Advanced Nuclear Energy Science and Engineering

Nuclear Energy · Answer Key · 17 Questions

1. What is the primary mechanism by which neutrons are slowed down in a thermal nuclear reactor to achieve criticality?

A) Neutron scattering by heavy nuclei
B) Neutron absorption and subsequent re-emission
C) Elastic scattering with light nuclei (moderator)
D) Neutron capture followed by alpha decay

2. The concept of a "breeding ratio" in a nuclear reactor refers to the ratio of:

A) Fissile material produced to fissile material consumed
B) Heat generated to electrical power output
C) Neutrons absorbed by fuel to neutrons absorbed by control rods
D) Radioactive waste generated to useful energy produced

3. In the context of nuclear fuel, what is the significance of the "neutron multiplication factor" (k)?

A) It quantifies the rate of heat transfer from the fuel rods.
B) It represents the ratio of neutrons produced in one generation to the neutrons lost in the previous generation.
C) It measures the efficiency of control rod insertion for power regulation.
D) It indicates the level of radioactivity in the spent fuel.

4. Which of the following is a key characteristic of a Fast Breeder Reactor (FBR) compared to a Light Water Reactor (LWR)?

A) It uses heavy water as a moderator.
B) It primarily uses thermal neutrons to sustain the chain reaction.
C) It can produce more fissile material than it consumes.
D) It operates at significantly lower temperatures.

5. What is the primary reason for the use of zirconium alloys (like Zircaloy) as cladding material for nuclear fuel rods in most power reactors?

A) High neutron absorption cross-section
B) Excellent thermal conductivity and resistance to high temperatures and neutron bombardment
C) Low melting point for easy reprocessing
D) High density to prevent radiation leakage

6. The Curie (Ci) is a unit of radioactivity. What does it specifically measure?

A) The absorbed dose of radiation

B) The number of disintegrations per second

C) The energy imparted by ionizing radiation

D) The biological effect of radiation exposure

7. What phenomenon is responsible for the delayed neutrons emitted by certain fission products, which is crucial for reactor control?

A) Neutrino oscillations

B) Beta decay of some fission fragments

C) Spontaneous fission of heavy isotopes

D) Gamma ray emission

8. In nuclear reactor safety, what is the primary function of the containment building?

A) To house the turbines and generators

B) To prevent the release of radioactive materials into the environment in case of an accident

C) To absorb excess neutrons and control the reaction rate

D) To cool the reactor core during normal operation

9. Which of the following describes the process of "neutron activation analysis"?

A) Measuring the decay rate of fissile isotopes

B) Inducing radioactivity in a sample by neutron bombardment to identify its elemental composition

C) Calculating the critical mass of a nuclear material

D) Tracking the movement of radioactive isotopes in the environment

10. The "Samarium Effect" in nuclear reactors refers to:

A) The increase in reactivity due to the presence of samarium isotopes.

B) The buildup of samarium-149, a strong neutron absorber, which reduces reactivity over time.

C) The spontaneous emission of samarium isotopes during fission.

D) The decay of samarium isotopes into more fissile materials.

11. What is the primary advantage of using Thorium-232 as a potential nuclear fuel precursor over Uranium-238?

A) Thorium-232 is more readily fissionable by thermal neutrons.

B) Thorium-232 has a higher natural abundance and produces less long-lived transuranic waste upon neutron capture and decay.

C) Thorium-232 requires less moderator to achieve criticality.

D) Thorium-232 has a significantly higher heat output per unit mass.

12. In a Pressurized Water Reactor (PWR), what is the primary purpose of the pressurizer?

A) To control the flow rate of coolant through the core.
B) To maintain a high pressure in the primary coolant loop to prevent boiling.
C) To remove decay heat from the spent fuel.
D) To generate steam for the turbines.

13. Which nuclear reaction is the basis for nuclear fission in most power reactors?

A) Proton-proton chain reaction
B) Deuterium-tritium fusion
C) Neutron-induced fission of heavy isotopes like Uranium-235 or Plutonium-239
D) Beta decay of radioactive elements

14. The "burnup" of nuclear fuel is a measure of:

A) The rate at which fuel rods corrode.
B) The amount of fission products that have accumulated within the fuel.
C) The energy extracted from the fuel, typically expressed in megawatt-days per metric ton of heavy metal (MWd/tU).
D) The temperature reached by the fuel during operation.

15. What is the specific activity of a radioactive isotope?

A) The total number of atoms in a sample.
B) The rate at which alpha particles are emitted.
C) The number of radioactive decays per unit mass or volume per unit time.
D) The half-life of the isotope.

16. In the context of nuclear waste management, "vitrification" is a process used for:

A) Compacting low-level radioactive waste.
B) Encasing high-level radioactive waste in a stable glass matrix.
C) Incinerating radioactive organic materials.
D) Diluting liquid radioactive waste.

17. What is the main difference between a "chain reaction" and a "controlled chain reaction" in nuclear reactors?

A) A chain reaction involves only gamma rays, while a controlled chain reaction involves neutrons.
B) A chain reaction is spontaneous and uncontrolled, while a controlled chain reaction maintains a stable neutron population for power generation.
C) A chain reaction requires a moderator, while a controlled chain reaction does not.
D) A chain reaction produces heat, while a controlled chain reaction produces electricity directly.