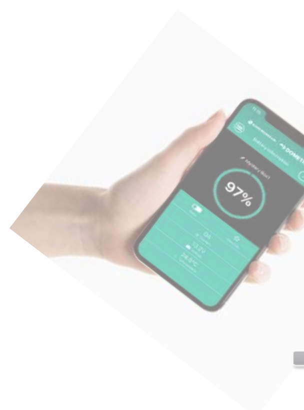
Video-worksheet

Harnessing redox reactions to provide electrical energy

Reductant	A reductant is a species that loses electrons to another species and is itself oxidised. Eg. Zn(s) → Zn^{2+}(aq) + $2e^{-}$, Zn(s) is the reductant
Oxidant	An oxidant is a species that gains electrons from another species and is itself reduced. Eg. Cu^{2+}(aq) + $2e^{-}$ → Cu(s) , Cu^{2+} is the oxidant
Cathode (+)	It is the electrode where the electrons in a battery flow to. It is where the oxidant is found.
Anode (-)	It is the electrode where the electrons in a battery come from. It is where the reductant is found.
Electromotive force (EMF)	EMF is the energy available to drive electrons around a circuit.

Two useful resources for the completion of this worksheet.

Oxidants in increasing strength

Reductants in increasing strength

Reaction	Standard electrode potential (E^0) in volts at 25 °C
$F_2(g) + 2e^- \rightleftharpoons 2F^-(aq)$	+2.87
$H_2O_2(aq) + 2H^+(aq) + 2e^- \rightleftharpoons 2H_2O(l)$	+1.77
$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightleftharpoons Mn^{2+}(aq) + 4H_2O(l)$	+1.51
$PbO_2(s) + 4H^+(aq) + 2e^- \rightleftharpoons Pb^{2+}(aq) + 2H_2O(l)$	+1.47
$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^- \rightleftharpoons 2Cr^{3+}(aq) + 7H_2O(l)$	+1.36
$Cl_2(g) + 2e^- \rightleftharpoons 2Cl^-(aq)$	+1.36
$O_2(g) + 4H^+(aq) + 4e^- \rightleftharpoons 2H_2O(l)$	+1.23
$Br_2(l) + 2e^- \rightleftharpoons 2Br^-(aq)$	+1.09
$Ag^+(aq) + e^- \rightleftharpoons Ag(s)$	+0.80
$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$	+0.77
$O_2(g) + 2H^+(aq) + 2e^- \rightleftharpoons H_2O_2(aq)$	+0.68
$I_2(s) + 2e^- \rightleftharpoons 2I^-(aq)$	+0.54
$O_2(g) + 2H_2O(l) + 4e^- \rightleftharpoons 4OH^-(aq)$	+0.40
$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$	+0.34
$Sn^{4+}(aq) + 2e^- \rightleftharpoons Sn^{2+}(aq)$	+0.15
$2H^+(aq) + 2e^- \rightleftharpoons H_2(g)$	0.00
$Pb^{2+}(aq) + 2e^- \rightleftharpoons Pb(s)$	−0.13
$Sn^{2+}(aq) + 2e^- \rightleftharpoons Sn(s)$	−0.14
$Ni^{2+}(aq) + 2e^- \rightleftharpoons Ni(s)$	−0.25
$Co^{2+}(aq) + 2e^- \rightleftharpoons Co(s)$	−0.28
$Fe^{2+}(aq) + 2e^- \rightleftharpoons Fe(s)$	−0.44
$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s)$	−0.76
$2H_2O(l) + 2e^- \rightleftharpoons H_2(g) + 2OH^-(aq)$	−0.83
$Mn^{2+}(aq) + 2e^- \rightleftharpoons Mn(s)$	−1.18
$Al^{3+}(aq) + 3e^- \rightleftharpoons Al(s)$	−1.66
$Mg^{2+}(aq) + 2e^- \rightleftharpoons Mg(s)$	−2.37
$Na^+(aq) + e^- \rightleftharpoons Na(s)$	−2.71
$Ca^{2+}(aq) + 2e^- \rightleftharpoons Ca(s)$	−2.87
$K^+(aq) + e^- \rightleftharpoons K(s)$	−2.93
$Li^+(aq) + e^- \rightleftharpoons Li(s)$	−3.04

Figure 1 – Electrochemical series as found in the VCAA data-booklet item 1 page 2.

Six easy steps to design a galvanic cell.

1. Identify the strongest oxidant and the strongest reductant.

2. Check that the reaction is spontaneous.

3. Place the oxidant and reductant in separate half-cells.

4. Choose the electrodes

- ***If the conjugate pair in the half cell contains a metal, use that metal as the electrode.***
- ***If no metal is present, use an inert electrode.***

5. Connect the two electrodes with a wire.

6. Connect the two half cells with a salt bridge

Figure 2 – 6 steps to follow in constructing and labelling a viable galvanic cell.

1. Using silver and copper metals as well as 1M solutions of $AgNO_3$ and $CuSO_4$ draw a labelled, functional galvanic cell.

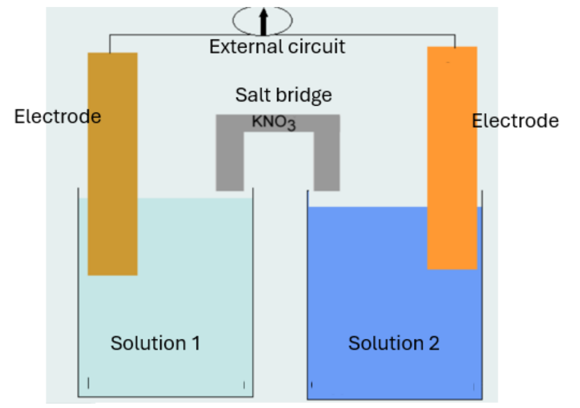


Figure 3 – Template to question 1

a. Label the following:

- Anode
- Cathode
- Electrolyte in each half cell
- Direction of electron flow
- Direction of negative ion flow
- write the oxidation and reduction half equations

Oxidation ____

Reduction ____

b. Give the value of the cell EMF.

2. A galvanic cell uses the following half-cells $Ag(s) \mid Ag^{+}(aq)$ and $Sn(s) \mid Sn^{2+}(aq)$

a. On a diagram of the cell label the following:
- Anode
- Cathode
- Electrolyte in each half cell
- Direction of electron flow
- Direction of negative ion flow
- write the oxidation and reduction half equations

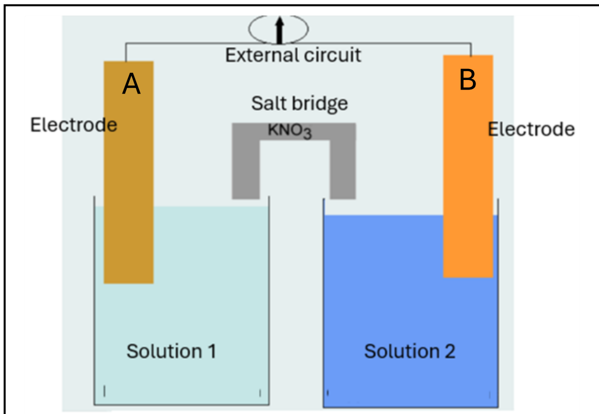


Figure 4 – Template to question 2

b. Indicate the material each electrode is made of. A. ____________________ B. _____________________

c. Identify a suitable electrolyte for the salt bridge and explain why it is suitable.

____

____

____

____

3. A galvanic cell is constructed using a:

- tin half-cell with Sn^{2+}(aq) and Sn^{4+}(aq)
- copper half-cell with Cu(s) and Cu^{2+}(aq)
- $NaNO_3$(aq) salt bridge

a. Draw a diagram of the cell, in the space provided on the right. clearly label the:

- anode and cathode (show polarity)
- material electrodes are made of
- direction of electron and positive charge flow.
- electrolyte in each half cell
- oxidation and reduction half equations

Oxidation ____

Reduction ____

b. Explain the role of $NaNO_3$(aq) .

____

____

____

____

____

____

____

____

____

____

4. A student attempts to construct a galvanic cell using magnesium metal and a carbon rod as electrodes and $Mg(NO_3)_2$ and $Mn(NO_3)_2$ solutions. The cell is shown on the right, fig. 5 and once connected undergoes a redox reaction.

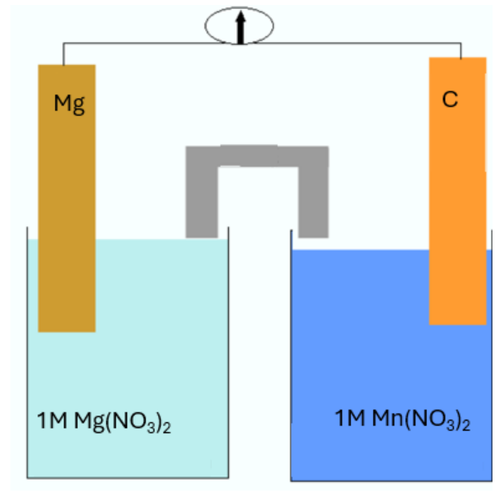


Figure 5 – Galvanic cell to question 4

a. Is this a viable galvanic cell? Justify your answer.

____

____

____

____

____

____

____

____

b. What is seen forming on the Mg electrode after some time of cell operation. Justify your answer with two half equations.

____

____

____

____

____

____

____

____

5. The galvanic cell shown on the right was constructed by a student.

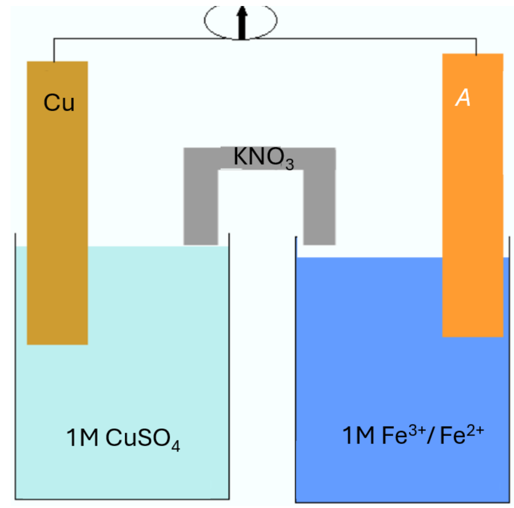


Figure 6 – Galvanic cell to question 5

a. Label or write the:
   - anode and cathode
   - direction of electron and anion flow.
   - oxidation and reduction reactions.

   Oxidation ____

   Reduction ____

b. What is the impact on the cell EMF if the electrolyte in the salt bridge is changed to $Zn(NO_3)_2(aq)$? Justify your answer.

____
____
____
____
____
____

c. Identify the substance electrode *A* is made from. Explain your choice.

____
____
____
____
____