7.3 Half-Life

1. Measuring the rate of radioactive decay processes: Half-life

Half-life: Average time for half of a radioactive substance to decay.

Rate of decay:  Exponential

Mass of a radioactive material: $A = A_0\left(\frac{1}{2}\right)^{\frac{t}{h}}$ (h is half-life)

Neon-19 has a half-life of 17.22 s. What mass of neon-19 will remain from a 100 mg initial sample after 30 s?

G: $h = 17.22\text{s}$, $A_0 = 100\text{mg}$, $t = 30\text{s}$

R: A E: $A = A_0\left(\frac{1}{2}\right)^{\frac{t}{h}}$

S: $A = (100\text{mg})\left(\frac{1}{2}\right)^{(30/17.22)} = 29.9\text{mg} = 30\text{mg}$

S: ∴ 30 mg remain.

A 100 mg sample of magnesium-27 decays by 7% of its previous mass every minute. Determine its half-life and state the half-life decay equation.

Time (min)	Initial mass (mg)	Final mass (mg)
0	100	100 − 7 = 93
1	93	93 − 6.51 = 86.49
2	86.49	−6.05 = 80.44
3	80.44	74.81
4	74.81	69.57
5	69.57	64.70
6	64.70	60.17
7	60.17	55.96
8	55.96	52.04
9	52.04	48.40
10	48.40	45.01

93 × 0.07 = 6.51

= 80.44 × 0.93

∴ h = 9.5 min

$A = A_0\left(\frac{1}{2}\right)^{t/9.5}$

2. Applications of half-life: Carbon dating

Half-life of carbon-14: 5730 years

Carbon-14 decay: $^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}e$ (β-negative)

Carbon-14 absorption: $CO_2 \rightarrow$ Plants $\rightarrow$ animals $\rightarrow$ Us
(fixed ratio of C-14 : C-12 while living)

Half-life of aluminum-26: 720 000 years

Aluminum-26 decay: $^{26}_{13}Al \rightarrow {}^{26}_{12}Mg + {}^{0}_{+1}e$ (β-positive).

$\Rightarrow$ date interstellar rocks (meteorites)

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