CHEM1612 Worksheet 10: Electrochemistry

Model 1: Reduction Potentials

The **standard reduction potential**, E^0_{red} has units of volts (V) and is a measure of a species ability to attract electrons. The *more positive* the reduction potential, the *stronger* is the attraction for electrons. Put another way, the *more positive* the reduction potential, the easier the reduction occurs. Some standard reduction potentials are given below.

	Reduction reaction	E^0_{red} (V)
(1)	$Ag^+(aq) + e^- \rightarrow Ag(s)$	+0.80
(2)	$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	+0.34
(3)	$Sn^{2+}(aq) + 2e^- \rightarrow Sn(s)$	-0.14
(4)	$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$	-0.76

Critical thinking questions

1. Which is a stronger **oxidising** agent: Ag^+ or Cu^{2+}? Explain how you can tell in terms of the reduction potentials.

2. If reactions (1) and (2) are added together as a redox reaction which do you think will proceed as a reduction and which as an oxidation? (*Hint*: which one will reverse?)

3. Apply the same logic to reactions (3) and (4). Does it matter that they both have negative reduction potentials?

Model 2: Voltaic Cells

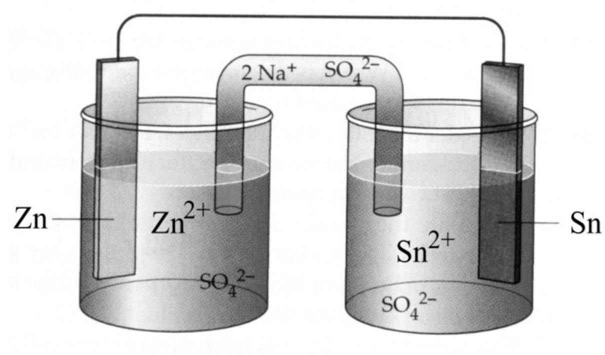
We can harness the electrical energy in a redox reaction, to make a battery, by setting up a **voltaic cell**. To do this, two half reactions are separated into compartments and electrodes are used to facilitate the electron transfer. The potentials for the two reactions are:

$Sn^{2+}(aq) + 2e^- \rightarrow Sn(s)$ $\quad E^0_{red}$ = -0.14 V

$Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$ $\quad E^0_{ox}$ = +0.76 V

This gives an overall voltmeter reading of:

$E^0_{cell} = E^0_{ox} + E^0_{red}$ = +0.62 V.



Critical thinking questions

1. Explain why the Zn half reaction is proceeding as an oxidation and why +0.76 V is used as the potential for its half cell instead of -0.76 V as in the table in Model 1?

2. Which electrode (Zn or Sn) will *lose* mass and which one will *gain* mass?

3. Does oxidation or reduction occur at the cathode?

4. Which of the following statements are correct?

   (a) Electrons flow through the wire, towards the zinc electrode.
   (b) Electrons flow through the wire, towards the tin electrode.
   (c) Electrons flow through the salt bridge, towards the zinc electrode.
   (d) Electrons flow through the salt bridge, towards the tin electrode.

5. Electrons flow from the *negative* electrode to the *positive* electrode. Which is positive, the anode or the cathode?

6. The salt bridge contains Na^+(aq) and SO_4^{2-}(aq). Do these ions *move* when the cell is operating and, if so, in which direction(s)?

7. If an electrochemical cell with Ag and Cu electrodes was setup, what would be the two half reactions, which would be the cathode and which would be the anode, and what would be the standard cell potential? (*Hint*: use the standard reduction potentials in Model 1.)

8. If an electrochemical cell with Sn and Cu electrodes was setup, what would be the two half reactions, which would be the cathode and which would be the anode, and what would be the standard cell potential?

9. If an electrochemical cell with Sn and Zn electrodes was setup, what would be thetwo half reactions, which would be the cathode and which would be the anode, and what would be the standard cell potential?

10. Which combination of the half cells in Table 1 would make the highest voltage battery?

11. Nicotine adenine dinucleotide (NAD) is involved in redox chemistry throughout the respiratory system. The reduced form of NAD is written as NADH and the oxidised form is written as NAD^+. The standard reduction reaction and potential of NAD is given by:

$$NAD^+ + H^+ + 2e^- \rightarrow NADH \quad E° = -0.105\ V$$

NAD is combined with each of the following reactions:

(a) $CO_2 + H^+ + 2e^- \rightarrow HCOO^-$ $\quad E° = -0.20\ V$
(b) $O_2 + 4H^+ + 4e^- \rightarrow H_2O$ $\quad E° = +0.82\ V$

Write the overall reaction for each of the cells in the direction of spontaneous change. Is the NAD reduced or oxidised in these reactions?