⑦ The Decay Constant, activity and Half-Life.

→ radioactive decay happens spontaneously [poljubno vezpadu] and at random

→ if a radio active sample contains N radio active nuclei, than the number ΔN of nuclei, that decay in a small time interval Δt is proportional to N

$$\frac{\Delta N}{\Delta t} \sim N$$

$$\Rightarrow \Delta N = -\lambda N \Delta t$$

negative number

; λ .. decay constant
.. speed or rate at which the isotope decays

→ Activity (or decay rate) of a sample → number of decays per second

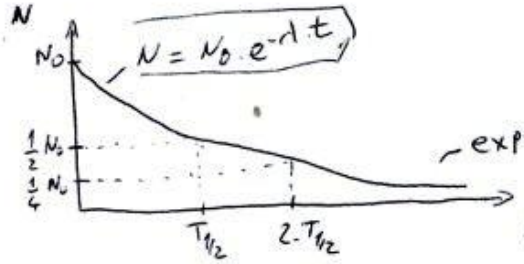
$$R = \left|\frac{\Delta N}{\Delta t}\right| = \lambda \cdot N$$

→ activity is higher for isotopes with bigger λ

→ activity is higher for isotopes with bigger number of undecayed atoms

unit $[R]$ = Bq ... bequerel → 1 Bq = 1 decay/s

→ decay curve



e = 2,71... euler's constant

- exponential function

→ half-life $T_{1/2}$ ... the time it takes for half of a given number of radioactive nuclei to decay

$$\frac{N_0}{2} = N_0 \cdot e^{-\lambda \cdot T_{1/2}}$$

$$\frac{1}{2} = \frac{1}{e^{\lambda \cdot T_{1/2}}}$$

$$\ln 2 = \lambda \cdot T_{1/2}$$

$$T_{1/2} = \frac{\ln 2}{\lambda} = \frac{0{,}693}{\lambda}$$

E.g.: $N_0 = 16$ nuc.
$T_{1/2} = 5$ s

t	0	5	10	15
N	16	8	4	2

radioactive isotope	half-life
boron-12	0.02 seconds
radon-220	52 seconds
iodine-128	25 minutes
radon-222	3.8 days
strontium-90	28 years
radium-226	1602 years
carbon-14	5730 years
plutonium-239	24 400 years
uranium-235	7.1×10^8 years
uranium-238	4.5×10^9 years

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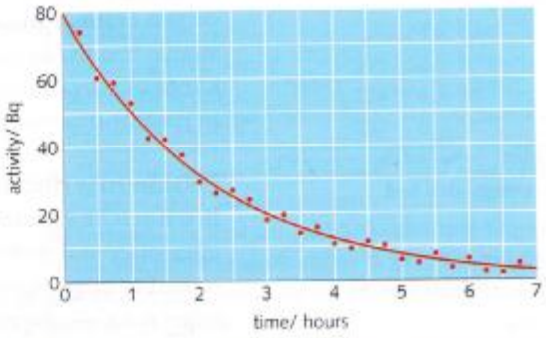
To answer questions 1 and 2, you will need information from the table of half-lives on the opposite page.

1 If samples of strontium-90 and radium-226 both had the same activity today, which would have the lower activity in 10 years' time?

2 If the activity of a sample of iodine-128 is 800 Bq, what would you expect the activity to be after
a) 25 minutes **b)** 50 minutes **c)** 100 minutes?

3 The graph on the right shows how the activity of a small radioactive sample varied with time.
a) Why are the points not on a smooth curve?
b) Estimate the half-life of the sample.



29.1 True or False: A radioactive atom always decays after two half-lives have elapsed.

29.2 What fraction of a radioactive sample has decayed after three half-lives have elapsed? (a) 1/8 (b) 3/4 (c) 7/8 (d) none of these

29.3 Suppose the decay constant of radioactive substance A is twice the decay constant of radioactive substance B. If substance B has a half-life of 4 h, what's the half-life of substance A? (a) 8 h (b) 4 h (c) 2 h

EXAMPLE 29.2 The Activity of Radium

GOAL Calculate the activity of a radioactive substance at different times.

PROBLEM The half-life of the radioactive nucleus $^{226}_{88}$Ra is 1.6×10^3 yr. If a sample initially contains 3.00×10^{16} such nuclei, determine **(a)** the initial activity in curies, **(b)** the number of radium nuclei remaining after 4.8×10^3 yr, and **(c)** the activity at this later time.