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**CHEMISTRY**
**STANDARD LEVEL**
**PAPER 2**

Wednesday 12 May 2010 (afternoon)

1 hour 15 minutes

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.
- Section A: answer all of Section A in the spaces provided.
- Section B: answer one question from Section B. Write 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 numbers of the questions answered in the candidate box on your cover sheet and indicate the number of sheets used in the appropriate box on your cover sheet.



0110

## SECTION A

*Answer **all** the questions in the spaces provided.*

**1.** The percentage by mass of calcium carbonate in eggshell was determined by adding excess hydrochloric acid to ensure that all the calcium carbonate had reacted. The excess acid left was then titrated with aqueous sodium hydroxide.

(a) A student added 27.20 $cm^3$ of 0.200 $mol\,dm^{-3}$ HCl to 0.188 g of eggshell. Calculate the amount, in mol, of HCl added. *[1]*

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(b) The excess acid requires 23.80 $cm^3$ of 0.100 $mol\,dm^{-3}$ NaOH for neutralization. Calculate the amount, in mol, of acid that is in excess. *[1]*

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(c) Determine the amount, in mol, of HCl that reacted with the calcium carbonate in the eggshell. *[1]*

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(d) State the equation for the reaction of HCl with the calcium carbonate in the eggshell. *[2]*

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(e) Determine the amount, in mol, of calcium carbonate in the sample of the eggshell. *[2]*

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*(This question continues on the following page)*

*(Question 1 continued)*

(f) Calculate the mass **and** the percentage by mass of calcium carbonate in the eggshell sample. *[3]*

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(g) Deduce **one** assumption made in arriving at the percentage of calcium carbonate in the eggshell sample. *[1]*

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**2.** Draw and label an energy level diagram for the hydrogen atom. In your diagram show how the series of lines in the ultraviolet and visible regions of its emission spectrum are produced, clearly labelling each series. *[4]*

**3.** Consider the bonding and structure of the period 3 elements.

(a) Explain the increase in the melting point from sodium to aluminium. *[2]*

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(b) Explain why sulfur, $S_8$, has a higher melting point than phosphorus, $P_4$. *[2]*

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(c) Explain why silicon has the highest melting point and argon has the lowest melting point. *[2]*

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**4.** One important property of a rocket fuel mixture is the large volume of gaseous products formed which provide thrust. Hydrazine, $N_2H_4$, is often used as a rocket fuel. The combustion of hydrazine is represented by the equation below.

$$N_2H_4(g) + O_2(g) \rightarrow N_2(g) + 2H_2O(g) \qquad \Delta H_c^{\ominus} = -585\,kJ\,mol^{-1}$$

(a) Hydrazine reacts with fluorine to produce nitrogen and hydrogen fluoride, all in the gaseous state. State an equation for the reaction. *[2]*

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(b) Draw the Lewis structures for hydrazine and nitrogen. *[2]*

(c) Use the average bond enthalpies given in Table 10 of the Data Booklet to determine the enthalpy change for the reaction in part (a) above. *[3]*

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(d) Based on your answers to parts (a) and (c), suggest whether a mixture of hydrazine and fluorine is a better rocket fuel than a mixture of hydrazine and oxygen. *[2]*

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## SECTION B

*Answer **one** question. Write your answers on the answer sheets provided. Write your session number on each answer sheet, and attach them to this examination paper and your cover sheet using the tag provided.*

**5.** The periodic table shows the relationship between electron arrangement and the properties of elements and is a valuable tool for making predictions in chemistry.

(a) (i) Identify the property used to arrange the elements in the periodic table. *[1]*

(ii) Outline **two** reasons why electronegativity increases across period 3 in the periodic table and **one** reason why noble gases are not assigned electronegativity values. *[3]*

(b) (i) Define the term *first ionization energy* of an atom. *[2]*

(ii) Explain the general increasing trend in the first ionization energies of the period 3 elements, Na to Ar. *[2]*

(iii) Explain why sodium conducts electricity but phosphorus does not. *[2]*

(c) The word *redox* comes from a combination of the terms *reduction* and *oxidation*. Redox reactions affect our daily lives.

The overall reaction that takes place in a voltaic cell is shown below.

$$Pb(s) + PbO_2(s) + 2H_2SO_4(aq) \rightarrow 2PbSO_4(s) + 2H_2O(l)$$

(i) Determine the oxidation number of lead in Pb, $PbO_2$ and $PbSO_4$. *[1]*

(ii) Deduce the oxidation and reduction half-equations taking place at the negative lead electrode (anode) and the positive lead(IV) oxide electrode (cathode). Deduce the oxidizing and reducing agents and state the direction of the electron flow between the electrodes. *[4]*

(iii) In order to determine the position of three metals in a reactivity series, the metals were placed in different solutions of metal ions. The table below summarizes whether or not a reaction occurred.

| | **$Ag^+(aq)$** | **$Cu^{2+}(aq)$** | **$Pb^{2+}(aq)$** |
|---|---|---|---|
| **Ag (s)** | | No reaction | No reaction |
| **Cu (s)** | Reaction | | No reaction |
| **Pb (s)** | Reaction | Reaction | |

State the equations for the **three** reactions that take place. Use this information to place the metals Ag, Cu and Pb in a reactivity series, with the strongest reducing agent first, and explain your reasoning. *[5]*

**6.** (a) Water is an important substance that is abundant on the Earth's surface. Water dissociates according to the following equation.

$$H_2O(l) \rightleftharpoons H^+(aq) + OH^-(aq)$$

(i) State the equilibrium constant expression for the dissociation of water. *[1]*

(ii) Explain why even a very acidic aqueous solution still has some $OH^-$ ions present in it. *[1]*

(iii) State and explain the effect of increasing temperature on the equilibrium constant above given that the dissociation of water is an endothermic process. *[3]*

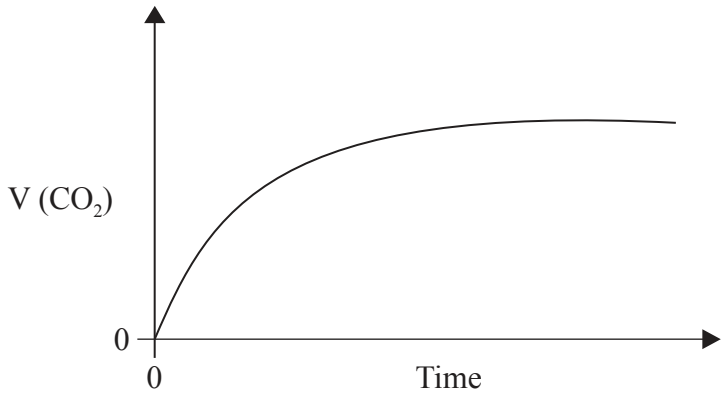
(iv) The pH of a solution is 2. If its pH is increased to 6, deduce how the hydrogen ion concentration changes. *[2]*

(b) In carbonated drinks containing dissolved carbon dioxide under high pressure, the following dynamic equilibrium exists.

$$CO_2(aq) \rightleftharpoons CO_2(g)$$

Describe the effect of opening a carbonated drink container and outline how this equilibrium is affected. *[2]*

(c) The graph below shows how the volume of carbon dioxide formed varies with time when a hydrochloric acid solution is added to **excess** calcium carbonate in a flask.




(i) Explain the shape of the curve. *[3]*

(ii) Copy the above graph on your answer sheet and sketch the curve you would obtain if **double** the volume of hydrochloric acid solution of **half** the concentration as in the example above is used instead, with all other variables kept constant from the original. Explain why the shape of the curve is different. *[4]*

*(This question continues on the following page)*

*(Question 6 continued)*

(iii) Outline **one** other way in which the rate of this reaction can be studied in a school laboratory. Sketch a graph to illustrate how the selected variable would change with time. *[2]*

(iv) Define the term *activation energy* and state **one** reason why the reaction between calcium carbonate and hydrochloric acid takes place at a reasonably fast rate at room temperature. *[2]*

**7.** (a) Alkenes are an economically and chemically important family of organic compounds.

(i) The reaction of alkenes with bromine water provides a test for unsaturation in the laboratory. Describe the colour change when bromine water is added to chloroethene. *[1]*

(ii) Deduce the Lewis structure of chloroethene and identify the formula of the repeating unit of the polymer poly(chloroethene). *[2]*

(iii) Besides polymerization, state **two** commercial uses of the reactions of alkenes. *[2]*

(b) But-2-ene can be converted to butan-2-one in **two** stages.

(i) Draw the structural formulas of but-2-ene and butan-2-one. *[2]*

(ii) Deduce a reaction pathway for the **two** stages of the reaction. Your answer should include the fully balanced equation for each stage of the reaction **and** the reagents and conditions for the two stages. *[5]*

(c) (i) Deduce the structural formulas of the **two** alcohol isomers of molecular formula $C_3H_8O$. Name each isomer and identify each as either a primary or a secondary alcohol. *[3]*

(ii) Oxidation of the alcohol isomers lead to the formation of different organic products. Determine the structures of the organic products formed from the oxidation of each alcohol isomer in (c) (i) above and list the conditions required to obtain the different products. *[5]*