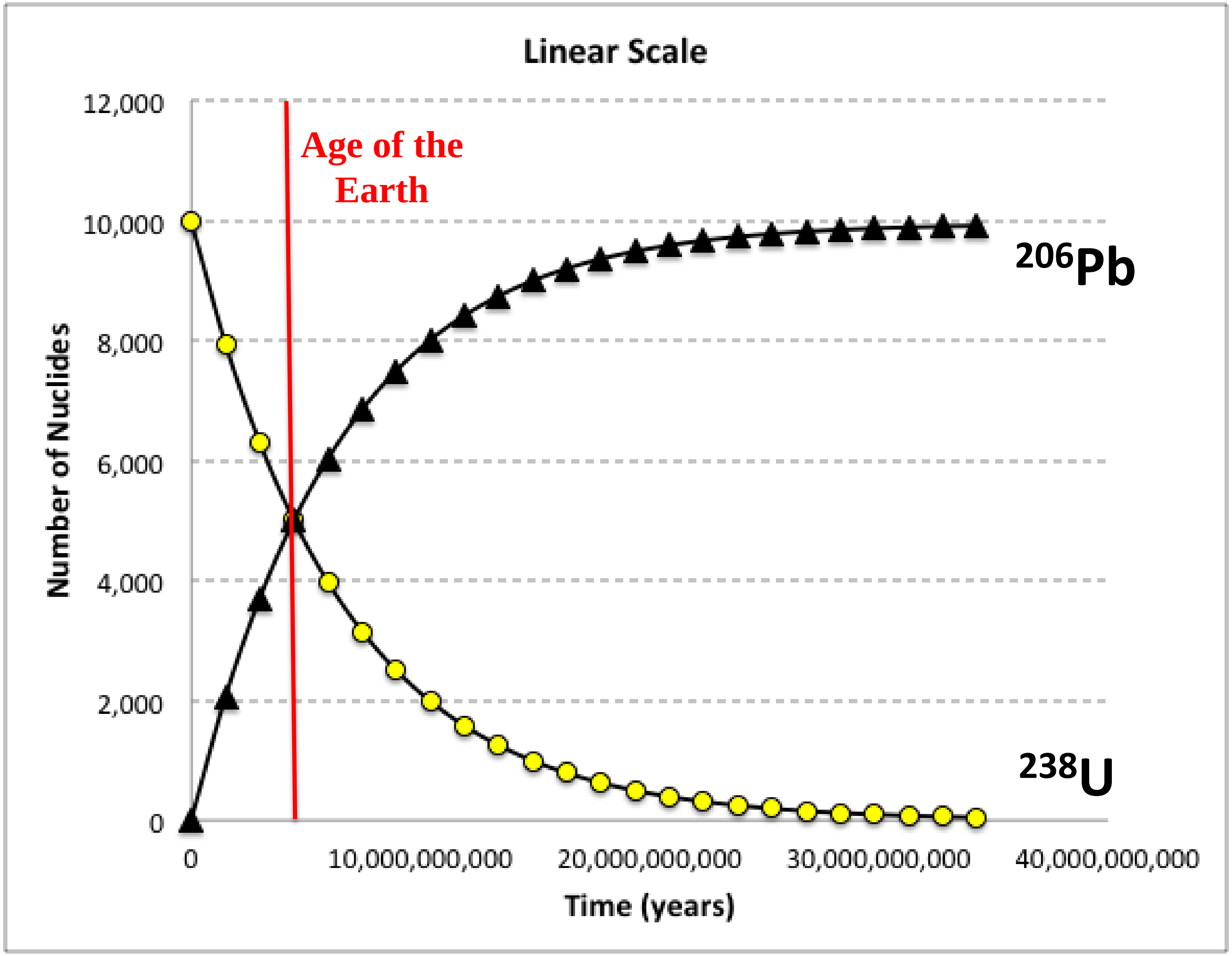
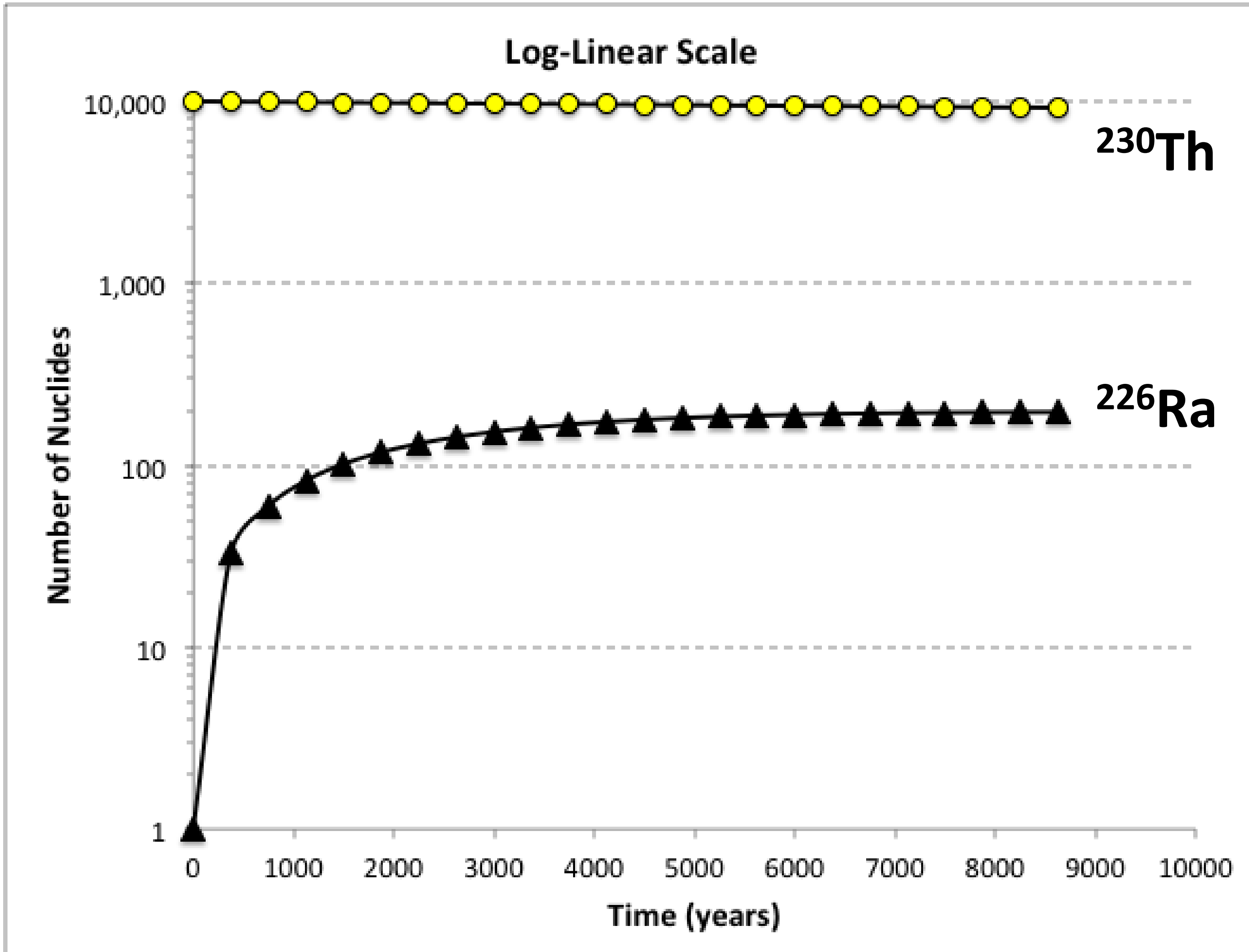
Simple Decay ($^{238}U \longrightarrow {}^{206}Pb$)



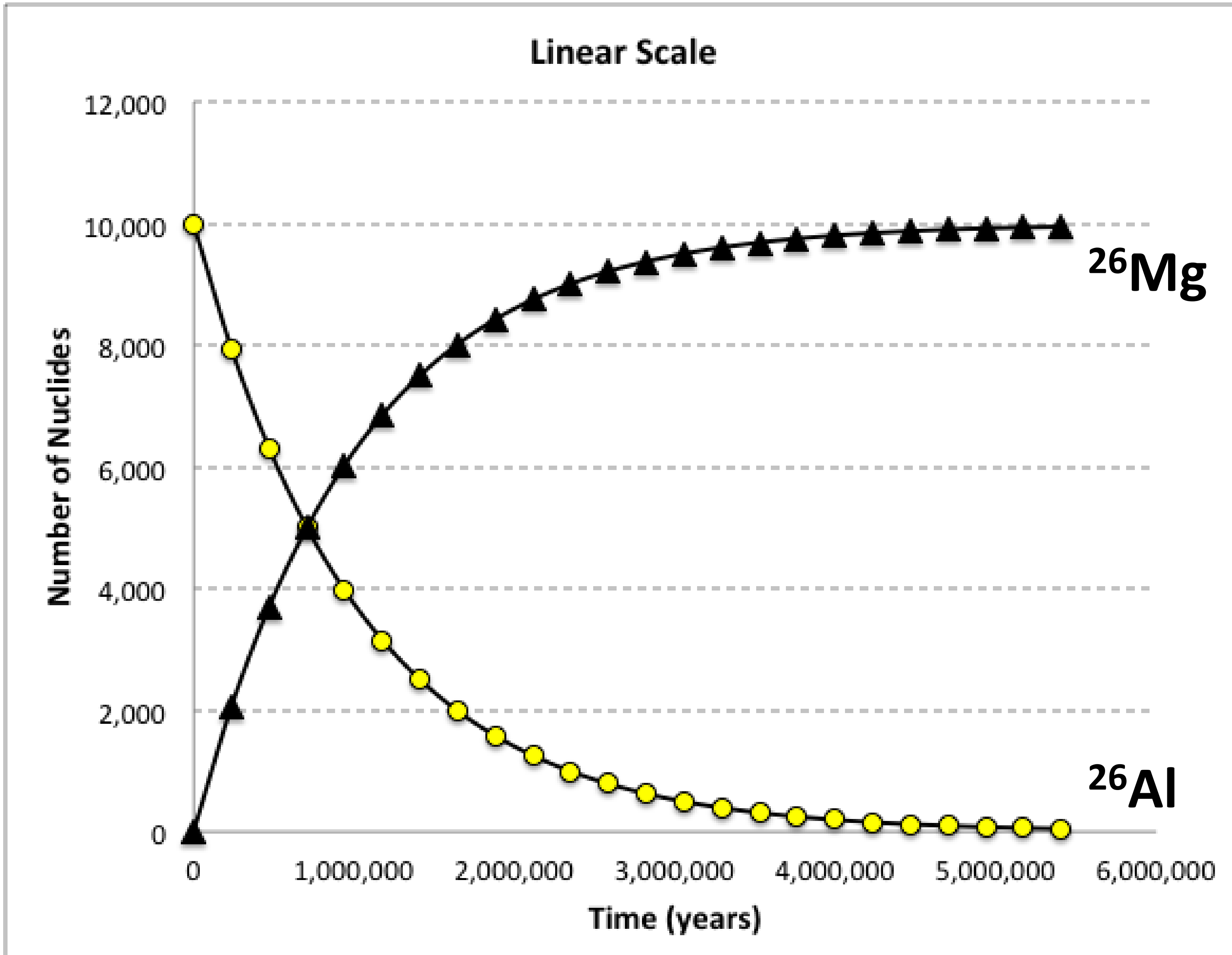
Peucker-Ehrenbrink, 2012

Decay Series ($^{230}Th \longrightarrow ^{226}Ra$)



Peucker-Ehrenbrink, 2012

Extinct Radionuclide ($^{26}Al \longrightarrow {}^{26}Mg$)



Peucker-Ehrenbrink, 2012

Important Extinct Radionuclides

Parent	*Daughter*	*Decay*	*Half-life (My)*	*Decay const.*
^{26}Al	^{26}Mg		0.716	9.8 10^{-7}
^{41}Ca	^{41}K	e^--capture	0.103	6.7 10^{-6}
^{53}Mn	^{53}Cr	e^--capture	3.7	1.9 10^{-7}
^{60}Fe	^{60}Ni	two β^-	1.5	4.7 10^{-7}
^{107}Pd	^{107}Ag	β^-	6.5	1.1 10^{-7}
^{129}I	^{129}Xe	β^-	15.7	4.3 10^{-8}
^{146}Sm	^{142}Nd	alpha	103	6.7 10^{-9}
^{182}Hf	^{182}W	two β^-	9.0	7.7 10^{-8}

How to calculate isotope abundances from isotope ratios

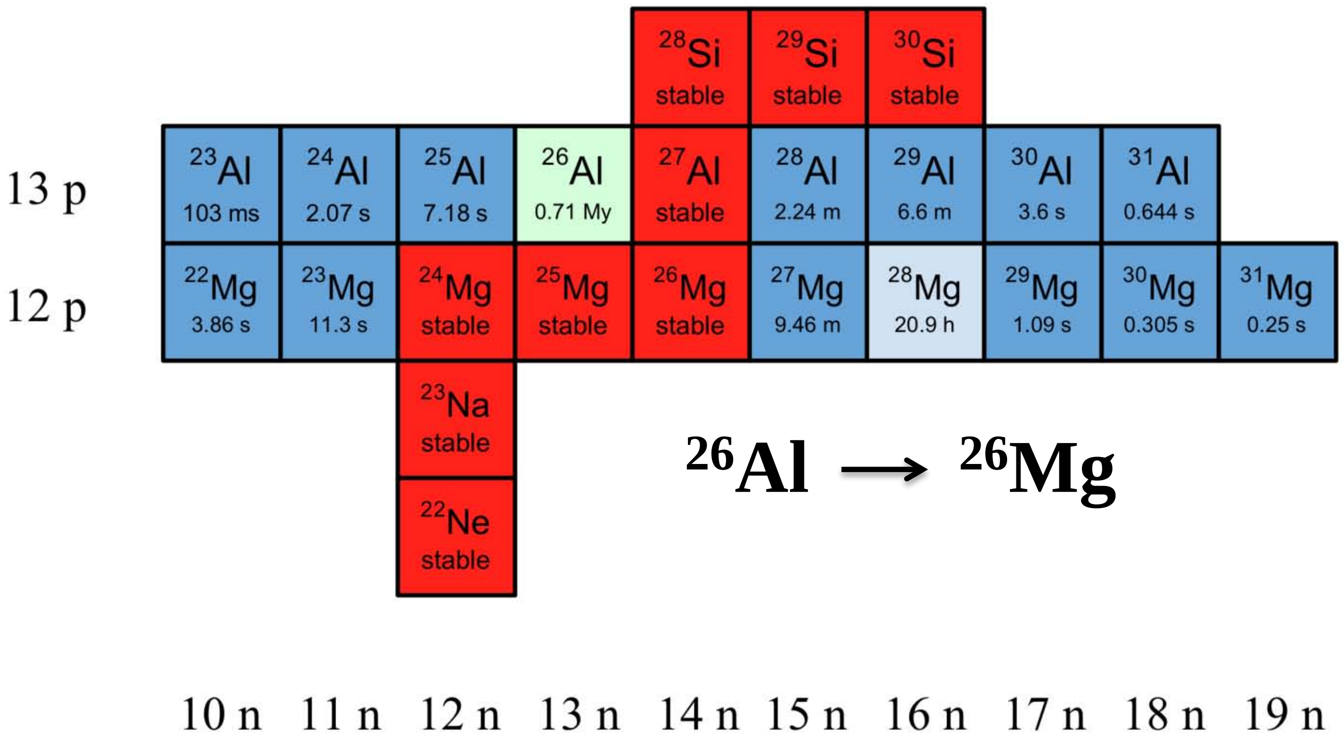
isotope ratios: $^{26}Mg/^{24}Mg = 0.1394$
$^{25}Mg/^{24}Mg = 0.1266$
$^{24}Mg/^{24}Mg = 1.0000$

Ratio sum = 1.2660

renormalize to ratio sum: $^{26}Mg/^{24}Mg = 0.1101$
$^{25}Mg/^{24}Mg = 0.1000$
$^{24}Mg/^{24}Mg = 0.7899$

New ratio sum = 1.0000

abundances: $^{26}Mg = 11.01\ \%$
$^{25}Mg = 10.00\ \%$
$^{24}Mg = 78.99\ \%$



e^- capture: $p^+ + e^- \longrightarrow n + \nu_e + E$

β^+- decay: $p^+ \longrightarrow n + e^+ + \nu_e + E$ **(check conservation laws)**

Important Extinct Radionuclides

Parent	*Daughter*	*Decay*	*Half-life (My)*	*Decay const.*
^{26}Al	^{26}Mg	e^- and β+	0.716	$9.8\ 10^{-7}$
^{41}Ca	^{41}K	e^--capture	0.103	$6.7\ 10^{-6}$
^{53}Mn	^{53}Cr	e^--capture	3.7	$1.9\ 10^{-7}$
^{60}Fe	^{60}Ni	2 beta minus	1.5	$4.7\ 10^{-7}$
^{107}Pd	^{107}Ag	beta minus	6.5	$1.1\ 10^{-7}$
^{129}I	^{129}Xe	beta minus	15.7	$4.3\ 10^{-8}$
^{146}Sm	^{142}Nd	alpha	103	$6.7\ 10^{-9}$
^{182}Hf	^{182}W	2 beta minus	9.0	$7.7\ 10^{-8}$

Extinct Radionuclides

Remember "Simple Decay":

1) $$-dN_1/dt = \lambda_1 N_1$$

What happens in a simple decay scheme if λ_1 is so large, i.e. the half-life is so short, that none of the original radioisotope remains today? For example, consider the decay of ^{26}Al to ^{26}Mg with a half-life of 705,000 years:

2) $$^{26}Mg_t = {}^{26}Mg_0 + {}^{26}Al\,(e^{\lambda t} - 1)$$

The ^{26}Al that was present during the early history of the solar system has decayed.

However, that ^{26}Al has decayed to ^{26}Mg. The amount of "extra" ^{26}Mg is a function of the initial ratio of Al to Mg in a sample and the timing of the formation of the sample. It will have more "extra" ^{26}Mg if it formed early during the period when ^{26}Al was still abundant. We can therefore state that

3) $$^{26}Mg/^{24}Mg_t = {}^{26}Mg/^{24}Mg_0 + {}^{26}Al/^{24}Mg$$

We substitute the second, unknown, term with:

4) $$^{26}Al/^{24}Mg_t = (^{26}Al/^{27}Al)_t\ (^{27}Al/^{24}Mg)_t$$

Rearrange:

5) $$^{26}Mg/^{24}Mg_t = {}^{26}Mg/^{24}Mg_0 + (^{26}Al/^{27}Al)_t\ (^{27}Al/^{24}Mg)_t$$

This is the equation of a line ($y = b + mx$) in $^{26}Mg/^{24}Mg_t$ over ($^{27}Al/^{24}Mg$) space where the slope (m) is

6) $$m = {}^{26}Al/^{27}Al_t$$

Extinct Radionuclide Systematics

Figure of $^{26}Mg/^{24}Mg$ vs. $^{27}Al/^{24}Mg$ with model isochron lines and "forbidden region" removed due to copyright restrictions.

See figure 10.4 on page 122 of Tolstikhin, Igor and Jan Kramers. "The Evolution of Matter: From the Big Bang to the Present Day." Cambridge University Press, 2008.

Extinct Radionuclide Systematics

Figure of $^{26}Mg/^{24}Mg$, $^{27}Al/^{24}Mg$, and $\delta^{26}Mg$ values in the Allende and meteorite and Melilite mantle minerals removed due to copyright restrictions.

See figure 10.6 on page 125 of Tolstikhin, Igor and Jan Kramers. "The Evolution of Matter: From the Big Bang to the Present Day." Cambridge University Press, 2008.

Extinct Radionuclide Systematics

Figure of $^{26}Mg/^{24}Mg$, $^{27}Al/^{24}Mg$, and $\delta^{26}Mg$ values in meteorites removed due to copyright restrictions.

See figure 10.7 on page 126 of Tolstikhin, Igor and Jan Kramers. "The Evolution of Matter: From the Big Bang to the Present Day." Cambridge University Press, 2008.