# PHYSICS

# BOOKS - OSWAAL PUBLICATION PHYSICS (KANNADA ENGLISH)

# NUCLEI

## Topic 1 Very Short Answer Type Questions

**1.** How does nuclear radius of an atom depend on its mass number ?

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**2.** A radioactive element ${}_{92}X^{238}$ emits one $\alpha$-particle and one $\beta$' particle in succession.

What is the mass number of new element formed?

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**3.** What is the SI unit of activity?

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**4.** What is mean life of a radioactive element?

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**5.** State the law of radiactive disintegration.

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**6.** Name the anti-particle of an electron.

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**7.** Identify the particle P in the following nuclear reaction.

$$X_Z^A \rightarrow Y_{Z+1}^A + e_{-1}^0 + P$$

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## Topic 1 Short Answer Type Questions I

**1.** Two nuclei have mass numbers in the ratio 8 : 125. Calculate the ratio of their nuclear radii.

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**2.** Show that the density of nucleus over a wide range of nuclei is constant independent of mass number.

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**3.** Calculate the half-life period of a radioactive substance, if its activity drops to $16^{th}$ of its initial value in 30 years.

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## Topic 1 Short Answer Type Questions Ii

**1.** Write the expression for the half life of a radioactive element.

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**2.** What are the characteristics of nuclear forces?

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**3.** A given number of atoms, $N_0$ of a radioactive element with a half life T is uniformly distributed in the blood stream of a

(i) Normal person A having total volume V of blood in the body.

(ii) Person B in need of blood transfusion having a volume V' of blood in the body.

The number of radioactive atoms per unit volume in the blood streams of the two persons after a time $nT$ are found to be $N_1$ and $N_2$.

Prove mathematically that the additional volume of blood that needs to be transfused in the body of person B equals $\left(\frac{N_2 - N_1}{N_2}\right)$ V.

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**4.** The half-life of $^{238}_{92}U$ undergoing a-decay is $4.5 \times 10^9$ years. What is the activity of 1g sample of $^{238}_{92}U$?

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**5.** State the law of radioactivity and hence, show that $N = N_0 e^{-\lambda t}$.

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**6.** (a) The number of nuclei of a given radioactive nucleus, at times $t = 0$ and $t = T$, are $N_0$ and $(N_0/n)$ respectively. Obtain an expression for the half life $(T_{1/2})$ of this nucleus in terms of n and T.

(b) Identify the nature of the 'radioactive radiations', emitted in each step of the 'decay

chain' given below:

$$_{Z}^{A}X \rightarrow {}_{Z-2}^{A-4}Y \rightarrow {}_{Z-2}^{A-4}Y \rightarrow {}_{Z-1}^{A-4}W$$

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**7.** State the law of radioactive decay.

Plot a graph showing the number (N) of undecayed nuclei as a function of time (t) for a given radioactive sample having half life $T_{1/2}$. Depict in the plot, the number of undecayed nuclei at (i) $t = 3T_{1/2}$ and (ii) $t = 5T_{1/2}$.

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**8.** (a) Write symbolically the $\beta$-decay process of phosphorus.

(b) Derive an expression for the average life of a radionuclide. Give its relationship with the half-life.

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**9.** (i) Define 'activity' of a radioactive material and write its S.I. unit.

(ii) Plot a graph showing variation of activity of

a given radioactive sample with time.

(iii) The sequence of stepwise decay of a radioactive nucleus is

$$D \xrightarrow{\alpha} D_1 \xrightarrow{\beta-} D_2$$

If the atomic number and mass number of $D_2$ are 71 and 176 respectively, what are their corresponding values for D ?

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## Topic 1 Long Answer Type Questions I

**1.** State the law of radioactivity and hence, show that $N = N_0 e^{-\lambda t}$.

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**2.** Write the expression for the half life of a radioactive element.

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**3.** (a) Define the terms (i) half-life $\left(T_{1/2}\right)$ and (ii) average life $(\tau)$. Find out their relationships with the decay constant $(\lambda)$.

(b) A radioactive nucleus has a decay constant, $\lambda = 0.3465$ (day)$^{-1}$. How long would it take the nucleus to decay to 75% of its initial amount?

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## Topic 1 Numerical Problems

**1.** Determine the mass of $Na^{22}$ which has an activity of 5mCi. Half life of $NA^{22}$ is 2.6 years. Avogadro number $= 6.023 \times 10^{23}$ atoms.

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**2.** A given coin has a mass of 3.0g . Calculate the nuclear energy that would be required to separate all the neutrons and protons from each other . For simplicity, assume that the coin is entirely made of $._{29}^{63}Cu$ atoms (of mass 62.92960 u)

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## Topic 2 Very Short Answer Type Questions

**1.** What is meant by specific binding energy ?

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**2.** Write the relation for binding energy (BE) (in MeV) of a nucleus of mass ${}^{A}_{Z}M$, atomic number (Z) and mass number (A) in terms of

the masses of its constituents - neutrons and protons.

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**3.** In a typical nuclear reaction, e.g.

$_1^2H + _1^2H \rightarrow _2^3He + n + 3.27$ Mev,

although number of nucleons is conserved, yet energy is released. How ? Explain.

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**4.** What characteristic property of nuclear force explains the constancy of binding energy per nucleon (BE/A) in the range of mass number 'A' lying $30 < A < 170$ ?

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**5.** State any three feautures of nuclear force

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## Topic 2 Short Answer Type Questions I

**1.** Draw a plot of BE/A versus mass number A for $2 \leq A \leq 170$. Use this graph to explain the release of energy in the process of nuclear fusion of two light nuclei.

OR

Using the curve for the binding energy per nucleon as a function of mass number A, state clearly how the release in energy in the processes of nuclear fission and nuclear fusion can be explained.

OR

Draw a plot of the binding energy per nucleon as a function of mass number for a large number of nuclei, $2 < A < 240$. How do you explain the constancy of binding energy per nucleon in the range $30 < A < 170$ using the property that nuclear force is short-ranged ?

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**2.** A heavy nucleus X of mass number 240 and binding energy per nucleon 7.6 MeV is split into two fragments Y and Z of mass numbers

110 and 130. The binding energy of nucleons in Y and Z is 8.5 Me V per nucleon. Calculate the energy Q released per fission in Me V.

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## Topic 2 Short Answer Type Questions Ii

**1.** Define the terms (i) mass defect, (ii) binding energy for a nucleus and state the relation between the two.

For a given nuclear reaction, the B.E./nucleon

of the product nucleus/nuclei is more than that for the original nucleus/nuclei. Is this nuclear reaction exothermic or endothermic in nature? Justify your choice.

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**2.** Draw a plot of potential energy of a pair of nucleons as a function of their separations. Mark the regions where the nuclear force is (i) attractive and (ii) repulsive. Write any two characteristic features of nuclear forces.

OR

Draw a plot of potential energy of a pair of nucleons as a function of their separation. Write two important conclusions which you can draw regarding the nature of nuclear forces.

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## Topic 2 Long Answer Type Questions

**1.** Distinguish between nuclear fission and nuclear fusion.

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**2.** Show that 1 amu = $932 MeV$.

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## Topic 2 Numerical Problems

**1.** The half life of $_{38}Sr^{90}$ isotope is 28 years. What is the rate of disintegration of 15 mg of this isotope? (Given Avogadro No $= 6.023 \times 10^{23}$)

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**2.** A thermal neutron strikes $U_{92}^{235}$ nucleus to produce fission. The nuclear reaction is as given below :

$n_0^1 + U_{92}^{235} \rightarrow Ba_{56}^{141} + Kr_{36}^{92} + 3n_0^1 + E$

Calculate the energy released in MeV. Hence calculate the total energy released in the fission of 1 Kg of $U_{92}^{235}$.

Given mass of $U_{92}^{235} = 235.043933$ amu

Mass of neutron $n_0^1 = 1.008665$ amu

Mass of $Ba_{56}^{141} = 140.917700$ amu

Mass of $Kr_{36}^{92} = 91.895400$ amu

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**3.** Calculate the energy released in the following nuclear reaction and hence calculate

the energy released when 235 gram of uranium-235 undergoes fission.

$U_{92}^{235} + n_0^1 \rightarrow Kr_{36}^{92} + Ba_{56}^{141} + 3n_0^1$

Rest masses of $U^{235}$, $Ba^{141}$, $Kr^{92}$ and neutron are 235.04390 amu, 140.91390 amu, 91.89730 amu and 1.00867 amu respectively. Avogadro number $= 6.023 \times 10^{23}$.

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