

Calcium



Calcium has numerous dietary sources. USDA

Calcium is the chemical element with atomic number 20; it has an atomic mass of 40.078 atomic mass units (amu). The chemical symbol for calcium is Ca. Calcium is a soft gray alkaline earth metal, and is the fifth most abundant element by mass in the Earth's crust; moreover, it is the fifth most abundant dissolved ion in seawater both in terms of number of atoms and mass, after sodium, chloride, magnesium, and sulfate.[1]

Calcium is an essential nutrient for almost all living organisms, with vital roles in cellular metabolism, especially with regard to movement of the calcium ion Ca^{++} into and out of the cytoplasm functions as a signal for many cellular processes. As a chief component needed in mineralization of bones and shells, calcium is the most abundant metal by mass in a large number of faunal species, especially vertebrates, testudines and mollusca.

Previous Element: <u>Potassium</u>	20
Next Element: <u>Scandium</u>	Ca 40.08
Physical Properties	
Color	Silvery-white

Phase at Room Temp.	solid
Density (g/cm ³)	1.55
Hardness (Mohs)	1.5
Melting Point (<u>K</u>)	1112.2
Boiling Point (<u>K</u>)	1767
Heat of Fusion (kJ/mol)	9.3
Heat of Vaporization (kJ/mol)	151
Heat of Atomization (kJ/mol)	178
Thermal Conductivity (J/m sec K)	201
Electrical Conductivity (1/mohm cm)	255.754
Source	Calcite (oxide)
Atomic Properties	
Electron Configuration	[Ar]4s ²
Number of <u>Isotopes</u>	22 (6 natural)
Electron Affinity (kJ/mol)	---
First Ionization Energy (kJ/mol)	589.8
Second Ionization Energy (kJ/mol)	1145.4
Third Ionization Energy (kJ/mol)	4911.8
Electronegativity	1
Polarizability (Å ³)	22.8
Atomic Weight	40.08
Atomic Volume (cm ³ /mol)	25.9
Ionic Radius ²⁻ (pm)	---
Ionic Radius ¹⁻ (pm)	---

Atomic Radius (pm)	197
Ionic Radius ¹⁺ (pm)	---
Ionic Radius ²⁺ (pm)	114
Ionic Radius ³⁺ (pm)	---
Common Oxidation Numbers	+2
Other Oxid. Numbers	---
Abundance	
In Earth's Crust (mg/kg)	4.15×10 ⁴
In Earth's Ocean (mg/L)	4.12×10 ²
In Human Body (%)	1.43%
Regulatory / Health	
CAS Number	7440-70-2
OSHA Permissible Exposure Limit (PEL)	No limits
OSHA PEL Vacated 1989	No limits
NIOSH Recommended Exposure Limit (REL)	No limits
Sources: <u>Mineral Information Institute</u> <u>Jefferson Accelerator</u> <u>Laboratory</u> <u>EnvironmentalChemistry.com</u>	

Natural occurrence



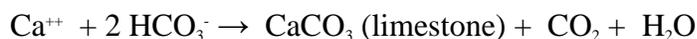
Karst limestone formation at the edge of the Anjajavy Forest along the Indian Ocean, Madagascar. Source: C.Michael Hogan

Elemental calcium is not found in the natural environment on Earth. As a solid calcium occurs chiefly in sedimentary rock, especially in limestone and in the specific minerals calcite, dolomite and gypsum. Some of the most dramatic occurrences are in limestones, where stalactites and stalagmites are formed in underground caverns under favorable conditions of pH, temperature and ionic concentration of calcium. Calcium is additionally found in certain igneous and metamorphic rocks: principally in the silicates:^[2] plagioclase, amphiboles, pyroxenes, garnet and some serpentine rocks.

Biogeochemical cycles

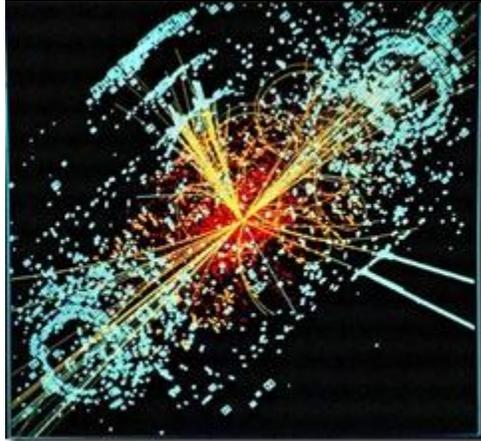
Calcium is a key link between tectonics, climate and the carbon cycle. Since mountain block uplift exposes calcium bearing strata to chemical weathering, significant release occurs of Ca^{++} into surface waters. Much of this dissolved calcium ultimately is transported to the oceans, where it reacts with dissolved carbon dioxide to produce limestone. Certain quantities of this limestone precipitates to the sea floor where it is incorporated into new rock strata. Dissolved carbon dioxide, together with carbonate and bicarbonate ions, are termed dissolved inorganic carbon.

The actual reaction is more complex, involving bicarbonate ion (HCO_3^-), which is produced when carbon dioxide ionizes in pH levels found in oceans.



Note that at pH levels of the oceans, most of the CO_2 produced in this reaction is immediately converted back into HCO_3^- . The reaction thus results in a net transport of carbon dioxide from the ocean or atmosphere into the lithosphere.^[3] This cycling is a significant sink for carbon dioxide, and provides an important negative feedback loop for carbon dioxide additions to the atmosphere, and thus a key mitigation measure to potential global warming.

Isotopes



Creation of the newest element ununseptium by collision of ^{48}Ca and ^{249}Bk .

There are four stable calcium isotopes (^{40}Ca , ^{42}Ca , ^{43}Ca , ^{44}Ca); in addition, ^{46}Ca and ^{48}Ca are radioactive, but possess extremely long half-lives. Furthermore radioactive ^{41}Ca also is produced in the uppermost meter of the Earth crust by neutron activation of ^{40}Ca ; moreover, ^{41}Ca has the long half-life of 103,000 years. ^{41}Ca is received much attention in stellar studies because it decays to ^{41}K , a critical indicator of solar-system anomalies.

Ninety seven percent of naturally occurring calcium is in the form of ^{40}Ca , which is one of the daughter products of ^{40}K decay, along with the daughter ^{40}Ar . While potassium-argon dating has been widely employed extensively in the earth sciences field, the utility of this dating technique is limited due to the minute quantities of argon gas that are required to be measured; in practical terms the technique is useful where long geological time scales are involved (e.g. the order of 100,000 years);^[5] moreover, as measurement techniques steadily improve, the utility is rising.

Notable properties

Calcium possesses the lightest density of all the alkali earth metals. It is chemically reactive and is so soft that it can be cut with a knife, although it is somewhat harder than lead. As a metal it is silvery in appearance; to produce the metallic form, one usually utilizes electrolysis upon a fused salt like calcium chloride. When exposed to the air in its metallic form, a coating is quickly formed as a whitish gray oxide and nitride coating. Unlike magnesium, it is difficult to ignite; however, upon combustion it manifests a brilliant brick-red high intensity luminescence. As a metal,

calcium reacts with water, rapidly producing hydrogen gas, but exuding little heat. If the metal has been powdered, the reaction with water is more robust, due to the considerably greater surface area.



Bright red flame of calcium being combusted

Calcium has a higher electrical resistivity than copper or aluminium. Calcium actually has an electrical conductivity about forty percent that of copper; however, its conductivity under normal atmospheric conditions is usually limited by its chemical reactivity with air.

Ionic solutions of calcium salts are generally colorless. Many calcium salts are not soluble in water. When in solution, the calcium ion to the human taste varies with its anion, being reported variously as moderately salty, sour or mineral like. It has been demonstrated that many fauna can taste calcium, and use this sense to detect the mineral in salt licks.^[6]

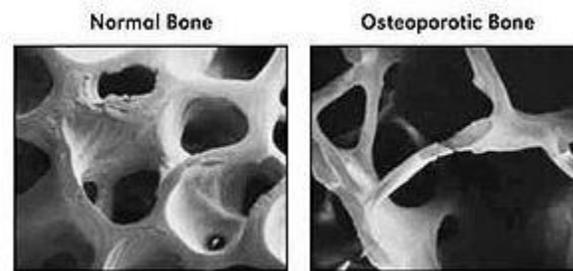
Example compounds

Calcium phosphate leads to the formation of calcium hydroxylapatite, the mineral portion of human and animal bones and dentin.^[7] The mineral portion of some corals can also be transformed into hydroxylapatite.

Calcium hydroxide (slaked lime), employed in numerous chemical refinery processes, is produced from applying heat to limestone at temperatures above 825 °C, following by hydration. When lime is mixed with sand, it hardens into a mortar and is converted into plaster after carbon dioxide uptake. Mixed with other compounds, lime forms an component of Portland cement. Calcium carbonate, one of the common compounds of calcium, can be heated to form quicklime (CaO). After hydration, quicklime is converted to slaked lime (Ca(OH)₂), which is a cheap commodity utilized widely in the chemical manufacturing industry.^[8] Chalk and marble are other alternative forms of calcium carbonate.

Other notable calcium compounds are calcium sulfate, calcium chloride, calcium sulfide, calcium carbide and calcium hypochlorite.

Faunal metabolism



Normal vs. osteoporotic bone viewed by electron micrograph. Only with extreme magnification can one see the massive damage from calcium deficiency. Source: U.S. CDC

Calcium is the most abundant mineral not only in the human body but for many other faunal species. A human adult body has about one kilogram of calcium, 99 percent of which is stored in bones as calcium phosphate. Human extracellular fluid holds around 22.5 mmol, almost half of which is within blood plasma. About 500 mmol of calcium is exchanged between bone and the extracellular fluid within a complete daily cycle.^[9] Hypocalcaemia in humans is the condition of deficient calcium concentration in blood plasma; this deficit circumstance is one in which less than 90 milligrams/liter or ionized calcium concentration less than 45 milligrams/liter). This condition is an electrolyte imbalance that can lead to osteoporosis;^[10] it is important to note that it is the ionized calcium which is key to metabolic regulation. Conversely, elevated blood calcium levels, known as hypercalcaemia, can lead to adverse health effects including heart arrhythmia, depression and peptic ulcers.

Hypocalcaemia is also studied in depth for dairy cows, other domestic animals and fauna in the wild. In the case of dairy cows the condition is linked to inferior milk production and other disease issues.^[11]

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