NUCLEAR CHEMISTRY

KINETICS: RADIOACTIVE DECAY RATES

CHEMISTRY 165 // SPRING 2020

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PRACTICE PROBLEM 1

^{60}Co decays with a half-life of 5.27 years to produce ^{60}Ni. Calculate the fraction of original sample of ^{60}Co that will remain after 15 years has passed.

– answer –

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Because radioactive decay obeys first-order kinetics, we can apply the integrated rate law to find the fraction:

$$\frac{N_t}{N_0} = 0.5^{\frac{t}{t_{1/2}}}$$

$$= 0.5^{\frac{15\ \mathrm{yr}}{5.27\ \mathrm{yr}}}$$

$$\frac{N_t}{N_0} = 0.139$$

PRACTICE PROBLEM 2

^{239}Pu decays with a half-life of $t_{1/2} = 2.41 \times 10^4$ years. Calculate the time it would take for a sample of ^{239}Pu to decay to 2.5% of its original population.

— answer —

PRACTICE PROBLEM 2

^{239}Pu decays with a half-life of $t_{1/2} = 2.41 \times 10^4$ years. Calculate the time it would take for a sample of ^{239}Pu to decay to 2.5% of its original population.

— answer —

Because radioactive decay obeys first-order kinetics, we can apply the integrated rate law to find the time:

$$t = -\frac{t_{1/2}}{\ln 2} \ln \frac{N_t}{N_0}$$

$$= -\frac{2.41 \times 10^4 \text{ yr}}{\ln 2} \ln \frac{2.5}{100}$$

$$t = 1.28 \times 10^5 \text{ yr}$$

PRACTICE PROBLEM 3

A lump of charcoal (A) has a measured ^{14}C decay rate of 50 counts per hour. A recently made piece of coal (B) of the same mass has a decay rate of 170 counts per hour. If the half life of carbon-14 is 5730 years, how old is charcoal A?

— answer —

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A lump of charcoal (A) has a measured ^{14}C decay rate of 50 counts per hour. A recently made piece of coal (B) of the same mass has a decay rate of 170 counts per hour. If the half life of carbon-14 is 5730 years, how old is charcoal A?

— answer —

Because radioactive decay obeys first-order kinetics, we know the rate law is: Rate = kN.

In order to determine the age of sample A, we need to use the integrated rate law:

$$t = -\frac{t_{1/2}}{\ln 2} \ln \frac{N_t}{N_0}$$

However, this requires us to determine the ratio $\frac{N_t}{N_0}$, which we can do by comparing the two rates.

$$\frac{\mathrm{Rate_A}}{\mathrm{Rate_B}} = \frac{kN_\mathrm{A}}{kN_\mathrm{B}}$$
$$\frac{50\ \mathrm{counts/hr}}{170\ \mathrm{counts/hr}} = \frac{N_\mathrm{A}}{N_\mathrm{B}}$$
$$\frac{N_\mathrm{A}}{N_\mathrm{B}} = 0.29_4$$

$$t = -\frac{t_{1/2}}{\ln 2} \ln \frac{N_t}{N_0}$$
$$= -\frac{5730\ \mathrm{yr}}{\ln 2} \ln(0.29_4)$$
$$t = 1.01 \times 10^4\ \mathrm{yr}$$