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**Calcium**

From Wikipedia, the free encyclopedia

[Jump to navigation](https://en.wikipedia.org/wiki/Calcium#mw-head) [Jump to search](https://en.wikipedia.org/wiki/Calcium#p-search)

This article is about the metallic element. For other uses, see [Calcium (disambiguation)](https://en.wikipedia.org/wiki/Calcium_(disambiguation)).

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| --- | --- |
| Calcium,  20Ca | |
| [Calcium unter Argon Schutzgasatmosphäre.jpg](https://en.wikipedia.org/wiki/File:Calcium_unter_Argon_Schutzgasatmosph%C3%A4re.jpg) | |
| **General properties** | |
| **Appearance** | dull gray, silver; with a pale yellow tint[[1]](https://en.wikipedia.org/wiki/Calcium#cite_note-1) |
| [**Standard atomic weight**](https://en.wikipedia.org/wiki/Standard_atomic_weight) **(*A*r, standard)** | 40.078(4)[[2]](https://en.wikipedia.org/wiki/Calcium#cite_note-CIAAW2016-2) |
| **Calcium in the** [**periodic table**](https://en.wikipedia.org/wiki/Periodic_table) | |
| |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 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[Neon](https://en.wikipedia.org/wiki/Neon) | | [Sodium](https://en.wikipedia.org/wiki/Sodium) | [Magnesium](https://en.wikipedia.org/wiki/Magnesium) |  | | | | | | | | | | | | | | | | | | | | | | | | [Aluminium](https://en.wikipedia.org/wiki/Aluminium) | [Silicon](https://en.wikipedia.org/wiki/Silicon) | [Phosphorus](https://en.wikipedia.org/wiki/Phosphorus) | [Sulfur](https://en.wikipedia.org/wiki/Sulfur) | [Chlorine](https://en.wikipedia.org/wiki/Chlorine) | [Argon](https://en.wikipedia.org/wiki/Argon) | | [Potassium](https://en.wikipedia.org/wiki/Potassium) | Calcium | [Scandium](https://en.wikipedia.org/wiki/Scandium) |  | | | | | | | | | | | | | | [Titanium](https://en.wikipedia.org/wiki/Titanium) | [Vanadium](https://en.wikipedia.org/wiki/Vanadium) | [Chromium](https://en.wikipedia.org/wiki/Chromium) | [Manganese](https://en.wikipedia.org/wiki/Manganese) | [Iron](https://en.wikipedia.org/wiki/Iron) | [Cobalt](https://en.wikipedia.org/wiki/Cobalt) | [Nickel](https://en.wikipedia.org/wiki/Nickel) | [Copper](https://en.wikipedia.org/wiki/Copper) | [Zinc](https://en.wikipedia.org/wiki/Zinc) | [Gallium](https://en.wikipedia.org/wiki/Gallium) | [Germanium](https://en.wikipedia.org/wiki/Germanium) | [Arsenic](https://en.wikipedia.org/wiki/Arsenic) | [Selenium](https://en.wikipedia.org/wiki/Selenium) | [Bromine](https://en.wikipedia.org/wiki/Bromine) | [Krypton](https://en.wikipedia.org/wiki/Krypton) | | [Rubidium](https://en.wikipedia.org/wiki/Rubidium) | [Strontium](https://en.wikipedia.org/wiki/Strontium) | [Yttrium](https://en.wikipedia.org/wiki/Yttrium) |  |  | | | | | | | | | | | | | [Zirconium](https://en.wikipedia.org/wiki/Zirconium) | [Niobium](https://en.wikipedia.org/wiki/Niobium) | [Molybdenum](https://en.wikipedia.org/wiki/Molybdenum) | [Technetium](https://en.wikipedia.org/wiki/Technetium) | [Ruthenium](https://en.wikipedia.org/wiki/Ruthenium) | [Rhodium](https://en.wikipedia.org/wiki/Rhodium) | [Palladium](https://en.wikipedia.org/wiki/Palladium) | [Silver](https://en.wikipedia.org/wiki/Silver) | [Cadmium](https://en.wikipedia.org/wiki/Cadmium) | [Indium](https://en.wikipedia.org/wiki/Indium) | [Tin](https://en.wikipedia.org/wiki/Tin) | [Antimony](https://en.wikipedia.org/wiki/Antimony) | [Tellurium](https://en.wikipedia.org/wiki/Tellurium) | [Iodine](https://en.wikipedia.org/wiki/Iodine) | [Xenon](https://en.wikipedia.org/wiki/Xenon) | | [Caesium](https://en.wikipedia.org/wiki/Caesium) | [Barium](https://en.wikipedia.org/wiki/Barium) | [Lanthanum](https://en.wikipedia.org/wiki/Lanthanum) | [Cerium](https://en.wikipedia.org/wiki/Cerium) | [Praseodymium](https://en.wikipedia.org/wiki/Praseodymium) | [Neodymium](https://en.wikipedia.org/wiki/Neodymium) | [Promethium](https://en.wikipedia.org/wiki/Promethium) | [Samarium](https://en.wikipedia.org/wiki/Samarium) | [Europium](https://en.wikipedia.org/wiki/Europium) | [Gadolinium](https://en.wikipedia.org/wiki/Gadolinium) | [Terbium](https://en.wikipedia.org/wiki/Terbium) | [Dysprosium](https://en.wikipedia.org/wiki/Dysprosium) | [Holmium](https://en.wikipedia.org/wiki/Holmium) | [Erbium](https://en.wikipedia.org/wiki/Erbium) | [Thulium](https://en.wikipedia.org/wiki/Thulium) | [Ytterbium](https://en.wikipedia.org/wiki/Ytterbium) | [Lutetium](https://en.wikipedia.org/wiki/Lutetium) | [Hafnium](https://en.wikipedia.org/wiki/Hafnium) | [Tantalum](https://en.wikipedia.org/wiki/Tantalum) | [Tungsten](https://en.wikipedia.org/wiki/Tungsten) | [Rhenium](https://en.wikipedia.org/wiki/Rhenium) | [Osmium](https://en.wikipedia.org/wiki/Osmium) | [Iridium](https://en.wikipedia.org/wiki/Iridium) | [Platinum](https://en.wikipedia.org/wiki/Platinum) | [Gold](https://en.wikipedia.org/wiki/Gold) | [Mercury (element)](https://en.wikipedia.org/wiki/Mercury_(element)) | [Thallium](https://en.wikipedia.org/wiki/Thallium) | [Lead](https://en.wikipedia.org/wiki/Lead) | [Bismuth](https://en.wikipedia.org/wiki/Bismuth) | [Polonium](https://en.wikipedia.org/wiki/Polonium) | [Astatine](https://en.wikipedia.org/wiki/Astatine) | [Radon](https://en.wikipedia.org/wiki/Radon) | | [Francium](https://en.wikipedia.org/wiki/Francium) | [Radium](https://en.wikipedia.org/wiki/Radium) | [Actinium](https://en.wikipedia.org/wiki/Actinium) | [Thorium](https://en.wikipedia.org/wiki/Thorium) | [Protactinium](https://en.wikipedia.org/wiki/Protactinium) | [Uranium](https://en.wikipedia.org/wiki/Uranium) | [Neptunium](https://en.wikipedia.org/wiki/Neptunium) | [Plutonium](https://en.wikipedia.org/wiki/Plutonium) | [Americium](https://en.wikipedia.org/wiki/Americium) | [Curium](https://en.wikipedia.org/wiki/Curium) | [Berkelium](https://en.wikipedia.org/wiki/Berkelium) | [Californium](https://en.wikipedia.org/wiki/Californium) | [Einsteinium](https://en.wikipedia.org/wiki/Einsteinium) | [Fermium](https://en.wikipedia.org/wiki/Fermium) | [Mendelevium](https://en.wikipedia.org/wiki/Mendelevium) | [Nobelium](https://en.wikipedia.org/wiki/Nobelium) | [Lawrencium](https://en.wikipedia.org/wiki/Lawrencium) | [Rutherfordium](https://en.wikipedia.org/wiki/Rutherfordium) | [Dubnium](https://en.wikipedia.org/wiki/Dubnium) | [Seaborgium](https://en.wikipedia.org/wiki/Seaborgium) | [Bohrium](https://en.wikipedia.org/wiki/Bohrium) | [Hassium](https://en.wikipedia.org/wiki/Hassium) | [Meitnerium](https://en.wikipedia.org/wiki/Meitnerium) | [Darmstadtium](https://en.wikipedia.org/wiki/Darmstadtium) | [Roentgenium](https://en.wikipedia.org/wiki/Roentgenium) | [Copernicium](https://en.wikipedia.org/wiki/Copernicium) | [Nihonium](https://en.wikipedia.org/wiki/Nihonium) | [Flerovium](https://en.wikipedia.org/wiki/Flerovium) | [Moscovium](https://en.wikipedia.org/wiki/Moscovium) | [Livermorium](https://en.wikipedia.org/wiki/Livermorium) | [Tennessine](https://en.wikipedia.org/wiki/Tennessine) | [Oganesson](https://en.wikipedia.org/wiki/Oganesson) | | [Mg](https://en.wikipedia.org/wiki/Magnesium) ↑ **Ca** ↓ [Sr](https://en.wikipedia.org/wiki/Strontium) | | [potassium](https://en.wikipedia.org/wiki/Potassium) ← **calcium** → [scandium](https://en.wikipedia.org/wiki/Scandium) | | | | |
| [**Atomic number**](https://en.wikipedia.org/wiki/Atomic_number)(*Z*) | 20 |
| [**Group**](https://en.wikipedia.org/wiki/Group_(periodic_table)) | [group 2 (alkaline earth metals)](https://en.wikipedia.org/wiki/Alkaline_earth_metal) |
| [**Period**](https://en.wikipedia.org/wiki/Period_(periodic_table)) | [period 4](https://en.wikipedia.org/wiki/Period_(periodic_table)#Period_4) |
| [**Block**](https://en.wikipedia.org/wiki/Block_(periodic_table)) | [s-block](https://en.wikipedia.org/wiki/S-block) |
| [**Element category**](https://en.wikipedia.org/wiki/Names_for_sets_of_chemical_elements#Category) | [alkaline earth metal](https://en.wikipedia.org/wiki/Alkaline_earth_metal) |
| [**Electron configuration**](https://en.wikipedia.org/wiki/Electron_configuration) | [[Ar](https://en.wikipedia.org/wiki/Argon)] 4s2 |
| Electrons per shell | 2, 8, 8, 2 |
| **Physical properties** | |
| [**Phase**](https://en.wikipedia.org/wiki/Phase_(matter)) **at**[**STP**](https://en.wikipedia.org/wiki/Standard_conditions_for_temperature_and_pressure) | [solid](https://en.wikipedia.org/wiki/Solid) |
| [**Melting point**](https://en.wikipedia.org/wiki/Melting_point) | 1115 [K](https://en.wikipedia.org/wiki/Kelvin) ​(842 °C, ​1548 °F) |
| [**Boiling point**](https://en.wikipedia.org/wiki/Boiling_point) | 1757 K ​(1484 °C, ​2703 °F) |
| [**Density**](https://en.wikipedia.org/wiki/Density)(near r.t.) | 1.55 g/cm3 |
| when liquid (at m.p.) | 1.378 g/cm3 |
| [**Heat of fusion**](https://en.wikipedia.org/wiki/Enthalpy_of_fusion) | 8.54 [kJ/mol](https://en.wikipedia.org/wiki/Kilojoule_per_mole) |
| [**Heat of vaporisation**](https://en.wikipedia.org/wiki/Enthalpy_of_vaporization) | 154.7 kJ/mol |
| [**Molar heat capacity**](https://en.wikipedia.org/wiki/Molar_heat_capacity) | 25.929 J/(mol·K) |
| [**Vapour pressure**](https://en.wikipedia.org/wiki/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**](https://en.wikipedia.org/wiki/Oxidation_state) | +1,[[3]](https://en.wikipedia.org/wiki/Calcium#cite_note-West-3) **+2** (a strongly [basic](https://en.wikipedia.org/wiki/Base_(chemistry)) oxide) |
| [**Electronegativity**](https://en.wikipedia.org/wiki/Electronegativity) | Pauling scale: 1.00 |
| [**Ionisation energies**](https://en.wikipedia.org/wiki/Ionization_energy) | * 1st: 589.8 kJ/mol * 2nd: 1145.4 kJ/mol * 3rd: 4912.4 kJ/mol * ([more](https://en.wikipedia.org/wiki/Molar_ionization_energies_of_the_elements#calcium)) |
| [**Atomic radius**](https://en.wikipedia.org/wiki/Atomic_radius) | empirical: 197 [pm](https://en.wikipedia.org/wiki/Picometre) |
| [**Covalent radius**](https://en.wikipedia.org/wiki/Covalent_radius) | 176±10 pm |
| [**Van der Waals radius**](https://en.wikipedia.org/wiki/Van_der_Waals_radius) | 231 pm |
| [Color lines in a spectral range](https://en.wikipedia.org/wiki/File:Calcium_spectrum_visible.png)  [**Spectral lines**](https://en.wikipedia.org/wiki/Spectral_line) **of calcium** | |
| **Other properties** | |
| [**Crystal structure**](https://en.wikipedia.org/wiki/Crystal_structure) | ​[face-centred cubic](https://en.wikipedia.org/wiki/Cubic_crystal_system) (fcc)  [Face-centered cubic crystal structure for calcium](https://en.wikipedia.org/wiki/File:Cubic-face-centered.svg) |
| [**Speed of sound**](https://en.wikipedia.org/wiki/Speed_of_sound)thin rod | 3810 m/s (at 20 °C) |
| [**Thermal expansion**](https://en.wikipedia.org/wiki/Coefficient_of_thermal_expansion) | 22.3 µm/(m·K) (at 25 °C) |
| [**Thermal conductivity**](https://en.wikipedia.org/wiki/Thermal_conductivity) | 201 W/(m·K) |
| [**Electrical resistivity**](https://en.wikipedia.org/wiki/Electrical_resistivity_and_conductivity) | 33.6 nΩ·m (at 20 °C) |
| [**Magnetic ordering**](https://en.wikipedia.org/wiki/Magnetism) | [diamagnetic](https://en.wikipedia.org/wiki/Diamagnetism) |
| [**Magnetic susceptibility**](https://en.wikipedia.org/wiki/Magnetic_susceptibility) | +40.0·10−6 cm3/mol[[4]](https://en.wikipedia.org/wiki/Calcium#cite_note-4) |
| [**Young's modulus**](https://en.wikipedia.org/wiki/Young%27s_modulus) | 20 GPa |
| [**Shear modulus**](https://en.wikipedia.org/wiki/Shear_modulus) | 7.4 GPa |
| [**Bulk modulus**](https://en.wikipedia.org/wiki/Bulk_modulus) | 17 GPa |
| [**Poisson ratio**](https://en.wikipedia.org/wiki/Poisson%27s_ratio) | 0.31 |
| [**Mohs hardness**](https://en.wikipedia.org/wiki/Mohs_scale_of_mineral_hardness) | 1.75 |
| [**Brinell hardness**](https://en.wikipedia.org/wiki/Brinell_hardness_test) | 170–416 MPa |
| [**CAS Number**](https://en.wikipedia.org/wiki/CAS_Registry_Number) | 7440-70-2 |
| **History** | |
| [**Discovery**](https://en.wikipedia.org/wiki/Timeline_of_chemical_element_discoveries) **and first isolation** | [Humphry Davy](https://en.wikipedia.org/wiki/Humphry_Davy) (1808) |
| **Main** [**isotopes of calcium**](https://en.wikipedia.org/wiki/Isotopes_of_calcium) | |
| |  |  |  |  |  | | --- | --- | --- | --- | --- | | [**Iso­tope**](https://en.wikipedia.org/wiki/Isotope) | [**Abun­dance**](https://en.wikipedia.org/wiki/Natural_abundance) | [**Half-life**](https://en.wikipedia.org/wiki/Half-life) **(*t*1/2)** | [**Decay mode**](https://en.wikipedia.org/wiki/Radioactive_decay) | [**Pro­duct**](https://en.wikipedia.org/wiki/Decay_product) | | **40Ca** | 96.941% | [stable](https://en.wikipedia.org/wiki/Stable_isotope) | | | | **41Ca** | [trace](https://en.wikipedia.org/wiki/Trace_radioisotope) | 1.03×105 y | [ε](https://en.wikipedia.org/wiki/Electron_capture) | [41K](https://en.wikipedia.org/wiki/Potassium-41) | | **42Ca** | 0.647% | stable | | | | **43Ca** | 0.135% | stable | | | | **44Ca** | 2.086% | stable | | | | **45Ca** | [syn](https://en.wikipedia.org/wiki/Synthetic_radioisotope) | 162.7 d | [β−](https://en.wikipedia.org/wiki/Beta_decay) | [45Sc](https://en.wikipedia.org/wiki/Scandium-45) | | **46Ca** | 0.004% | stable | | | | **47Ca** | syn | 4.5 d | β− | [47Sc](https://en.wikipedia.org/wiki/Scandium-47) | | [γ](https://en.wikipedia.org/wiki/Gamma_ray) | – | | [**48Ca**](https://en.wikipedia.org/wiki/Calcium-48) | 0.187% | 6.4×1019 y | [β−β−](https://en.wikipedia.org/wiki/Double_beta_decay) | [48Ti](https://en.wikipedia.org/wiki/Titanium-48) | | |
| * [view](https://en.wikipedia.org/wiki/Template:Infobox_calcium) * [talk](https://en.wikipedia.org/wiki/Template_talk:Infobox_calcium) * [edit](https://en.wikipedia.org/w/index.php?title=Template:Infobox_calcium&action=edit)   | [references](https://en.wikipedia.org/wiki/List_of_data_references_for_chemical_elements) | |

**Calcium** is a [chemical element](https://en.wikipedia.org/wiki/Chemical_element) with symbol **Ca** and [atomic number](https://en.wikipedia.org/wiki/Atomic_number) 20. As an [alkaline earth metal](https://en.wikipedia.org/wiki/Alkaline_earth_metal), calcium is a reactive metal that forms a dark oxide-nitride layer when exposed to air. Its physical and chemical properties are most similar to its heavier homologues [strontium](https://en.wikipedia.org/wiki/Strontium) and [barium](https://en.wikipedia.org/wiki/Barium). It is the fifth most abundant element in Earth's crust and the third most abundant metal, after [iron](https://en.wikipedia.org/wiki/Iron) and [aluminium](https://en.wikipedia.org/wiki/Aluminium). The most common calcium compound on Earth is [calcium carbonate](https://en.wikipedia.org/wiki/Calcium_carbonate), found in [limestone](https://en.wikipedia.org/wiki/Limestone) and the fossilised remnants of early sea life; [gypsum](https://en.wikipedia.org/wiki/Gypsum), [anhydrite](https://en.wikipedia.org/wiki/Anhydrite), [fluorite](https://en.wikipedia.org/wiki/Fluorite), and [apatite](https://en.wikipedia.org/wiki/Apatite) are also sources of calcium. The name derives from [Latin](https://en.wikipedia.org/wiki/Latin_language) *calx* "lime", which was obtained from heating limestone.

Some calcium compounds were known to the ancients, though their chemistry was unknown until the seventeenth century. Pure calcium was isolated in 1808 via [electrolysis](https://en.wikipedia.org/wiki/Electrolysis) of its oxide by [Humphry Davy](https://en.wikipedia.org/wiki/Humphry_Davy), who named the element. Calcium compounds are widely used in many industries: in foods and pharmaceuticals for calcium supplementation, in the paper industry as bleaches, as components in cement and electrical insulators, and in the manufacture of soaps. On the other hand, the metal in pure form has few applications due to its high reactivity; still, in small quantities it is often used as an alloying component in steelmaking, and sometimes, as a calcium–lead alloy, in making automotive batteries.

Calcium is the most abundant metal and the fifth-most abundant element in the [human body](https://en.wikipedia.org/wiki/Human_body#Composition). As [electrolytes](https://en.wikipedia.org/wiki/Electrolyte), calcium ions play a vital role in the [physiological](https://en.wikipedia.org/wiki/Physiology) and [biochemical](https://en.wikipedia.org/wiki/Biochemistry) processes of organisms and [cells](https://en.wikipedia.org/wiki/Cell_(biology)): in [signal transduction](https://en.wikipedia.org/wiki/Signal_transduction) pathways where they act as a [second messenger](https://en.wikipedia.org/wiki/Second_messenger); in [neurotransmitter](https://en.wikipedia.org/wiki/Neurotransmitter) release from [neurons](https://en.wikipedia.org/wiki/Neurons); in contraction of all [muscle](https://en.wikipedia.org/wiki/Muscle) cell types; as cofactors in many [enzymes](https://en.wikipedia.org/wiki/Enzyme); and in [fertilization](https://en.wikipedia.org/wiki/Fertilization). Calcium ions outside cells are important for maintaining the [potential difference](https://en.wikipedia.org/wiki/Potential_difference) across excitable [cell membranes](https://en.wikipedia.org/wiki/Cell_membrane) as well as proper bone formation.



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**Characteristics**

**Classification**

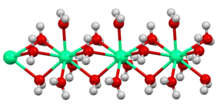
Calcium is a very ductile silvery metal (sometimes described as pale yellow) whose properties are very similar to the heavier elements in its group, [strontium](https://en.wikipedia.org/wiki/Strontium), [barium](https://en.wikipedia.org/wiki/Barium), and [radium](https://en.wikipedia.org/wiki/Radium). A calcium atom has twenty electrons, arranged in the [electron configuration](https://en.wikipedia.org/wiki/Electron_configuration) [Ar]4s2. Like the other elements placed in group 2 of the periodic table, calcium has two [valence electrons](https://en.wikipedia.org/wiki/Valence_electron) in the outermost s-orbital, which are very easily lost in chemical reactions to form a dipositive ion with the stable electron configuration of a [noble gas](https://en.wikipedia.org/wiki/Noble_gas), in this case [argon](https://en.wikipedia.org/wiki/Argon). Hence, calcium is almost always [divalent](https://en.wikipedia.org/wiki/Divalent) in its compounds, which are usually [ionic](https://en.wikipedia.org/wiki/Ionic_compound). Hypothetical univalent salts of calcium would be stable with respect to their elements, but not to [disproportionation](https://en.wikipedia.org/wiki/Disproportionation) to the divalent salts and calcium metal, because the [enthalpy of formation](https://en.wikipedia.org/wiki/Enthalpy_of_formation) of MX2 is much higher than those of the hypothetical MX. This occurs because of the much greater [lattice energy](https://en.wikipedia.org/wiki/Lattice_energy) afforded by the more highly charged Ca2+ cation compared to the hypothetical Ca+ cation.[[5]](https://en.wikipedia.org/wiki/Calcium#cite_note-Greenwood112-5)

Calcium, strontium, barium, and radium are always considered to be [alkaline earth metals](https://en.wikipedia.org/wiki/Alkaline_earth_metal); the lighter [beryllium](https://en.wikipedia.org/wiki/Beryllium) and [magnesium](https://en.wikipedia.org/wiki/Magnesium), also in group 2 of the periodic table, are often included as well. Nevertheless, beryllium and magnesium are significantly different from the other members of the group in their physical and chemical behaviour: they behave more like [aluminium](https://en.wikipedia.org/wiki/Aluminium) and [zinc](https://en.wikipedia.org/wiki/Zinc) respectively and have some of the weaker metallic character of the [post-transition metals](https://en.wikipedia.org/wiki/Post-transition_metal), which is why the traditional definition of the term "alkaline earth metal" excludes them.[[6]](https://en.wikipedia.org/wiki/Calcium#cite_note-6) This classification is mostly obsolete in English-language sources, but is still used in other countries such as Japan.[[7]](https://en.wikipedia.org/wiki/Calcium#cite_note-7) As a result, comparisons with strontium and barium are more germane to calcium chemistry than comparisons with magnesium.[[5]](https://en.wikipedia.org/wiki/Calcium#cite_note-Greenwood112-5)

**Physical**

Calcium metal melts at 842 °C and boils at 1494 °C; these values are higher than those for magnesium and strontium, the neighbouring group 2 metals. It crystallises in the [face-centered cubic](https://en.wikipedia.org/wiki/Face-centered_cubic) arrangement like strontium; above 450 °C, it changes to an [anisotropic](https://en.wikipedia.org/wiki/Anisotropy) [hexagonal close-packed](https://en.wikipedia.org/wiki/Hexagonal_close-packed) arrangement like magnesium. Its density of 1.55 g/cm3 is the lowest in its group.[[5]](https://en.wikipedia.org/wiki/Calcium#cite_note-Greenwood112-5) Calcium is harder than [lead](https://en.wikipedia.org/wiki/Lead) but can be cut with a knife with effort. While calcium is a poorer conductor of electricity than [copper](https://en.wikipedia.org/wiki/Copper) or [aluminium](https://en.wikipedia.org/wiki/Aluminium) by volume, it is a better conductor by mass than both due to its very low density.[[8]](https://en.wikipedia.org/wiki/Calcium#cite_note-Ropp-8) While calcium is infeasible as a conductor for most terrestrial applications as it reacts quickly with atmospheric oxygen, its use as such in space has been considered.[[9]](https://en.wikipedia.org/wiki/Calcium#cite_note-Ullmann484-9)

**Chemical**

[](https://en.wikipedia.org/wiki/File:Ca(aq)6_improved_image.tif)

Structure of the polymeric [Ca(H2O)6]2+ center in hydrated calcium chloride, illustrating the high coordination number typical for calcium complexes.

The chemistry of calcium is that of a typical heavy alkaline earth metal. For example, calcium spontaneously reacts with water more quickly than magnesium and less quickly than strontium to produce [calcium hydroxide](https://en.wikipedia.org/wiki/Calcium_hydroxide) and hydrogen gas. It also reacts with the [oxygen](https://en.wikipedia.org/wiki/Oxygen) and [nitrogen](https://en.wikipedia.org/wiki/Nitrogen) in the air to form a mixture of [calcium oxide](https://en.wikipedia.org/wiki/Calcium_oxide) and [calcium nitride](https://en.wikipedia.org/wiki/Calcium_nitride).[[10]](https://en.wikipedia.org/wiki/Calcium#cite_note-CRC-10) When finely divided, it spontaneously burns in air to produce the nitride. In bulk, calcium is less reactive: it quickly forms a hydration coating in moist air, but below 30% [relative humidity](https://en.wikipedia.org/wiki/Relative_humidity) it may be stored indefinitely at room temperature.[[11]](https://en.wikipedia.org/wiki/Calcium#cite_note-Ullmann483-11)

Besides the simple oxide CaO, the [peroxide](https://en.wikipedia.org/wiki/Peroxide) CaO2 can be made by direct oxidation of calcium metal under a high pressure of oxygen, and there is some evidence for a yellow [superoxide](https://en.wikipedia.org/wiki/Superoxide) Ca(O2)2.[[12]](https://en.wikipedia.org/wiki/Calcium#cite_note-12) Calcium hydroxide, Ca(OH)2, is a strong base, though it is not as strong as the hydroxides of strontium, barium or the alkali metals.[[13]](https://en.wikipedia.org/wiki/Calcium#cite_note-13) All four dihalides of calcium are known.[[14]](https://en.wikipedia.org/wiki/Calcium#cite_note-14) [Calcium carbonate](https://en.wikipedia.org/wiki/Calcium_carbonate) (CaCO3) and [calcium sulfate](https://en.wikipedia.org/wiki/Calcium_sulfate) (CaSO4) are particularly abundant minerals.[[15]](https://en.wikipedia.org/wiki/Calcium#cite_note-Greenwood122-15) Like strontium and barium, as well as the alkali metals and the divalent [lanthanides](https://en.wikipedia.org/wiki/Lanthanide) [europium](https://en.wikipedia.org/wiki/Europium) and [ytterbium](https://en.wikipedia.org/wiki/Ytterbium), calcium metal dissolves directly in liquid [ammonia](https://en.wikipedia.org/wiki/Ammonia) to give a dark blue solution.[[5]](https://en.wikipedia.org/wiki/Calcium#cite_note-Greenwood112-5)

Due to the large size of the Ca2+ ion, high coordination numbers are common, up to 24 in some [intermetallic compounds](https://en.wikipedia.org/wiki/Intermetallic_compound) such as CaZn13.[[16]](https://en.wikipedia.org/wiki/Calcium#cite_note-16) Calcium is readily complexed by oxygen [chelates](https://en.wikipedia.org/wiki/Chelate) such as [EDTA](https://en.wikipedia.org/wiki/Ethylenediaminetetraacetic_acid) and [polyphosphates](https://en.wikipedia.org/wiki/Polyphosphate), which are useful in [analytic chemistry](https://en.wikipedia.org/wiki/Analytic_chemistry) and removing calcium ions from [hard water](https://en.wikipedia.org/wiki/Hard_water). In the absence of [steric hindrance](https://en.wikipedia.org/wiki/Steric_hindrance), smaller group 2 cations tend to form stronger complexes, but when large [polydentate](https://en.wikipedia.org/wiki/Polydentate) [macrocycles](https://en.wikipedia.org/wiki/Macrocycle) are involved the trend is reversed.[[15]](https://en.wikipedia.org/wiki/Calcium#cite_note-Greenwood122-15)

Although calcium is in the same group as magnesium and [organomagnesium compounds](https://en.wikipedia.org/wiki/Organomagnesium_compound) are very commonly used throughout chemistry, organocalcium compounds are not similarly widespread because they are more difficult to make and more reactive, although they have recently been investigated as possible [catalysts](https://en.wikipedia.org/wiki/Catalyst).[[17]](https://en.wikipedia.org/wiki/Calcium#cite_note-17)[[18]](https://en.wikipedia.org/wiki/Calcium#cite_note-18)[[19]](https://en.wikipedia.org/wiki/Calcium#cite_note-19)[[20]](https://en.wikipedia.org/wiki/Calcium#cite_note-20)[[21]](https://en.wikipedia.org/wiki/Calcium#cite_note-21) Organocalcium compounds tend to be more similar to organoytterbium compounds due to the similar [ionic radii](https://en.wikipedia.org/wiki/Ionic_radius) of Yb2+ (102 pm) and Ca2+ (100 pm). Most of these compounds can only be prepared at low temperatures; bulky ligands tend to favor stability. For example, calcium di[cyclopentadienyl](https://en.wikipedia.org/wiki/Cyclopentadienyl), Ca(C5H5)2, must be made by directly reacting calcium metal with [mercurocene](https://en.wikipedia.org/w/index.php?title=Mercurocene&action=edit&redlink=1) or [cyclopentadiene](https://en.wikipedia.org/wiki/Cyclopentadiene) itself; replacing the C5H5 ligand with the bulkier C5(CH3)5 ligand on the other hand increases the compound's solubility, volatility, and kinetic stability.[[22]](https://en.wikipedia.org/wiki/Calcium#cite_note-22)

**Isotopes**

Main article: [Isotopes of calcium](https://en.wikipedia.org/wiki/Isotopes_of_calcium)

Natural calcium is a mixture of five stable [isotopes](https://en.wikipedia.org/wiki/Isotope) (40Ca, 42Ca, 43Ca, 44Ca, and 46Ca) and one isotope with a half-life so long that it can be considered stable for all practical purposes ([48Ca](https://en.wikipedia.org/wiki/Calcium-48), with a half-life of about 4.3 × 1019 years). Calcium is the first (lightest) element to have six naturally occurring isotopes.[[10]](https://en.wikipedia.org/wiki/Calcium#cite_note-CRC-10)

By far the most common isotope of calcium in nature is 40Ca, which makes up 96.941% of all natural calcium. It is produced in the [silicon-burning process](https://en.wikipedia.org/wiki/Silicon-burning_process) from fusion of [alpha particles](https://en.wikipedia.org/wiki/Alpha_particle) and is the heaviest stable nuclide with equal proton and neutron numbers; its occurrence is also supplemented slowly by the decay of [primordial](https://en.wikipedia.org/wiki/Primordial_nuclide) [40K](https://en.wikipedia.org/wiki/Potassium-40). Adding another alpha particle would lead to unstable 44Ti, which quickly decays via two successive [electron captures](https://en.wikipedia.org/wiki/Electron_capture) to stable 44Ca; this makes up 2.806% of all natural calcium and is the second-most common isotope. The other four natural isotopes, 42Ca, 43Ca, 46Ca, and 48Ca, are significantly rarer, each comprising less than 1% of all natural calcium. The four lighter isotopes are mainly products of the [oxygen-burning](https://en.wikipedia.org/wiki/Oxygen-burning_process) and silicon-burning processes, leaving the two heavier ones to be produced via neutron-capturing processes. 46Ca is mostly produced in a "hot" [s-process](https://en.wikipedia.org/wiki/S-process), as its formation requires a rather high neutron flux to allow short-lived 45Ca to capture a neutron. 48Ca is produced by [electron capture](https://en.wikipedia.org/wiki/Electron_capture) in the [r-process](https://en.wikipedia.org/wiki/R-process) in [type Ia supernovae](https://en.wikipedia.org/wiki/Type_Ia_supernova), where high neutron excess and low enough entropy ensures its survival.[[23]](https://en.wikipedia.org/wiki/Calcium#cite_note-Cameron-23)[[24]](https://en.wikipedia.org/wiki/Calcium#cite_note-Clayton-24)

46Ca and 48Ca are the first "classically stable" nuclides with a six-neutron or eight-neutron excess respectively. Although extremely neutron-rich for such a light element, 48Ca is very stable because it is a [doubly magic nucleus](https://en.wikipedia.org/wiki/Magic_number_(physics)), having 20 protons and 28 neutrons arranged in closed shells. Its [beta decay](https://en.wikipedia.org/wiki/Beta_decay) to 48[Sc](https://en.wikipedia.org/wiki/Scandium) is very hindered because of the gross mismatch of [nuclear spin](https://en.wikipedia.org/wiki/Nuclear_spin): 48Ca has zero nuclear spin, being [even–even](https://en.wikipedia.org/wiki/Even_and_odd_atomic_nuclei), while 48Sc has spin 6+, so the decay is [forbidden](https://en.wikipedia.org/wiki/Forbidden_mechanism) by the conservation of [angular momentum](https://en.wikipedia.org/wiki/Angular_momentum). While two excited states of 48Sc are available for decay as well, they are also forbidden due to their high spins. As a result, when 48Ca does decay, it does so by [double beta decay](https://en.wikipedia.org/wiki/Double_beta_decay) to 48[Ti](https://en.wikipedia.org/wiki/Titanium) instead, being the lightest nuclide known to undergo double beta decay.[[25]](https://en.wikipedia.org/wiki/Calcium#cite_note-NUBASE-25)[[26]](https://en.wikipedia.org/wiki/Calcium#cite_note-26) The heavy isotope 46Ca can also theoretically undergo double beta decay to 46Ti as well, but this has never been observed; the lightest and most common isotope 40Ca is also doubly magic and could undergo double [electron capture](https://en.wikipedia.org/wiki/Electron_capture) to 40[Ar](https://en.wikipedia.org/wiki/Argon), but this has likewise never been observed. Calcium is the only element to have two primordial doubly magic isotopes. The experimental lower limits for the half-lives of 40Ca and 46Ca are 5.9 × 1021 years and 2.8 × 1015 years respectively.[[25]](https://en.wikipedia.org/wiki/Calcium#cite_note-NUBASE-25)

Apart from the practically stable 48Ca, the longest lived [radioisotope](https://en.wikipedia.org/wiki/Radioisotope) of calcium is 41Ca. It decays by electron capture to stable 41[K](https://en.wikipedia.org/wiki/Potassium) with a half-life of about a hundred thousand years. Its existence in the early Solar System as an [extinct radionuclide](https://en.wikipedia.org/wiki/Extinct_radionuclide) has been inferred from excesses of 41K: traces of 41Ca also still exist today, as it is a [cosmogenic nuclide](https://en.wikipedia.org/wiki/Cosmogenic_nuclide), continuously reformed through [neutron activation](https://en.wikipedia.org/wiki/Neutron_activation) of natural 40Ca.[[24]](https://en.wikipedia.org/wiki/Calcium#cite_note-Clayton-24) Many other calcium radioisotopes are known, ranging from 34Ca to 57Ca: they are all much shorter-lived than 41Ca, the most stable among them being 45Ca (half-life 163 days) and 47Ca (half-life 4.54 days). The isotopes lighter than 42Ca usually undergo [beta plus decay](https://en.wikipedia.org/wiki/Beta_plus_decay) to isotopes of potassium, and those heavier than 44Ca usually undergo [beta minus decay](https://en.wikipedia.org/wiki/Beta_minus_decay) to isotopes of [scandium](https://en.wikipedia.org/wiki/Scandium), although near the [nuclear drip lines](https://en.wikipedia.org/wiki/Nuclear_drip_line) [proton emission](https://en.wikipedia.org/wiki/Proton_emission) and [neutron emission](https://en.wikipedia.org/wiki/Neutron_emission) begin to be significant decay modes as well.[[25]](https://en.wikipedia.org/wiki/Calcium#cite_note-NUBASE-25)

Like other elements, a variety of processes alter the relative abundance of calcium isotopes.[[27]](https://en.wikipedia.org/wiki/Calcium#cite_note-27) The best studied of these processes is the mass-dependent [fractionation](https://en.wikipedia.org/wiki/Isotope_fractionation) of calcium isotopes that accompanies the precipitation of calcium minerals such as [calcite](https://en.wikipedia.org/wiki/Calcite), [aragonite](https://en.wikipedia.org/wiki/Aragonite) and [apatite](https://en.wikipedia.org/wiki/Apatite) from solution. Lighter isotopes are preferentially incorporated into these minerals, leaving the surrounding solution enriched in heavier isotopes at a magnitude of roughly 0.025% per atomic mass unit (amu) at room temperature. Mass-dependent differences in calcium isotope composition are conventionally expressed by the ratio of two isotopes (usually 44Ca/40Ca) in a sample compared to the same ratio in a standard reference material. 44Ca/40Ca varies by about 1% among common earth materials.[[28]](https://en.wikipedia.org/wiki/Calcium#cite_note-28)

**History**

[](https://en.wikipedia.org/wiki/File:Ein_Ghazal_Venus.jpg)

One of the ['Ain Ghazal Statues](https://en.wikipedia.org/wiki/%27Ain_Ghazal_Statues), made from [lime plaster](https://en.wikipedia.org/wiki/Lime_plaster)

Calcium compounds were known for millennia, although their chemical makeup was not understood until the 17th century.[[29]](https://en.wikipedia.org/wiki/Calcium#cite_note-Greenwood108-29) Lime as a [building material](https://en.wikipedia.org/wiki/Lime_(material))[[30]](https://en.wikipedia.org/wiki/Calcium#cite_note-minerals.usgs-30) and as [plaster for statues](https://en.wikipedia.org/wiki/Lime_plaster) was used as far back as around 7000 BC.[[31]](https://en.wikipedia.org/wiki/Calcium#cite_note-31) The first dated [lime kiln](https://en.wikipedia.org/wiki/Lime_kiln) dates back to 2500 BC and was found in [Khafajah](https://en.wikipedia.org/wiki/Khafajah), [Mesopotamia](https://en.wikipedia.org/wiki/Mesopotamia).[[32]](https://en.wikipedia.org/wiki/Calcium#cite_note-32)[[33]](https://en.wikipedia.org/wiki/Calcium#cite_note-33) At about the same time, dehydrated [gypsum](https://en.wikipedia.org/wiki/Gypsum) (CaSO4·2H2O) was being used in the [Great Pyramid of Giza](https://en.wikipedia.org/wiki/Great_Pyramid_of_Giza); this material would later be used for the plaster in the tomb of [Tutankhamun](https://en.wikipedia.org/wiki/Tutankhamun). The climate of present-day Italy being warmer than that of Egypt, the [ancient Romans](https://en.wikipedia.org/wiki/Ancient_Roman) instead used lime mortars made by heating [limestone](https://en.wikipedia.org/wiki/Limestone) (CaCO3); the name "calcium" itself derives from the Latin word *calx* "lime".[[29]](https://en.wikipedia.org/wiki/Calcium#cite_note-Greenwood108-29) [Vitruvius](https://en.wikipedia.org/wiki/Vitruvius) noted that the lime that resulted was lighter than the original limestone, attributing this to the boiling of the water; in 1755, [Joseph Black](https://en.wikipedia.org/wiki/Joseph_Black) proved that this was due to the loss of [carbon dioxide](https://en.wikipedia.org/wiki/Carbon_dioxide), which as a gas had not been recognised by the ancient Romans.[[34]](https://en.wikipedia.org/wiki/Calcium#cite_note-Weeks-34)

In 1787, [Antoine Lavoisier](https://en.wikipedia.org/wiki/Antoine_Lavoisier) suspected that lime might be an oxide of a fundamental [chemical element](https://en.wikipedia.org/wiki/Chemical_element). In his table of the elements, Lavoisier listed five "salifiable earths" (i.e., ores that could be made to react with acids to produce salts (*salis* = salt, in Latin): *chaux* (calcium oxide), *magnésie* (magnesia, magnesium oxide), *baryte* (barium sulfate), *alumine* (alumina, aluminium oxide), and *silice* (silica, silicon dioxide). About these "elements", Lavoisier speculated:

We are probably only acquainted as yet with a part of the metallic substances existing in nature, as all those which have a stronger affinity to oxygen than carbon possesses, are incapable, hitherto, of being reduced to a metallic state, and consequently, being only presented to our observation under the form of oxyds, are confounded with earths. It is extremely probable that barytes, which we have just now arranged with earths, is in this situation; for in many experiments it exhibits properties nearly approaching to those of metallic bodies. It is even possible that all the substances we call earths may be only metallic oxyds, irreducible by any hitherto known process.[[35]](https://en.wikipedia.org/wiki/Calcium#cite_note-35)

Calcium, along with its congeners magnesium, strontium, and barium, was first isolated by [Humphry Davy](https://en.wikipedia.org/wiki/Humphry_Davy) in 1808. Following the work of [Jöns Jakob Berzelius](https://en.wikipedia.org/wiki/J%C3%B6ns_Jakob_Berzelius) and [Magnus Martin af Pontin](https://en.wikipedia.org/w/index.php?title=Magnus_Martin_af_Pontin&action=edit&redlink=1) on [electrolysis](https://en.wikipedia.org/wiki/Electrolysis), Davy isolated calcium and magnesium by putting a mixture of the respective metal oxides with [mercury(II) oxide](https://en.wikipedia.org/wiki/Mercury(II)_oxide) on a [platinum](https://en.wikipedia.org/wiki/Platinum) plate which was used as the anode, the cathode being a platinum wire partially submerged into mercury. Electrolysis then gave calcium–mercury and magnesium–mercury amalgams, and distilling off the mercury gave the metal.[[29]](https://en.wikipedia.org/wiki/Calcium#cite_note-Greenwood108-29)[[36]](https://en.wikipedia.org/wiki/Calcium#cite_note-36) However, pure calcium cannot be prepared in bulk by this method and a workable commercial process for its production was not found until over a century later.[[34]](https://en.wikipedia.org/wiki/Calcium#cite_note-Weeks-34)

**Occurrence and production**

[](https://en.wikipedia.org/wiki/File:Pamukkale_Hierapolis_Travertine_pools.JPG)

[Travertine](https://en.wikipedia.org/wiki/Travertine) terraces in [Pamukkale](https://en.wikipedia.org/wiki/Pamukkale), Turkey

At 3%, calcium is the fifth [most abundant element in the Earth's crust](https://en.wikipedia.org/wiki/Abundance_of_the_chemical_elements), and the third most abundant metal behind [aluminium](https://en.wikipedia.org/wiki/Aluminium) and [iron](https://en.wikipedia.org/wiki/Iron).[[29]](https://en.wikipedia.org/wiki/Calcium#cite_note-Greenwood108-29) It is also the fourth most abundant element in the [lunar highlands](https://en.wikipedia.org/wiki/Lunar_highlands).[[11]](https://en.wikipedia.org/wiki/Calcium#cite_note-Ullmann483-11) [Sedimentary](https://en.wikipedia.org/wiki/Sedimentary_rocks) [calcium carbonate](https://en.wikipedia.org/wiki/Calcium_carbonate) deposits pervade the Earth's surface as fossilized remains of past marine life; they occur in two forms, the [rhombohedral](https://en.wikipedia.org/wiki/Rhombohedral) [calcite](https://en.wikipedia.org/wiki/Calcite) (more common) and the [orthorhombic](https://en.wikipedia.org/wiki/Orthorhombic) [aragonite](https://en.wikipedia.org/wiki/Aragonite) (forming in more temperate seas). Minerals of the first type include [limestone](https://en.wikipedia.org/wiki/Limestone), [dolomite](https://en.wikipedia.org/wiki/Dolomite), [marble](https://en.wikipedia.org/wiki/Marble), [chalk](https://en.wikipedia.org/wiki/Chalk), and [iceland spar](https://en.wikipedia.org/wiki/Iceland_spar); aragonite beds make up the [Bahamas](https://en.wikipedia.org/wiki/Bahamas), the [Florida Keys](https://en.wikipedia.org/wiki/Florida_Keys), and the [Red Sea](https://en.wikipedia.org/wiki/Red_Sea) basins. [Corals](https://en.wikipedia.org/wiki/Coral), [sea shells](https://en.wikipedia.org/wiki/Sea_shell), and [pearls](https://en.wikipedia.org/wiki/Pearl) are mostly made up of calcium carbonate. Among the other important minerals of calcium are [gypsum](https://en.wikipedia.org/wiki/Gypsum) (CaSO4·2H2O), [anhydrite](https://en.wikipedia.org/wiki/Anhydrite) (CaSO4), [fluorite](https://en.wikipedia.org/wiki/Fluorite) (CaF2), and [apatite](https://en.wikipedia.org/wiki/Apatite) ([Ca5(PO4)3F]).[[29]](https://en.wikipedia.org/wiki/Calcium#cite_note-Greenwood108-29)

The major producers of calcium are [China](https://en.wikipedia.org/wiki/China) (about 10000 to 12000 [tonnes](https://en.wikipedia.org/wiki/Tonne) per year), [Russia](https://en.wikipedia.org/wiki/Russia) (about 6000 to 8000 tonnes per year), and the [United States](https://en.wikipedia.org/wiki/United_States) (about 2000 to 4000 tonnes per year). [Canada](https://en.wikipedia.org/wiki/Canada) and [France](https://en.wikipedia.org/wiki/France) are also among the minor producers. In 2005, about 24000 tonnes of calcium were produced; about half of the world's extracted calcium is used by the United States, with about 80% of the output used each year.[[9]](https://en.wikipedia.org/wiki/Calcium#cite_note-Ullmann484-9) In Russia and China, Davy's method of electrolysis is still used, but is instead applied to molten [calcium chloride](https://en.wikipedia.org/wiki/Calcium_chloride).[[9]](https://en.wikipedia.org/wiki/Calcium#cite_note-Ullmann484-9) Since calcium is less reactive than strontium or barium, the oxide–nitride coating that results in air is stable and [lathe](https://en.wikipedia.org/wiki/Lathe) machining and other standard metallurgical techniques are suitable for calcium.[[37]](https://en.wikipedia.org/wiki/Calcium#cite_note-Greenwood110-37) In the United States and Canada, calcium is instead produced by reducing lime with aluminium at high temperatures.[[9]](https://en.wikipedia.org/wiki/Calcium#cite_note-Ullmann484-9)

**Geochemical cycling**

Main article: [Carbonate–silicate cycle](https://en.wikipedia.org/wiki/Carbonate%E2%80%93silicate_cycle)

Calcium provides a link between [tectonics](https://en.wikipedia.org/wiki/Tectonics), [climate](https://en.wikipedia.org/wiki/Climate), and the [carbon cycle](https://en.wikipedia.org/wiki/Carbon_cycle). In the simplest terms, uplift of mountains exposes calcium-bearing rocks to chemical weathering and releases Ca2+ into surface water. These ions are transported to the ocean where they react with dissolved CO2 to form [limestone](https://en.wikipedia.org/wiki/Limestone) (CaCO  
3), which in turn settles to the sea floor where it is incorporated into new rocks. Dissolved CO2, along with [carbonate](https://en.wikipedia.org/wiki/Carbonate) and [bicarbonate](https://en.wikipedia.org/wiki/Bicarbonate) ions, are termed "[dissolved inorganic carbon](https://en.wikipedia.org/wiki/Total_inorganic_carbon)" (DIC).[[38]](https://en.wikipedia.org/wiki/Calcium#cite_note-Berner-38)

The actual reaction is more complicated and involves the bicarbonate ion (HCO−  
3) that forms when CO2 reacts with water at seawater [pH](https://en.wikipedia.org/wiki/PH):

Ca2+  
+ 2HCO−  
3 → [CaCO  
3](https://en.wikipedia.org/wiki/Limestone)([s](https://en.wikipedia.org/wiki/Solid)) + CO  
2 + H  
2O

At seawater pH, most of the CO2 is immediately converted back into HCO−  
3. The reaction results in a net transport of one molecule of CO2 from the ocean/atmosphere into the [lithosphere](https://en.wikipedia.org/wiki/Lithosphere).[[39]](https://en.wikipedia.org/wiki/Calcium#cite_note-39) The result is that each Ca2+ ion released by chemical weathering ultimately removes one CO2 molecule from the surficial system (atmosphere, ocean, soils and living organisms), storing it in carbonate rocks where it is likely to stay for hundreds of millions of years. The weathering of calcium from rocks thus scrubs CO2 from the ocean and atmosphere, exerting a strong long-term effect on climate.[[38]](https://en.wikipedia.org/wiki/Calcium#cite_note-Berner-38)[[40]](https://en.wikipedia.org/wiki/Calcium#cite_note-40)

**Uses**

The largest use of calcium is in [steelmaking](https://en.wikipedia.org/wiki/Steelmaking), due to its strong [chemical affinity](https://en.wikipedia.org/wiki/Chemical_affinity) for oxygen and [sulfur](https://en.wikipedia.org/wiki/Sulfur). Its oxides and sulfides, once formed, give liquid lime [aluminate](https://en.wikipedia.org/wiki/Aluminate) and sulfide inclusions in steel which float out; on treatment, these inclusions disperse throughout the steel and became small and spherical, improving castability, cleanliness and general mechanical properties. Calcium is also used in maintenance-free [automotive batteries](https://en.wikipedia.org/wiki/Automotive_battery), in which the use of 0.1% calcium–[lead](https://en.wikipedia.org/wiki/Lead) alloys instead of the usual [antimony](https://en.wikipedia.org/wiki/Antimony)–lead alloys leads to lower water loss and lower self-discharging. Due to the risk of expansion and cracking, [aluminium](https://en.wikipedia.org/wiki/Aluminium) is sometimes also incorporated into these alloys. These lead–calcium alloys are also used in casting, replacing lead–antimony alloys.[[41]](https://en.wikipedia.org/wiki/Calcium#cite_note-Ullmann485-41) Calcium is also used to strengthen aluminium alloys used for bearings, for the control of graphitic [carbon](https://en.wikipedia.org/wiki/Carbon) in [cast iron](https://en.wikipedia.org/wiki/Cast_iron), and to remove [bismuth](https://en.wikipedia.org/wiki/Bismuth) impurities from lead.[[37]](https://en.wikipedia.org/wiki/Calcium#cite_note-Greenwood110-37) Calcium metal is found in some drain cleaners, where it functions to generate heat and [calcium hydroxide](https://en.wikipedia.org/wiki/Calcium_hydroxide) that [saponifies](https://en.wikipedia.org/wiki/Saponification) the fats and liquefies the proteins (for example, those in hair) that block drains.[[42]](https://en.wikipedia.org/wiki/Calcium#cite_note-Rumack-42) Besides metallurgy, the reactivity of calcium is exploited to remove [nitrogen](https://en.wikipedia.org/wiki/Nitrogen) from high-purity [argon](https://en.wikipedia.org/wiki/Argon) gas and as a [getter](https://en.wikipedia.org/wiki/Getter) for oxygen and nitrogen. It is also used as a reducing agent in the production of [chromium](https://en.wikipedia.org/wiki/Chromium), [zirconium](https://en.wikipedia.org/wiki/Zirconium), [thorium](https://en.wikipedia.org/wiki/Thorium), and [uranium](https://en.wikipedia.org/wiki/Uranium). It can also be used to store hydrogen gas, as it reacts with hydrogen to form solid [calcium hydride](https://en.wikipedia.org/wiki/Calcium_hydride), from which the hydrogen can easily be re-extracted.[[37]](https://en.wikipedia.org/wiki/Calcium#cite_note-Greenwood110-37)

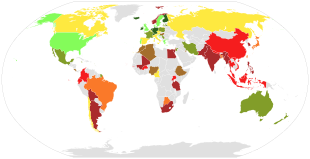
Calcium isotope fractionation during mineral formation has led to several applications of calcium isotopes. In particular, the 1997 observation by Skulan and DePaolo[[43]](https://en.wikipedia.org/wiki/Calcium#cite_note-43) that calcium minerals are isotopically lighter than the solutions from which 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 44Ca/40Ca ratio in soft tissue rises and vice versa. Because of this relationship, calcium isotopic measurements of urine or blood may be useful in the early detection of metabolic bone diseases like [osteoporosis](https://en.wikipedia.org/wiki/Osteoporosis).[[44]](https://en.wikipedia.org/wiki/Calcium#cite_note-44) A similar system exists in seawater, where 44Ca/40Ca tends to rise when the rate of removal of Ca2+ by mineral precipitation exceeds the input of new calcium into the ocean. In 1997 Skulan and DePaolo presented the first evidence of change in seawater 44Ca/40Ca over geologic time, along with a theoretical explanation of these changes. More recent papers have confirmed this observation, demonstrating that seawater Ca2+ concentration is not constant, and that the ocean is never in a "steady state" with respect to calcium input and output. This has important climatological implications, as the marine calcium cycle is closely tied to the [carbon cycle](https://en.wikipedia.org/wiki/Carbon_cycle).[[45]](https://en.wikipedia.org/wiki/Calcium#cite_note-45)[[46]](https://en.wikipedia.org/wiki/Calcium#cite_note-46)

Many calcium compounds are used in food, as pharmaceuticals, and in medicine, among others. For example, calcium and phosphorus are supplemented in foods through the addition of [calcium lactate](https://en.wikipedia.org/wiki/Calcium_lactate), [calcium diphosphate](https://en.wikipedia.org/wiki/Calcium_diphosphate), and [tricalcium phosphate](https://en.wikipedia.org/wiki/Tricalcium_phosphate). The last is also used as a polishing agent in [toothpaste](https://en.wikipedia.org/wiki/Toothpaste) and in [antacids](https://en.wikipedia.org/wiki/Antacid). [Calcium lactobionate](https://en.wikipedia.org/wiki/Calcium_lactobionate) is a white powder that is used as a suspending agent for pharmaceuticals. In baking, [calcium monophosphate](https://en.wikipedia.org/w/index.php?title=Calcium_monophosphate&action=edit&redlink=1) is used as a [leavening agent](https://en.wikipedia.org/wiki/Leavening_agent). [Calcium sulfite](https://en.wikipedia.org/wiki/Calcium_sulfite) is used as a bleach in papermaking and as a disinfectant, [calcium silicate](https://en.wikipedia.org/wiki/Calcium_silicate) is used as a reinforcing agent in rubber, and [calcium acetate](https://en.wikipedia.org/wiki/Calcium_acetate) is a component of [liming rosin](https://en.wikipedia.org/w/index.php?title=Liming_rosin&action=edit&redlink=1) and is used to make metallic soaps and synthetic resins.[[41]](https://en.wikipedia.org/wiki/Calcium#cite_note-Ullmann485-41)

**Biological and pathological role**

Main article: [Calcium in biology](https://en.wikipedia.org/wiki/Calcium_in_biology)

|  |  |
| --- | --- |
| Age-adjusted daily calcium recommendations (from U.S. Institute of Medicine RDAs)[[47]](https://en.wikipedia.org/wiki/Calcium#cite_note-47) | |
| **Age** | **Calcium (mg/day)** |
| 1–3 years | 700 |
| 4–8 years | 1000 |
| 9–18 years | 1300 |
| 19–50 years | 1000 |
| >51 years | 1000 |
| Pregnancy | 1000 |
| Lactation | 1000 |

[](https://en.wikipedia.org/wiki/File:Calcium_intake_world_map.svg)

Global dietary calcium intake among adults (mg/day).[[48]](https://en.wikipedia.org/wiki/Calcium#cite_note-48)

  <400

  400-500

  500-600

  600-700

  700-800

  800-900

  900-1000

  >1000

Calcium is an [essential element](https://en.wikipedia.org/wiki/Essential_element) needed in large quantities. The Ca2+ ion acts as an [electrolyte](https://en.wikipedia.org/wiki/Electrolyte) and is vital to the health of the muscular, circulatory, and digestive systems; is indispensable to the building of bone; and supports synthesis and function of blood cells. For example, it regulates the contraction of muscles, nerve conduction, and the clotting of blood. As a result, intra- and extracellular calcium levels are tightly regulated by the body. Calcium can play this role because the Ca2+ ion forms stable [coordination complexes](https://en.wikipedia.org/wiki/Coordination_complex) with many organic compounds, especially [proteins](https://en.wikipedia.org/wiki/Protein); it also forms compounds with a wide range of solubilities, enabling the formation of [skeletons](https://en.wikipedia.org/wiki/Skeleton).[[49]](https://en.wikipedia.org/wiki/Calcium#cite_note-Ullmann489-49)

Calcium ions may be complexed by proteins through binding the [carboxyl groups](https://en.wikipedia.org/wiki/Carboxyl_group) of [glutamic acid](https://en.wikipedia.org/wiki/Glutamic_acid) or [aspartic acid](https://en.wikipedia.org/wiki/Aspartic_acid) residues; through interacting with [phosphorylated](https://en.wikipedia.org/wiki/Phosphorylation) [serine](https://en.wikipedia.org/wiki/Serine), [tyrosine](https://en.wikipedia.org/wiki/Tyrosine), or [threonine](https://en.wikipedia.org/wiki/Threonine) residues; or by being [chelated](https://en.wikipedia.org/wiki/Chelation) by γ-carboxylated amino acid residues. [Trypsin](https://en.wikipedia.org/wiki/Trypsin), a digestive enzyme, uses the first method; [osteocalcin](https://en.wikipedia.org/wiki/Osteocalcin), a bone matrix protein, uses the third. Some other bone matrix proteins such as [osteopontin](https://en.wikipedia.org/wiki/Osteopontin) and bone [sialoprotein](https://en.wikipedia.org/w/index.php?title=Sialoprotein&action=edit&redlink=1) use both the first and the second. Direct activation of enzymes by binding calcium is common; some other enzymes are activated by noncovalent association with direct calcium-binding enzymes. Calcium also binds to the [phospholipid](https://en.wikipedia.org/wiki/Phospholipid) layer of the [cell membrane](https://en.wikipedia.org/wiki/Cell_membrane), anchoring proteins associated with the cell surface.[[49]](https://en.wikipedia.org/wiki/Calcium#cite_note-Ullmann489-49) As an example of the wide range of solubility of calcium compounds, [monocalcium phosphate](https://en.wikipedia.org/wiki/Monocalcium_phosphate) is very soluble in water, 85% of extracellular calcium is as [dicalcium phosphate](https://en.wikipedia.org/wiki/Dicalcium_phosphate) with a solubility of 2.0 [mM](https://en.wikipedia.org/wiki/Molar_concentration) and the [hydroxyapatite](https://en.wikipedia.org/wiki/Hydroxyapatite) of bones in an organic matrix is [tricalcium phosphate](https://en.wikipedia.org/wiki/Tricalcium_phosphate) at 100 µM.[[49]](https://en.wikipedia.org/wiki/Calcium#cite_note-Ullmann489-49)

About three-quarters of dietary calcium is from dairy products and grains, the rest being accounted for by vegetables, protein-rich foods, fruits, sugar, fats, and oil. Calcium supplementation is controversial, as the bioavailability of calcium is strongly dependent on the solubility of the salt involved: calcium citrate, malate, and lactate are highly bioavailable while the oxalate is much less so. The intestine absorbs about one-third of calcium eaten as the [free ion](https://en.wikipedia.org/wiki/Radical_ion), and plasma calcium level is then regulated by the kidneys. [Parathyroid hormone](https://en.wikipedia.org/wiki/Parathyroid_hormone) and [vitamin D](https://en.wikipedia.org/wiki/Vitamin_D) promote the formation of bone by allowing and enhancing the deposition of calcium ions there, allowing rapid bone turnover without affecting bone mass or mineral content. When plasma calcium levels fall, cell surface receptors are activated and the secretion of parathyroid hormone occurs; it then proceeds to stimulate the entry of calcium into the plasma pool by taking it from targeted kidney, gut, and bone cells, with the bone-forming action of parathyroid hormone being antagonised by [calcitonin](https://en.wikipedia.org/wiki/Calcitonin), whose secretion increases with increasing plasma calcium levels.[[49]](https://en.wikipedia.org/wiki/Calcium#cite_note-Ullmann489-49)

Excess intake of calcium may cause [hypercalcaemia](https://en.wikipedia.org/wiki/Hypercalcaemia). However, because calcium is absorbed rather inefficiently by the intestines, high serum calcium is more likely caused by excessive secretion of parathyroid hormone (PTH) or possibly by excessive intake of vitamin D, both which facilitate calcium absorption. It may also be due to bone destruction that occurs when tumours [metastasize](https://en.wikipedia.org/wiki/Metastasize) within bone. All these conditions result in excess calcium salts being deposited in the heart, blood vessels, or kidneys. Symptoms include anorexia, nausea, vomiting, memory loss, confusion, muscle weakness, increased urination, dehydration, and metabolic bone disease. Chronic hypercalcaemia typically leads to [calcification](https://en.wikipedia.org/wiki/Calcification) of soft tissue and its serious consequences: for example, calcification can cause loss of elasticity of [vascular walls](https://en.wikipedia.org/wiki/Vascular_wall) and disruption of laminar blood flow—and thence to [plaque rupture](https://en.wikipedia.org/wiki/Vulnerable_plaque) and [thrombosis](https://en.wikipedia.org/wiki/Thrombosis). Conversely, inadequate calcium or vitamin D intakes may result in [hypocalcaemia](https://en.wikipedia.org/wiki/Hypocalcaemia), often caused also by inadequate secretion of parathyroid hormone or defective PTH receptors in cells. Symptoms include neuromuscular excitability, which potentially causes [tetany](https://en.wikipedia.org/wiki/Tetany) and disruption of conductivity in cardiac tissue.[[49]](https://en.wikipedia.org/wiki/Calcium#cite_note-Ullmann489-49)

As calcium is heavily involved in bone manufacture, many bone diseases can be traced to problems with the organic matrix or the hydroxyapatite in molecular structure or organisation. For example, [osteoporosis](https://en.wikipedia.org/wiki/Osteoporosis) is a reduction in mineral content of bone per unit volume, and can be treated by supplementation of calcium, vitamin D, and biphosphates. Calcium supplements may benefit the serum lipids in women who have passed [menopause](https://en.wikipedia.org/wiki/Menopause) as well as older men; in post-menopausal women calcium supplementation also appears to be inversely correlated with cardiovascular disease. Inadequate amounts of calcium, vitamin D, or phosphates can lead to the softening of bones, known as [osteomalacia](https://en.wikipedia.org/wiki/Osteomalacia).[[49]](https://en.wikipedia.org/wiki/Calcium#cite_note-Ullmann489-49)

**Safety**

**Metallic calcium**

|  |  |
| --- | --- |
| Calcium | |
| **Hazards** | |
| [GHS pictograms](https://en.wikipedia.org/wiki/GHS_hazard_pictograms) | [The flame pictogram in the Globally Harmonized System of Classification and Labelling of Chemicals (GHS)](https://en.wikipedia.org/wiki/File:GHS-pictogram-flamme.svg) |
| [GHS signal word](https://en.wikipedia.org/wiki/Globally_Harmonized_System_of_Classification_and_Labelling_of_Chemicals) | Danger |
| [GHS hazard statements](https://en.wikipedia.org/wiki/GHS_hazard_statement) | H261 |
| [GHS precautionary statements](https://en.wikipedia.org/wiki/GHS_precautionary_statements) | P231+232, P422[[50]](https://en.wikipedia.org/wiki/Calcium#cite_note-50) |
| [NFPA 704](https://en.wikipedia.org/wiki/NFPA_704) | NFPA 704 four-colored diamond  [3](https://en.wikipedia.org/wiki/NFPA_704#Red)  [0](https://en.wikipedia.org/wiki/NFPA_704#Blue)  [1](https://en.wikipedia.org/wiki/NFPA_704#Yellow)  [~~W~~](https://en.wikipedia.org/wiki/NFPA_704#White) |

Because calcium reacts exothermically with water and acids, calcium metal coming into contact with bodily moisture results in severe corrosive irritation.[[51]](https://en.wikipedia.org/wiki/Calcium#cite_note-Ullmann487-51) When swallowed, calcium metal has the same effect on the mouth, oesophagus, and stomach, and can be fatal.[[42]](https://en.wikipedia.org/wiki/Calcium#cite_note-Rumack-42) However, long-term exposure is not known to have distinct adverse effects.[[51]](https://en.wikipedia.org/wiki/Calcium#cite_note-Ullmann487-51)

**Calcium in food**

Because of concerns for long-term adverse side effects, including calcification of arteries and kidney stones, both the U.S. Institute of Medicine (IOM) and the [European Food Safety Authority](https://en.wikipedia.org/wiki/European_Food_Safety_Authority) (EFSA) set [Tolerable Upper Intake Levels](https://en.wikipedia.org/wiki/Tolerable_upper_intake_level) (ULs) for combined dietary and supplemental calcium. From the IOM, people of ages 9–18 years are not to exceed 3,000 mg/day combined intake; for ages 19–50, not to exceed 2,500 mg/day; for ages 51 and older, not to exceed 2,000 mg/day.[[52]](https://en.wikipedia.org/wiki/Calcium#cite_note-52) The EFSA set the UL for all adults at 2,500 mg/day, but decided the information for children and adolescents was not sufficient to determine ULs.[[53]](https://en.wikipedia.org/wiki/Calcium#cite_note-53)

**See also**

|  |  |
| --- | --- |
| [**Books**](https://en.wikipedia.org/wiki/Wikipedia:Books) View or order collections of articles | * https://upload.wikimedia.org/wikipedia/commons/thumb/a/a8/Office-book.svg/30px-Office-book.svg.png[***Calcium***](https://en.wikipedia.org/wiki/Book:Calcium) * https://upload.wikimedia.org/wikipedia/commons/thumb/a/a8/Office-book.svg/30px-Office-book.svg.png[***Period 4 elements***](https://en.wikipedia.org/wiki/Book:Period_4_elements) * https://upload.wikimedia.org/wikipedia/commons/thumb/a/a8/Office-book.svg/30px-Office-book.svg.png[***Alkaline earth metals***](https://en.wikipedia.org/wiki/Book:Alkaline_earth_metals) * https://upload.wikimedia.org/wikipedia/commons/thumb/a/a8/Office-book.svg/30px-Office-book.svg.png[***Chemical elements (sorted alphabetically)***](https://en.wikipedia.org/wiki/Book:Chemical_elements_(sorted_alphabetically)) * https://upload.wikimedia.org/wikipedia/commons/thumb/a/a8/Office-book.svg/30px-Office-book.svg.png[***Chemical elements (sorted by number)***](https://en.wikipedia.org/wiki/Book:Chemical_elements_(sorted_by_number)) |
|  | |
| [**Portals**](https://en.wikipedia.org/wiki/Portal:Contents/Portals) Access related topics | * [Papapishu-Lab-icon-6.svg](https://en.wikipedia.org/wiki/File:Papapishu-Lab-icon-6.svg)[***Chemistry portal***](https://en.wikipedia.org/wiki/Portal:Chemistry) |
|  | |
| Find out more on Wikipedia's [**Sister projects**](https://en.wikipedia.org/wiki/Wikipedia:Wikimedia_sister_projects) | * https://upload.wikimedia.org/wikipedia/en/thumb/4/4a/Commons-logo.svg/22px-Commons-logo.svg.png[Media](https://commons.wikimedia.org/wiki/Special:Search/Calcium) from Commons * https://upload.wikimedia.org/wikipedia/en/thumb/0/06/Wiktionary-logo-v2.svg/30px-Wiktionary-logo-v2.svg.png[Definitions](https://en.wiktionary.org/wiki/Special:Search/calcium#English) from Wiktionary * https://upload.wikimedia.org/wikipedia/commons/thumb/f/fa/Wikibooks-logo.svg/30px-Wikibooks-logo.svg.png[Textbooks](https://en.wikibooks.org/wiki/Special:Search/Wikijunior:The_Elements/Calcium) from Wikibooks * https://upload.wikimedia.org/wikipedia/commons/thumb/9/91/Wikiversity-logo.svg/30px-Wikiversity-logo.svg.png[Learning resources](https://en.wikiversity.org/wiki/Special:Search/Calcium_atom) from Wikiversity |

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  *Meija, J.; et al. (2016).* [*"Atomic weights of the elements 2013 (IUPAC Technical Report)"*](https://www.degruyter.com/downloadpdf/j/pac.2016.88.issue-3/pac-2015-0305/pac-2015-0305.xml)*.* [*Pure and Applied Chemistry*](https://en.wikipedia.org/wiki/Pure_and_Applied_Chemistry)*.* ***88*** *(3): 265–91.* [*doi*](https://en.wikipedia.org/wiki/Digital_object_identifier)*:*[*10.1515/pac-2015-0305*](https://doi.org/10.1515%2Fpac-2015-0305)*.*

  *Krieck, Sven; Görls, Helmar; Westerhausen, Matthias (2010). "Mechanistic Elucidation of the Formation of the Inverse Ca(I) Sandwich Complex [(thf)3Ca(μ-C6H3-1,3,5-Ph3)Ca(thf)3] and Stability of Aryl-Substituted Phenylcalcium Complexes". Journal of the American Chemical Society.* ***132*** *(35): 12492–12501.* [*doi*](https://en.wikipedia.org/wiki/Digital_object_identifier)*:*[*10.1021/ja105534w*](https://doi.org/10.1021%2Fja105534w)*.* [*PMID*](https://en.wikipedia.org/wiki/PubMed_Identifier)[*20718434*](https://www.ncbi.nlm.nih.gov/pubmed/20718434)*.*

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  Greenwood and Earnshaw, pp. 112–3

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**External links**

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* [Calcium](http://www.periodicvideos.com/videos/020.htm) at [*The Periodic Table of Videos*](https://en.wikipedia.org/wiki/The_Periodic_Table_of_Videos) (University of Nottingham)
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