General Physics

Lecture Three / Theoretical

Energy

First stage

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2024-2025

Energy

Energy is the ability to do work

The law of conservation of energy states that energy may be transformed from one form to another, but it cannot be created or destroyed; the total amount of energy is constant. For example, electrical energy is converted into light energy and heat energy in an electric light bulb. The unit of energy and work is the same, the joule

There are many forms of energy. Two forms of mechanical energy often are used in radiologic science: kinetic energy and potential energy.

1. Kinetic energy is the energy associated with the motion of an object as expressed by the following:

What is the Kinetic Energy of a 150 kg object that is moving with a speed of 15 m/s?

$KE = \frac{1}{2} mv^2$

KE = ?

m = 150kg

v = 15m/s

$KE = \frac{1}{2} (150kg) (15\ m/s)^2$

$KE = \frac{1}{2} (150kg)(225)$

KE = 16875J

An object moving with a speed of 35 m/s and has a kinetic energy of 1500 J, what is the mass of the object.

$KE = \frac{1}{2} mv^2$

KE = 1500J

m = ?

v = 35m/s

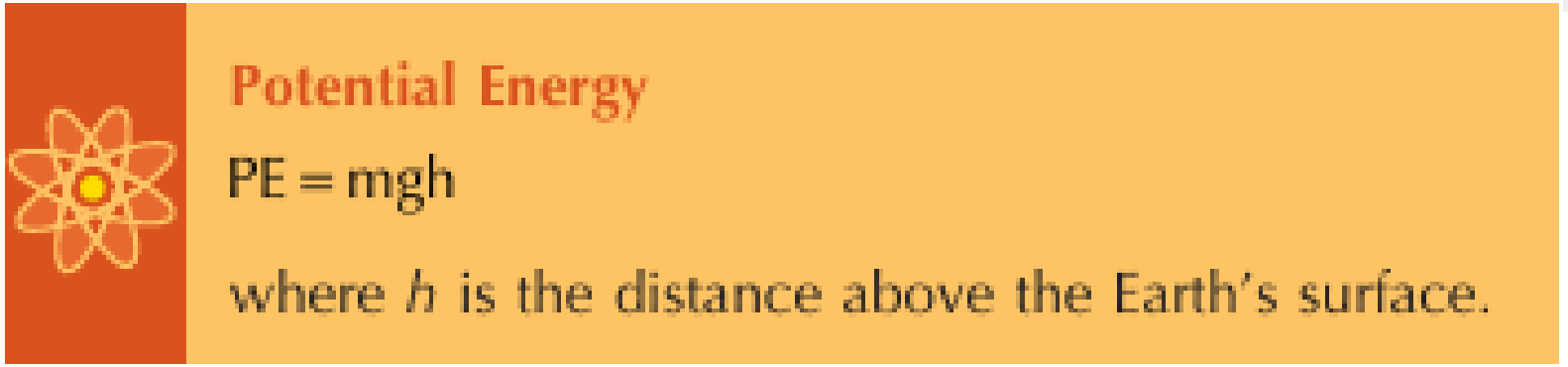
$2KE/v^2 = m$ OR $m = 2KE/v^2$ (rearrange equation)

$m = 2(1500J)/(35)^2$

$m = 3{,}000/1225$

m = 2.45kg

2. Potential energy is the stored energy of position or configuration. Four common examples of potential energy include a skydiver waiting to jump from an airplane, a rubber band that has been stretched out between two fingers, water sitting behind a dam, and the energy in a battery. All four examples are examples of stored energy that has the potential to do work upon its release.



Question: A radiographer holds a 6-kg x-ray tube 1.5 m above the ground. What is its potential energy?

Answer: Potential energy = mgh

$$= 6\ \text{kg} \times 9.8\ \text{m/s}^2 \times 1.5\ \text{m}$$
$$= 88\ \text{kg m}^2/\text{s}^2$$
$$= 88\ \text{J}$$

3. Chemical energy is the energy stored within chemical bonds of a substance. These chemical bonds link atoms with other atoms and molecules with other molecules. Since chemical energy is stored, it's a form of potential energy that comes from electrons' arrangement in atoms and ions.

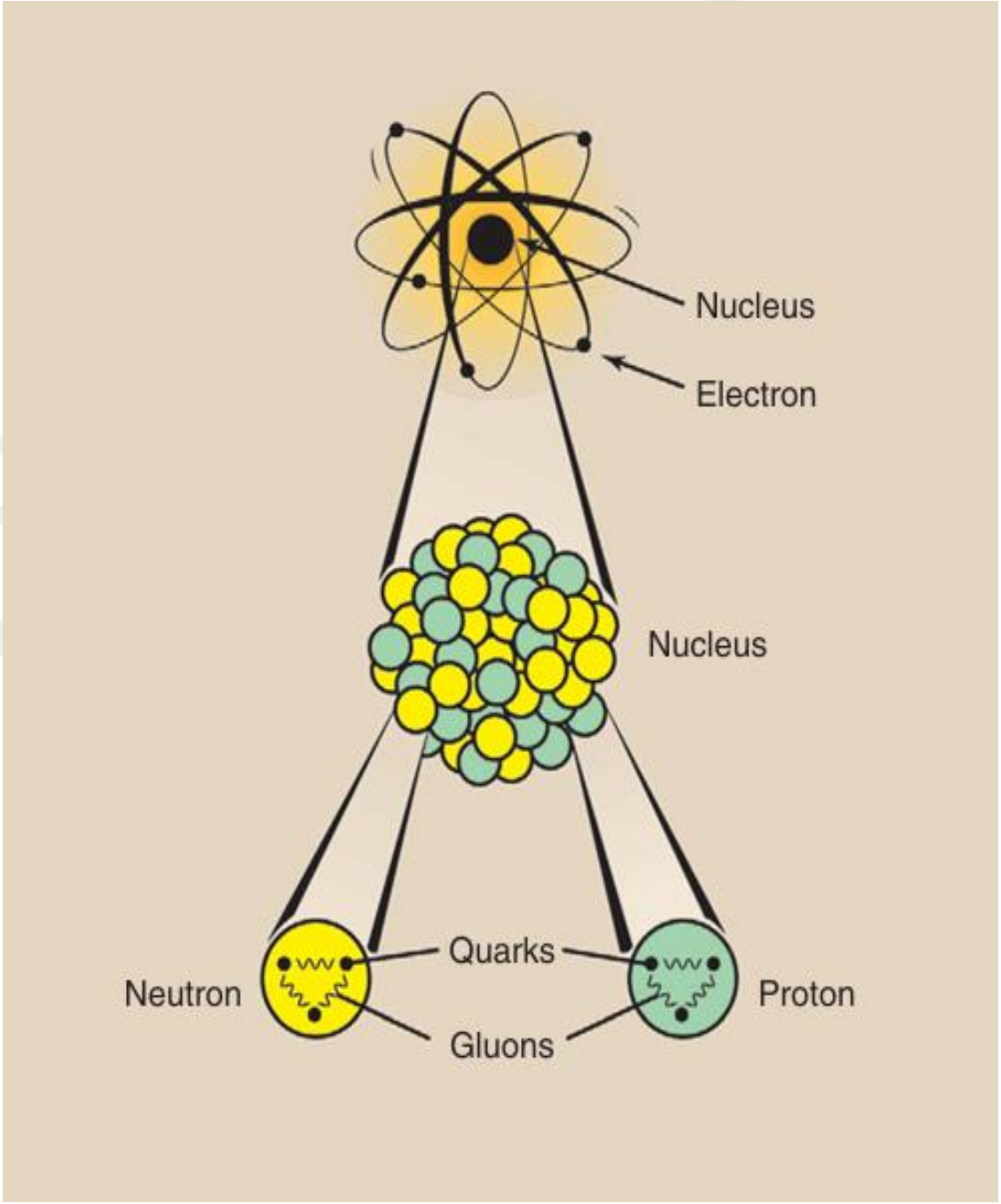
4. Electrical energy is caused by the movements of electrons in one direction. The faster they move, the more electrical energy they carry. Although any charged particle such as protons, electrons, cations, anions, positrons can produce electrical energy, the most common current carrier are electrons. Alternating current (AC) is a prominent example of electrical energy. It is generated by almost all power plants and used by most power distribution systems. It is considered a form of kinetic energy that comes from the flow of electric charge.

5. Thermal energy comes from the heated up objects. As the temperature of an object increases, its atoms and molecules move faster and collide with each other at higher rates. Example: When you place a pot of water on the stove, the internal energy of the heated element (in the stove) is transferred to the water within the pot. This ultimately raises the temperature of the water, causing water molecules to move faster. A form of Kinetic Energy due to the motion of atoms and molecules.

Every object in the universe is made of atoms. Each atom contains electrons, protons, neutrons, and a nucleus. Unlike normal chemical reactions that form molecules, nuclear reactions involve changes in the atom's nucleus, which ultimately causes a change in the atom itself. When a heavy nucleus splits into lighter nuclei (fission) or nuclei combine to form a bigger and heavier nucleus (fusion), a massive amount of energy is released. This energy is called 6. nuclear energy.

Example: Existing nuclear power plants use nuclear fission of uranium and plutonium to produce electricity. They are cheaper, more efficient, and environment-friendly than traditional plants that use coal and gas to generate electricity.

A form of Potential Energy stored in the nucleus (core) of the atom.



7. Electromagnetic energy is perhaps the least familiar form of energy. It is the most important for our purposes, however, because it is the type of energy that is used in x-ray imaging. In addition to X-rays, electromagnetic energy includes radio waves; microwaves; and ultraviolet, infrared, and visible light.

Frequently, matter and energy exist side by side a moving automobile has mass and kinetic energy; boiling water has mass and thermal energy.

Perhaps the strangest property associated with matter and energy is that they are interchangeable, a characteristic first described by Albert Einstein in his famous theory of relativity.

Einstein's mass-energy equivalence equation is a cornerstone of that theory.

This mass-energy equivalence serves as the basis for the atomic bomb, nuclear power

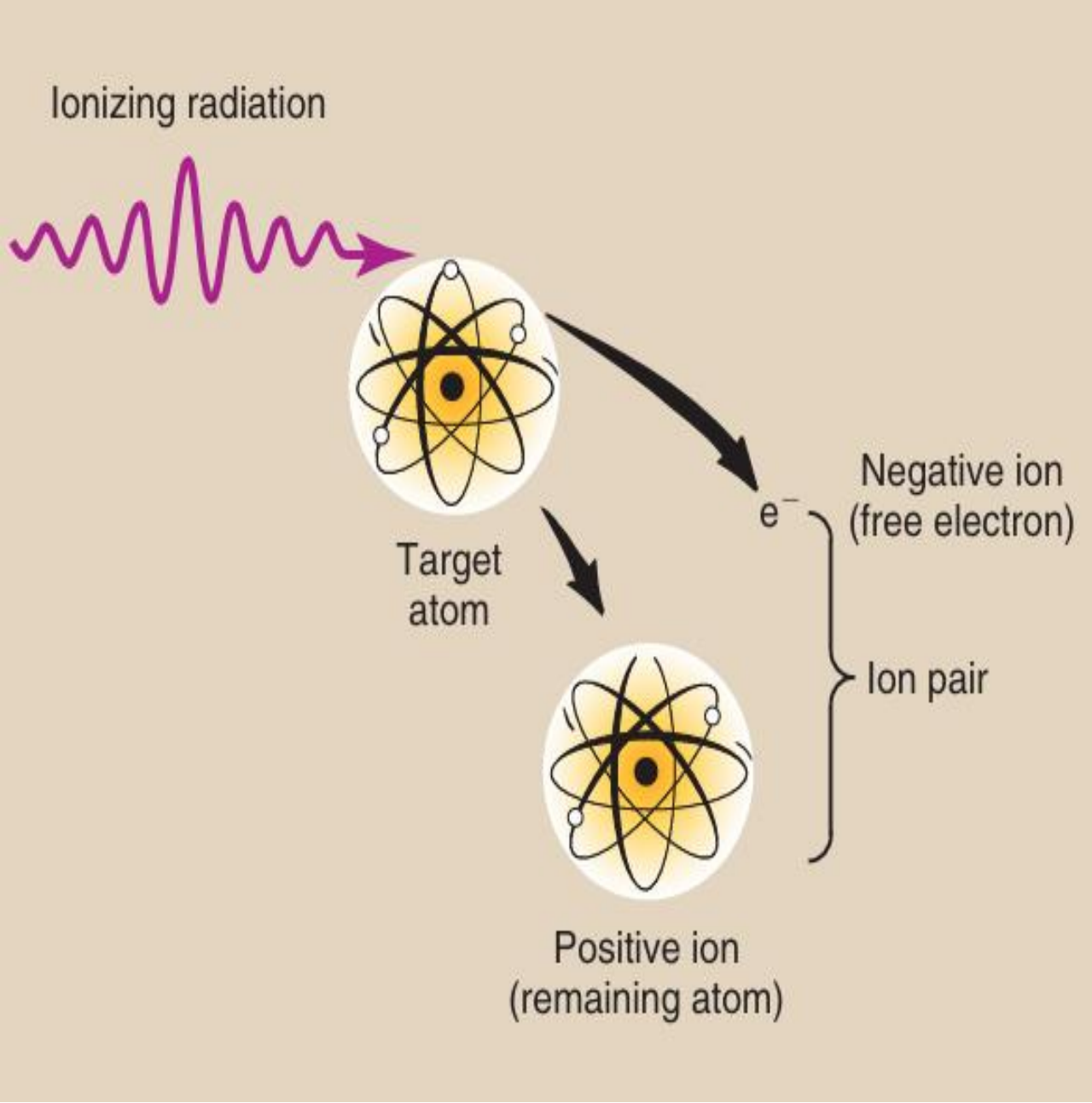
$$E = mc^2$$

where E is energy, m is mass, and c is the velocity (speed) of electromagnetic radiation (light) in a vacuum.

Energy emitted and transferred through space is called radiation.

Electromagnetic energy is usually referred to as electromagnetic radiation or, simply, radiation

Ionizing radiation is any type of radiation that is capable of removing an orbital electron from the atom with which it interacts. This type of interaction between radiation and matter is called ionization. Ionization occurs when an X-ray passes close to an orbital electron of an atom and transfers sufficient energy to the electron to remove it from the atom. The ionizing radiation may interact with and ionize additional atoms. The orbital electron and the atom from which it was separated are called an ion pair. The electron is a negative ion, and the remaining atom is a positive ion. X-rays, gamma rays, and ultraviolet light are the only forms of electromagnetic radiation with sufficient energy to ionize.



Many types of radiation are harmless, but ionizing radiation can injure humans. We are exposed to many sources of ionizing radiation. These sources can be divided into two main categories: natural environmental radiation and man-made radiation.

Natural environmental radiation results in an annual dose of approximately 3 millisieverts (mSv). Man -made radiation results in 3.2 mSv annually. An mSv is the unit of effective dose.

Natural environmental radiation consists of four components: cosmic rays, terrestrial radiation, internally deposited radionuclides, and radon.

Cosmic rays are particulate and electromagnetic radiation emitted by the sun and stars.

Terrestrial radiation results from deposits of uranium, thorium, and other radionuclides in the Earth.

The largest source of natural environmental radiation is radon. Radon is a radioactive gas that is produced by the natural radioactive decay of uranium.

Diagnostic X-rays constitute the largest man-made source of ionizing radiation (3.2mSv/yr).

Other sources of man-made radiation include nuclear power generation, research applications, industrial sources, and consumer items.

Comprehensive Set of MCQs

1. What does the law of conservation of energy state?

A) Energy can be created and destroyed.
B) Energy is always kinetic.
C) Energy can be transformed but cannot be created or destroyed.
D) Energy only exists in chemical bonds.
E) Energy is constant and always thermal.

Answer:

1. Which is an example of potential energy?

A) A moving car
B) A stretched rubber band
C) Water boiling on a stove
D) A running fan
E) Sunlight

Answer:

Comprehensive Set of MCQs

3. What type of energy is stored in chemical bonds?

A) Kinetic energy
B) Potential energy
C) Chemical energy
D) Thermal energy
E) Electrical energy

Answer:

4. What does Einstein's equation $E=mc^2$ describe?

A) Conservation of momentum
B) Energy transfer in electrical circuits
C) Mass-energy equivalence
D) Thermal expansion
E) Electromagnetic radiation

Answer:

Comprehensive Set of MCQs

5. What is the largest natural source of environmental radiation?

A) Cosmic rays
B) Terrestrial radiation
C) Radon
D) Internally deposited radionuclides
E) Diagnostic X-rays

Answer:

6. What is the annual effective dose of man-made radiation?

A) 1 mSv
B) 2 mSv
C) 3.2 mSv
D) 5 mSv
E) 10 mSv

Answer:

Comprehensive Set of MCQs

7. Which energy type is used in X-ray imaging?

A) Thermal energy
B) Nuclear energy
C) Electromagnetic energy
D) Electrical energy
E) Kinetic energy
Answer:

8. What does the term "ion pair" refer to in ionization?

A) A pair of atoms
B) An electron and a proton
C) A separated electron and its atom
D) A nucleus and a neutron
E) Two bonded molecules
Answer:

Comprehensive Set of MCQs

9. Which component of natural environmental radiation originates from the sun and stars?

A) Terrestrial radiation
B) Cosmic rays
C) Radon
D) Internally deposited radionuclides
E) Ultraviolet radiation
Answer:

10. What type of reaction changes an atom's nucleus?

A) Chemical reaction
B) Nuclear reaction
C) Thermal reaction
D) Physical reaction
E) Electrical reaction
Answer:

Comprehensive Set of MCQs

11. What is the primary energy carrier in an alternating current (AC) circuit?

A) Protons
B) Neutrons
C) Electrons
D) Positrons
E) Photons
Answer:

12. What is the largest man-made source of ionizing radiation?

A) Nuclear power plants
B) Diagnostic X-rays
C) Cosmic rays
D) Consumer electronics
E) Radon
Answer:

Comprehensive Set of MCQs

13. What is the effective annual dose from natural environmental radiation?

A) 1 mSv
B) 2 mSv
C) 3 mSv
D) 3.2 mSv
E) 5 mSv
Answer:

14. What is the term for energy emitted and transferred through space?

A) Conduction
B) Radiation
C) Reflection
D) Diffraction
E) Induction
Answer: