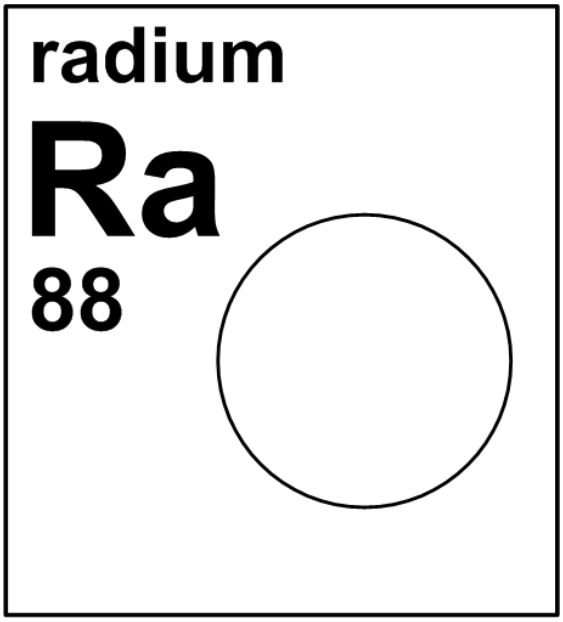
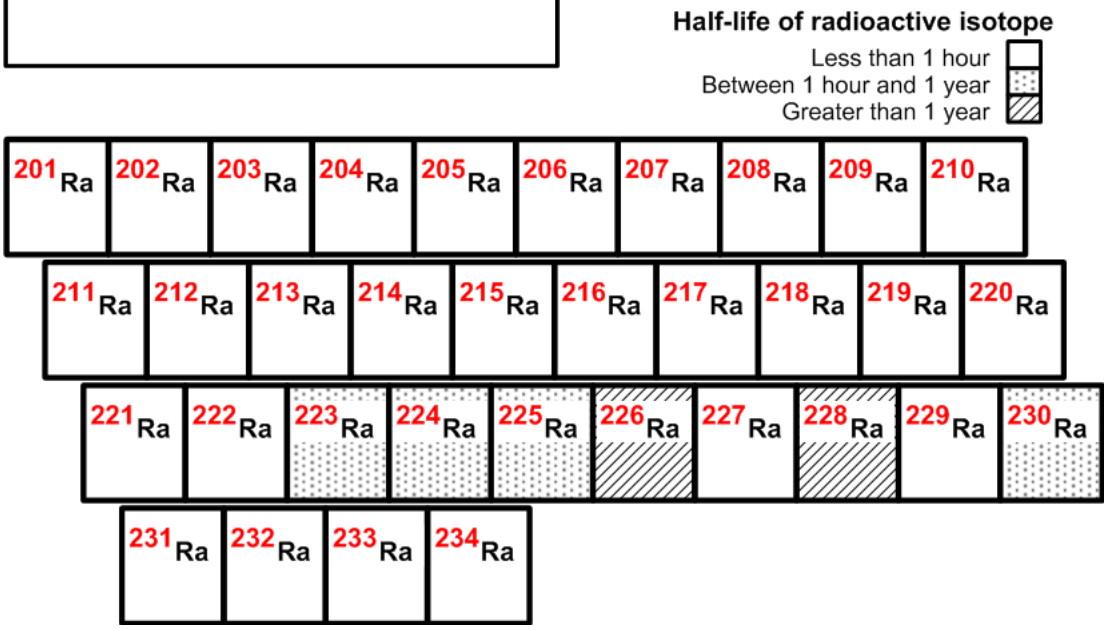
4.88 radium



Stable isotope	Relative atomic mass	Mole fraction
(none)		



4.88.1 Radium isotopes in Earth/planetary science

The **radioactive isotopes** ^{223}Ra (with a **half-life** of 275 hours), ^{224}Ra (with a half-life of 88 hours), ^{226}Ra (with a half-life of 1600 years), and ^{228}Ra (with a half-life of 5.75 years) are used as **tracers** to determine water flow rates. They are ideal environmental tracers because they behave conservatively once released into a water mass (meaning only mixing and decay processes affect their distribution) [575]. The activity ratios $A(^{224}\text{Ra})/A(^{223}\text{Ra})$, $A(^{223}\text{Ra})/A(^{226}\text{Ra})$, $A(^{224}\text{Ra})/A(^{228}\text{Ra})$, and $A(^{228}\text{Ra})/A(^{226}\text{Ra})$ have been used in lake studies to monitor and detect water inflow and mixing, to determine sources of inflowing water, and to monitor introduced

water masses as they move within a body of water (i.e. a lake) [575, 576]. For example, submarine groundwater discharge is an important pathway that transports dissolved substances from aquifers below a seabed to the coastal ocean. Submarine groundwater discharge can be difficult to quantify because it is both spatially and temporally variable. As a result, its relative importance in coastal ocean chemical budgets is commonly poorly known. Peterson et al. [569] used an hourly time series of measurements of multiple radium isotopes ^{223}Ra, ^{224}Ra, and ^{226}Ra to quantify submarine groundwater discharge. They also used ^{222}Rn (with a half-life of 3.8 days) measurements to independently quantify submarine groundwater discharge.

4.88.2 Radium isotopes in geochronology

^{226}Ra and ^{228}Ra can be used for dating materials up to a few thousand years in age because the half-lives of ^{226}Ra and ^{228}Ra are 1,600 years and 5.75 years, respectively, even though the long-lived ^{226}Ra is found in nature as a result of its continuous production by the decay of ^{238}U. For example, long-lived ^{226}Ra has been used to date a limestone cave in central Switzerland, Indian Ocean corals, and Pleistocene gravel terraces [577]. The activity ratio $A(^{224}\text{Ra})/A(^{223}\text{Ra})$ is a potential age calculator for old lake water because the low ^{223}Ra and ^{224}Ra activities in old lake water are relatively unaffected by mixing [576].

4.88.3 Radium isotopes in medicine

^{226}Ra is used in **brachytherapy** (Figure 4.88.1), which is a method of localized treatment of various types of cancer. A sealed implant (such as a rod, seed, or needle) containing the **radioactive isotope** ^{226}Ra is inserted into or near a patient's tumor to apply a high dose of radiation to the tumor. The sealed implant is inserted by a physician or by an automated device (called a remote afterloader), and it is removed from the patient once the tumor is destroyed [72, 578].

Fig. 4.88.1: Brachytherapy seeds shown with a penny (19-mm diameter) for scale (modified from [579]).