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**CHEMISTRY**
**STANDARD LEVEL**
**PAPER 3**

Wednesday 12 November 2008 (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.



0124

**Option A – Higher physical organic chemistry**

**A1.** Bromate(V) ions and iodide ions react in the presence of an acid according to the following equation.

$$BrO_3^-(aq) + 6I^-(aq) + 6H^+(aq) \rightarrow 3I_2(aq) + 3H_2O(l) + Br^-(aq)$$

The rate of this reaction was studied using different initial concentrations of reactants at the same temperature.

| Experiment | $[BrO_3^-(aq)]$ / mol dm$^{-3}$ | $[I^-(aq)]$ / mol dm$^{-3}$ | $[H^+(aq)]$ / mol dm$^{-3}$ | Relative initial rate |
|---|---|---|---|---|
| 1 | 0.2 | 0.6 | 0.4 | 1 |
| 2 | 0.4 | 0.6 | 0.4 | 2 |
| 3 | 0.4 | 1.2 | 0.4 | 4 |
| 4 | 0.4 | 0.6 | 0.8 | 8 |

(a) Define the term *rate of reaction*. *[1]*

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(b) Deduce the order of the reaction with respect to *[3]*

(i) $BrO_3^-(aq)$ . . . . . .

(ii) $I^-(aq)$ . . . . . .

(iii) $H^+(aq)$ . . . . . .

(c) Deduce the rate expression for this reaction. *[1]*

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*(This question continues on the following page)*

*(Question A1 continued)*

(d) In a separate experiment the rate of the following reaction between nitrogen dioxide and carbon monoxide was investigated.

$$NO_2(g) + CO(g) \rightarrow NO(g) + CO_2(g)$$

The following mechanism was proposed:

$$NO_2(g) + NO_2(g) \rightarrow NO_3(g) + NO(g) \quad \textit{slow}$$
$$NO_3(g) + CO(g) \rightarrow NO_2(g) + CO_2(g) \quad \textit{fast}$$

Deduce the rate expression for this reaction. *[1]*

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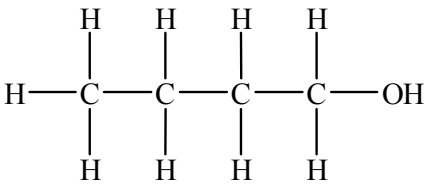
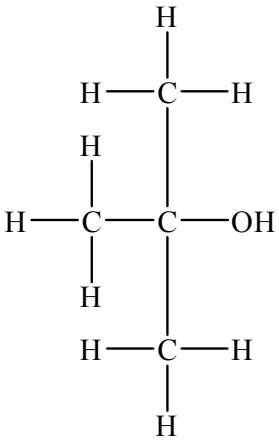
**A2.** Butan-1-ol and 2-methylpropan-2-ol are structural isomers.

butan-1-ol



2-methylpropan-2-ol



(a) State the main difference between the infrared spectra of both compounds. *[1]*

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(b) Complete the following table to describe their $^1$H NMR spectra. Ignore any peaks due to a reference. *[4]*

| Compound | Total number of peaks | Ratio of relative areas under each peak |
|---|---|---|
| butan-1-ol | | |
| 2-methylpropan-2-ol | | |

(c) Explain why the mass spectra of these two isomers both have peaks with the following *m/z* values: *[3]*

*m/z* = 74 . . . . . .

. . . . . .

*m/z* = 29 . . . . . .

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**A3.** (a) Write the equation for the ionization of propanoic acid, $C_2H_5COOH$, in water. *[1]*

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(b) Write the expression for the ionization constant, $K_a$, for this reaction. *[1]*

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(c) Calculate the pH of a $1.00 \times 10^{-2}$ mol dm$^{-3}$ aqueous solution of propanoic acid. (The value for the p$K_a$ of propanoic acid is given in Table 16 of the Data Booklet.) *[4]*

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**Option B – Medicines and drugs**

**B1.** Both aspirin and heroin are analgesics. Their structures are given in Table 21 of the Data Booklet.

(a) Explain why both aspirin and heroin can be described as esters. *[1]*

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(b) Describe the mode of action for each of the two analgesics. *[4]*

aspirin . . . . . .

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heroin . . . . . .

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(c) State a serious side effect of aspirin. *[1]*

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(d) The taking of heroin can lead to tolerance. Describe what is meant by *tolerance* and explain why it is a particularly dangerous problem with heroin. *[2]*

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**B2.** Magnesium hydroxide, $Mg(OH)_2$, and sodium hydrogencarbonate, $NaHCO_3$, are two common antacids.

(a) State an equation for each of these antacids to show how they neutralise excess hydrochloric acid in the stomach. *[2]*

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(b) Antacids often contain alginates and anti-foaming agents. Explain their functions. *[2]*

alginates . . . . . .

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anti-foaming agents . . . . . .

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**B3.** (a) Outline the major contributions made by Florey and Chain in the development of penicillin. *[3]*

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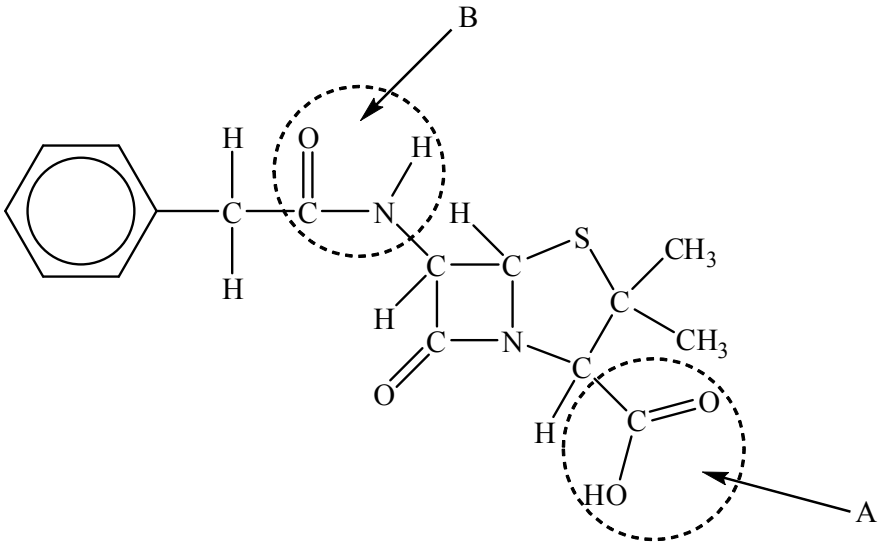
(b) The original penicillin developed by Florey and Chain is known as Penicillin G. It contains several different functional groups. Two of them have been circled and labelled A and B in the structure given below.




Identify the functional groups A and B. *[2]*

A . . . . . .

B . . . . . .

(c) Explain why the overuse of Penicillin G has reduced its effectiveness as an antibiotic. *[2]*

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(d) Explain how the structure of penicillin G can be modified to produce different penicillins that are still effective antibiotics. *[1]*

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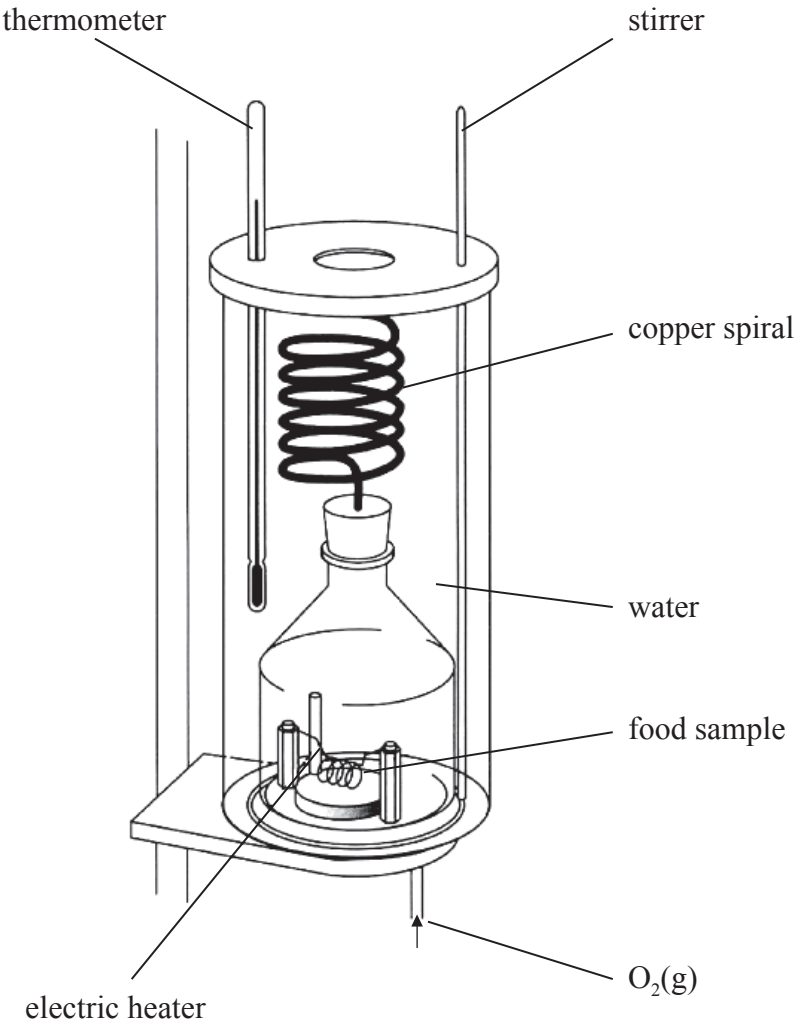
**Option C – Human biochemistry**

**C1.** On the side of a packet of a breakfast cereal it states that 45.0 g of the cereal provides 649 kJ of energy.

To check this value a student combusted 2.19 g of the cereal in a food calorimeter.




The heat produced increased the temperature of 600 g of water in the calorimeter by 11.2 °C. The specific heat capacity of water = 4.18 $J g^{-1} K^{-1}$.

(a) (i) Calculate the energy content of 45.0 g of the breakfast cereal. *[2]*

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*(This question continues on the following page)*

*(Question C1 continued)*

(ii) Suggest **two** reasons why the result obtained was not completely accurate. *[2]*

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(b) It states on the side of the cereal packet that some of the energy comes from both saturated and unsaturated fats.

(i) Give the structural formula of a fat, using R to represent an alkyl group. *[1]*

(ii) Describe how the structure of an unsaturated fat is different from that of a saturated fat. *[1]*

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(iii) Fats are often described by their iodine number. It was found that 7.61 g of iodine, $I_2$, reacted with 0.0100 mol of an unsaturated fat in the breakfast cereal. What can be deduced about the structure of this unsaturated fat in the breakfast cereal from this information? *[2]*

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*(This question continues on the following page)*

*(Question C1 continued)*

(iv) Explain why the melting point of an unsaturated fat is lower than that of a saturated fat with a similar molecular mass. *[3]*

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**C2.** The structure of vitamin D is given in the Data Booklet.

(a) Explain why it is not correct to classify vitamin D as a steroid. *[1]*

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(b) Explain why vitamin D is fat soluble even though it contains a polar –OH group. *[1]*

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(c) Explain why vitamin D is able to decolourize a solution of bromine. *[1]*

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(d) Describe and explain what will be observed in young children who are suffering from a severe and prolonged lack of vitamin D. *[2]*

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**C3.** (a) State what is meant by a *hormone*. *[1]*

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(b) One particular hormone is oestradiol. State where in the body oestradiol is produced. *[1]*

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(c) The structures of oestradiol and testosterone are given in Table 22 of the Data Booklet.

(i) Name **one** functional group present in oestradiol but absent in testosterone. *[1]*

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(ii) Name **two** functional groups present in testosterone but absent in oestradiol. *[1]*

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**Option D – Environmental chemistry**

**D1.** (a) Explain why carbon dioxide is a greenhouse gas whereas nitrogen, which is the main constituent of air, is not. *[3]*

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(b) Farm animals such as cows also contribute significantly to global warming by producing methane. Suggest why cows mainly convert grass into methane rather than carbon dioxide and water. *[1]*

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(c) List **two** other gases apart from carbon dioxide and methane that also contribute to global warming. *[1]*

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(d) Global warming can also be affected by the presence of particulates in the atmosphere. Outline how particulates can affect the Earth's temperature. *[2]*

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**D2.** (a) When rain falls it dissolves and reacts with some of the carbon dioxide present in the air to form carbonic acid, $H_2CO_3(aq)$. Explain why rain water containing only carbonic acid is not classified as acid rain. *[2]*

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(b) List **two** acids from different sources that are present in acid rain and state **one** major source due to human activity for each acid. *[2]*

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(c) Acid rain can damage buildings containing calcium carbonate or magnesium carbonate. Give the **ionic** equation for the reaction of aqueous hydrogen ions with carbonate ions. *[1]*

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(d) Acid rain alters the soil. Explain what effect this has on plant growth. *[2]*

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**D3.** (a) About 97 % of the water on the Earth is salt water. State where most of the fresh water on the Earth is located. *[1]*

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(b) Fresh water can be made fit for drinking by adding chlorine. Explain why chlorine is added and apart from taste and smell, state **one** disadvantage of using chlorine for this purpose. *[2]*

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(c) Fresh water can be obtained from sea water by the process of reverse osmosis. Explain how reverse osmosis works. *[3]*

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**Option E – Chemical industries**

**E1.** Iron is produced in a blast furnace. Traditionally the basic raw materials added to the furnace were iron ore, coke, limestone and hot air.

(a) The reducing agent in the blast furnace is mainly carbon monoxide. Give equations showing **two** different ways in which carbon monoxide is formed from the raw materials in a blast furnace. *[3]*

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(b) In a modern blast furnace the hot air is mixed with natural gas and the hydrogen produced also acts as a reducing agent. Give the equation for the reduction of the ore triiron tetroxide, $Fe_3O_4$, using hydrogen as the reducing agent. *[1]*

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(c) One of the impurities in the iron ore is silicon dioxide. Explain how this is removed during the production of iron in the blast furnace. *[2]*

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(d) State the main impurity in the iron produced in a blast furnace. *[1]*

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(e) Both steel and aluminium cans are often mixed together for recycling. Suggest a simple way in which they can be separated. *[1]*

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**E2.** (a) Suggest **two** reasons why it is necessary to remove the sulfur found in crude oil **before** the oil is refined. *[2]*

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(b) State the major use for the sulfur that is removed from crude oil. *[1]*

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(c) One of the refining processes is cracking. Describe the conditions used for hydrocracking. *[2]*

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(d) Another type of cracking is thermal cracking. State the equation for the cracking of decane, $C_{10}H_{22}$, to produce octane and state the major use for the other organic product. *[2]*

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**E3.** (a) Draw the repeating unit for poly(propene). *[1]*

(b) Using poly(propene) as an example, describe the structural difference between *isotactic* and *atactic* polymers. *[2]*

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(c) Suggest why isotactic polymers are tough whereas atactic polymers are softer and more flexible. *[2]*

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**Option F – Fuels and energy**

**F1.** (a) Give the nuclear equation to describe the emission of one alpha particle from an atom of uranium-235. *[2]*

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(b) U-235 decays in a series of steps to give Pb-207 as the final product. Deduce the number of alpha and beta particles emitted during the conversion of one atom of U-235 to one atom of Pb-207. *[2]*

Number of alpha particles emitted . . . . . .

Number of beta particles emitted . . . . . .

(c) Define the term *half-life*. *[1]*

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(d) The half-life of U-235 is $7.13 \times 10^8$ years. If 2.40 kg of U-235 were present in a particular area $4.278 \times 10^9$ years ago, calculate the mass of the original U-235 that remains today. *[2]*

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*(This question continues on the following page)*

*(Question F1 continued)*

(e) Nuclear energy can be obtained from the bombardment of U-235 with neutrons. As well as the fuel rods, nuclear reactors also contain moderators and control rods. For each of these, state **one** material used and describe its function. *[4]*

Moderator:

Made from . . . . . .

Function . . . . . .

. . . . . .

Control rods:

Made from . . . . . .

Function . . . . . .

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**F2.** (a) Octane, $C_8H_{18}$, comes from petroleum, and natural gas is essentially methane.

(i) Give the equation for the complete combustion of octane. *[1]*

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(ii) The enthalpies of combustion of methane and octane are –890 and –5510 kJ $mol^{-1}$ respectively. Determine which of the two fuels provides more heat energy when 1.00 kg of each fuel is completely combusted. *[2]*

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(b) In the future cars may be powered by hydrogen-oxygen fuel cells rather than gasoline (petrol). Discuss **two** advantages and **two** disadvantages of using a fuel cell rather than gasoline in cars. *[4]*

Advantages . . . . . .

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Disadvantages . . . . . .

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(c) Give the half-equations for the reactions taking place at the positive electrode and the negative electrode in a hydrogen-oxygen fuel cell. *[2]*

Positive electrode . . . . . .

Negative electrode . . . . . .