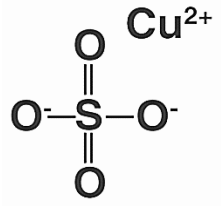
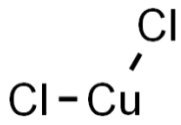
CHAPTER 4. CHEMICAL AND PHYSICAL INFORMATION

4.1 CHEMICAL IDENTITY

Copper is a transition metal and Group 11 essential element on the periodic table, atomic number 29, that can occur naturally in elemental form. Copper displays four oxidation states: Cu(0), Cu(I), Cu(II), and Cu(III). Its industrial uses include electrical products and equipment, wiring, piping, sheet metal, building material, machinery, and motors. Copper is essential to human health and is found in many foods. Copper sulfate ($CuSO_4$) is an inorganic compound that can occur in nature. It is the most common compound used in commercial applications. It is the most widely used copper salt and is an ingredient in pesticide formulations. Copper chloride is another important copper salt. It is used as a catalyst in chemical reactions and in dyeing, printing, and fungicides (Budavari et al. 1996). Copper nanoparticles are formed through natural processes or can be manmade. They are primarily used as antimicrobial, antibacterial and antifungal agents. A summary of copper nanoparticle toxicity is in Section 2.21. Table 4-1 lists common synonyms, trade names, and other pertinent identification information for copper, copper sulfate, and copper chloride.

Table 4-1. Chemical Identity of Copper, Copper Sulfate and Copper Chloride

Characteristic	Copper	Copper Sulfate	Copper Chloride
Chemical Name	Copper	Copper Sulfate	Copper Chloride
Synonym(s) and Registered trade name(s)	M1; M2; M3; M4; Cuprum; Gold Bronze; 1721 Gold; Bronze powder; Cobre; Cuivre; Rame; Allbri Natural Copper; M3R; M3S; E 115; OFHC CU	Cupric Sulfate; Copper (II) sulfate; cupric sulfate anhydrous; copper sulphate; Blue stone; copper monosulfate; Hylinec; Trinagle; Delcup, cupric sulphate; sulfuric acid copper (2+) salt (1:1); monocopper sulfate	copper(II) chloride; cupric chloride; cupric chloride anhydrous; cupric chloride dihydrate
Chemical formula	Cu	$CuSO_4$	$CuCl_2$
Chemical structure	Cu		
CAS registry number	7440-50-8	7758-98-7	7447-39-4

Source: PubChem 2020

4.2 PHYSICAL AND CHEMICAL PROPERTIES

Copper is a metallic solid that is malleable and has high thermal conductivity, high electrical conductivity, low corrosivity, and alloying ability. Its malleability is attributed to its relatively low number of electrons on its outer shell. The properties of copper typically vary with purity. Metallic copper is naturally a reddish color, and when exposed to oxygen in the air, it forms copper oxide which is black (Haynes 2015). As copper reacts with carbon dioxide in the air, copper carbonates, which are usually green, form. Copper is positioned below hydrogen in the electromotive-force series (lower reactivity); therefore, it will not displace hydrogen ions in water, and thus has no single displacement interaction with water. It is soluble in dilute acid and in ammonia with the presence of an oxidizing agent. Copper will undergo galvanic corrosion when in contact with other metals. Copper sulfate is typically produced by treating hot copper with sulfuric acid. The resulting material is a white-green solid when anhydrous and blue crystals when hydrated ($CuSO_4.5H_2O$), and it readily absorbs water (Haynes 2015). Copper chloride is produced by reaction of metallic copper with chlorine. It is a yellow-brown powder in the anhydrous form**.** Table 4-2 lists important physical and chemical properties of copper, copper sulfate, and copper chloride.

Table 4-2. Physical and Chemical Properties of Metallic Copper, Copper Sulfate, and Copper Chloride

Property	Copper	Copper (II) Sulfate	Copper (II) Chloride
Molecular weight	63.55 g/mol	159.61 g/mol	134.45 g/mol
Color	Reddish, lustrous	White, off-white when dehydrated; blue crystals when hydrated	Yellow to brown
Physical state	Solid	Solid	Solid
Melting point	1083°C (1981°F)	590°C	630°C
Boiling point	2595°C (4703°F)	650°C	993°C
Density: At 20°C/4°C	8.94	3.6	3.39
Odor	Odorless	Pleasant Odor	Odorless
Odor threshold: Water Air	 No data No data	 No data No data	 No data No data
Taste threshold	No data	No data	No data
Solubility: Water Organic solvent(s)	 Insoluble Slightly soluble in dilute acid and ammonia water	 Soluble Soluble in methanol Insoluble in ethanol	 Soluble in acetone, ethanol
Partition coefficients:			

Table 4-2. Physical and Chemical Properties of Metallic Copper, Copper Sulfate, and Copper Chloride

Property	Copper	Copper (II) Sulfate	Copper (II) Chloride
Log K_{OW} Log K_{OC}	No data No data	No data No data	No data No data
Vapor pressure At 20°C	1 mm Hg at 1628°C	No data	No data
Henry's law constant	No data	No data	No data
Autoignition temperature	No data	No data	No data
Flashpoint	No data	No data	No data
Flammability limits	No data	No data	No data
Conversion factors	Since these substances exist in the atmosphere in the particulate state, the concentration is expressed as mg/m^3.		
Explosive limits	No data	No data	No data

Source: Haynes 2015; PubChem 2020