

UNIT NINE

Engineering materials Joining methods



Reading 1

Read the text below which provides general information about engineering materials. Then do the Reading task that follows.

Engineering materials

The choice of materials used by engineers is guided by the *properties* of each material and at what cost they can be used. In general, engineering materials are classified in metals and non-metals.

Metals are further divided into *ferrous* (iron-containing) and non-ferrous (containing no iron). Ferrous materials have been used widely in engineering projects and among them *cast iron* and *steel* are the most used ferrous materials. They are both *alloys*, mixtures of iron and carbon with steel containing smaller proportion of *carbon* in comparison to cast iron. A variety of other elements can be used to

improve the physical properties of steel; *chromium* is often used for example to improve the corrosion profile of steel.

Non-ferrous materials that are most commonly used include *aluminum*, *copper*, *bronze* and *brass*.

In terms of non-metals, *plastics* and *ceramics* make up two of the broadest categories. Plastics are further categorized in *thermoplastics*, which can undergo repeated cycles of heating, and *thermosets* which cannot be heated again due to the chemical changes they sustain.

Source: Adapted from <http://www.engineershandbook.com/Materials/>

➔ Reading task

Decide whether the following statements are *true* or *false*.

1. Non-ferrous materials are a subdivision of non-metals.
2. Copper is one of the most widely used non-metals.
3. Materials properties determine the choice of materials used in engineering.
4. Ferrous materials contain iron.
5. Cast iron and steel are not alloys.
6. Thermosets can undergo repeated cycles of reheating.
7. Ceramics are widely used non-metals.
8. Chromium is used to improve the conductivity of iron.
9. Steel contains less carbon compared to cast iron.
10. Bronze and brass belong to the non-metals materials.

1.	2.	3.	4.	5.
6.	7.	8.	9.	10.



Fig. 1: A steel foundry in Chicago

Word study

Match the terms on the left with their definitions on the right using the information provided in Reading 1.

1. thermoplastics	a. materials that can not be softened on heating
2. brass	b. a generic term describing a family of iron alloys containing 1,8–4,5% carbon
3. alloy	c. a metal composed primarily of copper and zinc
4. cast iron	d. metallic substance composed of two or more elements, as either a mixture, compound, or solid solution
5. thermosets	e. plastic materials that melt to a liquid when heated and freeze to a brittle, very glassy state when cooled sufficiently

1.	2.	3.	4.
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Pre-reading task

Work in pairs to match the uses/properties of metals and non-metals in Column A with the correct materials in Column B. Two of the items in Column B have the same uses.

COLUMN A	COLUMN B
USES / PROPERTIES	METALS / NON-METALS
1. Utensils, foil	a. Tin
2. Steels, cast iron	b. Copper
3. Flash bulbs, lightweight alloys	c. Gold
4. Aircraft alloys	d. Magnesium
5. Alloys	e. Silver
6. Plating	f. Iron
7. Coins, alloys	g. Zinc
8. Galvanizing	h. Nickel
9. Conductors	i. Chromium
10. Batteries	j. Manganese
11. Tin plate for tin cans	k. Aluminum
12. Plate, alloys, jewellery	l. Lead

COLUMN A	COLUMN B
13. Plate, alloys, jewellery	m. Titanium
14. Steel manufacture, welding	n. Chlorine
15. Matches	o. Oxygen
16. Pigment, lubricant	p. Sulphur
17. Chemicals, paper	q. Phosphorus
18. Bleach, disinfectant	r. Carbon

1.	2.	3.	4.	5.
6.	7.	8.	9.	10.
11.	12.	13.	14.	15.
16.	17.	18.	—	—

Reading 2

Read the text below which provides general information about metals and non-metals. Then do the Reading task that follows.

Metals and Non-metals

One of the broadest classifications of the materials found on Earth is that of metals and non-metals. The elements of the *periodic table* have been therefore classified into two categories based on their properties and their behavior under specific conditions. The classification is based largely on whether the substance in question conducts heat and electricity. Metals conduct heat and electricity whereas non-metals do not. Apart

from being a conductor of heat and electricity, the “typical” metal element has a *shiny luster*, it is *ductile* and *malleable* and is *solid* at room temperature. As exceptions *gold*, *silver* and *copper* are indeed metals but are colored, which is usually a characteristic attributed to non-metals. Also a group of elements do not seem to fit in any category comfortably and have been termed as the “*metalloids*”, with *arsenic* being one of the most well-known elements to fall into this category.

At the atomic level, metals and non-metals display fundamental differences in their *atomic bonds* and their *spatial organization*. In fact, the way electrons are “organized” in the atoms of metal and non-metal substances account for their *conductivity*. Metal atoms comprise *loosely held* electrons in the *outer shell* in contrast to non-metals. These metallic electrons take part in the electron flow when metals conduct electricity. Silver and copper are the metals with the most loosely held electrons and therefore they make the best conductors of electricity. On the

other hand, non-metals have fixed atoms, often attached to *adjacent* atoms through *shared* electrons, therefore preventing the flow of electricity.

One further attribute of metals that can be linked to their electronic structure is the “*metallic luster*”. Due to the weak bonds holding the *valence electrons* together, there is a good reflection of the light on a metallic surface. On the contrary, the fixed electrons of non-metals cannot reflect light waves in the same way.

Source: Adapted from http://inorganic-chemistry.suite101.com/article.cfm/metals_and_nonmetals

➔ Reading task 1

Read the text again and find words which mean the following:

1. Capable of being shaped or formed, as by hammering or pressure.
.....
2. Of definite shape and volume, neither liquid nor gaseous.
.....
3. A tabular arrangement of the elements according to their atomic numbers so that elements with similar properties are in the same column.
.....
4. A highly poisonous metallic element having three allotropic forms, yellow, black, and gray.
.....
5. The force that holds two or more units of matter together.
.....
6. The ability or power to conduct or transmit heat, electricity, or sound.
.....
7. Brilliance or radiance of light, brightness.
.....
8. An electron in an outer shell of an atom that can participate in forming chemical bonds with other atoms.
.....

9. Close to, lying near.

10. In a non-fastening or restraining manner.

1.	2.	3.	4.	5.
6.	7.	8.	9.	10.

Word study

Join the words in the left hand column with these on the right to form collocations which appear in the two previous texts.

1.	engineering	A.	luster
2.	atomic	B.	atoms
3.	adjacent	C.	iron
4.	shiny	D.	project
5.	cast	E.	table
6.	periodic	F.	organization
7.	valence	G.	bond
8.	spatial	H.	electrons

1.	2.	3.	4.
5.	6.	7.	8.

Use of English

Fill in the gaps of the following text using the words from the list below.

substance	solid	diamond
use	soft	non-metal
liquid	arrangement	characteristics

Focus on Non-Metals

Two of the most well-known 1. materials are carbon and sulfur. Carbon is encountered free in nature in two forms: graphite and diamond. The difference between the two is striking and is attributed to the 2. of the atoms, which essentially dictates the character of each 3. and its uses, for example 4. is extremely hard and perfectly suited for use as industrial grinding material. Graphite on the other hand exhibits weak atomic bonds, and is basically arranged in sheets on top of one another which is what makes it 5. and perfectly suited for 6. as a lubricant. Sulfur is another example of non-metal element with completely different sets of 7. compared to carbon. It exists as a yellow 8.; when it is heated it turns into 9., comprising eight-atom-molecules arranged in rings. At higher temperatures, however the rings open up and form long chains resulting in a highly viscous liquid.

➔ Reading task 2 – Cloze

Skim the passage quickly to get the gist, and then select the appropriate word for each blank from the choices provided.

Focus on metals

The most well-known metal materials are iron, 1., copper and lead. Iron has a crystalline structure at room 2., with each atom being neighbored by eight others. At over 900 degrees the configuration becomes even more

1. a. silicon b. carbon
c. aluminum

2. a. temperature b. humidity
c. dryness

compact, with twelve neighboring atoms for each one. Steel is an alloy of **3.** and carbon, often with an admixture of other elements. Steels of various types contain from 0,04 percent to 2,25 percent of carbon. Aluminium is a strongly electropositive metal and extremely reactive. In contact with **4.**, aluminium rapidly becomes covered **5.** a tough, transparent layer of aluminium oxide that resists further **6.** action. For this reason, materials made of aluminium do not tarnish or rust. Copper is also oxidized producing a gray-green patina which grows **7.** the longer the exposure persists. Lead has been used since antiquity. It is toxic if absorbed at high enough levels, but nonetheless it is widely used in the construction of **8.** systems and batteries. It is also extensively used in the production of **9.**

- 3. a. silver b. iron**
c. chromium
- 4. a. hydrogen b. air**
c. water
- 5. a. onto b. into**
c. with
- 6. a. anti-corrosive b. rusty**
c. corrosive
- 7. a. thinner b. thicker**
c. taller
- 8. a. pipe b. plating**
c. bulb
- 9. a. ingredients b. alloys**
c. metalloids

➔ Reading task 3

Complete the table below by grouping the following attributes according to their metallic or non-metallic nature.

1. Colored 2. No heat conducting 3. Solid at room temperature
 4. Shiny luster 5. Comprise fixed atoms 6. Electricity conducting

METAL	NON-METAL
.....
.....
.....
.....
.....
.....

➔ Reading task 4

Match the materials (metal, non-metal or alloy) provided in the box below with the statements in Column B. More than one statement might be linked to a single material.

IRON ALUMINUM SULPHUR COPPER LEAD CARBON

	COLUMN A	COLUMN B
	MATERIALS	STATEMENTS
1.is primarily used in piping and batteries in spite of toxicity.
2.is crystalline at room temperature.
3.is a yellow solid.
4.produces a gray-green patina upon oxidation.

5.	.....	...is reactive chemically: it combines with oxygen when it is exposed to the outer air.
6.	.....	...it occurs free in nature in two crystalline forms: diamond and graphite.
7.	.....	...many acids, including concentrating nitric acid, have no effect on it because its oxide layer is impervious to them.
8.	.....	...provides shielding against radioactivity.

Pre-reading task

Work in pairs to answer the following questions.

- ❖ What is corrosion?
- ❖ How does corrosion make a structure more expensive?
- ❖ How does stainless steel resist corrosion?
- ❖ Which metal is used for marine parts and why?

Reading 3

Read the text below to check your answers to the questions of the pre-reading task.

Corrosion

Corrosion can be broadly defined as any chemical process which *harms* the properties of any material. It affects all materials used in engineering and especially metals. The overall effect is a reduction in the

material life time and an increase in costs through the need of extra measures such as paint, etc. Although no material can stay corrosion-free, metals that can resist corrosion effectively have been developed. Such metals include *stainless steel*

which contain chromium at varying percentages, aimed at protecting the metal from corrosion. Chromium forms an oxide film around the metal making it corrosion-resistant. Some metals however, called noble metals, are so inactive chemically that they do not suffer corrosion from the atmosphere; among them are silver, gold, and platinum. Alloys made from copper and nickel are also corrosion-resistant. For example Monel metal (an alloy made from

roughly 60% nickel and 30% copper) is resistant to both fresh and salt water corrosion. It is therefore used for marine engine parts, and for other surfaces like ships' propellers which are in contact with sea water. Cupronickels (a corrosion-resistant alloy of copper containing up to 40 percent nickel) have also a similar resistance to fresh and sea water. They are mainly used to make tubes.

Source: Adapted from <http://www.answers.com/topic/corrosion>

➔ Reading task 1

Match the sentence parts in Column A with their appropriate counterparts in Column B to formulate true sentences.

	COLUMN A	COLUMN B
1.	Chromium forms...	a. ...the metal's lifespan and overall properties
2.	Metals are particularly prone to ...	b. ...an oxide film around the metal.
3.	Corrosion affects...	c. ...corrosion
4.	Stainless steels contain....	d. ...chromium at varying percentages

1. 2. 3. 4.

Word study – Vocabulary building

Using your dictionary, complete the table below with the correct word forms which can also be found in Reading 1.

	Verb	Noun	Adjective
1.	.....	corrosion	.....
2.	—	.....	chemical
3.	.....	.....	processable
4.	.....	.....	resistant
5.	to create	.....	.....
6.	.....	leadership / leader	.....
7.	.....	container	.....



Fig. 2: The result of corrosion on metal