

## Radioactivity

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## Types of Radioactive Decay

- There are three types of radioactive decay
- They are distinguished on the basis of their ionizing and penetrating power
- Called alpha, beta, and gamma radiation (or particles)

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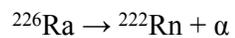
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## Alpha ( $\alpha$ )

- The nucleus of a helium atom (2p, 2n)



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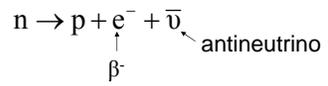
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### Beta Negative ( $\beta^-$ )

- Electron (but not an orbital electron)



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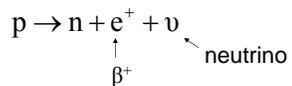
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### Beta Positive ( $\beta^+$ )

- Positron  
– Identical to an electron but with a positive charge



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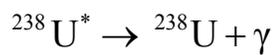
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### Gamma ( $\gamma$ )

- Photons with very high energy
- The decaying nucleus is in an excited state



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## Ionizing Radiation

- Radiation with enough energy so that during an interaction with an atom, it can remove tightly bound electrons from the orbit of an atom, causing the atom to become charged or ionized

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## Alpha and Beta Particles

- Considered directly ionizing because they carry a charge and can, therefore, interact directly with atomic electrons through coulombic forces

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## Gamma Rays

- Electromagnetic, indirectly ionizing radiation
- Electrically neutral (as are all electromagnetic radiations) and do not interact with atomic electrons through coulombic forces.

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## Applications of Ionizing Radiation

- Smoke alarm
- “Glow in the dark” materials
- X-rays
- Medical treatment
- Sterilization of medical products
- Food preservation

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## Health Effects of Ionizing Radiation

- Any living tissue in the human body can be damaged by ionizing radiation in a unique manner
- The body attempts to repair the damage, but sometimes the damage is of a nature that cannot be repaired or it is too severe or widespread to be repaired
- Also mistakes made in the natural repair process can lead to cancerous cells.

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## Short Term Effects

- Radiation burns
- Radiation sickness (radiation poisoning)
  - premature aging or even death
  - The symptoms of radiation sickness include: nausea, weakness, hair loss, skin burns or diminished organ function.

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## Long Term Effects

- Cancer
- DNA mutation

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Exposure (rem)	Health Effect	Time to Onset (without treatment)
5-10	changes in blood chemistry	
50	nausea	hours
55	fatigue	
70	vomiting	
75	hair loss	2-3 weeks
90	diarrhea	
100	hemorrhage	
400	possible death	within 2 months
1,000	destruction of intestinal lining internal bleeding and death	1-2 weeks
2,000	damage to central nervous system loss of consciousness; and death	minutes hours to days

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## Non-ionizing Radiation

- Electromagnetic radiation that does not have enough energy to ionize atoms

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## Applications of Non-ionizing Radiation

- Visible light
- Communications
  - radio, television, cell phone, wifi
- Microwave oven
- Tanning beds

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## Health Effects of Non-Ionizing Radiation

- Normal exposure to non-ionizing radiation has no health risks
- Overexposure to certain types of non-ionizing radiation may result in some discomfort
  - UV (sunburn)
  - Microwave (heating up, cooking)

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## Why are some nuclei stable and others are unstable?

- There are about 2500 nuclides
- Only about 300 are stable
- As the number of protons in the nucleus increases, the electrostatic repulsion increases
- However, the strong nuclear force does not increase proportionally (it is a short range force)

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- Extra neutrons are needed to ensure stability by increasing the nuclear force, but not increasing the electrostatic force
  - However, too many extra neutrons will make the nucleus unstable by favoring decays of neutrons into protons
- In other words, there is a limit to how large a nucleus can get

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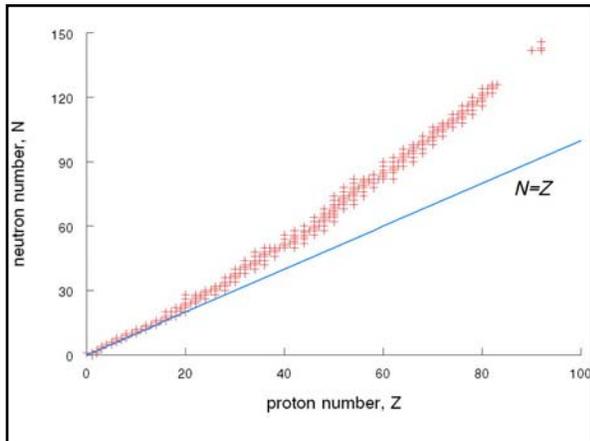
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### Half-life

- A macroscopic sample of any radioactive isotope consists of a vast number of radioactive nuclei
- The nuclei decay one by one randomly over a period of time
- It is assumed that each nucleus has the same probability of decaying in each second it exists

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- Therefore, we can determine on a probabilistic basis approximately how many disintegrations will occur over a given time period
- The time it takes for half of the nuclei in a sample to disintegrate is known as the half-life

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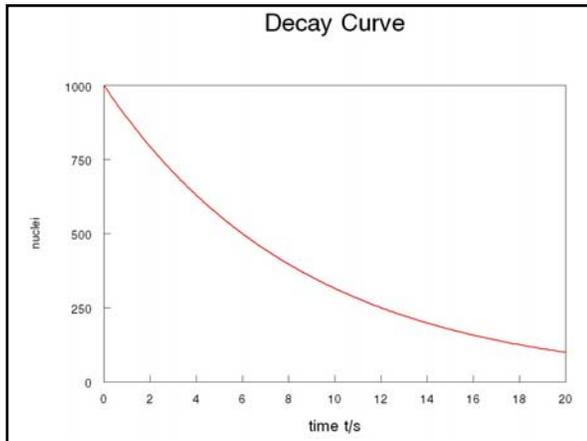
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### Detecting Radiation

- Radiation is detected by using a device known as a Geiger-Muller tube
- The outside of the tube is negatively charged
- Inside the tube is a positively charged cathode
- The tube is charged to a few hundred volts
- The tube is filled with a gas

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- Radiation enters the tube through a glass window
- The radiation ionizes the gas
- The positive ions accelerate towards the outside and the negative ions accelerate towards the cathode
- This registers as a current to the counter connected to the tube

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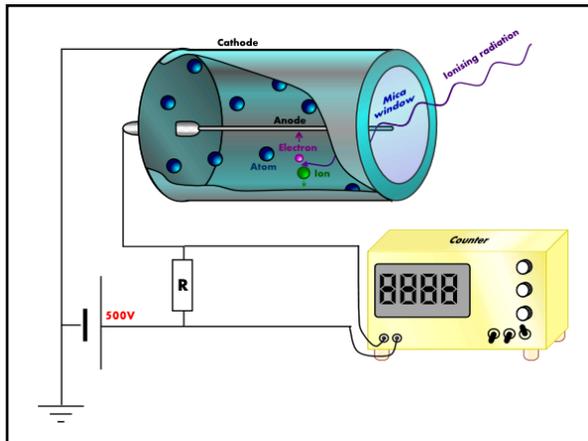
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### Measuring Half-life

- Half-life is measured by counting the number of decays that occur over a period of time (activity)
- If the sample has a short half-life we can measure the activity for short time intervals (seconds)
- If the sample has a long half-life, we must count for longer periods of time (maybe days)

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