PHYS 1200 Physics of Everyday Experience

Review questions and exercises for Lecture 36 (MP-4)

1. Some radioactive nuclei emit beta particles which are electrons. Since there are no electrons in the nucleus, where do the betas come from?
2. In nuclear reactions the masses of the products can be less than the masses of the reactants. What happens to the lost mass?
3. What is ionizing radiation?
4. What is radiation sickness?
5. Who discovered (a) fission, (b) radioactivity?
6. Who is considered the father of the (a) atom bomb, and (b) hydrogen bomb?
7. Who major process are responsible for the release of huge amounts of energy in nuclear reactions?
8. What is a chain reaction?
9. What is the practical distinction between a nuclear reactor and a nuclear bomb?
10. Which country produces the largest percentage of its electrical power from nuclear energy?
11. How is the release of nuclear energy controlled in a reactor?
12. How is nuclear energy used to produce electricity?
13. What is meant by the enrichment of uranium?
14. The first nuclear weapons were based on what process?
15. What is required for nuclear fuel to detonate?
16. How did the design of the plutonium bomb differ from that of the uranium bomb?
17. What is nuclear fusion?
18. What process is the energy source for stars?
19. What is the fallout of the detonation of a nuclear weapon?
20. What is ITER?

Answers:

1. Beta emission is due to a process called beta decay in which a neutron in the nucleus decays into a proton and an electron.
2. The lost mass is converted into energy according to Einstein's famous formula $E = mc^2$.
3. Ionizing radiation is radiation, photons or particles, that when entering the body can produce ionization (removal of electrons) of the atoms and molecules in the cells.
4. Radiation sickness is the general term used to describe the harmful effects of ionizing radiation in the body.
5. (a) Otto Hahn and Lise Meitner; (b) Marie Curie.
6. (a) Enrico Fermi; (b) William Teller.
7. Nuclear fission (splitting heavy nuclei into lighter nuclei) and nuclear fusion (combining light nuclei into heavier nuclei).
8. A chain reaction occurs when one neutron splits a nucleus and two neutrons are emitted which then each split 2 more nuclei producing 4 neutrons, etc.
9. The practical difference between a reactor and a bomb is that in a reactor the nuclear energy is released in a controlled manner, while in a bomb the energy is released in an uncontrolled manner.
10. France
11. The core of a nuclear reactor contains control rods which are made of a material that absorbs neutrons and prevents them from penetrating into the fuel rods. The control rods can be removed or inserted to control the reaction rate and the rate at which nuclear energy is released.
12. The nuclear energy that is released in the fuel rods causes the fuel rods to get very hot. This heat is carried off by a coolant liquid which is then used to heat water and produce steam which powers the turbine of the electric generator.
13. Natural uranium from a mine is over 99% U-238 and less than 1% U-235. Only the U-235 undergoes nuclear fission (U-235 is "fissionable"). Weapons grade uranium must contain at least 20 % U-235. The enrichment process is a method of separating the U-238 and U-235, leaving uranium that is at least 20% U-235.
14. Nuclear fission – "splitting the atom".
15. To detonate nuclear fuel, a critical mass is required. In a nuclear bomb, two blobs of fissionable material are brought together very quickly (using explosives) to form a critical mass.

16. In the uranium bomb, a slug of fissionable uranium was thrust into another slug of uranium for make a critical mass. In the plutonium bomb a spherical geometry was used in which a annular layer of U-238 surrounded a core of Pu-239. An explosive layer surrounding the U-238 drove it into the Pu-239 core forming a critical mass.
17. Nuclear fusion is a process in which light nuclei are fused together to form a heavier nuclei with the release of huge amounts of energy. The most common fusion reaction combines deuterium and tritium to from alpha particles.
18. Nuclear fusion.
19. Fallout is the term used to describe the radioactive materials that are released when a nuclear weapon is detonated.
20. ITER stands for International Thermonuclear Experimental Reactor. This is a large experimental device under construction in the south of France in which a controlled release of fusion energy is designed to occur. The hope is that more energy will be released than was necessary to power the device initially – self-sustaining. The energy released would be used to generate electrical power. ITER holds the promise of an unlimited supply of electricity, since the basic fuel tritium, can be obtained from sea water.