Conventions for Galvanic Cells

1. Reduction occurs at the cathode; oxidation occurs at the anode.

2. The cathode is given a positive sign (⊕), and the anode is given a negative sign (⊖).

3. Electrons flow through the external circuit (wire) from the anode to the cathode.

4. Positive ions (cations) migrate toward the cathode; negative ions (anions) migrate toward the anode.

5. A porous disk or salt bridge separating the two sides of the cell allows ion migration between the two compartments, thereby maintaining electrical neutrality as the cell runs.

6. The voltage of the cell is taken to be positive. If a meter gives a negative reading, the probes have been attached in reverse, or the direction of electron flow in the external circuit has been reversed, owing to a change in the concentrations of reactants and/or products in the cell.

7. Electrodes are usually conductive solids (sometimes liquid mercury is used), which may or may not be participants in the cell reaction. If neither the oxidized nor reduced form of a couple is a suitable conductive material for fabricating an electron (e.g., H^+/H_2, Cl_2/Cl^-), an inert electrode (e.g., Pt wire, graphite rod) must be used to make electrical contact with the species of the couple.

8. When using *standard cell notation*, the anode is shown on the left and the cathode is shown on the right. Vertical lines (|) represent phase boundaries (e.g., solid-to-liquid, solid-to-gas). Double vertical lines (‖) represent a salt bridge connecting the two halves of the cell. Sometimes, the composition of the salt bridge is given in the area between the double lines (expanded). A porous disk, used in place of a salt bridge, is sometimes indicated by a series of vertical dots (⋮) or the double vertical line notation.

Examples of Standard Galvanic Cell Notation

Example (porous disk or unspecified salt bridge; anions not specified):

$$\mathrm{Zn}\,|\,\mathrm{Zn^{2+}}\ (1.00\ \mathrm{M})\,\|\,\mathrm{Cu^{2+}}\ (1.00\ \mathrm{M})\,|\,\mathrm{Cu}$$

Cell reaction:

$$\mathrm{Cu^{2+}}(aq) + \mathrm{Zn}(s) \rightleftharpoons \mathrm{Cu}(s) + \mathrm{Zn^{2+}}(aq)$$

Example (anions included; salt bridge contents specified):

$$\mathrm{Cu}\,|\,\mathrm{Cu(NO_3)_2}(aq)\ 1.00\ \mathrm{M}\,|\,\mathrm{KNO_3}(aq)\ 1.00\ M\,|\,\mathrm{AgNO_3}(aq)\ 1.00\ \mathrm{M}\,|\,\mathrm{Ag}$$

Cell reaction:

$$2\mathrm{Ag^{+}}(aq) + \mathrm{Cu}(s) \rightleftharpoons 2\mathrm{Ag}(s) + \mathrm{Cu^{2+}}(aq)$$

Example (porous disk; anions not specified; inert electrodes used):

$$\mathrm{Pt}\,|\,\mathrm{Br^{-}}\ (0.010\ M),\ \mathrm{Br_2}(l)\,\vdots\,\mathrm{MnO_4^{-}}\ (0.010\ \mathrm{M}),\ \mathrm{Mn^{2+}}\ (0.15\ \mathrm{M}),\ \mathrm{H^{+}}(1.0\ \mathrm{M})\,|\,\mathrm{Pt}$$

Cell reaction:

$$2\mathrm{MnO_4^{-}}(aq) + 16\mathrm{H^{+}}(aq) + 10\mathrm{Br^{-}}(aq) \rightleftharpoons 2\mathrm{Mn^{2+}}(aq) + 5\mathrm{Br_2}(l) + 8\mathrm{H_2O}(l)$$