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CHEMISTRY
STANDARD LEVEL
PAPER 2

Candidate session number

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Tuesday 8 May 2012 (afternoon)

1 hour 15 minutes

Examination code

2	2	1	2	–	6	1	1	7

INSTRUCTIONS TO CANDIDATES

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Section A: answer all questions.
- Section B: answer one question.
- Write your answers in the boxes provided.
- A calculator is required for this paper.
- A clean copy of the ***Chemistry*** *Data Booklet* is required for this paper.
- The maximum mark for this examination paper is *[50 marks]*.

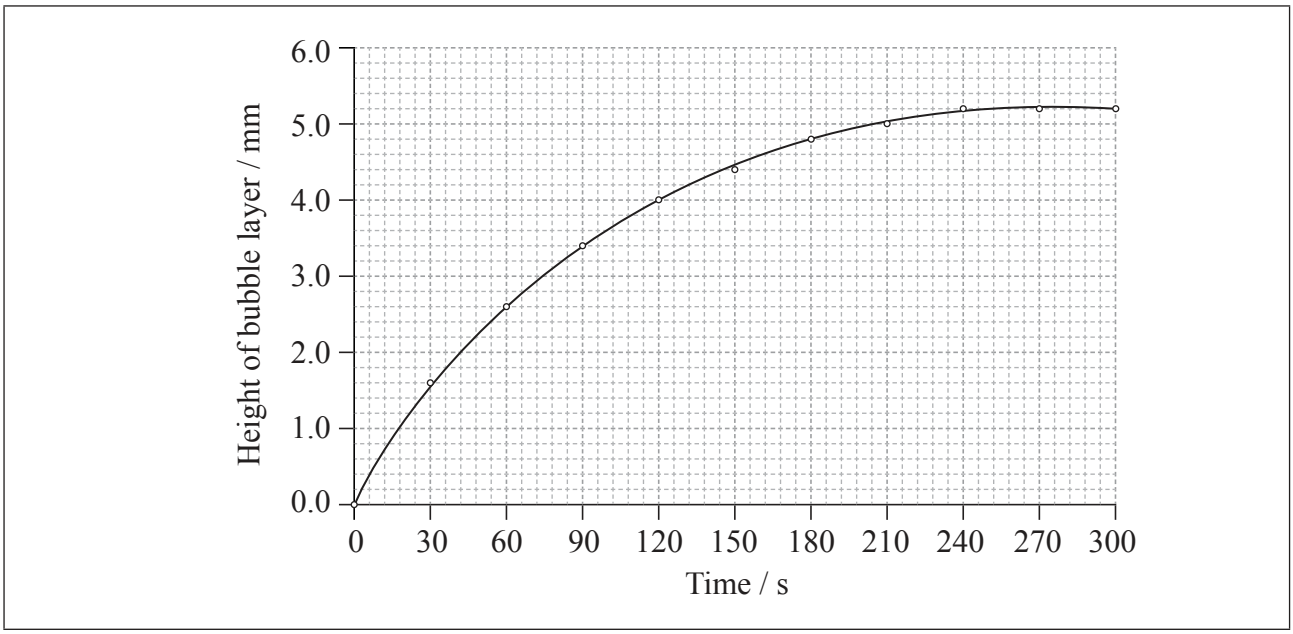
SECTION A

*Answer **all** questions. Write your answers in the boxes provided.*

1. Hydrogen peroxide, $H_2O_2(aq)$, releases oxygen gas, $O_2(g)$, as it decomposes according to the equation below.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

50.0 cm^3 of hydrogen peroxide solution was placed in a boiling tube, and a drop of liquid detergent was added to create a layer of bubbles on the top of the hydrogen peroxide solution as oxygen gas was released. The tube was placed in a water bath at 75 °C and the height of the bubble layer was measured every thirty seconds. A graph was plotted of the height of the bubble layer against time.



(a) Explain why the curve reaches a maximum. *[1]*

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(This question continues on the following page)

(Question 1 continued)

(b) Use the graph to calculate the rate of decomposition of hydrogen peroxide at 120 s. *[3]*

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(c) The experiment was repeated using solid manganese(IV) oxide, $MnO_2(s)$, as a catalyst.

(i) Draw a curve on the graph opposite to show how the height of the bubble layer changes with time when manganese(IV) oxide is present. *[1]*

(ii) Explain the effect of the catalyst on the rate of decomposition of hydrogen peroxide. *[2]*

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(This question continues on the following page)

(Question 1 continued)

(d) The decomposition of hydrogen peroxide to form water and oxygen is a redox reaction.

(i) Deduce the oxidation numbers of oxygen present in each of the species below. *[2]*

Species	Oxidation number of oxygen
H_2O_2	
H_2O	
O_2	

(ii) State two half-equations for the decomposition of hydrogen peroxide. *[2]*

Oxidation:

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Reduction:

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2. A student added 7.40×10^{-2} g of magnesium ribbon to 15.0 cm^3 of 2.00 $mol\,dm^{-3}$ hydrochloric acid. The hydrogen gas produced was collected using a gas syringe at 20.0 °C and 1.01×10^5 Pa.

(a) State the equation for the reaction between magnesium and hydrochloric acid. *[1]*

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(b) Determine the limiting reactant. *[3]*

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(c) Calculate the theoretical yield of hydrogen gas:

(i) in mol. *[1]*

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(ii) in cm^3, under the stated conditions of temperature and pressure. *[2]*

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(This question continues on the following page)

(Question 2 continued)

(d) The actual volume of hydrogen measured was lower than the calculated theoretical volume. Suggest **two** reasons why the volume of hydrogen gas obtained was less. *[2]*

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3. (a) State the equation for the reaction between sodium and water. *[1]*

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(b) State and explain **one** difference between the reactions of sodium and potassium with water. *[2]*

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4. (a) ^{131}I is a radioactive isotope of iodine.

(i) Define the term *isotope*. *[1]*

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(ii) Determine the number of neutrons in one atom of iodine-131. *[1]*

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(iii) Identify **one** use of iodine-131 in medicine and explain why it is potentially dangerous. *[2]*

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(b) Discuss the use of carbon-14 in carbon dating. *[3]*

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SECTION B

*Answer **one** question. Write your answers in the boxes provided.*

5. (a) An organic compound, **X**, with a molar mass of approximately 88 g mol^{-1} contains 54.5 % carbon, 36.3 % oxygen and 9.2 % hydrogen by mass.

(i) Distinguish between the terms *empirical formula* and *molecular formula*. *[2]*

Empirical formula:

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Molecular formula:

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(ii) Determine the empirical formula of **X**. *[2]*

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(iii) Determine the molecular formula of **X**. *[1]*

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(This question continues on the following page)

(Question 5 continued)

(iv) **X** is a straight-chain carboxylic acid. Draw its structural formula. *[1]*

(v) Draw the structural formula of an isomer of **X** which is an ester. *[1]*

(vi) The carboxylic acid contains two different carbon-oxygen bonds. Identify which bond is stronger and which bond is longer. *[2]*

Stronger bond:

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Longer bond:

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(This question continues on the following page)

(Question 5 continued)

(b) (i) State and explain which of propan-1-ol, $CH_3CH_2CH_2OH$, and methoxyethane, $CH_3OCH_2CH_3$, is more volatile. *[3]*

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(ii) Propan-1-ol, $CH_3CH_2CH_2OH$, and hexan-l-ol, $CH_3(CH_2)_4CH_2OH$, are both alcohols. State and explain which compound is more soluble in water. *[2]*

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(This question continues on the following page)

(Question 5 continued)

(c) Graphite is used as a lubricant and is an electrical conductor. Diamond is hard and does not conduct electricity. Explain these statements in terms of the structure and bonding of these allotropes of carbon. *[6]*

Graphite:

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Diamond:

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6. (a) Distinguish between the terms *strong base* and *weak base*, and state one example of each. *[3]*

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(b) Ammonia, NH_3, is a base according to both the Brønsted–Lowry and the Lewis theories of acids and bases.

(i) State the equation for the reaction of ammonia with water. *[1]*

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(ii) Explain why ammonia can act as a Brønsted–Lowry base. *[1]*

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(iii) Explain why ammonia can also act as a Lewis base. *[1]*

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(This question continues on the following page)

(Question 6 continued)

(c) (i) When ammonium chloride, $NH_4Cl(aq)$, is added to excess solid sodium carbonate, $Na_2CO_3(s)$, an acid–base reaction occurs. Bubbles of gas are produced and the solid sodium carbonate decreases in mass. State **one** difference which would be observed if nitric acid, $HNO_3(aq)$, was used instead of ammonium chloride. *[1]*

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(ii) Deduce the Lewis structures of the ammonium ion, NH_4^+, and the carbonate ion, CO_3^{2-}. *[2]*

Ammonium ion Carbonate ion

(iii) Predict the shapes of NH_4^+ and CO_3^{2-}. *[2]*

NH_4^+:

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CO_3^{2-}:

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(This question continues on the following page)

(Question 6 continued)

(d) The equation for the reaction between sodium hydroxide, NaOH, and nitric acid, HNO_3, is shown below.

$$NaOH(aq) + HNO_3(aq) \rightarrow NaNO_3(aq) + H_2O(l) \qquad \Delta H = -57.6 \text{ kJ mol}^{-1}$$

(i) Sketch and label an enthalpy level diagram for this reaction. *[3]*

(ii) Deduce whether the reactants or the products are more energetically stable, stating your reasoning. *[1]*

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(iii) Calculate the change in heat energy, in kJ, when 50.0 cm^3 of 2.50 $mol\,dm^{-3}$ sodium hydroxide solution is added to excess nitric acid. *[2]*

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(This question continues on the following page)

(Question 6 continued)

(e) When 5.35 g ammonium chloride, $NH_4Cl(s)$, is added to 100.0 cm^3 of water, the temperature of the water decreases from 19.30 °C to 15.80 °C. Determine the enthalpy change, in kJ mol^{-1}, for the dissolving of ammonium chloride in water. *[3]*

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7. Halogenoalkanes can be classified as primary, secondary or tertiary.

(a) (i) State the meaning of the term *isomers*. *[1]*

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(ii) Deduce the structural formulas of 2-bromobutane and 1-bromo-2-methylpropane, and identify each molecule as primary, secondary or tertiary. *[4]*

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(Question 7 continued)

(b) Alkanes undergo few reactions other than combustion and halogenation.

(i) Explain why alkanes have low reactivity. *[2]*

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(ii) Outline the meaning of the term *homolytic fission*. *[1]*

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(iii) Describe the meaning of the symbol Br•. *[1]*

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(iv) State an equation for the reaction of ethane with bromine. *[1]*

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(This question continues on the following page)

(Question 7 continued)

(v) Explain the reaction of ethane with bromine using equations for the initiation step, two propagation steps and one termination step. *[5]*

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(c) Under certain conditions but-2-ene can react with water to form butan-2-ol.

(i) Identify a suitable catalyst for this reaction. *[1]*

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(This question continues on the following page)

(Question 7 continued)

(ii) But-2-ene can be converted to 2-bromobutane and then to butan-2-ol as follows:

$$CH_3CH{=}CHCH_3 \xrightarrow{\mathbf{I}} CH_3CH(Br)CH_2CH_3 \xrightarrow{\mathbf{II}} CH_3CH(OH)CH_2CH_3$$

Identify the reagent(s) and conditions necessary for each of the steps **I** and **II**. *[4]*

Step **I**:

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Step **II**:

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Please **do not** write on this page.

Answers written on this page
will not be marked.

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