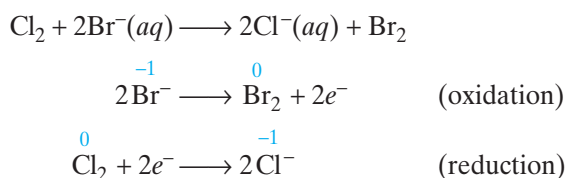


active oxidizing agent. Because of its strong attraction for its own electrons, the fluoride ion is the weakest reducing agent. The negative ion of a strong oxidizing agent is a weak reducing agent.

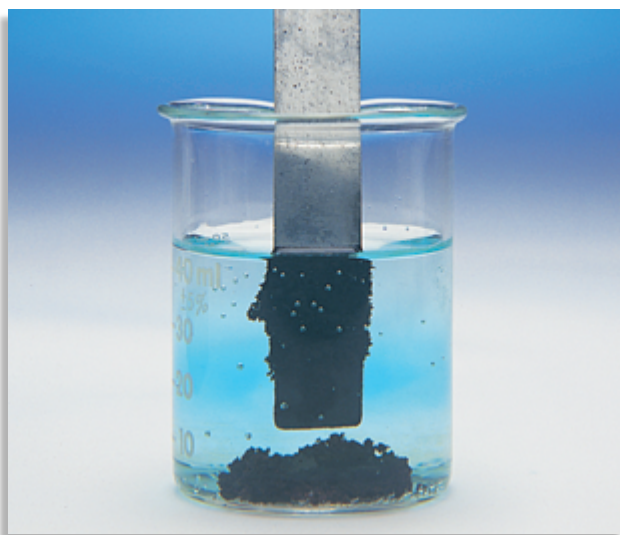
The positive ion of a strong reducing agent is a weak oxidizing agent. As shown in **Table 3**, Li atoms are strong reducing agents because Li is a very active metal. When Li atoms oxidize, they produce  $\text{Li}^+$  ions, which are unlikely to reacquire electrons, so  $\text{Li}^+$  ions are weak oxidizing agents.

The left column of each pair also shows the relative abilities of metals listed in the table to displace other metals from their compounds. Zinc, for example, appears above copper. Thus, zinc is the more active reducing agent, and it displaces copper ions from solutions of copper compounds, as illustrated in **Figure 5**. The copper(II) ion, on the other hand, is a more active oxidizing agent than the zinc ion.

Nonmetals and some important ions also are included in the series in **Table 3**. Any reducing agent is oxidized by the oxidizing agents below it. Observe that  $\text{F}_2$  displaces  $\text{Cl}^-$ ,  $\text{Br}^-$ , and  $\text{I}^-$  ions from their solutions.  $\text{Cl}_2$  displaces  $\text{Br}^-$  and  $\text{I}^-$  ions, and  $\text{Br}_2$  displaces  $\text{I}^-$  ions. The equation for the displacement of  $\text{Br}^-$  by  $\text{Cl}_2$  is as follows.



In every redox reaction, there is one reducing agent and one oxidizing agent. In the preceding example,  $\text{Br}^-$  is the reducing agent and  $\text{Cl}_2$  is the oxidizing agent.



**FIGURE 5** Zinc displaces copper ions from a copper(II) sulfate solution. Metallic copper precipitates.

**TABLE 3** Relative Strength of Oxidizing and Reducing Agents

	Reducing agents	Oxidizing agents	
↑	Li	$\text{Li}^+$	
	K	$\text{K}^+$	
	Ca	$\text{Ca}^{2+}$	
	Na	$\text{Na}^+$	
	Mg	$\text{Mg}^{2+}$	
	Al	$\text{Al}^{3+}$	
	Zn	$\text{Zn}^{2+}$	
	Cr	$\text{Cr}^{3+}$	
	Fe	$\text{Fe}^{2+}$	
	Ni	$\text{Ni}^{2+}$	
	Sn	$\text{Sn}^{2+}$	
	Pb	$\text{Pb}^{2+}$	
Increasing strength ↑	$\text{H}_2$	$\text{H}_3\text{O}^+$	↑ Increasing strength
	$\text{H}_2\text{S}$	S	
	Cu	$\text{Cu}^{2+}$	
	$\text{I}^-$	$\text{I}_2$	
	$\text{MnO}_4^{2-}$	$\text{MnO}_4^-$	
	$\text{Fe}^{2+}$	$\text{Fe}^{3+}$	
	Hg	$\text{Hg}_2^{2+}$	
	Ag	$\text{Ag}^+$	
	$\text{NO}_2^-$	$\text{NO}_3^-$	
	$\text{Br}^-$	$\text{Br}_2$	
	$\text{Mn}^{2+}$	$\text{MnO}_2$	
	$\text{SO}_2$	$\text{H}_2\text{SO}_4$ (conc.)	
	$\text{Cr}^{3+}$	$\text{Cr}_2\text{O}_7^{2-}$	
	$\text{Cl}^-$	$\text{Cl}_2$	
	$\text{Mn}^{2+}$	$\text{MnO}_4^-$	
	$\text{F}^-$	$\text{F}_2$	↓