1 Basic principles of radiation physics

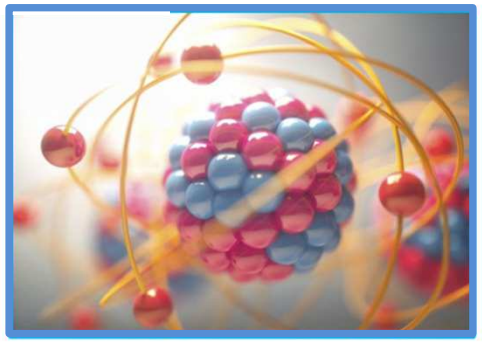
What is radiation?

QUICK GUIDE
RADIATION EXPOSURE

▪ A process in which atomic particles or waves of energy travel through a material medium or space.

Basic model of a neutral atom

- Atoms are composed of three smaller particles referred to as
  - **protons** (positively charged),
  - **neutrons** (neutral charge),
  - **electrons** (negatively charged).
- Electrons (-) orbit a nucleus of protons (+) and neutrons.
- Most atoms are **neutral atoms**, meaning that **the number of protons = the number of electrons.**
- Neutral atoms have a net charge of **zero.**

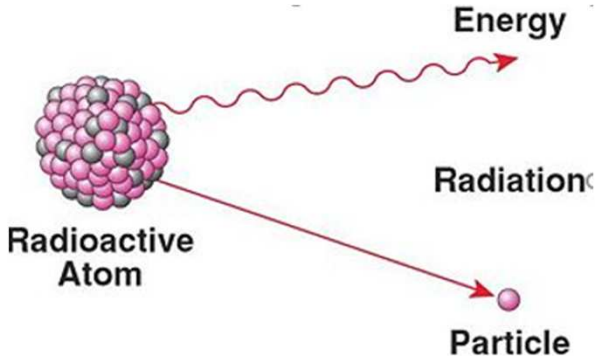


Stable versus unstable atom

- If the nucleus of an atom is unstable for any reason, such as **an excess of internal energy**, it will attempt to reach stability by ejecting protons or neutrons, as well as other particles, or by releasing energy in other forms.
- This process is referred to as **radioactivity** and the unstable atom is a **radioactive atom**.

Causes of instability (decay):

- Too much mass in the nucleus (α)
- Too many neutrons in the nucleus (β)
- Too much energy in the nucleus (γ)



What is ionizing radiation?

There are two categories of radiation: ionizing and non-ionizing.

▪ In common usage, *radiation* refers to **ionizing radiation**, that is, energy in the form of atomic or subatomic particles, or electromagnetic waves that is sufficient to free an electron from an atom or molecule, causing it to become ionized. The term may also refer to **non-ionizing radiation**, such as radio waves, heat or visible light. Particles or waves of energy radiate (travel outward in all directions) from a source.

▪ Both ionizing and non-ionizing radiation can be harmful to organisms. In general, ionizing radiation is more harmful to living organisms than non-ionizing radiation deposited per unit of energy, as the ions produced have the potential to cause chemical changes in cells and DNA damage.

2 Basic principles of radiation physics

▪ Types of ionizing radiation

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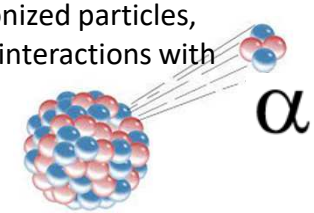
Alpha radiation

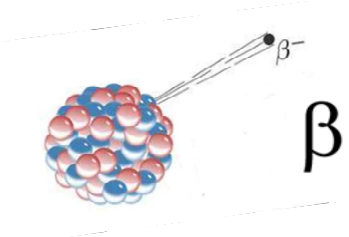
- Atomic particles that interact with matter.
- Only penetrate a few centimeters of air or a few millimeters of low-density material.
- Alpha are the most ionized particles, therefore have more interactions with materials.



Alpha particles do not penetrate the skin and cause no damage to tissues below.

Beta radiation

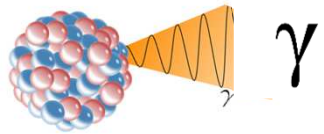
- Particles that can travel few meters in the air.
- Can be stopped by a wall made of wood, glass or aluminum.



Clothing provides some protection against beta radiation.

Gamma radiation

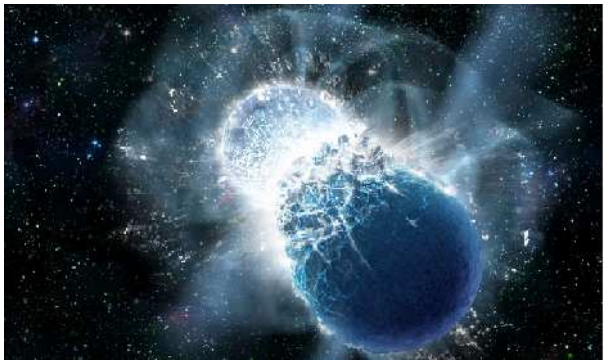
- Composed of photons.
- Penetrates much further through matter than either alpha or beta radiation.
- Gamma radiation frequently accompanies the emission of alpha and beta radiation during a radioactiv accident.



Gamma radiation can be stopped by a wall/panel of lead or concrete.

Neutron radiation

- **Free neutrons** are emitted from nuclei as a result of spontaneous or induced **nuclear fission.**
- **Neutron radiation** consists of these high-speed nuclear particles that have an exceptional ability to penetrate other materials. Short half-life of 15 minutes.



- Only form of ionizing radiation that can make objects radioactive –this process (**neutron activation**) produces many of the radioactive sources used in medical, academic and industrial applications.

Because of their exceptional ability to penetrate other materials, neutrons can travel great distances in air and require very thick hydrogen-containing materials (such as concrete or water) to block them.

3 Measuring radiation

▪ Units and devices for measurement

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RADIATION EXPOSURE

Measuring Radiation

There are four different but interrelated units for measuring radioactivity, exposure, absorbed dose, and dose equivalent. These can be remembered by the mnemonic **R-E-A-D**

- **Radioactivity** refers to the amount of ionizing radiation released by a material. **(Bq)**
- **Exposure** describes the amount of radiation traveling through the air. Many radiation monitors measure exposure. **(C/kg)**
- **Absorbed dose** describes the amount of radiation absorbed by an object or person (that is, the amount of energy that radioactive sources deposit in materials through which they pass). **(Gy)**
- **Dose equivalent** (or effective dose) combines the amount of radiation absorbed and the medical effects of that type of radiation. **(Sv)**

There are 3 main units commonly used in the **International System of Units** (ISU), as a dose (unit) or dose rate (unit/hours):

- **The becquerel (Bq)** is the unit of radioactivity. It is defined as the activity of a quantity of radioactive material.
- **The Gray (Gy)** is the unit of absorbed radiation dose of ionizing radiation.
- **The Sievert (Sv)** reflects the biological effects of ionizing radiation as opposed to just the absorbed dose .

1 Gray = 1 millisievert (mSv) = 1000µSv

SIMPSONS GUIDE TO RADIATION

Bequerel [Bq]
How brightly your Cesium glows

Gray [Gy]
How brightly Cesium will make you glow

Sieverts [Sv]
How many extra eyes will you have after glowing?

Detection Equipment

Personal dosimeter
IRSN

Detects Gamma + X-ray

Radiometer
RadEye™ G10

Detects Gamma + X-ray

Operational Dosimeter
apvl EPD Mk3 BG

Detects β + γ + χ

Contamination detector
RadEye™ B20

Detects low level α + β
Detects Gamma + X-ray

RADIATION DOSES Millisievert (mSv): Typical exposure to background radiation = 2.4 mSv/year. Chernobyl nuclear plant worker = 6,000 mSv.

4 Radiation exposure

- Spread of radioactive contamination after a nuclear accident
- Routes of exposure

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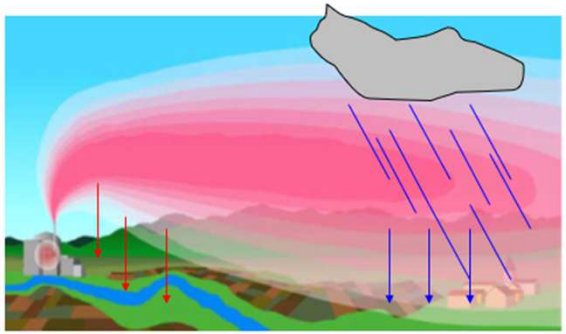
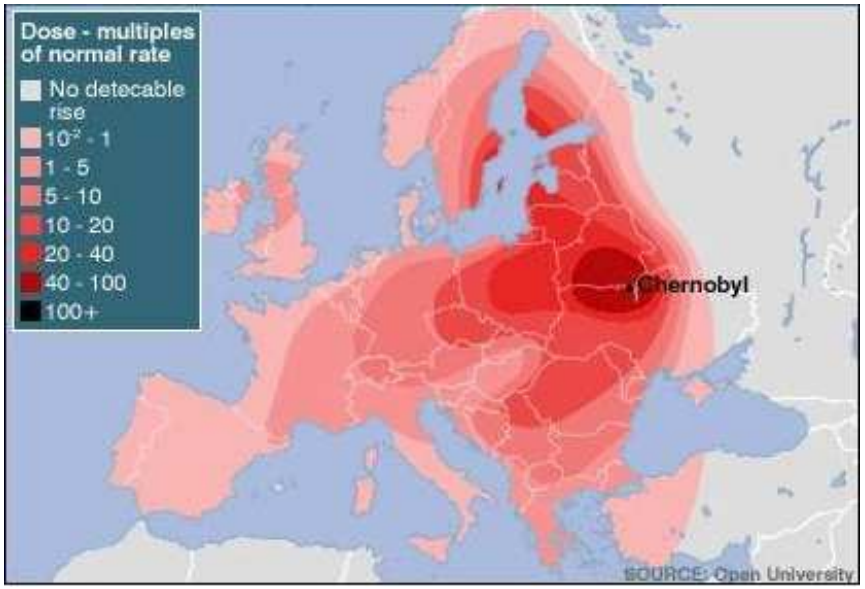
How does radioactive contamination spread following a nuclear accident?

Following a major nuclear accident, the release of a large amount of radioactivity into the environment is the critical risk for contamination.



Dry deposition — Wet deposition

- Releases can last from a few hours to several days depending on the type of accident.
- Deposit on surfaces, whether natural or cultivated areas, as well as built-up areas.
- Deposition is **not only a matter of distance**, depends on the topography of the area, the wind and where rainfall occurred.
- It can then form the "radioactive deposition spots," even at some distance from the site.



Routes of exposure

External exposure = when the source of radiation (radioactive object, "cloud" of radioactivity in the air, deposits on soils, built surfaces, etc.) is external to the human body.

- Reduce exposure **by moving away** from the source of radioactivity, **or by reducing the time spent** nearby or **by interposing barriers of high density** between the source and the exposed person.
- **Staying inside a solid building** whose interior is not contaminated will thus provide protection against external irradiation outside.
- **However, when the irradiation due to the contamination of the external environment is too significant, the temporary or permanent evacuation of the affected area is preferable.**

Routes of exposure

You can be exposed to the radioactivity present in different ways:

Internal exposure = radioactive materials that enter the human body by inhalation, ingestion or to a lesser extent via injury.

- To reduce this exposure, **shelter inside** an enclosed building during the passage of the radioactive plume through the air,
- or use **protective equipment** that filters the breathed air (FFP3 mask sufficient).
- **Consume only canned food and water free of contamination.**
- Do not to bring your hands to your mouth (eating, smoking).
- Clean hands save lives.

The atmospheric spread of radioactivity generally is not immediate but may occur after a delay of hours or days.