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HSC Trial Examination 2004

Chemistry

This paper must be kept under strict security and may only be used on or after the afternoon of Friday 6 August, 2004, as specified in the NEAP Examination Timetable

General Instructions

Reading time 5 minutes

Working time 3 hours

Board-approved calculators may be used.

Write using blue or black pen.

Draw diagrams using pencil.

A data sheet and a Periodic Table are provided at the back of this paper.

Total Marks 100

Section I Pages 2–15

Total marks 75

This section has two parts, Part A and Part B

Part A — 15 marks
- Attempt Questions 1–15.
- Allow about 30 minutes for this part.

Part B — 60 marks
- Attempt Questions 16–27.
- Allow about 1 hour and 45 minutes for this part

Section II Pages 16—22

Total marks 25

- Attempt ONE question from Questions 28–32.
- Allow about 45 minutes for this section.

Students are reminded that this is a trial examination only and cannot in any way guarantee the content or the format of the 2004 Chemistry Higher School Certificate examination.

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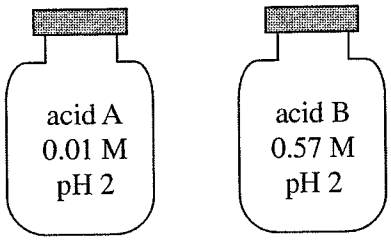
1. A small amount of acid is added to a buffer solution. As a result the pH of this solution will

(A) not change.
(B) decrease slightly.
(C) increase slightly.
(D) approach pH = 7.

2. During a firsthand investigation, a student recorded the following results:
Metal Q displaces ions of metal R. Metal R displaces ions of both metals X and Y. Both metals X and Y displace ions of metal Z.
Based on these results, the student predicted that a galvanic cell using these metals could be set as follows:

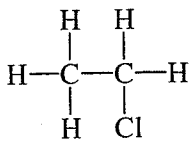
	Anode	*Cathode*	*Electrons move from*
(A)	Q	Z	$Z \rightarrow Q$
(B)	Q	Z	$Q \rightarrow Z$
(C)	X	Y	$X \rightarrow Y$
(D)	R	X	$X \rightarrow R$

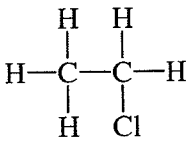
3. Consider the following reagent bottles of acids:

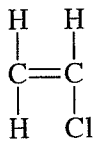


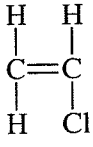
In comparing these two solutions we can say that
(A) the $[H^+]$ is greater in the solution of acid A.
(B) the $[H^+]$ is greater in the solution of acid B.
(C) the acids are of equal strength.
(D) A is the stronger acid.

4. Which of the following provides the correct information about the monomer known as vinyl chloride?

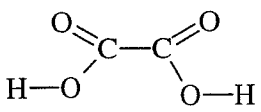
(A)  chloroethane

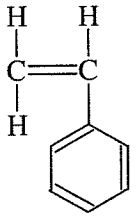
(B)  chloroethene

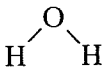
(C)  chloroethane

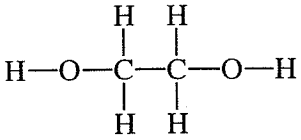
(D)  chloroethene

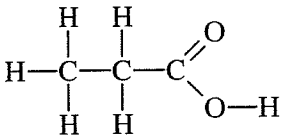
5. Consider the following expanded structural formulas:

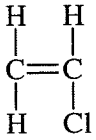
(i) 

(ii) 

(iii) 

(iv) 

(v) 

(vi) 

The compounds which could be reacted together to form a condensation polymer are

(A) (i) and (iv).
(B) (ii) and (vi).
(C) (iii) and (v).
(D) (i) and (ii).

6. Consider each of the following equations:

(i) $HCl_{(aq)} \rightarrow H^+_{(aq)} + Cl^-_{(aq)}$
(ii) $HCl_{(aq)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + Cl^-_{(aq)}$
(iii) $NH_{3(aq)} + H_2O_{(l)} \rightarrow NH_4^+{}_{(aq)} + OH^-_{(aq)}$
(iv) $NaOH_{(aq)} \rightarrow Na^+_{(aq)} + OH^-_{(aq)}$

An acid can be defined as a proton donor. This can be seen in

(A) equation (i) only.
(B) equation (ii) only.
(C) equations (ii) and (iii).
(D) all of the equations.

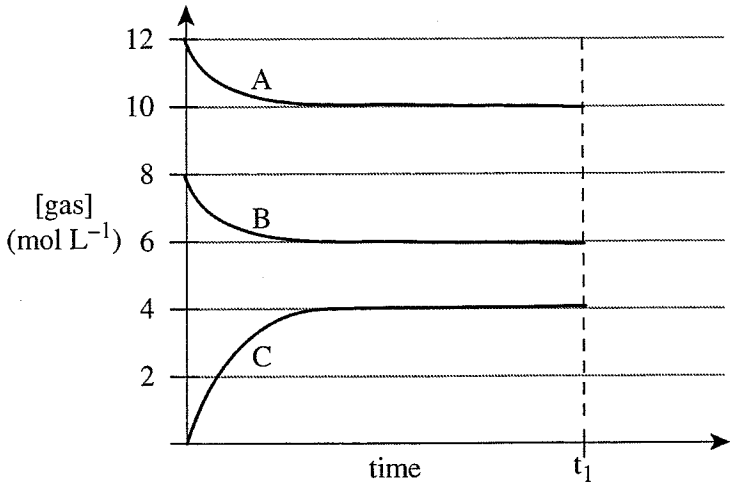
7. The formation of ammonia from its constituent elements can be summarised using the following equation:

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$$

The formation of ammonia is reduced when the reaction is conducted under conditions of

(A) high temperature and low pressure.
(B) low temperature and high pressure.
(C) high temperature and high pressure.
(D) low temperature and low pressure.

8. It is known that gases A and B reach equilibrium as they react together to form gas C. The variation in concentration of these gases was monitored and graphed as illustrated below.



By applying Le Chatelier's principle, it can be predicted that at time t_1 the yield of the forward reaction will

(A) increase if pressure is increased.
(B) decrease if pressure is increased.
(C) decrease if pressure is decreased.
(D) not be affected by a change in pressure.

9. The pH of a 10 mL HCl solution was determined to be a value of 1. Water was added to this solution until its pH changed to a value of 2. The amount of water added was

(A) 10 mL.
(B) 20 mL.
(C) 90 mL.
(D) 100 mL.

10. 40 mL of 5 mol L^{-1} HCl is added to 20 mL of 5 mol L^{-1} NaOH. Which of the following correctly summarises the results?

	Temperature Change	*Final pH of mixture*
(A)	increase	= 7
(B)	increase	< 7
(C)	decrease	> 7
(D)	decrease	< 7

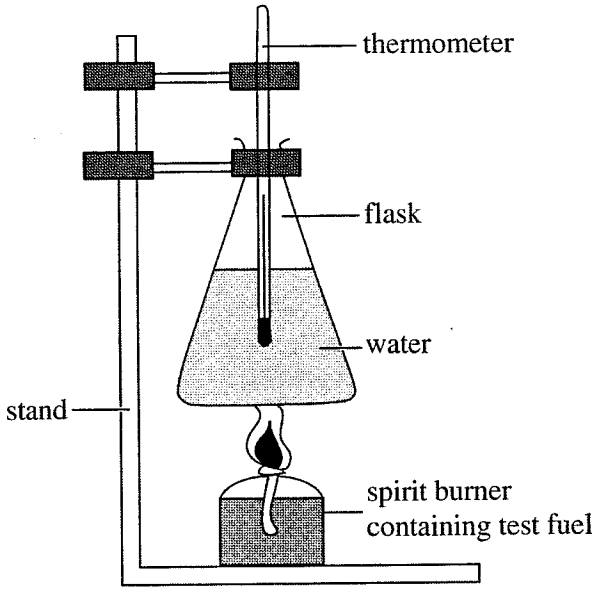
11. A chemist was asked to analyse a supply of drinking water for the presence of common ions and hardness. The most common ion in drinking water is chloride. Identify the test that would allow the chemist to detect the concentration of chloride ions present.

(A) A flame test.
(B) Addition of $AgNO_3$.
(C) Titration with $AgNO_3$.
(D) Atomic absorption spectroscopy.

12. To test for water hardness the chemist should test for the presence of

(A) calcium and carbonate ions.
(B) calcium and magnesium ions.
(C) carbonate and phosphate ions.
(D) phosphate and sulfate ions.

Questions 13 and 14 refer to the following information.



A student measured the heat of combustion of ethanol using the experimental set up shown.

	Mass H_2O used	*Change in mass of fuel*	*Change in temperature*
Results	400 g	1.16 g	10.1°C

13. Based on the information above, the heat of combustion for ethanol is

(A) 48.97 kJ mol^{-1}.
(B) 4.69 kJ mol^{-1}.
(C) 185.8 kJ mol^{-1}.
(D) 670 kJ mol^{-1}.

14. The comment which best describes the validity and reliability involved in this experiment is:

(A) method is valid, producing reliable results.
(B) method is invalid, producing unreliable results.
(C) method is invalid, but results are more reliable since the experiment was repeated.
(D) method is reliable, producing valid results.

15. A 1.0 g sample of fertiliser was dissolved in water and excess barium chloride was added to precipitate 1.6 g of white barium sulfate. The percentage mass of sulfate in the fertiliser is

(A) 89%
(B) 66%
(C) 22%
(D) 41%

Part B

Total marks 60
Attempt Questions 16–27.
Allow about 1 hour and 45 minutes for this part.

Answer Part B questions in the spaces provided.
Show all relevant working in questions that require calculations.

Marks

Question 16 (5 marks)

The production of ethanol from ethylene can be expressed as follows:

$$\text{ethylene} + \text{compound X} \xrightarrow{\text{catalyst Y}} \text{ethanol}$$

(a) Identify compound X. **1**

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(b) Identify catalyst Y. **1**

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(c) One of the many uses of ethanol is as a solvent of both polar and non-polar substances. Account for the use of ethanol in these ways. **3**

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Marks

Question 17 (3 marks)

Discuss the benefits associated with the use of radioisotopes in either industry or medicine. **3**

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Question 18 (3 marks)

Certain salts dissolve in water to lower its pH.

(a) Identify such a salt. **1**

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(b) With the help of an equation, explain how the pH is lowered. **2**

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Question 19 (4 marks)

You have performed a firsthand investigation to prepare and test a natural acid/base indicator.

(a) Recall the procedure you used to prepare this indicator. **2**

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(b) Identify an everyday situation in which an indicator is used and explain why it is necessary to use the indicator. **2**

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Marks

Question 20 (7 marks)

The allotropes of oxygen, O_2 and O_3, are both common in the Earth's atmosphere. However, they are found in different layers of the atmosphere.

(a) Identify the layer of the atmosphere in which O_2 is most abundant. **1**

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(b) Identify the layer of the atmosphere in which O_3 is most abundant. **1**

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(c) With the use of Lewis electron dot structures, show how the shapes of ozone and oxygen are different. **2**

(d) Oxygen is sparingly soluble in water. Explain why ozone is considerably more soluble in water. **3**

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Marks

Question 21 (6 marks)

Water quality can be determined by considering a number of factors, one of which is pH.

(a) Identify two other factors. **2**

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(b) It is important to test water quality. Name two factors that affect pH in water supplies. **2**

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(c) Using pH as an example, how would you determine if a water body was polluted? **2**

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Question 22 (3 marks)

Citric acid and acetic acid are both weak acids.

(a) Write the structural formula of each acid. **2**

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(b) State why citric acid is stronger than acetic acid. **1**

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Marks

Question 23 (5 marks)

A titration was carried out using 0.246 mol L^{-1} HCl to standardise 25.0 mL aliquots of a solution of the weak base, sodium carbonate. An appropriate indicator was chosen to show the end point of the neutralisation. The results gained are shown in the table below.

Run	*1*	*2*	*3*	*4*	*5*
Initial burette volume (mL)	0.5	23.6	0.7	23.5	0.2
Final burette volume (mL)	23.5	45.8	23.0	46.2	22.4

(a) Calculate the concentration of the sodium carbonate solution. Justify the steps in your calculation. **3**

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(b) The student had a choice of indicators: **2**

- methyl orange; changes from red to orange from pH 3.0 to 4.5.
- phenolphthalein; changes from colourless to pink from pH 8.3 to 10.0.

Select the indicator that should be used for this titration, giving a reason for your choice.

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Marks

Question 24 (7 marks)

Consider the following electrochemical cell:

$$X_{(s)} \mid X^{2+}_{(aq)} \parallel Y^{+}_{(aq)} \mid Y_{(s)}$$

(a) Draw a labelled diagram of this cell, clearly indicating the direction of electron and ion flow. **3**

(b) The EMF of the cell under standard conditions is 0.96 V. Given that the reduction potential for $Y^{+}_{(aq)} + e^{-} \rightleftharpoons Y_{(s)}$ is 0.52 V, write the oxidation half-equation for the cell, including its voltage. **2**

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(c) The cell will eventually reach a state of equilibrium. Use Le Chatelier's Principle to justify the prediction that if the concentration of $Y^{+}_{(aq)}$ is increased, the voltage will also increase. **2**

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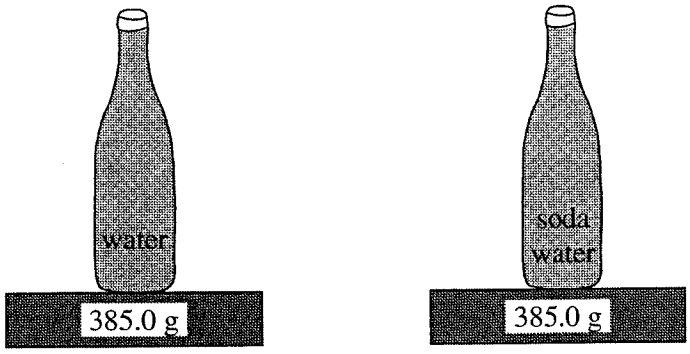
Marks

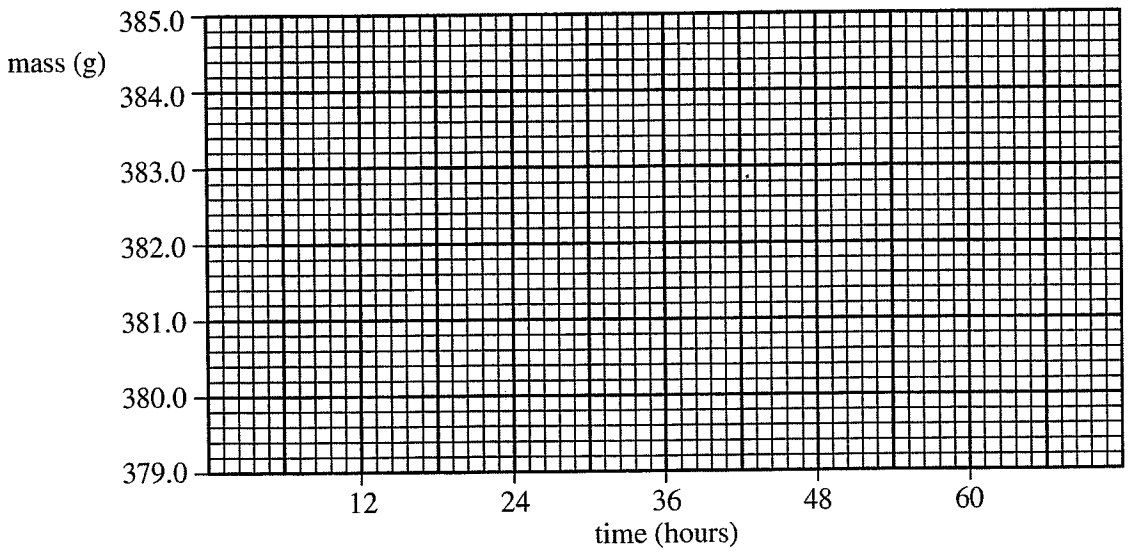
Question 25 (7 marks)

As part of your practical work you decarbonated a beverage. A student decarbonated a sample of soda water by opening the bottle it was in and leaving it for a period of time, weighing it at regular intervals. She also used a non-carbonated sample of water as a control, recording its mass at the same intervals.



	mass (g)					
	Initial	*After 12 hours*	*24 hours*	*36 hours*	*48 hours*	*60 hours*
soda water	385.0	382.6	381.1	380.7	380.3	380.0
plain water	385.0	384.7	384.2	383.7	383.4	383.0

(a) Graph the information shown for each water sample on the same graph. **2**



(b) Interpret the trends shown in the graph. **2**

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Marks

(c) Use the graph to determine the volume of CO_2 gas produced at 25°C and 100 kPa. Show your working. **2**

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Question 26 (4 marks)

Car manufacturers opposed a proposal for legislation to ensure a percentage of ethanol was added to Australian petrol. Discuss the scientific issues on which the proposal was based and why it was rejected. **4**

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Marks

Question 27 (7 marks)

Assess the effectiveness of steps taken to alleviate the problems associated with the use of CFCs. **7**

Section II

Total 25 Marks
Attempt ONE question from Questions 28–32.
Allow about 45 minutes for this section.
Answer the question in a writing booklet. Extra writing booklets are available.
Show all relevant working in questions that require calculations.

Marks

Question 28 — Industrial Chemistry (25 marks)

(a) (i) Identify the product of the Solvay process. **1**

(ii) Hydrogen carbonate is produced as an important intermediary product of the Solvay process. Describe the formation of hydrogen carbonate. **3**

(b) During your practical work you performed a firsthand investigation to carry out a saponification and test of the product.

(i) Describe ONE precaution you took to minimise hazards. **1**

(ii) Outline the procedures you used to produce the product of saponification and to test the product. **3**

(c) Analyse the technical and environmental difficulties involved in the production of sodium hydroxide using the mercury and diaphragm cell processes that led to the development of the membrane cell process. **5**

(d) The production of sulfuric acid is one of the most important industrial processes for industrialised nations.

(i) Identify one industrial use of sulfuric acid. **1**

(ii) The yield limiting step is the production of SO_3 from SO_2. **3**
Compare how reaction conditions affect the rate and the extent of this reaction.

(iii) Explain the role of oleum in the production of sulfuric acid. **2**

(e) Evaluate the usefulness and environmental problems of the three types of detergents. **6**

Marks

Question 29 — Shipwrecks, Corrosion and Conservation (25 marks)

(a) During your practical work you performed a firsthand investigation to compare the effectiveness of different protections used to coat a metal to prevent its corrosion.

(i) Outline the procedure you used to perform this investigation. **2**

(ii) Give a reason why such coatings prevent corrosion of these metals. **1**

(b) Outline a procedure used to restore a non-metallic artefact from a shipwreck submerged in the ocean for many years. **3**

(c) The Statue of Liberty in New York Harbour is made of copper sheets which are bolted onto a frame made of stainless steel. When the Statue was first erected, an iron frame had been used. However, considerable corrosion of the iron occurred, requiring its replacement. **4**

Using relevant equations, explain how the conditions in which the original iron frame was placed accelerated its corrosion.

(d) Iron structures and metallic artefacts discovered at shipwrecks in great depths of ocean water are often found to have extensive corrosion. It is now recognised that despite the extremely cold conditions, anaerobic bacteria and an acidic environment are major factors that contribute to this corrosion process.

(i) Explain what effect cold temperatures should have on the corrosion of these metal structures and artefacts. **2**

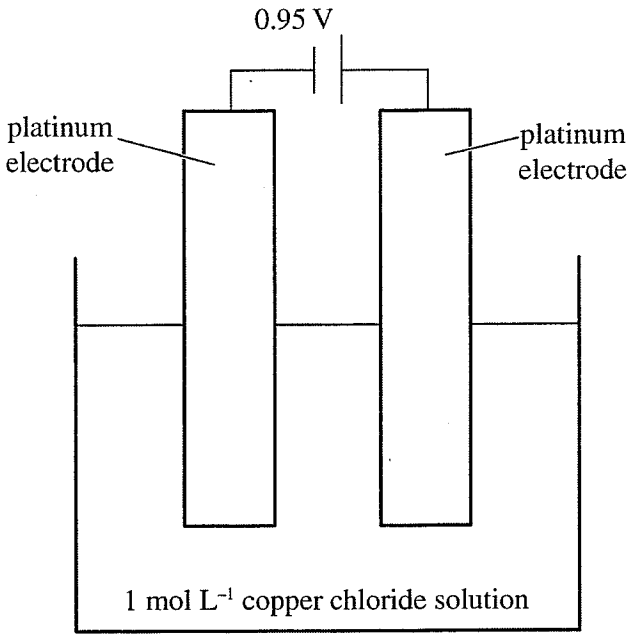
(ii) With the use of appropriate equations, outline how the acidic environment is a major factor in this corrosion process. **3**

(iii) Describe the processes involving these anaerobic bacteria that result in the corrosion of the iron structures. **3**

Marks

Question 29 (Continued)

(e) In her study of electrolytic cells, a student came across the following diagram. 7



Based on this diagram, the student made the following predictions:

- The voltage was insufficient to form copper and chlorine by electrolysis of the solution.
- The mass of the anode would increase as copper formed on it.
- A gas would form at the other electrode.
- The pH of the electrolyte will not change.

Assess each of these predictions. Support your assessment with appropriate data and equations where possible to identify products. If the students's prediction is incorrect, provide an alternate prediction

Marks

Question 30 — The Biochemistry of Movement (25 marks)

(a) (i) Draw and label the generalised structural formula of an amino acid. **2**

(ii) Briefly explain how the binding site of a protein forms. **2**

(b) As part of the study of this option you performed a firsthand investigation to compare the structures of glucose and glycogen.

(i) Describe the equipment or resources you chose to carry out this investigation. **2**

(ii) Compare the structures of glucose and glycogen. **2**

(c) Analyse the role of the processes of oxidation and reduction in aerobic respiration. **5**

(d) (i) Explain the role of calcium ions in muscle contraction. **1**

(ii) Describe the arrangement of actin and myosin filaments in skeletal muscle. **2**

(iii) Describe the process of muscle contraction and explain why ATP is consumed. **3**

(e) Evaluate how an understanding of the biochemical pathways involved in supplying energy to muscles will assist in developing methods to improve performance of athletes in the future. **6**

Marks

Question 31 — The Chemistry of Art (25 marks)

(a) (i) Scandium and zinc are d-block elements but not transition elements. Explain why. **3**

(ii) The ion $[Cr(NH_3)_4Cl_2]^{2+}$ exists in two forms. Draw one possible form, clearly identifying any ligand present. **2**

(b) A painting in Byron Bay was allegedly stolen this year. The painting was an Impressionist work, supposedly painted by Cezanne in the period 1880–1890. **4**

Describe both a destructive technique and a non-destructive technique forensic chemists could use to identify whether the painting was painted by Cezanne or not.

(c) Discuss how pigments used for various purposes have changed over time. In your answer make reference to particular colour. **5**

(d) As part of your course you investigated the oxidising strength of $KMnO_4$.

(i) Describe a safety precaution you had to take during the investigation. **2**

(ii) Relate oxidising strength, oxidation number and standard electrode potential, using $KMnO_4$ as an example. **3**

(e) Evaluate the usefulness of the Bohr model of the atom in terms of its ability to explain the emission spectra of hydrogen and helium. **6**

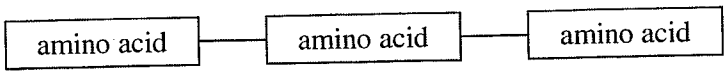
Question 32 — Forensic Chemistry (25 marks)

(a) (i) Outline the precautions necessary to prevent contamination during collection of samples for forensic analysis. **2**

(ii) Discuss the importance of accuracy in forensic chemistry. **2**

(b) Outline the operation of a mass spectrometer. **2**

(c) The following diagram represents one aspect of protein structure.



(i) Identify the major functional groups in an amino acid. **1**

(ii) Describe the nature of the bond which links amino acids together in a protein. **2**

(iii) Discuss the role of electrophoresis in identifying the origins of biological molecules, including proteins and DNA. **4**

(d) The following data table shows the results of carbohydrate analysis of two different samples.

Sample	*Cellulose*	*Starch*	*Glycogen*
1	present	present	absent
2	absent	present	present

(i) Based on its carbohydrate composition, identify the most probable source of sample 2 as either plant or animal material. **1**

(ii) Outline the procedure used to identify starch in sample 1. **2**

(iii) With the aid of a chemical equation, describe the chemical reaction which produces starch. **3**

(e) Evaluate the use of line emission spectra to identify trace elements in forensic samples. **6**

End of paper