



CHEMISTRY
STANDARD LEVEL
PAPER 3

Wednesday 8 November 2000 (morning)

1 hour 15 minutes

Name

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INSTRUCTIONS TO CANDIDATES

- Write your candidate name and number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all of the questions from three of the Options in the spaces provided. You may continue your answers in a continuation answer booklet, and indicate the number of booklets used in the box below. Write your name and candidate number on the front cover of the continuation answer booklets, and attach them to this question paper using the tag provided.
- At the end of the examination, indicate the letters of the Options answered in the boxes below.

| OPTIONS ANSWERED | | EXAMINER | TEAM LEADER | IBCA |
|---|-------|--------------|--------------|--------------|
| | | /15 | /15 | /15 |
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| NUMBER OF CONTINUATION BOOKLETS USED | | TOTAL /45 | TOTAL /45 | TOTAL /45 |

[10]

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A2. (a) Use the Valence Shell Electron Pair Repulsion (VSEPR) theory to deduce the shapes of the following three molecules which all have carbon as the central atom.

(i) HCN [1]

(ii) H₂CO [1]

(iii) H₂CCl₂ [1]

(b) Silicon is below carbon in Group 4 of the Periodic Table. It can form a complex ion with chlorine with the formula [SiCl₆]²⁻.

(i) How many pairs of outer shell electrons are around the central silicon atom in the complex ion? [1]

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(ii) Deduce the shape of the complex ion. [1]

Option B – Higher physical chemistry

B1. The formula and the pK_a value for propanoic acid are given in Table 16 in the Data Booklet.

- (a) Write an equation for the dissociation of propanoic acid in water. [1]

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- (b) Give the equilibrium expression and the value of K_a for the dissociation of propanoic acid in water. [2]

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- (c) Determine the hydrogen ion concentration of a $0.010 \text{ mol dm}^{-3}$ aqueous solution of propanoic acid. [2]

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- (d) Calculate the pH of the solution formed when 200 cm^3 of $0.010 \text{ mol dm}^{-3}$ NaOH is added to 300 cm^3 of $0.010 \text{ mol dm}^{-3}$ propanoic acid solution. [4]

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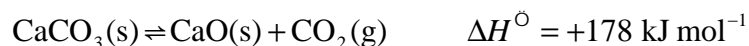
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B2. Limestone, CaCO_3 , decomposes according to the equation:



- (a) The numerical value for the standard entropy change is $161 \text{ J K}^{-1} \text{ mol}^{-1}$. Explain in terms of the reactants and products whether this value is positive or negative. [1]

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- (b) Use the above data to calculate a value for the standard Gibbs free energy change for the decomposition of limestone. [2]

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- (c) Explain what is meant by a *spontaneous* reaction. [1]

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- (d) At what temperature would the above reaction become spontaneous? [2]

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Option C – Human biochemistry

C1. Vitamin A is the general name for a group of substances that include retinol and retinal, both of which contain carbon to carbon double bonds.

- (a) As their names suggest retinol and retinal differ in their structures by one functional group. Give the structure of this functional group for each compound. [2]

Retinol:

Retinal:

- (b) In terms of electrons what is meant by the expression *double bond*? [1]

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- (c) The molecular formula of retinol is $C_{19}H_{30}O$. 100 cm^3 of blood contains about 30 mg of retinol. Calculate the approximate concentration of retinol in the blood in mol dm^{-3} . [2]

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- (d) Given the above information, state whether the solubility of retinol will be greater in water or in fat and explain your answer. [2]

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C2. The structure of thyroxine, a hormone, is given in the Data Booklet.

- (a) Name the element present in thyroxine which is absent from other hormones in the human body. [1]

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- (b) Apart from the –OH group attached to the benzene ring, name and draw the structures of **two** other functional groups in thyroxine. [4]

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- (c) State the general role of hormones and state how they are transported in the body. [2]

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- (d) What is the specific role of thyroxine in the human body? [1]

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Option D – Environmental chemistry

D1. When the pH of rain water falls below about 5.6 it is known as *acid rain*.

- (a) What is the ratio of the hydrogen ion concentration in acid rain with a pH of 4 compared to water with a pH of 7? [1]

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- (b) One of the two major acids present in acid rain originates mainly from the burning of coal. **Name** this acid and give equations to show how it is formed. [3]

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- (c) The second major acid responsible for acid rain originates mainly from internal combustion engines. **Name** this acid and state **two** different ways in which its production can be reduced. [3]

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- (d) Acid rain has caused considerable damage to buildings and statues made of marble (CaCO_3). Write an equation to represent the reaction of acid rain with marble. [1]

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- D2.** (a) In order to survive, fish require water containing dissolved oxygen. Discuss briefly how an increase in each of the following factors affects the amount of dissolved oxygen in a lake. [3]

(i) Temperature:

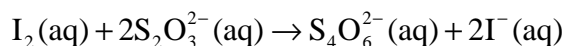
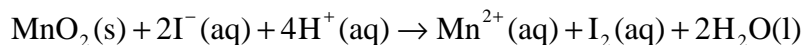
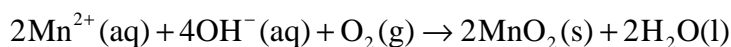
(ii) Organic pollutants:

(iii) Nitrates and phosphates:

- (b) Define *Biological Oxygen Demand (BOD)*. [1]

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- (c) In a method to find the concentration of dissolved oxygen, manganese(IV) oxide is formed. This is then used to release iodine which is titrated with standard thiosulfate solution. The equations for these three steps are:



1000 cm³ of a sample of water was processed by this method. It was found that 10.0 cm³ of 0.100 mol dm⁻³ Na₂S₂O₃ solution were required to react with the iodine produced. Calculate the concentration of dissolved oxygen in g dm⁻³ in the water sample. [3]

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Option E – Chemical industries

- E1.** (a) When iron is produced in a blast furnace the product is known as *pig iron*. Pig iron contains about 5 % impurities.
- (i) Name the major impurity found in pig iron. [1]
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- (ii) *Wrought iron* has a higher melting point than pig iron. From this information what can be deduced about the percentage of iron in wrought iron compared to pig iron? [1]
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- (b) Pig iron can be converted into steel in a basic oxygen converter. Iron is added to the converter, it is melted and then two chemicals are added.
- (i) Name the **two** chemicals added. [2]
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- (ii) Describe the essential processes that take place during the conversion of iron to steel. [2]
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-
- (c) Both iron and aluminium can be recycled. Suggest **one** reason why it is more economical to recycle aluminium than steel. [1]
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- E2.** (a) Explain why crude oil contains small amounts of sulfur. [1]

 (b) Why must the sulfur be removed from crude oil before further refining takes place? [1]

 (c) One of the chemical processes used in the refining of crude oil is *cracking*. Give a balanced equation for the thermal cracking of $C_{10}H_{22}$ and explain why the process is important. [2]

 (d) Crude oil can also be refined by *re-forming*. Two re-forming processes are *isomerisation* and *alkylation*. State the essential difference between the two processes. [2]

 (e) A third type of re-forming is *cyclisation and aromatisation*. One such example is the conversion of hexane to benzene using a catalyst at 500 °C and a pressure of 20 atmospheres.
 (i) Write a balanced equation for this reaction. [1]

 (ii) For which important industrial process is the inorganic product from this reaction used as a feedstock? [1]

Option F – Fuels and energy

- F1.** (a) When biomass, such as animal waste, decomposes in the absence of oxygen, *biogas* is formed. Name the main gas present in biogas. [1]
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- (b) When wood and crop residues are burnt in a limited amount of oxygen, a mixture of gases known as *producer gas* is formed. Name **one** combustible gas present in producer gas. [1]
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- (c) Name **two** substances hazardous to health which are produced when wood is burnt in an enclosed space. [2]
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- (d) Why is biomass likely to become more important as a fuel in the future? [1]
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F2. (a) In the context of nuclear reactions, explain the meaning of *fission*.

[1]

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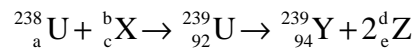
(b) Explain why a fission reaction results in the release of a large quantity of energy.

[1]

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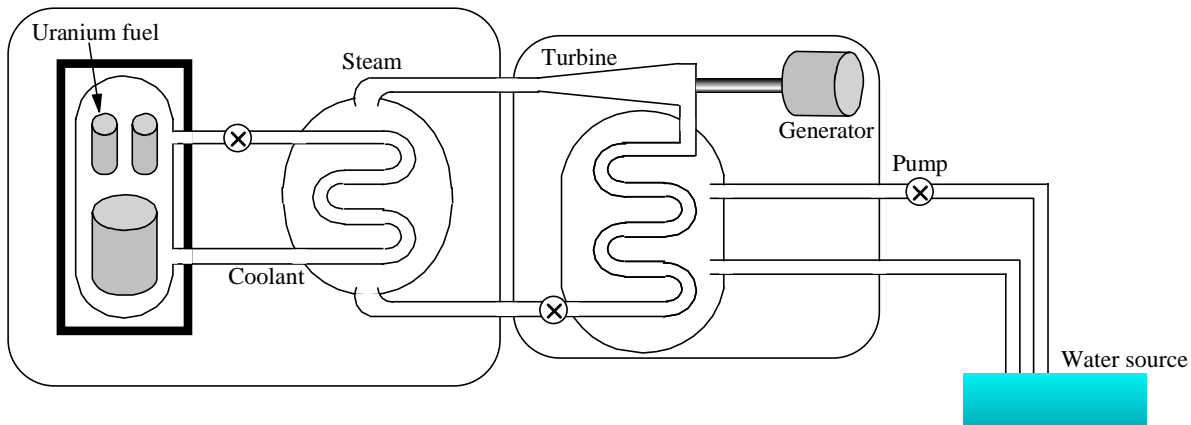
(c) The main reaction in a uranium reactor is fission of ^{235}U . A side reaction is caused when neutrons react with ^{238}U . Complete the following equation by filling in the symbols and values in the table below:

[4]



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|---|--|---|--|
| X | | b | |
| Y | | c | |
| Z | | d | |
| a | | e | |

(d) A diagram of a nuclear power plant to produce electricity is shown below:



The water which produces the steam to drive turbines in a nuclear power plant is not heated directly. Explain why more than one heat exchange loop is used and name **one** substance used in the primary cooling loop.

[2]

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(This question continues on the following page)

(Question F2 continued)

- (e) ^{14}C can be used for dating organic remains. Whilst a plant or animal is alive the amount of ^{14}C remains constant. At death the amount of ^{14}C decreases by a first order reaction with a half-life of 5730 years. In a living sample the $^{14}\text{C} : ^{12}\text{C}$ ratio is 1.2×10^{-12} . If an object is found with a $^{14}\text{C} : ^{12}\text{C}$ ratio of 1.5×10^{-13} , how old is the object?

[2]

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