Intensity of Radiation

ADVANCED AP

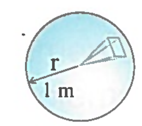
Intensity

The **intensity of radiation** measures how much energy flows per unit of area per second.

$$\text{Intensity (W/m}^2) = \frac{\text{Power (W)}}{\text{Area (m}^2)}, \quad I = \frac{P}{A}$$

Intensity

$$\underset{\text{Intensity (W/m}^2)}{I} = \frac{P \ \text{Power (W)}}{A \ \text{Area (m}^2)}$$



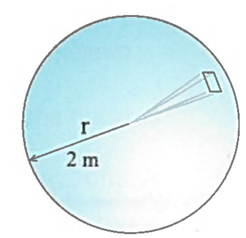
Area, $A = 4\pi r^2 = 12.6\ \text{m}^2$

Intensity, $I = \dfrac{100\ \text{W}}{12.6\ \text{m}^2} = 7.96\ \text{W/m}^2$

On a clear day, the intensity of sunlight on the surface of the Earth is about 1,000 watts per square meter (W/m^2). A good flashlight produces an intensity of about 100 W/m2 in the brightest part of the beam at a distance of a half- meter.

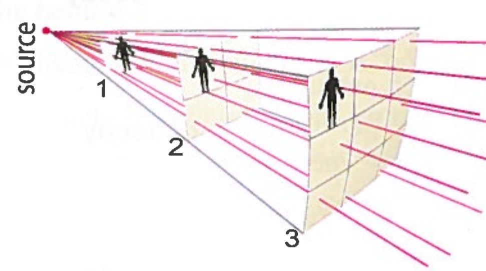
Inverse square law

When radiation comes from a single point, the intensity decreases inversely over the square of the distance. This is called the **inverse square law**. If you get two times farther away from a radiation source, the intensity goes down by a factor of 1/4, which is one divided by the square of two ($1/4 = 1/2^2$). If you get 10 times farther away, the intensity goes down by one divided by 10 squared ($1/100 = 1/10^2$).



Area, $A = 4\pi r^2 = 50.4\ \text{m}^2$

Intensity, $I = \dfrac{100\ \text{W}}{50.4\ \text{m}^2} = 1.99\ \text{W/m}^2$



The further we are from a source the smaller the amount of radiation exposure. Increasing the distance by 3 decreases the radiation by 9.

The inverse square law is a property of geometry. Think of a 100-watt light bulb at the center of a sphere of radius r. The intensity at the surface of the sphere is 100 watts divided by the area of the sphere ($4\pi r^2$). At twice the distance, the area of the sphere is four times greater. Since the same amount of power is spread over a larger area, the intensity goes down. Mathematically, the area goes up like the square of the radius, so the intensity goes down like the inverse square of the radius. This is the inverse square law.

Chemistry terms

intensity of radiation - the amount of energy that flows per unit area per second.
inverse square law - the intensity of radiaiton emitted from a point source decreases inversely over the square of the distance.

Decay Reactions: Alpha Decay

Alpha decay

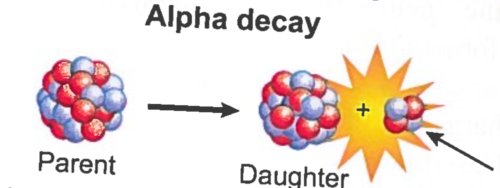
In **alpha decay** the original nucleus ejects two protons and two neutrons which is the nucleus of helium-4, ${}^4_2\text{He}$, also called alpha (α) particle. During alpha decay the emitted radiation is also called **alpha radiation** which is a fast moving ${}^4_2\text{He}$ nucleus.

Uranium-238 decays by releasing an α particle, ${}^4_2\text{He}$, and thorium-234, ${}^{234}_{90}\text{Th}$.

The original uranium atom is called the **parent nuclide** and the thorium atom is called the **daughter nuclide**.

$${}^{238}_{92}\text{U} \rightarrow {}^{234}_{90}\text{Th} + {}^4_2\text{He}$$

Alpha decay



Protons	Decrease by 2
Neutrons	Decrease by 2
Atomic number	Decrease by 2
Mass number	Decrease by 4

alpha particles deposit their energy over small distances

When the α particle hits a molecule it transfers energy to it and damages it. Damaged molecules in the cells of biological systems may result in cell death or the abnormal reproduction of cells. Since the α particles are very large, their ability to penetrate into matter is very limited. α radiation can be stopped by a sheet of paper. If an element that undergoes α decay is ingested it is very dangerous. As the α source is carried throughout the body the emitted α particles are in direct contact with the molecules in the cells of organs and can deposit their energy causing great damage.

Solved problem

Write the complete nuclear equation for the α decay of radium isotope ${}^{226}_{88}\text{Ra}$.

Relationships: *We need to find the type of the daughter nucleus X, the atomic number Z and the mass number A.* ${}^{226}_{88}\text{Ra} \rightarrow {}^A_Z\text{X} + {}^4_2\text{He}$

Solve: *First: Balance the atomic number and the mass number.*

- *By balancing the mass number we obtain A=222*
- *By balancing the atomic number we obtain Z=86*

Second: Look at the periodic table to determine the identity of the unkown daughter element.

- *Since the atomic number is 86 the daughter nuclide is radon (Rn).*

Answer: *The complete α decay equation is* ${}^{226}_{88}\text{Ra} \rightarrow {}^{222}_{86}\text{Rn} + {}^4_2\text{He}$

Chemistry terms

alpha decay - happens when a nucleus decays by releasing a helium nucleus.
alpha radiation - the radiation associated with alpha decay.
parent nuclide - the original nucleus involved in a nuclear reaction.
daughter nuclide - the nucleus resulting from a nuclear reaction.