



**CHEMISTRY
 HIGHER LEVEL
 PAPER 3**

Friday 11 May 2001 (morning)

1 hour 15 minutes

Name

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Number

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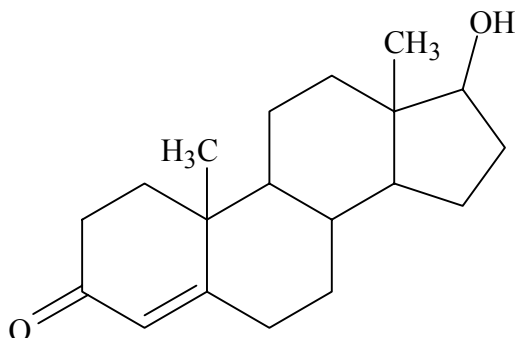
INSTRUCTIONS TO CANDIDATES

- 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 two 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
	/25	/25	/25
	/25	/25	/25
NUMBER OF CONTINUATION BOOKLETS USED	TOTAL	TOTAL	TOTAL
.....	/50	/50	/50

Option C – Human biochemistry

C1. The hormone testosterone has the structure:



(a) State what is meant by the term *hormone*. [1]

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(b) (i) Name the gland which is the **major** source of testosterone in humans. [1]

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(ii) Testosterone is a member of a group of compounds called *steroids*. Certain steroids have useful medical applications. However, in recent years steroid abuse amongst athletes has become more common. Describe briefly the use **and** abuse of steroids. [3]

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(c) Circle **two** functional groups in the structure of testosterone above, labelling them **A** and **B**. Name both functional groups. [2]

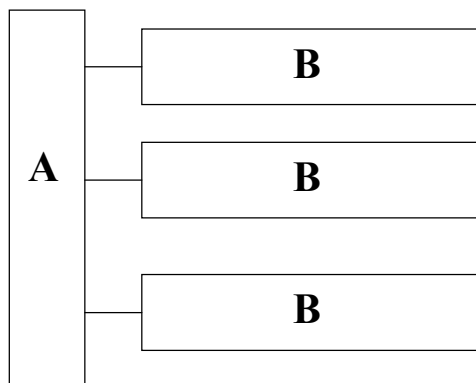
Functional group **A**:

Functional group **B**:

(d) By referring to the structure of cholesterol in Table 21 of the Data Booklet, give **one** structural difference between testosterone and cholesterol. [1]

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C2. The diagram below represents a molecule of a fat.



(a) If the molecule is hydrolysed, what product would be formed from **A**? [1]

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(b) What general name is given to the products formed from **B**? [1]

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(c) State the conditions needed to carry out the hydrolysis of a fat. [1]

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(d) An experiment was carried out using a calorimeter to determine the calorific value of a 'low fat' chocolate bar with a mass of 50.0 g. The complete oxidation (combustion) of a 10 g sample of the chocolate bar raised the temperature of 500 g of water to 86.5 °C. The initial temperature of the water was 19.0 °C. Calculate the calorific value (in kJ) of the chocolate bar. [4]

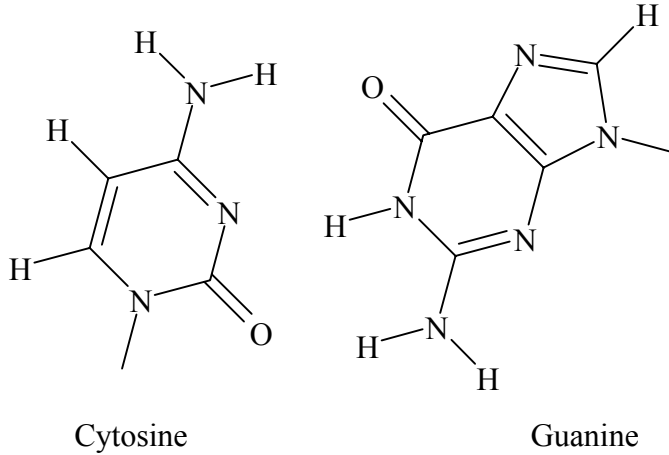
(The specific heat capacity of water = 4.18 J g⁻¹ K⁻¹.)

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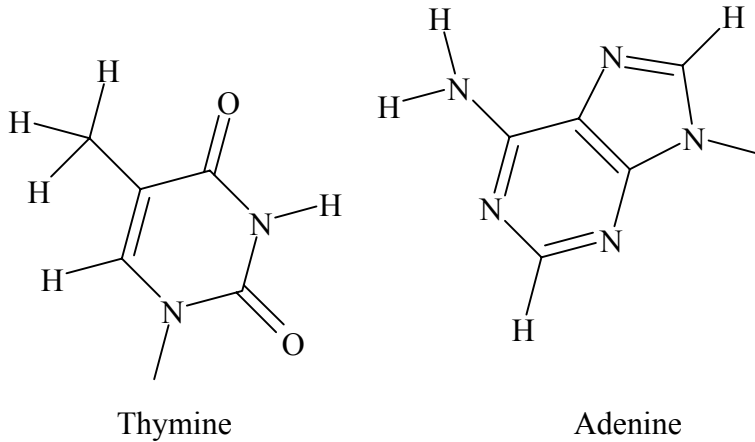
C3. (a) DNA consists of two helical strands of nucleotides bonded together. The diagrams below show which base pairs bond to each other. State what kind of bond holds the two strands of DNA together and show these bonds on each diagram. State which other **two** molecules are bonded to a base to form a *nucleotide* and describe how individual nucleotides are joined to form a single strand of DNA.

[6]

Cytosine pairs with guanine



Thymine pairs with adenine



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(This question continues on the following page)

(Question C3 continued)

- (b) A few drops of blood are found at the scene of a crime. Describe the stages in preparing a DNA profile from the blood sample. [4]

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Option D – Environmental chemistry

D1. Two of the greenhouse gases which contribute to global warming are carbon dioxide and methane.

(a) Name **one** other greenhouse gas. [1]

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(b) (i) Name **one** natural and **one** man-made source of carbon dioxide. [2]

Natural:

Man-made:

(ii) Name **one** natural and **one** man-made source of methane. [2]

Natural:

Man-made:

(c) Explain how greenhouse gases are thought to cause global warming. [3]

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D2. (a) Two processes used to treat sewage are *filtration* and *chemical precipitation*.

(i) Name the type of substance removed by *filtration* and the equipment used to do this. [2]

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(ii) Name the type of substance removed by *chemical precipitation* and a chemical used to do this. [2]

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(b) (i) State **two** advantages of treating drinking water with ozone rather than chlorine. [2]

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(ii) Other than cost, name **one** disadvantage of treating drinking water with ozone rather than chlorine. [1]

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D3. Explain how secondary pollutants are produced in photochemical smog. State why these substances are undesirable, and suggest **three** ways in which photochemical smog could be reduced.

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Option E – Chemical industries

E1. (a) State **two** functions of the coke fed into the blast furnace during the extraction of iron from iron ore. [2]

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(b) The cast iron produced in the furnace contains the impurities carbon and silica. Describe how these impurities are removed to produce pure steel.

(i) Carbon: [2]

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(ii) Silica: [2]

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E2. (a) Write an equation for the thermal cracking of hexane. Give **one** use for **each** of the products of your reaction. [3]

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(b) (i) Name a catalyst used in catalytic cracking. [1]

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(ii) What other condition is needed for catalytic cracking? [1]

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(c) How do the products of catalytic cracking and hydrocracking differ? [2]

Catalytic cracking:

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Hydrocracking:

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E3. Most chemical processes have associated environmental hazards. State **one** potential problem linked to oil refining and iron production.

Oil refining: [1]

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Iron production: [1]

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E4. *This question should be answered with reference to section 12 of the Data Booklet, 'Thermodynamics of metal extraction.'*

Explain **each** of the following:

On the Ellingham diagram, the line representing ΔG^\ominus (standard Gibbs free energy change) for the reaction $2\text{C(s)} + \text{O}_2\text{(g)} \rightarrow 2\text{CO(g)}$ has a negative slope (gradient), in the opposite direction to the other lines on the diagram.

[2]

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When carbon is heated in oxygen at 2000 K, the main product of the reaction is carbon monoxide, CO(g) . At 500 K, the main product is carbon dioxide, $\text{CO}_2\text{(g)}$.

[2]

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E5. The basis of the chlor-alkali industry is the production of sodium hydroxide and chlorine from sodium chloride. Describe the *diaphragm cell* used in the electrolysis of sodium chloride. Refer to the processes taking place at both the cathode and anode electrodes in your answer. Suggest **one** advantage and **one** disadvantage of using the diaphragm cell instead of the mercury cell.

[6]

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Option F – Fuels and energy

F1. In a given location, the earth’s surface receives 1.26×10^6 units of solar energy. Green plants (e.g. algae) absorb 1.26×10^4 units of this energy.

(a) (i) What percentage of the sun’s energy is absorbed by the green plants? [1]

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(ii) Suggest **two** reasons why the remainder of the sun’s energy is not absorbed by green plants. [2]

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(b) (i) Name the process by which green plants use the sun’s energy to convert water and carbon dioxide into glucose (biomass). [1]

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(ii) Give a balanced chemical equation for the reaction. [1]

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(c) (i) State **two** methods in which biomass can be converted into energy: [2]

1

2

(ii) For **one** of the above methods, state **one** advantage and **one** disadvantage of the process. [2]

Advantage:
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Disadvantage:
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(This question continues on the following page)

(Question F1 continued)

- (d) (i) Outline how the algae and plankton in ancient oceans were converted into crude oil. [3]

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- (ii) State **three** disadvantages of using oil as an energy source. [3]

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F2. (a) Compare the properties of semiconductors with metals and insulators. [2]

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(b) State the function of a *photovoltaic cell* and describe how it works. State **one** advantage and **one** disadvantage of using such a cell. [6]

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(c) Explain the factors that affect the voltage and power available from a battery. [2]

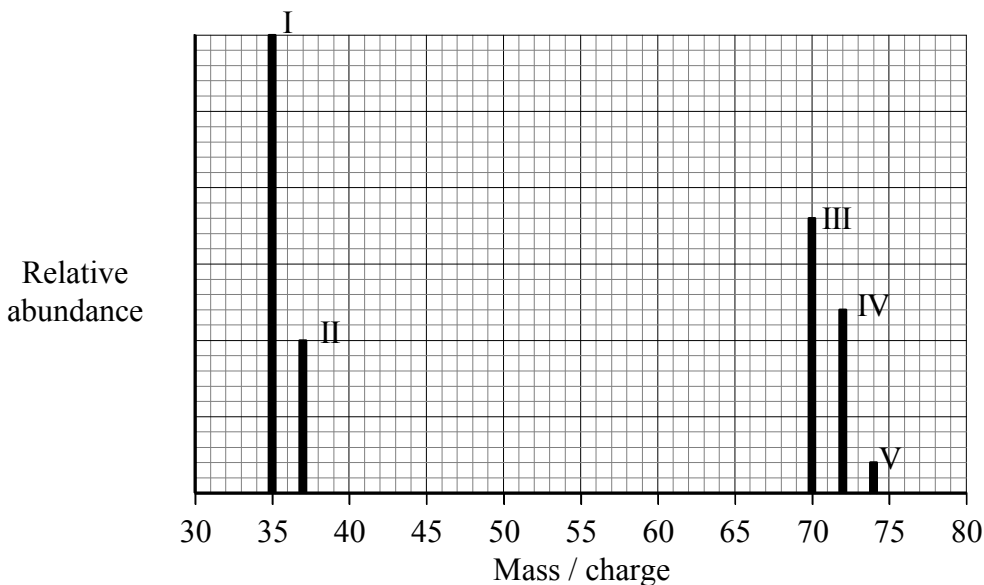
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Option G – Modern analytical chemistry

G1. The diagram below represents the spectrum of chlorine, consisting of five peaks, labelled I, II, III, IV and V respectively. **Peak I is due to the $^{35}\text{Cl}^+$ ion.**



- (a) What analytical technique would give a spectrum like that shown above? [1]
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- (b) State why the spectrum of chlorine consists of more than two peaks. [1]
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- (c) Suggest what peaks II and IV might be due to. [2]
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- (d) Using the spectrum above, find the isotopic composition of chlorine and justify your answer. [2]
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- (e) (i) How is a molecular ion formed? [1]
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- (ii) What information could be obtained from the mass/charge value of the molecular ion? [1]
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G2. (a) State the type of electron transitions that cause colour in complexes of transition metals. [1]

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(b) Which analytical technique would give bond length and bond angle data for a sample of a transition metal complex? [1]

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G3. (a) Draw the shapes of the water and carbon dioxide molecules and describe what occurs at the molecular level during the absorption of infrared radiation by these molecules. [5]

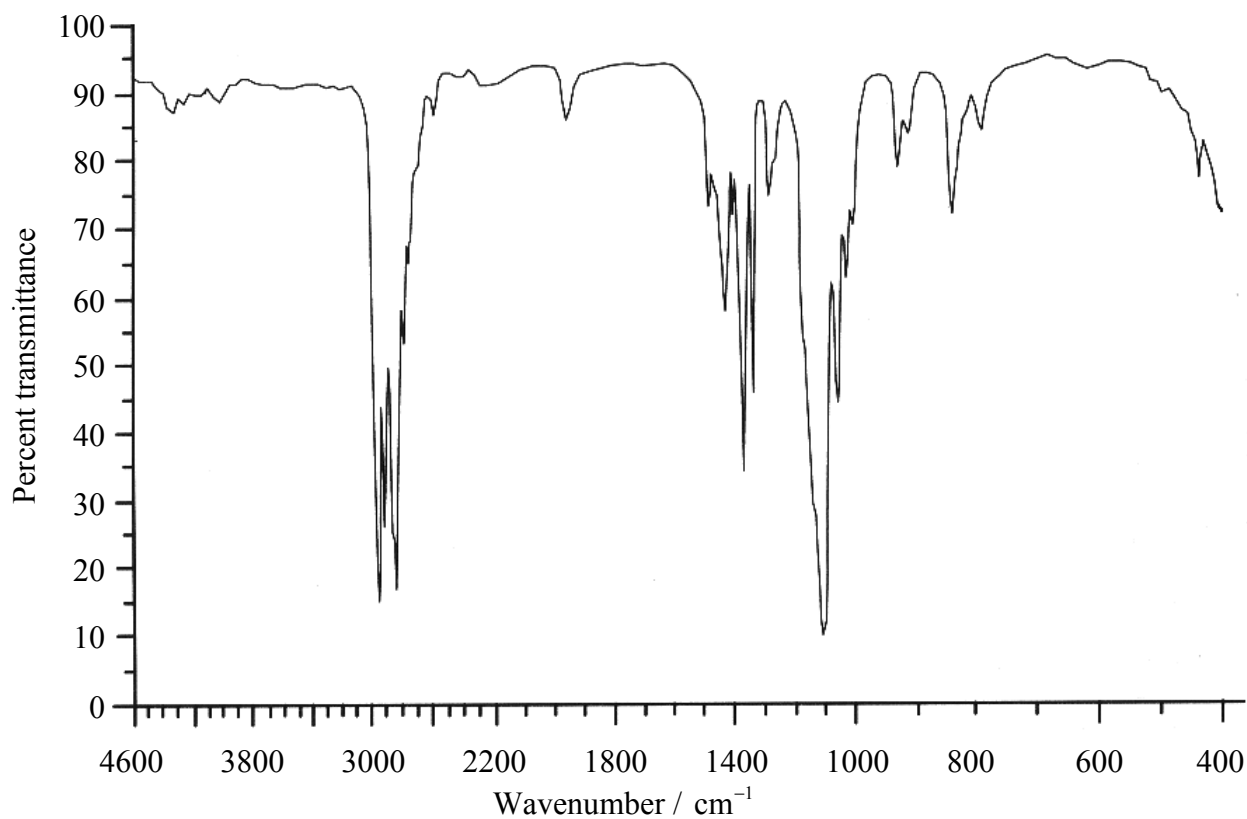
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(Question G3 continued)

(b) The infrared spectrum of one of the following compounds is shown below:

- $\text{CH}_3\text{CH}_2\text{OCH}_2\text{CH}_3$
- $\text{CH}_3\text{CH}_2\text{CO}_2\text{H}$
- $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$
- $\text{CH}_3\text{CH}_2\text{CO}_2\text{CH}_2\text{CH}_3$



(This question continues on the following page)

(Question G3 (b) continued)

- (i) Using Table 18 in the Data Booklet, determine which compound the spectrum represents and give its full structural formula. Explain how you made your choice. [6]

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- (ii) For **each** of the other three compounds, state the infrared absorption values that would allow you to distinguish between them. [4]

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Option H – Further organic chemistry

H1. This question is about isomers with the general formula C_nH_{2n} .

- (a) (i) Draw the structures of the two geometrical (*cis/trans*) isomers of C_4H_8 , giving their full names.

[3]

- (ii) Write the mechanism for the reaction of the *cis* isomer of C_4H_8 with bromine (dissolved in a non-polar solvent).

[2]

- (b) (i) There are four isomers with the formula C_5H_{10} which contain a three-membered carbon ring. Draw these isomers and label them **A**, **B**, **C** and **D**.

[4]

- (ii) Indicate, by writing two letters (chosen from **A**, **B**, **C** and **D**) a pair of isomers that are *structural* isomers and a pair that are *geometrical* isomers.

[2]

Structural isomers:

Geometrical isomers:

(This question continues on the following page)

(Question H1 Part (b) continued)

(iii) From the four isomers **A**, **B**, **C** and **D**, draw the structure of an isomer that shows *optical isomerism* and mark the *chiral centre* with an asterisk (*). [2]

(c) Use the examples from parts (a) and (b) to explain the existence of *geometrical* isomers. [2]

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(d) Suggest a reason why compounds containing three-membered carbon rings are less stable than those containing four-membered rings. [1]

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- H2.** (a) Nitration of aromatic compounds can be carried out using nitric acid. Draw the structures of the two major products of the mononitration of phenol using dilute nitric acid, and label them **X** and **Y**. Suggest a structure for a product if concentrated nitric acid were used and label it **Z**. Explain why the conditions for the mononitration of phenol are much milder than for the mononitration of benzene.

[5]

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- (b) Some of the compounds in (a), arranged from the most acidic to the least acidic, follow the order:



Discuss this trend.

[4]

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