

CHEMISTRY
STANDARD LEVEL
PAPER 3

Candidate number

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Wednesday 19 May 2004 (morning)

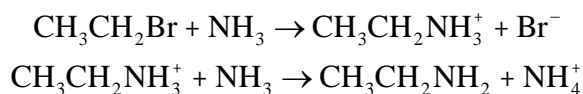
1 hour

INSTRUCTIONS TO CANDIDATES

- Write your candidate number in the box above.
- Do not open this examination paper until instructed to do so.
- Answer all of the questions from two of the Options in the spaces provided. You may continue your answers on answer sheets. Write your candidate number on each answer sheet, and attach them to this examination paper using the tag provided.
- At the end of the examination, indicate the letters of the Options answered in the candidate box on your cover sheet and indicate the number of answer sheets used in the appropriate box on your cover sheet.

Option A – Higher Physical Organic Chemistry

A1. Bromoethane reacts with ammonia as follows.



The mechanism for this reaction is described as S_N2.

- (a) State the meaning of each of the symbols in S_N2. [2]

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- (b) State the name of the organic product of the reaction, CH₃CH₂NH₂. [1]

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- (c) Explain, using “curly arrows” to show the movement of electron pairs, the mechanism of the attack by ammonia on bromoethane, and show the structure of the transition state. [4]

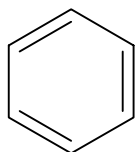
- (d) The infrared spectrum of CH₃CH₂NH₂ shows two absorptions not shown by bromoethane. Identify the bonds responsible for these absorptions. [1]

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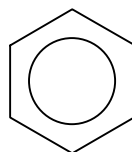
- (e) Determine the number of peaks, and the ratio of the areas under them, in the ¹H NMR spectrum of CH₃CH₂NH₂. [2]

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A2. The structure of benzene can be represented in two ways.



structure **A**



structure **B**

- (a) Use information from Table 9 of the Data Booklet to explain why structure **B** is used instead of structure **A**. [2]

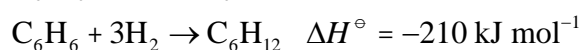
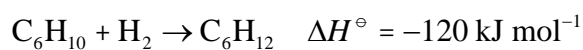
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- (b) The enthalpy changes for the hydrogenation of cyclohexene and benzene are as follows



Explain how this information can be used to support the statement that structure **B** is more stable than structure **A**. [3]

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A3. The value of the ionic product constant of water, K_w , at 60 °C is $5.60 \times 10^{-14} \text{ mol}^2 \text{ dm}^{-6}$.

(a) State the expression for K_w . [1]

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(b) Calculate the values of $[\text{H}^+]$ and pH in water at 60 °C. [3]

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(c) The value of $[\text{OH}^-]$ in water at 60 °C is greater than the value at room temperature. Explain why water is not alkaline at 60 °C. [1]

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Option B – Medicines and Drugs

B1. The structures of some analgesics are shown in Table 21 of the Data Booklet. Refer to this table when answering parts (b) and (c) of this question.

- (a) Explain the difference in the method of action of mild analgesics and strong analgesics. [2]

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- (b) State the name of the nitrogen-containing functional group in each of the following molecules. [2]

Paracetamol

Heroin

- (c) Naturally-occurring morphine can be converted into synthetic heroin by reaction with ethanoic acid. Identify the group in the morphine molecule that reacts with ethanoic acid, the name of the type of reaction and the other product of the reaction. [3]

Group in morphine molecule

Type of reaction

Other product of reaction

B2. Penicillins are molecules that can kill harmful micro-organisms. Their general structure is shown in Table 21 of the Data Booklet.

- (a) State the type of micro-organism killed by penicillins and explain how they do this. [4]

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- (b) Explain the effect of overprescription of penicillins. [3]

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- B3.** (a) Describe the differences between bacteria and viruses, by referring to their structures and the way they multiply. [4]

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- (b) Outline **two** ways in which antiviral drugs work. [2]

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Option C – Human Biochemistry

- C1.** (a) The structures of three important vitamins are shown in Table 22 of the Data Booklet. State the name of each one and deduce whether each is water-soluble or fat-soluble, explaining your choices by reference to their structures. [5]
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- (b) Identify the metal ion needed for the maintenance of healthy bones and state the name of the vitamin needed for its uptake. [2]
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- (c) State the name of the vitamin responsible for maintaining healthy eyesight and the name of the functional group which is most common in this vitamin. [2]
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- (d) Identify **one** major function of vitamin C in the human body and state the name of the most common disease caused by deficiency of this vitamin. [2]
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- (e) Fresh fruits and vegetables are good sources of vitamin C. Explain why some meals made from these foods may contain little vitamin C. [2]
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C2. The structures of two sex hormones, progesterone and testosterone, are shown in Table 22 of the Data Booklet.

- (a) State the names of **two** functional groups that are present in **both** hormones. [2]

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- (b) Identify which of the two hormones is the female sex hormone and where in the human body it is produced. [2]

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- (c) Outline the mode of action of oral contraceptives. [3]

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Option D – Environmental Chemistry

D1. The term *greenhouse effect* is used to describe a natural process for keeping the average temperature of the Earth’s surface nearly constant.

- (a) Describe the greenhouse effect in terms of radiations of different wavelengths. [4]

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- (b) Water vapour acts as a greenhouse gas. State the main natural and man-made sources of water vapour in the atmosphere. [2]

Natural source

Man-made source

- (c) Two students disagreed about whether carbon dioxide or methane was more important as a greenhouse gas.

- (i) State **one** reason why carbon dioxide could be considered more important than methane as a greenhouse gas. [1]

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- (ii) State **one** reason why methane could be considered more important than carbon dioxide as a greenhouse gas. [1]

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(This question continues on the following page)

(Question D1 continued)

- (d) Discuss the effects of global warming on the Earth.

[4]

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- D2.** (a) Describe how pure water can be obtained from sea water by ion exchange (you may assume that sea water is sodium chloride solution).

[5]

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- (b) Explain why water purified by ion exchange may be further treated with ozone, and state **two** advantages of using ozone rather than chlorine.

[3]

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Option E – Chemical Industries

E1. A major product of oil refining is fuel for automobiles. Two processes used in the refinery are sulfur removal and reforming.

- (a) (i) Explain why sulfur is removed from oil. [2]

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- (ii) Some of the sulfur in oil is present as hydrogen sulfide. One method of removing this is by reaction with the carbonate ion, CO_3^{2-} , during which hydrogen sulfide is converted into HS^- ions. Deduce the equation for this reaction. [1]

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- (iii) Hydrogen sulfide can also be reacted with sulfur dioxide to produce one of the raw materials for sulfuric acid manufacture. Deduce the equation for this reaction. [2]

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- (b) The process of reforming converts straight-chain alkanes into more useful hydrocarbons. For example, hexane, $\text{CH}_3(\text{CH}_2)_4\text{CH}_3$, can be converted into the compounds $(\text{CH}_3\text{CH}_2)_2\text{CHCH}_3$ and C_6H_6 .

- (i) For each of these conversions, state the type of reforming process and the name of the compound formed. [4]

$(\text{CH}_3\text{CH}_2)_2\text{CHCH}_3$

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C_6H_6

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- (ii) The formation of C_6H_6 from hexane results in another product. Identify this product and state **one** industrial use for it. [2]

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E2. Aluminium is produced on a large scale by the electrolysis of alumina.

- (a) Give the formula of alumina. [1]

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- (b) Explain why cryolite is used in the process. [2]

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- (c) Write an equation to show what happens to each of the following ions during electrolysis. [2]

Al^{3+}

O^{2-}

- (d) Identify the material used for the positive electrodes (anodes) and explain, with the help of an equation, why it has to be replaced regularly. [3]

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- (e) Suggest why much more aluminium is recycled than iron. [1]

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Option F – Fuels and Energy

F1. State **two** advantages of converting coal to a liquid fuel. [2]

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F2. One of the compounds present in gasoline is heptane, C_7H_{16} . Heptane has an octane number of 0.

(a) State the name of the problem that occurs when heptane is used as the fuel in an automobile engine. [1]

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(b) State the name of the alkane that has an octane number of 100. [2]

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(c) Outline the structural difference between heptane and the alkane in (b). [1]

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(d) Suggest **one** type of substance that could be added to heptane to increase the octane number of the fuel. [1]

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(This question continues on the following page)

(Question F2 continued)

- (e) A sample of heptane was burned in a calorimeter. Calculate the molar enthalpy of combustion of heptane using the following data.

Mass of heptane burned = 2.00 g

Mass of water in calorimeter = 250 g

Temperature change of water = 52.7 °C

[5]

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- F3.** (a) Radioactive isotopes can emit α , β and γ radiation, each of which has its own characteristics.

List these radiations in **decreasing** order (starting with the largest value) of: [4]

mass

charge magnitude

penetrating power

amount of deflection in an electric field

- (b) Discuss the similarities and differences between *nuclear fission* and *nuclear fusion*, in terms of the masses and energies of the particles involved. [3]

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- (c) State which of the two nuclear processes in (b) is used on a large scale to generate electricity. [1]

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