STEM AMBASSADOR

Nuclear Energy: I'm in the middle of a (nuclear) Chain Reaction

Objectives

Students will:

• Make predictions.

• Understand nuclear fission using a model.

• Demonstrate the concept of a chain reaction.

Fast facts

Subject: Chemistry/Physics

Age range: 5+ years old

Ambassador preparation time: 15 minutes

Demonstration time required: 15 minutes

Location: Science Fair

Overview

Nuclear fission is the process of an unstable atom (uranium-235 or plutonium-239) splitting into two smaller atoms (fission products), producing two or three free neutrons and releasing a very large amount of energy. Fission is the process by which energy is produced in a nuclear reactor. To control this reaction, control rods are used.

The students will take part in a practical demonstration to help understand how a large atomic nucleus can be split into two smaller particles, which will release neutrons and create a chain reaction.

Equipment

• Balloons

Links to purchase the equipment are given at the end of the guide (Equipment Purchase Links section).

NATIONAL NUCLEAR LABORATORY

Precautions

Ensure there are no trip hazards present, and you have a large enough floor area for a small group to gather. Ensure no one is allergic to the latex in the balloons, if so, ensure that they wear gloves.

Procedure

1. Have the students stand in a tightly packed group and give each student two balloons.

2. In a fission reaction, a neutron must be released to get the reaction going. The students are going to simulate nuclear fission reactions by throwing 'neutrons' (balloons).

3. Start the simulation by asking one student to throw their 'neutron' (balloon) into the air.

4. If the 'neutron' (balloon) touches a student, the student should throw both of their balloons in the air. This will continue until all the balloons are in the air.

5. Retrieve all the balloons and reset so that each student has two again. However, this time select a couple of students to be 'control rods'. Their job is to grab balloons out the air during the 'reaction'. Control rods are used to prevent fission reactions spiralling out of control and becoming dangerous. The amount of fission rods that are present will affect the rate of the nuclear reaction. Begin the 'reaction' again and let it run for a few minutes.

What is different about this reaction?

6. Repeat a few times adding or taking away 'control rods'.

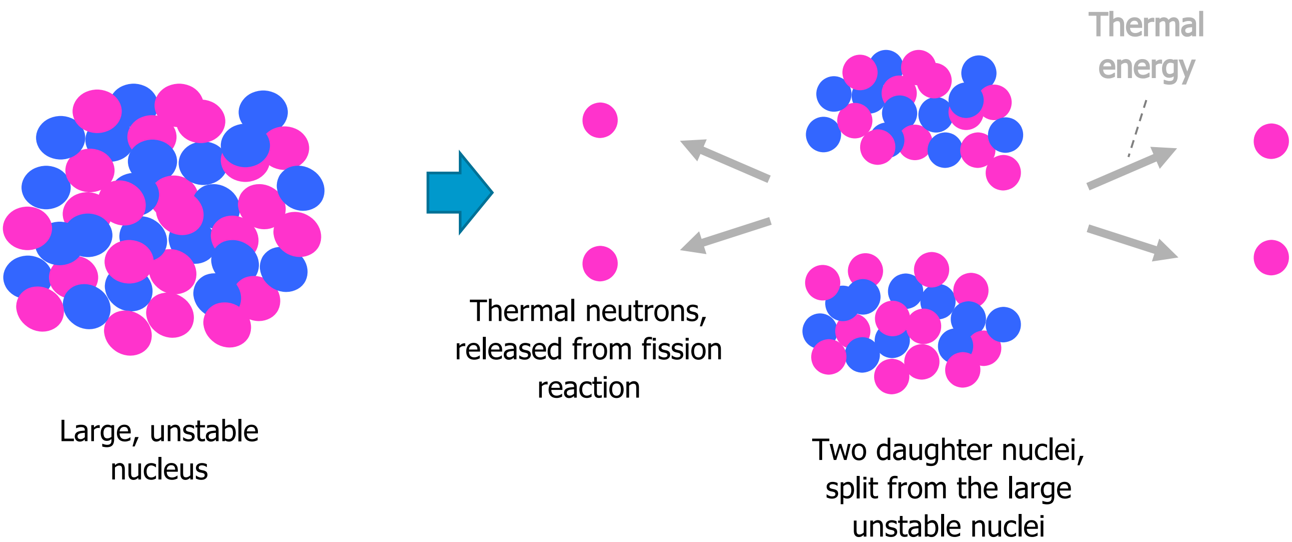
7. You can now discuss nuclear fission, how we control nuclear reactors, what is a chain reaction and critical/sub/supercritical masses with the students.

Discussion

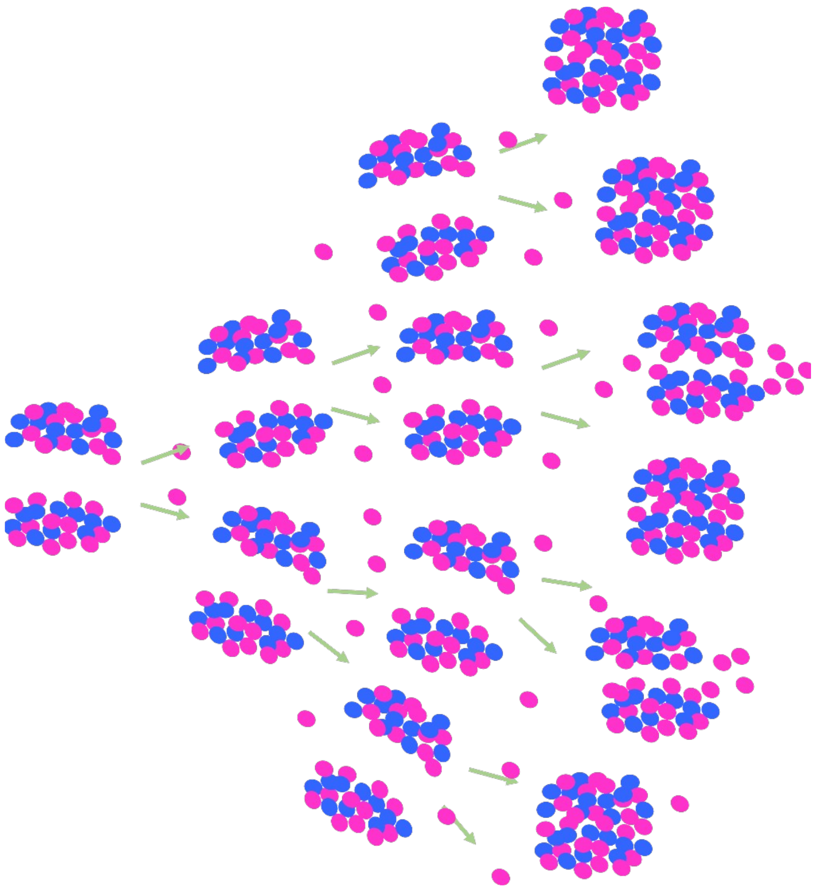
There are two kinds of nuclear power; fission and fusion. Both types of reaction release energy and during each the centre of the atom (nucleus) is changed. Nuclear fission works by splitting the nucleus apart. Uranium-235 or plutonium-239 are two isotopes that are often used in fission reactions. They have massive, unstable nuclei that can be used to start a chain reaction.

In nuclear fission the bonds that hold a nucleus together are broken and thermal energy is released. The remaining parts of the original nucleus then form two daughter nuclei with roughly equal mass, as well as some thermal neutrons.

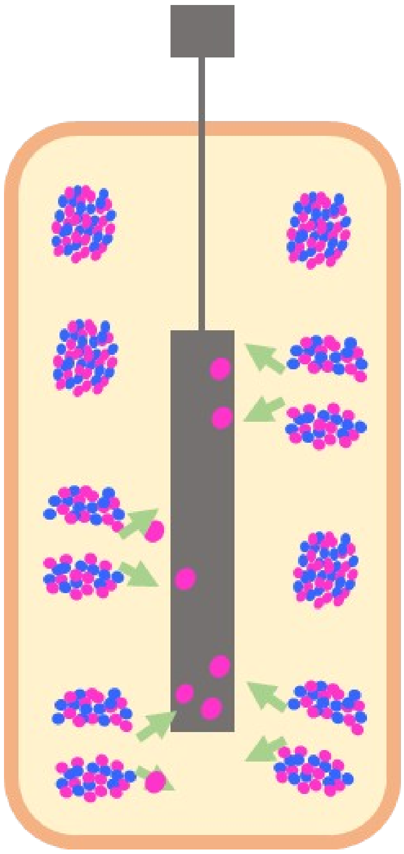
Nuclear Chain Reactions



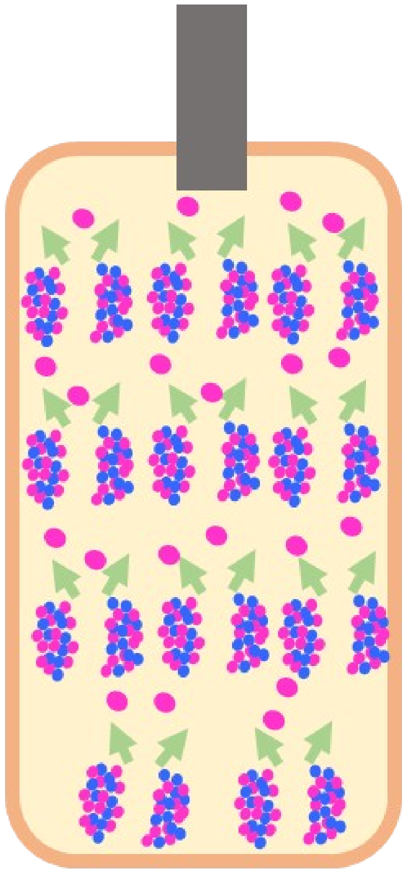
These thermal neutrons can be used to start a chain reaction. When these neutrons collide with other unstable nuclei they can cause a chain reaction. Each fission reaction produces more neutrons which can collide with more nuclei, extending the process indefinitely and producing more and more energy.



If uncontrolled this chain reaction can release so much energy that it could cause an explosion. Nuclear reactors control this reaction using control rods. They contain elements of boron, silver, indium, or cadmium to absorb some of the neutrons. Lowering and raising the rods into the reactor can control the rate of the reactions, allowing the energy from the reactions to be harnessed to generate electricity. In a nuclear power station, this is done by using the heat energy from the fission reactions to boil water and make high pressure steam. This steam turns a turbine, which turns a generator and generates electricity.



Nuclear reactor with control rod lowered. The control rod is absorbing neutrons to keep the reaction proceeding at a safe and steady rate.



Nuclear reactor with control rod lifted. With no control rod there are many thermal neutrons and a chain reaction is occurring with lots of thermal energy

Equipment Purchase Links

• Balloons:

https://www.amazon.co.uk/Balloons-12-inch-Multicoloured-Decorations/dp/B0BGLCKRCH/ref=sr_1_9?crid=EUT2SXNE4J1Z&keywords=balloons%2Bmultipack&qid=1692006357&sprefix=baloons%2Bmutipack%2Caps%2C106&sr=8-9&th=1