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Role and Applications of Alloys in Everyday Life

*Rohit Kumar**
Department of Chemistry, Annie Besant College of Engineering and Management, University of Lucknow, Lucknow, Uttar Pradesh, India

ABSTRACT

An alloy is a mixture of metals or a mixture of a metal and another element. Alloys are defined by a metallic bonding character. An alloy may be a solid solution of metal elements (a single phase) or a mixture of metallic phases (two or more solutions). Melting point: Put the alloy, a piece of tin and a piece of lead into a sand tray. All three samples should be the same distance from the middle of the dish. Heat the dish gently in the middle. When two of the metals have melted, stop heating. Enhance the hardness of a metal: An alloy is harder than its components. Pure metals are generally soft. The hardness of a metal can be enhanced by alloying it with another metal or nonmetal. Brass is an alloy made from copper and zinc. Unlike pure metals, most alloys do not have a single melting point, but a melting range during which the material is a mixture of solid and liquid phases slush). An alloy is a mixture of two or more metals. Some familiar examples of alloys include brass, bronze, pewter cast and wrought iron, steel, coin metals, and solder (pronounced SOD-der; a substance used to join other metallic surfaces together). Copper alloys have exceptional electrical and thermal performance, good corrosion resistance, high ductility and relatively low cost. Copper alloy is used in airtight seals and copper tin alloys are primarily used for sleeve bearings due to its strength and ductile properties. An alloy is a mixture of two elements, one of which is a metal. Alloys often have properties that are different to the metals they contain. This makes them more useful than the pure metals alone. For example, alloys are often harder than the metal they contain.

Keywords: brass, gold, mixture of alloy, strength and ductile properties, zinc

***Corresponding Author**
E-mail: kumarrohit198900@gmail.com

INTRODUCTION

An alloy is a "mixture of metals". 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 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 [1]. 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 is probably best known as a way of making the semiconductors used in electronic circuits and computer chips [2].

Almost every metal you encounter in daily life is an alloy. It is easier to name the relative few cases where pure metals are used [3].

- Jewelry favors pure gold and silver because they are more valuable than "debased" metals (precious metals alloyed with non-precious metals). Pure gold is also almost impervious to corrosion.

- Pure copper is use for electrical wiring and cookware, because any addition to copper decreases its conductivity of electricity or heat. It is also used for household water pipes.
- Pure aluminum is sometimes used for wire as well.
- Pure mercury is used because of its low melting and boiling points and high density.
- Pure tin is often used for pipe organs, because it sounds nice and stays shiny. It was also used to line steel cans used for canning foods, because it's non-toxic and resists corrosion. (When people talk about "tin cans", they mean tin-lined steel can.).
- Relatively pure iron is used for decorative wrought iron because it's easy to work.
- There are more examples like these. But almost everything you think of when you think "metal" is an alloy. Steel and cast iron is alloy of iron and carbon (and other stuff, often). Brass is copper plus zinc; bronze is copper plus tin. Almost any aluminum item you see is actually alloyed with silicon (if it's cast) or other metals (to add strength) [3].

Alloys – **Higher Tier**

Alloys are used in everyday life. Scientists are developing new alloys to fit a range of new applications [4].

Table 1. *Application of alloys.*

Alloy	Reason for alloy	Used for
Gold with copper, nickel, silver or platinum	Increases strength	 Jewelry
Nitinol	Returns to its original shape when squashed	 Spectacle frames
Nitinol	Returns to its original shape when warmed	Nitinol tubes are used to open up damaged arteries

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 (Table 2) [5].

Table 2. *Different uses of alloys for different purposes.*

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 nickel)	Copper (75%), nickel (25%), plus small amounts of manganese.	Coins.
Duralumin	Aluminum (94%), copper (4.5–5%), magnesium (0.5–1.5%), manganese (0.5–1.5%).	Automobile and aircraft body parts, military equipment.
Gunmetal	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 (50-70%), lead (30-50%), copper, antimony, and other metals. Newer solders dispense with lead for health reasons. A typical modern solder has 99.25% tin and 0.75% copper.	Connecting electrical components into circuits.
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 chainsaws.
Sterling silver	Silver (92.5%), copper (7.5%).	Cutlery, jewelry, medical tools, musical instruments.
White gold (18 carat)	Gold (75%), palladium (17%), silver (4%), copper (4%)	Jewelry.
Wood's metal	Bismuth (50%), lead (26.7%), tin (13.3%), cadmium (10%).	Solder, melting element in sprinkler systems.

Methods of Extracting Metals

The method used to extract a metal from its ore depends upon the stability of its compound in the ore, which in turn depends upon the reactivity of the metal:

- The oxides of very reactive metals, such as aluminum, form stable oxides and other compounds. A lot of energy is needed to reduce them to extract the metal.
- The oxides of lesser reactive metals, such as iron, form less stable oxides and other compounds. Relatively little energy is needed to reduce them to extract the metal.
- So, the method of extraction of a metal from its ore depends on the metal's position in the reactivity series (Table 3) [6].

Table 3. *Reactivity and extraction method.*

Metal	**Reactivity**
• Potassium, sodium, calcium, magnesium, aluminum	Extract by electrolysis
Carbon	
• Zinc, iron, tin, lead	Extract by reaction with carbon or carbon monoxide
Hydrogen	
• Copper, silver, gold, platinum	Extracted by various chemical reactions

Reactive metals such as aluminum are extracted by electrolysis, while a less-reactive metal such as iron may be extracted by reduction with carbon. Gold, because it is so unreactive, is found as the native metal and not as a compound, so it does not need to be chemically separated. However, chemical reactions may be needed to remove other elements that might contaminate the metal [7].

Oxidation and Reduction

Oxidation is the gain of oxygen by a substance. For example, magnesium is oxidised when it reacts with oxygen to form magnesium oxide:

Magnesium + Oxygen → magnesium oxide

$2Mg + O_2 \rightarrow 2MgO$

Reduction is the loss of oxygen from a substance. For example, copper oxide can be reduced to form copper if it is reacted with hydrogen:

Copper oxide + hydrogen → copper + water

$CuO + H_2 \rightarrow Cu + H_2O$

Many ores contain metal oxides; therefore, many metals can be extracted from their ores by reduction reactions. The method used to extract a given metal depends on how reactive it is:

- very reactive metals – electrolysis
- less reactive metals – reduction

Rusting

Iron and steel rust when they come into contact with water and oxygen: this is a form of corrosion. Both water and oxygen are needed for rusting to occur. Rusting is an oxidation reaction. The iron reacts with water and oxygen to form hydrated iron(III)oxide, which we see as rust [8]. Here is the word equation for the reaction:

Iron + water + oxygen → hydrated iron(III) oxide

In the experiment below (Figure 1), the nail does not rust when air – containing oxygen – or water is not present:

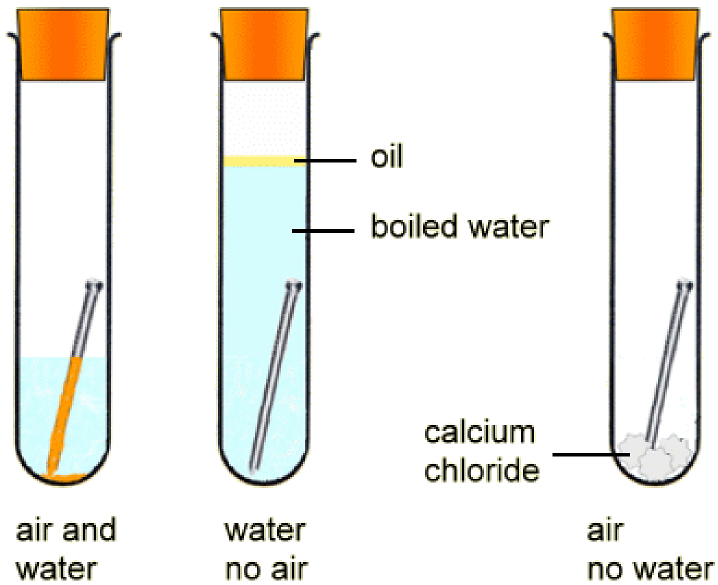

Fig. 1. *Calcium chloride absorbs water in the right-hand test tube.*

Salt dissolved in water does not cause rusting, but it does speed it up, as does acid rain. Aluminum does not rust (corrode) because its surface is protected by a natural layer of aluminum oxide which prevents the metal below from coming into contact with air and oxygen. Unlike rust, which can flake off the surface of iron and steel objects, the layer of aluminum oxide does not flake off. More reactive elements are more likely to oxidise [9].

Uses of Metals

We use different metals for different jobs as they have different properties: it's important to choose the right metal for the job (Table 4).

Table 4. *Selection of proper metal.*

Metal	**Properties**	**Uses**
Aluminum 	Low density, does not corrode	Suitable for the bodies of planes
Copper 	Good conductor of electricity, does not react with water	Electrical wires as it is a good conductor Water pipes due to its low reactivity
Gold 	Very good conductor of electricity, unreactive	Electrical connections on circuit boards – due to its conductivity Jewelry – due to its lack of reactivity
Steel 	Cheap and strong	Suitable for building material

When you answer questions on properties of metals it's important to make sure that the property you give is relevant to the use you've been asked about, *e.g.*, copper is unreactive with water but that is not relevant if the question asks you about its use in electrical wires.

The properties of a metal are changed by including other elements, such as carbon. A mixture of two or more elements, where at least one element is a metal, is called an alloy. Alloys contain atoms of different sizes, which distort the regular arrangements of atoms. This makes it more difficult for the layers to slide over each other, so alloys are harder than the pure metal (Figure 2) [10].

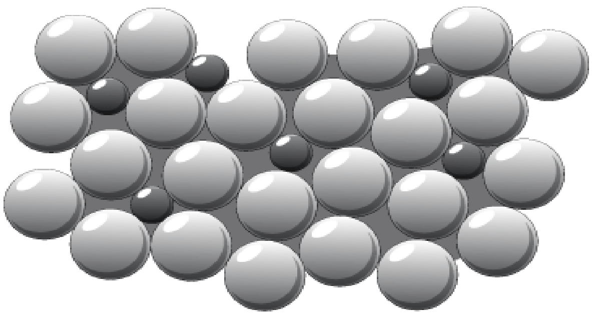

Fig. 2. *Figure showing more difficultly for layers of atoms to slide over each other in alloys.*

Copper, gold and aluminum are too soft for many uses. They are mixed with other metals to make them harder for everyday use [11]. For example:

- Brass, used in electrical fittings, is 70% copper and 30% zinc.
- 18 carat gold, used in jewelry, is 75% gold and 25% copper and other metals.
- Duralumin, used in aircraft manufacture, is 96% aluminum and 4% copper and other metals.

Smart alloys can return to their original shape after being bent. They are useful for spectacle frames and dental braces.

Some Common Alloys in Everyday Life

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 [12]. There are lots of different variations on most alloys and the precise mixture can vary widely, so the percentage figures you see quoted in different books will often not agree exactly (Table 5).

Table 5. *Uses of alloys in our daily routine life.*

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.
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Duralumin	Aluminum (94%), copper (4.5–5%), magnesium (0.5–1.5%), manganese (0.5–1.5%).	Automobile and aircraft body parts, military equipment.
Gunmetal	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.
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Sterling silver	Silver (92.5%), copper (7.5%).	Cutlery, jewelry, medical tools,

		musical instruments.
White gold (18 carat)	Gold (75%), palladium (17%), silver (4%), copper (4%)	Jewelry.
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CONCLUSION

The uses of alloys are vast, and they can be manipulated to serve different functions by combining metals to produce alloys with specific properties ideal for the application. The use of alloys is vast in several different industries, ranging from military and medical equipment to commercial and industrial materials. Some examples of alloys are copper, stainless steel, aluminum and bronze, with each of them having different properties and which are very essentials and plays a very important role in our routine life.

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