2002
Higher School Certificate
Trial Examination

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 – 29
Allow about 1 hour 45 minutes for this part

Section II
Total marks (25)
Attempt ONE question from Questions 30-34
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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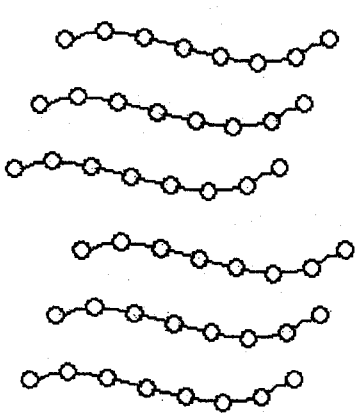
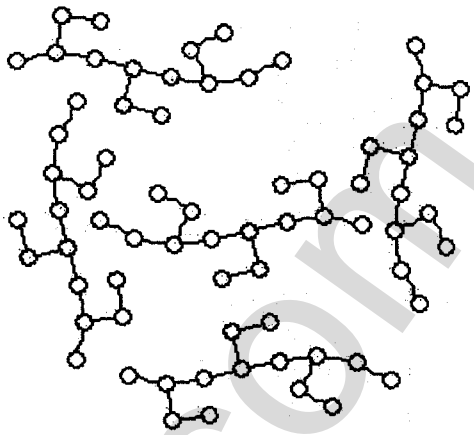
11				
12				
13				
14				
15				

1. Each line in the diagram below represents a strand in the polymer chain polyethylene.



Polymer A



Polymer B

Compared with Polymer B, Polymer A would:

(A) be more rigid and dense
(B) more easily dissolve in a non-polar substance such as kerosene
(C) react rapidly with bromine water
(D) take much longer to break down in sunlight

2. Bromine water can be used to distinguish between:

(A) ethane and propane
(B) propane and propene
(C) ethene and propene
(D) ethane and ethanol

3. Which of the following metals could reduce iron(II) ions in aqueous solution?

(A) zinc
(B) tin
(C) copper
(D) silver

4. Consider the reaction described by the equation below:

$$C_2H_5OH \rightarrow C_2H_4 + H_2O$$

This reaction is an example of:

(A) polymerisation
(B) hydration
(C) dehydration
(D) addition

5. The table below gives some properties of radioactive isotopes

Name	Radiation emitted	Half Life
Americium-241	α	432 years
Carbon-14	β	5.7×10^3 years
Magnesium-27	β	9.5 minutes
Sodium-24	β,γ	15 hours

The isotope that is most suitable for detecting leaks in water pipes would be.

(A) Americium-241
(B) Carbon-14
(C) Magnesium-27
(D) Sodium-24

Questions 6 and 7 refer to the table below which shows the colour ranges of three acid–base indicators.

Indicator	Very acidic						Neutral						Very basic		
pH	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Bromothymol blue	yellow						→6.0	7.6←					blue		
Methyl orange	red			→3.1	4.5←			yellow							
Phenolphthalein	colourless								→8.3		10.0←		red		

6. A solution is yellow in bromothymol and methyl orange, and colourless in phenolphthalein. What is the pH range of the solution?

(A) 7.5 to 8.5
(B) 6.0 to 7.5
(C) 4.5 to 6.0
(D) 8.5 to 10.0

7. 0.1 mol L^{-1} citric acid ($C_6H_8O_7$) solution is neutralised with a solution of 0.1 mol L^{-1} sodium hydroxide (NaOH). The best indicator for this titration would be:

(A) methyl orange
(B) phenolphthalein
(C) a mixture of methyl orange and bromothymol blue.
(D) bromothymol blue

8. Three pieces of apparatus used in titrations are a conical flask, a burette and a pipette. Which of these pieces of apparatus should be rinsed with distilled water immediately prior to use in a titration?

(A) all three
(B) conical flask only
(C) burette only
(D) pipette only

9. The pH of four acids and their concentrations are shown in the table below.

Acid	Conc. (mol L^{-1})	pH
A	0.1	1.0
B	0.05	1.0
C	0.01	2.0
D	0.1	2.0

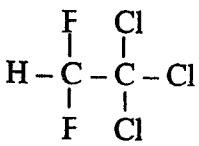
Which acid in the table is the weakest?

(A) A
(B) B
(C) C
(D) D

10. The pH of a solution of magnesium hydroxide of concentration 4.5×10^{-3} mol L^{-1} is closest to:

(A) 11.9
(B) 11.6
(C) 2.1
(D) 2.4

11. What is the correct systematic name for the following compound?



(A) 1,1,2,2,2 – difluorotrichloroethane
(B) ethane – 1,1 – difluoride – 2,2,2 – trichloride
(C) 1,1,1 – trichloro – 2,2 – difluoroethane
(D) trichlorodifluoroethane

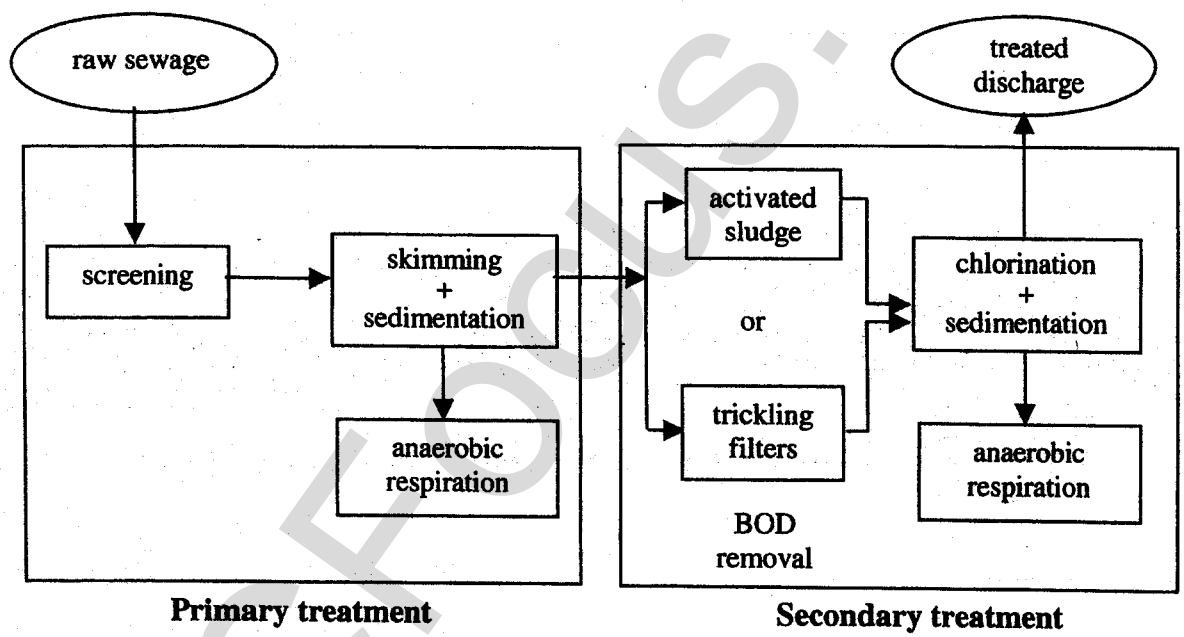
12. A student analysed a sample of water from an underground spring which was suspected to be contaminated with certain metallic ions.

The student added dilute hydrochloric acid to the solution and noted no changes. She then added dilute ammonia to a second sample and also noted no change. She then performed a flame test and noted a faint but distinct red colour.

The ion in the water is most probably:

(A) Fe^{3+}
(B) Ba^{2+}
(C) Cu^{2+}
(D) Ca^{2+}

13. The diagram below represents the stages in the treatment of sewage.



Secondary treatment chlorination would be used to:

(A) adjust the pH
(B) improve the BOD levels
(C) kill pathogens
(D) activate enzymes necessary for sewage digestion

14. The technique best suited to detecting low concentrations of metal ions in solutions would be:

(A) fractional distillation
(B) gas-liquid chromatography (GLC)
(C) atomic absorption spectroscopy (AAS)
(D) nuclear magnetic resonance spectroscopy (NMR)

15. The following table shows the potential release of acid into waterways from some minerals as a result of mining.

Potential acid release from some alunite group minerals		
Mineral	**Formula**	**moles H^+/mole**
Plumbojarosite	$PbFe_6(SO_4)_4(OH)_{12}$	6
Benverite	$Pb(Cu,Fe,Al)_3(SO_4)_2(OH)_6$	0 – 5
Natrojarosite	$NaFe_3(SO_4)_2(OH)_6$	3
Alunite	$KAl_3(SO_4)_2(OH)_6$	0

The most noticeable effect of run off from a mine waste heap with a high concentration of plumbojarosite into a nearby stream would be:

(A) a rapid rise in BOD levels
(B) pH levels would drop
(C) dissolved oxygen levels would drop
(D) eutrophication would begin

Section I - continued

Part B

Total marks (60)
Attempt questions 16 – 29
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 (6 marks) **Marks**

Many cosmetic and pharmaceutical preparations require the use of a solvent such as ethanol, which can be produced by the fermentation of sugars.

(a) Relate the use of ethanol as a solvent to the nature of the ethanol molecule. **2**

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(b) Describe the conditions required to produce ethanol by the fermentation of glucose. **2**

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(c) Explain how mass changes can be used to monitor the fermentation reaction. A suitable equation should be included in your answer. **2**

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Question 17 (2 marks) **Marks**

The table below compares some properties of ethanol and diesel for use as fuels in motor vehicles. Assess ONE advantage and ONE disadvantage for ethanol as a fuel. **2**

Property	Ethanol	Diesel (approximate values)
Flashpoint	13°C	60-70°C
Ignition temperature	365°C	315°C
Enthalpy of combustion	30 MJ kg^{-1}	45 MJ kg^{-1}
Solubility in water	soluble	insoluble

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Question 18 (5 marks)

The equations below show the half reactions involved in the operation of a vanadium redox cell.

$$V^{3+} + e^- \Leftrightarrow V^{2+} \quad E^0 = -0.26\ V$$

$$VO_2^+ + 2H^+ + e^- \Leftrightarrow VO^{2+} + H_2O \quad E^0 = 1.00\ V$$

The reaction direction depends on whether the cell is charging or discharging.

(a) Identify the anode reaction when the cell is operating as a galvanic cell. **1**

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(b) Write the overall cell reaction when the cell is operating as a galvanic cell. **1**

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(c) Calculate the theoretical cell voltage that this cell could deliver under standard conditions. **1**

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Question 18 continues on next page

Question 18 (continued) **Marks**

(d) Describe ONE advantage of the vanadium redox cell in terms of its impact on society or the environment. 2

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Question 19 (3 marks)

Poly(chloroethene) is an addition polymer often referred to as poly(vinyl chloride) or PVC.

Describe how an addition polymer is formed using poly(chloroethene) as an example. 3

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Question 20 (4 marks) **Marks**

"Radioactive carbon dating" is the name of a process used to date historical artifacts and specimens by determining the amount of the carbon-14 radioisotope present in the sample.

(a) Write an equation to represent the beta decay of carbon-14. **1**

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(b) Identify an instrument that could be used to detect the radiation emitted from a radioisotope such as carbon-14. **1**

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(c) Other radioisotopes are used in medicine for both diagnostic purposes and treatment. Give an example of a radioisotope used and analyse benefits associated with the use of this radioisotope. **2**

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Question 21 (2 marks)

When 1.5 L of HCl gas and 1.8 L of NH_3 gas are mixed, a white solid of NH_4Cl is formed. Calculate the mass of NH_4Cl formed if the gas volumes were measured at 25°C and 101.3 kPa. **2**

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Question 22 (3 marks) **Marks**

Choose an example of an amphiprotic substance and write equations to help explain its behaviour in acidic and basic solutions. **3**

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Question 23 (8 marks) **Marks**

(a) To perform an esterification reaction in the laboratory a student was provided with methanol and propanoic acid, which she heated together under reflux with a catalyst.

(i) Name the ester which could be synthesised. **1**

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(ii) Draw a structural formula for this ester. **1**

(iii) Name a suitable catalyst for this reaction. **1**

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(iv) Justify the use of heating under reflux for this experiment. **2**

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Question 23 continues on next page

Question 23 (continued) **Marks**

(b) The ester formed in the above reaction has a molar mass of 88 g and boils at 78°C. Two other substances with the same molar mass are:

1-pentanol	BP 138°C
butanoic acid	BP 163°C

Explain the difference in boiling points between these three substances. **3**

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Question 24 (4 marks)

An equilibrium exists between gaseous and dissolved carbon dioxide in water as shown by the following equation:

$$CO_{2(g)} \Leftrightarrow CO_{2(aq)}$$

With reference to Le Chatelier's principle explain the following:

(a) fizzing occurs when a bottle of a carbonated drink is opened. **2**

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(b) It is observed that the fizzing is less if the bottle is kept under refrigeration rather than at room temperature. Deduce whether the dissolving process is exothermic or endothermic; explaining your reasoning. **2**

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Question 25 (4 marks) **Marks**

In a titration it is found that 20.0 mL of 0.200 mol L^{-1} sulfuric acid is required to neutralise 25.0 mL of a potassium hydroxide solution.

(a) Write a balanced equation for the neutralisation. **1**

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(b) Calculate the concentration of the potassium hydroxide in mol L^{-1}. **2**

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(c) Calculate the mass of the potassium hydroxide in 5 litres of the above solution. **1**

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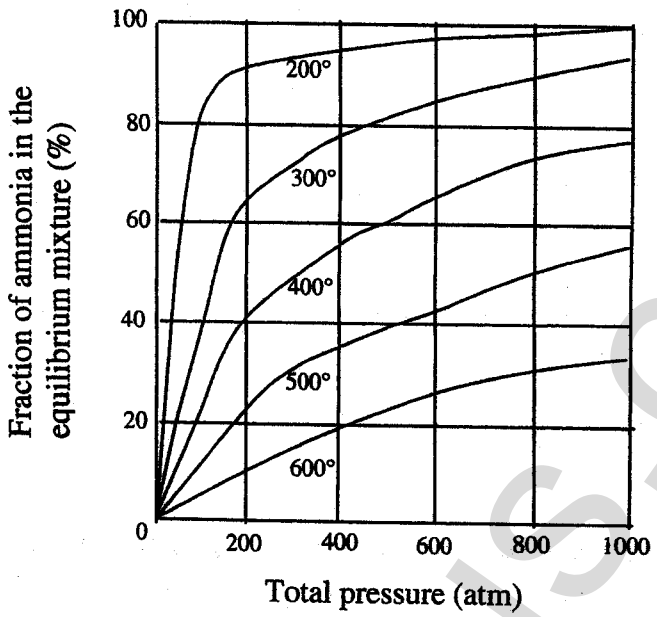
Question 26 (5 marks) **Marks**

The graphs below show the fraction of ammonia present at equilibrium when nitrogen and hydrogen are reacted in a pressure vessel.



(a) Write a balanced equation for this reaction. **1**

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(b) Referring to Le Chatelier's principle:

(i) explain why the gas mixture is compressed during the industrial manufacture of ammonia. **1**

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(ii) Explain why only temperatures of 400-500°C are used in the manufacture of ammonia although a higher temperature would accelerate the reaction. **1**

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Question 26 continues on the next page

Question 26 (continued)

(c) Identify one reason for close monitoring of the gas stream entering the reaction vessel in the industrial synthesis of ammonia. 1

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(d) Identify ONE industrial use of ammonia. 1

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Question 27 (3 marks)

The data below gives the percentage composition of air by volume at sea level for a town on the far north coast of NSW.

Constituent	Symbol	Volume % in air	Molar mass
Nitrogen	N_2	78.084	28.01
Oxygen	O_2	20.9476	32.00
Argon	Ar	0.934	39.95
Carbon dioxide	CO_2	0.037	44.01
Neon	Ne	0.001818	20.18
Helium	He	0.000524	4.00
Methane	CH_4	0.00017	16.04

(a) Calculate the moles of oxygen present in 20 litres of this air at 25°C and 101.3 kPa. 1

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(b) Calculate the mass of argon which could be extracted from 200 litres of this air. 2

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Question 28 (7 marks) **Marks**

A student analysed a 2.85 gram sample of washing powder for its phosphorus content. The phosphorus was precipitated as $Mg_2P_2O_7$ and then filtered. The mass of the precipitate was 0.125 gram.

(a) To assure accuracy describe TWO procedures that the student needed to undertake after filtration and before determining the mass of the precipitate. **2**

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(b) Determine the percentage, by mass, of phosphorus in the washing powder. **2**

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(c) Phosphorus in detergents in the form of phosphates acts as low cost builders, but together with nitrates cause pollution in waterways through the process of eutrophication.

Outline and describe the effects of eutrophication in natural waterways. **3**

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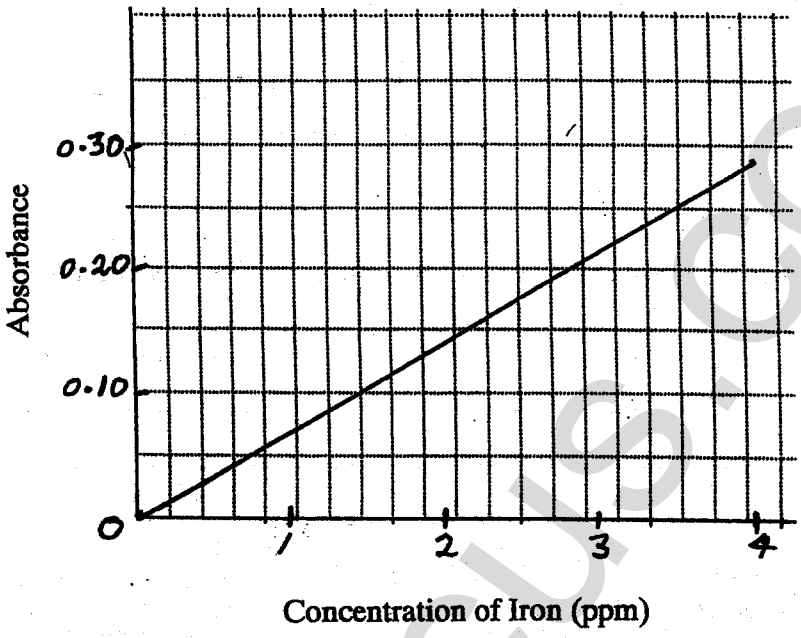
STUDENT NUMBER/NAME: ... ...

Question 29 (4 marks) **Marks**

A food company developed a new breakfast chocolate drink containing iron which is essential to human health.

The graph below shows the absorbance of a number of standard solutions containing iron using an Atomic Absorption Spectrometer.



A 10.0 mL sample of the chocolate drink was diluted to 50.0 mL and placed into the spectrometer. It was found to have an absorbance of 0.190.

(a) What is the concentration of iron, in ppm, in the undiluted chocolate drink? **1**

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(b) What mass of iron would you consume by drinking a 260 mL (260 g) glass of the chocolate drink? **1**

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(c) The recommended daily allowance of iron for people over 12 years of age is 18 mg. What percent of your daily needs does a 260 mL glass of the chocolate drink provide? **1**

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(d) Why was the chocolate drink diluted before its absorbance determined? **1**

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Section II

Total marks (25)

Attempt ONE question from Questions 30 – 34
Allow about 45 minutes for this part

Answer the question in a separate writing booklet. Extra writing booklets are available.
Show all relevant working in questions involving calculations.

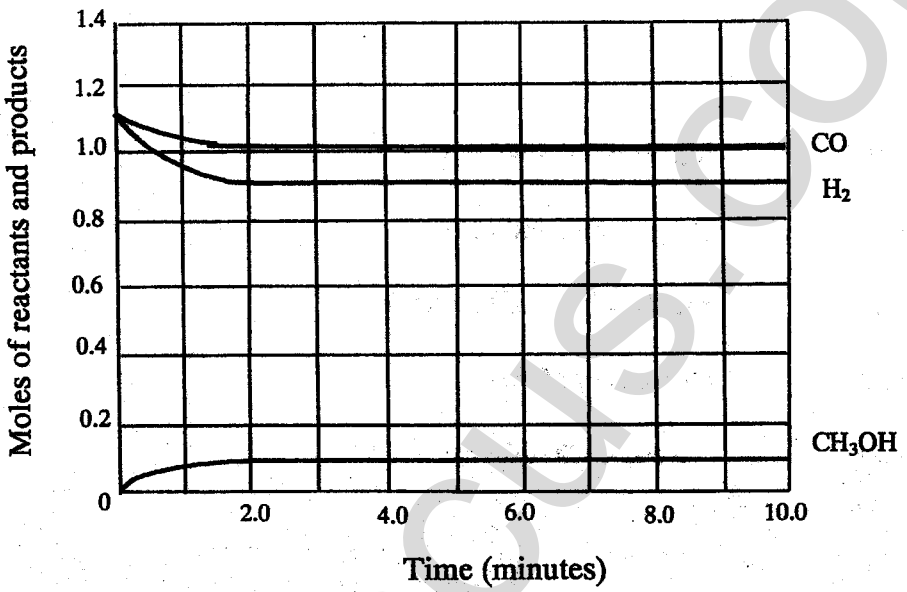
STUDENT NUMBER/NAME: ... ...

Question 30 – Industrial Chemistry (25 marks) **Marks**

(a) Methanol is produced according to the following equation:

$$CO_{(g)} + 2H_{2(g)} \Leftrightarrow CH_3OH_{(g)} : \Delta H = -103 \text{ kJ mol}^{-1}$$

The graph below shows the result of an experiment when CO and H_2 gases were added to a 10 L vessel at a temperature of 500°C.



(i) Write an expression for the equilibrium constant. **1**

(ii) Calculate the value of the equilibrium constant under the above conditions. **1**

(iii) If the experiment was carried out at a temperature of 250°C, what effect would this have on the value of the equilibrium constant? **1**

(b) (i) For the Solvay process identify the TWO principal raw materials and the TWO main products. **2**

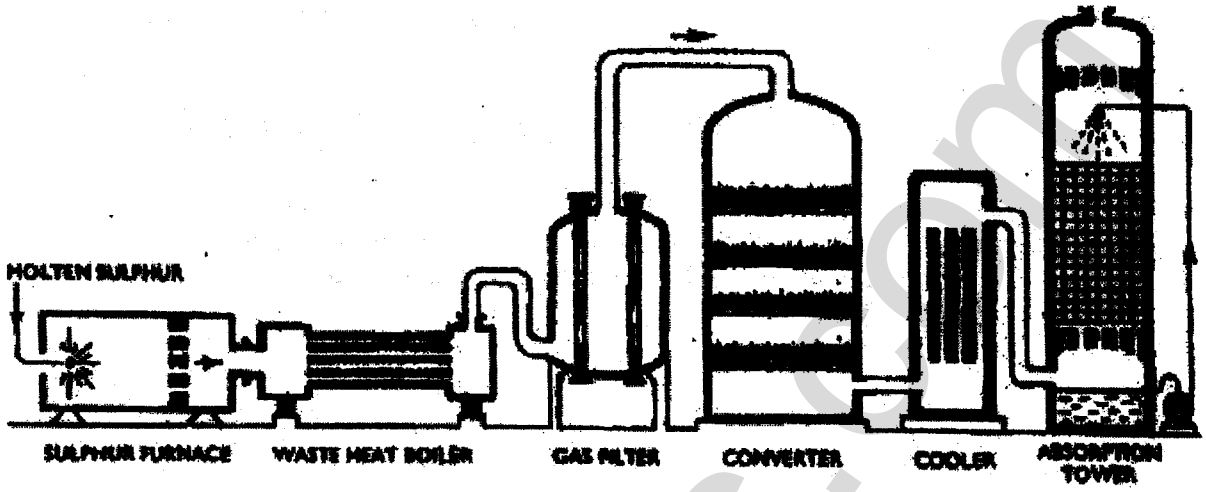
(ii) Identify TWO criteria used to locate a plant using the Solvay process. **2**

(c) Describe the chemical reaction used to produce a soap and analyse soap's cleaning action with reference to its chemical structure. **5**

Question 30 – Industrial Chemistry continued on the next page

Question 30 – Industrial Chemistry (continued) **Marks**

(d) The diagram below shows the equipment required for the commercial production of sulfuric acid.



(i) Write an equation for the production of sulfur trioxide in the converter **1**

(ii) Identify two conditions to maximise the yield of sulfur trioxide. **2**

(iii) Referring to the properties of sulfuric acid, assess safety precautions in preparing a dilute solution from the concentrated acid. **3**

(e) The operation of a sodium hydroxide plant, using the mercury cell process, has caused controversy during this year arising from its location in the Sydney suburb of Botany.

Briefly describing the mercury cell process and products, evaluate the technical and environmental issues for operating this plant. **7**

End of Question 30

STUDENT NUMBER/NAME: .....

Question 31 – Shipwrecks and Salvage (25 marks) **Marks**

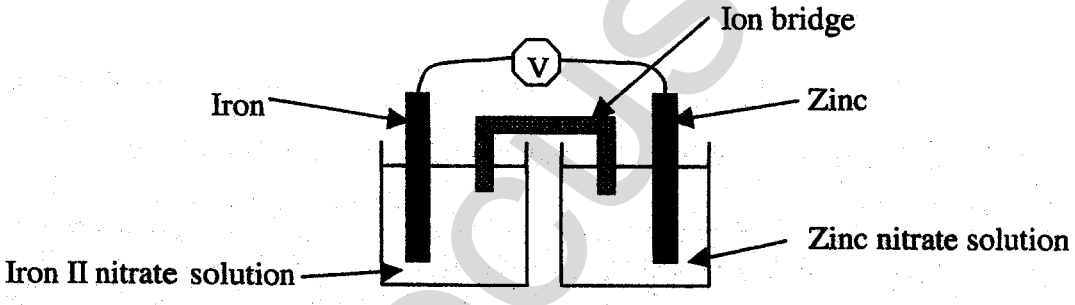
(a) (i) The following pieces of information represent data obtained from an electrochemist's notebook

$$Sn_{(s)} \,|\, Sn^{2+}_{(aq)} \,||\, Mn^{2+}_{(aq)} \,|\, Mn_{(s)}$$

Predict which metal will corrode by using a list of standard potentials. **1**

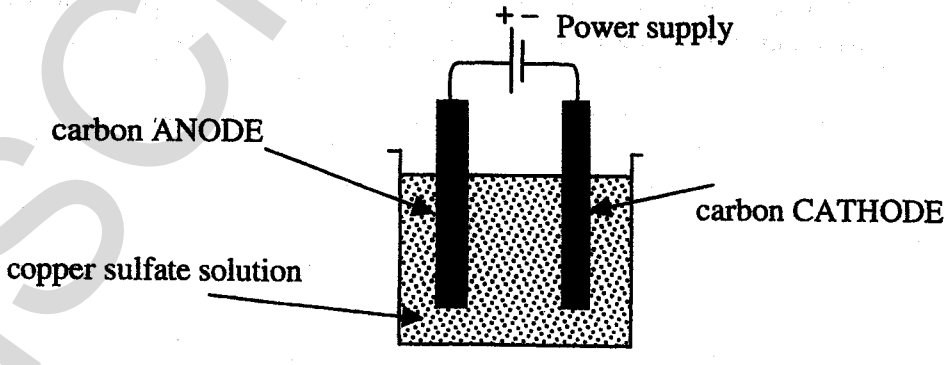
(ii) Process information to supply the net ionic equation for the above electrochemical cell and predict the expected voltage of the cell under standard conditions. **2**

(b) (i) In the electrochemical cell shown:



Identify the ANODE in this device. Justify your choice. **2**

(ii) Examine the oxidation-reduction device shown below :



This device, an electrolytic cell will be similar to one that you prepared in a first hand investigation that you conducted.

Outline TWO observations, one at the ANODE and one at the CATHODE, that you would see as electrolysis occurred over a period of time. **2**

Question 31 – Shipwrecks and Salvage continued on the next page

Question 31 – Shipwrecks and Salvage (continued) **Marks**

(c) A marine archaeologist has recently discovered a 600 year old wreck at the bottom of a Norwegian fjord (an ocean filled glacial valley). Describe all of the relevant issues in the preparing and preserving of pieces of wood from the wreck so that they can be displayed in a local museum. **5**

(d) (i) Identify a passivating metal. **1**

(ii) Outline an experiment that you have undertaken to compare the corrosion rates of metals in different acidic & neutral conditions. **2**

(iii) The research done by deep-sea explorers such as Bob Ballard on deep ocean wrecks such as the RMS Titanic suggests that earlier predictions of slow corrosion rates at great depths were apparently incorrect.
In light of your studies discuss this dilemma. **3**

(e) Imagine that you are the Manager of Operations for the Silver Star Line with a fleet of five steel ships trading between Sydney and London carrying container cargo.

Outline the range of corrosion protection measures available to you. Make a comparison of their effectiveness to protect the steel of the ships hulls. Justify your recommendation to the owners of the Silver Star Line as to the best type of protection to prevent the corrosion of their ships. **7**

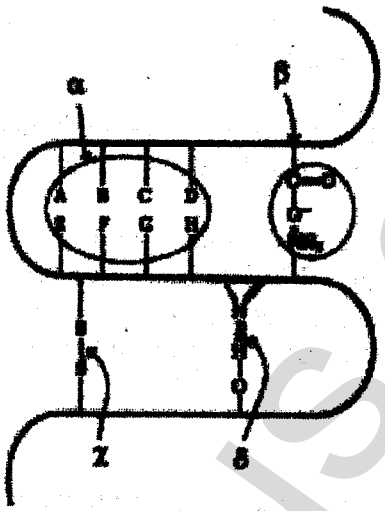
End of Question 31

STUDENT NUMBER/NAME: ... ...

Question 32 – The Biochemistry of Movement (25 marks) **Marks**

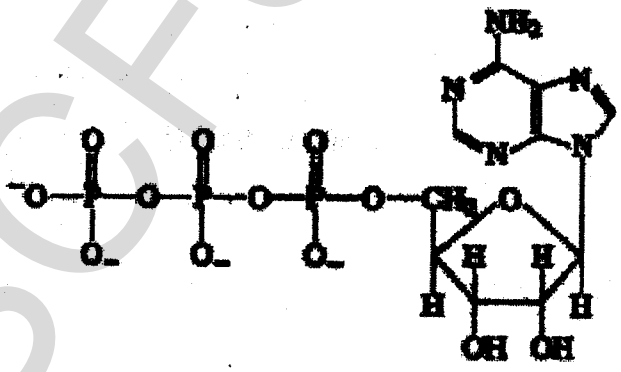
(a) (i) Draw the generalized structural formula for an amino acid. **1**

(ii) The diagram below shows four kinds of interacting forces that help to maintain the tertiary structure of the looped polypeptide chain of a globular protein.



Identify and explain the four kinds of interacting forces (α, β, χ and δ) for maintaining the tertiary structure of the globular protein. **2**

(b) Adenosine triphosphate (ATP) is used as an energy source for nearly all cellular metabolic processes.



(i) "The ATP molecule contains three phosphate groups linked by high energy phosphodiester bonds; when ATP is converted to ADP, one of the phosphodiester bonds is broken releasing energy."
Assess the validity of this statement. **2**

(ii) Describe how ADP can be converted back to ATP. **2**

Question 32 – Biochemistry of Movement continued on next page

Question 32 – Biochemistry of Movement (continued) **Marks**

(c) Compare and contrast the differences in structure, function and use of substrates (fuels) of Type 1 (slow twitch) and Type 2 (fast twitch) muscle cells. **5**

(d) (i) Define *heat of combustion*. **1**

(ii) Outline a procedure that could be used to determine the heat of combustion per mole of a named lipid. **2**

(iii) Describe ways in which the accuracy and reliability could be improved in the procedure described in part (ii). **3**

(e) Co-enzyme A (CoA) is a very essential compound in the oxidation of glucose and fatty acids for the release of energy.

Analyse the role and the interaction of Co-enzyme A in the oxidation of glucose and fatty acids in the human body. **7**

End of Question 32

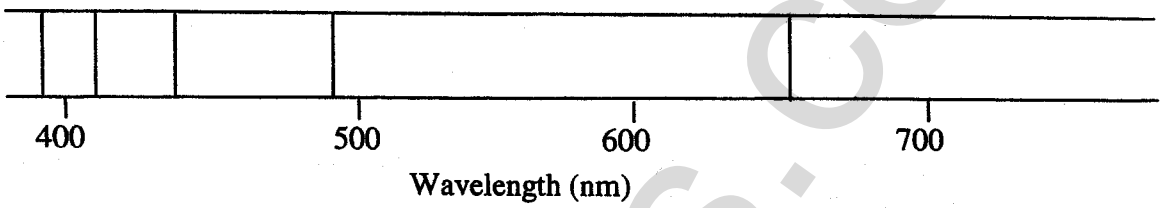
STUDENT NUMBER/NAME: .....

Question 33 – Chemistry of Art (25 marks) **Marks**

(a) (i) Write the ground state configuration of the manganese atom using subshell notation. **1**

(ii) Identify the changes in colour and oxidation state when the permanganate ion is changed to the manganese(II) ion. **2**

(b) The visible spectrum of hydrogen is shown below:



These lines are generated by electrons moving between the n = 2 and higher levels.

(i) Explain why hydrogen gas is colourless at room temperature. **1**

(ii) Evaluate the Bohr model of the atom in accounting for this spectrum **3**

(c) Identify the structure and evaluate the uses in medicine or research, of a coordination complex you have investigated for this topic. **5**

(d) (i) Explain the use of the term "d-block elements" for the transition metals. **1**

(ii) Outline reasons for the multiple oxidation states of transition metals. **2**

(iii) Account for the trends in density, melting points and magnetic properties of the first transition series, in terms of atomic structure. **3**

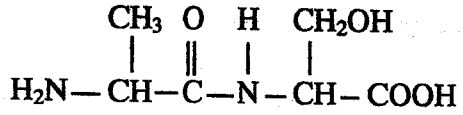
(e) Select a pigment used in paint and describe its origin, composition, extraction and means of application to a surface. **7**

End of Question 33

STUDENT NUMBER/NAME: ... ...

Question 34 – Forensic Chemistry (25 marks) **Marks**

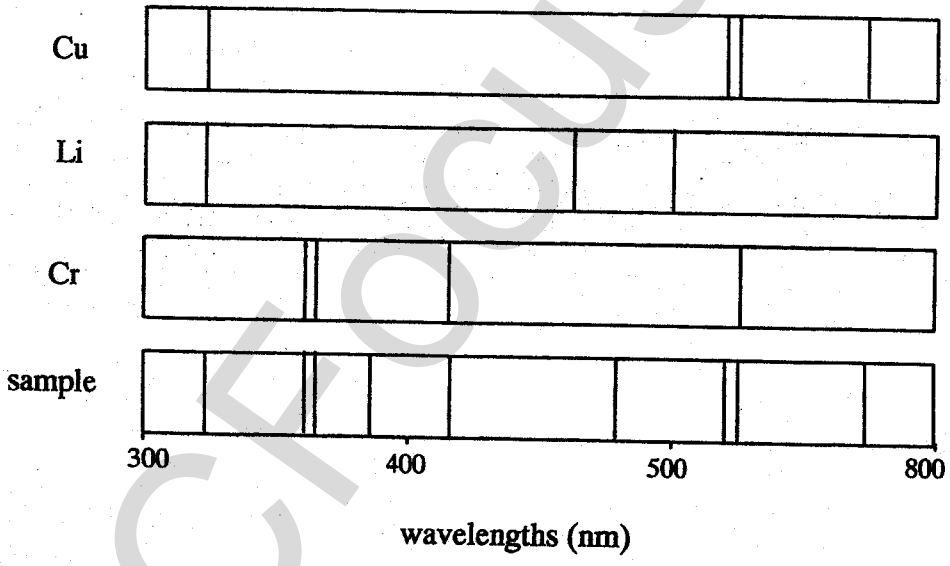
(a) (i) The structure below represents a dipeptide formed by the alanine and serine amino acids.



Write a chemical equation to show the hydrolysis of this dipeptide to form alanine and serine. **1**

(ii) Electrophoresis can be used to separate mixtures of amino acids. Explain why the pH of the electrolyte used in electrophoresis is an important consideration. **2**

(b) The emission spectrum of a sample of material is shown below along with the emission spectra of a number of elements.



(i) Describe the conditions under which atoms will emit light. **2**

(ii) Use the emission spectra shown above to explain how such information can assist analysis of the origins of a mixture. **2**

(c) Explain how potassium permanganate can be used to distinguish between glycerol, 1-propanol and cyclohexane. **5**

Question 34 – Forensic Chemistry continued on next page

Question 34 – Forensic Chemistry (continued) **Marks**

(d) A forensic chemist can perform a series of tests to determine whether a sample of organic material is a carbohydrate, and if it has plant or animal origins. Examples of carbohydrates include cellulose, starch and glycogen.

(i) Identify the monomer unit that makes up starch. **1**

(ii) Describe tests that can be used in the school laboratory to identify separate samples of starch and cellulose. **2**

(iii) Compare the structures of cellulose, starch and glycogen. **3**

(e) Assess the value of scanning tunnelling microscopy to the forensic chemist. **7**

End of Question 34

NSW INDEPENDENT TRIAL EXAMS – 2002
CHEMISTRY - SUGGESTED ANSWERS

SECTION I - PART A

1	A	2	B	3	A	4	C	5	D	6	C	7	B	8	B
9	D	10	A	11	C	12	D	13	C	14	C	15	B		

SECTION I - PART B

16. (a) The ethanol molecule is polar (1 mk) and has strong dipole-dipole attractions with other molecules, acting as a solvent for a range of polar substances (1 mk)
(Hydrogen bonding as an alternative) (1 mk)

(b) Any two of: (2 mk)
temperature in range 30-40°C
dilute aqueous sugar solution
yeast to provide enzymes
anaerobic environment

(c) As fermentation proceeds the reaction mixture decreases in mass due to the loss of carbon dioxide. (1 mk)

$C_6H_{12}O_6 \rightarrow 2C_2H_6O + 2CO_{2(g)}$ (1 mk)

17. Advantage: any one of: (1 mk)
water soluble (spills clean up and fire safety)
easily ignited
renewable

Disadvantage: any one of: (1 mk)
lower energy density
flash point below ambient temperature

18. (a) $V^{2+} \rightarrow V^{3+} + e^-$ (1mk)

(b) $VO_2^+ + 2H^+ + V^{2+} \rightarrow VO^{2+} + H_2O + V^{3+}$ (1 mk)

(c) 1.26 V (1 mk)

(d) The cell can be recharged. It has a long life. It is highly efficient. All reactions occur in solution, with inert electrodes. It is relatively inexpensive. It can be used for electric vehicles and thus reduce pollution from petrol driven cars.(2 marks for any one reason and relating it to society/environment) (2 mks)

19. Addition polymers are formed when unsaturated monomer units join without loss of atoms. (1 mk)

Chloroethene has the structure $CH_2=CHCl$ (1 mk)

During polymerisation the double bonds open out, providing electrons for bonding to other monomer molecules. (1 mk)

20. (a) $_6C^{14} \rightarrow {}_7N^{14} + \beta$ (1 mk)

(b) Geiger-Muller tube, scintillation counter, photo film or cloud/bubble chamber (1mk)

(c) Any valid example eg: Iodine-121 (1 mk) to treat hyperactive thyroid by destroying some cells, a less invasive treatment than surgery (1 mk) (2 mks)

21 Moles HCl (limiting reactant) = 1.5/24.47 = 0.0613 mol (1 mk)
Mass NH_4Cl formed = 0.0613 x mol. mass = 0.0613 x 53.5 = 3.28 g (1 mk)

22. eg: sodium hydrogen carbonate (or the hydrogen carbonate ion) (1 mk)
This species acts as a proton donor and acceptor, shown by:-
$HCO_3^- + H_3O^+ \rightarrow H_2CO_3 + H_2O$ (or $CO_2 + 2H_2O$) (1 mk)
$HCO_3^- + OH^- \rightarrow CO_3^{2-} + H_2O$ (1 mk)

23. (a) (i) methyl propanoate (1 mk)
(ii) $CH_3CH_2COOCH_3$ or expanded formula (1 mk)
(iii) any strong acid, phosphorus pentoxide etc (1 mk)
(iv) Heating under reflux increases the reaction rate (higher temperature) (1 mk)
while preventing loss of reactants or products by vaporisation to outside. (1 mk)
(b) The ester has low polarity resulting in much weaker intermolecular forces (1 mk)
than in pentanol and butanoic acid which both have polar OH groups. (1 mk)
With an additional O atom butanoic acid is still more polar OR
Pentanol and butanoic acid also form hydrogen bonds.
The boiling points reflect the strengths of these intermolecular forces. (1 mk)

24. (a) Opening the bottle causes a decrease in pressure causing the equilibrium to shift to the side of greatest number of gaseous molecules, therefore formation of more gaseous CO_2 (2 mk)
(b) As lowering the temperature favours the formation of aqueous CO_2, this reaction is the reaction that produces heat, therefore the forward reaction as written is exothermic. (2 mk)

25. (a) $H_2SO_4 + 2KOH \rightarrow K_2SO_4 + 2H_2O$ (1 mk)
(b) no. of moles of KOH = 2 x no. of moles of H_2SO_4
25.0 x [KOH] = 2 x 0.200 x 0.0200 (1 mk)
[KOH] = 0.320 mol L^{-1}
(c) Mass KOH = molarity x volume x mol. mass
= 0.32 x 5 x 56.1 (1 mk)
= 89.8g

26. (a) $N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$ (1 mk)
(b) (i) As the forward reaction occurs with a decrease in the number of gas molecules, Le Chatelier's principle states that increasing the pressure causes the equilibrium to move to the right, increasing the yield of ammonia. (1 mk)
(ii)As shown in the graph (or predicted by Le Chatelier) a higher temperature would reduce the equilibrium yield of ammonia, so that the reaction is carried out at the lowest temperature which affords an acceptably fast reaction. (1 mk)
(c) Any one of: (1 mk)
To maintain the 3:1 stoichiometric ratio of hydrogen:nitrogen, to prevent an excess of either in the chamber.
To ensure no oxygen is present, to avoid explosion with hydrogen.
To ensure no S compounds are present, to avoid inactivating the catalyst.
(d) One of fertilisers, production of nitric acid, dyes, explosives, Solvay process etc (1 mk)

27. (a) moles of oxygen = 20 x 0.2095/24.47 = 0.171 mol (1 mk)
(b) moles of argon = 200 x 0.00934/24.47 = 0.0763 mol (1 mk)
mass of argon = moles x mol. mass = 0.0763 x 39.95 =3.05 g (1 mk)

28. (a) Wash the precipitate with distilled water (1 mk)
Dry the precipitate (1 mk)

(b) Moles of ppte. = 0.125/mol. mass = 0.125/222.56 = 5.62×10^{-4}
Moles of P present = 2 x moles ppte (1 mk)
$=1.123 \times 10^{-3}$ mol
% P in detergent = 1.123 x 30.97 x 100/2.85 = 1.22% (1 mk)

(c) Excess nutrients such as nitrates and phosphates can cause excessive growth of algae and other organisms in waterways.(1 mk) One type of alga that may grow excessively is blue/green algae which is toxic to livestock and can affect humans. The algal growth blocks the entry of sunlight, and increases BOD (1 mk) creating an anoxic environment leading to death of aquatic organisms.(1mk) (3 mks)

29. (a) [Fe] = 2.6 x 50/10 = 13 ppm (1 mk)
(b) Mass of Fe in 260 g = $13 \times 260 \times 10^{-6}$ = 3.38 mg (1 mk)
(c) % daily allowance = 3.38 x 100/18 = 18.8% (1 mk)
(d) The undiluted drink has a concentration beyond the calibration scale for the spectrometer used. (1 mk)

SUGGESTED ANSWERS TO OPTIONS

QUESTION 30 – INDUSTRIAL CHEMISTRY

(a) (i) $k = [CH_3OH]/([H_2]^2 \times [CO])$ (1 mk)

(ii) Concentrations = 1.0/10, 0.9/10 and 0.1/10
$k = 0.01/ (0.09^2 \times 0.1) = 12.3$ (1 mk)

(iii) As the forward reaction is exothermic the equilibrium constant would increase, with the equilibrium shifting to the right. (1 mk)

(b) (i) Raw materials: brine (sodium chloride) & calcium carbonate (limestone) (1 mk)
Products: sodium carbonate & calcium chloride (solution) (1 mk)

(ii) Proximity to seawater or salt deposit
Proximity of limestone deposit
Means of disposal of calcium chloride waste
Energy supply
Proximity to markets and/or workforce Any two (2 mk)

(c) Soap is manufactured by the saponification of fats and oils with sodium hydroxide solution to form glycerol and the sodium salts of fatty acids (soaps). (2 mk)
The anion of the soap is the cleaning agent, consisting of a long hydrophobic alkyl chain joined to the hydrophilic carboxyl group. ~~~~~~~~~~COO^- (1 mk)
Greasy 'dirt' particles become dissolved into the alkyl chains of a collection of soap molecules, the hydrophilic carboxyl groups allowing the assembly (a micelle) to disperse in the water.
(Alt; a suitable diagram and short description) (2 mk)

(d) (i) $SO_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow SO_{3(g)}$ (1 mk)

(ii) Increase the oxygen concentration
Lower the temperature
Increase the pressure
(Use a catalyst to reach equilibrium more quickly) Any two (2 mk)

(iii) Sulfuric acid is a very strong acid, oxidising agent and dehydrating agent. (1 mk)
The acid must be handled only with protective glasses and gloves. (1 mk)
Dilution must be carried out by slowly adding the acid to water, with stirring. (1 mk)

30.(e) The mercury cell electrolyses sodium chloride solution with an inert anode, where chlorine is produced, and a mercury pool cathode into which sodium metal dissolves. The mercury amalgam flows into a tank of water into which the sodium dissolves forming sodium hydroxide and hydrogen. Thus the main products are sodium hydroxide, chlorine and hydrogen. (3 mk)

Technical considerations:

Proximity to electric power, transport facilities, workforce, raw materials.

Skilled staff monitoring operation to prevent release of toxic substances (chlorine, mercury, sodium hydroxide) or explosion (hydrogen); a very high level of plant safety is needed. Any 2 (2 mk)

Environmental:

Minimise impact of plant (noise, light, emissions) and transport operations on surrounding population.

Need to remove all mercury from waste discharge to waterways.

Release of chlorine to be kept below maximum permitted level. Any 2 (2 mk)

QUESTION 31 - SHIPWRECKS & SALVAGE

(a) (i) manganese (1 mk)

(ii) $Mn_{(s)} \rightarrow Mn^{2+} + 2e^-$ +1.18 V

$Sn^{2+} + 2e^- \rightarrow Sn_{(s)}$ - 0.14 V

$Mn_{(s)} + Sn^{2+} \rightarrow Mn^{2+} + Sn_{(s)}$ +1.04 V (2 mk)

Criteria	Marks
Correct net equation and correct voltage calculation	2
Either correct net equation OR Correct voltage calculation	1

(b) (i) Zinc metal electrode is the Anode. Reference to an E^o Potential Table indicates that zinc is more readily oxidised than iron. (2 mk)

Criteria	Marks
Zinc electrode identified as ANODE **AND** a correct supporting piece of information eg. reference to E^0 Table	2
Zinc electrode identified as Anode, no justification or an incorrect justification	1

(ii) Bubbles of a gas (most likely to be oxygen gas) forming around the location of the anode and at the cathode, copper metal is electroplating the electrode. (2 mk)

Criteria	Marks
Correct observation occurring at the Anode **AND** Correct observation occurring at the Cathode	2
A correct observation occurring at one electrode	1

(c) Preparing (5 mk)

Removal of any calcareous deposits by physical means such as chipping with a small drill as other methods of chemical treatment such as acid baths would damage the wood. Long immersion in fresh water with repeated water changes to permit removal of soluble salts so as to prevent damage from rapid drying out of the wood

Preserving: Impregnation the timber with an inert chemical material to fill the empty spaces inside the wood that were filled previously with the sea water as the wood will shrink and distort without this preservative step. Maintain the timber in conditions of controlled humidity, temperature and light as this will minimize any further degradation of the wood.

31. (c)

Criteria	Marks
Detailed descriptions of all processes At least TWO methods of preparing and TWO methods of preserving of wooden artifacts …	4 - 5
At least ONE method of preparation AND ONE method of preserving wooden artifacts … One description to be detailed	2 - 3
A method of preparing wood OR preserving wooden artifacts after long immersion in the sea.	1

(d) (i) Any suitable passivating metal e.g. aluminium (1 mk)

(ii) Organise and weigh multiple pieces of equal sized masses of magnesium, iron and lead.
Place a single sample of each metal into a single test-tube.
Use similar shaped & sized test-tubes. Add equivalent amounts of water to each tube.
Leave some tubes with only metal & water.
To some tubes add 5 droplets of and to others add 10 drops of 2M H_2SO_4.
Leave all test-tubes for a similar specified period of time e.g.7 days
Wash and dry all pieces of metal then reweigh to determine any metal loss through corrosion.
Determine if any relationship exists between the degree of corrosion and the acidity of the conditions in which they were placed. (2 mk)

Criteria	Marks
Main features of a feasible method described AND the concept of controlling all features except acidity and possibly the metal type described	2
Main features of a feasible method described	1

(iii) The dilemma exists because recent research is conflicting with traditionally accepted chemistry thinking.
Traditional thinking was that at the bottom of the ocean, it is absolutely dark and extremely cold (almost 0 ^oC) and conditions of low oxygen levels, these conditions would lower reaction rates thereby reducing the rate of corrosion of iron is shipwrecks.
Recent discoveries are showing that the waste products of particular types of chemosynthetic bacteria are acidic in nature, these acidic conditions cause acceleration of the rate of corrosion of steel in the very deep ocean. (3 mk)

Criteria	Marks
Discusses why a dilemma exists Mentions a reason for slow corrosion e.g. low temps slowing reaction rates OR Mentions a reason for newly discovered corrosion rates i.e. bacterial wastes causing acidic conditions which speed corrosion	3
Mentions a reason for slow corrosion e.g. low temps slowing reaction rates AND Mentions a reason for newly discovered corrosion rates i.e. bacterial wastes causing acidic conditions which speed corrosion	2
Mentions a reason for slow corrosion e.g. low temps slowing reaction rates OR Mentions a reason for newly discovered corrosion rates i.e. bacterial wastes causing acidic conditions which speed corrosion	1

31.(e) Possible Corrosion Protection Alternatives (7 mk)

Painting to prevent water & oxygen reacting with the iron in steel.
Painting with special resins to prevent water & oxygen reacting with the iron in steel.
Impressed Electrical Currents run through the metal of the hull as one electrode from the ships generators and another electrode external to the ship sets up a circuit to reduce the oxidation of the hull.
Sacrificial Anodes where pieces of more reactive metal e.g. zinc are attached to the ship so that they are corroded in preference to the metal of the ships hull.

Comparisons

Painting is the cheapest and lowest technology approach.
Sacrificial anodes are more expensive as they require regular replacement of the more active metal which has been corroded away. Not a viable option for extremely large vessels.
Impressed current systems are very expensive to establish but are fairly cost effective over the lifetime of the vessel and have the advantage of weighing less than sacrificial anode systems.

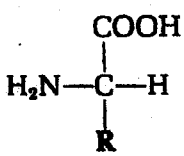
Recommendation

The recommendation to the Silver Star Line is to paint the vessels with special resin based paints as these form hard abrasion resistant surfaces that protect the steel from the conditions which cause corrosion. This choice is done because it is cost effective (relatively cheap), it is simple to apply and provides a good initial level of protection to the metal.

Criteria	Marks
Chooses a preferred method of corrosion protection and gives one or more reasons to justify that choice	4 - 5
Makes a COMPARISON of the TWO or more methods of corrosion protection for steel	2 - 3
Outlines at least TWO methods of corrosion protection for steel	1

QUESTION 32 - BIOCHEMISTRY OF MOVEMENT

(a) (i) for drawing the correct structure (1 mk)



R represents the side chain or an R group which is different in each amino acid

(ii) identifying and explaining the four kinds of interacting forces. (2 mk)

α is the hydrophobic forces between the hydrophobic R groups of some non-polar amino acids like phenylalanine, leucine, isoleucine, methionine, valine, tryptophan.
β is the electrostatic forces between oppositely charged R groups, e.g. the negatively charged $COOH^-$ of a glutamic acid residue with the $-^+NH_3$ of a lysine residue in an adjacent loop.
χ is the disulfide bonds formed from a cysteine residue with another cysteine residue in an adjacent loop. This is the strongest of all the four factors.
δ is the hydrogen bonding forces between the hydroxyl group of a serine, for example with a ring nitrogen atom of a histidine residue in an adjacent loop of the same chain.
These non-covalent interactions (α, β and δ) are individually weak but collectively strong.
χ is a covalent cross-linkage which is strong in force.
(Although the native tertiary conformations of globular proteins are the stablest forms their polypeptide chains can assume, the tertiary conformation of globular proteins must not be regarded as absolutely rigid and fixed. Many globular proteins normally undergo changes in their conformation in the course of their biological function, e.g. enzyme molecules can change their conformation when they bind their substrate.)

32. (a) (ii) continued

Without the tertiary structure, the protein will not be able to function properly. Those four interactions are of vital importance to the function of the protein.
Heat and various other treatments can denature or unfold native globular proteins by disturbing the various kinds of interacting forces.

(b) (i) *2 marks for assessing the validity of the statement. No mark will be given if a student says the statement is correct.* (2 mk)

The statement is incorrect and misleading, since it wrongly suggests that the bond itself contains the energy. This is not the case. In fact the breaking of the chemical bonds requires input of energy.

$ATP + H_2O \rightarrow ADP + P_1$

The free energy released by the hydrolysis of the phosphate esters thus does not come from the specific bond that is broken but results from the fact that the products of the reaction have a smaller free energy content than the reactants.
It is however quite appropriate to use the term "high-energy phosphate compound" to referring to ATP having a large negative ΔG° of hydrolysis.

(ii) *2 marks for describing briefly how ATP can be replenished from oxidative phosphorylation or 1 mark only for just mentioning oxidative phosphorylation without further descriptions.* (2 mk)

The oxidation of NADH and $FADH_2$ is coupled with the phosphorylation of ADP to produce ATP. This oxidative phosphorylation is a multi-stage pathway, where a total of about ten redox reactions occur. It can be briefly represented by the following equation :

$NADH + H^+ + 3P_1 + 3ADP + \frac{1}{2}O_2 \rightarrow NAD^+ + 3ATP + H_2O$

(c) *1 mark for stating the similarities* (5 mk)
4 marks for stating the differences. Out of these 4 marks, 2 marks for structural differences, 1 mark for functional differences and 1 mark for differences in the use of substrates.

<u>Similarities :</u>

Both Type 1 and Type 2 muscle cells are for contraction which bring about movement of the body and part of the body.
Both types of muscle cells contain multi-nucleated cells made from a bundle of about one thousand fibrils. These fibrils consist of alternating sections of thick and thin filaments.
Thick filaments consist of myosin. Thin filaments consist of actin. During muscle contraction, the thin actin filaments and the thick myosin filaments slide past each other. The area of overlap is extended as a muscle contracts.
Both types of muscle cells require the presence of both calcium ions and ATP.

<u>Differences</u>

	Type 1	Type 2
Structures	fewer contractile filaments, many mitochondria, richly supplied with blood vessels	many contractile filaments, fewer mitochondria, reduced supply of blood vessels
Functions	slow twitching, used for light, endurance exercises	fast twitching, used for heavy sprinting style exercises
Use of substrates	can use glucose, fatty acids, amino acids as fuels; adequate oxygen supply, ATP is derived from the process of oxidative phosphorylation	use muscle-stored glycogen as fuel.

32.(d) *1 mark for writing the definition of heat of combustion* (5 mk)
2 marks for describing the experiment. Out of these 2 marks, 1 mark for briefly explaining the mathematical treatment
1 mark for describing how to improve the accuracy
1 mark for describing how to improve the reliability

(i) The amount of heat released when 1 mole of a substance undergoes complete combustion in oxygen.

(ii) An example of the named lipid can be glyceryl tristearate. A known mass of the lipid is burnt in a small spirit burner. A suitable wick is used. Heat produced by the combustion of the lipid is absorbed in 200 mL of water contained in a 250 mL conical flask, the bottom of which is about 4 cm above the burner.
By finding the rise in temperature of the water, the amount of heat can be calculated using the formula $H = m.c.T$
Heat change = mass of water x specific heat capacity x rise in temperature
By dividing the mass of the lipid burnt with the molecular mass of the lipid, the number of mole of the lipid used can be calculated.
The molar heat of combustion can be calculating by dividing the heat evolved with the number of mole of lipid.

(iii) The accuracy can be improved by reducing the heat loss to the environment by insulating the flask and shielding the apparatus from all drafts. The heat loss to the flask can be taken into account by calculating the heat absorbed by the glass if the specific heat capacity of the glass is known.
The reliability of the experiment can be improved if complete combustion of the lipid is insured. Oxygen gas can be supplied during the combustion. The experiment can be carried out with a bomb calorimeter.

(e) *2 marks for describing how acetyl Co-A is formed via glycolysis* (7 mk)
1 mark for describing how the acetyl-CoA is fed into the TCA cycle.
2 marks for describing how fatty acids are converted to fatty acyl-CoA
1 mark for describing how acetyl-CoA from β oxidation of fatty acids is fed into TCA cycle.
1 mark for mentioning the role of the β oxidation of fatty acids in the inhibition of the pyruvate conversion to acetyl CoA

The metabolism of glucose consists of two stages – glycolysis and tricarboxylic acid cycle. In glycolysis, each glucose molecule is broken down into 2 molecules of pyruvate via several intermediate compounds.
Under aerobic conditions the two pyruvate produced by glycolysis enter the mitochondria where they continue to undergo oxidation. The pyruvate reacts with co-enzyme A in the presence of pyruvate dehydrogenase to form acetyl–coenzyme A (acetyl–CoA) and CO_2, accompanied by the reduction of NAD+ to NADH.
pyruvate + coenzyme A + NAD^+ → acetyl–coenzyme A + CO_2 + NADH
Acetyl-CoA is the starting compound for the TCA cycle. Acetyl Co-A reacts with oxaloacetate (a 4 carbon compound) to form citrate (a 6 carbon compound).
6 carbon compounds are converted to 5 carbon compounds and to 4 carbon compounds with the release of carbon dioxide and hydrogen. Hydrogen passes through the cytochrome chain to generate ATP.
Fatty acids must be transported to the mitochondrial matrix and activated before they can be oxidised. The metabolism fatty acids requires the presence of coenzyme A, the carrier molecule. Fatty acids are converted to an activated fatty acyl–CoA by the action of ATP as shown in the equation:
fatty acid + CoA + ATP → fatty acyl–CoA + AMP + PP^1

The fatty acyl–CoA is now ready for β oxidation. This is a four-step process with each step catalysed by an enzyme. The process involves the reduction of one molecule of each of the coenzymes NAD^+ and FAD. The end result of the oxidation is the production of acetyl–CoA and another fatty acyl–CoA molecule, which is now shorter by two carbon atoms than the original fatty acid.

fatty acyl–CoA + FAD + NAD^+ + CoA + H_2O →

fatty acyl (containing 2 less C atoms)–CoA + acetyl–CoA + $FADH_2$ + NADH + H^+

This process can be repeated, removing two carbon atom sections each time, until the full acyl carbon chain of the fatty acid has been oxidised into acetyl–CoA. This oxidation of fatty acids produces large quantities of energy in the form of ATP.

Fatty acid oxidation is in direct competition with glucose metabolism, with both the fatty acids and pyruvate competing for CoA. There is a finite amount of CoA available in the cell's cytoplasm. Thus high levels of fatty acid entering a cell can inhibit the metabolism of pyruvate by consuming the CoA required.

When a person is starving, the β oxidation of fatty acids will dominate.

QUESTION 33 - CHEMISTRY OF ART

(a) (i) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^5$ (1 mk)

(ii) Colour changes from purple to colourless (1 mk)

Oxidation state changes from +7 to +2 (1 mk)

(b) (i) At room temperature all atoms have their electron in the n=1 level, so that no transitions involving the n=2 level are possible. (1 mk)

(ii) Features of Bohr model for H atom:

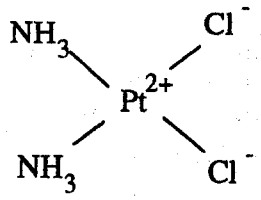
Electron in circular orbit around nucleus

Possible orbits restricted to certain energy values. (1 mk)

Light is emitted when electrons fall from higher to lower energy levels. (1 mk)

Line spectrum is generated by electron transitions between energy levels, where the line frequency is proportional to the energy difference. (1 mk)

(c) eg., cisplatin $Pt(Cl)_2(NH_3)_2$ which consists of a platinum ion Pt^{2+} with two ammonia molecules and two chloride ions as ligands.



Each ligand bonds to the Pt^{2+} ion using an electron pair to form a coordinate covalent bond.(Lewis bases) - diagram (3 mks)

Cisplatin is used as an anticancer agent in treating tumours. It binds to DNA chains in cancer cells, thus preventing their replication. (2 mks)

(d) (i)Transition metals have incomplete d-subshells of the n=3, n=4 and n=5 shells.(1 mk)

(ii) The electrons of the d and s subshells have similar energy values. (1 mk)These metals can form ions by losing varying numbers of electrons from the d subshell and the preceding s subshell, leading to a variety of oxidation states (1 mk) (2 mks)

(iii)The melting points increase from Sc to V then decrease, with Zn having the lowest value. The trend reflects the number of d electrons available for bonding and the number of empty orbitals available. (1 mk)

The density increases from Sc to Cu due to increasing atomic mass and decreasing

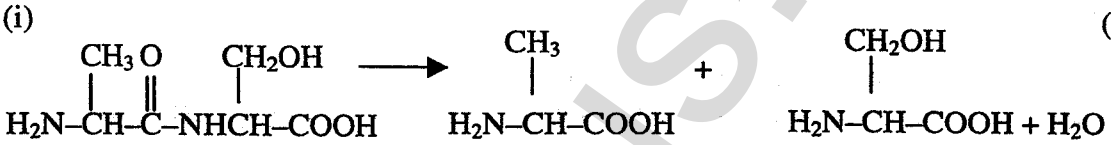
atomic radius. (Zinc, with filled d subshell has a lower density) (1 mk)
Magnetism is shown only by Fe, Co and Ni which have unpaired d electrons in their structure. (1 mk)

(e) eg: only (select pigment, origin, composition (3mks), extraction (1mk), application (3mks).

Ochres are found in various colours, these reflecting varying degrees of hydration of iron oxides. They are formed by chemical weathering near the earth's surface. Red ochre contains anhydrous iron(III) oxide Fe_2O_3, yellow ochre approximates $Fe_2O_3.H_2O$, while brown ochre is nearly pure limonite FeO(OH). All ochres are highly insoluble, their extraction consisting of excavation and grinding to a fine powder. Aborigines sometimes applied ochre directly to cave walls or mixed the ochre with a spreading agent such as orchid juice, wax, honey, egg yolk or plant gums. Modern paints use spreading agents, such as oil or aqueous solutions in a similar way. The agent must be sufficiently viscous to prevent running and bind the pigment particles together as the agent evaporates or dries. The agent itself has little colour so that the paint deposit retains the colour of the original pigment.

QUESTION 34 - FORENSIC CHEMISTRY

(a) (i) (1 mk)



1 mark for correct balanced equation

(ii) During electrophoresis charged particles migrate through an electrolyte when a voltage is applied. The speed at which the particles move depends on their size and charge. When separating amino acids, the pH of the electrolyte will influence the charge on each amino acid. At low pH, the amino acid molecules will be positively charged, at high pH, they will be positively charged and at an intermediate pH they will be neutral. The actual pH at which these charges form is different for each amino acid.

Criteria	Marks
an outline of the electrophoresis process a description of the charges on amino acids at high, low and intermediate pH's an understanding that different amino acids become charged at different pH's	2
only 1 of the above criteria	1

(b) (i) Atoms need to absorb energy in order to promote one or more of its electrons to energy levels than those fill when in ground state. This energy may be given to the atom by heating to a high temperature, by applying a high electrical voltage or by subjecting the atom to certain frequencies of electromagnetic radiation. The light is emitted when the electrons in the excited states fall back to their "normal" ground state energy level.

Criteria	Marks
demonstrate an awareness of at least two types of energy that can be absorbed to excirte an atom	2
reference to absorbing energy	1

(b) (ii) Each element has its own unique emission spectrum, as seen by the Cu, Li and Cr spectra shown above. This spectrum is not affected by the presence of atoms of other elements. A spectrum produced by a mixture of elements will contain spectral lines of all the elements present, although closely spaced lines may not be completely resolved and weak lines may not show up.
The sample spectrum shown shows all the spectral lines in the Cu and Cr spectra, indicating their presence in the sample. Some of the lines in the Li spectrum are not present indicating that Li is not present in the sample. The presence of additional lines not in the Cu, Li or Cr samples suggests the presence of another element.
In soil analysis, detection of an unusual element in a sample can sometimes pinpoint the location from which the sample originated. While this technique identifies the elements present in the sample, it does not give any indication of the nature of the compounds present

Criteria	Marks
discussion of how the presence of an element can be identified in a mixed sample spectrum discusison of how the absence of spectral lines can indicate the absence of an element in any significant quantity identifying that another unknown element is present in the sample	2
discussion of how the presence of an element can be identified in a mixed sample spectrum with reference to the sample shown OR identifying that CU and Cr are both present in sample the spectrum shown	1

(c) KMnO4 is a strong oxidising agent changing from purple to brown in colour when it reacts. A cold, dilute, aqueous solution of $KMnO_4$ will react differently with the three compounds named.
$KMnO_{4(aq)}$ does not react with cyclohexane and so retains its original purple colour when added to a sample of cyclohexane.
$KMnO_{4(aq)}$ will oxidise both glycerol and 1-propanol, changing from purple to brown. It is the OH functional group in these compounds that reacts. Glycerol is a triol, so three times as much $KMnO_4$ will be required to react with an amount of glycerol compared with an equal amount of 1-propanol.
Therefore by measuring the amount of $KMnO_4$ required for complete reaction samples of glycerol and 1-propanol can be distinguished.

Criteria	Marks
describes the use of dilute aqueous $KMnO_4$ as a oxidising agent describes observations made when $KMnO_4$ is mixed with all three compounds named explains why glycerol reacts with more $KMnO_4$ than 1-propanol	4-5
describes observations made when $KMnO_4$ is mixed with some of the compounds named OR explains why glycerol reacts withmore $KMnO_4$ than 1-propanol	2-3
describes observations made when $KMnO_4$ reacts	1

(d) (i) Glucose (1 mk)

(ii) Drops of iodine solution, when added to an aqueous solution or suspension of starch, will form a deep blue colour. Drops of a solution of calcofluor, when added to a finely divided sample of cellulose dispersed in water will produce a mixture that will emit a blue glow when placed under a UV light source.

Criteria	Marks
describes tests (including observations) for both cellulose or starch	2
identifies tests for both cellulose and starch OR describes a test for cellulose or starch	1

(iii) Cellulose, starch and glycogen are all biopolymers made glucose monomer units. Glucose may exist in a number of isomeric forms, two of which are called α-glucose and β-glucose. Cellulose consists of long chains of β-glucose units (typically between 200 to 400 units) joined together. Because of the β- arrangement of the OH group on the carbonyl carbon in glucose, every second glucose unit in the cellulose chain is inverted producing a very linear, unbranched chain. These linear chains intertwine, forming hydrogen bonds with one another, to form fibres. Starch and glycogen consist of α-glucose units joined together, each unit the same way up, producing chains that curl around into globular shapes. Starch may consist of between 60 to 6000 glucose units, the shorter chains being unbranched while the longer chains are branched. Glycogen is a highly branched chain typically only a few hundred glucose units long.

Criteria	Marks
identifies that cellulose is compoased of different isomers of glucose than is starch or glycogen description of the arrangement of the glucose units resulting in different shaped chains in cellulose compared to starch or glycogen identifying the branching of the polymer chains in stgarch and glycogen and the lack of branching in cellulose outlining some differences between stach and glycogen	3
identifies glucose as the common monomer unit in at least two of cellulose, starch or glycogen description of the inverted arrangement of alternate glucose uints in cellulose OR identifying the n\branching of the polymer chains in starch &/or glycogen	2
identifies that cellulose, starch or glycogen are polymers made of glucose monomer units.	1

(e) Scanning tunnelling microscopy is a valuable tool to the forensic chemist. Even though it cannot be used on all objects, it does given detailed information about the surface of an object that cannot be obtained by most other analytical techniques. It can be performed on very small samples of material and it is a non-destructive analytical technique, although the small electric current used may damage some sensitive materials.
Although it can only be used for analysing the surface of conducting materials, when used in conjunction with other techniques that analyse the composition of the material, it can allow the identification of an individual source of the material, allowing the matching of unique surface details. These details will be a result of the unique conditions to which an individual object will be exposed over time such as weathering conditions, stains and surface deposits. Similar detailed surface analysis of non-conducting materials requires a slightly different technique.
Scanning tunnelling microscopy uses a very fine needle which is moved at a specific height above the surface features. When a voltage is applied between the needle and the surface, electrons in the surface move to the tip of the needle producing a small current. Vertical movement of the needle maintains a constant current and hence a constant n\height above the surface. This vertical movement can be used to produce a detailed image of the surface. Surface features of less than one nanometre in height or width can be detected.

Criteria	Marks
clear outline of the how the scanning tunnelling microsocpe works an explanation of the types of images produced by a scanning tunnelling microscope demonstrates an understanding of some of the advantages and some of the limitations of using scanning tunnelling microscopy with reference to the value of the infoermation gained to the forensic chemist	7
outlien of how the scanning tunnelling microscope works description of the types of images produced by a scanning tunnelling micrscope description of some of the advantages and liitaions of using scanning tunnelling microscopy	5-6
description of the types of images produced by a scanning tunnelling microscope ND outline of how the c\scanning tunnelling microscope works OR a descrition of some of the advantages and limitations of using scanning tunnelling microscopy	3-4
description of the types of images produced by a scanning tunnelling microscope OR description of some of the advantages and/or limitaions of using scanning tunnelling microscopy	1-2

Chemistry

2002 Trial Examination Mapping Grid

Question	Marks	Content 9.	Syllabus outcomes H..	Targeted performance bands
1	1	2.1	3,9	2-3
2	1	2.2	3,9	2-3
3	1	2.4	3,6,7	3-4
4	1	2.3	4,11	3-4
5	1	2.5	4,6,14	4-5
6	1	3.1,3.3	14	3-4
7	1	3.1,3.4	12,14	3-4
8	1	1,3.4	11,12	2-3
9	1	3.2	8,14	4-5
10	1	3.3	10	4-5
11	1	4.4	6,14	3-4
12	1	4.2	6,8	2-3
13	1	4.5	4,14	2-3
14	1	4.3	1,11	2-3
15	1	4.5	8,14	3-4
16(a)	2	2.3	2,6	3-5
16(b)	2	1,2.3	7,12,14	2-6
16(c)	2	1,2.3	11,9,13	2-6
17(a)	2	2.3	4,14,13	2-5
18(a)	1	2.4	8,13,14	3-4
18(b)	1	2.4	8,13	3-4
18(c)	1	2.4	8,14	3-4
18(d)	2	2.4	3,4	2-5
19	3	2.1	6,9,13	3-5
20(a)	1	2.5	2,6,13	3-4
20(b)	1	1,2.5	11,13	2-3
20(c)	2	2.5	1,3,4,11	3-6
21	2	3.2	8,10,13	4-5
22	3	3.4	6,8,13	3-6

Question	Marks	Content 9.	Syllabus outcomes H..	Targeted performance bands
23(a)(i)	1	3.5	9,13	4-6
23(a)(ii)	1	3.5	6,13	3-4
23(a)(iii)	1	3.5	9	4-5
23(a)(iv)	2	1,3.5	11.13	4-6
23(b)	3	3.5	2,6	3-4
24(a)	2	3.2	8,13	3-4
24(b)	2	3.2	8,13,14	3-5
25(a)	1	3.4	6,8,13	3-4
25(b)	2	3.4	10,13	3-4
25(c)	1	3.4	10,13	2-4
26(a)	1	4.1	8,13	2-3
26(b)(i)	1	4.1	8,11,13	3-4
26(b)(ii)	1	4.1	8,11,13	2-3
26(c)	2	4.1	3,11,13	2-3
26(d)	1	4.1	4	3-5
27(a)	1	4.4	10,13	4-6
27(b)	2	2.1,4.4	10,13	3-4
28(a)	2	1,4.5	11,13	3-4
28(b)	2	4.5	10,13	3-4
28(c)	3	4.5	4,8,13	4-6
29(a)	1	1,4.3	10,14	
29(b)	1	1,4.3	10,13	
29(c)	1	1,4.3	10,13	
29(d)	1	1	11,12,13	
TOTAL	=75			

Question	Marks	Content 9.	Syllabus outcomes H..	Targeted performance bands
Option 1: Industrial Chemistry				
30(a)(i)	1	5.2	8,10	2-4
30(a)(ii)	1	5.2	10,13	2-4
30(a)(iii)	1	5.2	12,8,13	4-5
30(b)(i)	2	5.6	3,7	2-3
30(b)(ii)	2	5.6	4,11,13	4-5
30(c)	5	5.5	2,3,6	4-6
30(d)(i)	1	5.3	8,10	2-4
30(d)(ii)	2	5.3	3,8,13	2-4
30(d)(iii)	3	5.3	1,11,13	3-5
30(e)	7	5.4	3,4,8,13	3-6
Option 2: Shipwrecks and Salvage				
31(a)(i)	1	6.3,6.4	7,10	3-4
31(a)(ii)	2	6.3	7,8,10	3-4
31(b)(i)	2	6.3	8,11,13	3-4
31(b)(ii)	2	1,6.3	6,8,13	2-4
31(c)	5	6.7	3,8,16	3-6
31(d)(i)	1	6.6	6,13	2-3
31(d)(ii)	2	6.6	11,12	3-5
31(d)(iii)	3	6.5,6.6	3,14,15	3-6
31(e)	7	6.4	3,8,13,14,16	2-6
Option 3: Biochemistry of Movement				
32(a)(i)	1	7.4	2,13	2-3
32(a)(ii)	2	7.4	2,13	3-5
32(b)(i)	2	7.1	2,7,9,10,13	3-4
32(b)(ii)	2	7.1	2,7,9,10,13	3-4
32(c)	5	7.5,7.6	2,13	3-6
32(d)(i)	1	1,7.3	2,5,7,8,9,10,11, 12,13,14,15,16	2-6
32(d)(ii)	2	1,7.3		2-6
32(d)(iii)	3	1,7.3		2-6
32(e)	7	7.8,7.9, 7.10	2,7,9,10,13,16	3-6

Question	Marks	Content 9.	Syllabus outcomes H..	Targeted performance bands
Option 4: Chemistry of Art				
33(a)(i)	1	8.4	2,6,13	3-4
33(a)(ii)	2	8.5	6,13	2-4
33(b)(i)	1	8.3,8.4	6,14	4-5
33(b)(ii)	3	8.3	2,6	3-6
33(c)	5	8.7	3,4,13	3-6
33(d)(i)	1	8.4	6	2-3
33(d)(ii)	2	8.5	6,7,13	3-4
33(d)(iii)	3	8.6	6,8,13	4-6
33(e)	7	8.1,8.2	1,3,4,8,13	2-6
Option 5: Forensic Chemistry				
34(a)(i)	1	9.4	9	3-5
34(a)(ii)	2	9.4	4,8,9	5-6
34(b)(i)	2	9.7	6,7	3-5
34(b)(ii)	2	9.7	3,4	2-5
34(c)	5	9.1,9.3	8,9,10,14	3-6
34(d)(i)	1	9.2	9	2-3
34(d)(ii)	2	9.2	8,8,11	2-4
34(d)(iii)	3	9.2	9	3-5
34(e)	7	9.6	1,3,4	3-6