2004
HIGHER SCHOOL CERTIFICATE
TRIAL EXAMINATION

CHEMISTRY
2 Unit

GENERAL INSTRUCTIONS

- Reading Time: 5 Minutes
- Working Time: 3 Hours
- Board approved calculators may be used
- Write using blue or black pen
- Diagrams to be done in pencil
- Write your name/number on each page

SECTION I Total Marks: (75)

This Section has two parts: Part A and Part B

PART A: Total marks (15)

Attempt all questions

Allow about 30 minutes for this Part.

PART B: Total marks (60)

Attempt all questions

Allow about 1 hour, 45 minutes for this Part

SECTION II

Total Marks: (25)

Attempt ONE question

Allow about 45 minutes for this section

THIS PAPER MUST NOT BE REMOVED FROM THE EXAMINATION ROOM

NAME/NUMBER: .....

SECTION I
(25 MARKS)

PART A
MULTIPLE CHOICE ANSWER SHEET

Instructions

Total marks – (15)
Attempt questions – 1 to 15
Allow approximately 30 minutes for this section
Marks will not be allocated for a question with more than one response.

Select the best alternative A, B, C or D and place an X in the box in the appropriate space on the grid below.

	A	B	C	D
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SECTION I

Total Marks: (75)

PART A
Total Marks (15)
Attempt questions 1 - 15
Allow about 30 minutes for Part A

Use the multiple choice answer sheet provided

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1. When long chain hydrocarbons in crude oil are catalytically cracked to produce smaller molecules, the following reaction can occur:

$$C_{11}H_{24} \longrightarrow C_9H_{20} + X$$

What is the name of molecule *X*?

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

2. A certain liquid hydrocarbon decolorizes bromine water quickly in the dark. Which of the following could have been this hydrocarbon?

(A) cyclohexane (B) hexene (C) 1-propanol (D) octane

3. In an experiment in a particle accelerator with the isotope sodium-24, a neutron is captured by the Na-24 nucleus, forming a new isotope of sodium. This new isotope decays by alpha-particle emission, producing a daughter nucleus.

The daughter nucleus is:

(A) aluminium-28 (B) fluorine-20 (C) neon-20 (D) fluorine-21

4. The equation for the reaction in which HPO_4^{2-} is acting as a Lowry-Bronsted base is:

(A) $HPO_4^{2-} + 2\ Na^+ \longrightarrow Na_2HPO_4$ (B) $HPO_4^{2-} + H_2O \longrightarrow H_3O^+ + PO_4^{3-}$

(C) $HPO_4^{2-} + H_3O^+ \longrightarrow H_2O + H_2PO_4^-$ (D) $HPO_4^{2-} + OH^- \longrightarrow H_2O + PO_4^{3-}$

5. Ethanol is widely used as a solvent in cosmetics, food flavourings and medicines. What possible intermolecular forces can ethanol exert on other molecules?

(A) covalent bonds, dispersion forces

(B) dipole/dipole interactions, dispersion forces

(C) covalent bonds, hydrogen bonds, dispersion forces

(D) dispersion forces, dipole/dipole interactions, hydrogen bonds

6. Naturally coloured compounds which occur in some flowers can be used as a test for:

(A) the presence of electrolytes in soil

(B) chemical indicators in soil

(C) the acidity and basicity of soil

(D) the colour range of compounds in soil

7. Sulphur dioxide is a toxic, colourless, non-flammable gas. It can be detected in air by its pungent odour. Sulphur dioxide can be formed by reacting

(A) water and sulphuric acid

(B) acetic acid and sulphuric acid

(C) sodium sulphite and oxygen

(D) copper sulphide and oxygen

8. The table shows the pH of some naturally occurring substances:

Substance	**Approximate pH**	**Substance**	**Approximate pH**
Stomach acid	2	Tomato juice	4
Lemon juice	3	Sea water	8

The next table shows the properties of four acid-base indicators:

Name	Colour in		pH range in which colour changes
	Low pH	High pH	
Phenolphthalein	Colourless	Pink	8.3 - 10.0
Phenol red	Yellow	Red	6.8 - 8.4
Methyl red	Pink	Yellow	4.4 - 6.2
Methyl yellow	Red	Yellow	2.4 - 4.0

Which mixture has the correct colour next to it?

(A) lemon juice + phenolphthalein $\longrightarrow$ pink

(B) saliva + phenol red $\longrightarrow$ yellow

(C) sea water + methyl red $\longrightarrow$ pink

(D) stomach acid + methyl yellow $\longrightarrow$ yellow

9. Bromine water can be used to distinguish between:

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

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

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

11. Consider the reaction described by the equation below:

$$C_2H_5OH \longrightarrow C_2H_4 + H_2O$$

This reaction is an example of:

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

12. The pHs of 0.2 molar solutions of citric acid, acetic acid and hydrochloric acid are 2.0, 2.7 and 0.7 respectively.

This means that the hydrogen ion concentration of:

(A) hydrochloric acid is about 100 times that of acetic acid
(B) acetic acid is about 1/3 more than that of citric acid
(C) citric acid is about 3 times that of hydrochloric acid
(D) acetic acid is about ¼ that of hydrochloric acid

13. The HCO_3^- is an amphiprotic species as shown by the equations:

$$HCO_3^-{}_{(aq)} + HCl_{3(aq)} \longrightarrow H_2CO_{3(aq)} + Cl^-{}_{(aq)}$$
$$HCO_3^-{}_{(aq)} + OH^-{}_{(aq)} \longrightarrow CO_3^{2-}{}_{(aq)} + H_2O_{(l)}$$

The conjugate base of $HCO_3^-{}_{(aq)}$ is:

(A) OH^- (B) H_2CO_3 (C) H_2O (D) CO_3^{2-}

14. Calcium hydroxide $Ca(OH)_2$ dissociates completely in water. The pH of 0.005 mol L^{-1} calcium hydroxide solution in water is:

(A) 12.0 (B) 11.7 (C) 2.3 (D) 2.0

15. Which one of the acids below occurs naturally?

(A) Phosphoric acid
(B) Hydrobromic acid
(C) Ascorbic acid
(D) Nitric acid

NAME: .....

SECTION I - PART B

Total marks (60)

Attempt ALL questions

Allow about 1 hour and 45 minutes for this Part

Answer all questions in the spaces provided. Show all relevant working in questions involving calculations.

16. Choose an example of an amphiprotic substance and write relevant equations to help explain its behaviour in acidic and basic solutions: (3 marks)

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

(i) Name the ester which could be synthesised: (1 mark)

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(ii) Draw a structural formula for this ester: (2 marks)

(iii) Name a suitable catalyst: (1 mark) .....

(iv) Justify the use of heating under reflux for this experiment: (3 marks)

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

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

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

(a) Fizzing occurs when a bottle of carbonated drink is opened: (2 marks)

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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 marks)

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19. (a) Name a radioisotope used in medicine: (1 mark)

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(b) Describe how the radioisotope is used: (1 mark)

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(c) Justify, from answers to (a) and (b) above, the maintaining of the nuclear reactor at Lucas Heights in NSW: (2 marks)

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20. 2.447 L of ammonia gas (measured at 25°C and 101.3 kPa) are bubbled into a closed flask that contains 200 mL of 0.500 mol L^{-1} sulfuric acid. All the ammonia is allowed to react.

The equation for the reaction is:

$$2NH_{3(g)} + H_2SO_4(aq) \longrightarrow (NH_4)_2SO_4(aq)$$

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(a) Calculate the number of moles of sulfuric acid left unreacted: (2 marks)

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(b) The excess sulfuric acid is titrated with sodium hydroxide solution which has a pH of 14.3. What volume of sodium hydroxide is required for complete neutralisation? (3 marks)

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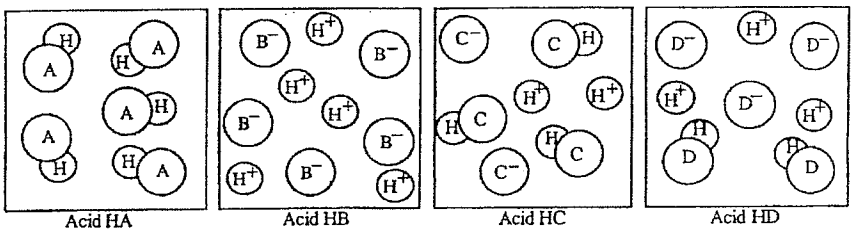
21. Each diagram below represents the number and type of chemical species (other than water molecules) present in the same volume of four different acidic solutions.



(a) Which is the strongest acid? Give a reason for your choice: (1 mark)

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(b) In an experiment, a student mixed 15.0 mL of 0.030 mol L^{-1} HCl with 20.0 mL of 0.010 mol L^{-1} $Ba(OH)_2$

(i) Write an equation for the reaction: (1 mark)

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(ii) Calculate the pH of the resulting solution: (4 marks)

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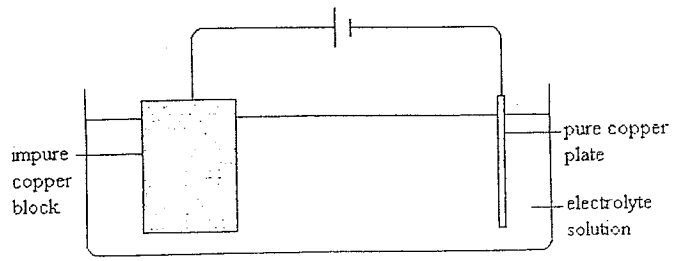
22. The diagram shows the set-up for the electrolytic refining of copper.



(a) Name a suitable electrolyte: (1 mark)

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(b) Write the half equation for the reaction which occurs where this electrolyte is in contact with the pure copper: (1 mark)

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(c) The impure copper acts as the anode in this electrolytic cell. What process takes place at the anode of any cell? (1 mark)

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23. (a) Explain how the Lowry-Bronsted definition of an acid differs from the Arrhenius definition of an acid. Your answer should include examples: (1 mark)

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(b) Ammonium nitrate (HN_4NO_3) is an acidic salt. Outline why this is so. Include an equation in your answer: (2 marks)

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(c) In the following reaction, is water behaving as an acid or base? Explain your answer: (1 mark)

$$HCl_{(g)} + H_2O_{(l)} \longrightarrow H_3O^+ + Cl^-$$

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(d) From the species involved in the reaction in part (c) give the formulas for one conjugate acid/base pair: (1 mark)

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24. (a) To extract metal from sulphide ores, the ore is "roasted" in air. A by-product of the reaction is the poisonous gas sulphur dioxide. Write the equation for the roasting of the ore copper pyrites (copper II sulphide). (1 mark)

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(b) Calculate the volume of sulphur dioxide gas produced (measured at 101.3 kPa and 25°C) from the roasting of 1 tonne (= 1000 kg = 10^6 g) of copper pyrites. (3 marks)

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(c) The acid in part (b) can further oxidise, giving acid rain. Write an equation between acid rain (assume it to be sulfuric acid) and marble statues (assume marble to be calcium carbonate). (1 mark)

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

$$V^{3+} + e^- \Longleftrightarrow V^{2+} \quad E^o = -0.26\ V$$

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

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 mark)

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(b) Write the overall cell reaction when the cell is operating as a galvanic cell. (2 marks)

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

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(d) Describe one advantage of the vanadium redox cell in terms of its impact on society or the environment. (3 marks)

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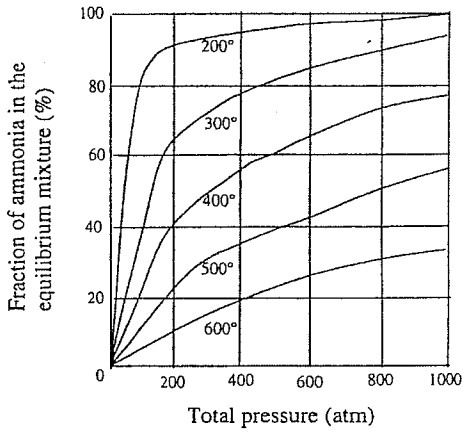
26. The graphs below show the fraction of ammonia present at equilibrium when nitrogen and hydrogen are reacted in a pressure vessel.



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

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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 mark)

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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 mark)

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

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(d) Identify one industrial use of ammonia: (1 mark)

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27. Ozone (O_3) and oxygen (O_2) are allotropes of the element oxygen. Ozone is present in the upper atmosphere where it acts as a "shield" to incoming ultraviolet radiation.

(a) (i) Chlorofluorocarbon (CFCs) can lower the concentration of ozone in the upper atmosphere. Name the element present in CFCs that is directly responsible for the destruction of ozone molecules in the upper atmosphere: (1 mark)

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(ii) Identify one source of CFCs in the upper atmosphere: (1 mark)

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(iii) The CFC "Freon-12" is dichlorodifluoromethane. Draw the structural formula of this compound: (1 mark)

(b) The table below shows some properties of oxygen and ozone.

	Density of Liquid/g mL^{-1}	Melting Point/^oC	Boiling Point/^oC
Oxygen, O_2	1.15	-219	-183
Ozone, O_3	1.16	-193	-111

Select one of these properties. Account for the difference in this property between O_2 and O_3 in terms of their molecular structure and/or bonding. (2 marks)

Property selected: .....

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SECTION II
Total Marks (25)

Attempt ONE question from Questions 28 to 32

Allow about 45 minutes for this Part

Question 28: Industrial Chemistry

Question 29: Shipwrecks, Corrosion and Conservation

Question 30: The Biochemistry of Movement

Question 31: The Chemistry of Art

Question 32: Forensic Science

Question 28: (25 Marks) **Industrial Chemistry**

(a) Ammonia is produced commercially from hydrogen and nitrogen by a process called the Haber process. All substances are gases.

(i) Write a balanced equation for the reaction. (2 marks)

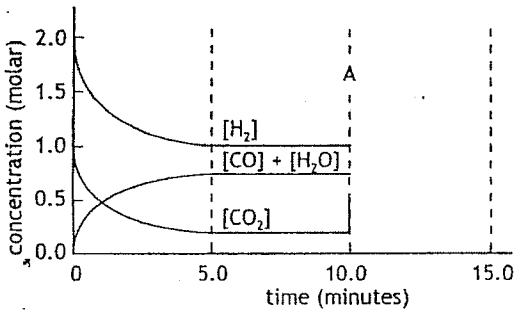
(ii) This reaction is an exothermic reaction but is carried out at high temperatures in industry (450°C).

Explain fully this apparent contradiction of conditions in light of Le Chatelier's principle and activation energy. (3 marks)

(iii) Name one other reaction condition that is altered to increase the yield of ammonia from this reaction, and state how it affects the amount of ammonia produced (3 marks)

(b) Consider the following equilibrium and graph:

$$H_2(g) + CO_2(g) \Leftrightarrow H_2O(g) + CO(g) \qquad \Delta H = 40 \text{ kJ mol}^{-1}$$



1. What is added to the reaction vessel at time A? (1 mark)
2. What effect does this change have on:
   (i) the concentration of carbon monoxide (1 mark)
   (ii) the concentration of carbon dioxide (1 mark)
   (iii) the temperature of the reaction vessel (1 mark)
3. What effect, if any, would occur if the total pressure of the system were increased? (1 mark)
4. What effect would an increase (at time = 15 minutes) in temperature have on this equilibrium? (1 mark)
5. How would the graph shown be different if the reaction was repeated in the presence of a catalyst? Illustrate your answer by plotting (on the axes supplied) the changes in concentrations of reactants and products for the first ten minutes of the catalysed reaction. (1 mark)

(c) (i) Sulfur occurs in the elemental state in large deposits in the USA. Ordinary mining methods cannot be used because of quicksand or water which cover the deposits. The Frasch process is used successfully for the extracting of sulphur. On what two physical properties of sulphur does the Frasch process depend? (2 marks)

(ii) Sulfuric acid is made by the contact process. The main reaction is the reversible reaction in which sulphur dioxide and oxygen form sulphur trioxide.

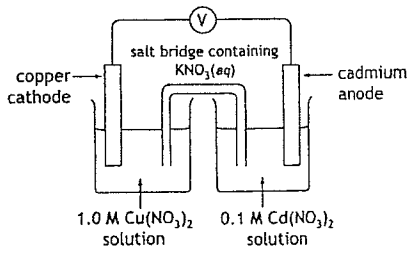
(i) Write a balanced equation for the reaction.

(ii) Name the catalyst used. (2 marks)

(d) Describe the chemical reaction used to produce soap and analyse soap's cleaning action with reference to its chemical structure. (6 marks)

Question 29: (25 Marks) **Shipwrecks, Corrosion & Conservation**

(a) A galvanic cell was constructed as shown below:



The voltmeter reading was 0.75 V.

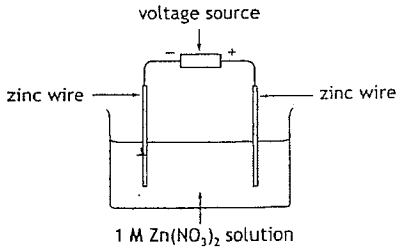
(i) Briefly explain the purpose of the salt bridge (1 mark)

(ii) Write a net ionic equation to represent the reaction which occurs in the cell when the voltmeter is replaced by a conductor (1 mark)

(iii) What do you understand by the term "standard reduction potential"? (2 marks)

(iv) Calculate the standard reduction potential (E^o) for the anode half cell (2 marks)

For the electrolysis cell shown in the following diagram, a voltage is applied across the wire sin the direction shown. When current flows, zinc metal is deposited on one of the zinc wires.



(v) State Faraday's First Law of Electrolysis (1 mark)

(vi) Calculate the mass of zinc deposited when a current of 0.48 A flows through it for 140 min. (The Faraday constant is 96 500 C mol^{-1}) (2 marks)

(b) Aluminium is a much more reactive metal than iron, yet aluminium remains unaffected by weather conditions for many years, when iron corrodes away very quickly. Why? (2 marks)

(c) The ship *RMS Titanic* sank on its first voyage across the Atlantic Ocean in 1912. In 1985, deep-sea researcher, Bob Ballard, was able to use deep-sea submersibles to locate, explore and photograph the wreck lying on the ocean floor in 3810 metres of water.

(i) The environmental conditions at the wreck of the *RMS Titanic* have been described as "extremely cold, totally dark with tremendous pressures due to the depth of the water."

Predict how these conditions would affect the rate of corrosion of this shipwreck's steel hull. (2 marks)

(ii) Explain the different rate of corrosion for a submerged ship such as the *Titanic* with that of a ship such as the *Cherry Venture* (located on the coast of Fraser Island, Queensland) which is fully exposed at low tide. (2 marks)

(iii) Explain how bacterial activity contributes to corrosion at great depth. (2 marks)

(iv) A piece of leather clothing was removed from a 600-year-old wreck in the Mediterranean Sea by divers. It was in "reasonable condition" at the time of removal from the wreck but as the water evaporated from it at the surface, it underwent progressive deterioration. Using your knowledge of artefact preservation, account for this deterioration as evaporation occurred. (2 marks)

(d) The iron hulls of ships are fitted with magnesium bars to protect them from corrosion by sea water.

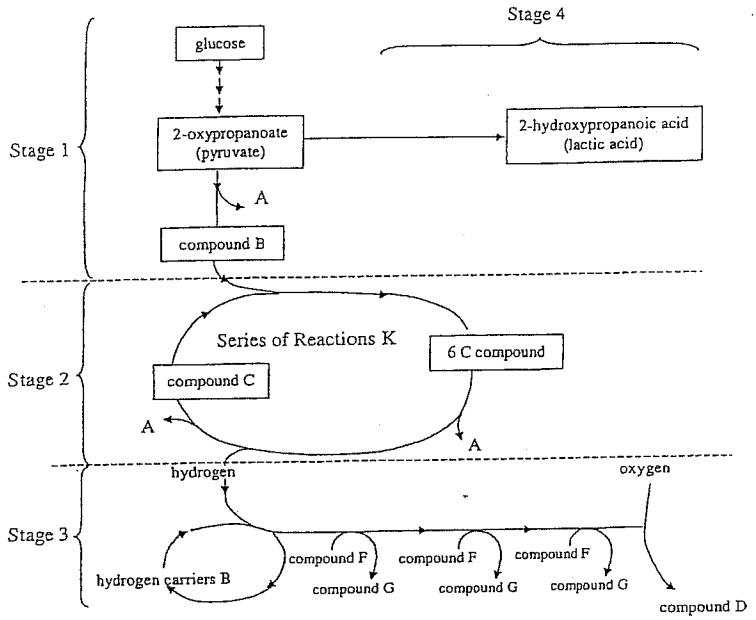
(i) Describe how magnesium protects a ship against corrosion, naming the process involved. (2 marks)

(ii) Using equations, determine if a copper coating would be effective in protecting iron-hulled ships from corrosion. (2 marks)

(iii) Explain <u>two</u> other methods of protecting a ship's hull from corrosion. (2 marks)

Question 30: (25 marks) **The Biochemistry of Movement**

(a) The diagram below represents an outline of the four stages of respiration in muscle cells:



(i) Identify which Stages occur during aerobic respiration. (1 mark)

(ii) State the name for Stage I. (1 mark)

(iii) State the name of compound B. (1 mark)

(iv) What is the name given to the series of reactions K in Stage 2? (1 mark)

(v) State the exact location within the cell where the series of reactions K occurs. (1 mark)

(vi) Stage 2 is regarded as oxidative decarboxylation. What is the meaning of "decarboxylation"? (1 mark)

(vii) Write an equation to show how the oxidised form of hydrogen carrier B changes to the reduced form. (1 mark)

(viii) Identify compound D. (1 mark)

(ix) State the name of Stage 3. (1 mark)

(x) Name the exact location within the cell where phosphorylation of compound F occurs. (2 marks)

(xi) When does the cell carry out Stage 4? (1 mark)

(b) (i) Define *viscosity*. (1 mark)

(ii) Outline a procedure that could be used to compare the viscosity of pure glycerol and a glycerol solution. (2 marks)

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

(c) The energy requirements for different types of skeletal muscle are met by the interaction of separate energy output systems. (7 marks)

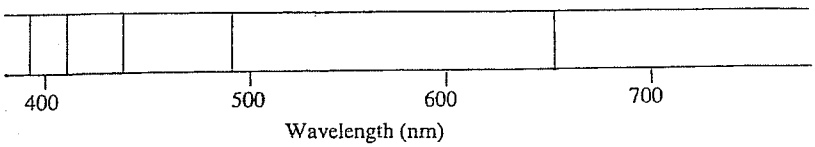
Analyse the role and interaction of the energy output systems used by skeletal muscle.

Question 31: (25 marks) **The Chemistry of Art**

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

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

(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 mark)

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

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

(d) From earliest times, people have used colour to decorate their surroundings. Readily available minerals were used by Aboriginal people to prepare pigments used in traditional art.

(i) Name and describe the chemical composition of TWO minerals used by Aboriginal people to prepare pigments. (2 marks)

(ii) Other than colour, describe how ONE physical property that the pigments used by Aboriginal people needed to possess so that they would be effective as decorative paint. (2 marks)

(e) The discovery of new mineral deposits has made a range of new pigments available for the production of modern paint.

(i) Describe the general composition of modern paint. In your answer, describe the function of each component. (3 marks)

(ii) Name ONE mineral used to make pigment for modern paint. Describe its composition and state the colour of the pigment that is produced from the mineral. (3 marks)

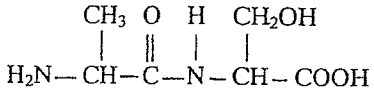
(f) During your course, you performed a first-hand investigation to determine the flame colour of a range of metallic ions.

(i) Name ONE metallic ion used in your investigation and state its colour. (1 mark)

(ii) Explain why some elements are able to produce coloured flames. (2 marks)

Question 32: (25 marks) **Forensic Science**

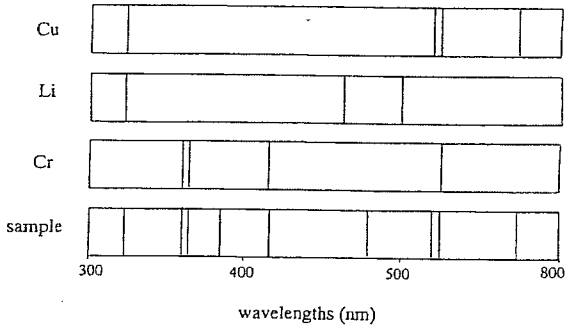
(a) (i) The structure below represents a dipeptide formed by the alanine and serine amino acids:



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

(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 marks)

(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 marks)

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

(c) A forensic scientist is often analysing very small samples of material. The results of these analyses may be used as evidence in a court of law so accuracy is critical. Outline TWO precautions that may be necessary to ensure accuracy and prevent contamination of samples for analysis. (2 marks)

(d) (i) The structure of deoxyribonucleic acid (DNA) contains hydrogen bonds between adenine and thymine, and between guanine and cytosine bases.

Outline the structure and composition of DNA, including an explanation of the role of these hydrogen bonds. (3 marks)

(ii) The DNA molecular chain contains "coding" sequences (the genes) and "non-coding" sequences (between the genes).

DNA analysis is a powerful tool for identifying whether two different samples came from the same person, related people or different persons. It can also be used to identify the parents of an individua.

Explain why analysis of DNA allows identification of individuals and relationships between people. (3 marks)

(e) Advances in technology have provided forensic chemists with a range of methods that can be useful in the analysis of very small samples of material, such as mass spectrometry and atomic emission spectroscopy.

(i) Outline how a mass spectrometer works, indicating how this technology can be used by a forensic chemist. (3 marks)

(ii) All elements have an identifiable emission spectrum and this can be used to identify trace elements. Explain why excited atoms in the gas phase emit only certain wavelengths of light and account for the fact that each element produces its own signature line emission spectrum. (2 marks)

(f) (i) What class of compounds is used to break proteins into fragments of different lengths? (1 mark)

(ii) Describe the processes of electrophoresis and chromatography in separating organic compounds. (4 marks)