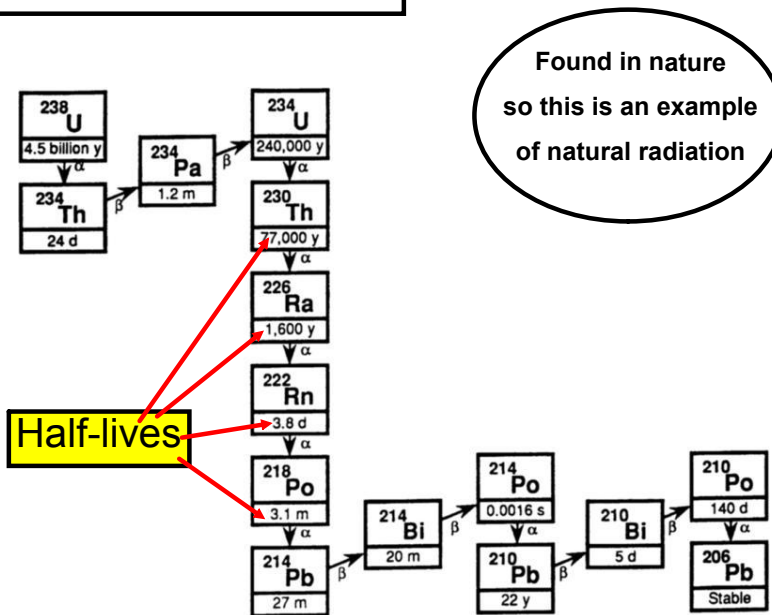


Half-Lives of Radioactive Isotopes

U-238 Decay Chain:



Half-life: for a radioactive isotope, it is the amount of time that it takes for half of the atoms in a sample to decay (e.g. by α - or β -decay) into a different element.

e.g. The half-life of U-238 is 4.5 billion years.

So, if 20g U-238 is present in a sample now, then in 4.5 billion years there will be 10g left (half of the 20g will have decayed, or transmuted, into Th-234).

Half-Life is a constant for each radioactive isotope.

This means that, for U-238 it is ALWAYS 4.5 billion years.

The half-life for Th-234 is ALWAYS 24 days.

The half-life for Pa-234 is ALWAYS 1.2 minutes.

These half-lives don't change, even if the temperature, pressure or surface area is increased!

Some half-life problems:

1. Uranium-238 has a half-life of 4.5×10^9 years. If 2 tonnes of U-238 are stored away, how much will be left after 13.5×10^9 years?

$1000\ 000\ 000$ (1 tonne = 1000 kg)

time	mass
0	2 tonnes
$+4.5 \times 10^9$ yrs	1 tonne $\div 2$
$+4.5 \times 10^9$ yrs	0.5 tonne $\div 2$
13.5×10^9 yrs	0.25 tonne

ANS
0.25 tonne

2. Strontium-90 has a half-life of 28 years. How long will it take for 0.1 mg of Sr-90 to decay to 0.0125 mg?

Beginning time	mass	Starting mass
0	0.1 mg	
$+28$ yrs	0.05 mg $\div 2$	
$+28$ yrs	0.025 mg $\div 2$	
84 yrs	0.0125 mg	

ANS
84 yrs !

3. Radiation emitted by the decay of Co-60 is used in treating cancer patients. A 500 g sample of Co-60 is purchased by a hospital. What mass of Co-60 is left after 26.5 years? The half-life of Co-60 is 5.3 years.

Time	Mass	Starting mass
half-life 0	500g	
$+5.3$ yrs	250g	
$+5.3$ yrs	125g	
$+5.3$ yrs	62.5g	
$+5.3$ yrs	31.25g	
26.5 yrs	15.625g	

ANS
15.625g

4. a) Iodine-131 is used in medical diagnostic and treatment procedures. The half-life of I-131 is 8 days. How much of a 340 g sample of I-131 will remain after 24 days?

Time	Mass
0	340g
8	170g
16	85g
24	42.5g

42.5g
Will be left

- b) Why do you think that radioactive isotopes with short half-lives are used in medical treatments?

They leave the body more quickly.

5. C-14 undergoes beta decay and its half-life is 5720 years.

a) Write the equation for the beta decay of C-14.



b) Given 250 g of C-14, how many grams of C-14 will remain after 17 ~~190~~ years?

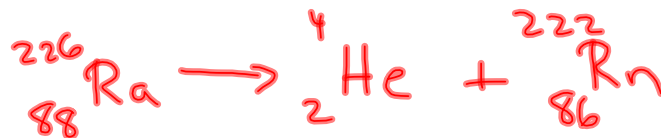
31.25g 😊

Time	Mass
0	250g
5720	125g
11440	62.5g
17160	31.25g

c) Where did the "lost" C-14 go?

It turned into N-14

6. a) Ra-226 decays through alpha decay. Write the equation for this transmutation.



b) How long will it take for a 5-tonne sample of Ra-226 to decay until there is only 0.156 tonne left? The half-life of Ra-226 is 1620 years.

ANS:
8100 yrs.

time	mass
0	5 tonne
1620y	2.5 tonne
3240y	1.25 t
4860y	0.625 t
6480y	0.3125
8100y	0.156 t

→ ans

c) What has happened to the "missing" Ra-226?

Turned into Rn-222

7. a) A half-tonne of U-238 is stored away. How long will it take before only 0.03125 tonne of U-238 remains? (see #1 for half-life)

→ 0.5 tonne
 18×10^9 y
 (or 1.8×10^{10} y)

time	mass
0	0.5 tonne
4.5×10^9	0.25 tonne
9×10^9	0.125 tonne
13.5×10^9	0.0625 "
18×10^9	0.03125 t.

- b) How will this time (found in (a)) be affected if the U-238 is ground up into a powder?

NO EFFECT!

8. a) A 10kg metal pipe contains 804 g of Pb-209. What mass of this isotope will remain after 13.2 hours?

The half-life of Pb-209 is 3.3 hours.

ANS: 50.25g

Relevant

time	mass
0	804 g
3.3 h	402 g
6.6 h	201 g
9.9 h	100.5g
13.2 h	50.25

- b) If the 10kg metal pipe in (a) is heated to 200 degrees Celcius, then what effect will this have on the rate at which the Pb-209 decays?

NO EFFECT

9. Ac-228 has a half life of 6 hours. How much of a 5.0 mg sample would remain after one day?

time	mass
0	5.0 mg
6 h	2.5 mg
12 h	1.25 mg
18 h	0.625 mg
24 h	0.3125 mg

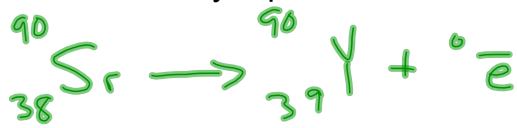
1 day = 24 h

9.

ANS
0.3125 mg

10. A 5kg bone contains 648mg of Sr-90. The half-life of Sr-90 is 29 years. Sr-90 undergoes beta decay. → Relevant

a) Write the beta decay equation for this transmutation.



b) How long will it be before only 20.25mg of Sr-90 remains.

145 yrs

time	mass
0	648
29	324
58	162
87	81
116	40.5
145	20.25

c) Determine the mass of the product isotope that has been produced during this beta decay.

mass # = 90

180g of

11. Radon gas is one of the air contaminants near Uranium mines.

Rn-222 undergoes alpha decay and its half-life is 3.8 days.

What mass of Rn-222 would remain after 19 days?

ANS

5.625g

time	mass
0	180g
3.8 d	90g
7.6	45g
11.4	22.5g
15.2	11.25g
19	5.625g

12. If the Radon gas in question 11 is collected and placed in a very small container to increase its pressure, how will this affect the rate at which the isotope decays?

NO EFFECT!

