6 Useful Elements and Compounds

Chemistry plays an important role in our lives. The food we eat consists of complex chemical compounds. It is digested and burnt (on respiration) to give us energy. Digestion and respiration are long chains of chemical reactions. Chemical reactions are also involved in the extraction of metals and nonmetals, and the preparation of alloys, glass, fertilisers, soaps, paints, medicines, and so on. The list is inexhaustible.

Metals and Nonmetals

For a chemical study, elements are often divided into two classes—metals and nonmetals—on the basis of their general properties. Of the 114 elements known today, 90 are metals and the remaining 24 are nonmetals.

Metals

We generally look for a metal when we need a strong material. This is because metals are in general hard and strong. Some examples of metals are potassium (K), calcium (Ca), sodium (Na), magnesium (Mg), aluminium (Al), iron (Fe), zinc (Zn), tin (Sn), copper (Cu), mercury (Hg), silver (Ag), gold (Au) and platinum (Pt).

General properties of metals

Metals have the following general properties.

1. *They are generally hard, strong solids.* For example, aluminium, iron, zinc, tin and copper are hard, strong solids. They are strong enough to bear heavy loads.

   Exceptions: Sodium and potassium are soft solids which can be cut with a knife, and mercury is a liquid in ordinary conditions.
2. *They have a lustre, known as metallic lustre.* For example, aluminium, iron, zinc, copper, silver and gold are all lustrous. Such metals can be polished also.
3. *When struck, metals produce a sound called a metallic sound or metallic clink.* Recall the ringing of a bell.
4. *Metals are malleable.* In other words, they can be beaten or rolled into sheets. A piece

Fig. 6.1 Metals such as copper, silver, gold and iron are hard and shiny, whereas solid nonmetals such as carbon and sulphur are dull and brittle.


Fig. 6.2 Metals are ductile and malleable—they can be drawn into wires or pressed to form sheets or foils.

of aluminium, iron, copper or silver can be beaten or rolled into thin sheets. Common examples are, the silver foils used to decorate sweets and aluminium foils used to pack foodstuff.

5. *Metals are ductile*, i.e., they are flexible and can be drawn into wires. For example, iron, aluminium, copper, silver and gold can be easily drawn into wires.

6. *Metals are good conductors of heat*, i.e., they allow heat to pass through them easily. Hold one end of an iron nail with your fingers and place the other end in a flame. You will feel the heat. (Let go of the nail as soon as it warms up.)

   Due to this property, we use metal utensils in kitchens. Heat supplied at one part of the utensil is conducted all over it.

7. *Metals are good conductors of electricity*, i.e., they allow an electric current to pass through them easily. This is why electricity is transmitted from one point to another through metal wires, like those of copper or aluminium.

   Silver is the best conductor of electricity; the next best is copper and then aluminium.

Uses of metals

Metals are of great use to us.

1. As metals are good conductors of electricity, they are used in making wires for electrical connection and transmission. Copper wires are used for domestic wiring and aluminium wires for long-distance transmission. Aluminium is lighter and cheaper than copper.

2. Iron is a very useful metal as it is tough, strong and cheap. It is used for making tools, machines and agricultural equipment, and also in house construction.

   However, it rusts, which makes it lose its strength. To prevent rusting, iron is usually galvanised. Galvanisation is done by immersing an iron article in molten zinc, then taking it out and allowing it to cool. Zinc forms a firm coating over iron and prevents rusting.

   Galvanised iron (GI) sheets are used in making trunks, GI pipes for supplying water, and GI wires for making barbed wire and wire nets.

   Iron coated with tin is used to make cans.

3. Iron, aluminium and copper are used in making domestic utensils. Nonstick utensils are usually made of iron coated with such a polymer which is not affected by heat. You will learn about polymers in the next chapter.

4. When ignited, magnesium burns in air with a dazzling white light. Magnesium in the form of powder or turnings is, therefore, used to a great extent in fireworks.

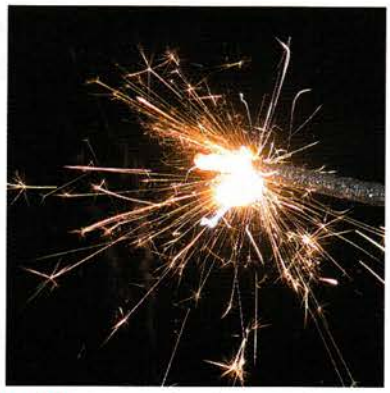

Fig. 6.3 Magnesium is used in fireworks.

5. Mercury is a liquid that does not stick to glass. At the same time, it is a good conductor of heat. So it is used for making thermometers. Mercury placed in a thermometer bulb, attached to a capillary, expands or contracts as it gets heated or cooled. The length of the mercury column in the thermometer gives a measure of the temperature.
6. Silver, gold and platinum are noble metals as they do not easily react with other substances. Once polished, they retain their sheen for a long time. They are, therefore, used for making jewellery. Small amounts of silver and copper are mixed with gold to make it tough.
7. Artificial teeth were earlier usually made of silver or gold. Tooth cavities are filled with what are known as dental amalgams—alloys of silver or tin with mercury.

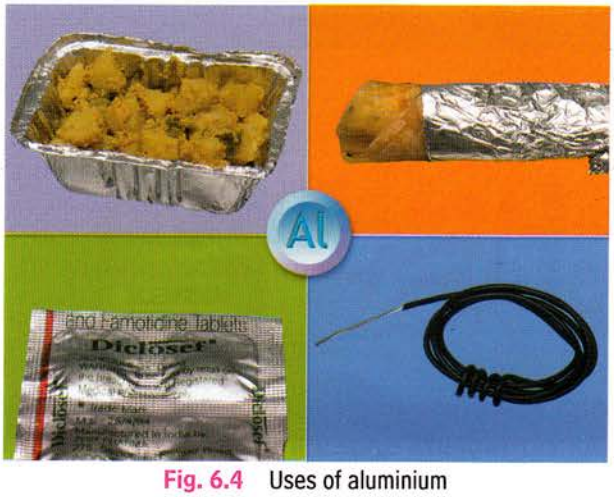

Fig. 6.4 Uses of aluminium

8. Aluminium foil, which is very light, is used to pack food, medicines, etc. Aluminium is also used for making electric wires and utensils.

Nonmetals

In contrast to metals, nonmetals are not known for strength. They are

- usually lustreless (dull), except graphite and iodine;
- brittle, if solid;
- bad conductors of heat; and
- bad conductors of electricity (except graphite).

They do not produce a metallic clink.

Of the 24 nonmetals known today,

- 12 are solids (e.g., carbon, silicon, phosphorus, sulphur, iodine),
- 1 is a liquid (bromine), and
- 11 are gases (e.g., hydrogen, nitrogen, oxygen, fluorine, chlorine, helium, neon, argon).

Uses of nonmetals

Let us study the uses of some common nonmetals.

Oxygen You have already learnt that oxygen is a constituent of air. Let us briefly see how it is useful to us.

- All combustion processes need oxygen.
- It is required for respiration. It burns food in our body to give us energy.

$$\underset{\text{glucose}}{C_6H_{12}O_6} + \underset{\text{oxygen}}{6O_2} \longrightarrow \underset{\text{carbon dioxide}}{6CO_2} + \underset{\text{water}}{6H_2O} + \text{energy}$$

Aquatic animals derive oxygen from dissolved air.

- Oxygen is given to patients who suffer from respiratory problems.
- Divers use a mixture of oxygen and helium for respiration.

- With acetylene, oxygen is used in oxyacetylene torches to cut and weld metals.
- It is required in large quantities in the iron and steel industry.
- It is used in the manufacture of sulphuric and nitric acids.
- Liquid oxygen is used to burn rocket fuel.

Nitrogen Nitrogen is also a constituent of air.

- Plants use nitrogen to manufacture proteins.
- Liquid nitrogen is used to preserve blood, corneas or other donated organs.
- Due to its inertness, it is used for filling food packages. (Food does not go bad in an inert medium.)
- It is used in the manufacture of ammonia and urea.

Carbon Charcoal and lampblack are non-crystalline forms of carbon. Carbon is found in two crystalline forms—diamond and graphite. Diamond and graphite have the following uses.

- Diamond is used as a gem as also for cutting rocks or glass.
- Graphite is a good conductor of electricity and is, therefore, used as an electrode.

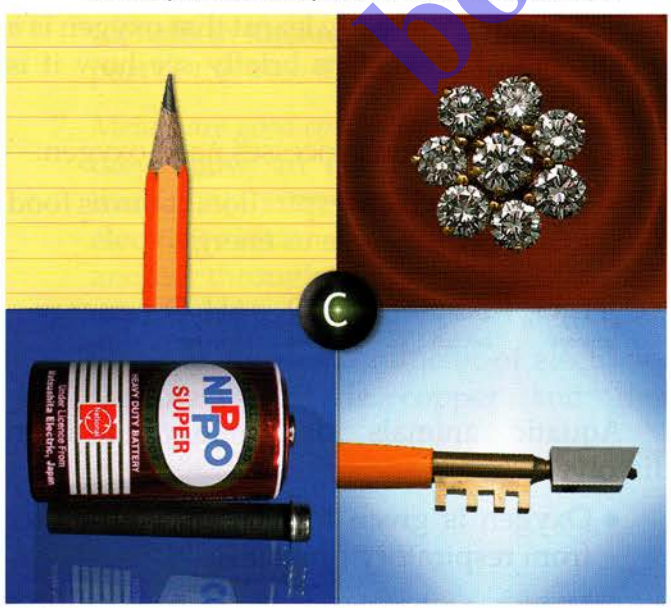

Fig. 6.5 Uses of carbon—in pencils, in jewellery, in cells as electrodes and in glass cutters

- The crystal structure of graphite is such that one layer slides over the other, making it a good lubricant. Since its melting point is high, it can be used as a lubricant in machines that acquire high temperatures while being operated.
- Graphite is also used in the manufacture of pencils.

Chlorine Chlorine is a greenish yellow gas and is highly reactive.

- It is used in the manufacture of the useful plastic polyvinyl chloride (PVC).
- It is used to disinfect water, as it kills germs. This is done either by passing chlorine gas through water or by treating water with bleaching powder.
- It is used as a bleach in paper and textile industries. Household bleaches also contain chlorine compounds.
- Chlorine is used in the manufacture of hydrochloric acid.
- It is also used in the manufacture of pesticides like Gammexene.

Iodine Though a nonmetal, iodine is a lustrous black solid. It sublimes slowly to form a violet vapour over the solid inside a stoppered bottle.

- Iodine is an antiseptic. Its alcoholic solution (with some potassium iodide), which is reddish brown in colour and is known as tincture iodine, is applied on

Fig. 6.6 Uses of iodine

cuts. A paste of iodine in petroleum jelly gives relief from pain.

- Lack of iodine in the human body causes many diseases, mainly related to the thyroid gland. Physicians recommend that patients suffering from such diseases take what is known as iodised salt in their diet. Iodised salt is table salt mixed with sodium iodate.

Helium Helium is a noble-gas element. It is the lightest gas next to hydrogen.

- It is used for filling balloons. It is safer than hydrogen as it does not catch fire.
- A mixture of helium and oxygen is used by divers for respiration.

Neon Neon is also a noble-gas element.

- Neon is used mainly for illumination. It produces an orange-red light in a discharge tube and is used in advertisement signs.

Argon Argon is the most abundant noble gas present in air.

- It is used to fill electric bulbs.
- Mixed with a little mercury vapour in a discharge tube, it gives a green light. So argon is used in green signs.

Alloys

A solid solution, i.e., a homogeneous mixture, of a metal with other metal(s) or nonmetal(s) is called an alloy.

For example,

(i) steel is an alloy of iron, manganese and carbon, and

(ii) brass is an alloy of copper and zinc.

An alloy is usually harder and stronger than the parent metal(s) and at the same time, it resists corrosion. This is why alloying is done. Some common alloys with their uses are mentioned in Table 6.1

Table 6.1 Some common alloys

Alloy	Constituents	Properties	Uses
Steel	Iron with very small amounts of carbon (0.1–1.5%) and manganese	Hard and strong	For making railway tracks, coaches, locomotives, ships, bridges, buildings, etc.
Stainless steel	Steel containing chromium (~18%) and nickel (~8%)	Hard, strong and rustproof	For making utensils, cutlery, valves, etc.
Manganese steel	Steel containing manganese (>10%)	Hard and strong	For making railway tracks
Brass	Copper with some zinc (up to 40%)	Tough and corrosion-resistant	For making utensils, bullets, and reeds and strings for musical instruments
Bronze	Copper with tin (~10%)	Hard and corrosion-resistant	For making statues, medals, etc.
Duralumin	Aluminium with some copper (~4%) and a little manganese and magnesium	Light and tough	For making light-weight instruments and aircraft bodies
Magnalium	Aluminium with magnesium and copper	Light and tough	For making aircraft

Gold alloys Pure gold is soft and so not suitable for making jewellery. It is, therefore, made harder and stronger by alloying it with silver, copper, or both. The alloy is still malleable.

The purity of gold is reckoned in carats. Pure gold is 24 carats. By 22-carat gold we mean that the sample contains 22 parts of pure gold and 2 parts of the alloying agents. Generally, 22-carat gold is suitable for making jewellery.

Fig. 6.7 A bronze statue, a brass vase, and things made of stainless steel

Amalgams Alloys of mercury are called amalgams. Silver and tin amalgams are used in dentistry. Other amalgams have many laboratory and industrial uses.

Solutions we use

Chemical reactions generally take place faster in solution. All chemical reactions in our body occur in solution.

We use several solutions in everyday life. Let us discuss some of them.

Soda water Soda water is a solution of carbon dioxide (dissolved under pressure) in water. It is a highly refreshing drink when you are exhausted.

Glucose solution A solution of glucose in water gives instant energy. Glucose burns during respiration to give carbon dioxide, water and energy.

Solution of sugar with lemon juice In solution cane sugar is slowly converted into glucose and fructose in the presence of lemon juice. Glucose gives you energy.

Solution of sugar or glucose and salt Blood cells require a minimum concentration of salt within them. If there is a loss of salt by way of excessive perspiration or vomiting, a solution of sugar or glucose with salt should be consumed.

A solution of glucose and salt, called *glucose-saline solution*, is intravenously injected to a patient suffering from dehydration.

Useful Organic Compounds

Organic compounds are of vital importance to all living beings. Besides playing an important role in the survival of plants and animals, they are useful to mankind in various ways.

Simple Organic Compounds—Hydrocarbons

Hydrocarbons are the simplest organic compounds, containing only carbon and hydrogen. When ignited, they burn to give carbon dioxide, water vapour and a large amount of heat. So they are used as fuels.

Hydrocarbons like methane (CH_4), ethane (C_2H_6), propane (C_3H_8) and butane (C_4H_{10}) are gases. Petrol, diesel and kerosene are mixtures of hydrocarbons containing larger numbers of carbon atoms.

Petrol and diesel are used as fuels in motor vehicles, but they produce fumes which are bad for the environment.

Gaseous hydrocarbons burn better and produce no fumes. So they are more environment-friendly than the liquid hydrocarbons. They are mostly used in the following forms.

Compressed natural gas (CNG)

Natural gas is obtained from petroleum wells, and mainly contains methane. When compressed, it is called compressed natural gas (CNG), which is used as a fuel in motor vehicles

like buses, trucks and autorickshaws.

$$\underset{\text{methane}}{CH_4} + 2O_2 \xrightarrow{\text{burning}} CO_2 + 2H_2O + \text{heat}$$

Liquefied petroleum gas (LPG)

In the petroleum industry, gaseous hydrocarbons are also obtained by breaking larger hydrocarbon molecules. Butane (C_4H_{10}) is the main product. When liquefied, it is called liquefied petroleum gas (LPG), which is used as a domestic fuel.

$$2\underset{\text{butane}}{C_4H_{10}} + 13O_2 \xrightarrow{\text{burning}} 8CO_2 + 10H_2O + \text{heat}$$

Fig. 6.8 An LPG cylinder

Gobar gas

Cow dung (*gobar* in Hindi) on decay gives methane. Cow dung is available in plenty in rural areas and dairy farms. Methane is prepared by allowing the cow dung to decay in what are called 'gobar gas' plants. The gas is used as a domestic fuel.

$$\text{Cow dung} \xrightarrow{\text{microorganisms}} \underset{\text{methane}}{CH_4}$$

Complex Organic Compounds—Carbohydrates and Proteins

Carbohydrates and proteins are organic nutrients—essential for our growth.

Carbohydrates

Carbohydrates contain carbon, hydrogen and oxygen linked in a particular manner. Glucose, sucrose (cane sugar), starch (found in rice, wheat, maize, etc.) and cellulose (found in wood) are common examples of carbohydrates. Glucose and sucrose are sweet in taste and so they are sugars. There are other sugars also, e.g., fructose (found in honey and some fruits) and lactose (found in milk). Sugars contain up to twelve carbon atoms.

Starch is a complicated carbohydrate containing a large number of glucose units. Plants store their food as starch. So starch is found in many cereals. On digestion, starch is converted into glucose, which during respiration gives us energy.

$$\underset{\text{glucose}}{C_6H_{12}O_6} + 6O_2 \xrightarrow{\text{respiration}} 6CO_2 + 6H_2O + \text{heat}$$

$$\text{Starch} \xrightarrow{\text{digestion}} \text{Glucose} \xrightarrow{\text{respiration}} CO_2 + H_2O + \text{heat}$$

Cellulose is also a carbohydrate containing a large number of smaller units. Being tough, it forms the walls of plant cells. It is not digested by humans but digested by animals like cows.

Proteins

Proteins are highly complicated organic substances containing carbon, hydrogen, oxygen, nitrogen and sulphur. They are important for our growth and development. They constitute our muscles, blood cells, hormones, hair and nails. They also form an important part of our genes. We get proteins from pulses, beans, milk, fish, eggs and meat.

Useful Inorganic Compounds

Compounds obtained from mineral sources are known as inorganic compounds. Common salt, calcium carbonate, hydrochloric acid, sulphuric acid and copper sulphate are some examples of such compounds. They are useful in many ways. Let us now discuss some important inorganic compounds.

1. Common salt (NaCl) It is obtained from rocks

and by the evaporation of sea water. It is an essential part of our food.

2. Hydrochloric acid (HCl) It is obtained upon the reaction of (a) NaCl and H_2SO_4, and (b) hydrogen and chlorine. It is used as a bathroom-cleaning agent, and in many industries. It also plays an important role in the digestion of food in our body.

3. Baking soda ($NaHCO_3$) Baking soda is manufactured by using NaCl. It is used for raising dough.

4. Washing soda ($Na_2CO_3 \cdot 10H_2O$) It, too, is obtained by using NaCl. It is used for washing clothes and linen.

5. Soda ash (Na_2CO_3) Soda ash is obtained by heating washing soda. It is used in the manufacture of glass.

6. Marble and limestone ($CaCO_3$) They are mined from quarries.

Marble is used to make floors and tiles, and also monuments.

Limestone is used in the manufacture of cement. It is also employed in the extraction of metals, and as a source of carbon dioxide.

7. Quicklime (CaO) Quicklime is obtained by strongly heating limestone.

It is used for preparing slaked lime.

$$CaCO_3 \rightarrow CaO + CO_2 \uparrow$$

8. Slaked lime [$Ca(OH)_2$] It is obtained by treating quicklime with water.

$$CaO + H_2O \rightarrow Ca(OH)_2$$

It is used in mortars, and as whitewash. It is also employed in the manufacture of bleaching powder.

9. Bleaching powder ($CaOCl_2$) Bleaching powder is obtained upon the reaction of slaked lime and chlorine.

$$Ca(OH)_2 + Cl_2 \rightarrow CaOCl_2 + H_2O$$

It is used as a bleach for fabrics, and as a source of chlorine for disinfecting water.

$$CaOCl_2 + H_2O \rightarrow Ca(OH)_2 + Cl_2$$

10. Zinc oxide (ZnO) Zinc oxide is obtained from zinc minerals. It is used as a white paint.

11. Gypsum ($CaSO_4 \cdot 2H_2O$) It is obtained as a mineral. It is used for manufacturing plaster of Paris. It finds application in the cement industry.

12. Plaster of Paris ($CaSO_4 \cdot \frac{1}{2}H_2O$) Plaster of Paris is obtained by heating gypsum. A paste of it in water sets like plaster. So it is used for plastering broken bones or making moulds and statues.

13. Blue vitriol ($CuSO_4 \cdot 5H_2O$) It is obtained from copper minerals. A mixture of slaked lime with blue vitriol (called Bordeaux mixture) is used as a fungicide.

Points to Remember

- Metals are
  - (i) generally hard, strong solids,
  - (ii) lustrous,
  - (iii) malleable,
  - (iv) ductile,
  - (v) good conductors of heat, and
  - (vi) good conductors of electricity.

- Nonmetals are
  (i) usually dull-looking (except graphite and iodine),
  (ii) brittle, if solid,
  (iii) bad conductors of heat, and
  (iv) bad conductors of electricity (except graphite).
- A solid solution, i.e., a homogeneous mixture, of a metal with other metal(s) or nonmetal(s) is called an alloy.
- An alloy is usually harder and stronger than the parent metal(s) and, at the same time, it resists corrosion.
- Simple organic compounds like hydrocarbons are mostly used as fuels.
- Carbohydrates and proteins are organic nutrients required for our growth.
- Sugars, starch and cellulose are carbohydrates. Carbohydrates contain carbon, hydrogen and oxygen.
- Proteins contain carbon, hydrogen, oxygen, nitrogen and sulphur.

Exercise

Short-Answer Questions

1. Name a metal that is soft.
2. Name a metal that is used in fireworks.
3. Mention a use of diamond other than in jewellery.
4. Which salt is added to iodise common salt?
5. What part of pure gold is there in a sample of 22-carat gold?
6. Name the major constituent of each of the following alloys.
   (a) Brass and bronze
   (b) Duralumin and magnalium
   (c) Steel
7. Which condition of the body requires an intravenous injection of glucose-saline solution?
8. Give the name and formula of the hydrocarbon present in natural gas as well as 'gobar gas'.
9. What do the abbreviations CNG and LPG stand for?
10. Name a sugar other than sucrose.
11. Name a carbohydrate other than a sugar.
12. What are the following called?
    (a) The process of coating iron with zinc by dipping a piece of iron in molten zinc
    (b) A solid solution of a metal with other metal(s) or nonmetal(s)
    (c) Alloys of mercury
    (d) An organic compound containing only carbon and hydrogen

Long-Answer Questions

1. Mention three uses of nitrogen.
2. Describe three uses of graphite.
3. Name three noble gases and mention one use of each of them.

Objective Questions

Choose the correct option.

1. Which of the following metals is a liquid under ordinary conditions?
   (a) Aluminium (b) Zinc (c) Iron (d) Mercury

2. Which of the following nonmetals is lustrous?
   (a) Iodine (b) Carbon (c) Sulphur (d) Phosphorus
3. Which of the following elements is malleable and ductile?
   (a) Carbon (b) Aluminium (c) Sulphur (d) Phosphorus
4. Which of the following elements is used in respiration?
   (a) Nitrogen (b) Oxygen (c) Chlorine (d) Argon
5. Which of the following elements is used for disinfecting water?
   (a) Chlorine (b) Oxygen (c) Nitrogen (d) Neon
6. Which of the following elements is used in advertisement signs?
   (a) Neon (b) Oxygen (c) Nitrogen (d) Chlorine
7. From which of the following substances do you get protein?
   (a) Water (b) Rice (c) Pulses (d) Salts
8. What is the formula of bleaching powder?
   (a) $CaOCl_2$ (b) $Ca(OCl_2)$ (c) CaOCl (d) $CaCl_2$

Fill in the blanks.

1. Metals are ..... (lustrous/lustreless)
2. Metals are .....conductors of heat and electricity. (good/bad)
3. .....foils are used for packing foodstuff. (Iron/Aluminium)
4. Combustion processes need ..... (helium/oxygen)
5. Graphite is a .....conductor of electricity. (good/bad)
6. .....is used as a solid lubricant. (Diamond/Graphite)

Match the items given in column A with the formulae given in column B.

A	B
Gypsum	$Ca(OH)_2$
Quicklime	$CaCO_3$
Limestone	CaO
Slaked lime	$CaSO_4 \cdot 2H_2O$
Baking soda	$CaSO_4 \cdot \frac{1}{2}H_2O$
Washing soda	$NaHCO_3$
Plaster of Paris	$Na_2CO_3 \cdot 10H_2O$

Indicate which of the following statements are true and which are false.

1. Nonmetals are brittle, if solid.
2. All nonmetals are good conductors of electricity.
3. Hydrochloric acid is used as a bathroom cleaner.
4. Bordeaux mixture contains copper sulphate and gypsum.
5. Petrol, diesel and kerosene are mixtures of hydrocarbons.
6. Proteins are essential for the growth of our muscles.

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