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VCE Chemistry ¾

Introduction to Electrolysis [2.1]

Homework Solutions

Admin Info & Homework Outline:

Student Name	
Questions You Need Help For	
Compulsory Questions	Pg 2 – Pg 14
Supplementary Questions	Pg 15 – Pg 24

Section A: Compulsory Questions (51 Marks)

Sub-Section [2.1.1]: Identify Differences between Galvanic & Electrolysis for Electrodes, Energy Conversions, Electron Flow

Question 1 (4 marks)

a. Determine which of the following is true regarding the electrodes in electrolytic and galvanic cells. (1 mark)

A. The cathode is positively charged in a galvanic cell whilst negatively charged in an electrolytic cell.

B. The anode is positively charged in a galvanic cell whilst negatively charged in an electrolytic cell.

C. The anodes of an electrolytic cell and a galvanic cell are positively charged.

D. The anodes of an electrolytic cell and a galvanic cell are negatively charged.

b. Determine the **false** statement regarding the properties of galvanic and electrolytic cells. (1 mark)

A. Oxidation in galvanic and electrolytic cells occurs at the anode.

B. Electrons flow from anode to cathode in both cell types.

C. Galvanic and electrolytic cells convert chemical energy to electrical energy.

D. The anode is negatively charged in a galvanic cell.

c. Select the option which accurately describes the properties of galvanic and electrolytic cells. (2 marks)

A.

Cell type	Polarity of cathode	Reaction occurring at the cathode	Polarity of anode	Reaction occurring at the anode
Galvanic	−	Reduction	+	Oxidation
Electrolytic	+	Oxidation	−	Reduction

B.

Cell type	Polarity of cathode	Reaction occurring at the cathode	Polarity of anode	Reaction occurring at the anode
Galvanic	+	Reduction	−	Oxidation
Electrolytic	−	Oxidation	+	Reduction

C.

Cell type	Polarity of cathode	Reaction occurring at the cathode	Polarity of anode	Reaction occurring at the anode
Galvanic	+	Reduction	−	Oxidation
Electrolytic	+	Oxidation	−	Reduction

D.

Cell type	Polarity of cathode	Reaction occurring at the cathode	Polarity of anode	Reaction occurring at the anode
Galvanic	+	Reduction	−	Oxidation
Electrolytic	−	Oxidation	+	Reduction

Space for Personal Notes

Question 2 (2 marks)

Karthik is interested in the electrolytic cell which his lab teacher has set up for a practical session.

a. State the energy conversion occurring in the cell. (1 mark)

Electrical energy → Chemical energy (1).

b. Hence, determine whether electrolysis is exothermic or endothermic. (1 mark)

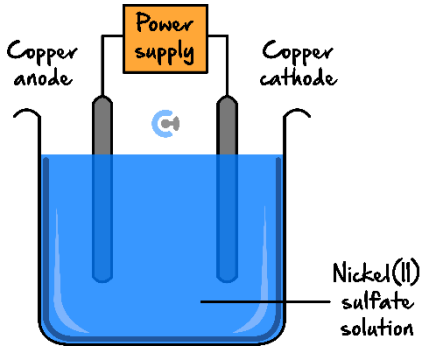
Endothermic.

Question 3 (2 marks)

a. Select the option which accurately describes the electron flow of galvanic and electrolytic cells. (1 mark)

	Galvanic Cells	Electrolytic Cells
A.	Anode to Cathode.	Cathode to Anode.
B.	Cathode to Anode.	Anode to Cathode.
C.	Cathode to Anode.	Cathode to Anode.
D.	Anode to Cathode.	Anode to Cathode.

b. Katie is analysing the electrolytic cell shown below:



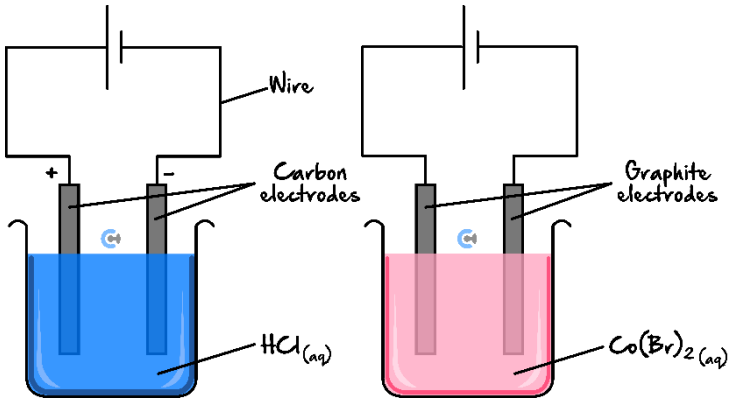
Determine the purpose of the nickel (II) sulphate solution. (1 mark)

To complete the circuit due to the absence of a salt bridge (1).

Sub-Section [2.1.2]: Write Equations & Calculate EMF Required for Electrolytic Reactions

Question 4 (9 marks)

a. Nour is electrolysing 1.0 *M* of HCl in the cell shown below.



i. Write the equation which occurs at the cathode. (1 mark)

$2H^+(aq) + 2e^- \rightleftharpoons H_2(g)$

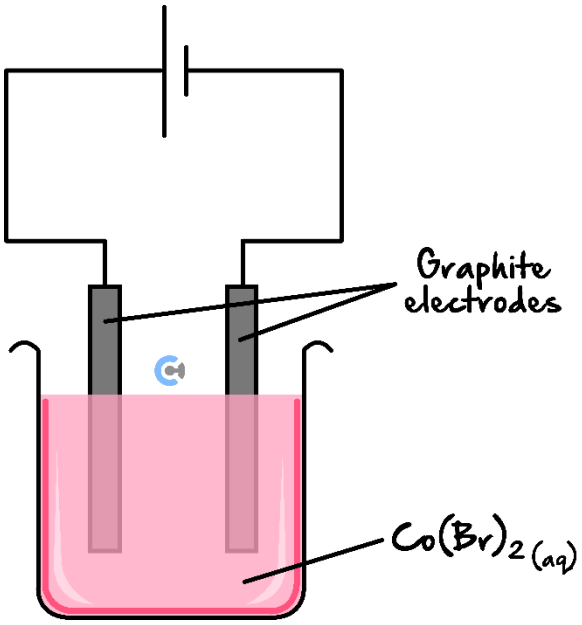
ii. Write the equation which occurs at the anode. (1 mark)

$2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$

iii. Hence, write the overall equation for the cell. (1 mark)

$2H_2O(l) \rightarrow O_2(g) + H_2(g) + 2H^+(aq)$

b. Rehansa is operating a cell containing 1.0 *M* of cobalt (II) bromide, shown below.



i. Write the half-equation which occurs at the cathode. (1 mark)

$Co^{2+}_{(aq)} + 2e^- \rightarrow Co_{(s)}$

ii. Write the half-equation which occurs at the anode. (1 mark)

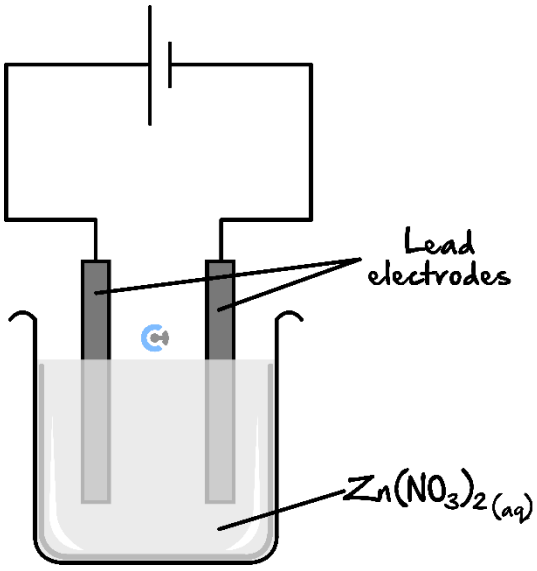
$2Br^-(aq) \rightarrow 2e^- + Br_2(I)$

iii. Write the overall equation for the cell. (1 mark)

$Co^{2+}(aq) + 2Br^-(aq) \rightarrow Co(s) + Br_2(I)$

$CoBr_2(aq) \rightarrow Co(s) + Br_2(I)$

c. Priyanka is operating a cell containing 1.0 *M* of zinc nitrate. The cell is shown below.



i. Write the half-equation which occurs at the cathode. (1 mark)

$Zn^{2+}_{(aq)} + 2e^- \rightarrow Zn_{(s)}$

ii. Write the half-equation which occurs at the anode. (1 mark)

$Pb_{(s)} \rightarrow Pb^{2+}_{(aq)} + 2e^-$

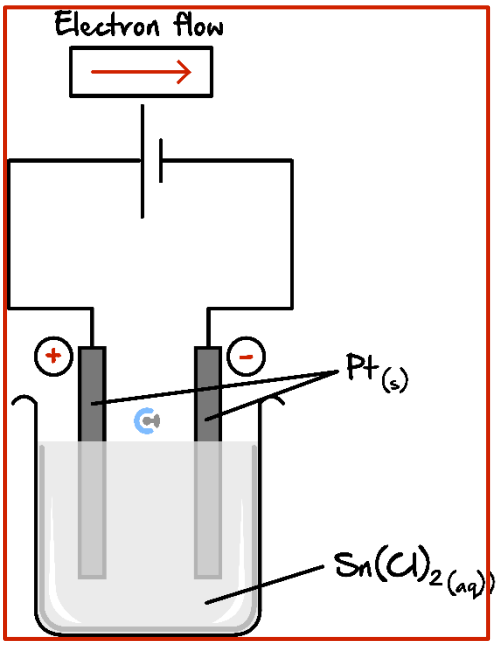
iii. Write the overall equation for the cell. (1 mark)

$Zn^{2+}_{(aq)} + Pb_{(s)} \rightarrow Pb^{2+}_{(aq)} + Zn_{(s)}$

Space for Personal Notes

Question 5 (16 marks)

a. Steven has set up an electrolytic cell containing tin (II) chloride, as shown below.



i. Write the half-equations for Steven's cell. (2 marks)

Cathode:

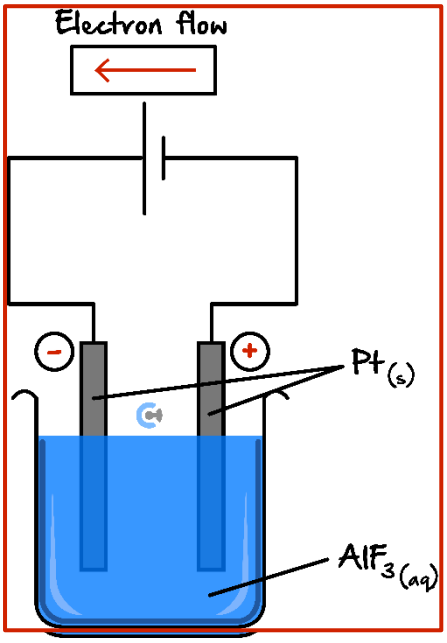
$Sn^{2+}_{(aq)} + 2e^- \rightarrow Sn_{(s)}$

Anode:

$Sn^{2+}_{(aq)} \rightarrow Sn^{4+}_{(aq)} + 2e^-$

ii. Label the electrode polarities and direction of electron flow in the diagram above. (2 marks)

b. Ivy has set up a cell containing aluminium fluoride.



i. Write the half-equations for Ivy's cell. (2 marks)

Oxidation Reaction":

$2H_2O_{(l)} \rightarrow O_{2(g)} + 4H^+_{(aq)} + 4e^-$

Reduction reaction:

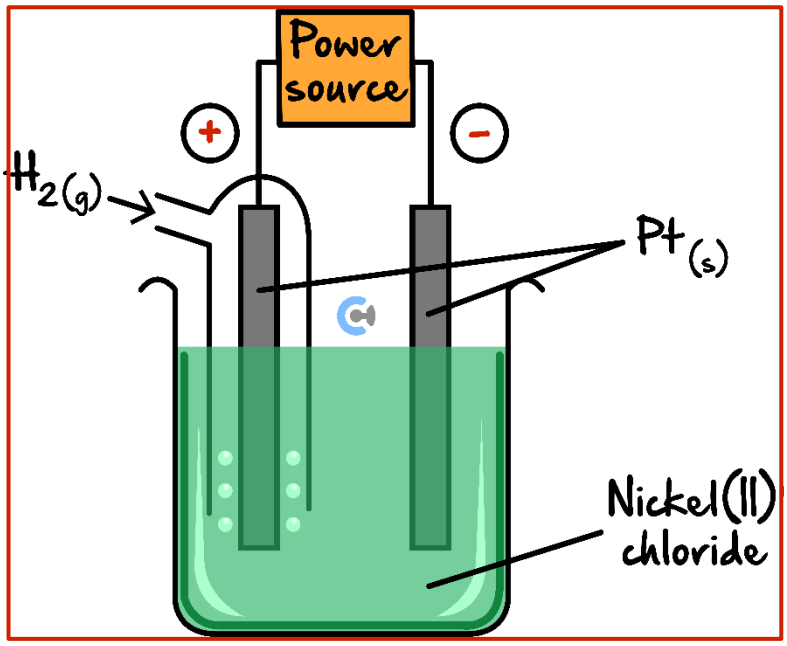
$2H_2O(l) + 2e^- \rightleftharpoons H_2(g) + 2OH^-(aq)$

ii. Label the electrode polarities and the direction of electron flow in the diagram above. (2 marks)

iii. Ivy inserts a pH metre into the electrolyte. State and justify the expected change in pH. (2 marks)

pH stays the same (1). OH^- is produced at cathode, but H^+ is produced at the anode so it stays neutral overall (2).

c. Leah sets up the following cell:



i. Write the half-equations which occur at the: (2 marks)

Cathode: $Ni^{2+}_{(aq)} + 2e^- \rightarrow Ni_{(s)}$

Anode: $H_{2(g)} \rightarrow 2H^+_{(aq)} + 2e^-$

ii. Label the electrodes as negatively and positively charged. (1 mark)

iii. As the reaction occurs, the colour of the electrolyte is seen to change. State and justify the expected change in the colour of the electrolyte. (2 marks)

The electrolyte colour will change from green to clear (1). This is because the concentration of Ni^{2+} ions decreases over time (2).

iv. Find the EMF required for the cell to operate. (1 mark)

$> 0.25\ V$ required.

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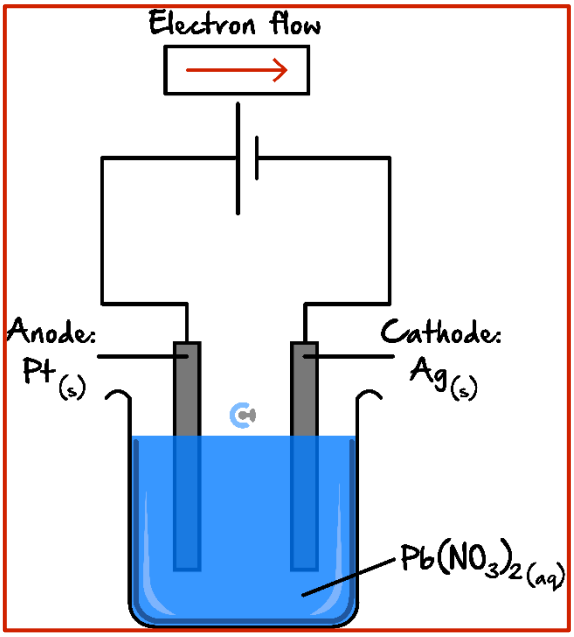
Question 6 (10 marks)

a. Subin has set up a cell containing 1.0 lead (II) nitrate as shown below.



i. Write the half-equations which take place at the: (2 marks)

Platinum electrode: $2H_2O_{(l)} \rightarrow 4H^+_{(aq)} + 4e^- + O_{2(g)}$

Silver electrode: $Pb^{2+}_{(aq)} + 2e^- \rightarrow Pb_{(s)}$

ii. Label the flow of electrons in the external circuit on the diagram above. (1 mark)

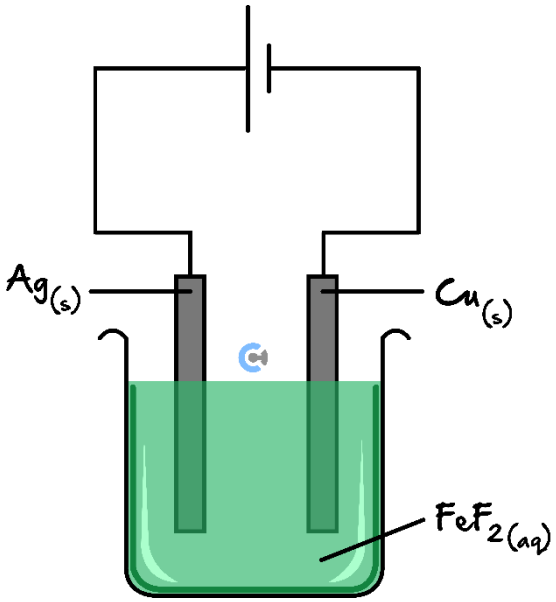
iii. State the EMF required for the cell to operate. (1 mark)

$> 1.36\ V$ required to operate the cell.

iv. State and justify the change in mass of the positive electrode observed. (2 marks)

No change in mass (1). The positive electrode is the anode and hence no change in mass occurs as water oxidises there (2).

b. 1.0 *M* of iron (II) fluoride is electrolysed in the cell shown below.



i. Write the overall reaction which takes place in the cell. (2 marks)

R.H.R:

$Fe^{2+}_{(aq)} + 2e^- \rightarrow Fe_{(s)}$

O.H.R:

$Fe^{2+}_{(aq)} \rightarrow Fe^{3+}_{(aq)} + e^-$

ii. State the expected observation at the negative electrode. (1 mark)

Increase in mass as Iron will reduce onto it (1).

iii. State the expected change in colour of electrolyte. (1 mark)

Green to yellow/brown colour as Fe^{2+} decreases in concentration and Fe^{3+} increases in concentration (1).

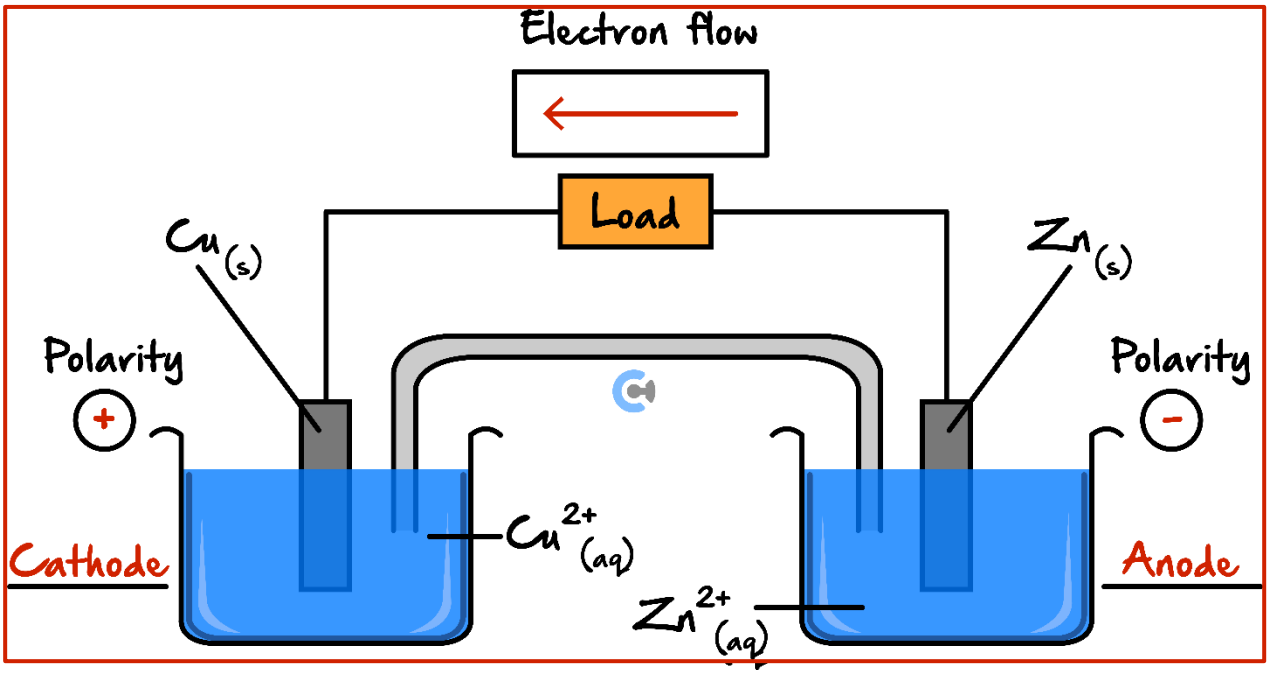
Space for Personal Notes

Sub-Section: The 'Final Boss'

Question 7 (8 marks)

a. Galvanic and electrolytic cells are often compared with each other.

A galvanic cell is set up between copper and zinc as shown below.



i. Label the flow of electrons in the box provided above. (1 mark)

ii. Label the polarities of electrodes and the cathode/anode on the diagram above. (1 mark)

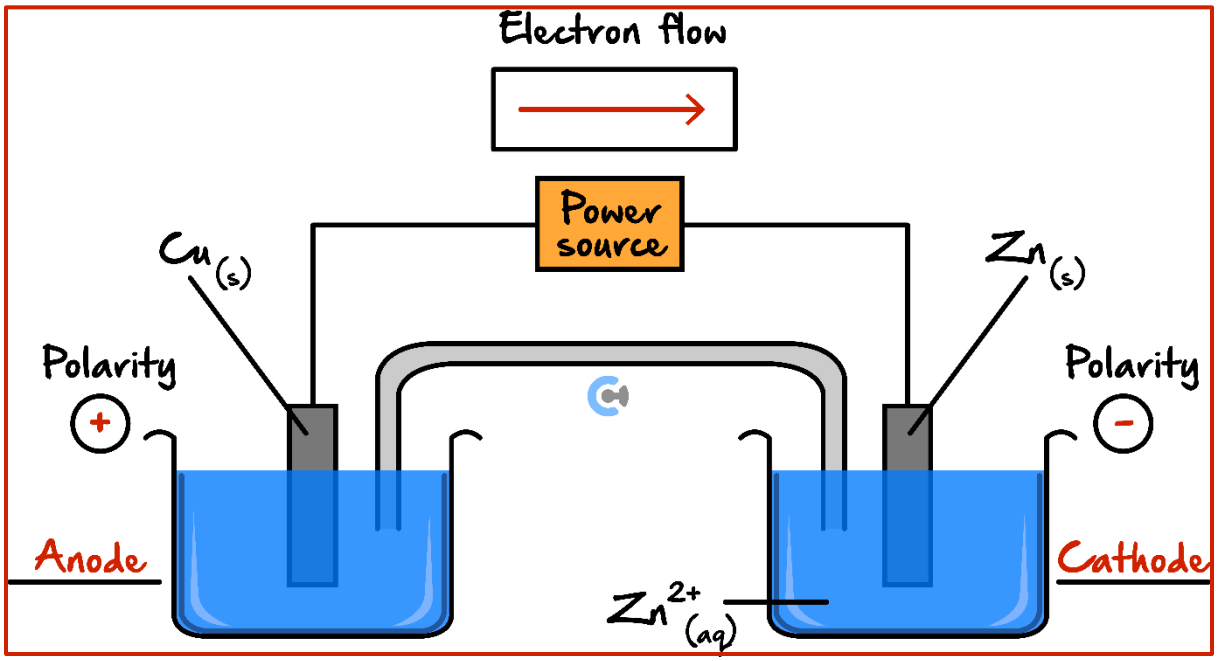
iii. Write the half-equation which occurs at the copper electrode. (1 mark)

Reduction:
$Cu^{2+}_{(aq)} + 2e^- \rightarrow Cu_{(s)}$

iv. State the energy conversion occurring within the cell. (1 mark)

(Chemical → Electrical energy)

b. The cell can also undergo electrolysis when electricity is passed through it. A diagram of the cell has been shown below, after the Cu^{2+} ions have run out.



i. Write the overall equation which takes place. (1 mark)

$Cu_{(s)} + Zn^{2+}_{(aq)} \longrightarrow Zn_{(s)} + Cu^{2+}_{(aq)}$

ii. Label the flow of electrons in the diagram above. (1 mark)

iii. Label the polarities of electrodes and cathode/anode on the diagram above. (1 mark)

iv. State energy conversion occurring within the cell. (1 mark)

Electrical to chemical energy (1).

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Section B: Supplementary Questions (27 Marks)

Sub-Section [2.1.1]: Identify Differences between Galvanic & Electrolysis for Electrodes, Energy Conversions, Electron Flow

Question 8 (3 marks)

a. Which of the following statements about electrolytic cells is correct? (1 mark)

A. Electrolytic cells undergo exothermic reactions that result in a lower enthalpy of products than reactants.

B. Electrolytic cells are expensive to produce due to their requirement for Pt(s) catalysts.

C. Electrolytic cells have the weakest oxidant and weakest reductant react together.

D. Electrolytic cells are an example of non-spontaneous reactions that produce chemical energy.

b. Determine the **false** statement regarding the properties of galvanic and electrolytic cells. (1 mark)

A. Reduction in galvanic and electrolytic cells occurs at the cathode.

B. Electrons flow from cathode to anode in an electrolytic cell.

C. Galvanic cells convert chemical energy to electrical energy whilst electrolytic cells convert electrical energy to chemical energy.

D. The cathode is positively charged in a galvanic cell.

c. The cathode of an electrolytic cell: (1 mark)

A. Has a positive polarity and reduction occurs.

B. Has a positive polarity and oxidation occurs.

C. Has a negative polarity and reduction occurs.

D. Has a negative polarity and oxidation occurs.

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Question 9 (2 marks)

Betty has set up a cell at school which requires electrical input to operate.

a. State the energy conversion occurring in the cell. (1 mark)

Electrical energy → Chemical energy (1).

b. Hence, determine whether electrolysis is exothermic or endothermic (1 mark)

Endothermic.

Space for Personal Notes

Question 10 (2 marks)

a. Select the option which accurately describes the electron flow of galvanic and electrolytic cells. (1 mark)

A.

Cell type	Electron flow
Galvanic	Positively to negatively charged electrode.
Electrolytic	Positively to negatively charged electrode.

B.

Cell type	Electron flow
Galvanic	Positively to negatively charged electrode.
Electrolytic	Negatively to negatively charged electrode.

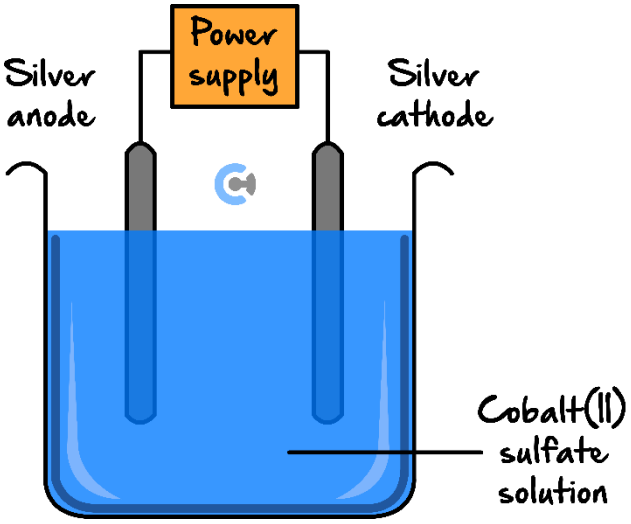
C.

Cell type	Electron flow
Galvanic	Negatively to positively charged electrode.
Electrolytic	Positively to negatively charged electrode.

D.

Cell type	Electron flow
Galvanic	Negatively to positively charged electrode.
Electrolytic	Negatively to positively charged electrode.

b. Katie is analysing the electrolytic cell shown below:



Determine the purpose of the Cobalt (II) sulphate solution. (1 mark)

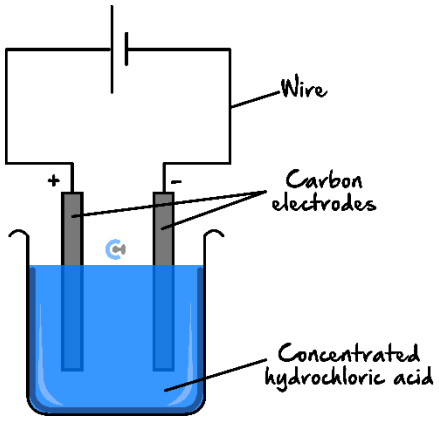
To complete the circuit due to the absence of a salt bridge (1).

Space for Personal Notes

Sub-Section [2.1.2]: Write Equations & Calculate EMF Required for Electrolytic Reactions

Question 11 (9 marks)

a. Michelle is electrolysing 3.0 *M* of HCl in the cell shown below.



i. Write the equation which occurs at the cathode. (1 mark)

$2H^+(aq) + 2e^- \rightleftharpoons H_2(g)$

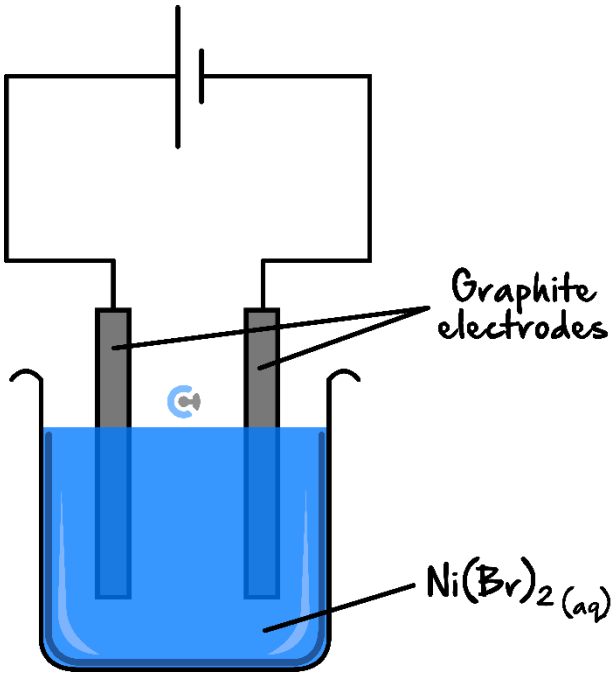
ii. Write the equation which occurs at the anode. (1 mark)

$2Cl^-_{(aq)} \longrightarrow Cl_{2(g)} + 2e^-$

iii. Hence, write the overall equation for the cell. (1 mark)

$2HCl_{(aq)} \longrightarrow Cl_{2(g)} + H_{2(g)}$

b. Dai is operating a cell containing 1.0 *M* of nickel (II) bromide, shown below.



i. Write the equation which occurs at the cathode. (1 mark)

$Ni^{2+}(aq) + 2e^- \rightleftharpoons Ni(s)$

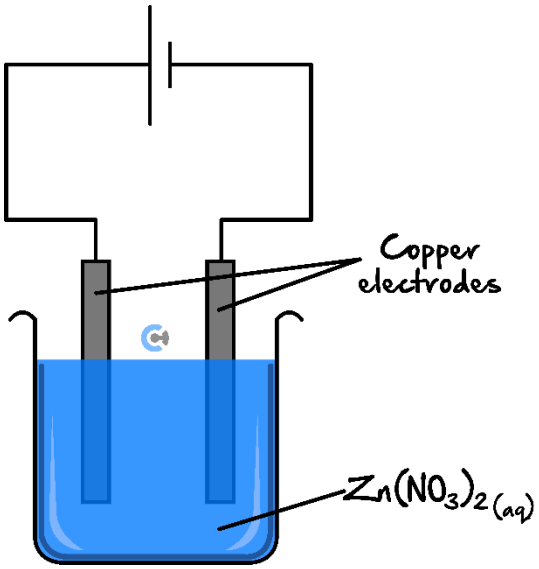
ii. Write the equation which occurs at the anode. (1 mark)

$2Br^-_{(aq)} \rightarrow 2e^- + Br_{2(l)}$

iii. Hence, write the overall equation for the cell. (1 mark)

$CO^{2+}(aq) + 2Br^-(aq) \rightarrow CO(s) + Br_2(I)$
$CoBr_2(aq) \rightarrow CO^{2+}(aq) + Br_2(I)$

c. Henry is operating a cell containing 1.0 *M* of zinc nitrate. The cell is shown below.



i. Write the equation which occurs at the cathode. (1 mark)

$Zn^{2+}_{(aq)} + 2e^- \rightarrow Zn_{(s)}$

ii. Write the equation which occurs at the anode. (1 mark)

$Cu_{(s)} \rightarrow Cu^{2+}_{(aq)} + 2e^-$

iii. Hence, write the overall equation for the cell. (1 mark)

$Cu_{(s)} + Zn^{2+}_{(aq)} \rightarrow Cu^{2+}_{(aq)} + Zn_{(s)}$

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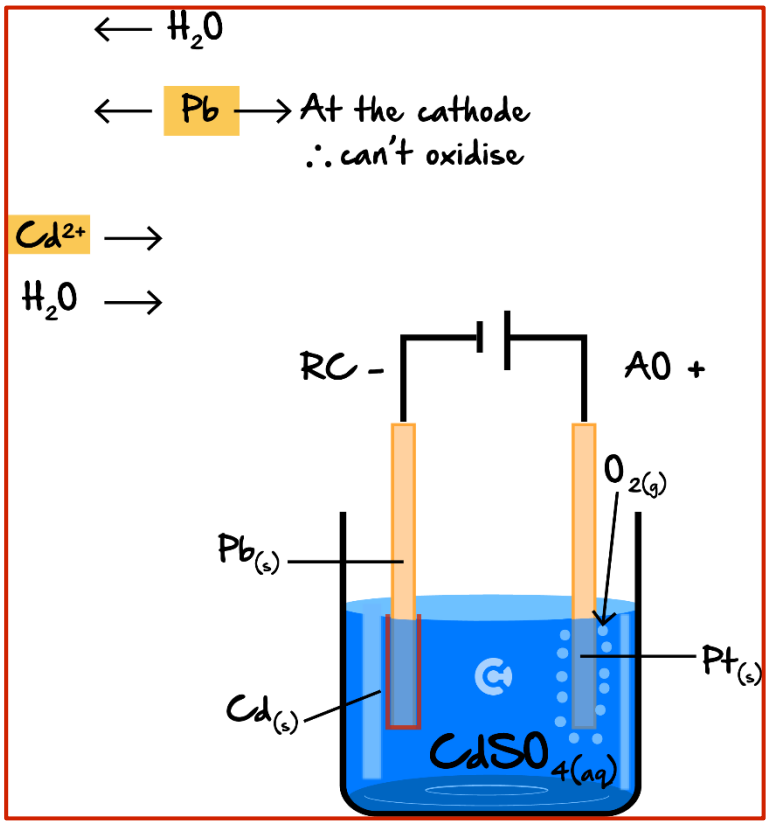
Question 12 (5 marks)

a. Draw a labelled cell for the electrolysis of $CdSO_4(aq)$ with a lead cathode and platinum anode. (2 marks)



b. Write the balanced half-equations occurring at the:

i. Anode. (0.5 marks)

$$2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$$

ii. Cathode. (0.5 marks)

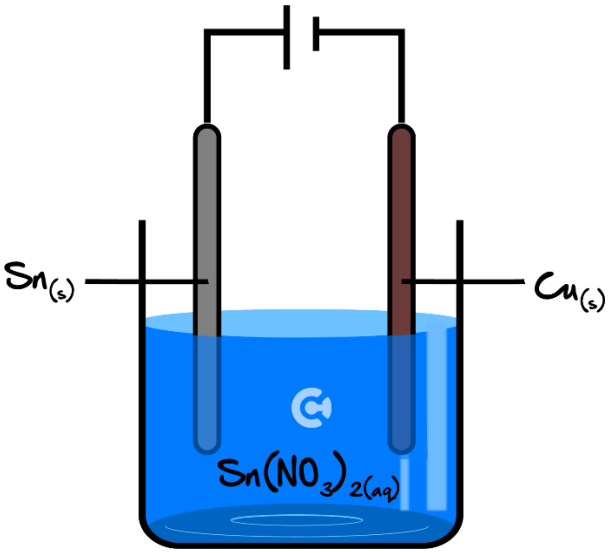
$$Cd^{2+}(aq) + 2e^- \rightarrow Cd(s)$$

c. List any observations made at either electrode. (2 marks)

- Decrease in pH at the anode.
- O_2 bubbles at the anode.
- Increase in mass/size of the cathode.

Question 13 (3 marks)

A solution of Tin (II) nitrate is being electrolysed in an electrolytic cell containing a copper cathode and tin anode. A diagram of the electrolytic cell is shown in the diagram below.



a. Write the balanced half-equations occurring at the:

i. Anode. (0.5 marks)

$Sn(s) \rightarrow Sn^{2+}(aq) + 2e^-$

ii. Cathode. (0.5 marks)

$Sn^{2+}(aq) + 2e^- \rightarrow Sn(s)$

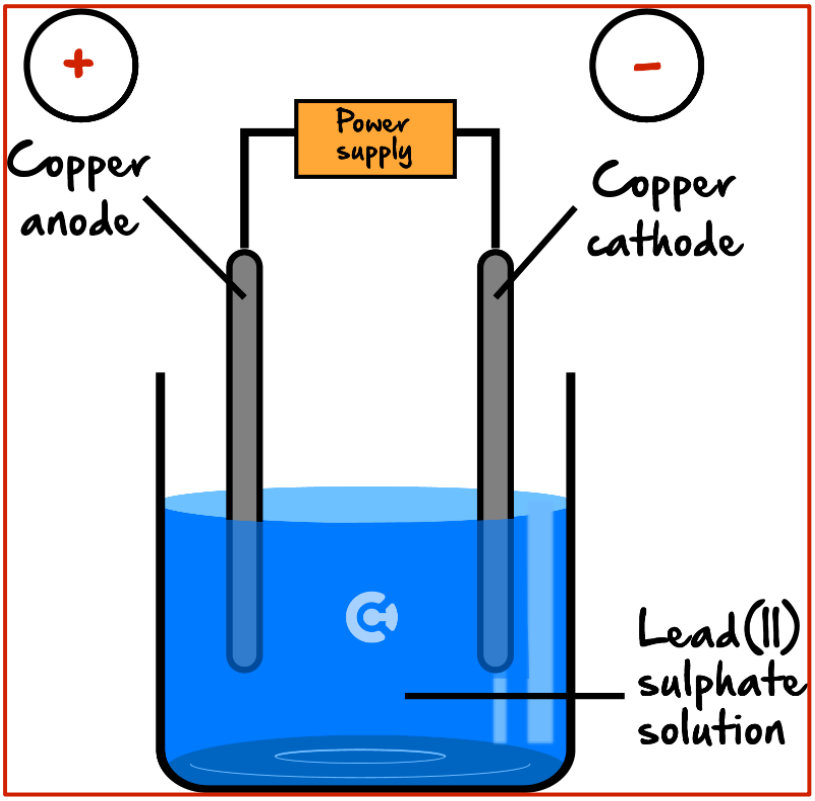
b. The cell is able to be ran for 30 minutes under standard conditions. When a separator membrane was added that prevented the flow of ions, the cell was only able to be run for 5 minutes. Explain what the separator membrane did to limit the run time of the cell. (2 marks)

The cell operates through Sn^{2+} ions being produced at the anode, that are then reduced at the cathode, effectively transfering Sn from anode to cathode. By adding the separator membrane, the Sn^{2+} produced at the anode was no longer able to move to the cathode. Thus, the cell stopped operating after it ran out of Sn^{2+} in the electrolyte and was unable to access the Sn^{2+} in the anode.

Space for Personal Notes

Question 14 (3 marks)

The electrolysis of 1 *M* solution of Lead (II) sulphate ($PbSO_4$) is undertaken with copper electrodes at 25°C. A diagram of this electrolytic process is shown in the following diagram below.



a. Label the polarity of each electrode in the diagram above. (1 mark)

b. Write the half-equations which occur at the:

i. Cathode. (0.5 marks)

$Pb^{2+}(aq) + 2e^- \rightarrow Pb(s)$

ii. Anode. (0.5 marks)

$Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$

c. List any observations seen at either electrode. (1 mark)

- Increase in mass/size of the cathode.
- Decrease in mass/size of the anode.
- Increase in intensity of blue colour.

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