

Plutonium (Pu) - Student Datasheet

Atomic number 94 - Actinide · radioactive synthetic/trace natural element - Group Actinide - Period 7 - f-block

Plutonium is a radioactive actinide with complex 5f-electron chemistry, several solid allotropes and isotope-dependent nuclear behavior. It is best understood by separating atomic chemistry, materials science and nuclear properties rather than treating “plutonium” as one simple fact.

Quick reference

Property	Value
Atomic number	94
Reference relative atomic mass	[244]
Electron configuration	[Rn] 5f ⁶ 7s ²
Important oxidation states	+3, +4, +5, +6
Density (α-Pu context)	≈19.7 g/cm ³
Melting point	913 K
Boiling point	3501 K
Room-temperature crystal	α-Pu · monoclinic P2 ₁ /m

Structure & orbitals

Reference isotope: ²³⁹Pu - 94 protons + 145 neutrons. Electron configuration: [Rn] 5f⁶ 7s².

Selected 7s and representative 5f (m=0, z(5z²−3r²)-type angular form) teaching views. Plutonium is an actinide with strongly coupled 5f/6d/7s physics; a simple one-electron orbital sketch cannot reproduce the many-electron solid.

Phase / temperature context

At approximately ambient pressure, plutonium passes through several solid allotropes before melting near 913 K. The multiple solid transitions are first-class regions, not one generic “solid” block.

Five things to remember

1. Atomic number 94 means 94 protons.
2. The reference ground-state configuration is [Rn] 5f⁶ 7s².
3. Plutonium has no stable isotopes.
4. Elemental plutonium has an unusually complex sequence of solid allotropes before melting.
5. Plutonium handling belongs to highly regulated professional environments; this page stays conceptual and non-operational.

Real-world context

Research reactors + fuel cycles

Plutonium isotopes occur in reactor fuel-cycle science; this page gives only high-level context.

Space power

Pu-238 heat has powered radioisotope systems on selected spacecraft.

Materials science

Multiple allotropes make plutonium a classic challenge in actinide metallurgy.

Safeguards

Because plutonium is radioactive and strategically sensitive, inventories and handling are tightly controlled.

Environment

Environmental monitoring can track trace plutonium from historical releases and nuclear activities.

Where on Earth? / geography modes

Research geography - Controlled facilities

Plutonium science is associated with licensed research, fuel-cycle and analytical facilities rather than natural-resource mining geography.

Examples/context: National laboratories; Licensed nuclear sites; Research institutes

Environmental context - Trace monitoring

Trace plutonium can be measured in environmental samples from historical global fallout and site-specific releases; this is monitoring geography, not natural abundance.

Examples/context: Global fallout record; Monitoring sites; Sediments/soils

Space power - Pu-238 systems

Selected planetary missions have used Pu-238 radioisotope power systems assembled under specialized government programs.

Examples/context: United States programs; Deep-space missions; Planetary science

Isotopes

Isotope	Status / timescale	Why it matters
²³⁸ Pu	≈87.7 y	strong decay-heat source used in some space-power systems
²³⁹ Pu	≈24,100 y	important reactor/fuel-cycle isotope
²⁴⁰ Pu	≈6,560 y	common co-produced isotope
²⁴⁴ Pu	≈80 million y	very long-lived isotope; trace primordial/natural occurrence has been studied

Evidence note

Isotope and atomic data are evaluated; allotrope transition temperatures vary somewhat by purity/pressure/source and are shown as approximate teaching boundaries. No operational nuclear-material instructions are provided.

Review questions

Does plutonium have any stable isotopes?

Answer: No. All plutonium isotopes are radioactive.

What is the room-temperature alpha-plutonium structure?

Answer: Monoclinic P21/m. Alpha-Pu is a low-symmetry monoclinic structure with 16 atoms in the conventional unit cell.

Why does the plutonium temperature bar show several solid regions?

Answer: Plutonium has several solid allotropes. Plutonium undergoes multiple solid-solid phase transitions before melting.

Which plutonium isotope is used as a heat source in some space-power systems?

Answer: ^{238}Pu . Pu-238 has strong decay heat and is used in selected radioisotope power systems.

Why is the plutonium page intentionally non-operational?

Answer: The goal is safe scientific education, not handling or processing instructions. The page explains evidence, isotopes and materials science while avoiding instructions for hazardous or strategically sensitive operations.

Reviewed sources

- Royal Society of Chemistry — Plutonium: <https://periodic-table.rsc.org/element/94/plutonium>
- NIST — Plutonium elemental/atomic data: <https://physics.nist.gov/cgi-bin/Elements/elInfo.pl?context=text&element=94>
- Los Alamos National Laboratory — Plutonium periodic-table entry: <https://periodic.lanl.gov/94.shtml>
- IAEA Nuclear Data Services: <https://www-nds.iaea.org/relnsd/vcharthtml/VChartHTML.html>
- Los Alamos / published plutonium metallurgy — α -Pu structure and allotropes:
https://www.lasg.org/MPF2/documents/LA-UR-12-23982_PlutoniumMetallurgy_Freibert_9Aug2012.pdf

ElementLookup.com - educational reference sheet. Interactive visualizations on the website include additional model/evidence notes.