



PHYSICS

BOOKS - NN GHOSH PHYSICS (HINGLISH)

NUCLEAR FISSION AND FUSION

Example

1. Calculate the binding energy of helium nucleus

(${}^4_2\text{He}$) and express the quantity in MeV and J

Mass of helium nucleus = 4.0028 *amu*

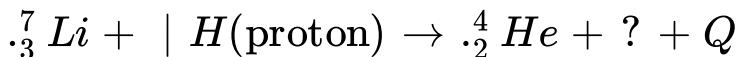
Mass of proton = 1.00758 *amu*

Mass of neutron = 1.00897 *amu*



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2. Complete the nuclear reaction and calculate the energy released.



Given that mass of lithium atom = 7.01822 amu

Mass of proton = 1.00812 amu

Mass of α - particle = 4.00390 amu

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3. Calculate how much coal is equivalent to 1kg of ${}^{235}\text{U}$

. Given that 200 MeV is released per fission process and

8000 kcal is released as heat of combustion of 1 kg of

coal. Avogadro constant = $6.1 \times 10^{26} \text{Kgmol}^{-1}$

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4. find the disintegration energy Q liberated in β^- and β^+ decays if the masses of the parent atom M_p the daughter atom M_d and an electron m are known.



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5. Making use of the table of atomic masses given above find:

(a) the mean binding energy per nucleon in ${}_{7}^{14}\text{N}$

(b) the binding energy of an alpha-particle in ${}_{8}^{16}\text{O}$.



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6. Making use of the table of atomic masses given above find the energy required for the separation of an ${}^{16}_8\text{O}$ nucleus into 4 identical particle



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7. Find the binding energy of a nucleus consisting of an equal number of protons and neutrons and with a radius one-and a -half times smaller that that of the ${}^{27}_{13}\text{Al}$ nucleus. Consult the atomic tables for required masses.



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8. Find the difference in binding energies of a neutron and a proton in a B^{11} nucleus. Explain why there is the difference.



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9. A particle of mass m strikes a stationary nucleus of mass M and activated an endoergic reaction. Show that the threshold kinetic energy required to initiate this reaction is $T_{th} = \frac{m + M}{M} |Q|$. Where Q is the energy of the reaction.



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Exercises

1. Calculate the binding energy of the lithium atom (${}^7_3\text{Li}$) from the following data:

$$\text{mass of proton} = 1.00759 \text{ amu}$$

$$\text{mass of neutron} = 1.00898 \text{ amu}$$

$$\text{mass of electron} = 0.00055 \text{ amu}$$

$$\text{mass of lithium atom} = 7.01818 \text{ amu}$$



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2. Find the minimum energy that a γ -ray must have to give rise to an electron-positron pair.

$$\text{Mass of electron} = 0.00055 \text{ amu}$$

$$\text{Mass of positron} = 0.00055 \text{ amu}$$



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3. Calculate the energy released by fission of 1 g of ${}_{92}^{235}\text{U}$, assuming that an energy of 200 MeV is released by fission of each atom of ${}_{92}^{235}\text{U}$. (Avogadro constant is $= 6.023 \times 10^{26} \text{kgmol}^{-1}$)



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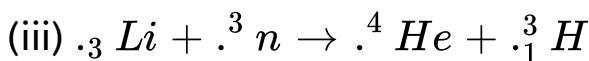
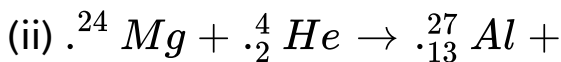
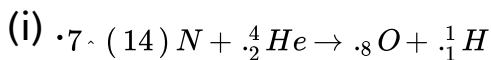
4. A reaction develop nuclear energy at the rate of $3 \times 10^4 \text{kW}$. How many atoms of ${}_{92}^{235}\text{U}$ undergo fission per second? How much ${}_{92}^{235}\text{U}$ is burnt in 1000 hours of operation ? (Assume that 200 Mev is released per fission and Avogadro constant is 6.023×10^{26} per kg mole)

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5. Calculate the amount of energy set free by the annihilation of an electron and a positron. Given that mass of electron = 0.00055 amu and positron = 0.00055 amu.

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6. Complete the following nuclear reactions:



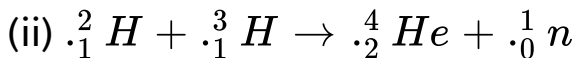
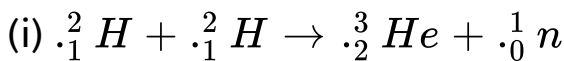
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7. Calculate the energy released in kilowatt-hours when 100g of ${}^7_3\text{Li}$ are converted into ${}^4_2\text{He}$ by proton bombardment. Mass of ${}^7_3\text{Li} = 7.0183\text{amu}$, mass of proton = 1.0081 amu. Write down the nuclear reaction.



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8. calculate the energy released in the nuclear fusion of isotopes of hydrogen



Given that mass of neutron = 1.00867 amu

mass of ${}^2_1H = 2.01410 \text{ amu}$

mas of ${}^3_1H = 3.01603 \text{ amu}$

mass of ${}^3_2H = 3.0160 \text{ amu}$

mass of ${}^4_2He = 4.00260 \text{ amu}$



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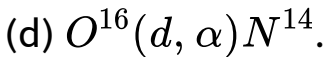
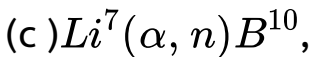
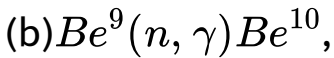
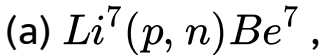
9. Using conservation laws show that an electron cannot absorb a photon completely.

[Hint : $h\nu = mc^2 - m_0c^2$ and $\frac{h\nu}{c} = mv$]



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10. Making use of the tables of atomic masses, determine the energies of the following reaction:



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11. Taking the values of atomic masses from the tables, find the maximum kinetic energy of beta-particles emitted by Be^{10} nuclei formed directly in the ground state.



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12. A stationary ${}_{82}^{200}\text{Pb}$ nucleus emits an α -particle with kinetic energy $T_{\alpha} = 5.77\text{MeV}$. Find the recoil velocity of a daughter nucleus. What fraction of the total energy liberated in this decay is accounted for by the recoil energy of daughter nucleus ?



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13. Making use of the tables of atomic masses, find:

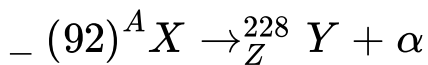
(a) the mean binding energy per one nucleon in O^{16} nucleus

(b) The binding energy of neutron and an alpha-particle in a B^{11} nuclues.



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14. A nucleus X, initially at rest , undergoes alpha dacay according to the equation ,



(a) Find the value of A and Z in the above process.

(b) The alpha particle produced in the above process is found to move in a circular track of radius $0.11m$ in a uniform magnetic field of 3 Tesla find the energy (in MeV) released during the process and the binding energy of the parent nucleus X

Given

that

$$: m(Y) = 228.03u, m\left({}_{-}(0)^1n\right) = 1.0029u.$$

$$m\left({}_{-}(2)^4He\right) = 4.003u, m\left({}_{-}(1)^1H\right) = 1.008u$$



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15. A uranium nucleus ${}^{235}\text{U}$ liberates 200 MeV per fission. 1.5 kg of uranium reacts during explosion of a uranium bomb. What is the mass of an equivalent TNT bomb if the heating capacity of TNT is $4.1 \times 10^6 \text{ J/kg}$?



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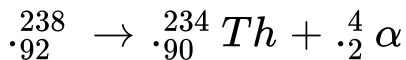
16. Can a silicon nucleus (${}_{14}^{31}\text{Si}$) transform into a phosphorus nucleus (${}_{15}^{31}\text{P}$)? What particle would be emitted in the process? What is their total energy?

$$m_{\text{Si}} = 30.97535 \text{ amu}, m_{\text{P}} = 30.97376 \text{ amu}$$



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17. Stationery nucleus ${}_{92}^{238}\text{U}$ decays by a emission generating a total kinetic energy T:

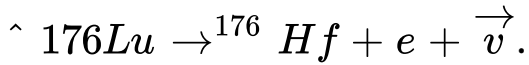


What is the kinetic energy of the α -particle?



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18. Find the maximum energy that a beta particle can have in the following decay



Atomic mass of ${}^{176}\text{Lu}$ is $175.942694u$ and that of

${}^{176}\text{Hf}$ is $175.941420u$.



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