<u>Open Book Examination</u>

The first obvious difference between alpha and beta decay is that alpha decay is made up of 2 protons and 2 neutrons (a helium nucleus) whereas beta is made up of 1 electron (produced by nuclear changes). Alpha radiation has a relative mass of 4 and is positively charged by 2 compared to that of beta which is just 0.00055 with a negative charge of 1. Beta radiation can travel a few metres and can be stopped by anything denser than aluminium foil. The deflection by electrical field is high. Alpha radiation has a range of only a few centimetres and is stopped by anything denser than paper. The deflection by electrical field here is low.

Alpha decay involves the emission of alpha particles and is common among the heavier elements with atomic numbers great than 83. Each time alpha particles are reduced the element from which they came will decrease in mass by 4 units and 2 nuclear charge units.

E.g. $${}^{224}_{88}Ra \longrightarrow {}^{220}_{86}Ra + {}^{4}_{2}He$$

Beta decay involves the emission of electrons and is common among the lighter elements where the isotopes contain a relatively large number of neutrons. The nuclear charge will increase by one unit for every electron released. (This is understandable as electrons and negatively charged).

E.g. $${}^{225}_{88}Ra \longrightarrow {}^{225}_{89}Ac + {}^{0}_{-1}e^-$$

A similarity between them both is that during decay of both alpha and beta the elements effected both change into different elements.

The difference between nuclear fission and natural radioactive decay is that fission is a nuclear process in which the nucleus of a heavy atom (e.g., Uranium) is split by a neutron, releasing a large amount of energy and additional neutrons. Whereas natural radioactive decay is, in it's very nature, a natural occurrence and comes in the form of alpha, beta (as explained above) and gamma radiation.

Fusion reactions are when two light atomic nuclei fuse together to form a single heavier nucleus of a new element. The process is exothermic and occurs only at very high temperatures. Reactions like this take place in the sun.

E.g.

$${}^{1}_{1}H + {}^{2}_{1}H \longrightarrow {}^{3}_{2}He + \gamma$$

In a fission reaction neutrons split heavy atoms like uranium which then release very high amounts of energy unless controlled.

E.g.

$${}^{235}U + N \longrightarrow {}^{236}U \longrightarrow {}^{92}Kr + {}^{141}Ba$$

Fission chain reactions allow us to control the amount of energy. Chain reactions occur because of interactions between neutrons and fissile isotopes (such as ${}^{235}U$). The chain reaction needs both the release of neutrons from fissile isotopes in the process of nuclear fission and the absorption of some of these neutrons in fissile isotopes. When an atom goes through nuclear fission, a few neutrons are ejected from the reaction. These free neutrons will then be absorbed by the surrounding fissile fuel and causes more fission reactions. The cycle repeats and is self-sustaining. Fission reactions produce energy we can use, the energy released can be used to heat water, produce steam and drive a turbine that generates electricity

The likelihood of a catastrophic accident in a fusion reactor in which injury or loss of life occurs is much smaller than that of a fission reactor. The primary reason is that the fission products in a fission reactor continue to generate heat through beta-decay for several hours or even days after reactor shut-down, meaning that a meltdown is possible even after the reactor has been stopped. In contrast, fusion needs precisely controlled conditions of temperature, pressure and magnetic field parameters in order to generate net energy. If the reactor were damaged, these parameters would be disrupted and the heat generation in the reactor would rapidly cease.

Controlling and using fusion reactions is slightly harder and is not widely used. However, if we could create a safe and effective way of producing fusion reactions then it would be far safer and more efficient than fission by far. Fusion reactions are harnessed by the Tokamak reactors, which use plasma technology. The main challenges for scientist who are developing fusion power stations are: There would be a short-term radioactive waste problem due to activation products. Some component materials will become radioactive during the lifetime of a reactor, due to bombardment with high-energy neutrons, and will eventually become radioactive waste. The volume of such waste would be similar to that due to activation products from a fission reactor.

There are also other concerns, principally regarding the possible release of tritium into the environment. It is radioactive and very difficult to contain since it can penetrate concrete, rubber and some grades of steel. As an isotope of hydrogen, it is easily incorporated into water, making the water itself weakly radioactive. With a half-life of 12.4 years, tritium remains a threat to health for about 125 years after it is created, as a gas or in water. It can be inhaled, absorbed through the skin or ingested. Inhaled tritium spreads throughout the soft tissues and tritiated water mixes quickly with all the water in the body.