



These stone, bronze, and iron tools represent three major ages of civilization.

METALS: PROPERTIES AND USES

Humans have been described as toolmakers. Readily available stone, wood, and natural fibers were the earliest materials used to make useful tools—hammers, chisels, knives, spears, and grinding devices. It was the discovery that fire could transform materials in certain rocks into strong, malleable metals, however, that triggered a dramatic leap in the growth of civilization.

Gold and silver, found as free elements rather than in chemical combination with other elements, were probably the first metals used by humans. These metals were formed into decorative objects and, later, into coins. Their relative unreactivity made them excellent materials for those uses.

It is estimated that copper has been used to make tools, weapons, utensils, and decorations for about 10 000 years. Bronze, an alloy of copper and tin, was developed about 3800 B.C. Thus humans moved from the Stone Age into the Bronze Age. See Figure 15.

Eventually early people developed iron metallurgy, the extraction of iron from its ores. This led to the start of the Iron Age, more than 3000 years ago. In time, as humans learned more about chemistry and fire, a variety of metallic ores were transformed into increasingly useful metals.

DISCOVERY OF METALS

ChemQuandary 1

Copper, gold, and silver are far from being the most abundant metals on Earth. Aluminum, iron, and calcium, for example, are all much more plentiful. Why, then, were copper, gold, and silver among the first metallic elements discovered?

You have explored some of the chemistry of metals and know, for example, that copper metal is more reactive than silver but less reactive than magnesium. A more complete activity series is given in the table in Figure 16. The table also includes brief descriptions of common methods for retrieving each metal from its ore.

In this list the most reactive metallic elements are at the top; less reactive elements are closer to the bottom. An activity list can be used to predict whether certain reactions can be expected. For example, you observed in the laboratory that zinc metal, which is more reactive than copper, reacted with copper ions in solution. However, zinc metal did not react with magnesium ions in solution. Why? Because zinc is less reactive than magnesium.

Metal Activity Series

Element	Metal Ion(s) Found in Minerals	Process Used to Obtain the Metal	State of Metal Obtained
Lithium	Li^+	Pass direct electric current through the molten mineral salt (electrometallurgy)	$\text{Li}(s)$
Potassium	K^+		$\text{K}(s)$
Calcium	Ca^{2+}		$\text{Ca}(s)$
Sodium	Na^+		$\text{Na}(s)$
Magnesium	Mg^{2+}		$\text{Mg}(s)$
Aluminum	Al^{3+}		$\text{Al}(s)$
Manganese	Mn^{2+}	Heat mineral with coke (C) or carbon monoxide (CO) (pyrometallurgy)	$\text{Mn}(s)$
Zinc	Zn^{2+}		$\text{Zn}(s)$
Chromium	Cr^{3+} , Cr^{2+}		$\text{Cr}(s)$
Iron	Fe^{3+} , Fe^{2+}		$\text{Fe}(s)$
Lead	Pb^{2+}	Heat (roast) mineral in air	$\text{Pb}(s)$
Copper	Cu^{2+} , Cu^+	(pyrometallurgy) or find the element free (uncombined)	$\text{Cu}(s)$
Mercury	Hg^{2+}		$\text{Hg}(l)$
Silver	Ag^+		$\text{Ag}(s)$
Platinum	Pt^{2+}		$\text{Pt}(s)$
Gold	Au^{3+} , Au^+		$\text{Au}(s)$

Figure 16 Metal activity series (in decreasing order of reactivity).

In general, a more reactive metallic element (higher in the activity series) will cause ions of a less reactive metallic element (lower in the activity series) to change to their corresponding metal.

TRENDS IN METAL ACTIVITY

Use the table in Figure 16 and the Periodic Table (page 104) to answer the following questions.

- Will iron (Fe) metal react with a solution of lead(II) nitrate, $\text{Pb}(\text{NO}_3)_2$?
 - Will platinum (Pt) metal react with a lead(II) nitrate solution?

c. Explain your answers to Questions 2a and 2b.
- Use specific examples from the activity series in your answers to these two questions:

 - Are least-reactive metals also the cheapest metals?
 - If not, what other factor(s) might influence the market value of a metal?