2003
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
75 marks
This section has two parts, Part A and Part B

Part A (pages 2 – 6)
Total marks (15)
Attempt questions 1 – 15
Allow about 30 minutes for this part

Part B (pages 7 – 16)
Total marks (60)
Attempt questions 16 – 27
Allow about 1 hour 45 minutes for this part

Section II (pages 17 – 24))
25 marks
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				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				

STUDENT NUMBER/NAME: .....

1. Americium-241 is a radioisotope used in domestic smoke detectors. The production of this transuranic element in a nuclear reactor is represented by the equations below.

$$^{239}_{94}\text{Pu} + 2\,\text{"X"} \rightarrow {}^{241}_{94}\text{Pu} \rightarrow {}^{241}_{95}\text{Am} + \text{"Y"}$$

The names of the particles represented by the letters "X" and "Y" respectively are:

(A) neutron and electron
(B) electron and proton
(C) neutron and proton
(D) proton and electron

2. The molecular formula for 2-pentanol is:

(A) C_5H_9OH
(B) $C_5H_{12}OH$
(C) $C_5H_{10}O$
(D) $C_5H_{12}O$

3. The conditions that would most favour the fermentation of sugar include:

(A) warmth, oxygen and water
(B) warmth, no oxygen, water
(C) no warmth, no oxygen, no water
(D) warmth, oxygen, no water

4. A galvanic cell is to be constructed using Mg / Mg^{2+} and Ag / Ag^{+} two half-cells each containing a piece of the solid metal partly immersed in an aqueous solution containing ions of the same metal. The anode in this galvanic cell is:

(A) magnesium which acts as the oxidant
(B) magnesium which acts as the reductant
(C) silver which acts as the oxidant
(D) silver which acts as the reductant

5. The table below shows the heat of combustion for 4 different alcohols.

Alcohol	Mol. mass (g)	Heat of combustion(kJ mol^{-1})
methanol	32	725
ethanol	46	1364
1-propanol	60	2016
1-butanol	74	2677

The alcohol with the greatest heating value in kJ kg^{-1} is:

(A) methanol
(B) ethanol
(C) 1-propanol
(D) 1-butanol

6. Some household cleaners contain strong bases such as sodium hydroxide. A student tested household cleaning solutions with litmus and recorded the results in the following table:

Cleaning solution	Colour of blue litmus	Colour of red litmus
X	blue	red
Y	blue	blue
Z	red	red

Sodium hydroxide could be present in:

(A) X and Y
(B) X and Z
(C) Y only
(D) Z only

7. What effect would the addition of dilute hydrochloric acid have on the following equilibrium?

$$CO_{2(aq)} + H_2O_{(l)} \leftrightarrow H^+_{(aq)} + HCO_3^-{}_{(aq)}$$

(A) The equilibrium would shift to the left, decreasing the concentration of HCO_3^-
(B) The equilibrium would shift to the right, increasing the concentration of HCO_3^-
(C) The equilibrium would not change
(D) The rate at which equilibrium is attained would be increased

8. A number of solutions were tested with a conductivity probe attached to a data logger. Which of the following solutions would record the highest conductivity reading?

(A) 0.01 mol L^{-1} HCl
(B) 0.1 mol L^{-1} HCl
(C) 0.01 mol L^{-1} CH_3COOH
(D) 0.1 mol L^{-1} CH_3COOH

9. A student used a pipette to transfer 25.0 mL of a solution to a flask. After draining the solution into the flask a small amount of solution remained in the tip of the pipette. To deliver the correct volume of solution to the flask the student should:

(A) blow the remaining solution into the flask
(B) touch the inside of the flask with the tip of the pipette
(C) shake the pipette to dislodge the remaining solution
(D) rinse the pipette with a small quantity of distilled water into the flask

10. The conjugate base of the NH_4^+ ion has the formula:

(A) NH_4OH
(B) OH^-
(C) NH_3
(D) NH_4^{2+}

11. Which of the following exhibits coordinate covalent bonding?

(A) oxygen molecule
(B) hydronium ion
(C) ammonia
(D) ethanol

12. One technique that can be used to indicate the presence of some cations in solutions is flame testing. When a platinum wire loop is placed into a solution containing barium ions, the resulting flame colour is:

(A) yellow
(B) scarlet
(C) brick red
(D) lime green

13. Atomic absorption spectroscopy was developed in Australia in the 1950s by Alan Walsh while working at CSIRO. This technique works on the principle that:

(A) glass prisms can reflect wavelengths
(B) electron beams bombard and ionise atoms
(C) gaseous atoms absorb specific wavelengths of light
(D) gaseous atoms give out specific wavelengths when excited

14. A suitable method to determine the sulfate content of a fertiliser is:

(A) acid/base titration
(B) atomic absorption spectroscopy
(C) pH measurement
(D) gravimetric analysis of a precipitate

15. The main factor that causes algal bloom in waterways is an increase in:

(A) acidity
(B) hardness
(C) phosphate concentration
(D) temperature

Section I – continued

Part B

Total marks (60)
Attempt questions 16 – 27
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 (4 marks) **Marks**

(a) Identify ONE example of an addition polymer and explain how this polymer is formed. **2**

.....

.....

.....

.....

(b) Describe uses of this polymer in terms of its properties. **2**

.....

.....

.....

.....

.....

.....

STUDENT NUMBER/NAME: .....

Question 17 (6 marks) **Marks**

Ethanol is widely used as a solvent. Most ethanol required for industrial use is produced using raw materials obtained from the refining of petroleum.

(a) Give the structural formula for ethanol **1**

(b) Write an equation for the production of ethanol, identifying any catalysts required. **2**

.....

.....

(c) Describe and account for two uses of ethanol as a solvent. **3**

.....

.....

.....

.....

.....

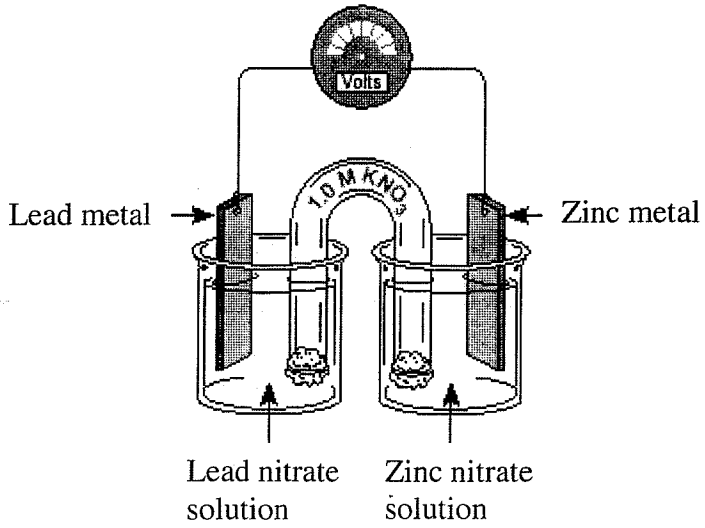
.....

.....

.....

Question 18 (5 marks) **Marks**

The diagram below shows a galvanic cell.



(a) Write an ionic equation to represent the overall reaction occurring in this galvanic cell. **1**

.....

.....

(b) Calculate the expected voltage of this cell under standard conditions. **1**

.....

.....

(c) Identify one example of a galvanic cell, and evaluate the impact this cell has had on society. **3**

.....

.....

.....

.....

.....

.....

.....

.....

STUDENT NUMBER/NAME: .....

Question 19 (5 marks) **Marks**

(a) Identify a radioisotope which is used in medicine or industry, and describe the method used to produce this isotope. **2**

.....

.....

.....

.....

(b) Assess the benefits and problems associated with the use of this radioisotope. **3**

.....

.....

.....

.....

.....

.....

Question 20 (4 marks)

You have carried out a first-hand investigation to prepare and test a natural indicator.

(a) Outline the procedure used to prepare and test the natural indicator. **2**

.....

.....

.....

.....

(b) Draw a table to show the results obtained in testing this indicator. **2**

.....

.....

.....

.....

.....

.....

STUDENT NUMBER/NAME: .....

Question 21 (6 marks) **Marks**

A sample of lignite, a high sulfur content coal, was analysed and found to contain 4.32% sulphur.

(a) Calculate the volume of sulfur dioxide, at 25°C and 100 kPa, that would be produced by burning 1.0 kg of lignite coal. **3**

.....

.....

.....

.....

.....

.....

(b) Assess the impact, on the environment, of using lignite as a fuel, writing equations where appropriate. **3**

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

STUDENT NUMBER/NAME: .....

Question 22 (7 marks)

Marks

To prepare a standard solution of sodium hydroxide a student first dissolved 1.0 g of solid sodium hydroxide in 250 mL of distilled water. By titration, 25.0 mL of this solution required 23.2 mL of standard 0.100 mol L^{-1} hydrochloric acid for neutralisation.

(a) Why is titration necessary to standardise the sodium hydroxide solution? **1**

.....

.....

.....

(b) Calculate the concentration of the standardised sodium hydroxide solution. **2**

.....

.....

.....

.....

.....

.....

(c) Describe the titration procedure for this standardisation. **4**

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Question 23 (4 marks) **Marks**

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

(a) Identify an ester by name and draw its structural formula. **2**

.....

.....

.....

(b) Explain the need for refluxing in this investigation. **2**

.....

.....

.....

.....

.....

.....

Question 24 (3 marks)

Define the term *buffer* in relation to acid-base systems and describe ONE example of buffer action in a natural system. **3**

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Question 25 (6 marks) **Marks**

The table below gives the concentration in parts per million, of some substances found in Sydney's tap water, along with the National Health and Medical Research Council (NHMRC) guidelines for maximum safe concentrations of these substances.

Substances	**Concentration in ppm in Sydney tap water**	**NHMRC guidelines concentration ppm**
Total dissolved solids	86	1000
Calcium ion	15	200
Chloride ion	19	400
Nitrate ion	0.4	12

(a) Describe a chemical test you could perform to test for the presence of chloride ion. **1**

.....

.....

.....

(b) Identify a possible source of nitrate ion in the tap water. **1**

.....

.....

(c) Identify one other substance which can affect water quality, and describe an adverse effect if this substance is at too high a concentration. **2**

.....

.....

.....

.....

(d) Sydney tap water has chlorine added in varying concentrations. Discuss the purpose of adding this chlorine. **2**

.....

.....

.....

.....

STUDENT NUMBER/NAME: .....

Question 26 (7 marks) **Marks**

The Haber Process is used in the synthesis of ammonia from gaseous hydrogen and nitrogen. The percentage conversion to ammonia at different temperatures and pressures is shown in the table below.

Temperature °C	Percentage conversion to ammonia at pressures indicated		
	250 atm	500 atm	1000 atm
150	94	97	99
350	44	74	83
550	12	28	34
750	6	14	17

(a) Write the equation for the Haber process. **1**

.....

(b) Justify whether the reaction is endothermic or exothermic. **2**

.....

.....

.....

(c) Analyse the effect of increasing pressure on this system. **2**

.....

.....

.....

(d) Justify the use of high pressure and a temperature of 300-400 °C in the industrial synthesis of ammonia. **2**

.....

.....

.....

.....

.....

.....

STUDENT NUMBER/NAME: .....

Question 27 (3 marks) **Marks**

The water in Sydney is very soft, but the water in Broken Hill is hard.

(a) Identify the cause of water hardness. **1**

.....

.....

.....

(b) Describe how you could quickly tell if a sample of water came from Sydney or Broken Hill. **2**

.....

.....

.....

.....

.....

.....

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 in a separate writing booklet. Extra writing booklets are available.

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

(a) A chemist performed three separate experiments to analyse the following equilibrium system:

$$\underset{\text{(colourless)}}{H_{2(g)}} + \underset{\text{(purple)}}{I_{2(g)}} \Leftrightarrow \underset{\text{(colourless)}}{2HI_{(g)}}$$

The forward reaction is endothermic, requiring 52 kJ mol^{-1}

All three experiments were carried out at the same pressure. Two of the experiments were carried out at the same temperature while the other was carried out at a different temperature.
The results of the experiments are shown in the table below.

Experiment	Concentration (mol L^{-1})					
	Initial			At equilibrium		
	$H_{2(g)}$	$I_{2(g)}$	$HI_{(g)}$	$H_{2(g)}$	$I_{2(g)}$	$HI_{(g)}$
1	1.000	1.000	0.000	0.228	0.228	1.544
2	1.000	2.000	3.000	0.526	1.526	3.948
3	0.000	0.625	0.750	0.0175	0.643	0.715

(i) Determine whether the experiment carried out at the DIFFERENT temperature was at a higher or lower temperature than that of the other two experiments. Explain your answer. **2**

(ii) Describe how the chemist could visually monitor the time when Experiment 1 reached equilibrium. **1**

(iii) After Experiment 1 reached equilibrium, the chemist doubled the concentration of H_2 and maintained a constant temperature.
Describe what would happen in the reaction vessel in response to this change and the effect this would have on the value of the equilibrium constant. **2**

(b) Outline a first-hand investigation you have carried out to saponify an oil or fat, including the method used to test the product. **4**

(c) Almost all of the sulfuric acid produced is made by the Contact process.

(i) The first stage in the Contact process involves the production of sulfur dioxide where liquid sulfur is sprayed into a combustion furnace where it burns in air at 1000°C. Write an equation to show the formation of sulfur dioxide. **1**

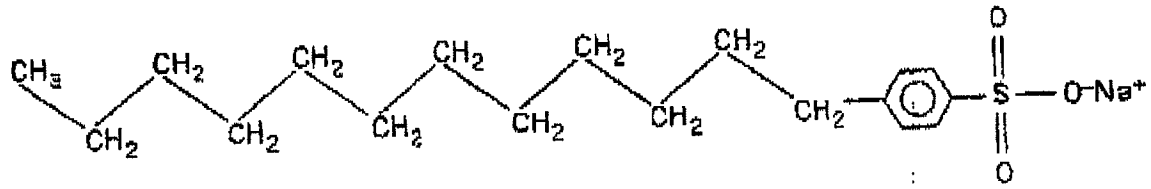
(ii) Identify the source of the sulfur. **1**

(iii) Describe ONE specific use of sulfuric acid in industry. **1**

Question 28 – Industrial Chemistry continues on next page

Question 28 (continued) **Marks**

(d) The diagram below shows the structure of a typical synthetic detergent molecule.



Distinguish between common soaps and synthetic detergents in terms of their chemical composition, structure of the molecule and their use as cleaning agents. **3**

(e) The equations below represent four of the steps in the production of sodium carbonate by the Solvay process but they are not in the correct sequence.

Step 1 $Ca(OH)_{2(s)} + 2NH_4Cl_{(aq)} \rightarrow CaCl_{2(aq)} + 2H_2O_{(l)} + NH_{3(g)}$

Step 2 $2NaHCO_{3(s)} \xrightarrow{heat} Na_2CO_{3(s)} + H_2O_{(l)} + CO_{2(g)}$

Step 3 $CaCO_{3(s)} \xrightarrow{heat} CaO_{(s)} + CO_{2(g)}$

$NaCl_{(aq,\ impure)} \xrightarrow{fractional\ crystallisation} NaCl_{(s,\ pure)}$

Step 4 $H_2O_{(l)} + NaCl_{(aq)} + CO_{2(g)} + NH_{3(g)} \longrightarrow NaHCO_{3(s)} + NH_4Cl_{(aq)}$

(i) Write the steps in the correct sequence that they occur in the Solvay process. **2**

(ii) Name the chemicals that are recycled during the Solvay process. **2**

(f) The processes of industrial chemistry have enabled scientists to develop replacements for natural products.

Identify and discuss the issues associated with the increased need for a natural resource that is not a fossil fuel and evaluate the progress made to solve the problems identified. **6**

End of Question 28

STUDENT NUMBER/NAME: .....

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

(a) (i) A plumber, while repairing some copper pipes under a house, attached the repaired pipe to a wooden beam using steel clips. Assuming that the steel clips are essentially iron, predict which metal will corrode using the standard reduction potentials given below. **1**

$Fe^{2+} + 2e^- \Leftrightarrow Fe_{(s)}$ $\quad E^0 = -0.44V$

$Cu^{2+} + 2e^- \Leftrightarrow Cu_{(s)}$ $\quad E^0 = 0.34\ V$

(ii) Steel is an alloy of various metals and non-metals. The properties of steel depend on the elements used and the percentage of each element in the steel.

Contrast the composition and properties of three types of steels. **3**

(b) The most common and economically destructive form of corrosion is the rusting of iron and steel. Describe the conditions under which rusting occurs and explain the process of rusting. **4**

(c) During the study of Shipwrecks, Corrosion and Conservation you carried out a first-hand investigation to identify the factors that affects the rate of an electrolysis reaction.

(i) Briefly recount the method followed in identifying several factors that affect the rate of an electrolysis reaction. **3**

(ii) Briefly recall a suitable conclusion to the above rate of electrolysis reaction. **2**

(d) (i) Explain the changes undergone by artefacts removed from wrecks which have been submerged for long periods of time. **1**

(ii) When the wreckage of the Titanic was first discovered by Robert Ballard in 1985 they were amazed by the amount of corrosion that was observed. This corrosion was due to sulfate-reducing bacteria. Describe the action of these sulfate-reducing bacteria around these wrecks. **2**

(iii) Many artefacts that are on public display in Maritime Museums have been carefully restored and conserved. Some of these chemical procedures are used to clean, preserve and stabilise the artefacts. Discuss a range of chemical procedures used. **3**

(e) Many scientist have contributed to our current theories on electrochemistry, none more so than Galvani, Davy, Volta and Faraday. Outline and analyse the impact of the work of these four scientists to our understanding of electron transfer reactions. **6**

End of Question 29

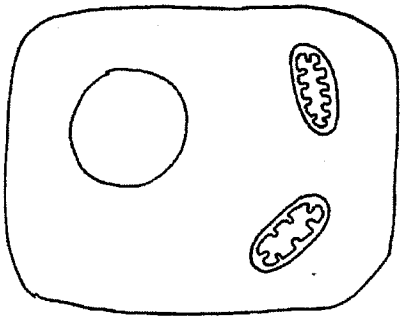
STUDENT NUMBER/NAME: .....

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

(a) (i) Identify the chemical which serves as the energy currency of every cell **1**

(ii) Using a sequence of two diagrams or a model, show how the structure of this chemical transfers energy. **2**

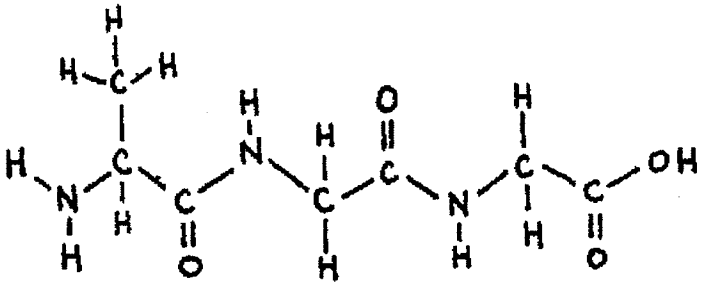
(b) The diagram below is a simplified sketch of a cell. The organelles are not drawn to scale.



Draw a larger copy of the diagram onto your Answer Book. Indicate the locations of the following reactions and name the ultra-structures involved : **4**

(i) glycolysis
(ii) TCA cycle
(iii) oxidative phosphorylation
(iv) oxidation of fatty acids

(c) (i) Amino acids are the building blocks of a polypeptide. The diagram below shows a tripeptide. Using a balanced chemical equation, show how this tripeptide can be broken down into amino acids. **3**



(ii) Although a polypeptide is a long chain of many amino acids, it is not a linear structure, but folds itself up into a particular shape, eg: a globular structure. How can this be possible and what is the significance of this? **3**

(d) Describe a practical investigation you have performed to observe the effect of either temperature or pH on the activity of an enzyme. Relate your results to changes in the primary, secondary and/or tertiary structure of the enzyme involved. **6**

(e) Discuss the cause and the mechanism for triggering a muscle contraction. **6**

End of Question 30

STUDENT NUMBER/NAME: .....

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

(a) Explain why the majority of ancient aboriginal cave paintings are made up of variations of the colours white, black, yellow and red. **3**

(b) (i) State the electron configuration of silicon in terms of subshells. **1**

(ii) The first five ionisation energies for silicon, in kJ mol^{-1}, are shown below:

1st	2nd	3rd	4th	5th
793	1 583	3 238	4 362	16 098

Explain the variation in the first five ionisation energies for silicon in terms of the atoms electronic configuration. **2**

(iii) Define the term electronegativity. **1**

(iv) Explain the relationship between the number of electrons in the outer shell of an element and its electronegativity. **2**

(c) Describe a first-hand investigation you have carried out to observe the colour changes in a transition element, as it changes its oxidation state. **4**

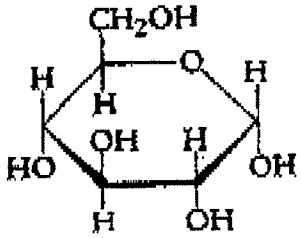
(d) Describe the methodology in laser microspectral analysis and assess its importance in the art world. **6**

(e) Using a specific coloured example, explain what is meant by a hydrated ion in solution and account for its structure, bonding and colour. **6**

End of Question 31

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

(a) Glucose has a molecular formula of $C_6H_{12}O_6$. Its structure is shown below.



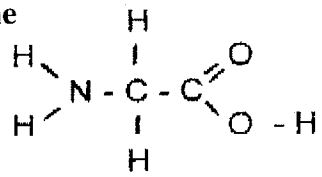
(i) Explain why glucose is classified as a carbohydrate. **1**

(ii) Sucrose is a disaccharide. Describe how sucrose is formed from glucose and fructose. **1**

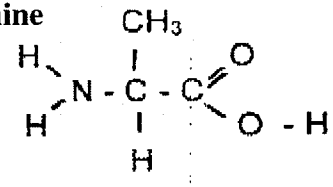
(iii) Glucose is classified as a reducing sugar, while sucrose is a non-reducing sugar. Describe the chemical difference between a reducing sugar and a non-reducing sugar and describe a test that can be performed to distinguish between the two. **2**

(b) The structure of some amino acids, glycine and alanine, is given below:

glycine



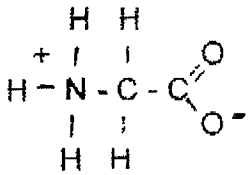
alanine



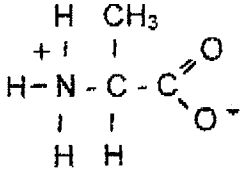
(i) Draw the structure of a dipeptide using these two amino acids to show how a peptide bond can link two amino acids together. **2**

In solution, amino acids usually exist as ions. The exact charge of the ion depends on the pH of the solution. The structure of some different amino acids at pH 6 is given below.

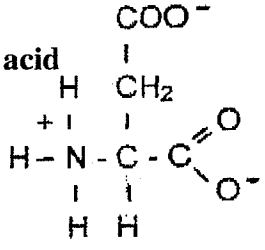
glycine



alanine



aspartic acid



(ii) Explain how electrophoresis, performed at a pH of 6, could be used to distinguish between solutions containing alanine and aspartic acid. **2**

(iii) Describe a change to the above electrophoresis process that would need to be made to enable a solution containing glycine to be distinguished from a solution containing alanine and explain how each would be identified. **2**

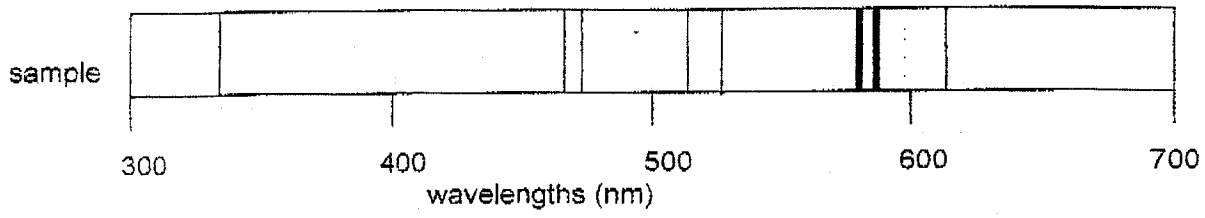
Question 32 – Forensic Chemistry continues on next page

Question 32 (continued) **Marks**

(c) A forensic scientist was called in to investigate a crime scene. A jewellery store had been broken into and a large quantity of jewellery had been taken. The thieves had gained access through a broken window near which some spots of fresh blood were found. The police had apprehended a suspect who had a small cut on his arm. Explain how a forensic scientist using DNA analysis would be able to assist police in their investigations. **5**

(d) Explain why destructive testing of material may be a problem in a forensic investigation. **3**

(e) Part of the emission spectrum of the element sodium is shown below.



(i) Describe a first-hand investigation that you have performed to observe the spectrum of sodium. **2**

(ii) Explain how an emission spectrum, such as the one above, is produced. **2**

(iii) Explain how information from emission spectra can assist the forensic chemist. **3**

End of Question 32

End of Paper