ABBOTSLEIGH

2 UNIT CHEMISTRY HSC COURSE

August Assessment 2001

Time Allowed: 3 hours

DIRECTIONS TO CANDIDATES
This paper contains **TWO** sections covering Core and Options.

SECTION 1: The Core (60 marks)
Attempt all questions in the answer book provided.

PART A: 10 Multiple choice questions (1 mark each)
PART B: Free response questions – answer in the spaces provided.

SECTION 2: The Options (40 marks)
Answer the questions on **ONE** of the following electives –

Forensic Chemistry **OR** Shipwrecks and Salvage.

Answers to be written on the paper provided and handed in as a separate bundle.

A Periodic table and data sheet is provided.

SECTION 1 – CORE
Part A
(10 multiple choice questions)

Each question is worth 1 mark.
Select the alternative A, B, C or D that best answers the question.
Mark your answers in pencil on the Answer Sheet provided.

1. Chlorine reacts with butene to form 1,2-dichlorobutane. This type of reaction is called:

   (A) addition.
   (B) oxidation.
   (C) hydrolysis.
   (D) substitution.

2. Which of the following solutions has the lowest pH?

   (A) 0.1M ethanoic (acetic) acid.
   (B) 0.1M hydrochloric acid.
   (C) 0.2M sodium hydroxide.
   (D) 0.2M nitric acid.

3. The oxidation number of nitrogen in $NO_{(g)}$, $N_2O_{(g)}$ and $N_2O_{4(g)}$ is:

   (A) 2, 4 and 6 respectively.
   (B) 4, 4 and 2 respectively.
   (C) 2, 1 and 2 respectively.
   (D) 2, 1 and 4 respectively.

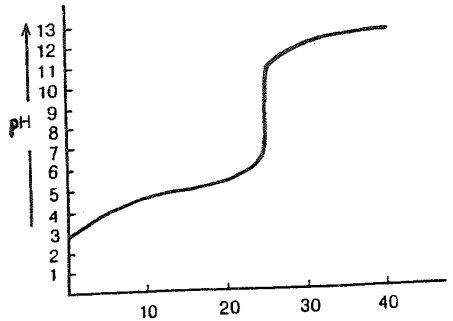
4. When fluorine is bubbled through a solution of sodium bromide, bromine gas is formed. The reaction could be represented as:

   $$2Br^-_{(aq)} + F_{2(g)} \rightarrow Br_{2(g)} + 2F^-_{(aq)}$$

   In this reaction:

   (A) F_2 is the reducing agent.
   (B) F_2 is the oxidant.
   (C) Br^- is the oxidising agent.
   (D) F^- is the reductant.

5. The diagram shows the titration curve of a dilute solution of sodium hydroxide and a dilute solution of acetic acid (ethanoic acid). The accompanying table shows a list of indicators and the pH ranges over which they are useful.



Indicator	pH Range
Bromocresol green	3.8 – 5.4
Methyl red	4.4 – 6.0
Methyl orange	3.1 – 4.4
Phenol red	6.8 – 8.4

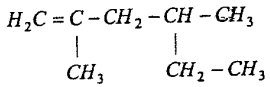
The most suitable indicator for this titration is:

(A) methyl orange.
(B) bromocresol green.
(C) methyl red.
(D) phenol red.

6. Equal volumes of $1molL^{-1}NaOH$ and $1molL^{-1}CH_3COOH$ are mixed thoroughly in a beaker. the resulting pH is:

(A) equal to 7, because the mixture is neutral.
(B) greater than 7, because an acidic salt is produced.
(C) greater than 7, because an alkaline salt is produced.
(D) less than 7, because an alkaline salt is produced.

7. What compound is shown?



(A) 2-methyl-4-ethyl-1-pentene
(B) 2,4-dimethyl-1-hexene
(C) 3,5-dimethyl-5-hexene
(D) 4-ethyl-2-methyl-1-pentene

8. The hydrogen carbonate ion $\left(HCO_3^-\right)$ is amphiprotic. Which statement is correct?

(A) HCO_3^- is the conjugate base of CO_3^{2-}
(B) H_2CO_3 is the conjugate acid of CO_3^{2-}
(C) CO_3^{2-} is the conjugate base of H_2CO_3
(D) H_2CO_3 is the conjugate acid of HCO_3^-

9. $50mL$ of a $0.200molL^{-1}$ solution of sodium hydroxide is diluted to $2.0L$ with distilled water. What is the pH of the diluted solution?

(A) 11.7
(B) 12.3
(C) 12.7
(D) 13.3

10. One of the best known condensation processes was discovered by Wallace Carothers in 1932 when he made nylon. The two compounds Carothers used to make nylon were adipic acid and a diamine. The products of the reaction would have been:

(A) nylon alone.
(B) nylon and water.
(C) nylon, adipic acid and a diamine.
(D) nylon, adipic acid, a diamine and water.

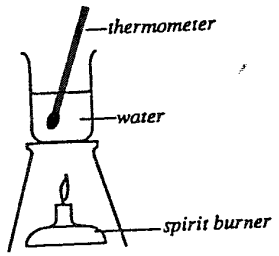
PART B
Questions 11-19 Free Response Questions

Marks allocated for each question are shown.

Marks

11. Outline the role of a chemist employed in a named industry or enterprise. In your answer state the branch of Chemistry undertaken by the chemist and the chemical principle that the chemist used. **(2)**

12. A chemistry student set up the following equipment to measure the heat of combustion of ethanol. Pure ethanol was used as the fuel in the spirit burner.



(a) In order to calculate the heat of combustion of ethanol, what measurements must the student make?

(b) In the experiment the student found that the combustion of 0.30g of ethanol produced an energy change of 5.2kJ. Calculate the experimental molar heat of combustion for ethanol.

(c) The accepted value for the heat of combustion of ethanol, 1364kJ mol^{-1}, is higher than the value obtained experimentally. Account for the difference between the two values.

(d) If ethanol is burnt in an insufficient supply of oxygen, it burns with a yellow flame due to the presence of carbon particles. Write a balanced equation for the reaction under these conditions. **(4)**

13. (a) Vinyl chloride has the formula $CH_2 = CH - Cl$. What is the systematic name for this compound?

(b) Draw diagrams using structural formulae to explain the formation of polyvinyl chloride (PVC) from vinyl chloride.

(c) Give one use for PVC, explaining the properties which make it suitable for this purpose. **(3)**

14. Britain's Nuclear Installations Inspectorate has recently released a report on nuclear waste storage. The report states that over 40 000 cubic metres of intermediate-level nuclear waste is in danger of leaking. The wastes have been produced by electricity-generating nuclear reactors. They include some plutonium, which is a fissionable material.

Plutonium is formed in two steps. In the first step, uranium-239 undergoes β-decay. The isotope formed also undergoes β-decay to create plutonium.

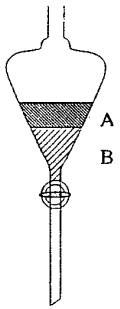
(a) Write the two nuclear equations which show how plutonium is formed.

(b) What problem could be caused by large amounts of plutonium leaking and accumulating?

(c) State one advantage of using a nuclear reactor to generate electricity over the use of fossil fuels, such as coal.

(d) Why must nuclear waste be stored safely for long periods of time? **(4)**

15. A student was given the task of separating as ester from water. She used the following piece of equipment.



(a) Name the piece of equipment.

(b) Layer A is the ester. Why is it separate from the water layer? Justify your answer in terms of the bonding present between the molecules in each layer.

(c) There may have been some acid remaining in the mixture. Name the chemical which is used to remove the excess acid.

(d) The ester formed was propyl butanoate. Write a balanced chemical equation, using structural formulae, to represent the formation of this ester.

(e) Explain why concentrated sulfuric acid is added to the reaction mixture in esterification.

(f) Explain why esterification is carried out under reflux. **(5)**

16. (a) The development of ideas about the nature of acids has changed since 1780, when Antoine Lavoisier proposed that acids were substances which contained oxygen. Outline the roles of Davy, Arrhenius, and Bronsted / Lowry in our present understanding of acids. (3)

(b) Use the reaction between the copper ion and ammonia shown in the equation below to explain how Lewis extended the definition of an acid.

$$Cu^{2+}_{(aq)} + 4NH_{3(g)} \rightleftharpoons Cu(NH_3)^{2+}_{4\,(aq)}$$

Use Lewis diagrams of the copper ion and ammonia to clarify your answer (full equation not necessary). (2)

17. The production of ammonia from nitrogen and hydrogen by the Haber process, is an important example of an equilibrium reaction. The reaction involves an energy change of 92kJ per mole of $N_2(g)$ used at 25°C. The yield of ammonia depends on both the temperature and pressure of the reactants. In the following table, the percentage yield of ammonia, at a pressure of $200 \times 10^2\,kPa$ for the reaction mixture, is given.

Temperature (°C)	Percentage yield of ammonia
200	90
300	64
350	51
400	39
500	20

(a) Predict whether the production of ammonia in this process is exothermic or endothermic. *Explain your answer.* (1)

(b) Write a balanced equation for the equilibrium involved in the production of ammonia. *Include the energy term and the physical states for all species.* (1)

(c) Explain, using Le Chatelier's principle, why the conditions of temperature and pressure used in the Haber process are a compromise. (4)

(d) The Haber process was developed into an important industrial process by Carl Bosch in 1914. Explain the significance of this development at that time in world history. (1)

(e) Give an example of a catalyst used in the Haber process and explain the advantage of its use. (1)

(f) State one reason why it is important to continuously monitor the reaction chamber in which the ammonia is produced. (1)

(g) Give one use of ammonia. (1)

18. (a) Describe briefly how ozone is formed in the stratosphere. Include 2 chemical equations as part of your answer. (2)

(b) Draw electron dot diagrams to shows the difference in bonding between O_2 and O_3 molecules. (2)

(c) Explain one difference in property between O_2 and O_3 in terms of their bonding. (2)

(d) The ozone in the earth's atmosphere can be regarded as a 'friend or foe'. discuss this statement with regard to the location and properties of naturally occurring ozone. (4)

19. The 'health' of diesel locomotives is monitored by analysis of oil samples taken from the motor. Railway chemists check viscosity and for the presence of water and metals in the oil using atomic absorption spectroscopy. A high concentration of a particular metal is often a good indication of a wearing component. In one such analysis for silver, 5mL of oil was diluted to 50mL in a suitable solvent and the following results were obtained.

Standard Solution Concentration (ppm)	Absorption
0.00	0.015
1.00	0.105
2.00	0.195
3.00	0.285
4.00	0.375
Sample	0.230

(a) Use the above table to plot a graph of absorption against concentration of silver. (2)

(b) Determine the concentration of silver in the diluted sample of oil. (1)

(c) Determine the concentration, in ppm, of silver in the original sample. (1)

(d) Calculate the concentration of silver in the original sample in moles per litre. (1)

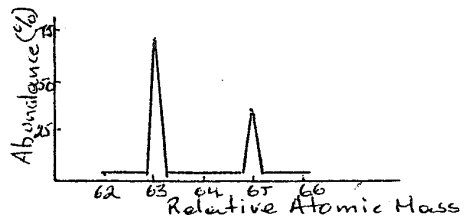
(e) Briefly explain how atomic absorption spectroscopy can be used to detect the presence of silver in the sample. (2)

SECTION 2 – OPTIONS

FORENSIC CHEMISTRY
Answer all questions.

1. (a) Briefly outline how a mass spectrometer works.

   (b) The mass spectrum for metallic copper is shown below.



   (i) What information does the mass spectrum provide?

   (ii) Explain why the observed relative atomic mass of copper is 63.55.

(6 marks)

2. (a) Which one could be classified as a carbohydrate? Explain your choice.

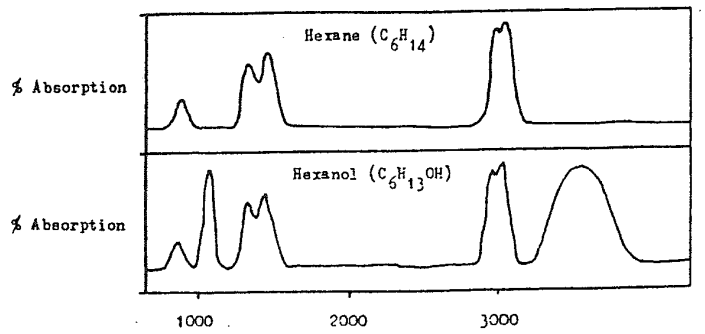
   (i) H_2CO_3
   (ii) $C_5H_{10}O_5$
   (iii) CH_3COOH
   (iv) $C_{10}H_8O$

   (b) Glycogen, cellulose and starch are called polysaccharides (polymers). Give the structural formula of the monomer unit.

   (c) Describe how these polymers (above) are different in terms of properties and structure.

(5 marks)

3. The infra-red spectra of hexane (C_6H_{14}) and hexanol ($C_6H_{13}OH$) are given below.



   (a) What is the cause of absorption peaks in the spectra?

   (b) Why are there two additional absorption peaks in the infra-red spectrum of hexanol?

   (c) Infra-red spectrometry is not always available. Outline a simple chemical test that could be used to distinguish between these two compounds. Include equations where necessary.

(4 marks)

4. Fatty acids are found in plants and animals. Fatty acids derived from plants are usually unsaturated. Both saturated and unsaturated fatty acids can be converted into lipids – fats and oils.

   (a) What is meant by the term unsaturated?

   (b) Give the name for the compound which reacts with fatty acids to form fats and oils.

   (c) Draw the structural formula for the fat formed from the compound named in (b) above and stearic acid, $CH_3(CH_2)_{16}COOH$.

   (d) Why is the fat in (c) above far less soluble in water than the compounds from which it is formed?

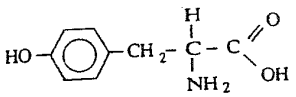
(4 marks)

5. Enkephalins are substances in the brain that can function as neurotransmitters. Leucine-enkephalin is one example which has the following sequence of amino acids:

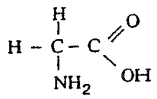
Tyr – Gly – Fly – Phe – Leu

(a) Enkephalins are members of what group of biochemicals?

(b) Tyr is the abbreviation for tyrosine which has the structural formula:



and Gly is the abbreviation for glycine which has the structural formula:



Draw the structural formula of Tyr-Gly.

(c) Name the type of bond linking the amino acids Tyr and Gly.

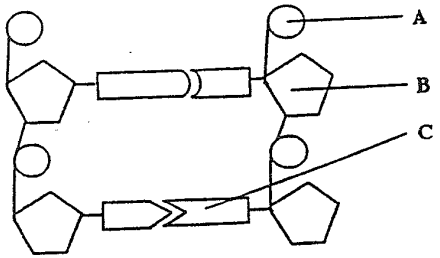
(d) The amino acid glycine can be represented as a zwitterion. Draw the zwitterionic form of glycine.

(e) Draw the ionic form which would predominate at low pH(<3).

(f) Chromatography and electrophoresis can both be used to separate a mixture of amino acids. For each technique state the property(ies) of amino acids that is used in the separation process.

(7 marks)

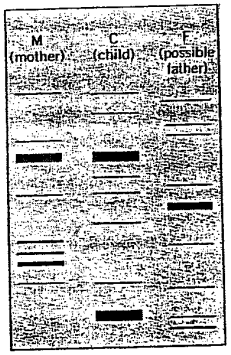
6. Pictured below is a diagram depicting a short length of DNA.



(a) What three major components of DNA do the symbols labelled A, B and C represent?

(b) In forensic work it is extremely important to avoid contamination of samples. Explain why it is especially significant in DNA analysis.

(c) DNA 'finger printing' is used in criminal cases and paternity cases. Consider the set of DNA evidence below.



Does the evidence suggest that the suspect was responsible? Explain your reasoning.

(6 marks)

2 UNIT CHEMISTRY – PART THREE
Shipwrecks and Salvage Option

A chemist wants to set up an electrochemical cell based on magnesium and copper.

(a) Give a sketch showing how the chemist could set up such a cell. Label your cell clearly, showing the chemicals she would use.

(b) (i) Assuming standard conditions, calculate the expected voltage of the cell.
(ii) How does your calculation show that the reaction is spontaneous?
(iii) As the cell operates, the voltage you calculated in (i) falls. Explain.

(c) What is the oxidizing agent in the cell reaction? Explain. **(5 marks)**

2. Television commercials about 'batteries' (which should correctly be called 'cells') often compare 'normal batteries' (Leclanche cells) with 'alkaline batteries'. The following stable shows some information about each type of cell.

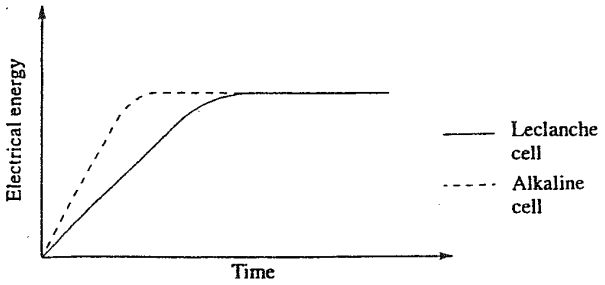
Property	*Cell Type*	
	Leclanche	*Alkaline*
outer casing	zinc	steel
anode	solid zinc outer casing	powdered zinc at centre
cathode	manganese (IV) oxide	manganese (IV) oxide
electrolyte	concentrated paste of NH_4Cl and $MnCl_2$	concentrated KOH

For both cells, the overall equations are quite complicated. However it is quite clear that both cells involve the oxidation of zinc.

(a) Write a half-equation which shows the process which occurs at the anodes in both cells.

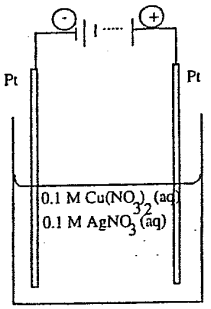
(b) "Normal batteries' can leak if left to run down in an appliance and are not replaced. Why can this leak develop?

(c)



According to the graph above, the times taken by 'alkaline batteries' and 'normal batteries' to develop their maximum electrical energies are not the same. Suggest a reason for this. **(3 Marks)**

3. A student is supplied with the following electrolytic cell



Volume of electrolyte = 1 L

The electrolyte has a volume of 1 L and is a mixture of 0.1M $Cu(N0_3)_2(aq)$, 0.1M $AgN0_3(aq)$. The electrodes are inert platinum.

A current of 0.1 A is passed through the electrolyte for 60 minutes. Calculate the mass of metal deposited on the cathode in this time. (You should assume that one metal is deposited completely before any other reaction begins.) **(5 marks)**

4. An absentminded yachtsman used iron rivets to secure an aluminium mast to a yacht.
Referring to the Redox Table, explain why this was not a sensible idea and suggest a suitable alternative to iron. **(2 marks)**

5. The corrosion of iron is a major industrial and domestic problem. Corrosion, and its prevention, cost billions of dollars worldwide each year.

(a) Iron sheeting can be protected from corrosion by galvanizing it

Explain how galvanizing prevents iron from corroding.

(b) (i) When a piece of iron is corroding, an electrochemical cell is set up.
The reduction half-reaction is
$O_2(g) + 2H_20(l) + 4e^- \rightarrow 4OH^-(aq)$

The oxidation half-reaction is
$Fe(s) \rightarrow Fe^{2+}(aq) + 2e^-$

Show that the corrosion of iron is a spontaneous reaction.

(ii) How do the electrons move from the oxidation site to the reduction site?

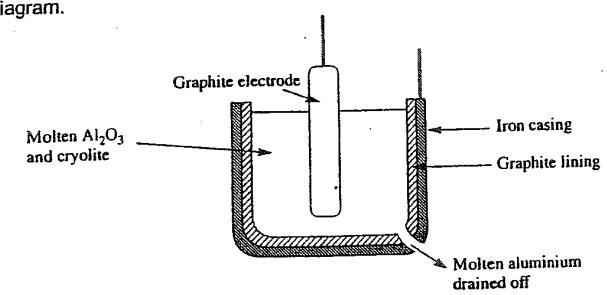
(iii) Explain why the corrosion of iron occurs more readily in an acidic environment.

(5 marks)

6. Refer to the table of information below for the following questions.

Substance	*Melting point (°C)*
aluminium	660
graphite	3730
iron	1540
aluminium oxide $A1_2O_3$	2045
Al_2O_3 and cryolite mixture	2020

The process of forming pure aluminium from aluminium oxide Al_2O_3 was first successfully performed in 1886. This process is shown in the following diagram.



A mixture of aluminium oxide and cryolite is kept molten in a large iron box lined with graphite. This lined box acts as the cathode. Another graphite electrode is placed into the mixture. During the electrolysis, carbon dioxide gas forms at this electrode. Molten aluminium falls to the bottom of the box and is drained off.

(a) Aluminium is more abundant than iron in the Earths crust. However, pure aluminium was not obtained until many hundreds of years after pure iron was obtained. Suggest a reason why it took so long to obtain pure aluminium.

(b) Using oxidation numbers, show whether the reaction of Al_2O_3 to form pure Al is an oxidation or a reduction process.

(c) Suggest a reason why a mixture of aluminium oxide and cryolite, rather than pure aluminium oxide, is used in this electrolytic cell.

(d) Give TWO reasons why graphite is used as the electrodes.

(e) Write a half equation which shows the formation of the aluminium.

(f) The anode in this cell needs to be replaced. Use a half-equation to help explain why this is so.

(g) Explain why an aqueous solution of aluminium oxide is not a suitable alternative to the aluminium oxide and cryolite mixture in this cell.

(9 marks)

7. Corrosion of ships is a major problem for shipowners and one that is both costly to combat and a constant concern.

(a) Explain why ships that are ocean going are more susceptible to corrosion than those that only sail in freshwater.

(b) Give one method used to protect

(i) the hull that is below the waterline.

(ii) the superstructure that is above the waterline.

(c) Explain the chemistry involved in your choice in (b)(i). **(6 marks)**

8. Shipwrecks are often exposed to the marine environment for hundreds of years. When discovered, even those that are found in deep water show considerable corrosion.

(a) How would you expect the low temperatures at great depths to affect the rate of corrosion. Explain.

(b) What is chiefly responsible for the majority of corrosion at depth.

(3 marks)

9. Saturation of wrecks by chloride and sulfate ions is the biggest challenge for conservators as they try to restore marine artifacts.

(a) Explain why chloride ions are such a problem.

(b) How do conservators remove chloride ions? Explain this process.

(4 marks)