NUCLEAR ENERGY

Nuclear Energy can be obtained from nuclear reactions. Nuclear reactions can be (broadly) divided into two types:

1. Nuclear Fusion
2. Nuclear Fission

NUCLEAR FUSION

This is the joining of two or more smaller nuclei to produce a much heavier nucleus. For example, the joining of Deuterium (an isotope of hydrogen) and Tritium (Another isotope of hydrogen) to produce helium atom, a neutron and energy

$${}_{1}^{2}H\,{}_{1}^{3}H \rightarrow {}_{2}^{4}He + {}_{0}^{1}n + Energy$$

Most of the energy from the sun is through Nuclear Fusion

ADVANTAGES OF NUCLEAR FUSION

1. The raw materials are readily available.
2. The raw materials are cheap.
3. The by-products are not radioactive.
4. A greater amount of energy is produced in fusion compared to fission.

NUCLEAR FISSION

This is defined as the splitting of a (heavy) nucleus into two or more smaller nuclei. For example, when uranium is bombarded with (a neutron or) neutrons, it will produce Barium and Krypton with more neutrons produced and energy generated

$${}_{92}^{238}U + {}_{0}^{1}n \rightarrow {}_{56}^{144}Ba + {}_{36}^{92}Kr + {}_{0}^{1}n + {}_{0}^{1}n + Energy$$

$${}_{92}^{238}U + {}_{0}^{1}n \rightarrow {}_{56}^{144}Ba + {}_{36}^{92}Kr + 2\,{}_{0}^{1}n + Energy$$

The production of more neutron in nuclear fission makes it a typical chain reaction. A chain reaction is a reaction that can keep itself going. It involves the production of mote neutrons which react with the first element which in this case is Uranium.

Note the following

1. Graphite rods are used to slow down the fast moving neutrons and thence slow down the overall reaction.
2. Boron rods are used to absorb the neutrons. Hence they stop the overall reaction.
3. Sodium vapor is also used to stop nuclear reactions (nuclear fission).

Nuclear fission is used in nuclear energy generation despite the greater amount of energy produced in nuclear fusion. This is because

1. In nuclear fusion, great amount of heat is evolved which may possibly affect the scientist running the reactions.

2. In nuclear fusion, large amount of energy is needed to overcome the repulsive forces between the hydrogen atoms. This is because hydrogen atoms are positively charged and conventionally, like charges repel.

APPLICATIONS OF NUCLEAR ENERGY

1. They are used in the generation of electricity
2. They are used for detecting leakages in underground pipes carrying oil
3. They are used to produce nuclear weapons such as the Atomic Bomb and the Nuclear Bomb.

MASS DEFECT EQUATION

Most nuclear reactions involve the loss of mass of the element. This loss of mass is called the mass defect. The mass defect is as a result of the emission of radiation.
According to Albert Einstein,

$E = \Delta m c^2$

BINDING ENERGY

This is defined as the energy required to hold the components of the nucleus together. It is also defined as the **energy equivalent** of the difference between (the sum of mass of the proton and neutron) and its atomic mass. From the mass defect equation,

$$Binding\ energy = (Mass\ defect) \times c^2$$

$$BE = \Delta m c^2$$

$$Mass\ defect = [Total\ Mass\ of\ proton + Tatal\ Mass\ of\ neutron] - Atomic\ mass$$

$$\Delta m = [T_p + T_n] - M$$

$$Total\ mass\ of\ proton = number\ of\ protons \times mass\ of\ a\ proton$$

$$T_p = n_p m_p$$

$$Total\ mass\ of\ neutron = number\ of\ neutrons \times mass\ of\ a\ neutron$$

$$T_n = n_n m_n$$

$$\Delta m = ([n_p m_p + n_n m_n] - M)$$

$$BE = ([n_p m_p + n_n m_n] - M) c^2$$

WAVE PARTICLE PARADOX

This concept explains how matter can exhibit a particle property and can also exhibit wave property. For example, electrons which are particles naturally have the particulate properties. However, electrons also undergo diffraction which is a property of waves.

The photoelectric effect also explains the particulate nature of light (even though light is a wave)
Wave particle paradox is just the explanation of the duality of matter which explains the dual nature of matter. Matter has two (major) natures which are the wave nature and the particle nature.

HEISENBERG’S UNCERTAINTY PRINCIPLE

This principle states that: “There is always an uncertainty in the simultaneous determination of the momentum and the position of a particle at any given time”
If ΔP is the uncertainty in the measurement of momentum
If Δx is the uncertainty in the measurement of position

$\Delta P \cdot \Delta x \geq h$
$P \times \lambda = h$
$\lambda = \frac{h}{P}$
But $P = mc$
$\lambda = \frac{h}{mc}$
This equation above is also known as **De-brogile equation**.

In simple terms, the uncertainty principle simply states that. If you do things simultaneously, there will be an uncertainty or defect in at least one of them and you can’t completely decide the maximum of each.