Alloy

You might see the word alloy described as a "mixture of metals", but that's a little bit misleading because some alloys contain only one metal and it's mixed in with other substances that are nonmetals (cast iron, for example, is an alloy made of just one metal, iron, mixed with one nonmetal, carbon). The best way to think of an alloy is as a material that's made up of at least two different chemical elements, one of which is a metal. The other components of an alloy (which are called alloying agents) can be either metals or nonmetals and they're present in much smaller quantities (sometimes less than 1 percent of the total). Although an alloy can sometimes be a compound (the elements it's made from are chemically bonded together), it's usually a solid solution (atoms of the elements are simply intermixed, like salt mixed with water).component of an alloy (often representing 90 percent or more of the material) is called the

The structure of alloys

If you look at a metal through a powerful electron microscope, you can see the atoms inside arranged in a regular structure called a crystalline lattice. Imagine a small cardboard box full of marbles and that's pretty much what you'd see. In an alloy, apart from the atoms of the main metal, there are also atoms of the alloying agents dotted throughout the structure. (Imagine dropping a few plastic balls into the cardboard box so they arrange themselves randomly among the marbles.)

Substitution alloys

If the atoms of the alloying agent replace atoms of the main metal, we get what's called a substitution alloy. An alloy like this will form only if the atoms of the base metal and those of the alloying agent are of roughly similar size. In most substitution alloys, the constituent elements are quite near one another in the periodic table. Brass, for example, is a substitution alloy based on copper in which atoms of zinc replace 10–35 percent of the atoms that would normally be in copper. Brass works as an alloy because copper and zinc are close to one another in the periodic table and have atoms of roughly similar size.

Interstitial alloys

Alloys can also form if the alloying agent or agents have atoms that are very much smaller than those of the main metal. In that case, the agent atoms slip in between the main metal atoms (in the gaps or "interstices"), giving what's called an interstitial alloy. Steel is an example of

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an interstitial alloy in which a relatively small number of carbon atoms slip in the gaps between the huge atoms in a crystalline lattice of iron.

How do alloys behave?

People make and use alloys because metals don't have exactly the right properties for a particular job. Iron is a great building material but steel (an alloy made by adding small amounts of nonmetallic carbon to iron) is stronger, harder, and rustproof. Aluminum is a very light metal but it's also very soft in its pure form. Add small amounts of the metals magnesium, manganese, and copper and you make a superb aluminum alloy called duralumin, which is strong enough to make airplanes. Alloys always show improvements over the main metal in one or more of their important physical properties (things like strength, durability, ability to conduct electricity, ability to withstand heat, and so on). Generally, alloys are stronger and harder than their main metals, less malleable (harder to work) and less ductile (harder to pull into wires).

How are alloys made?

You might find the idea of an alloy as a "mixture of metals" quite confusing. How can you mix together two lumps of solid metal? The traditional way of making alloys was to heat and melt the components to make liquids, mix them together, and then allow them to cool into what's called a solid solution (the solid equivalent of a solution like salt in water). An alternative way of making an alloy is to turn the components into powders, mix them together, and then fuse them with a combination of high pressure and high temperature. This technique is called powder metallurgy. A third method of making alloys is to fire beams of ions (atoms with too few or too many electrons) into the surface layer of a piece of metal. Ion implantation, as this is known, is a very precise way of making an alloy. It's probably best known as a way of making the semiconductors used in electronic circuits and computer chips. (Read more about this in our article on molecular beam epitaxy.)

Some Common Alloys

There are zillions of different alloys used for zillions of different purposes. We've listed 20 of the more common (or otherwise interesting) ones in the table below. There are lots of different variations on most alloys and the precise mixture can vary widely, so the percentage

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figures you see quoted in different books will often not agree exactly.

Alloy	Components	Typical uses
Alnico	Iron (50%+), aluminum (8–12%), nickel (15–25%), cobalt (5–40%), plus other metals such as copper and titanium.	Magnets in loudspeakers and pickups in electric guitars.
Amalgam	Mercury (45–55%), plus silver, tin, copper, and zinc.	Dental fillings.
Babbitt metal ("white metal")	Tin (90%), antimony (7–15%), copper (4–10%).	Friction-reducing coating in machine bearings.
Brass	Copper (65–90%), zinc (10–35%).	Door locks and bolts, brass musical instruments, central heating pipes.
Bronze	Copper (78–95%), tin (5–22%), plus manganese, phosphorus, aluminum, or silicon.	Decorative statues, musical instruments.
Cast iron	Iron (96–98%), carbon (2–4%), plus silicon.	Metal structures such as bridges and heavy-duty cookware.
Cupro-nickel	Copper (75%), nickel (25%), plus	Coins.

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(copper nickel)	small amounts of manganese.	
Duralumin	Aluminum (94%), copper (4.5–5%), magnesium (0.5–1.5%), manganese (0.5–1.5%).	Automobile and aircraft body parts, military equipment.
Gun metal	Copper (80–90%), tin (3–10%), zinc (2–3%), and phosphorus.	Guns, decorative items.
Magnox	Magnesium, aluminum.	Nuclear reactors.
Nichrome	Nickel (80%), chromium (20%).	Firework ignition devices, heating elements in electrical appliances
		.
Nitinol	Nickel (50–55%), titanium (45–50%).	Shape-memory alloy used in medical items, spectacle frames that spring back to shape, and temperature switches.
Pewter	Tin (80–99%) with copper, lead, and antimony.	Ornaments, used to make tableware before glass became more common.
Solder	Varies. Old-fashioned solders contain a mixture of tin (50-	Connecting electrical components into circuits.

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	70%), lead (30-50%), copper, antimony, and other metals. Newer solders dispense with lead for health reasons. A typical modern solder has 99.25 percent tin and 0.75 percent copper.	
Steel (general)	Iron (80–98%), carbon (0.2–2%), plus other metals such as chromium, manganese, and vanadium.	Metal structures, car and airplane parts, and many other uses.
Steel (stainless)	Iron (50%+), chromium (10–30%), plus smaller amounts of carbon, nickel, manganese, molybdenum, and other metals.	Jewelry, medical tools, tableware.
Stellite	Cobalt (67%), chromium (28%), tungsten (4%), nickel (1%).	Coating for cutting tools such as saw teeth, lathes, and chains aws.
Sterling silver	Silver (92.5%), copper (7.5%).	Cutlery, jewelry, medical tools, musical instruments.
Whit	Gold (75%),	Jewelry.

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