ALL SAINTS' COLLEGE

Science Department

Year 12 Chemistry ATAR

Test 5: Electrochemistry – Commercial Cells and Electrolysis

Name: ________________________________

Instructions to Students:

1. 50 minutes permitted
2. Attempt all questions
3. Write in the spaces provided
4. Show all working when required
5. All answers to be in blue or black pen, diagrams in pencil.

TOTAL	Final Percentage
/48	

ALL SAINTS' COLLEGE

Year 12 Chemistry ATAR

Electrochemistry – Commercial Cells and Electrolysis

Commercial Cells

1. One of the many practical applications of electrochemical cell theory is in the construction of dry cell "batteries". Over the years, companies have tried different chemical compounds to move beyond the original zinc/carbon primary cell to rechargeable secondary cells of more advanced construction.

One such cell is the nickel-cadmium, or "ni-cad" cells. These cells are known as secondary cells and are used in video cameras, phones and other cordless electrical devices

The equations involved with this type of cell are:

1. $Cd_{(s)} + 2OH^{-1}{}_{(aq)} \rightarrow Cd(OH)_{2(s)} + 2e^{-1}$ $\quad E° = +0.88V$

2. $NiO(OH)_{(s)} + H_2O_{(l)} + e^{-1} \rightarrow Ni(OH)_{2(s)}$ $\quad E° = +0.52V$

(a) Give the overall cell reaction.

____ (1 mark)

(b) State the expected EMF of the cell. ________________________ (1 mark)

(c) Despite their popularity, there are concerns with these type of cells, and all carry a safety warning specifically about their disposal. What is a potential safety concern with this type of battery?

____

____

____

(1 mark)

(d) These type of cells are known as "secondary" cells. Why is this?

____

____

(1 mark)

(e) List two advantages and disadvantages of secondary cells as opposed to traditional primary cells.

Advantages	Disadvantages
______________________	______________________
______________________	______________________

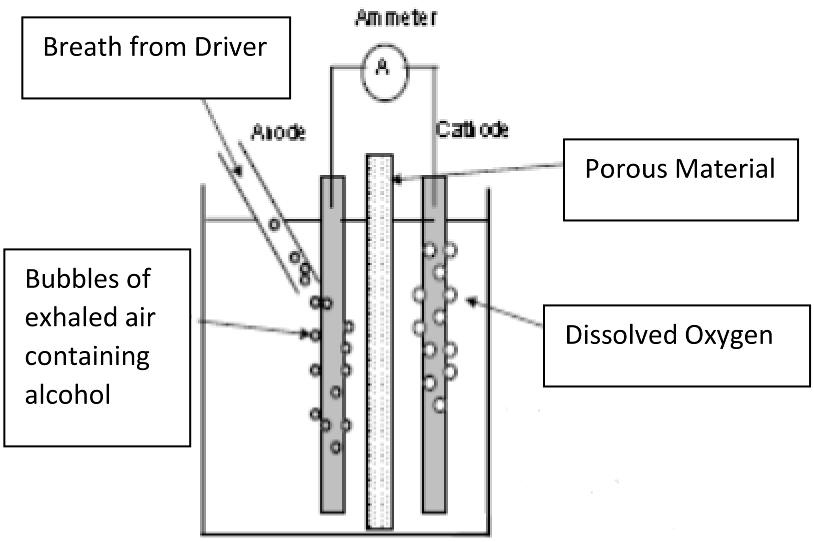
(2 marks)

2. Breathalysers work by analysing the amount of ethanol (C_2H_5OH) present in a driver's breath. Most modern breathalysers are based on fuel cell technology which is described below.

The fuel cell has two platinum electrodes with a porous acid-electrolyte material sandwiched between them. As the exhaled air from the driver flows past one side of the fuel cell, any alcohol in the breath is reacted at the other side at the platinum electrode producing ethanoic acid (acetic acid), hydrogen ions and electrons.

The electrons flow through a wire between the platinum electrodes. The oxygen moves to the lower portion of the fuel cell and is reacted to form hydroxide ions.

The more alcohol that is oxidised, the greater the electrical current. The current fed into a microprocessor and a digital reading of the blood alcohol level is shown on a screen on the device.



(a) Write the half-equation for the reaction of ethanol.

____

(b) Is this oxidation or reduction and at which electrode will this reaction take place?

____

(c) Write the half-equation for the reaction of oxygen at the other electrode.

___

(1 mark)

(d) Is this oxidation or reduction and at which electrode will this reaction take place?

___

(1 mark)

(e) Why must the acid-electrolyte material be porous?

___

(1 mark)

(f) What is the purpose of having electrodes made of platinum?

___

(1 mark)

(g) The ethanol cell produces a voltage of around 1.2V. Using a table of standard reduction potentials, predict the standard reduction potential of the ethanol/ethanoic half- cell.

___

(1 mark)

(h) Why is this estimate of the standard reduction potential only approximate?

___

___

(1 mark)

Continued on next page

Electrolysis

3.

(a) Draw a diagram to show the electrolysis of molten NaBr with platinum electrodes. Indicate the following:

(i) Anode and cathode.
(ii) Anode half equation.
(iii) Cathode half equation.
(iv) Overall reaction.
(v) E° for the process.
(vi) Positive and negative terminal.

(b) Why must the products of each half equation mentioned above be separated from one another?

____

____

(8 marks)

4. In 1807 Sir Humphry Davy electrolysed molten potassium hydroxide to produce the first drops of potassium metal. Bubbles of gas were observed at the anode. Write half-equations for the two electrode reactions.

____

____

(2 marks)

5. Write two half equations and a balanced cell reaction to explain the observations that a brown stream forms around one electrode and bubbles of gas are given off at the other when a strongly acidified aqueous solution of potassium iodide is electrolysed.

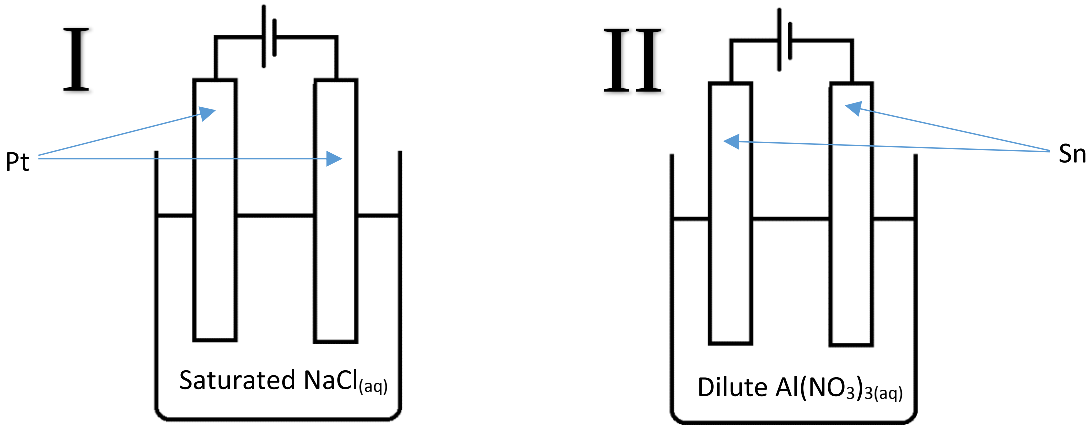
___

___

___

(3 marks)

6. Examine the two electrolytic cells below.



(a) Write the anode and cathode half-reactions and overall reaction for both cells immediately they are switched on.

Cell I ___

___

___

(3 marks)

Cell II ___

___

___

(3 marks)

(b) Calculate the minimum E.M.F. needed to electrolyse each solution under standard conditions.

(4 marks)

7. Copper metal is usually purified in an electrolytic cell with copper sulfate solution as the electrolyte. A raw copper bar containing many impurities (among them iron and silver metals) is used as the anode while the cathode is composed of pure copper.

(a) At the positive electrode the iron and copper are converted to ions but the silver is not - it falls to the bottom of the cell and is periodically removed. Briefly explain this difference in behaviour.

___

___

___

(2 marks)

(b) At the other electrode, copper is deposited but iron is not. Briefly explain why this is so.

___

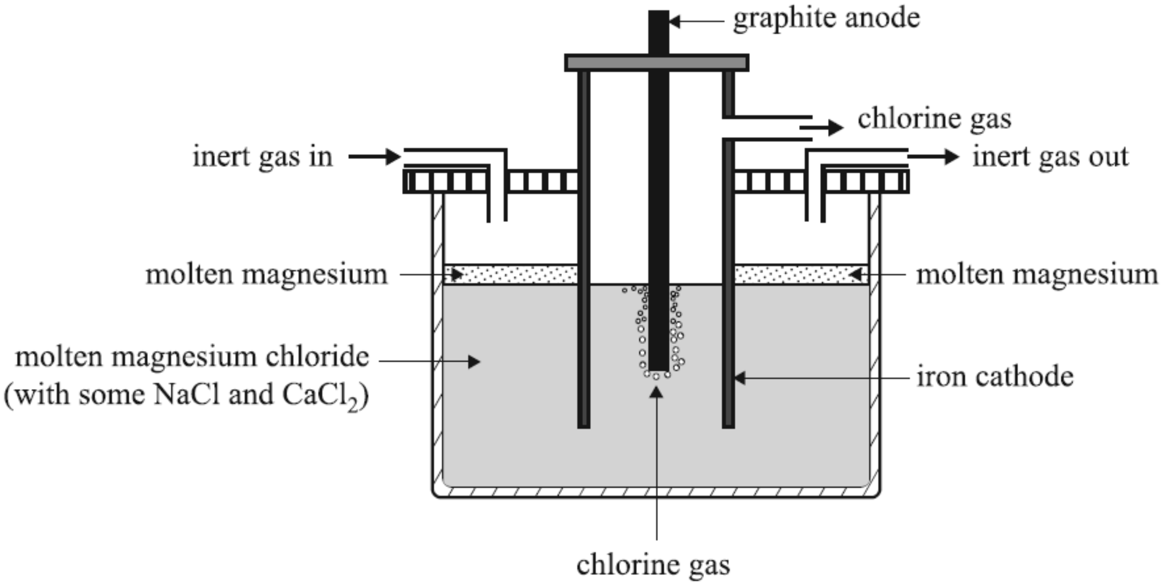
___

___

(1 mark)

8. Magnesium is one of the most abundant elements on Earth. It is used extensively in the production of magnesium-aluminium alloys. It is produced by the electrolysis of molten magnesium chloride.

A schematic diagram of the electrolytic cell is shown below.



The design of this cell takes into account the following properties of both magnesium metal and magnesium chloride:

- Molten magnesium reacts vigorously with oxygen.
- At the temperature of molten magnesium chloride, magnesium is a liquid.
- Molten magnesium has a lower density than molten magnesium chloride and forms a separate layer on the surface.

a. Write a balanced half-equation for the reaction occurring at each of

the cathode ____

the anode ____

(2 marks)

b. Explain why an inert gas is constantly blown through the cathode compartment.

____

____

____

(1 mark)

c. The melting point of a compound can often be lowered by the addition of small amounts of other compounds. In an industrial process, this will save energy. In this cell, NaCl and $CaCl_2$ are used to lower the melting point of $MgCl_2$.

Why can NaCl and $CaCl_2$ be used to lower the melting point of $MgCl_2$ but $ZnCl_2$ cannot be used?

____

____

____

____

____

(2 marks)

d. What difference would it make to the half-cell reactions if the graphite anode were replaced with an iron anode? Write the half-equation for any different half-cell reaction. Justify your answer.

____

____

____

____

____

____

(3 marks)

End of test