2005
Higher School Certificate
Trial Examination
(INDEPENDENT)

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Board approved calculators may be used
- Write using black or blue pen
- Draw diagrams using pencil
- A Data Sheet and Periodic Table are provided at the back of this paper
- Write your student number and/or name at the top of every page

Total Marks – 100

Section I
Total marks (75)
This section has two parts, Part A and Part B

Part A
Total marks (15)
Attempt questions 1 – 15
Allow about 30 minutes for this part

Part B
Total marks (60)
Attempt questions 16 – 27
Allow about 1 hour 45 minutes for this part

Section II (Page 16)
Total marks (25)
Attempt ONE question from Questions 28-32
Allow about 45 minutes for this section

This paper MUST NOT be removed from the examination room

STUDENT NUMBER/NAME: .....

STUDENT NUMBER/NAME: .....

Section I

Total marks (75)

Part A

Total marks (15)
Attempt questions 1 – 15
Allow about 30 minutes for this part

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				
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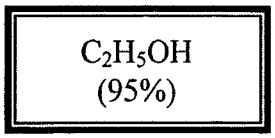
10				
11				
12				
13				
14				
15				

1. A reagent bottle on a laboratory shelf contains a colourless liquid and has the label:

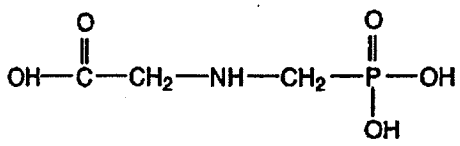


Which of the following is the most important piece of safety equipment when using this substance?

(A) eye protection
(B) a fire blanket
(C) gloves and apron
(D) a fume hood

2. Glyphosate is a white solid which is widely used as a weedicide (weedkiller). Its molecular structure is shown below.

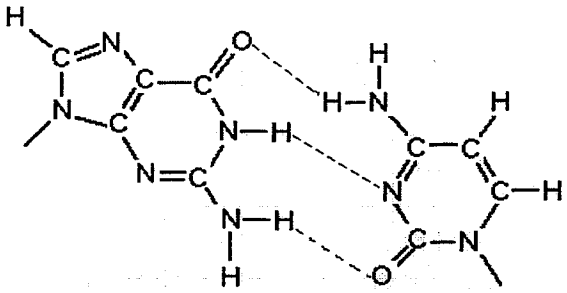
GLYPHOSATE (Roundup®)



Predict the extent of the solubility of glyphosate in water.

(A) very soluble
(B) moderately soluble
(C) slightly soluble
(D) not soluble

3. DNA is a double-stranded polymer. The diagram below shows the bonding between molecular units of two strands.



Identify the type of bonding between the molecular units, represented by the dotted lines.

(A) hydrogen bonding
(B) coordinate covalent bonding
(C) normal covalent bonding
(D) dispersion forces

4. What is measured by Biochemical Oxygen Demand (B.O.D.) for a sample of water?

(A) total number of aerobic organisms
(B) organisms and organic wastes
(C) inorganic and organic wastes
(D) oxygen needed to respire organic material

5. Which entry in the table below correctly identifies a Bronsted-Lowry acid-base pair?

	Acid	Base
(A)	H_2F_2	HF
(B)	H_2O	OH^-
(C)	HCO_3^-	H_2CO_3
(D)	CH_3COOH	CH_3OH

6. In a recent incident, mine wastewater carrying uranium, radium and other heavy metals was accidentally fed into the mineworkers' water supply. Testing showed the presence of uranium at levels up to 12 parts per million.

Which is the most suitable method of assay for uranium under these circumstances?

(A) gravimetric analysis by precipitation
(B) measurement of radioactivity of the water
(C) atomic absorption spectrophotometry (AAS)
(D) measurement of total dissolved solids by conductivity

7. Identify the reaction in which ethanol is produced from the by-products of the catalytic cracking of alkanes.

(A) fermentation of sugar
(B) reaction of ethylene with steam
(C) incomplete combustion of ethane
(D) reaction of ethane with concentrated sulfuric acid

8. The table shows the colours of three indicators at different hydrogen ion concentrations.

pH	Methyl Yellow	Thymol Blue	Bromophenol Blue
2	red	orange	yellow
3	red	yellow	yellow
4	yellow	yellow	blue

A solution is made by adding 5 mL of 1 mol L^{-1} sulfuric acid to 1000 mL of distilled water. Identify the colours of each of these indicators for this solution.

	Methyl Yellow	Thymol Blue	Bromophenol Blue
(A)	red	orange	yellow
(B)	red	yellow	yellow
(C)	yellow	yellow	blue
(D)	red	orange	blue

9. Identify the name which correctly identifies an isomer of $C_2H_4Cl_2$.

(A) 1,1-dichloropropane
(B) 2,2-dichloroethane
(C) 1,3-dichloromethane
(D) 1,2-dichloroethane

10. Identify the conditions which will improve the yield of methanol from the reaction:

$$CO_{(g)} + H_2O_{(g)} \rightleftharpoons CH_3OH_{(g)} + 120\ kJ$$

(A) low pressure and low temperature
(B) excess water and high pressure
(C) high temperature and high pressure
(D) platinum catalyst and low pressure

11. Which is the main factor leading to algal blooms and eutrophication in waterways?

(A) pH
(B) turbidity
(C) phosphate ions
(D) temperature

12. Which anion can be identified using silver nitrate solution?

(A) sulfate ion
(B) chloride ion
(C) acetate ion
(D) carbonate ion

13. Which action would result in an increase of 2 pH units?

(A) diluting 10 mL of 0.1 mol L^{-1} HCl to 200 mL
(B) diluting 10 mL of 0.1 mol L^{-1} NaOH to 200 mL
(C) diluting 10 mL of 0.1 mol L^{-1} HCl to 1000 mL
(D) diluting 10 mL of 0.1 mol L^{-1} NaOH to 1000 mL

14. In which reaction is there a coordinate covalent bond formed?

(A) hydroxide ion accepts a proton
(B) ammonia forms from nitrogen and hydrogen
(C) chlorine reacts with methane
(D) bromine reacts with propene

15. A class carried out measurements of the heat of combustion of ethanol. All groups used the same equipment and method. Their results are shown below:

Group No	1	2	3	4	5
Result/kJ g^{-1}	21	19	33	20	18

Which is the correct procedure for the Group 3 result in obtaining a class average?

(A) remove the result as an error.
(B) keep the result but do not include it in the average.
(C) include the result in the class average.
(D) change the result to match the rest of the class.

Section I – continued

Part B

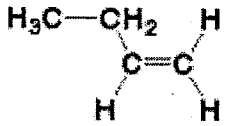
Total marks (60)
Attempt questions 16 – 26
Allow about 1 hour 45 minutes for this part

Answer the questions in the spaces provided.

Show all relevant working in questions involving calculations.

Question 16 (7 marks) **Marks**

A polymer can be made from the molecule shown below.



(a) Identify this substance. **1**

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(b) Construct a structural formula for 3 units of the polymer formed from this substance. **1**

(c) Assess the suitability of this polymer for use as fruit juice containers. **2**

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(d) A sample of this polymer was found to have an average molecular weight of 15000amu.
Determine the average length of the polymer chains, in monomer units. **2**

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(e) Identify this type of polymerisation reaction. **1**

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STUDENT NUMBER/NAME: .....

Question 17 (5 marks) **Marks**

Ordinary glass, as used in reagent bottles contains a large proportion of silicon (IV) oxide, also called silicon dioxide.

(a) Referring to the Periodic Table, describe the acid-base properties of silicon (IV) oxide. **1**

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(b) Explain why glass bottles are suitable for storing hydrochloric acid, but not for storing sodium hydroxide solution. Include a chemical equation in your answer. **2**

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(c) Suggest a suitable alternative material for storing sodium hydroxide, giving reasons for your choice. **2**

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Question 18 (4 marks)

Describe an experiment you have performed to investigate the conditions under which a galvanic cell is produced. **4**

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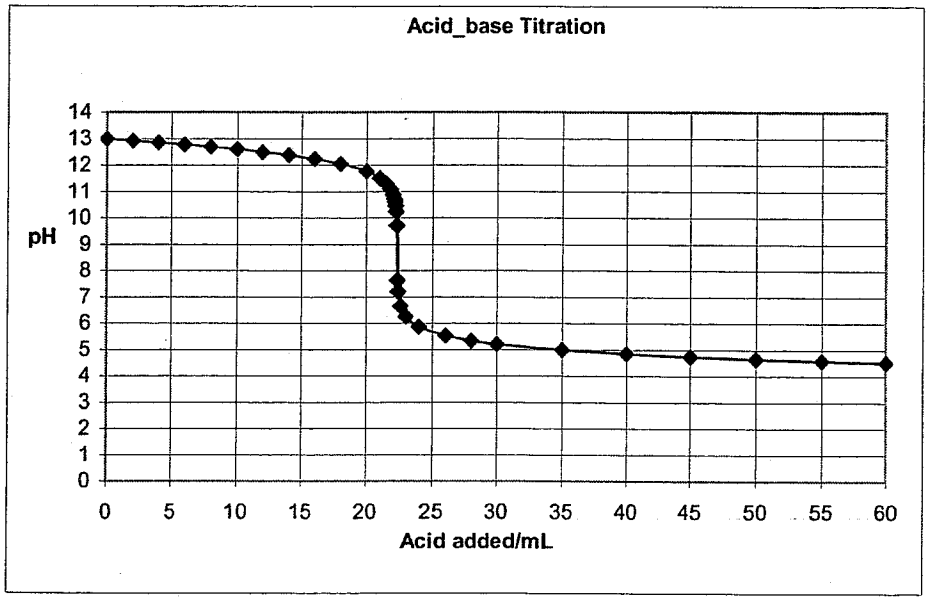
Question 19 (6 marks) **Marks**

The graph below shows the pH during an acid-base titration, as recorded by a datalogger. The base solution, with volume 25.00 mL had an initial concentration of 0.100 mol L^{-1}.



(a) Identify a possible base AND acid for this titration curve. **1**

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(b) Determine the neutralisation point for the titration AND calculate the concentration of the acid. Assume that both acid and base are monoprotic. **2**

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(c) Identify a suitable acid-base indicator for this titration. **1**

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(d) Identify the region of the curve where the mixture could act as an acid-base buffer and explain why buffering occurs in this region. **2**

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Question 20 (6 marks)

Natural gas is mainly methane AND is often claimed to be more "greenhouse-friendly", with reduced production of carbon dioxide from its combustion. This is in comparison to other fuels such as coal, which is mainly carbon. The heat of combustion of each of these under standard conditions are:

(natural gas) methane: 880 kJ mol^{-1}
(coal) carbon: 394 kJ mol^{-1}

(a) Calculate the mass of each fuel needed to produce 1 MJ of heat by combustion. **2**

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(b) Compare the mass of carbon dioxide resulting from the production of 1 MJ of heat from each fuel. **2**

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(c) Justify the claim that natural gas has lower carbon dioxide emissions than coal. **2**

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Question 21 (3 marks)

Outline the origin and effects of acid rain in industrial areas. **3**

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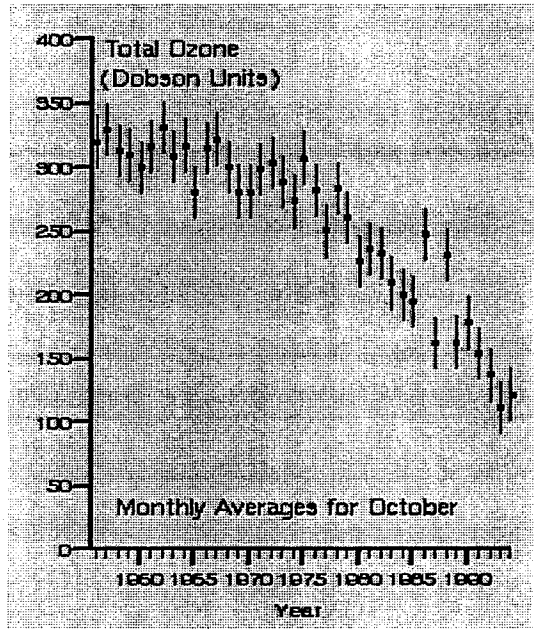
STUDENT NUMBER/NAME: .....

Question 22 (5 marks) **Marks**

The graph below plots the ozone levels in the stratosphere measured at a station in Antarctica from 1957 to 1997.



(a) Construct an electron dot (Lewis diagram) structure for ozone. **1**

(b) Analyse the graph above and describe the changes observed. **1**

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(c) Discuss, using relevant chemical equations, the effect of chlorofluorocarbons (CFC's) on ozone levels in the upper atmosphere. **3**

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Question 23 (4 marks) **Marks**

One cell which has been investigated as an alternative to the lead-acid cell is the rechargeable sodium-sulfur cell, where the electrodes consist of molten sodium and sulfur.

(a) Construct an equation for the anode reaction in a sodium-sulfur cell. **1**

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(b) Identify TWO advantages of the sodium-sulfur cell, when compared to the lead-acid cell. **2**

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(c) Assess ONE chemical safety issue to be considered with the use of a sodium-sulfur cell. **1**

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Question 24 (5 marks)

A gauge to monitor the thickness of cardboard as it is produced in a paper mill consists of a source of beta rays and a detector. The detector registers changes in the intensity of radiation passing through the cardboard.

(a) Justify the use of beta radiation for this application. **2**

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(b) Identify a suitable instrument to serve as the detector for this gauge. **1**

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Question 24 continues on the next page

Question 24 continued

(c) Describe advantages of this type of gauge compared with a mechanical instrument such as calipers. **2**

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Question 25 (6 marks) **Marks**

The concentration of sulfur dioxide in a gas stream is analysed by passing the gas through sodium hydroxide solution. It is found that 500 mL of standard 0.150 mol L^{-1} sodium hydroxide solution is neutralised by 95 L of the gas, at 298 K and 100 kPa.

(a) Construct an equation for the reaction of sulfur dioxide with sodium hydroxide solution. **1**

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(b) Calculate the number of moles and mass of sulfur dioxide. **2**

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(c) Determine the percentage by volume of sulfur dioxide in the gas stream. **2**

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(d) Identify ONE assumption made in using this method to analyse a gas for sulfur dioxide. **1**

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STUDENT NUMBER/NAME: .....

Question 26 (5 marks)

During your practical work you performed a first-hand investigation to prepare an ester.

(a) Identify the ester and write an equation for the reaction by which it was formed. **1**

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(b) Justify the reaction conditions you used in preparing the ester. **2**

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(c) Identify safety issues for this experiment and describe measures taken to address these issues. **2**

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STUDENT NUMBER/NAME: .....

Question 27 (4 marks)

Outline ways in which water from storage dams is treated to improve its quality for use in the home. **4**

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End of Section I

STUDENT NUMBER/NAME: .....

Section II

Total marks (25)

Attempt ONE question from Questions 28 – 32
Allow about 45 minutes for this part

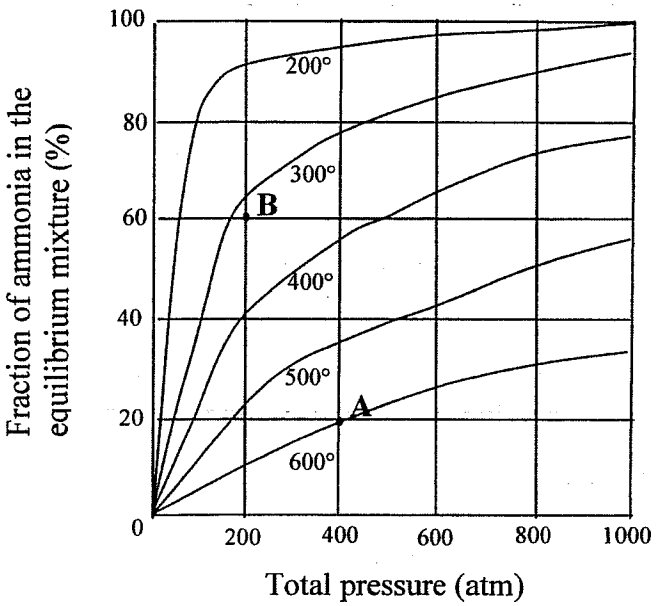
Answer the question on a separate page or writing booklet, if available.

STUDENT NUMBER/NAME: .....

Question 28 – Industrial Chemistry (25 marks) **Marks**

(a) Identify a chemical industry and outline the role of an industrial chemist in ensuring the efficiency and quality of production. **6**

(b) The graphs below show the fraction (%) of ammonia present at equilibrium when ammonia gas is placed in a pressure vessel with a catalyst.



(i) Determine the composition (pressure of each component) of the reaction mixture at points A and B, and use these values to calculate the equilibrium constant for each. **3**

(ii) Describe AND explain the effects of temperature and total pressure on the fraction of ammonia at equilibrium. **3**

(iii) Explain why ammonia is produced at temperatures of 400-500 °C. **2**

(c) With the aid of a suitable diagram, describe the production of sodium hydroxide by the membrane method. In your response, explain the advantages of this method over the use of the mercury (Castner-Kellner) cell and the Nelson cell. **5**

(d) (i) Identify the product and raw materials for the Solvay Process. **2**

(ii) Solvay plants were once located close to population centres, but are now located in more remote areas. Outline reasons for this change. **2**

(e) Outline the method used and results obtained in your investigation of the emulsifying action of a soap. **2**

End of Question 28

Question 29 – Shipwrecks, Corrosion and Conservation (25 marks) **Marks**

(a) (i) The first hydrothermal vent was discovered in 1977 and are known to exist in the Pacific and Atlantic oceans. Most are found at an average depth of about 2,100 meters in the areas of seafloor spreading along the Mid-Ocean Ridge system. Explain briefly how these hydrothermal vents add minerals to the ocean. **1**

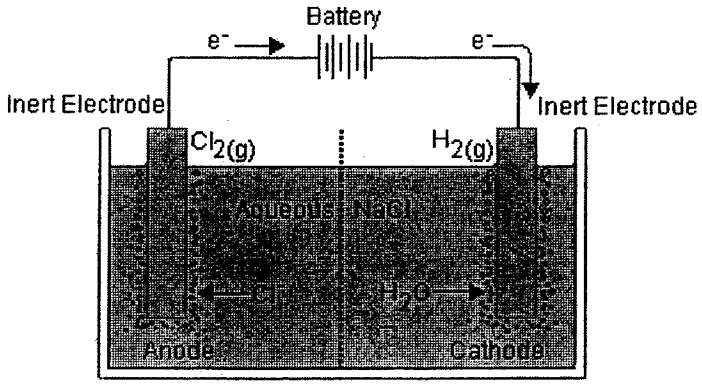
(ii) Luigi Galvani's work in the 1700's has increased our understanding of electron transfer reactions. Describe the work of Galvani in relation to electron transfer reactions. Explain the impact of his work on our understanding of these reactions. **2**

(b) (i) Steel is the main metal used in shipbuilding today. Steel is an alloy containing iron and many other elements. Identify the composition of TWO different steels AND briefly explain how the different compositions determine the steels properties. **2**

(ii) A very significant problem that all structural engineers face is corrosion. Describe TWO conditions which affect rusting. **2**

(c) During your course you conducted a first-hand investigation to compare the effectiveness of different protectants used to coat a metal such as iron from corrosion. Outline the method you used, the results obtained and discuss the effectiveness of the different protectants used. **5**

(d)



(i) Using the information from the above diagram, indicate using equations ONE possible anode AND cathode reaction that may occur at these electrodes. **1**

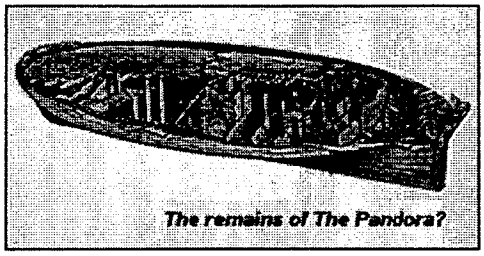
(ii) Describe how the nature of the electrode affects the electrolytic reaction. **2**

Question 29 continues on the next page

Question 29 continued

(iii) During your course you conducted a first-hand investigation to describe how the rate of corrosion of materials is different in varying oxygen and salt concentrations and at different temperatures. Compare how the rate of corrosion is affected by differing of oxygen, salt and temperature conditions. **3**

(e) On 29 August 1791, the Pandora was homeward bound via the Torres Strait when she struck a part of the Great Barrier Reef and sank. Thirty-one of the Pandora's crew and four of the mutineers drowned in the shipwreck. Among the many artefacts that have been recovered are a silver pocket watch, a wooden pencil and a leather pouch used as a weapon cover.


The remains of The Pandora?

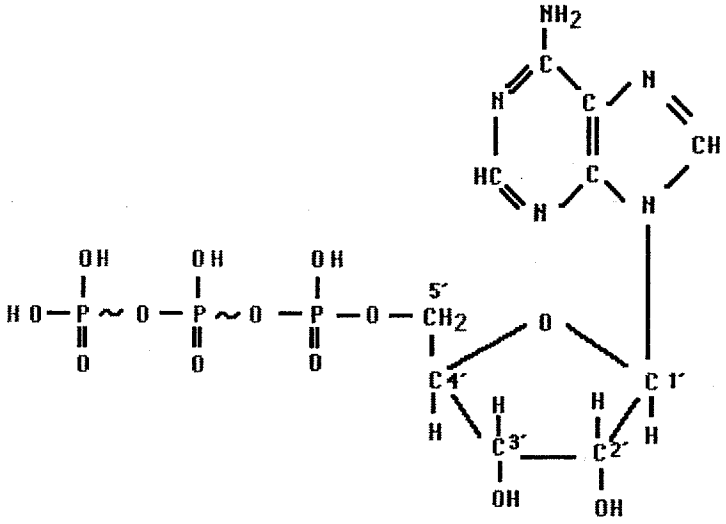
Discuss the range of chemical procedures which can be used to clean, preserve and stabilise the above artefacts. Describe the damage that would result if the wooden pencil and leather cover were removed from the water around the wreck and allowed to dry in the air.

7

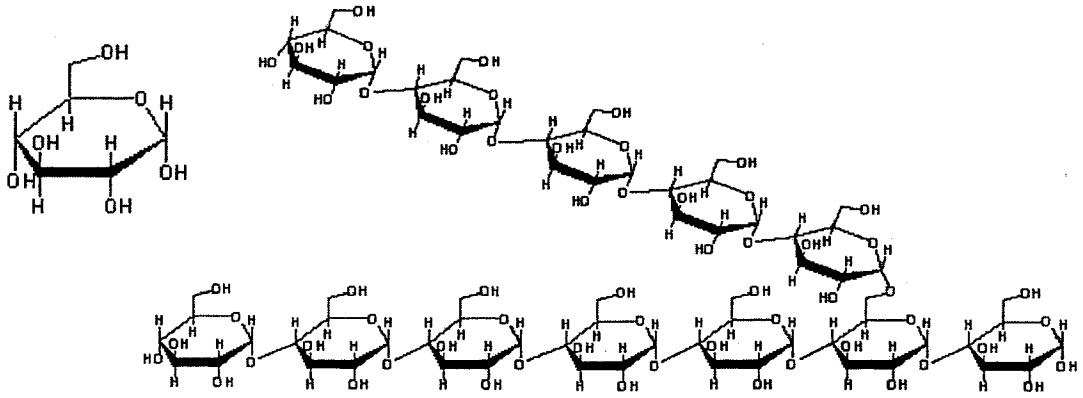
End of Question 29

Question 30 – Biochemistry of Movement (25 marks) **Marks**

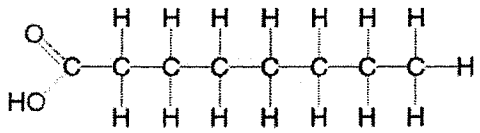
(a) (i) Identify the function of the molecule below. **1**



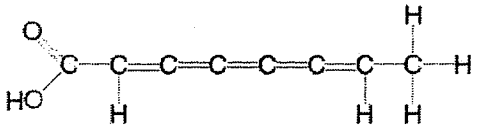
(ii) Identify molecule A and B from the diagrams below. **2**



(b) (i) The diagram below represents the general structure for a saturated and unsaturated fatty acid. With reference to these diagrams, identify the part of the molecule which should mix with the water and explain this phenomenon. **2**



Saturated



Unsaturated

(ii) Account for the process of denaturation of a protein. In this account, identify factors that denature proteins. **2**

Question 30 continues on the next page

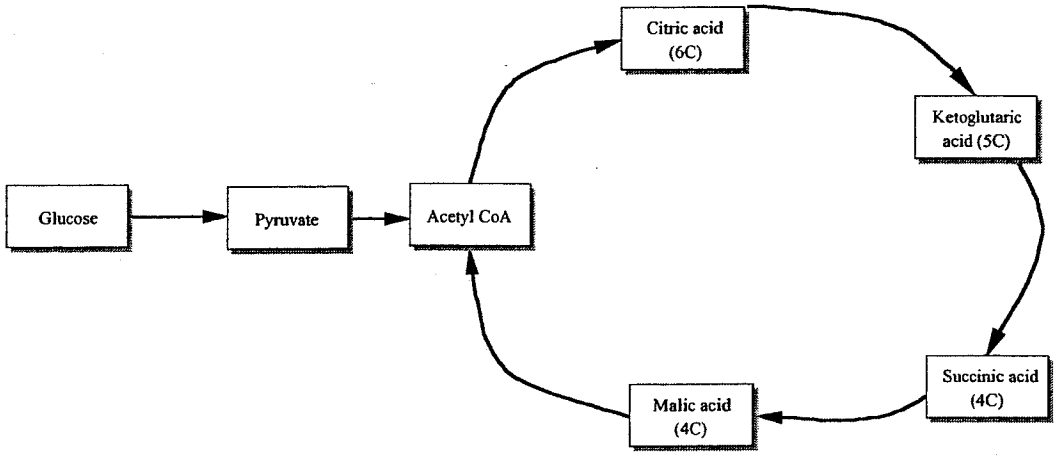
Marks

Question 30 continued

(c) During your course you conducted a first-hand investigation to observe the effect of changes in pH and temperature on the reaction of a named enzyme.

Name an enzyme you used during this investigation and briefly outline the method used in conducting this investigation.Explain your results by relating your explanation to the possible changes in primary, secondary and/or tertiary structure of the enzyme used. **5**

(d)



(i) Identify the part of the cell in which the reaction from glucose to pyruvate is carried out. **1**

(ii) Compare the total energy output from glycolysis to the total energy output from the TCA cycle. **2**

(iii) The final process of cellular respiration involves the oxidation of high energy compounds such as NADH and $FADH_2$ coupled with the phosphorylation of ADP to ATP. During the TCA cycle 3 molecules of NADH and 1 molecule of $FADH_2$ are produced.

Discuss the role of NADH and $FADH_2$ in ATP generation. Show some equations in your answer. **3**

(e) Outline the problems associated with the supply and use of fuels during sprinting and relate this to the sprinters muscle reliance on non-oxygen/non-mitochondrial based ATP production. **7**

End of Question 30

STUDENT NUMBER/NAME: .....

Question 31 – Chemistry of Art (25 marks) **Marks**

(a) Identify and describe the chemical composition of THREE examples of pigments used in traditional art by Aboriginal people.

For ONE of these pigments outline the properties which are important to its use in art. **6**

(b) During your practical work you performed a first-hand investigation to demonstrate the oxidising strength of potassium permanganate, $KMnO_4$.

(i) In terms of its electronic structure explain why manganese has a range of oxidation states. **3**

(ii) Outline the procedure used in your investigation, and describe the results obtained. **4**

(iii) Write a half-reaction equation for the reduction MnO_4^- ion to the manganese(II) state in acidic conditions. **2**

(c) When concentrated sodium chloride solution is added to a solution containing copper(II) ions the colour of the solution changes to lime green as the following equilibrium is established:

$$[Cu(H_2O)_4]^{2+} + 4Cl^- \rightleftharpoons [CuCl_4]^{2-}$$

(i) Draw a Lewis diagram of the complex ion formed in this reaction, and explain the nature of the bonds formed by the copper ion. **3**

(ii) Explain why the colour of the ion can be changed by this reaction. **2**

(d) The table below shows the first eight successive ionisation energies for the chromium atom.

Ionisation	Ionisation energy ($kJmol^{-1}$)
1st	653
2nd	1590
3rd	2990
4th	4770
5th	7070
6th	8700
7th	16600
8th	17700

(i) Write an equation to show the second ionisation for chromium. **1**

(ii) Explain how the trend in successive ionisation energies relates to the range of oxidation states of chromium. **3**

(iii) From the table predict the highest possible oxidation state for chromium. **1**

End of Question 31

STUDENT NUMBER/NAME: .....

Question 32 – Forensic Chemistry (25 marks) **Marks**

(a) Glucose is classified as a reducing sugar while sucrose is a non-reducing sugar. Both glucose and sucrose are classified as carbohydrates.

(i) State why glucose and sucrose are both classified as carbohydrates. **1**

(ii) With reference to the chemical difference between reducing and non-reducing sugars, explain how glucose and sucrose can be distinguished. **3**

(b) (i) In DNA analysis the DNA molecule is cut up into fragments using specific enzymes. These fragments can then be separated in a gel using electrophoresis producing a DNA fingerprint.

Explain how electrophoresis is able to separate DNA fragments. **2**

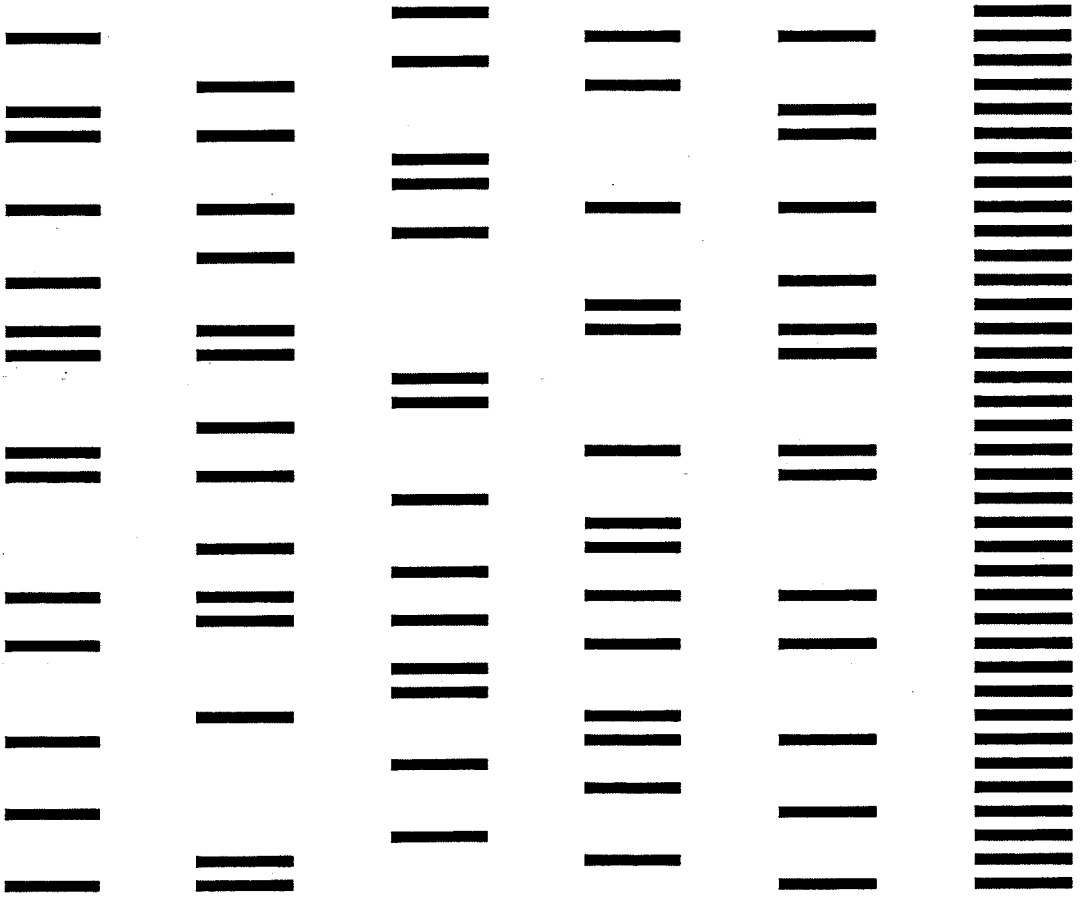
(ii) Chromatography and mass spectroscopy are two other analysis techniques used by forensic chemists. These techniques both allow the separation of components in a mixture to be achieved, although the purpose for their use can be very different.

Compare the ways in which chromatography and mass spectroscopy achieve the separation of components in a mixture, as opposed to electrophoresis. **4**

Question 32 continues on the next page.

Marks

(c) The DNA fingerprint of a 10 year old girl was taken and compared to DNA fingerprints from two adults and two other children as shown below.



Deduce the relationship of this 10 year old girl to each of these other people. Justify your answers and comment on the reliability of this method of determining relationships between people. **7**

(d) During your practical work you performed a first-hand investigation using flame tests and/or spectroscope analysis to identify and describe the emission spectrum of a range of elements including Na and Hg.

(i) Describe the main feature of the Na spectrum. **1**

(ii) Outline the procedure used in your investigation, and describe the results obtained. **3**

(iii) Explain how a line emission spectrum is formed and discuss how it can be used to identify the presence of elements in chemicals. **4**

End of Paper

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.

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number — 79 — Symbol of element
Atomic Weight — 197.0 — Name of element
Au — 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 65.39 Zinc	31 Ga 69.72 Gallium	32 Ge 72.61 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 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc [98.91] 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 Lanthanides	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.8 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 [210.0] Polonium	85 At [210.0] Astatine	86 Rn [222.0] Radon
87 Fr [223.0] Francium	88 Ra [226.0] Radium	89–103 Actinides	104 Rf [261.1] Rutherfordium	105 Db [262.1] Dubnium	106 Sg [263.1] Seaborgium	107 Bh [264.1] Bohrium	108 Hs [265.1] Hassium	109 Mt [268] Meitnerium	110 Uun — Ununnilium	111 Uuu — Unununium	112 Uub — Ununbium	113	114 Uuq — Ununquadium	115	116 Uuh — Ununhexium	117	118 Uuo — Ununoctium

Lanthanides

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm [146.9] 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 173.0 Ytterbium	71 Lu 175.0 Lutetium

Actinides

89 Ac [227.0] Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np [237.0] Neptunium	94 Pu [239.1] Plutonium	95 Am [241.1] Americium	96 Cm [244.1] Curium	97 Bk [249.1] Berkelium	98 Cf [252.1] Californium	99 Es [252.1] Einsteinium	100 Fm [257.1] Fermium	101 Md [258.1] Mendelevium	102 No [259.1] Nobelium	103 Lr [262.1] Lawrencium

Where the atomic weight is not known, the relative atomic mass of the most common radioactive isotope is shown in brackets.
The atomic weights of Np and Tc are given for the isotopes ^{237}Np and ^{99}Tc.