

Title Exploring radioactivity safely with potassium carbonate

Radioactivity infosheet

Natural versus artificial radioactivity

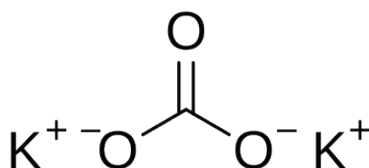
Although radiation is often associated with nuclear accidents or medical imaging, the majority of our exposure comes from natural sources. One major contributor is potassium-40 (^{40}K), an isotope found in all living organisms and many common substances, such as [bananas](#), salt substitutes, and potassium carbonate.



Image: Trang TRIEU/[Unsplash](#), [CC0](#)

Potassium in food and chemistry

Potassium is essential for human nutrition and widely used in food processing. Potassium carbonate (K_2CO_3), also known as potash, is a white, alkaline powder used in baking. It contains about 28% potassium by mass. A 5 kg sack of food-grade potassium carbonate will have an activity of about 85 kBq, but this remains far below the exemption limits defined by German radiation protection law.



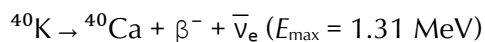
Left: Chemical structure of potassium carbonate. Right: A sample of anhydrous potassium carbonate

Images: Edgar181/[Wikimedia Commons](#), [Public Domain](#), Right: Walkerma/[Wikimedia Commons](#), [Public Domain](#)

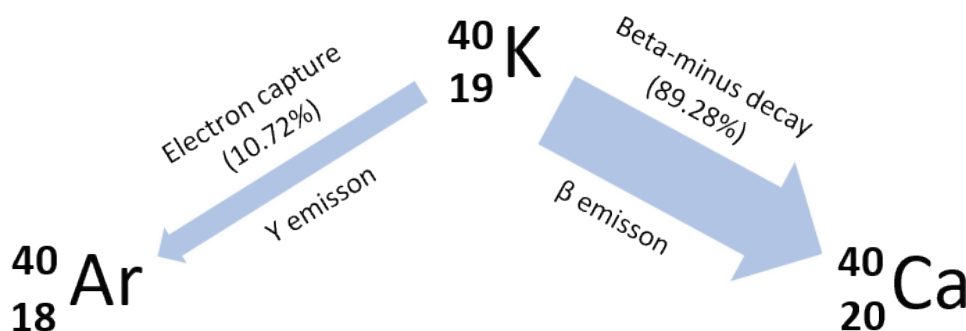
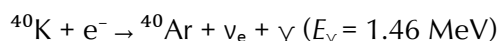
The decay of potassium-40

^{40}K is a naturally occurring radioactive isotope with a half-life of about 1.25 billion years. It decays through two main pathways:

Beta-minus decay (89.3%)



Electron capture (10.7%)



Two decay paths

Image: Tubas-en/[Wikimedia Commons](https://commons.wikimedia.org/wiki/File:Potassium-40_decay_paths.png), CC BY-SA 3.0

Gamma emission

"The daughter nuclide ^{40}Ar emits penetrating gamma radiation of 1.46 MeV, which contributes significantly to the external radiation exposure of humans."^[1] Gamma photons are emitted in 10.7% of all decays, but the gamma response of pancake gamma tubes is very low ($\approx 1\%$, depending on photon energy, compared to the beta response of $\approx 30\%$),^[2] so at first almost all your counts will be produced by electrons. The gamma flux is sufficient for measurement with standard G-M counters if you use a larger amount of potassium (25 kg bags of potassium carbonate or potassium chloride) and shield the beta radiation, which can be done simply with plastic of about 1–2 cm thick.

Specific activity and legal framework

The specific activity of potassium carbonate is about 17.5 Bq/g. German regulations (*Strahlenschutzverordnung* 2017) define an exemption limit of 1000 kBq for ^{40}K -containing materials. A typical classroom experiment using 5 kg of K_2CO_3 reaches only about 85 kBq.

Using 25 kg K_2CO_3 for gamma rays means approximately 425 kBq; both values are well below the legal threshold.

References

- [1] Krieger H (2007) *Grundlagen der Strahlungsphysik und des Strahlenschutzes*. Teubner. ISBN: 9783835101999
- [2] Steinmeyer P (2005) [G-M pancake detectors: Everything you've wanted to know](#). *RSO Magazine* **10**: 7–17.