GCE A level

1095/01

CHEMISTRY – CH5

P.M. TUESDAY, 17 June 2014

1 hour 45 minutes plus your additional time allowance

Surname ______________________

Other Names ______________________

Centre Number ______________________

Candidate Number 2 ______________________

| | For Examiner's use only | | |
|---|---|---|---|
| | Question | Maximum Mark | Mark Awarded |
| Section A | 1. | 10 | |
| | 2. | 12 | |
| | 3. | 18 | |
| Section B | 4. | 20 | |
| | 5. | 20 | |
| | Total | 80 | |

## ADDITIONAL MATERIALS

In addition to this examination paper, you will need:

- a calculator;
- an 8 page answer book;
- a copy of the PERIODIC TABLE supplied by WJEC. Refer to it for any RELATIVE ATOMIC MASSES you require.

## INSTRUCTIONS TO CANDIDATES

Use black ink, black ball-point pen or your usual method.

Write your name, centre number and candidate number in the spaces provided on the front cover.

SECTION A Answer ALL questions in the spaces provided.

SECTION B Answer BOTH questions in SECTION B in a separate answer book which should then be placed inside this question-and-answer book.

Candidates are advised to allocate their time appropriately between SECTION A (40 MARKS) and SECTION B (40 MARKS).

## INFORMATION FOR CANDIDATES

**The number of marks is given in brackets at the end of each question or part-question.**

**The maximum mark for this paper is 80.**

**Your answers must be relevant and must make full use of the information given to be awarded full marks for a question.**

**You are reminded that marking will take into account the Quality of Written Communication in all written answers.**

## SECTION A

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

**1. Ammonium salts are very important chemicals as they are used as a nitrogen source in fertilisers.**

**(a) When cold aqueous sodium hydroxide is added to an ammonium salt, the following equilibrium exists.**

$$NH_4^+(aq) + OH^-(aq) \rightleftharpoons NH_3(aq) + H_2O(l)$$

**Identify the TWO acid-base conjugate pairs in the equilibrium. [2]**

1(b) Ammonium chloride and sodium nitrite react together in aqueous solution to produce nitrogen gas. This can be represented by the ionic equation:

$$NH_4^+(aq) + NO_2^-(aq) \longrightarrow N_2(g) + 2H_2O(l)$$

The rate equation for the reaction is given below.

Rate = $k[NH_4^+][NO_2^-]$

(i) Complete the table of data for the above reaction. All experiments were carried out at the same temperature. [3]

| | $[NH_4^+(aq)]$ / mol dm$^{-3}$ | $[NO_2^-(aq)]$ / mol dm$^{-3}$ | Initial rate / mol dm$^{-3}$ s$^{-1}$ |
|---|---|---|---|
| 1 | 0.200 | 0.010 | $4.00 \times 10^{-7}$ |
| 2 | | 0.010 | $2.00 \times 10^{-7}$ |
| 3 | 0.200 | | $1.20 \times 10^{-6}$ |
| 4 | 0.100 | 0.020 | |

**1(b) (ii) Calculate the value of the rate constant, *k*, giving its units. [2]**

**Value of *k* =** ______________________________

**Units** ______________________________

1(b) (iii) State how the value of *k* will alter, if at all, if the concentration of $NH_4^+$ ions is increased. [1]

(iv) State, giving a reason, how the value of *k* will alter, if at all, if the temperature is increased. [2]

Total [10]

| |
|---|
| 10 |

**2(a)** **Write an expression for the ionic product of water, $K_w$, giving its units, if any. [2]**

**$K_w$ =**

**Units** ____________________

2(b) (i) The value for $K_w$ at 298 K is $1.0 \times 10^{-14}$. Explain why the pH of pure water at this temperature has a value of 7. [2]

______________________________________________

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______________________________________________

(ii) Calculate the pH of the final solution if $10\,cm^3$ of $0.10\ mol\ dm^{-3}$ hydrochloric acid is added to $990\,cm^3$ of pure water. [2]

pH = ______________________

2(c) Calculate the pH of a solution which is 0.010 mol dm$^{-3}$ with respect to ethanoic acid and 0.020 mol dm$^{-3}$ with respect to sodium ethanoate at 298 K. [3]

[$K_a$ for ethanoic acid = 1.78 × 10$^{-5}$ mol dm$^{-3}$ at 298 K]

pH = ____________________

2(d) If 10 $cm^3$ of 0.10 mol $dm^{-3}$ hydrochloric acid is added to 990 $cm^3$ of the solution described in (c) the change in pH is only 0.06. Explain why this change in pH is much smaller than that in (b)(ii).

[3]

Total [12]

| |
|---|
| 12 |

3. **Read the following passage and then answer the questions in the spaces provided.**

## HYDROGEN PEROXIDE

If a non-scientist knows only one chemical formula it is most likely to be $H_2O$ for water but how much do you know about another hydrogen oxide, hydrogen peroxide? A molecule of hydrogen peroxide has the molecular formula $H_2O_2$.

Most chemistry students first meet hydrogen peroxide as a colourless solution that is used to prepare oxygen. Bottles of hydrogen peroxide from a pharmacist are often labelled '20 volume'. This means that one volume of solution decomposes to give 20 volumes of oxygen gas. The equation for the decomposition is:

$$\underset{1\,dm^3}{2H_2O_2(aq)} \longrightarrow 2H_2O(l) + \underset{20\,dm^3}{O_2(g)}$$

This reaction is very slow at room temperature. However the addition of a suitable catalyst increases the rate of decomposition phenomenally. Manganese(IV) oxide, potatoes and blood are all effective. Potatoes and blood both contain the enzyme catalase and one catalase molecule decomposes 50 000 molecules of $H_2O_2$ per second!

Is hydrogen peroxide an oxidising agent or a reducing agent?

Both in the laboratory and at home hydrogen peroxide is most commonly used as an oxidising agent (so the hydrogen peroxide itself is reduced). The half-equation is:

Reduction $$H_2O_2 + 2H^+ + 2e^- \longrightarrow 2H_2O$$

Since some colouring matter is bleached by oxidation and the product of hydrogen peroxide's reduction is water, it is used as a safe bleaching agent particularly in hair treatment. A peroxide blonde is someone with almost white hair, usually as a result of treatment with hydrogen peroxide.

However, if hydrogen peroxide reacts with a more powerful oxidising agent such as potassium manganate(VII), the hydrogen peroxide will act as a reducing agent and will itself be oxidised.
The half-equation is:

Oxidation $$H_2O_2 \longrightarrow 2H^+ + O_2 + 2e^-$$

Therefore hydrogen peroxide can act as both oxidising agent and reducing agent. In fact, it can react with itself so that alternate molecules are oxidised and reduced.

The overall equation is obtained by adding the half-equations for the reduction and oxidation, giving

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

which is the standard decomposition equation!

- End of passage -

**3(a)** **Using outer electrons only, draw a dot and cross diagram to show the bonding in a hydrogen peroxide molecule (line 5). [1]**

**(b)** **Use the equation for the decomposition of hydrogen peroxide (line 12) to calculate the concentration, in mol $dm^{-3}$, of aqueous hydrogen peroxide solution in a bottle of '20 volume hydrogen peroxide' at 25 °C. [2]**

**[1 mol of oxygen occupies 24 $dm^3$ at 25 °C]**

**Concentration = ____________________ mol $dm^{-3}$**

3(c) Manganese(IV) oxide (lines 15-16) and potassium manganate(VII) (lines 34-35) are typical transition metal compounds.

(i) Give TWO reasons why transition metal compounds can act as catalysts. [2]

(ii) Explain why transition metal complex ions appear coloured. [4] QWC [1]

**3(d)** **In an acidic solution, hydrogen peroxide is oxidised to oxygen by potassium manganate(VII) (lines 34-38).**

**(i)** **Write the half-equation for the reduction of $MnO_4^-$ to $Mn^{2+}$ ions in acidic solution. [1]**

**(ii)** **Use your answer to (i) and the half-equation given in line 38 to deduce the overall equation for this reaction. [2]**

3(d) (iii) 20.0 $cm^3$ of an acidified solution of hydrogen peroxide required 14.80 $cm^3$ of a 0.020 mol $dm^{-3}$ solution of potassium manganate(VII) for complete reaction.

Calculate the concentration, in mol $dm^{-3}$, of the hydrogen peroxide solution. [3]

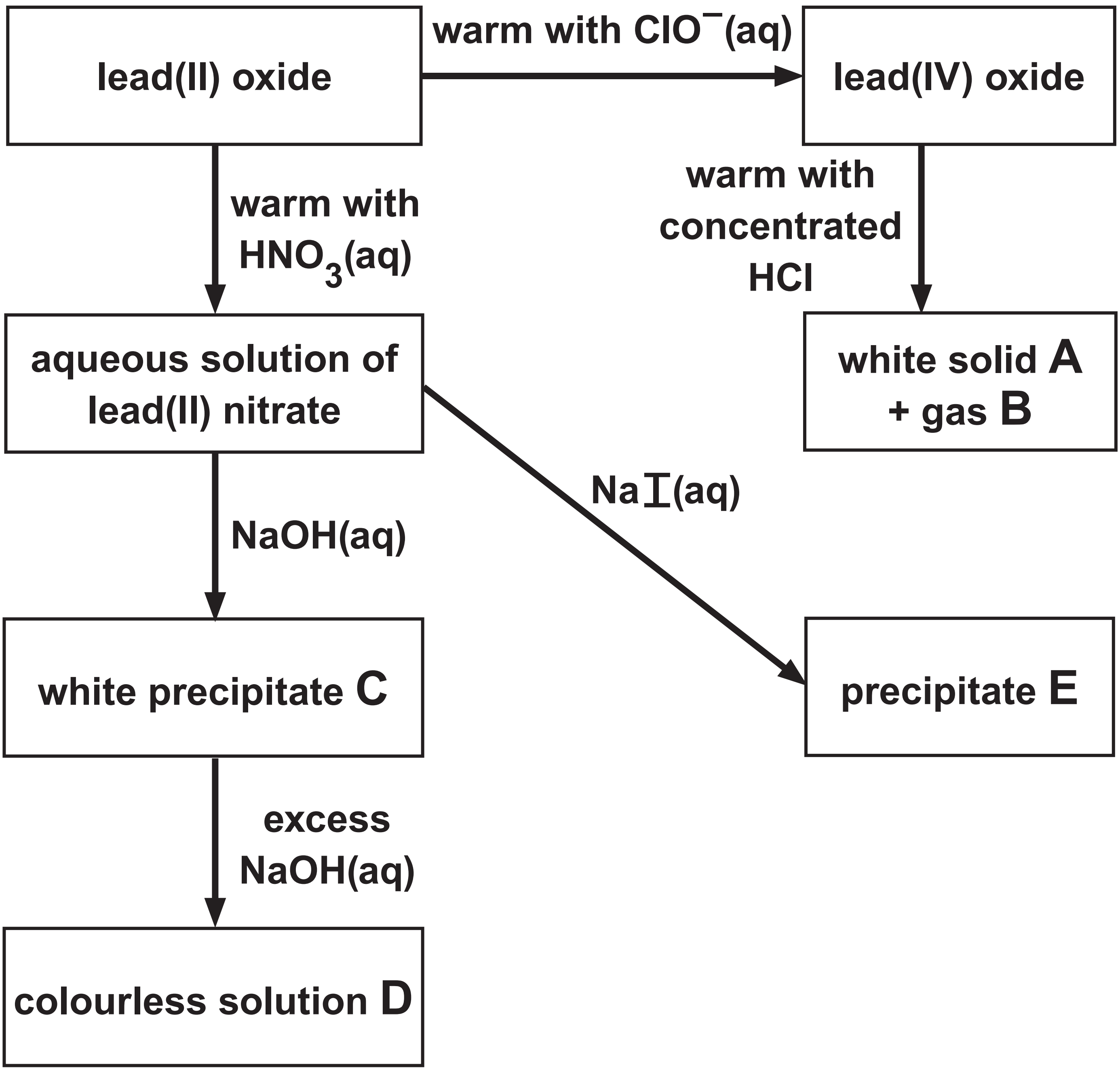
Concentration = ____________________________ mol $dm^{-3}$

3(e) **Explain, using oxidation states, why the decomposition of hydrogen peroxide (line 44) can be classified as a redox reaction. [2]**

**Total [18]**

| |
|---|
| |
| **18** |

**TOTAL SECTION A [40]**


lead(II) oxide
warm with $ClO^-(aq)$
lead(IV) oxide
warm with $HNO_3(aq)$
warm with concentrated HCl
aqueous solution of lead(II) nitrate
white solid **A** + gas **B**
NaI(aq)
NaOH(aq)
white precipitate **C**
precipitate **E**
excess NaOH(aq)
colourless solution **D**

## SECTION B

**Answer BOTH questions in the separate answer book provided.**

**4(a)** **The diagram opposite shows some of the reactions of lead compounds.**

**(i)** **State the role of lead(IV) oxide in the reaction with concentrated hydrochloric acid. [1]**

**(ii)** **Name white solid A and gas B. [2]**

**(iii)** **Give the formula of the lead-containing species present in colourless solution D. [1]**

**(iv)** **Give the colour of precipitate E. [1]**

**(v)** **Write the equation for the formation of lead(II) nitrate from lead(II) oxide. [1]**

4(b) Carbon is the first element in Group 4. Two of its allotropes are diamond and graphite. A compound that forms structures corresponding to diamond and graphite is boron nitride.

(i) Describe the structure of graphite and explain why HEXAGONAL boron nitride can adopt the same structure yet have different electrical conductivity properties. [4]

QWC [1]

(ii) State ONE use for the CUBIC boron nitride structure. [1]

**4(c)** **Another element in Group 4 is tin. At low temperatures tin exists as its grey form. At higher temperatures the white form is stable. The change can be represented by the equation:**

$$Sn_{(grey)} \longrightarrow Sn_{(white)} \qquad \Delta H^{\ominus} = 1.92\,kJ\ mol^{-1}$$

**The standard entropy values are 44.8 J $K^{-1}$ $mol^{-1}$ for grey tin and 51.5 J $K^{-1}$ $mol^{-1}$ for white tin.**

**(i)** **Calculate the minimum temperature needed to cause grey tin to change to white tin. [3]**

**(ii)** **During Napoleon's disastrous campaign in Russia from June to December in 1812 the tin buttons on his infantry's uniforms disintegrated. Suggest a reason why this might have happened. [1]**

**4(d)** **An important technological development in recent years has been the hydrogen fuel cell. This uses electrochemical methods to get energy from hydrogen.**

**(i)** **Write the half-equations for the processes occurring at the electrodes and an equation for the overall reaction. [3]**

**(ii)** **Give ONE disadvantage of using hydrogen fuel cells to power vehicles. [1]**

**Total [20]**

5(a) Chlorine reacts with aqueous sodium hydroxide in one of two ways, depending on the temperature used.

(i) Write the equation for the reaction of chlorine with

I cold aqueous sodium hydroxide, [1]

II hot aqueous sodium hydroxide. [1]

(ii) Classify this type of redox reaction. [1]

(b) Chlorine reacts with many elements to form chlorides. Explain why phosphorus forms two chlorides, $PCl_3$ and $PCl_5$, but nitrogen only forms $NCl_3$. [2]

(c) Most ionic chlorides, e.g. sodium chloride, are soluble in water. However some, e.g. silver chloride, are insoluble.

The enthalpy change of solution of an ionic compound and its solubility depend on the balance between two enthalpy changes. Name these enthalpy changes and state if they are endothermic or exothermic. Explain how the enthalpy change of solution of a compound and its solubility depend on the balance between them. [4] QWC [1]

| System | $E^{\ominus}$ / V |
|---|---|
| $\frac{1}{2}I_2(s) + e^- \rightleftharpoons I^-(aq)$ | +0.54 |
| $Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$ | +0.77 |
| $\frac{1}{2}Br_2(l) + e^- \rightleftharpoons Br^-(aq)$ | +1.09 |
| $\frac{1}{2}Cl_2(g) + e^- \rightleftharpoons Cl^-(aq)$ | +1.36 |
| $Ce^{4+}(aq) + e^- \rightleftharpoons Ce^{3+}(aq)$ | +1.45 |

5(d) Some standard electrode potentials, $E^{\ominus}$, are given opposite.

(i) Using the information from the table, state which of the HALIDES will reduce $Fe^{3+}$ to $Fe^{2+}$. Give a reason for your answer. [2]

(ii) Write the cell diagram of the cell formed by combining the $Fe^{3+}(aq)$, $Fe^{2+}(aq)$ and $Ce^{4+}(aq)$, $Ce^{3+}(aq)$ half cells and calculate the standard e.m.f. of this cell. [2]

QUESTION 5 CONTINUES ON PAGE 28

**5(e)** A flask containing an initial mixture of 0.100 mol of ethanoic acid and 0.083 mol of methanol was kept at 25 °C until the following equilibrium had been established.

$$CH_3COOH + CH_3OH \rightleftharpoons CH_3COOCH_3 + H_2O \quad \Delta H = -3\,kJ\,mol^{-1}$$

The ethanoic acid present at equilibrium required $32.0\,cm^3$ of a $1.25\,mol\,dm^{-3}$ solution of sodium hydroxide for complete reaction.

(i) Write an expression for the equilibrium constant, $K_c$, giving the units, if any. [2]

(ii) Calculate the number of moles of ethanoic acid present at equilibrium. [1]

(iii) Calculate the value of the equilibrium constant, $K_c$, for this reaction. [2]

(iv) State, giving a reason, what happens to the value of the equilibrium constant, $K_c$, if the temperature is increased. [1]

Total [20]

TOTAL SECTION B [40]

END OF PAPER