Warm-Up | Nuclear Energy

Fission and Fusion

Fission

- A large [nucleus] splits into smaller nuclei.
- The process is initiated by small high-energy particles bombarding the large nucleus.
- [Energy] is released.

Fusion

- Two [small] nuclei combine to form one large nucleus.
- The process is initiated by two small high-energy [particles] colliding with one another.
- Energy is released.

Lesson Objectives

By the end of this lesson, you should be able to:

- Describe how nuclear power [plants] work.
- Describe the issues surrounding nuclear [waste].

Science Practice: Weigh the merits of using nuclear energy to solve society's need for electrical energy by comparing a number of human, economic, and environmental costs and benefits.

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Words to Know

Fill in this table as you work through the lesson. You may also use the glossary to help you.

chain reaction	a self-sustaining series of chemical reactions in which the products of one reaction are the reactants in the next reaction
control rod	a physical cylinder of material that absorbs neutrons so they cannot initiate a fission reaction
critical mass	an amount of fissionable material capable of sustaining a constant rate of fission
generator	a device that converts mechanical energy into electrical energy
nuclear fuel	the material used in a nuclear reactor that provides fissionable atoms
nuclear power plant	a facility designed to generate electricity from fission reactions
nuclear waste	the matter remaining after fission reactions take place in a nuclear reactor
subcritical mass	an amount of fissionable material that is too small to sustain a constant rate of fission
supercritical mass	an amount of fissionable material that produces an accelerating rate of fission
turbine	a cylinder with blades that rotates when steam or other gas expands and moves across the blades

Instruction | Nuclear Energy

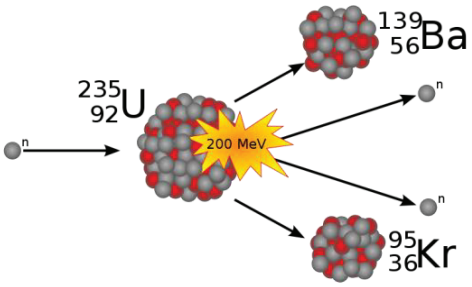
Slide 1

Lesson Question How is nuclear energy created and used?

Slide 2

Fission Reactions and Energy Release

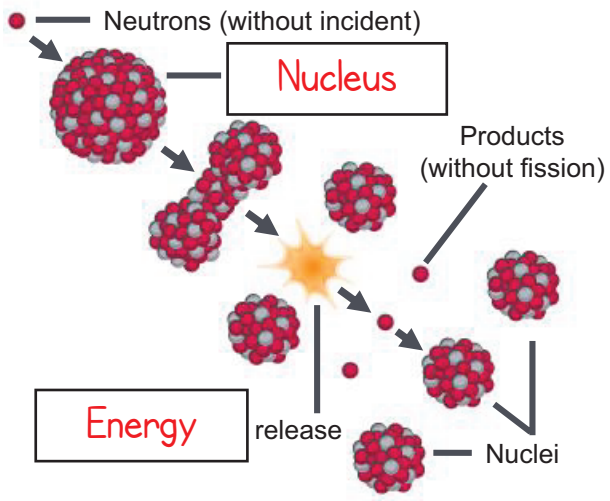
- Nuclear [binding] energies of product nuclei differ from that of the nucleus undergoing fission.
- One fission event releases [200] MeV energy.
- Producing 40-million kWh [electricity] requires:
  - 16,000 tons of [coal] or just 1 ton of uranium.



Chain Reactions

Each fission event:

- produces one or more neutrons.
- leads to more reactions as neutrons initiate more [fission] events.
  - A **chain reaction** is a self-sustaining series of [chemical] reactions in which the products of one reaction are the reactants in the next reaction.
- can produce a cascading effect if two or more neutrons are produced with each event.



Instruction | Nuclear Energy

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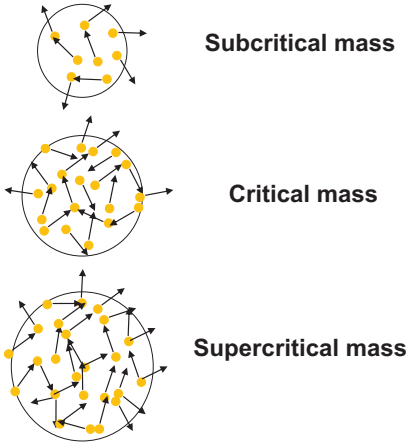
Critical Mass

Critical mass is an amount of fissionable material capable of sustaining a [constant] rate of fission.



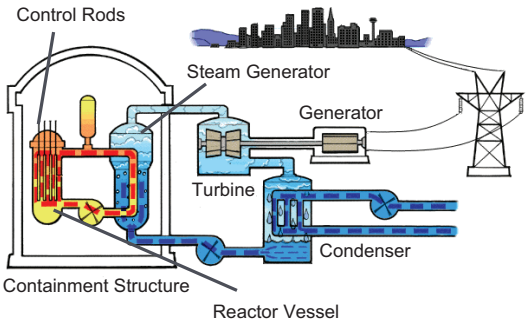
[Subcritical] **mass** is an amount of fissionable material too small to sustain a constant rate of fission; [reaction] slows and eventually [stops].

[Supercritical] **mass** is an amount of fissionable material that produces an [accelerating] rate of fission.

Slide 8

Nuclear Power Plant Design

- The [reactor] vessel contains fission reactions and releases thermal energy.
- Steam generator converts [water] to steam.
- The [turbine] has blades that rotate like a fan in response to expanding steam, driving a [generator], a device that converts mechanical energy to [electrical] energy.



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Slide 8

Controlled Nuclear Fission

Control rods:

- are physical cylinders that can be moved in or out of a nuclear reactor vessel.
- are [inert] and do not undergo fission themselves.
- absorb neutrons produced during fission reactions.
- decrease the fission process when dropped down into the reactor.
- [increase] the fission process when raised up out of the reactor.

Slide 11

Nuclear Fuel

Advantages

- Has a high natural abundance
- Requires much less [mass] than coal or oil to produce the same energy

Disadvantages

- Causes environmental damage from [mining]
- Creates radiation hazards to miners and other workers

Instruction | Nuclear Energy

Slide 11

Power Plant Operation

Advantages

- Is efficient
- Can be safe when proper procedures are carried out

Disadvantages

- Can lead to radiation leaks or even meltdown due to human error
- Can have natural disasters threaten safe operation

Nuclear Waste

Advantages

- Does not emit carbon dioxide
- Does not contribute to greenhouse gas buildup in the atmosphere

Disadvantages

- Is a radiation hazard
- Has an extremely long half-life, requiring long-term storage
- Must be contained to avoid environmental contamination

Summary | Nuclear Energy

Lesson Question

How is nuclear energy created and used?

Answer

(Sample answer) In the fission process, small high-energy particles bombard a large nucleus, causing it to split into smaller nuclei, which then release some energy. In the fusion process, two small nuclei collide with one another, combining to form one large nucleus and to release a small amount of energy.

Slide 2

Nuclear Chain Reactions

A chain reaction:

- produces a [product] that becomes a reactant in another round of the same reaction.
- is self-sustaining.
- can accelerate out of [control] in some cases.

Summary | Nuclear Energy

Slide 2

Nuclear Power Plant Design

Basic components

- Reactor vessel
- Steam generator
- Turbine and electric generator

Basic process

- Thermal energy → mechanical energy → electrical energy

Benefits and Risks of Nuclear Power

Benefits

- Efficient energy source
- Safe when proper procedures are followed
- No greenhouse gas emissions
- Abundance of uranium in nature

Risks

- Vulnerable to human error and natural disasters
- Hazardous nuclear waste stored for long time periods
- Environmental and health hazards associated with uranium mining

Summary | Nuclear Energy

Use this space to write any questions or thoughts about this lesson.