Introduction

This is a learning as well as an exam preparation video.

At the end of the video are practice assignments for you to attempt.

Please go to www.eastpoint.intemass.com/ or click on the link at the bottom of this video to do the assignments for this topic.

MEGAForte

Innovate. Educate.

Chapter 13: Nuclei

Chapter 13: Nuclei

Nucleus:

The entire positive charge and nearly the entire mass of atom is concentrated in a very small space called the nucleus of an atom.

The nucleus consists of protons and neutrons. They are called nucleons

Chapter 13: Nuclei

Nucleus:

Atomic Number:

The number of protons in the nucleus is called the atomic number. It is denoted by Z.

Mass number:

The total number of protons and neutrons present in a nucleus is called the mass number of the element. It is denoted by A.

Chapter 13: Nuclei

Nucleus:

The unit in which atomic and nuclear masses are measured is called atomic mass unit (u),

defined as $\frac{1}{12}$ of the mass of an atom of 6C12 isotope.

$$1u = \frac{1}{12} \times \frac{12}{6.02 \times 10^{23}}$$

$$1u = 1.66 \times 10^{-27} kg$$

$$1amu = 931\ MeV$$

Chapter 13: Nuclei

Nucleus:

Nuclear Mass:

The total mass of the protons and neutrons present in a nucleus is called the nuclear mass.

Nuclide:

A nuclide is a specific nucleus of an atom characterized by its atomic number Z and mass number

A. It is represented as, ZXA

Where X = chemical symbol of the element, Z = atomic number and A = mass number

Chapter 13: Nuclei

Isotopes:

The atoms of an element which have the same atomic number, but different mass number are

called isotopes.

Isotopes have similar chemical properties but different physical properties.

Chapter 13: Nuclei

Isobars:

The atoms having the same mass number, but different atomic number are called isobars.

Isotones:

The nuclides having the same number of neutrons are called isotones.

Chapter 13: Nuclei

Isomers:

These are nuclei with same atomic number and same mass number but in different energy states.

Electron Volt:

It is defined as the energy acquired by an electron when it is accelerated through a potential difference of 1 volt and is denoted by eV.

Chapter 13: Nuclei

Discovery of Neutron:

Neutron was discovered experimentally by Chadwick in the year 1932 and was awarded Nobel Prize in Physics in 1935 for their discovery. A neutron is a neutral particle carrying no charge and having mass roughly equal to the mass of a proton.

Now the mass of a neutron is known to a high degree of accuracy and is equal to mn = 1.67 x 10-27 kg. A free neutron is unstable and has a mean life of 1000 second. Whereas a free proton is stable. Neutron is however stable inside the nucleus.

Chapter 13: Nuclei

Size of the Nucleus:

- It is found that a nucleus of mass number A has a radius.

$$R = R_0 A^{\frac{1}{3}}$$

$$\text{where, } R_0 = 1.2 \times 10^{-15} \text{m}$$

- This implies that the volume of the nucleus, which is proportional to R3 is proportional A.

Chapter 13: Nuclei

Mass-Energy and Nuclear Binding Energy:

Mass-Energy:

Einstein gave the famous mass–energy equivalence $E = mc2$, here the energy equivalent of mass m is related by the above equation and c is the velocity of light in vacuum and is approximately equal to 3×108 m/s. Einstein's mass-energy relation has been experimentally verified in the study of nuclear reactions amongst nucleons, nuclei, electrons and other more recently discovered particles.

Chapter 13: Nuclei

Mass-Energy and Nuclear Binding Energy:

Nuclear Binding Energy:

Nucleus is made up of neutrons and protons. Therefore, mass of the nucleus (M) should be equal to the total mass of its protons and neutrons. However, it is found to be always less than this. This difference in mass (ΔM) is called the mass defect and is given by.

$$\Delta M = [Zm_p + (A - Z)m_n] - m$$

Chapter 13: Nuclei

Mass-Energy and Nuclear Binding Energy:

It is mass defect which appears in the form of binding energy, responsible for binding the nucleons together in the nucleus.

Chapter 13: Nuclei

Nuclear Force:

The force acting inside the nucleus or acting between nucleons is called nuclear force.

- Nuclear forces are the strongest forces in nature.
- It is a very short-range attractive force.
- It is non-central. non-conservative force.
- It is neither gravitational nor electrostatic force.
- It is independent of charge.
- It is 100 times that of electrostatic force and 1038 times that of gravitational force.

Chapter 13: Nuclei

Nuclear Force:

According to the Yukawa, the nuclear force acts between the nucleon due to continuous exchange of meson particles.

Chapter 13: Nuclei

Radioactivity:

It is the phenomenon of spontaneous disintegration of the nucleus of an atom with emission of one or more radiations like α-particle, β-particle or γ −rays.

Chapter 13: Nuclei

Radioactivity:

Radioactive Decay:

It is a nuclear transformation process in which the radioactive rays are emitted from the nucleus of the atom. This process cannot be accelerated and slow down by any physical or chemical process.

Chapter 13: Nuclei

Radioactivity Displacement Law:

It states that:

- When a radioactive nucleus emits an α -particle, atomic number decreases by 2 and mass number decreases by 4.
- When a radioactive nucleus emits β -particle, its atomic number increases by 1 but mass number remains same.
- The emission of a γ -particle does not change the mass number or the atomic number of the radioactive nucleus. The γ -particle emission by a radioactive nucleus lowers its energy state.

Chapter 13: Nuclei

Alpha Decay:

In this process, parent nucleus disintegrates to give a daughter nucleus and helium nucleus or an alpha-particle. Mass number of the daughter nucleus decreases by four units and atomic number decreases by two units. A typical example of this decay mode is.

$$U_{92}^{238} \rightarrow He_2^4 + Th_{90}^{234}$$

Thus, daughter nucleus is shifted in periodic table by 2 unit in backward direction.

Chapter 13: Nuclei

Beta Decay:

It is the process of emission of an electron from a radioactive nucleus. It may be represented as,

$$^{A}_{Z}X \rightarrow {}^{A}_{Z+1}Y + {}^{0}_{-1}e + \overline{V}$$

Chapter 13: Nuclei

Gamma Decay:

Alpha and beta decays of a radioactive nucleus leave the daughter nucleus in an excited state. If the excitation energy available with the daughter nucleus is not sufficient for further particle emission, it loses its energy by emitting electromagnetic radiations, also known as Gamma-rays. Mass and charge of the daughter nucleus remains the same as before the emission of Gammarays.

$$Ba_{56}^{137} \rightarrow Ba_{56}^{137} + \gamma$$

Chapter 13: Nuclei

Alpha and beta decays of a radioactive nucleus leave the daughter nucleus in an excited state. If the excitation energy available with the daughter nucleus is not sufficient for further particle emission, it loses its energy by emitting electromagnetic radiations, also known as Gamma-rays.

Mass and charge of the daughter nucleus remains the same as before the emission of Gammarays.

Chapter 13: Nuclei

Law of Radioactive Decay:

According to the law of radioactive disintegration the rate of spontaneous disintegration of a radioactive element is proportional to the number of nuclei present at that time. Mathematically, it can be written as

$$\frac{dN}{dt} \propto N \ldots (1)$$

Where, N is the number of atoms present at time t.
Removing Proportionality sign, we get

$$\frac{dN}{dt} = -\lambda N \ldots (2)$$

Chapter 13: Nuclei

Law of Radioactive Decay:

Where, λ is a constant of proportionality and is known as decay constant of the element.

Negative sign indicates that as t increase N decreases.

$$\frac{dN}{N} = -\lambda dt \ldots (3)$$

Integrating both sides, we have

$$\int \frac{dn}{N} = -\lambda \int dt$$

$$\log_e(N) = -\lambda t + C \ldots (4)$$

Chapter 13: Nuclei

Law of Radioactive Decay:

where C is constant of integration and is evaluated by the fact that at t = 0, number of atoms of the radioactive element is N0. Using this condition, we get

$$C = \log_e(N_0) \quad \dots (5)$$

Substituting this value of C in Eq. (5), we get

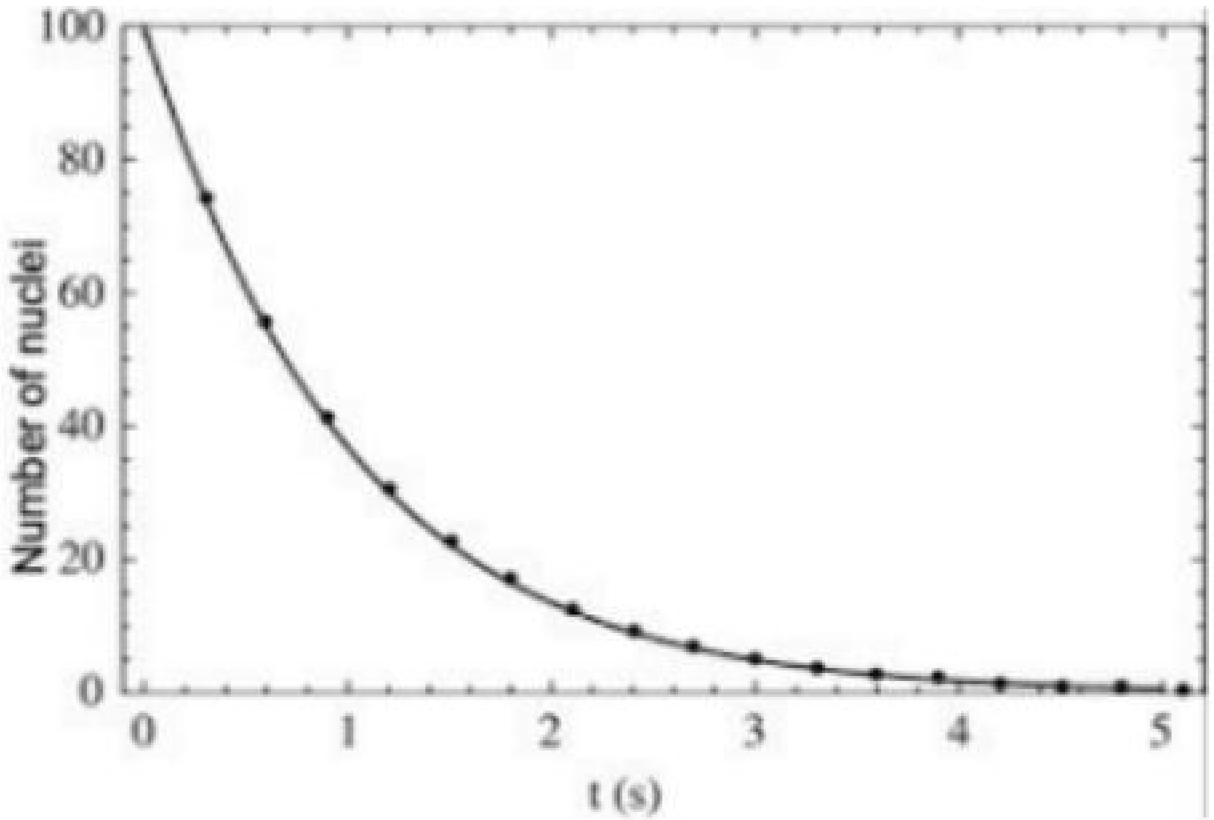
$$\log_e(N) = -\lambda + \log_e(N_0)$$

$$\log_e(N) - \log_e(N_0) = -\lambda t$$

$$\text{Thus, } N = N_0 e^{-\lambda t} \quad \dots (6)$$

Chapter 13: Nuclei

Law of Radioactive Decay:



Exponential decay curve

Chapter 13: Nuclei

Decay or disintegration Constant:

It may be defined as the reciprocal or the time interval in which the number of active nuclei in a given radioactive sample reduces to 36.8% of its initial value.

Chapter 13: Nuclei

Decay or disintegration Constant:

Half-life:

The half-life of a radioactive substance is the time in which one-half of its nuclei will disintegrate.

It is inversely proportional to the decay constant of the radioactive substance.

$$T_{\frac{1}{2}} = \frac{0.693}{\lambda}$$

Chapter 13: Nuclei

Decay or disintegration Constant:

Mean Life:

The mean-life of a radioactive sample is defined as the ratio of the combined age of all the atoms

and the total number of atoms in the given sample. It is given by,

$$\tau = \frac{T_{\frac{1}{2}}}{0.693} = 1.44T_{\frac{1}{2}}$$

Chapter 13: Nuclei

Decay or disintegration Constant:

Curie:

It is the SI unit of decay.

One curie is the decay rate of 3.7 × 1010 disintegrations per second.

Chapter 13: Nuclei

Decay or disintegration Constant:

Rutherford:

One Rutherford is the decay rate of 106 disintegrations per second.

Natural Radioactivity:

It is the phenomenon of the spontaneous emission of, α and γ radiations from the nuclei of naturally occurring isotopes.

Chapter 13: Nuclei

Decay or disintegration Constant:

Artificial or Induced Radioactivity:

It is the phenomenon of inducing radioactivity in certain stable nuclei by bombarding them by suitable high energy subatomic particles.

Nuclear Reaction:

It is a reaction which involves the change of stable nuclei of one element into the nucleus of another element.

Chapter 13: Nuclei

Nuclear Energy:

Nuclear Fission:

The process of the splitting of a heavy nucleus into two or more lighter nuclei is called nuclear fission. When a slow-moving neutron strikes with a uranium nucleus (92U

235), it splits into 56Ba144 and 36Kr89 along with three neutrons and a lot of energy.

$$U_{92}^{235} + n_0^1 \rightarrow Ba_{56}^{144} + Kr_{36}^{89} + 3n_0^1$$

Chapter 13: Nuclei

Nuclear Energy:

Nuclear fusion:

The process of combining of two lighter nuclei to form one heavy nucleus, is called nuclear fusion.

$$H_1^2 + H_1^2 \rightarrow He_2^3 + n_0^1$$

In this process, a large amount of energy is released. Hydrogen bomb is based on nuclear fusion. The source of Sun's energy is the nuclear fusion taking place at sun.

Chapter 13: Nuclei

Nuclear Energy:

Critical size and Critical Mass:

- The size of the fissionable material for which reproduction factor is unity is called critical size and its mass is called critical mass of the material.
- The chain reaction in this case remains steady or sustained.

Chapter 13: Nuclei

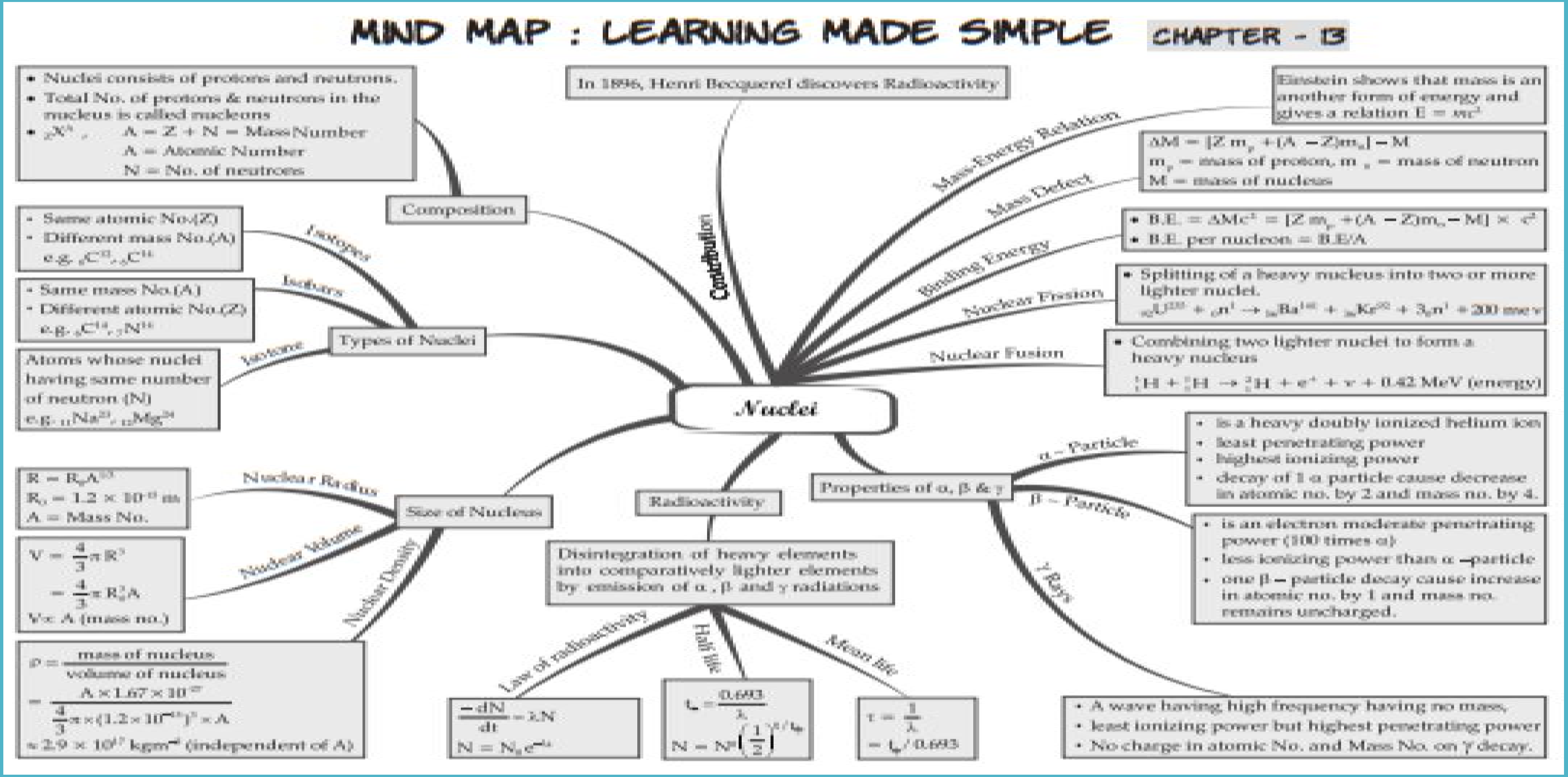
Nuclear Energy:

Moderator:

Any substance which is used to slow down fast-moving neutrons to thermal energies is called a moderator.

The commonly used moderators are water, heavy water (D2O) and graphite.

Chapter 13: Nuclei



Practice Assignments, Exam Prep Assignments for The CBSE Business Studies

1. You may now proceed to try out the exam preparation assignments.

2. ALL assignments will be marked and feedback will be given.

3. Should you need to speak to one of our tutors send your email to administration@intemass.com

4. Please proceed to the link www.eastpoint.intemass.com at the bottom of this video to commence with your practice.

MEGA FORTE

INTEGRATED EXAMINATION

GLOBAL LMS

& ASSIGNMENT SYSTEM

Please click **subscribe** to our video if you find the content useful.

ALL THE BEST WITH YOUR ASSIGNMENTS