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# Slides for Radioactive Decay

22.01 – Intro to Radiation

September 28 & 30, 2015

# Radioactive Decay

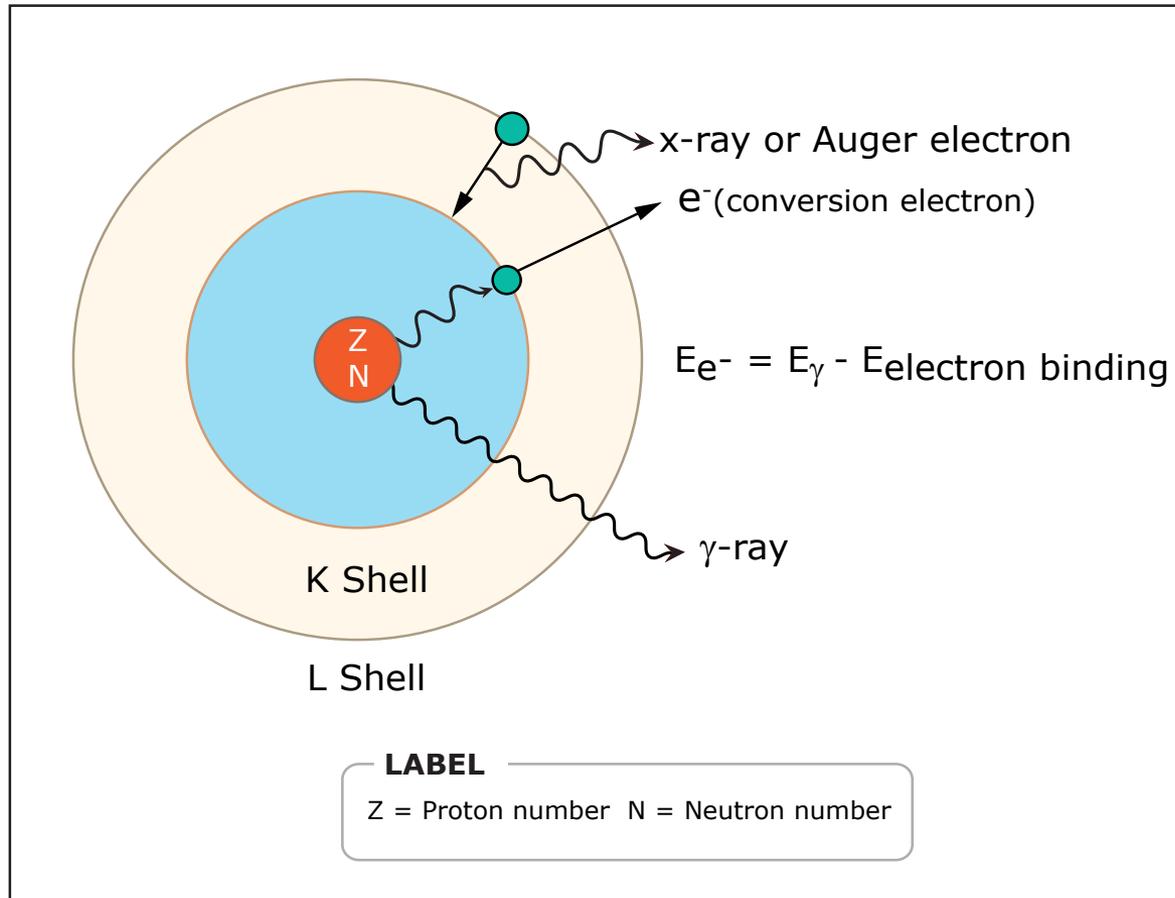


Image by MIT OpenCourseWare.

# Auger Electron Emission

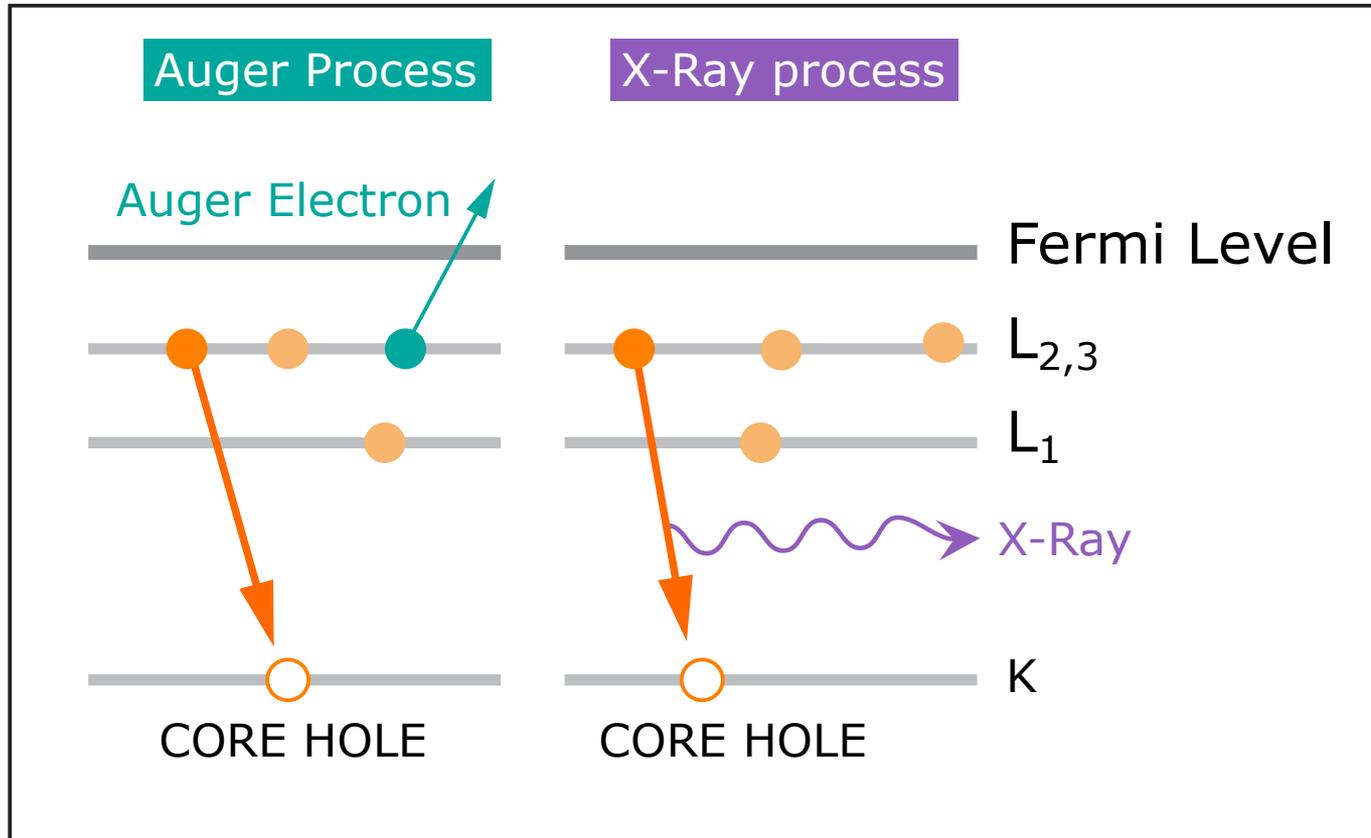
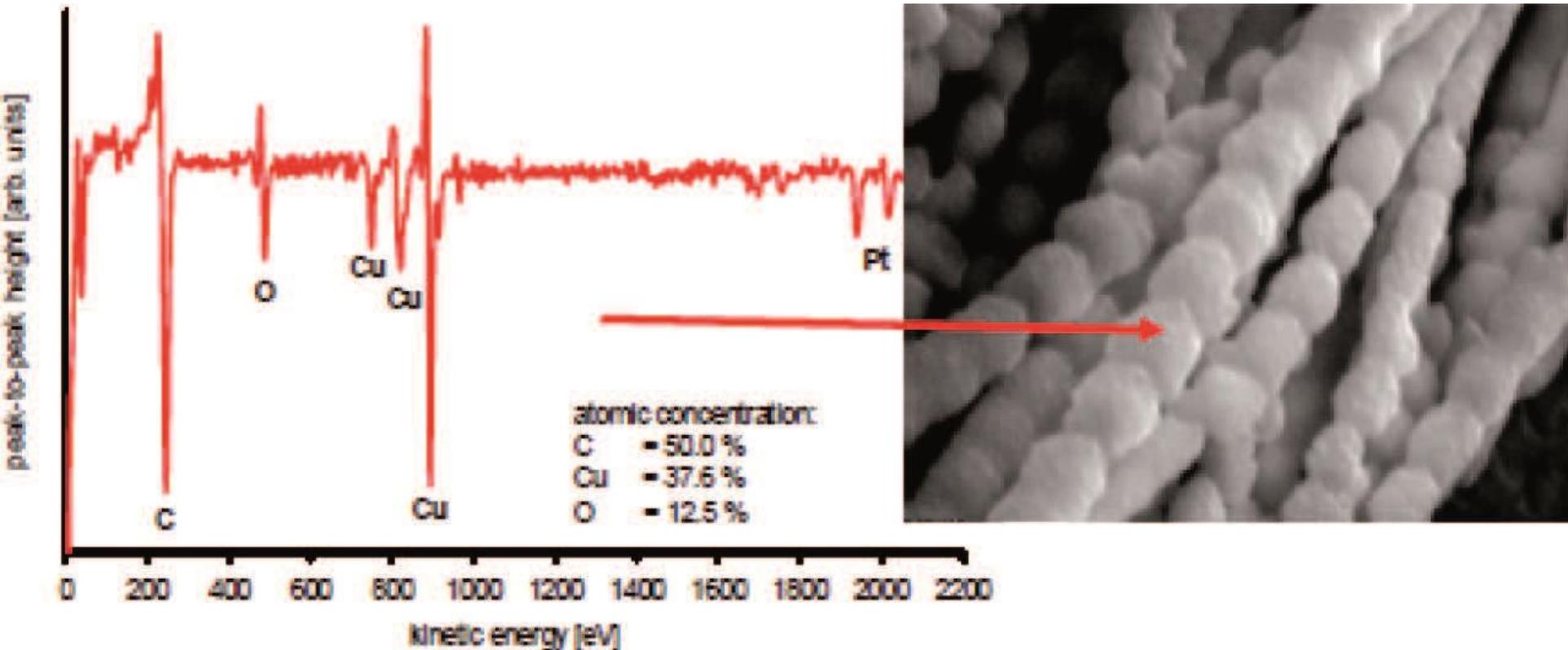


Image by MIT OpenCourseWare.

# Auger Electron Spectroscopy

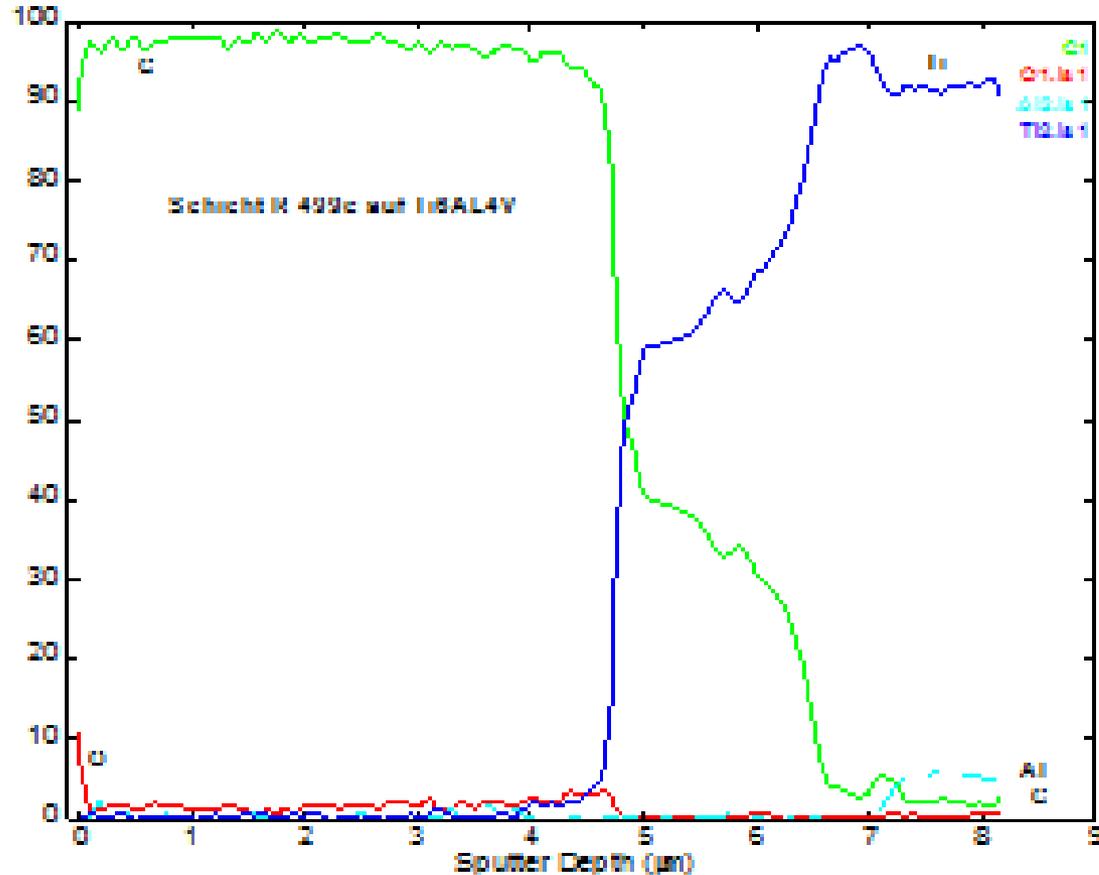
<https://www.knmf.kit.edu/AES.php>



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# Auger Depth Profiling

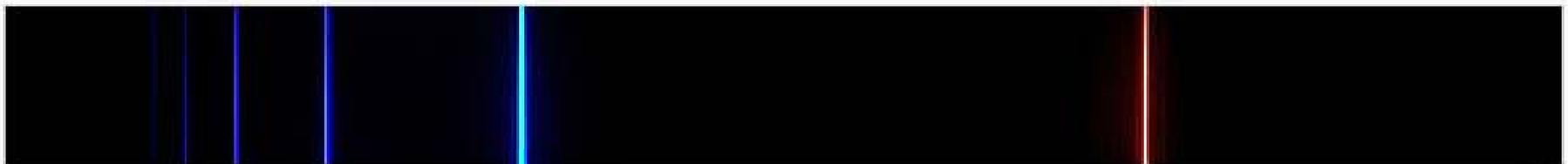
<https://www.knmf.kit.edu/AES.php>



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# Photon Emission Lines of Hydrogen

[https://en.wikipedia.org/wiki/Balmer\\_series](https://en.wikipedia.org/wiki/Balmer_series)



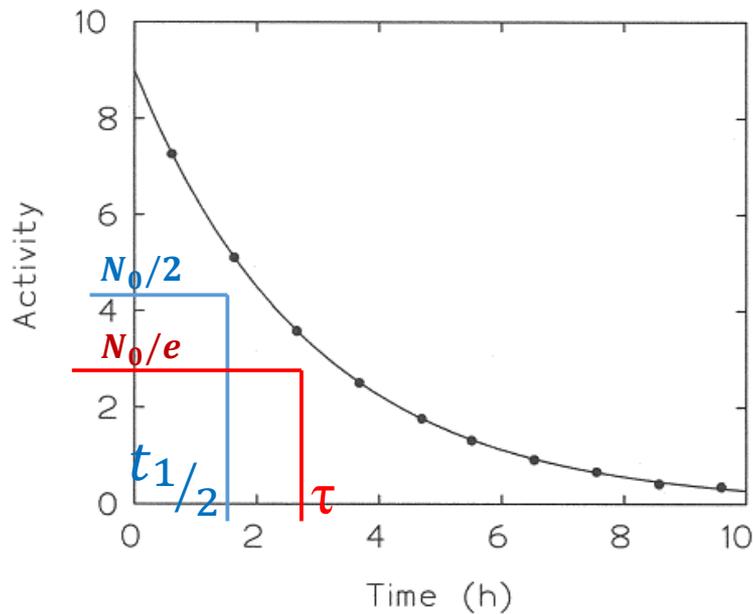
The visible hydrogen emission spectrum lines in the Balmer series. H-alpha is the red line at the right. The two leftmost lines are considered to be ultraviolet as they have wavelengths less than 400 nm.

Transition of $n$	3→2	4→2	5→2	6→2	7→2	8→2	9→2	$\infty$ →2
Name	H- $\alpha$	H- $\beta$	H- $\gamma$	H- $\delta$	H- $\epsilon$	H- $\zeta$	H- $\eta$	
Wavelength (nm) <sup>[2]</sup>	656.3	486.1	434.1	410.2	397.0	388.9	383.5	364.6
Color	Red	Blue-green	Violet	Violet	(Ultraviolet)	(Ultraviolet)	(Ultraviolet)	(Ultraviolet)

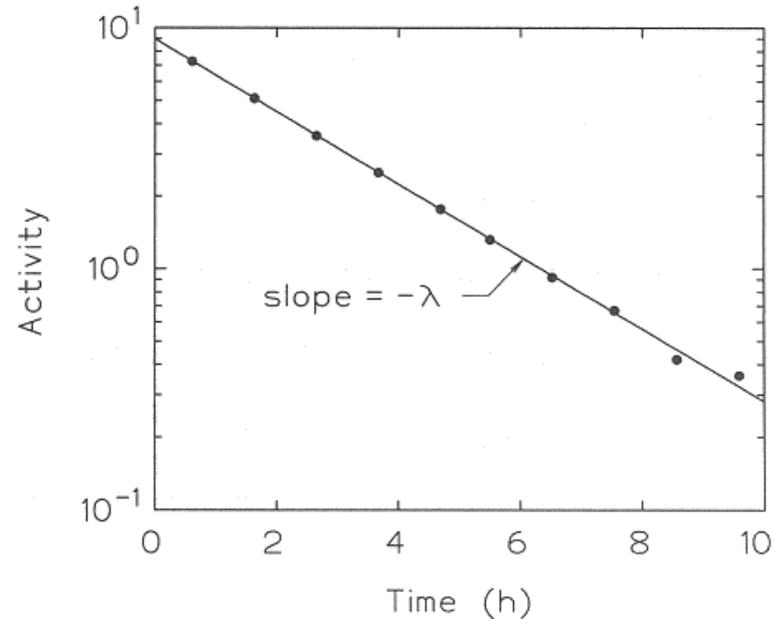
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# Half Life vs. Decay Constant

Yip, Sidney. *Nuclear Radiation Interactions*.



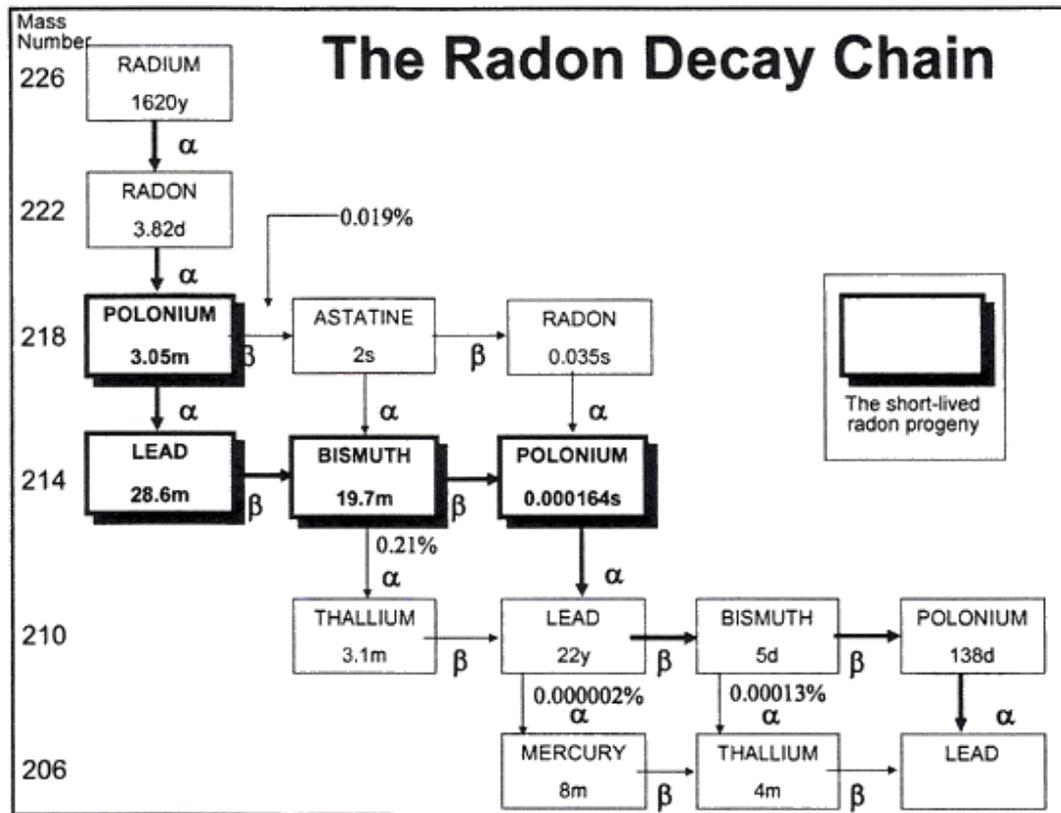
**Figure 5.15.** The activity of a radioactive sample with a half-life of two hours. At any time on the exponential curve, the activity is one-half of the activity two hours earlier.



**Figure 5.16.** Semilog plot of the decay of the sample's activity. The decay curve is a straight line with a slope of  $-\lambda$ , from which the half-life  $T_{1/2} = \ln 2/\lambda$  can be calculated.

Source: Yip, Sidney. *Nuclear Radiation Interactions*, 2014. © World Scientific Publishing Co. All rights reserved. This content is excluded from our Creative Commons license. For more information, see <http://ocw.mit.edu/help/faq-fair-use/>.

# The Radon Decay Chain



Courtesy of National Academies Press. Used with permission.

Source: National Research Council. *Health Effects of Exposure to Radon: BEIR VI*. The National Academies Press, 1999. doi:10.17226/5499.

# The Primordial Nuclides

Shultis, J. K., and R. E. Faw. *Fundamentals of Nuclear Science and Engineering*, 2nd Edition. CRC Press, 2007.

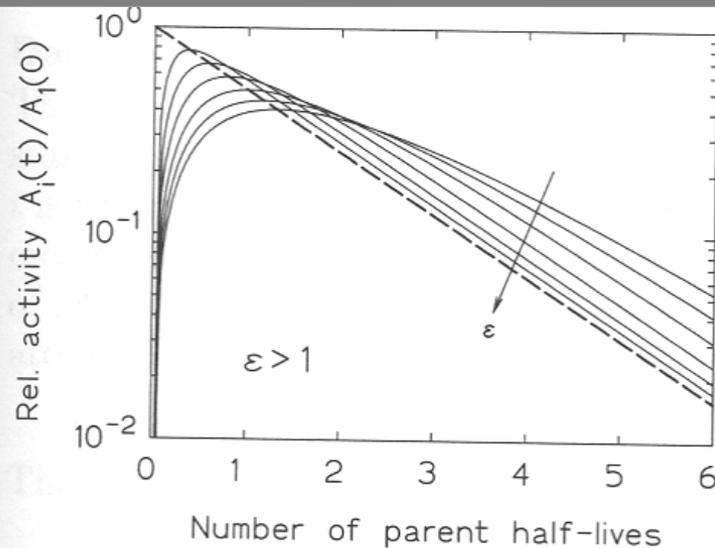
**Table 5.2.** The 17 isolated primordial radionuclides. Data taken from GE-NE [1996].

Radionuclide & the Decay Modes	Half-life (years)	% El. Abund.	Radionuclide & the Decay Modes	Half-life (years)	% El. Abund.
$^{40}_{19}\text{K}$ $\beta^-$ EC $\beta^+$	$1.27 \times 10^9$	0.0117	$^{50}_{23}\text{V}$ $\beta^-$ EC	$1.4 \times 10^{17}$	0.250
$^{87}_{37}\text{Rb}$ $\beta^-$	$4.88 \times 10^{10}$	27.84	$^{113}_{48}\text{Cd}$ $\beta^-$	$9 \times 10^{15}$	12.22
$^{115}_{49}\text{In}$ $\beta^-$	$4.4 \times 10^{14}$	95.71	$^{123}_{52}\text{Te}$ EC	$> 1.3 \times 10^{13}$	0.908
$^{138}_{57}\text{La}$ EC $\beta^-$	$1.05 \times 10^{11}$	0.090	$^{144}_{60}\text{Nd}$ $\alpha$	$2.38 \times 10^{15}$	23.80
$^{147}_{62}\text{Sm}$ $\alpha$	$1.06 \times 10^{11}$	15.0	$^{148}_{62}\text{Sm}$ $\alpha$	$7 \times 10^{15}$	11.3
$^{152}_{64}\text{Gd}$ $\alpha$	$1.1 \times 10^{14}$	0.20	$^{176}_{71}\text{Lu}$ $\beta^-$	$3.78 \times 10^{10}$	2.59
$^{174}_{72}\text{Hf}$ $\alpha$	$2.0 \times 10^{15}$	0.162	$^{180}_{73}\text{Ta}$ EC $\beta^+$	$> 1.2 \times 10^{15}$	0.012
$^{187}_{75}\text{Re}$ $\beta^-$	$4.3 \times 10^{10}$	62.60	$^{186}_{76}\text{Os}$ $\alpha$	$2 \times 10^{15}$	1.58
$^{190}_{78}\text{Pt}$ $\alpha$	$6.5 \times 10^{11}$	0.01			

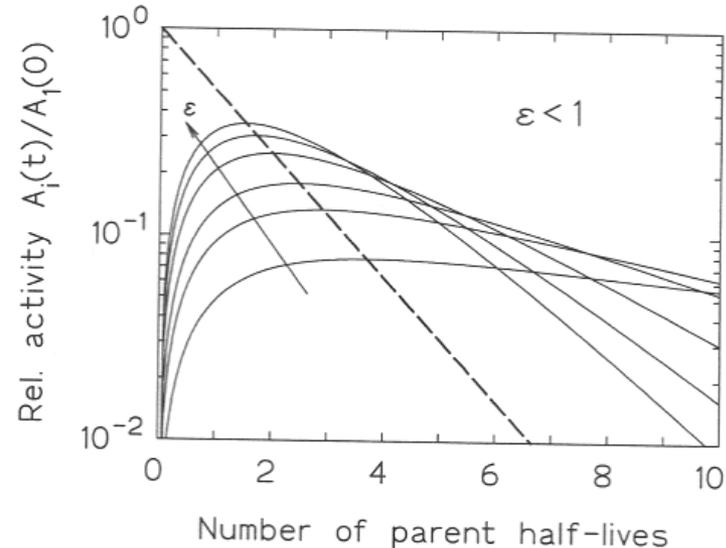
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Source: Shultis, J. K., and R. E. Faw. *Fundamentals of Nuclear Science and Engineering*, 2nd Edition. CRC Press, 2007.

# Series Decay Chains

Yip, Sidney. *Nuclear Radiation Interactions*.



**Figure 5.18.** Activity of the first daughter with a half-life less than that of the parent, i.e., the daughter's decay constant  $\lambda_2 = \epsilon\lambda_1$ ,  $\epsilon > 1$ . The six displayed daughter transients are for  $\epsilon = 1.2, 1.5, 2, 3, 5,$  and  $10$ . The heavy-dashed line is the parent's activity.



**Figure 5.19.** Activity of the first daughter with a half-life greater than that of the parent, i.e., the daughter's decay constant  $\lambda_2 = \epsilon\lambda_1$ ,  $\epsilon < 1$ . The six displayed daughter transients are for  $\epsilon = 0.9, 0.7, 0.5, 0.3, 0.2,$  and  $0.1$ . The heavy-dashed line is the parent's activity.

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22.01 Introduction to Nuclear Engineering and Ionizing Radiation  
Fall 2015

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