

1. What are the basic processes involved in nuclear power plants to generate electrical power?  
Uranium or another fissile isotope undergoes fission in a controlled chain reaction to generate heat. The heat is used to boil water, and the steam then spins a turbine that drives an electric generator.
2. Describe the main components of the nuclear reactor and what they do.
  - Fuel rods contain U-235 or fissionable isotope enriched to 5% for controlled fission chain reaction
  - Control rods contain  $^{10}\text{B}$  absorber (e.g. B) to control rate of chain reaction when inserted/removed
  - Moderator slows neutrons so they can initiate fission (thermal neutrons)
  - Coolant removes heat released by fission, transfers it to secondary system to boil water
3. What were the two biggest factors that led to both the Three Mile Island and Chernobyl nuclear power plant accidents?  
1. Operator error/inexperience caused mistakes. 2. Bad design/inadequate safety instruments.
4. Why did the plant in Chernobyl to experience two explosions?  
The reactor overheated, first causing steam pressure to build up and the reactor to explode, then the hot graphite reacted with  $\text{O}_2$  from the air in a second explosion.
5. What was the major difference for the Fukushima plant accident? What caused its reactors to explode?  
The initial cause of the accident was a natural disaster, rather than human error, which incapacitated the emergency systems. The reactors exploded when  $\text{H}_2$  gas was formed from Zn coating the fuel rods reacted with hot water, and then the  $\text{H}_2$  reacted with  $\text{O}_2$  from the air.

Watch the video “Fusion Energy Explained,” <https://youtu.be/N4yWhA1mVxA>

6. Why is fusion power not currently used to generate electrical power?  
We have yet to achieve a controlled fusion reaction in which more energy is released than needed to initiate and sustain the plasma.
7. What are some benefits of fusion as an energy source?  
It has an inexpensive, nearly infinite fuel source (H from  $\text{H}_2\text{O}$ ), it is extremely efficient, it generates no high-level radioactive wastes.

### **Article: The Alchemist’s Dream**

Read the attached article, “The Alchemist’s Dream” and answer the following questions

8. The first controlled fission reaction was set up at the University of Chicago. What basic substances made up the pile?  
Alternating layers of solid graphite bricks and bricks drilled out so they could contain two short, rounded cylinders of compressed uranium oxide powder. There were rods of cadmium supported on wood interspersed, and buckets of cadmium sulfide.

9. What was the purpose of the cadmium sulfide solution?

It was the “neutron fire extinguisher,” meant to slow the reaction if needed.

10. What was the purpose of the graphite?

To moderate (slow down) the speed of the neutrons so they could be captured by the uranium nuclei.

11. What material was used for the control rods?

Cadmium