UBC Physics 102

Lecture 2

Rik Blok

Outline

- ▷ Radioactivity
- ▷ Alpha decay
- ▷ Beta decay
- ▷ Gamma decay
- ▷ Rate of decay
- ▷ Half-life
- ▷ Activity
- ▷ Radioactive dating
- ▷ End

Radioactivity [Text: Sect. 42-3]

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γ (gamma)	photon	none	*very* light

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  - Smoke interrupts current to trip alarm.

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  - Produced by decay of neutron:

$$n \rightarrow p^{+} + e^{-} (+\text{ neutrino})$$

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- λ (lambda) is proportionality constant that sets rate.
- Can integrate to find how much material remains after time t,

$$\boxed{N(t) = N_0 e^{-\lambda t}.}$$

Half-life [Text: Sect. 42-8]

- **Derivation: Half-life, $T_{1/2}$**
  - The time it takes for half the original amount of isotope to decay. Is solution to

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- **Interactive Quiz: PRS 02b**
- **Definition:** ***Half-life,*** $T_{1/2}$

$$\boxed{T_{1/2} = \frac{\ln 2}{\lambda}}$$

Activity [Text: Sect. 42-8]

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  - Rate of decay, or number of decays per second of a sample.

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- **Example:**
  - $^{31}\mathrm{Si}$ has a half-life of of $2.62\ \mathrm{hr}$. What will the activity of a $1\ \mathrm{g}$ sample be after $1\ \mathrm{week}$?

Activity, contd

- **Solution:**
  - We know $\boxed{N(t) = N_0 e^{-\lambda t}}$. Then

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  - Need to calculate N_0, λ, and t. First, t (in hours) is $t = 1\ \mathrm{wk} = 168\ \mathrm{hr}$.
  - Now, use half-life, $\boxed{T_{1/2} = \frac{\ln 2}{\lambda}}$ to get λ,

$$\begin{aligned} \lambda &= \frac{\ln 2}{T_{1/2}} = \frac{0.693}{2.62\ \mathrm{hr}} \\ &= 0.265\ \mathrm{hr}^{-1}. \end{aligned}$$

Activity, contd

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$$\begin{aligned} N_0 &= 10^{-3} \text{ kg} \times \frac{1 \text{ u}}{1.66 \times 10^{-27} \text{ kg}} \times \frac{1 \text{ particle}}{31 \text{ u}} \\ &= 1.94 \times 10^{22} \text{ particles.} \end{aligned}$$

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  - So activity is

$$\begin{aligned} \left|\frac{dN}{dt}\right| &= \lambda N_0 e^{-\lambda t} \\ &= (0.265 \text{ hr}^{-1})(1.94\times10^{22} \text{ part.})e^{-(0.265 \text{ hr}^{-1})(168 \text{ hr})} \\ &= 238 \text{ particles/hr.} \quad \square \end{aligned}$$

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  - No longer absorbed after death so ${}^{14}\mathrm{C}$ decays.
  - Can estimate how long ago specimen died by using $\boxed{N(t) = N_0 e^{-\lambda t}}$ to determine time needed to get N down to current value,

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- **Discussion: Carbon dating, contd**
  - λ can be calculated from half-life, $T_{1/2} = 5730\ \mathrm{yr}$.
  - N_0 can be determined from total number of carbon atoms in sample.
  - Measure activity to get current N, from $\boxed{\left|\frac{dN}{dt}\right| = \lambda N}$.

End

- **Practice Problems:**
  - Ch. 42: Q. 7, 13, 19, 21, 25
  - Ch. 42: Pr. 35, 37, 39, 43, 45, 47, 49, 55, 63, 65

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- **Interactive Quiz: Feedback**

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- **Interactive Quiz: Feedback**
- **Tutorial Question: tut02**