

Chapter 20: Electrochemistry

Homework questions

- 1 The half-equations below show two redox systems and their standard electrode potentials:



- a** The two half-cells can be joined to form a cell.
- Draw a labelled diagram of the cell formed from these two half-cells, including the equipment required to measure the cell voltage. [3]
 - Explain the **two** functions of the salt bridge in the apparatus. [2]
 - Calculate the standard cell potential of the cell formed from these two half-cells. [1]
 - Write the equation for the chemical reaction taking place. [1]
 - On your diagram, draw an arrow showing the flow of electrons if a wire is used to connect both electrodes. [1]
- b** Describe what would happen to the cell potential if each of the following changes occurred. Explain each answer.
- Distilled water is added to the solution of $\text{Pb}^{2+}(\text{aq})$ ions in one of the half-cells. [4]
 - Solid copper(II) sulfate is added to the beaker containing the solution of $\text{Cu}^{2+}(\text{aq})$ ions. [4]
- c** The Nernst equation (see below) is used to deduce the effect of changing temperature and ion concentration on the value of a cell potential:

$$E = E^{\ominus} + \frac{RT}{zF} \ln \frac{[\text{oxidised form}]}{[\text{reduced form}]}$$

$$\text{At 298 K, this becomes } E = E^{\ominus} + \frac{0.059}{z} \log_{10} \frac{[\text{oxidised form}]}{[\text{reduced form}]}$$

- Explain the meaning of the term 'z' shown in the equation. [1]
- What is the electrode potential of the lead half-cell if the concentration of the $\text{Pb}^{2+}(\text{aq})$ ion is reduced to $0.001 \text{ mol dm}^{-3}$? [2]
- What is the electrode potential of the lead half-cell if the concentration of the $\text{Cu}^{2+}(\text{aq})$ ion is increased to 2.00 mol dm^{-3} ? [2]

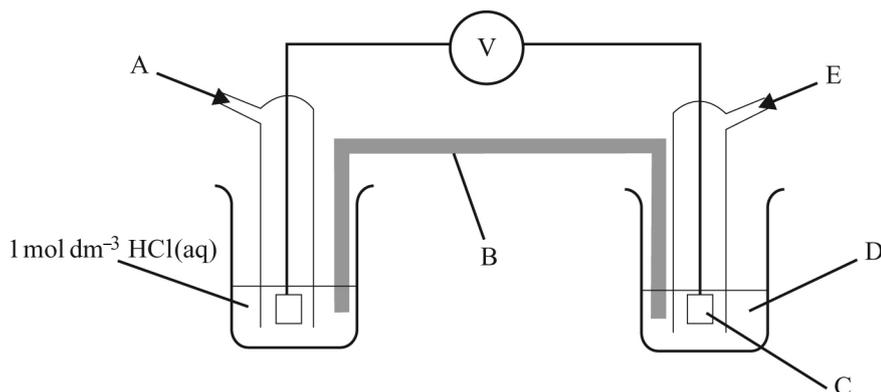
Total = 21

- 2 The element lead is a typical metallic element. In the laboratory it can be extracted from molten lead(II) bromide using electrolysis.

- a** Explain why the lead(II) bromide has to be molten before the electrolysis can be carried out. [2]
- b**
- At which electrode will lead be formed in the electrolysis? [1]
 - Write the equation for the formation of lead at this electrode. [1]
 - What mass of lead is formed at the electrode if a current of 0.4 A is passed through the electrolyte for 2 hours? [5]
- c**
- Give the equation for the formation of bromine at the other electrode. [1]
 - Does the formation of bromine involve oxidation or reduction? Explain your answer. [1]
 - The temperature of the electrolyte is maintained at 700 K and atmospheric pressure is $1.01 \times 10^5 \text{ N m}^{-2}$. What volume of bromine forms under these conditions? (Give your answer in cm^3 .) [4]

- d** Lead forms two compounds with chlorine. PbCl_2 is a white solid with a melting point of $498\text{ }^\circ\text{C}$ and which conducts electricity when molten. PbCl_4 is an oily liquid at room temperature and does not conduct electricity under any conditions.
- What type of structure explains the properties of lead(II) chloride?
Explain your answer. [3]
 - What type of structure would explain the properties of lead(IV) chloride?
Explain your answer. [3]
 - Draw a molecule of PbCl_4 and state the bond angles present. [2]
- Total = 23

- 3** The diagram below shows the apparatus used to find the standard electrode potential of chlorine.



- Write down the correct labels for the apparatus and chemicals labelled A to E. [6]
 - State the **two** main functions of the salt bridge? [2]
 - Explain how a salt bridge can be made in the laboratory. [2]
 - In the laboratory, chlorine can be prepared by the reaction between concentrated hydrochloric acid and solid potassium manganate(VII). The relevant half-equations are given below:

$\text{Cl}_2(\text{g}) + 2\text{e}^- \rightleftharpoons 2\text{Cl}^-(\text{aq})$	$E^\theta = +1.36\text{ V}$
$\text{MnO}_4^-(\text{aq}) + 8\text{H}^+(\text{aq}) + 5\text{e}^- \rightleftharpoons \text{Mn}^{2+}(\text{aq}) + 4\text{H}_2\text{O}(\text{l})$	$E^\theta = +1.52\text{ V}$

 - Write the full balanced ionic equation for the reaction. [2]
 - If dilute hydrochloric acid is used instead of concentrated hydrochloric acid, chlorine is **not** formed. Explain why. [5]
 - When the chlorine formed is passed into hot, concentrated sodium hydroxide, the following reaction takes place:

$$6\text{NaOH} + 3\text{Cl}_2 \rightarrow 5\text{NaCl} + \text{NaClO}_3$$
 - Explain why this is a disproportionation reaction. [3]
 - Name the compound NaClO_3 and calculate the mass formed when 60 cm^3 of chlorine (measured at room temperature and pressure) is passed through an excess of hot, concentrated sodium hydroxide solution. Give your answer to 2 decimal places. [5]
- Total = 25