Unit 17: Nuclear Chemistry

Nuclear Processes

This worksheet will cover nuclear fission and fusion, fundamental processes in nuclear chemistry. **Nuclear fission** involves splitting heavy atomic nuclei to release energy, while **fusion** combines lighter nuclei, generating even more energy. These processes lead to the creation of transuranium nuclides, elements with atomic numbers higher than uranium, offering valuable insights into nuclear physics and heavy element behavior, with potential implications for energy production in reactors requiring fissile material and control or extreme temperature and pressure for fusion reactions.

Questions:

1. How does nuclear fission differ from nuclear fusion? Why are both of these processes exothermic?

2. Both fusion and fission are nuclear reactions. Why is a very high temperature required for fusion, but not for fission?

3. Cite the conditions necessary for a nuclear chain reaction to take place. Explain how it can be controlled to produce energy, but not produce an explosion.

4. Describe how the potential energy of uranium is converted into electrical energy in a nuclear power plant.

5. Name three applications of nuclear reactions:

6. What are the key components of a nuclear chain reaction, and how does it sustain itself in a nuclear reactor?

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Answer Key:

1. How does nuclear fission differ from nuclear fusion? Why are both of these processes exothermic?

   Nuclear fission differs from nuclear fusion in that heavy nuclei divide into smaller nuclei in fission, whereas in fusion, two smaller nuclei join to generate heavier nuclei. In both of these reactions, they release huge amounts of energy, thus they are exothermic processes.

2. Both fusion and fission are nuclear reactions. Why is a very high temperature required for fusion, but not for fission?

   During the nuclear reaction of fission type, the process has a low activation barrier that can be achieved at a lower temperature while in the case of fusion the activation barriers are very high which leads to the requirement of a higher temperature.

3. Cite the conditions necessary for a nuclear chain reaction to take place. Explain how it can be controlled to produce energy, but not produce an explosion.

   The amount of neutrons produced by fission must equal or surpass the number of neutrons absorbed by the dual rods plus the number of neutrons that escape to the surroundings for a nuclear chain reaction to occur.

   It can be regulated by utilizing control rods that absorb the extra neutrons produced, allowing the rate to be controlled while avoiding an explosion.

4. Describe how the potential energy of uranium is converted into electrical energy in a nuclear power plant.

   Nuclear power reactors use heat produced during atomic fission to boil water and produce pressurized steam. The steam is routed through the reactor steam system to spin large turbine blades that drive magnetic generators to produce electricity.

5. Name three applications of nuclear reactions:
   a. Nuclear weapons
   b. Medicine (chemotherapy, PET scans, etc.)
   c. Nuclear power generation

6. What are the key components of a nuclear chain reaction, and how does it sustain itself in a nuclear reactor?

   The key components of a nuclear chain reaction include fissile material, neutrons, and a moderator. In a nuclear reactor, fissile material, such as uranium-235 or plutonium-239, absorbs neutrons and undergoes fission, releasing more neutrons. A moderator (also known as control rods) slows down these neutrons, increasing their likelihood of causing additional fissions. This sustained process of neutron absorption and fission is what sustains a nuclear chain reaction in a reactor, producing a controlled release of energy.