Calcium

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Calcium is a chemical element with symbol **Ca** and atomic number 20. Calcium is a soft gray Group 2 alkaline earth metal, fifth-most-abundant element by mass in the Earth's crust. The ion Ca^{2+} is also the fifth-most-abundant dissolved ion in seawater by both molarity and mass, after sodium, chloride, magnesium, and sulfate.[4] Free calcium metal is too reactive to occur in nature. Calcium is produced in supernova nucleosynthesis.

Calcium is essential for living organisms, particularly in cell physiology where movement of the calcium ion into and out of the cytoplasm functions as a signal for many cellular processes. As a major material used in mineralization of bone, teeth and shells, calcium is the most abundant metal by mass in many animals.

Calcium, $_{20}$Ca

Spectral lines of calcium

General properties	
Name, symbol	calcium, Ca
Appearance	dull gray, silver; with a pale yellow tint[1]
Calcium in the periodic table	
Atomic number (*Z*)	20
Group, block	group 2 (alkaline earth metals), s-block
Period	period 4
Element category	□ alkaline earth metal
Standard atomic weight (±) (A_r)	40.078(4)[2]
Electron configuration	[Ar] $4s^2$
per shell	2, 8, 8, 2
Physical properties	
Phase	solid

Notable characteristics

Calcium is reactive and relatively soft for a metal. Although harder than lead, it can be cut with a knife with difficulty. It is a silvery metallic element that can be extracted by electrolysis from a fused salt like calcium chloride.[52] When exposed to the air, it rapidly forms a gray-white coating of calcium oxide and calcium nitride. In bulk form (typically as chips or "turnings"), the metal is somewhat difficult to ignite, more difficult even than magnesium chips; but, when lit, the metal burns in air with a brilliant high-intensity orange-red light. Calcium metal reacts with water, producing hydrogen gas at a moderate rate without generating much heat, making it useful for generating hydrogen.[53] In powdered form, however, the reaction with water is extremely rapid, as the increased surface area of the powder accelerates the reaction. Part of the reason for the slowness of the calcium–water reaction is a partial passivation (chemically protective coating) of insoluble white calcium hydroxide; in acidic solutions, where this compound is more soluble, calcium reacts vigorously.

Flame test. Brick-red color originates from calcium.

With a density of 1.54 g/cm^3,[54] calcium is the lightest of the alkaline earth metals; magnesium (specific gravity 1.74) and beryllium (1.84) are denser though lighter in atomic mass. From strontium onward, the alkali earth metals become denser with increasing atomic mass. Calcium has two allotropes.[55]

Calcium metal has a higher electrical resistivity than copper or aluminium, yet weight-for-weight, due to its much lower density, it is a better conductor than either. Its use as such in terrestrial applications is usually limited by its high reactivity with air; however, it has potential for use as wiring in off-world applications.[56]

Calcium is the fifth-most-abundant element by mass in the human body, where it is an important cellular ionic messenger with many functions. Calcium also serves as a structural element in bone. It is the relatively high atomic number of calcium that causes bone to be radio-opaque. Of the human body's solid components after drying and burning of organics (as for example, after cremation), about a third of the total "mineral" mass remaining is the approximately one kilogram of calcium that composes the average skeleton (the remainder being mostly phosphorus and oxygen).

H and K lines

Visible spectra of many stars, including the Sun, exhibit strong emission lines of singly ionized calcium. Prominent among these are the H-line at 3968.5 Å and the K line at 3933.7 Å of singly ionized calcium, or Ca II. In the Sun or other stars with low temperatures, the prominence of the H and K lines in the

Melting point	1115 K (842 °C, 1548 °F)
Boiling point	1757 K (1484 °C, 2703 °F)
Density near r.t.	1.55 g/cm^3
when liquid, at m.p.	1.378 g/cm^3
Heat of fusion	8.54 kJ/mol
Heat of vaporization	154.7 kJ/mol
Molar heat capacity	25.929 J/(mol·K)

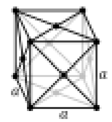
Vapor pressure

P (Pa)	**1**	**10**	**100**	**1 k**	**10 k**	**100 k**
at T (K)	864	956	1071	1227	1443	1755

Atomic properties

Oxidation states	**+2**, +1[3] (a strongly basic oxide)
Electronegativity	Pauling scale: 1.00
Ionization energies	1st: 589.8 kJ/mol 2nd: 1145.4 kJ/mol 3rd: 4912.4 kJ/mol (more)
Atomic radius	empirical: 197 pm
Covalent radius	176±10 pm
Van der Waals radius	231 pm

Miscellanea

Crystal structure	face-centered cubic (fcc) 
Speed of sound thin rod	3810 m/s (at 20 °C)
Thermal	22.3 µm/(m·K) (at 25 °C)

visible spectra can be an indication of strong magnetic activity in the chromosphere. Periodic variations of these active regions can indicate the rotation periods of these stars.[57]

Isotopes

Calcium has five stable isotopes (^{40}Ca, ^{42}Ca, ^{43}Ca, ^{44}Ca and ^{46}Ca), plus one more (^{48}Ca) that has such a long half-life, it can also be considered stable for all practical purposes. The 20% range in relative mass among naturally occurring calcium isotopes is greater than for any element other than hydrogen and helium. Calcium also has a cosmogenic isotope, radioactive ^{41}Ca, which has a half-life of 103,000 years. Unlike cosmogenic isotopes produced in the atmosphere, ^{41}Ca is produced by neutron activation of ^{40}Ca, primarily in the top metre of the soil column, where the cosmogenic neutron flux is still sufficiently strong. ^{41}Ca has 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, one of the daughter products of ^{40}K decay, along with ^{40}Ar. While K–Ar dating has been used extensively in the geological sciences, the prevalence of ^{40}Ca in nature has impeded its use in dating. Techniques using mass spectrometry and a double spike isotope dilution have been used for K-Ca age dating.

^{40}Ca has a nucleus of 20 protons and 20 neutrons and is the heaviest stable isotope of any element that has equal numbers of protons and neutrons. In supernova explosions, calcium is formed from the reaction of carbon with various numbers of alpha particles (helium nuclei), until the most common calcium isotope (containing 10 helium nuclei) has been synthesized.

Isotope fractionation

As with the isotopes of other elements, a variety of processes fractionate, or alter the relative abundance of, calcium isotopes.[61] The best studied of these processes is the mass-dependent fractionation of calcium isotopes that

expansion	
Thermal conductivity	201 W/(m·K)
Electrical resistivity	33.6 nΩ·m (at 20 °C)
Magnetic ordering	diamagnetic
Young's modulus	20 GPa
Shear modulus	7.4 GPa
Bulk modulus	17 GPa
Poisson ratio	0.31
Mohs hardness	1.75
Brinell hardness	170–416 MPa
CAS Number	7440-70-2
History	
Discovery and first isolation	Humphry Davy (1808)

Most stable isotopes of calcium

iso	NA	half-life	DM	DE (MeV)	DP
^{40}**Ca**	96.941%	is stable with 20 neutrons			
^{41}**Ca**	trace	1.03×10^5 y	ε	–	^{41}K
^{42}**Ca**	0.647%	is stable with 22 neutrons			
^{43}**Ca**	0.135%	is stable with 23 neutrons			
^{44}**Ca**	2.086%	is stable with 24 neutrons			
^{45}**Ca**	syn	162.7 d	β^-	0.258	^{45}Sc
^{46}**Ca**	0.004%	is stable with 26 neutrons			
^{47}**Ca**	syn	4.536 d	β^-	0.694, 1.99	^{47}Sc
			γ	1.297	–
^{48}**Ca**	0.187%	4.3×10^{19} y	$\beta^-\beta^-$	4.274	^{48}Ti

accompanies the precipitation of calcium minerals, such as calcite, aragonite and apatite, from solution. Isotopically light calcium is preferentially incorporated into minerals, leaving the solution from which the mineral precipitated enriched in isotopically heavy calcium. At room temperature the magnitude of this fractionation is roughly 0.25‰ (0.025%) per atomic mass unit (AMU). Mass-dependent differences in calcium isotope composition conventionally are expressed by the ratio of two isotopes (usually $^{44}Ca/^{40}Ca$) in a sample compared to the same ratio in a standard reference material. $^{44}Ca/^{40}Ca$ varies by about 1% among common earth materials.[62]

Calcium isotope fractionation during mineral formation has led to several applications of calcium isotopes. In particular, the 1997 observation by Skulan and DePaolo[63] that calcium minerals are isotopically lighter than the solutions from which the minerals precipitate is the basis of analogous applications in medicine and in paleooceanography. In animals with skeletons mineralized with calcium, the calcium isotopic composition of soft tissues reflects the relative rate of formation and dissolution of skeletal mineral. In humans, changes in the calcium isotopic composition of urine have been shown to be related to changes in bone mineral balance. When the rate of bone formation exceeds the rate of bone resorption, the ration $^{44}Ca/^{40}Ca$ in soft tissue rises. Soft tissue $^{44}Ca/^{40}Ca$ falls when bone resorption exceeds bone formation. Because of this relationship, calcium isotopic measurements of urine or blood may be useful in the early detection of metabolic bone diseases like osteoporosis.[64]

A similar system exists in the ocean, where $^{44}Ca/^{40}Ca$ in seawater tends to rise when the rate of removal of Ca^{2+} from seawater by mineral precipitation exceeds the input of new calcium into the ocean, and fall when calcium input exceeds mineral precipitation. It follows that rising $^{44}Ca/^{40}Ca$ corresponds to falling seawater Ca^{2+} concentration, and falling $^{44}Ca/^{40}Ca$ corresponds to rising seawater Ca^{2+} concentration. In 1997 Skulan and DePaolo presented the first evidence of change in seawater $^{44}Ca/^{40}Ca$ over geologic time, along with a theoretical explanation of these changes. More recent papers have confirmed this observation, demonstrating that seawater Ca^{2+} concentration is not constant, and that the ocean probably never is in “steady state” with respect to its calcium input and output.[65][66] This has important climatological implications, as the marine calcium cycle is closely tied to the carbon cycle (see below).

External links

- Wikipedia: Calcium (https://en.wikipedia.org/wiki/Calcium)