



CHEMISTRY
STANDARD LEVEL
PAPER 3

Thursday 9 November 2006 (morning)

1 hour

Candidate session number

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INSTRUCTIONS TO CANDIDATES

- Write your session 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 on answer sheets. Write your session number on each answer sheet, and attach them to this examination paper and your cover sheet 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.



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Option A – Higher physical organic chemistry**A1.** Benzene (C_6H_6) is the simplest aromatic hydrocarbon.

- (a) Discuss the structure and bonding present in benzene. [4]

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- (b) State, with a reason, the number of peaks in the
- 1H
- NMR spectrum of benzene. [2]

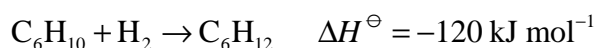
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- (c) Cyclohexene reacts with hydrogen to form cyclohexane.



Calculate the enthalpy change of hydrogenation of benzene to cyclohexane, assuming it has the cyclohexatriene [] structure.

[1]

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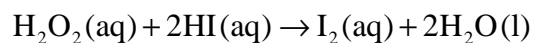
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- (d) The experimental value for the hydrogenation of benzene to cyclohexane is
- -207 kJ mol^{-1}
- . Explain why this value differs from the value calculated in (c). [1]

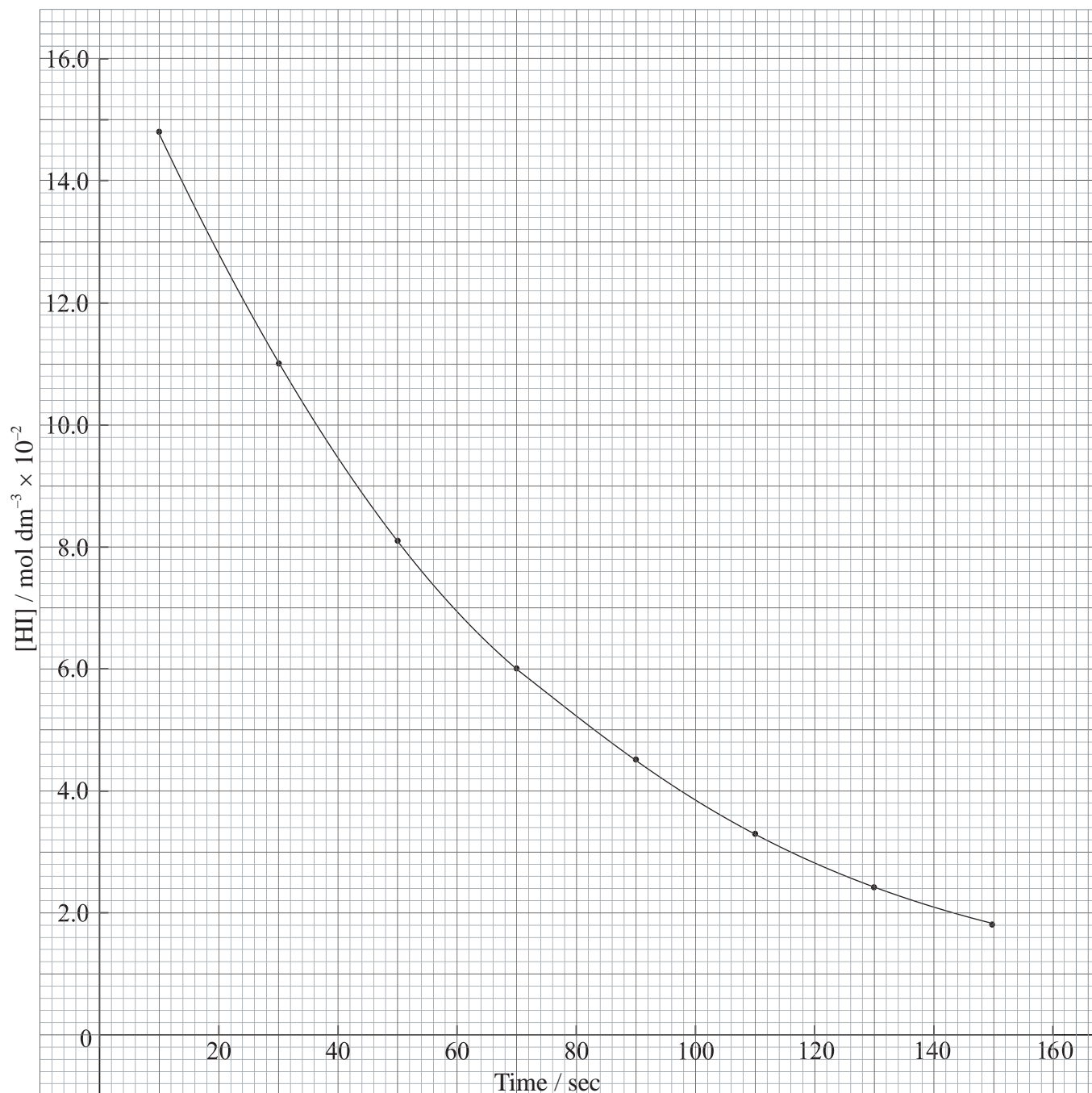
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- A2.** In a particular experiment, various concentrations of HI(aq) are reacted with a constant H_2O_2 (aq) concentration according to the following equation:



A graph of [HI] against time is as follows:



(This question continues on the following page)



(Question A2 continued)

- (a) Use the graph to deduce the order of reaction with respect to HI. Give a reason for your answer. [2]

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- (b) The order with respect to H_2O_2 is the same as HI. Deduce the rate expression for this reaction. [1]

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- (c) Determine the half-life of the reaction from the graph and calculate the value for the rate constant. [2]

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A3. In aqueous solution at 298K, ammonia is a weak base with a pK_b value of 4.75 and a K_b value of $1.7 \times 10^{-5} \text{ mol dm}^{-3}$.

(a) Write an equation for the reaction of ammonia with water. [1]

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(b) State the ionization constant expression, K_b for ammonia. [1]

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(c) Calculate the pH of a 0.25 mol dm^{-3} solution of ammonia. [3]

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(d) Determine the pH of a buffer solution containing 0.10 mol dm^{-3} of ammonia and 0.10 mol dm^{-3} of ammonium chloride. [2]

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Option B – Medicines and drugs

B1. Nicotine and caffeine are two common stimulants.

- (a) Apart from the methyl groups, state the name of **one** functional group, which is present in **both** nicotine and caffeine. [1]
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- (b) State the name of **one** functional group, which is present in caffeine, but absent in nicotine. [1]
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- (c) Suggest, with a reason, whether an aqueous solution of nicotine would be acidic, basic or neutral. [2]
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- (d) State **two** effects of consuming caffeine in large amounts. [1]
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- (e) State **two** short-term physical effects of nicotine consumption. [1]
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- (f) Explain the term *sympathomimetic* drug and state **one** example other than nicotine. [2]
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B2. (a) State the names of **four** main methods of administering drugs. [3]

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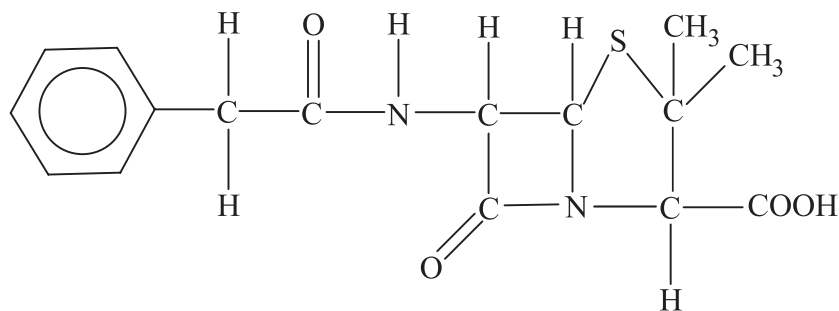
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(b) Explain what is meant by the term *placebo effect*. [1]

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- B3.** Penicillin G was the first antibiotic used to fight infections. The structure of this antibiotic is as follows:



- (a) Determine the molecular formula of penicillin G. [1]

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- (b) State **two** reasons for modifying the side chain in penicillin G. [2]

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- (c) Explain the difference between *broad-spectrum* and *narrow-spectrum* antibiotics. [1]

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- (d) Describe the mode of action of penicillin in preventing the growth of bacteria. [2]

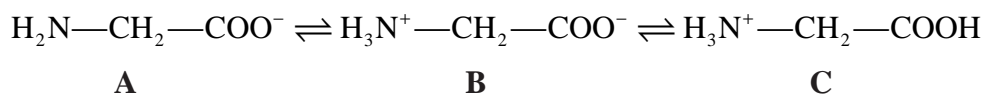
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- (e) Discuss **two** effects of over prescription of penicillin to humans. [2]

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Option C – Human biochemistry

- C1.** (a) The equilibria, which exist in an aqueous solution of glycine, are shown in the structures below.



State which of the forms A, B or C occurs in the greatest concentration at:

low pH:

high pH: [2]

- (b) A mixture of amino acids with different isoelectric points can be separated using electrophoresis.

- (i) Outline the essential features of electrophoresis. [3]

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- (ii) Arginine, glutamic acid and glycine undergo electrophoresis at pH 6.0. Using table 20 of the Data Booklet identify the amino acid that moves towards: [2]

the positive electrode:

the negative electrode:

- (c) The three major nutrients required by humans are proteins, carbohydrates and fats.

State **one** major function that is common to these three nutrients in the human body. [1]

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C2. Iodine number is defined as the number of grams of iodine that reacts with 100 g of a triglyceride in an addition reaction. The iodine number of palmitic acid ($M_r = 256$) is 0 and linolenic acid ($M_r = 278$) is 274.

- (a) Determine the number of double bonds in linolenic acid, showing your working. [3]

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- (b) Which acid (palmitic acid or linolenic acid) would have a higher melting point? Explain your choice. [2]

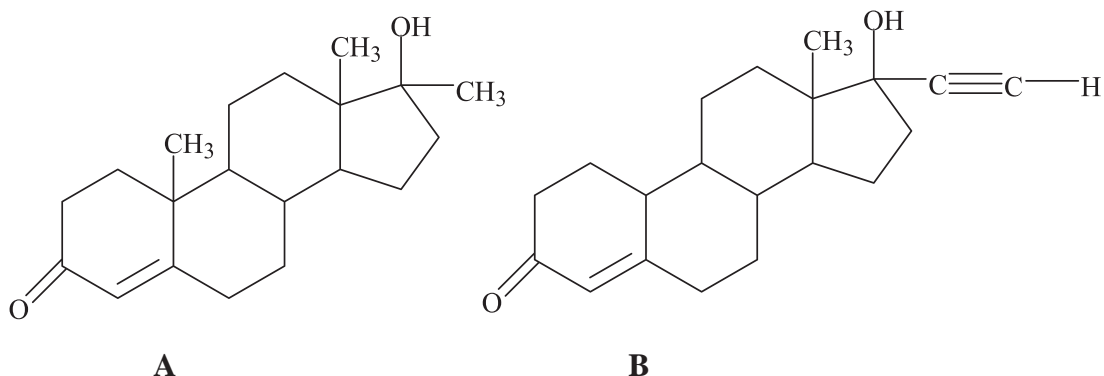
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C3. The structures of two synthetic hormones are shown below:



Hormone **A** is similar in structure to testosterone and hormone **B** is similar in structure to progesterone.

- (a) Explain why hormone **A** is prescribed to some patients. [2]

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- (b) Suggest why hormone **A** is banned for participants in major sporting events. [1]

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- (c) Describe how hormone **B** functions as an oral contraceptive. [2]

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- (d) Name **two** functional groups that are present in hormone **B** but absent in progesterone. [2]

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Option D – Environmental chemistry

D1. (a) Explain the term *acid rain* in terms of pH. [1]

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(b) Identify **two** acids that cause acid rain and describe the origin of each one. [4]

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(c) Write an equation to show how **one** of these acids is produced. [1]

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(d) Explain with the help of equations the process of fluidized bed combustion of coal. [3]

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D2. Large-scale combustion of fossil fuels has been a major source of increased levels of CO_2 in the atmosphere.

- (a) Describe a possible effect of higher levels of CO_2 in the atmosphere. [1]

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- (b) Explain how the effect in (a) is caused by the interaction between CO_2 and different types of radiation in the atmosphere. [2]

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- (c) Identify **one** natural method by which CO_2 is removed from the atmosphere and give an equation for the reaction. [2]

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D3. Waste water and sewage undergo primary, secondary and tertiary stages of treatment.

- (a) State **two** features of the activated sludge process that allow for the removal of impurities. [2]

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- (b) Identify **one** major source of phosphate in waste water. [1]

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- (c) State the type of reaction used to remove Pb^{2+} and PO_4^{3-} ions from waste water. For each ion, give an equation to show its removal. [3]

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Option E – Chemical industries

- E1.** (a) Crude oil may contain small amounts of H_2S . Write an equation to show how H_2S is removed from crude oil. [1]

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- (b) Crude oil is a mixture of volatile substances. The process of fractional distillation separates crude oil into different fractions.

- (i) Describe the process of fractional distillation. [4]

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- (ii) Explain why smaller molecules present in crude oil have relatively low boiling points. [1]

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- (c) One of the compounds obtained from fractional distillation is $\text{C}_{16}\text{H}_{34}$. Give an equation for the catalytic cracking of $\text{C}_{16}\text{H}_{34}$ to produce two molecules with the **same** number of carbon atoms. [1]

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E2. Polyethene is the most commonly used synthetic polymer. It is produced in low-density and high-density forms.

- (a) Identify which form has the higher melting point. Explain by reference to its structure and bonding. [4]

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- (b) State **one** disadvantage of using polyethene. [1]

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- (c) Describe how the properties of **two** named polymers can be modified by adding a different substance in each case. [4]

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- E3.** (a) Describe how reactive metals such as sodium are extracted from their ores. [2]

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- (b) Lead(II) sulfide is heated in air to give lead(II) oxide and a gaseous product. This is followed by reduction to the metal. Give an equation for each reaction. [2]

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Option F – Fuels and energy

- F1.** (a) ^{226}Ra emits one α particle and two β particles in a decay process.

Determine the atomic number and mass number of the final product formed by this decay process.

[2]

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- (b) The half-life of ^{90}Sr is 27 years. A sample of this nuclide has an initial activity of 8000 disintegrations per minute (dpm). Calculate the activity in dpm after 135 years.

[2]

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- F2.** (a) Both nuclear fusion and nuclear fission produce large amounts of energy. Describe **one** disadvantage and **two** advantages of nuclear fusion as compared to nuclear fission. [3]

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- (b) Both nuclear and conventional (fossil fuel) power plants generate electricity by producing heat that is used to convert water to steam.

- (i) Describe how heat is produced in **each** of the two power plants. [2]

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- (ii) State **two** advantages and **two** disadvantages of nuclear power plants as compared to conventional (fossil fuel) power plants. [4]

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- F3.** (a) (i) State the name of the process by which green plants use solar energy to produce biomass. [1]
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- (ii) Give a chemical equation for the process. [1]
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- (b) Biomass can be used to produce biogas and ethanol.
- (i) Identify the major component of biogas and describe how it is produced. [2]
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- (ii) State **two** conditions required for the production of ethanol from biomass. [2]
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- (iii) Give a chemical equation for the production of ethanol from biomass. [1]
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