2O_{(s)} + H_2O_{(l)} \rightarrow 2\ COH_{(aq)}$

(D) $Li_2O_{(s)} + H_2O_{(l)} \rightarrow HLiO_{3(aq)} + 2\ HLiO_{2(aq)}$
$CO_{(s)} + H_2O_{(l)} \rightarrow C(OH)_2$

Student Number: _____

19. In order to determine the possible cations in a sample of water, a student followed the following procedure:

	Method	Observation
Step 1	Excess hydrochloric acid was added to a portion of the sample.	A white precipitate formed, which did not darken when left exposed to UV light.
Step 2	The precipitate from Step 1 was filtered off and the filtrate retained.	
Step 3	Dilute sulphuric acid was added to some of the filtrate from Step 2.	No precipitate formed.
Step 4	Excess sodium hydroxide was added to some of the filtrate from Step 2.	A precipitate formed, which turned yellowish on standing for several hours.

The cations in the sample are likely to be:

(A) Pb^{2+} and Fe^{2+}
(B) Fe^{2+} and Ag^{+}
(C) Na^{+} and Pb^{2+}
(D) Ag^{+} and Na^{+}

20. The table below lists the boiling points of some alkanols and their corresponding alkanoic acids.

Alkanols		**Alkanoic Acids**	
Substance	*BP (K)*	*Substance*	*BP (K)*
Propan-1-ol	370	Propanoic acid	414
Butan-1-ol	390	Butanoic acid	434
Pentan-1-ol	411	Pentanoic acid	459

What causes the alkanoic acids to have higher boiling points than their corresponding alkanols?

(A) The greater dispersion forces between the molecules of the alkanoic acids
(B) The ionic bonding that occurs in the alkanoic acids when they become ionised
(C) The stronger acidic properties of the alkanoic acids
(D) The greater extent of hydrogen bonding between the alkanoic acid molecules

Student Number: _____

PART B – 55 marks

Attempt Questions 21 – 35
Allow about 1 hour and 45 minutes for this part.
Answer the questions in the spaces provided.
Show all relevant working in questions involving calculations.

Question 21. (3 marks) **Marks:**

Modern chemists have developed a wide range of batteries to cater for a wide range of applications. These include the silver button cell, fuel cells, the vanadium redox cell, the lithium cell and photovoltaic devices. **3**

Choose one of these cells and describe its chemistry and its impact on society.

Question 22. (3 marks)

Styrene and vinyl chloride are commercially significant monomers. **3**

Complete the table below:

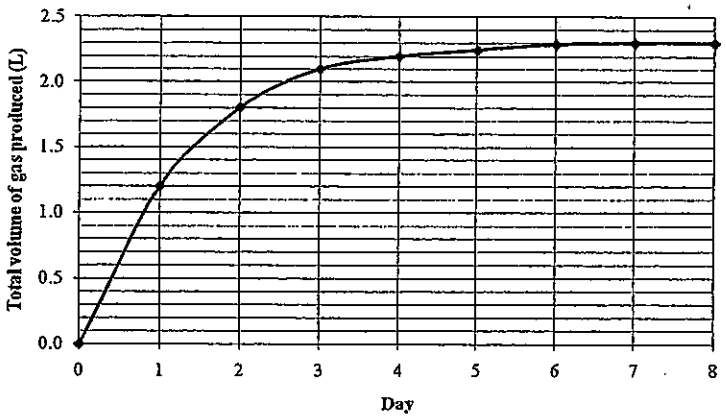
Common name of monomer	**Styrene**	**Vinyl Chloride**
Systematic name of monomer		
Structural formula		
An important use of the polymer		

Student Number: _____

Question 23. (4 marks) **Marks:**

Ethanol is readily available from renewable sources such as glucose or it may be produced using industrial methods from non-renewable sources.

A student conducted an investigation to produce ethanol from glucose. The graph shows the total volume of gas produced from the reaction vessel over 8 days. The reaction was conducted at 25°C and 100 kPa.



(a) Identify the process used to produce ethanol from glucose. **1**

(b) Calculate the mass of glucose that reacted over the 8 days. **2**

(c) Explain why ethanol (produced from sugar cane) could be considered as "renewable". **1**

Question 24 over page:

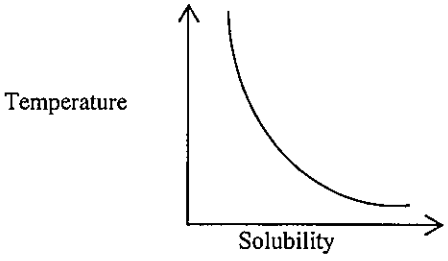
Student Number: _____

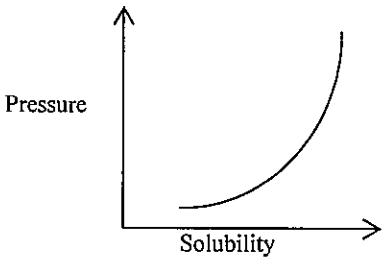
Question 24. (3 marks) **Marks:**

Cellulose contains the basic carbon-chain structures needed to build petrochemicals. Discuss the potential of cellulose as a raw material to do this. **3**

Question 25. (2 marks)

Carbon dioxide can be dissolved in water. It forms carbonic acid (H_2CO_3) on dissolving in an equilibrium reaction. Many soft drinks are 'carbonated', ie contain dissolved carbon dioxide to generate bubbles. The figure below indicates the relationship between the solubility of carbon dioxide in water with changes in temperature and pressure.





(a) Describe the relationship between the solubility of carbon dioxide in water and changes in temperature and pressure. **1**

(b) Write an equation for carbon dioxide dissolving in water. **1**

Student Number: _____

Question 26. (4 marks) **Marks:**

Uranium is the principle element used in nuclear reactors and in certain types of atomic bombs. ONE example of a nuclear fission reaction is:

$$^{235}_{92}U + {}^{1}_{o}n \rightarrow {}^{92}_{36}A + {}^{142}B + 2{}^{1}_{o}n$$

(a) Identify elements A and B. **1**

(b) Radioisotopes have a wide range of applications in fields like medicine and industry. However there are problems associated with their use.
With reference to ONE of the above fields, analyse the problems associated with using radioisotopes and how these problems are managed. **3**

Question 27. (2 marks)

Many packaged and processed foods include acids in the list of ingredients. Explain the use of acids as food additives. **2**

Student Number: _____

Question 28. (6 marks) **Marks:**

Some elements, referred to as trace elements, exist in the environment in very low concentrations which can only be measured in parts per million.

(a) Describe an appropriate technique for measuring these low concentrations. **2**

(b) Assess the impact of the process described in part (a) on the understanding of the effects of a named trace element. **4**

Question 29 over page:

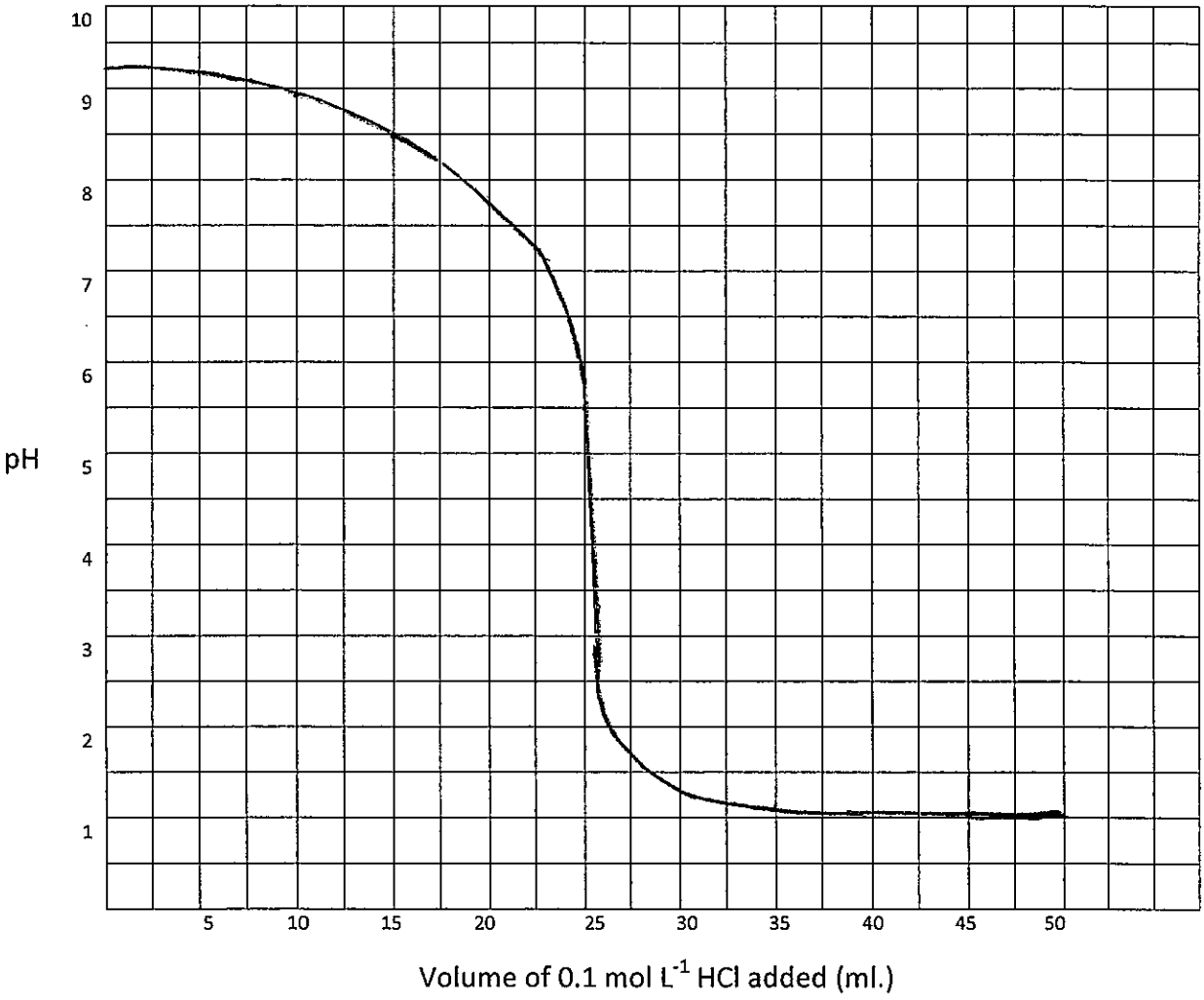
Student Number: _____

Question 29. (4 marks) **Marks:**

Jasmine bought a bottle of ammonia solution in her supermarket. She knows ammonia is a weak base. She decides to use computer based technology to determine the concentration of ammonia in the solution.

She dilutes the ammonia solution to one in ten with distilled water and titrates 25 mL samples of it by adding 0.1 $molL^{-1}$ hydrochloric acid from a burette at a constant rate having a pH probe dipping in the reaction vessel and attached to a data logger and computer.

Below is the titration curve generated during the addition of 50 mL of HCl to the ammonia solution at a constant rate.



(a) Suggest a suitable indicator which would identify the end point of this titration. 1

_____

Student Number: _____

Marks:

(b) Calculate the concentration of ammonia in the bottle she purchased. (Show working) **3**

Question 30. (3 marks)

A solution containing 0.1 $molL^{-1}$ sulfurous acid (H_2SO_3) and 0.1 $molL^{-1}$ sodium sulfite (Na_2SO_3) is a buffer.

(a) What is a buffer solution? **1**

(b) Explain using relevant equations how the solution above can act as a buffer. **2**

Question 31. (3 marks)

A solution was made using 25 mL of 0.25 mol L^{-1} hydrochloric acid and 75 mL of 0.05 $molL^{-1}$ potassium hydroxide. What is the pH of the solution? **3**

Student Number: _____

Question 32. (4 marks) **Marks:**

A student mixed 1-butanol and ethanoic acid together and heated them under reflux with a suitable catalyst.

(a) Name the ester which was produced in this reaction. **1**

_____

(b) Draw the structural formula for this ester. **1**

(c) Identify the catalyst used and outline two purposes for its addition. **2**

_____

_____

_____

Question 33. (7 marks)

The element oxygen is vital for life on earth in the form of O_2. In the atmosphere the element oxygen is also present in two other forms due to the conditions present and the reactions which result.

(a) Describe the chemical reactions which occur to produce these other forms. **2**

_____

_____

_____

_____

Student Number: _____

Marks:

(b) One of these is ozone gas.

(i) Draw the Lewis electron dot structure of the ozone molecule. **1**

(ii) Explain why ozone can be both beneficial and harmful to life on earth. **2**

(iii) Briefly outline the impact of CFCs on ozone concentrations. **2**

Question 34. (3 marks)

During your course, you performed an activity to model isomers of haloalkanes. Describe what you did and how the activity aided your understanding. **3**

Question 35 over page:

Student Number: _____

Question 35. (4 marks) **Marks:**

Under conditions of low oxygen levels, octane can undergo incomplete combustion according to the following chemical equation:

$$2C_8H_{18}(l) + 17O_2(g) \rightarrow 6C(s) + 4CO(g) + 6CO_2(g) + 18H_2O(l)$$

(a) Explain the need to monitor this process. **2**

(b) Calculate the mass of soot ($C(s)$) produced if 4.2 moles of octane are combusted in this way. **2**

Section II over page:

Student Number: _____

Section II (25 marks)

Allow about 45 minutes for this section.
Answer this question in a writing booklet.
Show all relevant working in questions involving calculations.

Question 36. Industrial Chemistry (25 marks) **Marks:**

(a) Describe the issues associated with the shrinking world resources of ONE identified natural product that is not a fossil fuel and identify a replacement material used. **2**

(b) Electrolysis is an important industrial process.

(i) Define *electrolysis*. **1**

(ii) Three methods of producing sodium hydroxide on an industrial scale are the mercury, diaphragm and membrane processes. Discuss the chemistry involved in each process and any technical and environmental issues that must be considered. **6**

(c) (i) Briefly describe an activity which could be used to model an equilibrium reaction. **2**

(ii) What do you consider to be a limitation in how well the activity models a real equilibrium reaction. **1**

(d) Nitrogen dioxide is formed by the reaction of nitrogen monoxide with oxygen gas:

$$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$$

A mixture of 2.5 mol NO and 1.2 mol O_2 was introduced into a 5 litre vessel. When the reaction reached equilibrium, only 0.5 mol of NO remained.

Calculate the equilibrium constant for the reaction. **2**

(e) Annual ammonia production worldwide is approaching 500 million tonnes.

(i) With reference to one important industrial use of ammonia, justify its importance to society. **2**

Student Number: _____

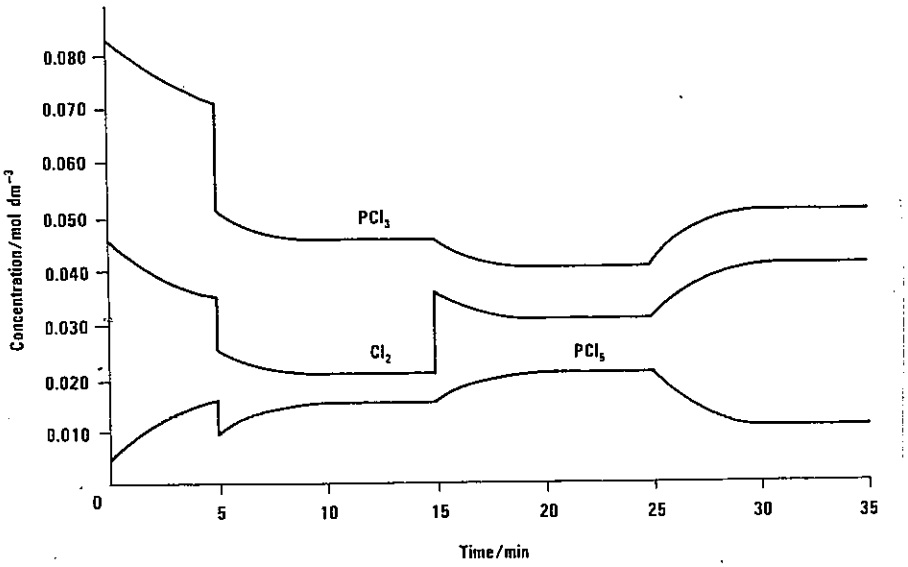
Marks:

(ii) The Haber Process for synthesising ammonia requires the application of chemical principles to maximise output while taking into account economic and safety considerations.
Describe and explain fully the reaction conditions used in modern ammonia production plants with reference to the above statement. **5**

(f) The concentration of the three substances in the reaction

$$PCl_3(g) + Cl_2(g) \rightleftharpoons PCl_5(g) \qquad \Delta H = -93 \text{ kJ mol}^{-1}$$

are shown on the graph below:



(i) Suggest what might have been done at the 5 minute mark. **1**

(ii) What would be the effect of adding a catalyst to the reaction at the 20 minute mark? **1**

(iii) What change must have occurred at the 25 minute mark? Justify your answer fully. **2**

The End

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						

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

Elements with atomic numbers 113 and above have been reported but not fully authenticated.

Standard atomic weights are abridged to four significant figures.

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

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

Chemistry

DATA SHEET

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

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}

Some useful formulae

$$\text{pH} = -\log_{10}[\text{H}^+] \qquad \Delta H = -mC\Delta T$$

Some standard potentials

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

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

Student Number: 2016 Trial

PART B – 55 marks

Marking Guidelines

Attempt Questions 21 – 35
Allow about 1 hour and 45 minutes for this part.
Answer the questions in the spaces provided.
Show all relevant working in questions involving calculations.

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

Question 21. (3 marks) **Marks:**

Modern chemists have developed a wide range of batteries to cater for a wide range of applications. These include the silver button cell, fuel cells, the vanadium redox cell, the lithium cell and photovoltaic devices. 3

Choose one of these cells and describe its chemistry and its impact on society.

Chemistry - 2Mks

Silver button cell
Anode – Zn
Cathode – Ag_2O
Electrolyte – KOH in porous medium
Anode Reaction – $Zn_{(s)} + 2OH^-_{(aq.)} \longrightarrow ZnO_{(s)} + H_2O_{(l)} + 2e^-$
Cathode Reaction – $Ag_2O_{(s)} + H_2O_{(l)} + 2e^- \longrightarrow 2Ag_{(s)} + 2OH^-_{(aq.)}$

1Mk

Used in small devices like watches etc. Constant voltage of 1.5V. etc. for impact on society.

* if there were no equations or wrong equations – 1½ marks max.

Question 22. (3 marks)

Styrene and vinyl chloride are commercially significant monomers. 3

Complete the table below:

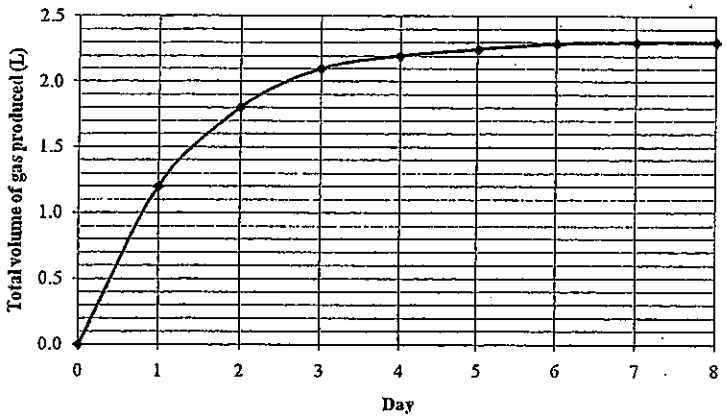
Common name of monomer	**Styrene**	**Vinyl Chloride**
Systematic name of monomer	Ethenyl benzene / Phenylethene	Chloroethene
Structural formula	$CH_2=CH$  or expanded form	$CH_2=CH-Cl$
An important use of the polymer	Car battery cases, tool handles, furniture, CD cases, disposable cups, foam packaging material (any 1)	electrical insulation, garden hoses, drainage & sewage pipes, household guttering & downpipes

Student Number: _____

Question 23. (4 marks) **Marks:**

Ethanol is readily available from renewable sources such as glucose or it may be produced using industrial methods from non-renewable sources.

A student conducted an investigation to produce ethanol from glucose. The graph shows the total volume of gas produced from the reaction vessel over 8 days. The reaction was conducted at 25°C and 100 kPa.



(a) Identify the process used to produce ethanol from glucose. 1

Fermentation

(b) Calculate the mass of glucose that reacted over the 8 days. 2

Vol. of gas produced = 2.3 L

$C_6H_{12}O_6(aq.) \xrightarrow{yeast} 2\,C_2H_5OH(aq.) + 2\,CO_2(g)$

$n_{CO_2} = \frac{V}{M.V} = \frac{2.3}{24.79} = 0.09278\ L$ (1 M)

$n_{Glucose} = \frac{1}{2} n\,CO_2$ (1:2 ratio) $= 0.04639$ (1 M) $\therefore m_{glucose} = nM$

$= 8.357\ g$

$= 8.4\ g$ or $8\ g$

(c) Explain why ethanol (produced from sugar cane) could be considered as "renewable". 1

Good reason explaining meaning of renewable – 1

~~just~~ not clear / good explanation – ½

Question 24 over page:

Student Number: _____

Question 24. (3 marks) **Marks:**

Cellulose contains the basic carbon-chain structures needed to build petrochemicals. Discuss the potential of cellulose as a raw material to do this. 3

2 Potential uses like

Cellulose ferment → Ethanol

Cellulose deferment → Ethanol dehyd. → Ethylene → Polymers.

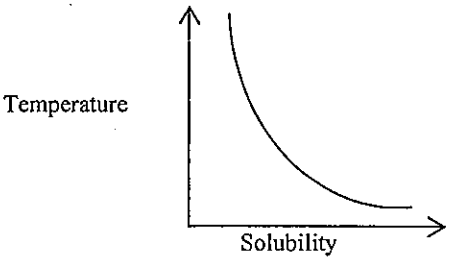
+ some explanation of why cellulose is preferred over petrochem or any reason why it's not being used at the moment

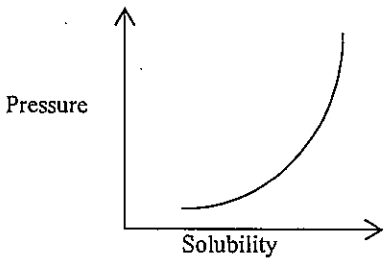
* Missing any 1 of the above 3 – 2 Mks.

3 Mks

Question 25. (2 marks)

Carbon dioxide can be dissolved in water. It forms carbonic acid (H_2CO_3) on dissolving in an equilibrium reaction. Many soft drinks are 'carbonated', ie contain dissolved carbon dioxide to generate bubbles. The figure below indicates the relationship between the solubility of carbon dioxide in water with changes in temperature and pressure.





(a) Describe the relationship between the solubility of carbon dioxide in water and changes in temperature and pressure. 1

↑ in temp ↓ solubility ½

↑ in pressure ↑ solubility ½

(b) Write an equation for carbon dioxide dissolving in water. 1

$CO_2(g) + H_2O(l) \rightleftharpoons H_2CO_3(aq.)$ or $\rightarrow$

States needed

$-\frac{1}{2}$ → if 1 state missing

0 → if no states.

1 Mk

$CO_2(g) \rightleftharpoons CO_2(aq.)$

or

$CO_2(g) + H_2O(l) \rightleftharpoons CO_2(aq.) + H_2O(l)$

Student Number: _____

Question 26. (4 marks) **Marks:**

Uranium is the principle element used in nuclear reactors and in certain types of atomic bombs. ONE example of a nuclear fission reaction is:

$$^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{92}_{36}A + {}^{142}B + 2{}^{1}_{0}n$$

(a) Identify elements A and B. **1**

A – Kr

B – Ba

(b) Radioisotopes have a wide range of applications in fields like medicine and industry. However there are problems associated with their use.
With reference to ONE of the above fields, analyse the problems associated with using radioisotopes and how these problems are managed. **3**

2 problems + 2 ways of managing (one of it had to be waste management as that's a major problem. Clearly Weakage) – 3

1 problem + 1 way of managing – 1½

(Max 2 Mks: if waste disposal is not identified as a problem & a way to manage it is addressed)

* 2½ without waste if the answers has identified leakage & 2 other problems with management)

Question 27. (2 marks)

Many packaged and processed foods include acids in the list of ingredients. Explain the use of acids as food additives. **2**

① Preserving used as a preservative ①

flavour enhancer ①

* Most students got '2' for this response.

Student Number: _____

Question 28. (6 marks) **Marks:**

Some elements, referred to as trace elements, exist in the environment in very low concentrations which can only be measured in parts per million.

(a) Describe an appropriate technique for measuring these low concentrations. 2

Identify Atomic Abarphic Spectroscopy (AAS) ½.
– a technique in which an solution of a metal ion (½) is sprayed into the flame (½) and the amount of light of a specific wavelength that is absorbed (½) by the vaporised metal ion is used to determine the concentration of the metal.

(b) Assess the impact of the process described in part (a) on the understanding of the effects of a named trace element. 4

* Most people named Lead or mercury as their trace element. (1).
– impact – must identify 2 uses.
eg/ used in soil samples → improve agriculture produce
OR//
blood/urine analysis → determine intervention required (1)
– Reliability + quick turn around of results.
eg// of trace elements: V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Mo, W, Sn, Si, Se. (must identify '1' correctly) (1)
– must talk about its impact & give an overall assessment. (1)

eg// The development of AAS has had a major impact on health for communities & agriculture & therefore the economy of the nation.

Question 29 over page:

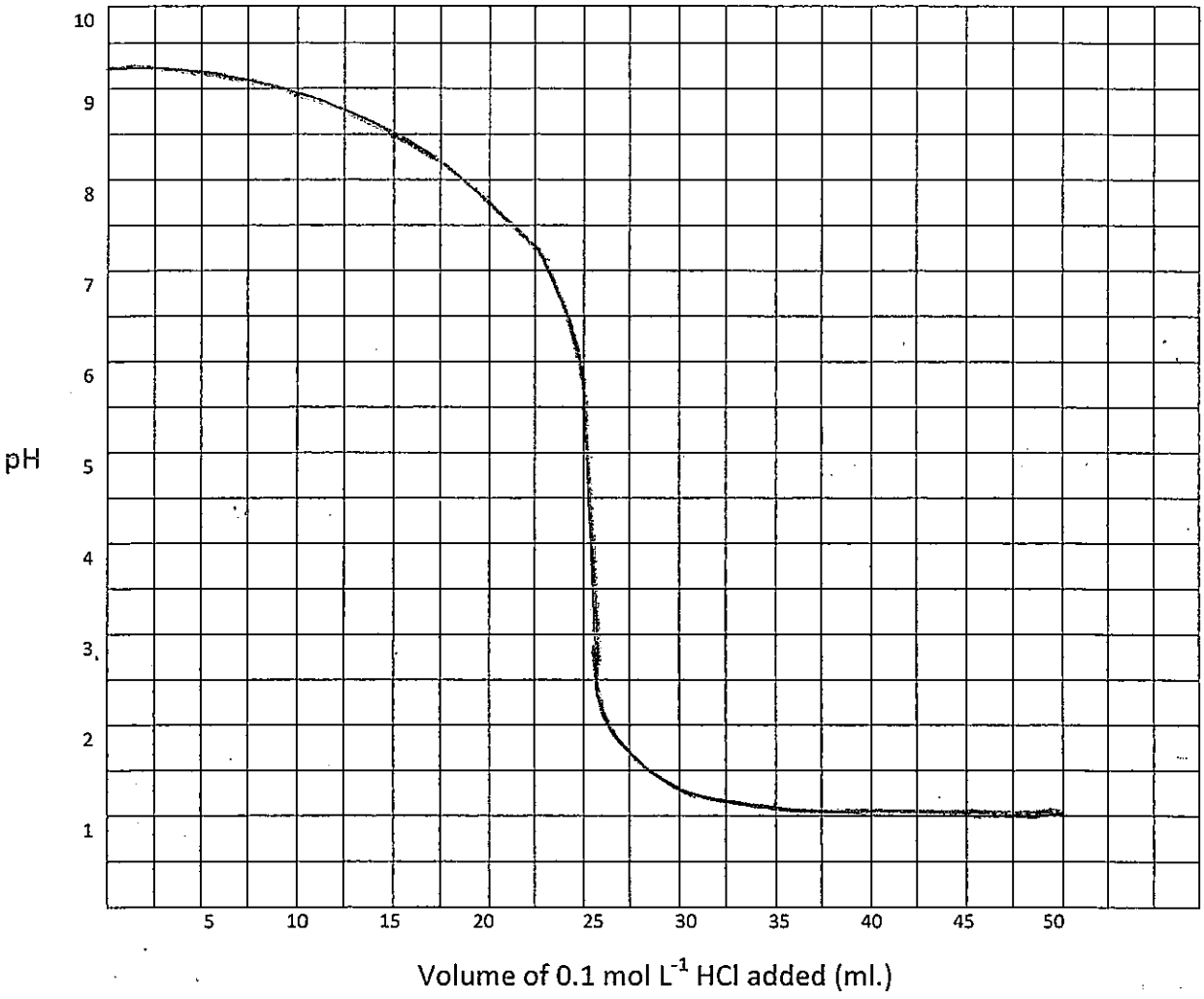
Student Number: _____

Question 29. (4 marks) **Marks:**

Jasmine bought a bottle of ammonia solution in her supermarket. She knows ammonia is a weak base. She decides to use computer based technology to determine the concentration of ammonia in the solution.

She dilutes the ammonia solution to one in ten with distilled water and titrates 25 mL samples of it by adding 0.1 $molL^{-1}$ hydrochloric acid from a burette at a constant rate having a pH probe dipping in the reaction vessel and attached to a data logger and computer.

Below is the titration curve generated during the addition of 50 mL of HCl to the ammonia solution at a constant rate.



(a) Suggest a suitable indicator which would identify the end point of this titration. **1**

Methyl orange.

Student Number: _____

Marks:

(b) Calculate the concentration of ammonia in the bottle she purchased. (Show working) 3

$NH_{3(l)} + HCl_{(aq)} \rightarrow NH_4Cl$ — (1).

$C_1V_1 = C_2V_2$

$\frac{C \times 25}{1000} = \frac{0.1 \times 25}{1000}$

$C_1 = \frac{0.1 \times 25/1000}{25/1000} = 0.1 mol/L$ (1)

Ammonia diluted 1 in 10

$\therefore 0.1 \times 10$

$= 1 mol/L$ — (1).

Question 30. (3 marks)

A solution containing 0.1 $molL^{-1}$ sulfurous acid (H_2SO_3) and 0.1 $molL^{-1}$ sodium sulfite (Na_2SO_3) is a buffer.

(a) What is a buffer solution? 1

A solution which can resist changes in pH upon addition of small amounts of acid or base.

(b) Explain using relevant equations how the solution above can act as a buffer. 2

(1) correct equation.

$H_2SO_3 + H_2O \rightleftharpoons HSO_3^- + H_3O^+_{(aq)}$ OR// $H_2SO_3 + 2NaOH \rightarrow Na_2SO_3 + 2H_2O$

(1) If HCl is added HSO_3^- ion will neutralise H_3O^+ & shift ←.

(1) If NaOH is added the sulfurous acid neutralises the excess base and shifts →.

As long as small amounts of acid/base are added, minimal change will occur.

* Answered poorly overall. Very few (2) marks given.

Question 31. (3 marks)

A solution was made using 25 mL of 0.25 mol L^{-1} hydrochloric acid and 75 mL of 0.05 $molL^{-1}$ potassium hydroxide. What is the pH of the solution? 3

$HCl + KOH \rightarrow KCl + H_2O$

$V = 0.025 L$ $v = 0.075 L$

$c = 0.25 mol/L$ $c = 0.05 mol/L$

$n = 0.00625$ $n = 0.00375$

$n_{HCl} - n_{KOH} = 0.00625 - 0.00375$

$= 0.0025$ moles.

(1)

$C = \frac{n}{V}$ (excess)

$= \frac{0.0025}{0.025 + 0.075}$ — (1)

$[H^+] = 0.025 mol/L$.

$pH = -\log_{10}[0.025]$

$= 1.6$ — (1)

Student Number: _____

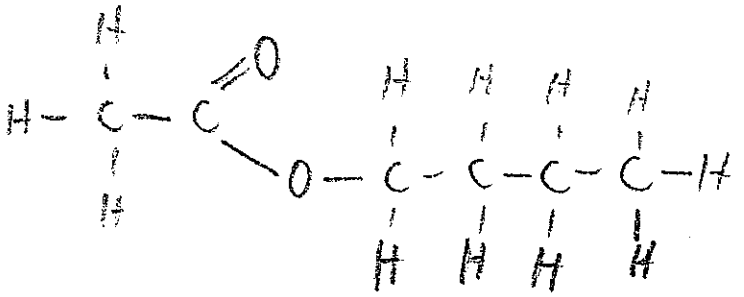
Question 32. (4 marks) **Marks:**

A student mixed 1-butanol and ethanoic acid together and heated them under reflux with a suitable catalyst.

(a) Name the ester which was produced in this reaction. **1**

butyl ethanoate (or 1-butyl ethanoate)

(b) Draw the structural formula for this ester. **1**



(no ½ mark) 1

(c) Identify the catalyst used and outline two purposes for its addition. **2**

concentrated (½) H_2SO_4 (½)
- increases reaction rate/similar (½)
- dehydrating agent (forcing equilibrium to right) (½)

Question 33. (7 marks)

The element oxygen is vital for life on earth in the form of O_2. In the atmosphere the element oxygen is also present in two other forms due to the conditions present and the reactions which result.

(a) Describe the chemical reactions which occur to produce these other forms. **2**

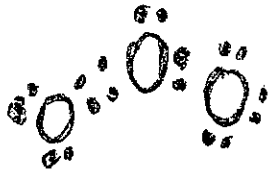
2 correct descriptions/equations but must mention correctly the words ozone and oxygen free radical	2
2 correct descriptions/equations	1½
1 correct description/equation	1
mentioning either ozone or oxygen free radical (if nothing else)	½

Student Number: _____

Marks:

(b) One of these is ozone gas.

(i) Draw the Lewis electron dot structure of the ozone molecule. 1



(no ½ marks) ✓

* must mention both spheres

(ii) Explain why ozone can be both beneficial and harmful to life on earth. 2

Ozone is beneficial in stratosphere* where it absorbs (dangerous) short UV wavelength UV light to protect life on earth etc ✓

harmful in troposphere* where it is toxic/poisonous to most life forms on the Earth ✓

(iii) Briefly outline the impact of CFCs on ozone concentrations. 2

Decreased $[O_3]$ ✓

+ one follow on eg. which has led to increased UVB rad^n reaching ground level → increased skin cancer/effect phytoplankton ✓

OR a description of how Cl can be "recycled" to continually destroy O_3 in the stratosphere → ozone hole etc.

Question 34. (3 marks)

During your course, you performed an activity to model isomers of haloalkanes.
Describe what you did and how the activity aided your understanding. 3

Molymod/molecular model kit used ✓

A specific haloalkane that was constructed eg. $C_2H_2F_4$ that could be made into other isomers and described how it was done ✓

Aided understanding by showing how many different isomers/compounds can be made from one molecule ✓

showing how compounds can have the same molecular formula but different structural formula

visualizing in 3D / vague ½

Question 35 over page:

Student Number: _____

Question 35. (4 marks) **Marks:**

Under conditions of low oxygen levels, octane can undergo incomplete combustion according to the following chemical equation:

$$2C_8H_{18}(l) + 17O_2(g) \rightarrow 6C(s) + 4CO(g) + 6CO_2(g) + 18H_2O(l)$$

(a) Explain the need to monitor this process. **2**

C is a lung irritant / CO is toxic / respiratory problems etc ✓
∴ mon. is needed to ensure increased amounts of O_2 is provided for complete combustion / similar meaning ✓

(b) Calculate the mass of soot ($C(s)$) produced if 4.2 moles of octane are combusted in this way. **2**

$n(C_{(Soot)}) = 6 \text{ mol} \div 2 \times 4.2$
$= 12.6 \text{ mol}$ (1)

$\therefore m(C_{(Soot)}) = 12.6 \times 12.01$
$= 151.3$ or 151_g (or 150_g) (1)

Section II over page:

KHS Trial 2016 OPTION MARKING

The descriptons given indicate what was required for full marks for the question

(a) Nitrogenous fertilisers: natural sources running out. Ammonia used the manufacture them.

or Rubber comes from a tree and not nearly enough can be produced for uses such as tyres for motor vehicles. Synthetic rubber made from crude oil – polymers makes up the shortfall.

(b) (i) The passage of an electric current through an electrolyte solution or molten electrolyte to bring about a chemical reaction.

(ii) Must include:

* brine used as electrolyte in all 3 cells

* anode and cathode material

* anode and cathode half equations

* decomposer equation for mercury cell

* technical- explanation of why product is or is not pure

* environmental- explanation of **why** both asbestos and mercury are problematic

(c) (i) clear description of what is being done eg molecular model kits and making molecules by joining balls etc then moving them and rearranging them

* *most alternatives described made little sense*

(ii) this would relate to which activity was described but eg – hard to simulate equal rates of forward and reverse process

(d) Correct answer: K = 400

1/2 mark for general equation 1 mark for calculating concentrations

If the answer was incorrect, working had to show logic and reasoning to gain any marks

(e) (i) Ammonia used to manufacture fertilisers. It is vital to replenish the nutrients in soil when crops are grown repeatedly. Natural fertilisers are insufficient so ammonia makes it possible to produce the huge quantities of crops necessary to feed the growing world population.

or Ammonia is used to manufacture explosives which are used in mining of coal and minerals. Demand by society for these commodities is ever increasing and without this substitute for naturally occurring nitrates there would be insufficient. (*not a good choice to answer the Q)*

(ii) * correct equation + either delta H term or statement that reaction is exothermic

* correct temperature + explanation in terms of kinetics and equilibrium

* correct pressure + explanation in terms of equilibrium + problems with high P relating to cost and safety

* catalyst + explained

* removal of product by liquefaction + addition of reactants in stoichiometric proportions

Stating 'Le Chatelier's principle' is not an explanation of anything!

(f) (i) reduction in P or increase in V

(ii) no effect as it's at equilib.

(iii) increase in T since equilib. has moved to left (endothermic) as seen by inc. reactants and dec. products

'Justify' means in terms of what the evidence(change in concs.)