

ELECTROCHEMISTRY

Check List

Make sure you

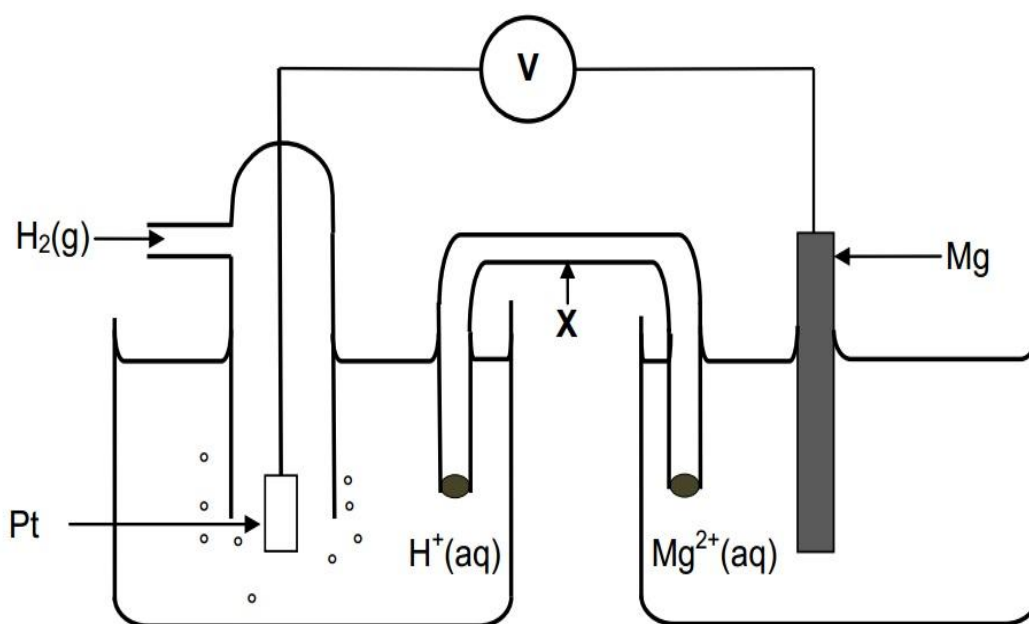
- Can explain how a galvanic and an electrolytic cell works basic
- Are able to describe the processes and identify the redox reactions that take place in electrolytic and galvanic cells
- Can explain what happens to current and potential difference when the reactions in a galvanic cell are in chemical equilibrium
- Are able to describe the standard hydrogen electrode and use cell notation for various galvanic cells
- Use standard electropotentials to determine the nature of reactions and to perform calculations
- Describe the use of electrolytic cells in the following processes:
 - The decomposition of copper Chloride
 - Electroplating
 - Electro refining of Copper
 - The recovery of Aluminium metal from Bauxite
 - The Chloro- Alkali Industry

Exam Questions

Question 1

(Adapted from DBE Feb 2013 Paper 2 Question 8)

The galvanic cell represented below consists of a hydrogen half-cell and a magnesium half-cell at standard conditions. The reading on the voltmeter is 2.36 V.





- 1.1 Apart from concentration, write down TWO other conditions needed for the hydrogen half-cell to function at standard conditions. (2)
- 1.2 Write down the name of the item of apparatus labelled X. (1)
- 1.3 Is magnesium the ANODE or CATHODE in the cell above? Refer to the relative strengths of reducing agents to explain the answer. (4)
- 1.4 Write down the cell notation for this cell. (3)
- 1.5 Calculate the standard reduction potential of the magnesium half-cell. Show ALL your working. (4)
- 1.6 Write down the balanced NET (overall) cell reaction that takes place in this cell. No spectator ions are required. (3)

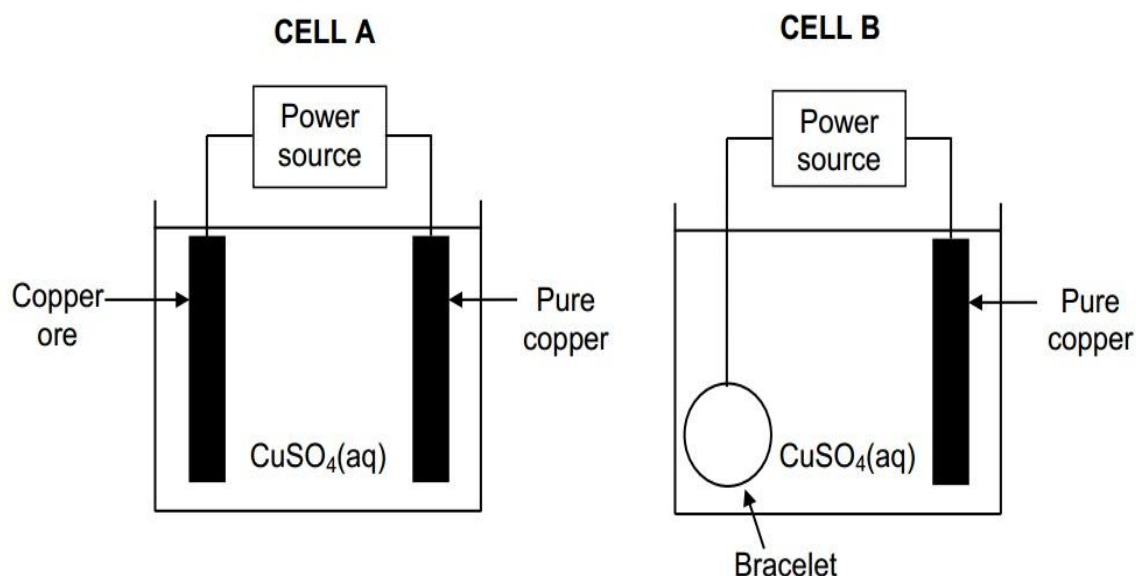
A learner adds a few drops of Universal indicator to the hydrogen half cell. She notices that while the cell is working the colour of the indicator changes regularly at first but then remains constant.

- 1.7.1 What would you expect to happen to the pH of the solution from the time the cell starts work till there is no change in the indicator colour. (2)
- 1.7.2 Explain why the indicator colour stops changing (3)

Question 2

(Adapted from DBE Feb 2013 Paper 2 Question 9)

The simplified diagrams below represent two electrochemical cells, **A** and **B**, used in INDUSTRY. Cell **A** is used in the purification of copper ore containing silver and platinum impurities. Cell **B** is used to electroplate a bracelet with a layer of copper.



- 2.1 Write down the name of the type of electrochemical cell (ELECTROLYTIC or GALVANIC) of which the above two cells are examples. (1)
- 2.2 Pure copper is used as one of the electrodes in each of the cells above. In which cell (**A** or **B**) is the pure copper the:
Cathode (1)
Anode

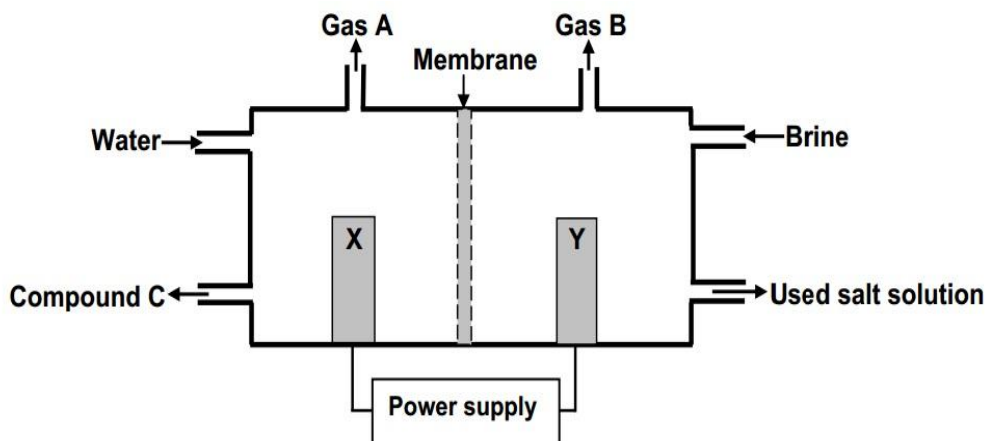


- 2.3 Consider cell **B**. Initially the $\text{CuSO}_4(\text{aq})$ has a blue colour.
- 2.3.1 How will the intensity of the blue colour change whilst the cell is functioning? Write down INCREASES, DECREASES or REMAINS THE SAME. Give a reason for the answer. (3)
- 2.3.2 Write down the half-reaction that takes place at the pure copper electrode. (2)
- 2.4 Consider cell A
- 2.4.1 Give a reason why the sludge formed in this cell is of economic importance. (1)
- 2.4.2 Name ONE negative impact that the energy usage in this process has on the environment. (2)

Question 3

(Adapted from DBE Nov 2011 Paper 2 Question 10)

The simplified diagram of a membrane cell used in the chlor-alkali industry is shown below. Gas **A**, gas **B** and compound **C** are the three major products formed during this process. **X** and **Y** represent the two electrodes.



- Write down the function of the membrane in this cell. (1)
- Which electrode, **X** or **Y**, is connected to the positive terminal of the power supply? Briefly explain how you arrived at the answer. (2)
- Write down the NAME or FORMULA of:
- Gas A (1)
- Gas C (1)
- Compound C (1)
- Write down the balanced net (overall) cell reaction taking place in this cell. (3)
- The chlor-alkali industry is sometimes blamed for contributing to the greenhouse effect. Briefly explain how the above cell contributes to the greenhouse effect. (2)

Question 4

(Adapted from DBE Nov 2010 Paper 2 Question 8)

The cell notation of a standard galvanic (voltaic) cell containing an unknown metal electrode **X** is shown below.

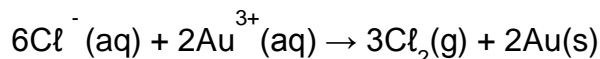


- 4.1 Name the component of the cell represented by the double vertical lines (||) in the above cell notation and explain its function. (3)
- 4.2 Identify the oxidising agent in the above cell. (1)
- 4.3 The initial reading on a voltmeter connected across the electrodes of the above cell is 1,53 V. Identify metal **X** by calculating the standard reduction potential of the unknown metal **X**. (5)
- 4.4 Write down the balanced equation for the net (overall) reaction taking place in this cell. Omit the spectator ions. (3)
- 4.5 How will the initial voltmeter reading be affected if the concentration of the electrolyte in the $\text{X(s)} \mid \text{X}^{3+} (\text{aq})$ half-cell is increased? Write down only INCREASES, DECREASES or REMAINS THE SAME. (2)

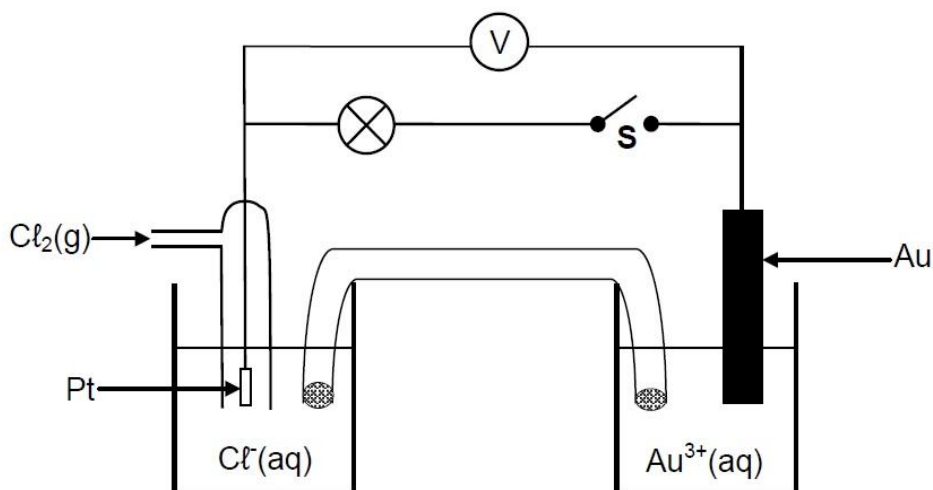
Question 5

(Adapted from DBE Nov 2013 Paper 2 Question 8)

The diagram below shows a galvanic cell operating under standard conditions. The cell reaction taking place when the cell is functioning is:



With switch **S** OPEN, the initial reading on the voltmeter is 0.14 V.



- 3.1 Write down the:
 - 3.1.1 NAME or FORMULA of the oxidising agent (1)
 - 3.1.2 Half-reaction which takes place at the anode (2)
 - 3.1.3 Cell notation for this cell (3)
- 3.2 Calculate the standard reduction potential of Au. (4)



Switch **S** is now closed and the bulb lights up.

- 3.3 How will the reading on the voltmeter now compare to the INITIAL reading of 0,14 V?
Write down only LARGER THAN, SMALLER THAN or EQUAL TO. Give a reason for the answer. (2)

SOLUTIONS TO ELECTROCHEMISTRY

Question 1

- 1.1 Pressure: 101,3 kPa (1,013 x 10⁵ Pa) Temperature: 25 °C (298 K)
1.2 Salt Bridge
1.3 Anode , Mg is a stronger reducing agent than H₂ and therefore (Mg) will be oxidised.
1.4 $\text{Mg(s)} \mid \text{Mg}^{2+}(1 \text{ mol}\cdot\text{dm}^{-3}) \parallel \text{H}^{+}(1 \text{ mol}\cdot\text{dm}^{-3}) \mid \text{H}_2(\text{g}) \mid \text{Pt(s)}$
1.5 $E^{\circ}_{\text{cell}} = E^{\circ}_{\text{cathode}} - E^{\circ}_{\text{anode}}$
 $2,36 = 0,00 - (E^{\circ}_{\text{anode}})$
 $E^{\circ}_{\text{anode}} = -2,36 \text{ V}$
1.6 $\text{Mg(s)} + 2\text{H}^{+}(\text{aq}) \rightarrow \text{Mg}^{2+}(\text{aq}) + \text{H}_2(\text{g})$

Question 2

- 2.1 Electrolytic
2.2
2.2.1 A
2.2.2 B
2.3
2.3.1 Remains the same
2.3.2 $\text{Cu} \rightarrow \text{Cu}^{2+} + 2\text{e}^{-}$
2.4
2.4.1 It contains precious metals
2.4.2 Consumes large amount of electricity/energy. Depletes coal resources. OR
Contributes to global warming. OR Habitats destroyed in mining of coal. OR
Contributes to acid rain.

Question 3

- 3.1 Allows only positive ions (cations/Na⁺ ions) to migrate to cathode half-cell.
3.2 Y, Chloride ions are oxidised at Y
3.3
3.3.1 H₂
3.3.2 Cl₂
3.3.3 NaOH
3.4 $2\text{H}_2\text{O} + 2\text{Cl}^{-} \rightarrow \text{H}_2 + 2\text{OH}^{-} + \text{Cl}_2$
3.5 Uses large amounts of electricity / energy. Combustion of coal during generation of electricity releases huge amounts of carbon dioxide into atmosphere.

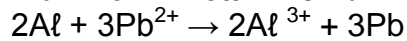
Question 4

- 4.1 Salt Bridge
4.2 Concentration of the electrolyte – 1 mol·dm⁻³
Temperature – 25 °C/298 K
4.3 Pb²⁺
4.4 $E^{\circ}_{\text{cell}} = E^{\circ}_{\text{cathode}} - E^{\circ}_{\text{anode}}$
 $1,53 = (-0,13) - E^{\circ}_{\text{anode}}$



$$E^{\circ}_{\text{anode}} = -1,66 \text{ (V)}$$

\therefore unknown metal X is Al



4.5 Decreases

4.6 0V

Question 5

5.1

5.1.1 Au^{3+}

5.1.2 $2\text{Cl}^{-} \rightarrow \text{Cl}_2 + 2\text{e}^{-}$

5.2 $\text{Pt(s)} \mid \text{Cl}^{-} (1 \text{ mol}\cdot\text{dm}^{-3}) \mid \text{Cl}_2(\text{g}) \parallel \text{Au}^{3+}(1 \text{ mol}\cdot\text{dm}^{-3}) \mid \text{Au(s)}$

$$E^{\circ}_{\text{cell}} = E^{\circ}_{\text{cathode}} - E^{\circ}_{\text{anode}}$$

$$0,14 = E^{\circ}_{\text{cathode}} - (1,36)$$

$$E^{\circ}_{\text{cathode}} = 1,50 \text{ V}$$

5.3 Smaller than: Decrease or drop in potential difference or voltage due to internal resistance or "lost volts"