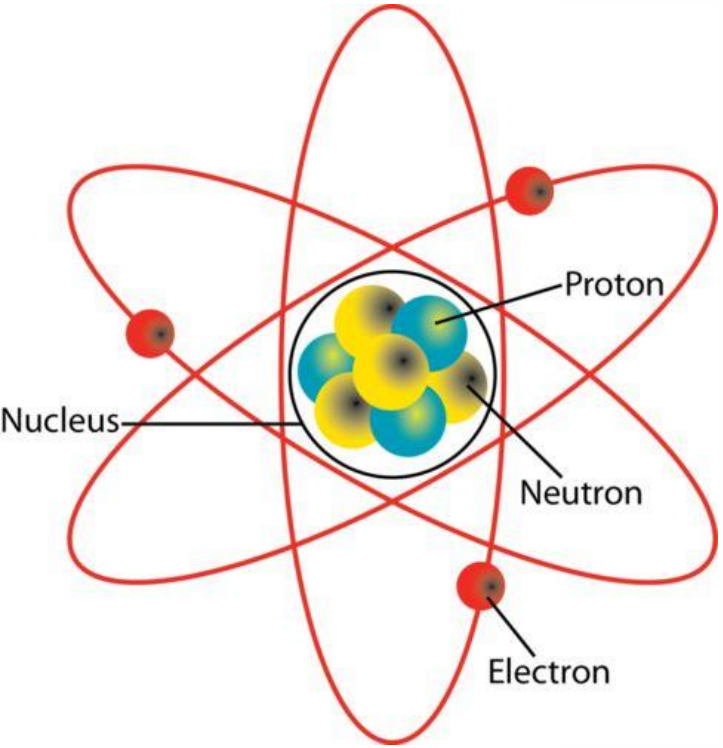
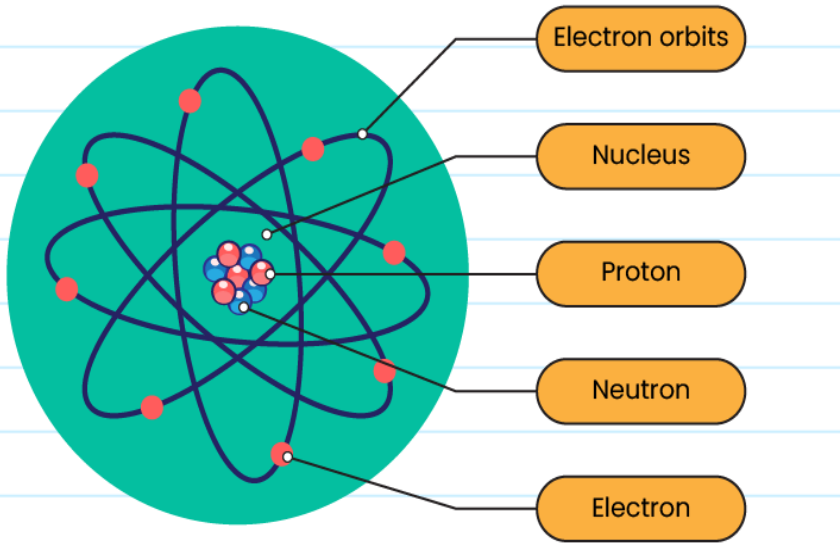
Physics Grade 12 LS/ GS



Chapter 18

Atom nucleus



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Quiz
Time
Be Smart
ACADEMY

Quiz Stability of Aluminum Duration: 20min

Aluminum North American is a chemical element in the boron group with symbol Al and its of atomic number is 13.

It is a silvery-white, soft, nonmagnetic, ductile metal.

By mass, Aluminum makes up about 8% of the Earth's crust.

Aluminum has many known isotopes, with mass numbers range from 21 to 42; however $^{27}_{13}Al$ has a natural abundance above 99.9%.

Quiz 1 Stability of Aluminum Duration: 20min

1. The density of aluminum is $2700 kg/m^3$ and its molar mass is 27 g/mol. Given $N_A = 6.022 \times 10^{23} mol^{-1}$
   a) Calculate the mass of an aluminum atom.
   b) Deduce the volume of the atom.
2. Knowing that the radius of a nucleon is $r_0 = 1.2 fm$. Determine the volume of its nucleus.
3. Compare the volume of the atom to that of its nucleus.
4. Knowing that the mass of its nucleus is $26.98153 u$. Determine the volume of its nucleus.

1. **The density of aluminum is $2700 kg/m^3$ and its molar mass is 27 g/mol. Given $N_A = 6.022 \times 10^{23} mol^{-1}$**

a) Calculate the mass of an aluminum atom.

$$n = \frac{m}{M} \qquad n = \frac{N}{N_A}$$

$$\frac{m}{M} = \frac{N}{N_A} \Rightarrow m = \frac{N \times M}{N_A}$$

$$m_{Al} = \frac{N \times M}{N_A} = \frac{1 \times 27 g/mol}{6.022 \times 10^{23} mol^{-1}}$$

$$m_{Al} = 4.48 \times 10^{-23} g$$

b) Deduce the volume of the atom.

$$\rho = \frac{m}{V} \Rightarrow V = \frac{m}{\rho} = \frac{4.48 \times 10^{-23} \times 10^{-3} kg}{2700 kg/m^3}$$

$$V_{at} = 1.66 \times 10^{-26} m^3$$

2. Knowing that the radius of a nucleon is $r_0 = 1.2 fm$. Determine the volume of its nucleus.

$$V = A.V_0 \Rightarrow V = A.\frac{4}{3}\pi r_0^3$$

$$V = 27\frac{4}{3}\pi(1.2 \times 10^{-15})^3 \Rightarrow V = 1.63 \times 10^{-43} m^3$$

3) Compare the volume of the atom to that of its nucleus.

$V_{at} = 1.66 \times 10^{-26} m^3$

$V_{nucleus} = 1.63 \times 10^{-43} m^3$

$$\frac{V_{at}}{V_{nucleus}} = \frac{1.66 \times 10^{-26}}{1.63 \times 10^{-43}}$$

$$\frac{V_{at}}{V_{nucleus}} = 1.02 \times 10^{14}$$

This means that $V_{at} > V_{nucleus}$

4. **Knowing that the mass of its nucleus is $26.98153u$. Determine the binding energy per nucleons then discuss its stability**

$$\Delta m = \left(\left[Zm_p + (A - Z)m_n\right] - m_{Na}\right)$$

$$\Delta m = \left(\left[(13 \times 1.00728 + (27 - 13)1.00866\right] - 26.98153\right)$$

$$\Delta m = \left(\left[13.09464 + 14.12124\right] - 26.98153\right)$$

$$\Delta m = (27.21588 - 26.98153)$$

$$\Delta m = 0.23435u$$

$$\Delta m = 0.23435u$$

$$\Delta m = 0.23435 \times 931.5 MeV/c^2$$

$$\Delta m = 218.29 MeV/c^2$$

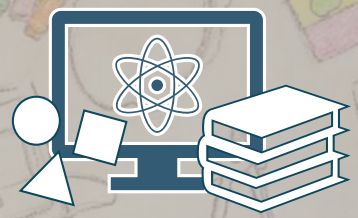
$$BE = \Delta m.c^2 = 218.29 \frac{MeV}{c^2} \times c^2$$

$$BE = 218.29 MeV$$

$$\frac{BE}{A} = \frac{218.29}{27} = 8.081 MeV/nucleon$$

The aluminum atom is stable since its BE/A $\geq 8 MeV$

The End




Quiz
Time
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Quiz Atomic nucleus Duration: 20min

The object of this exercise is to study the stability of different nuclei. $m_n = 1.0087u$; $m_p = 1.0073u$;1 u = 931.5 MeV/c^2.

Consider the table below that shows some physical quantities associated with certain nuclei.

Nucleus	$^{14}_{6}C$	$^{14}_{7}N$	$^{94}_{38}Sr$	$^{140}_{54}Xe$	$^{235}_{92}U$
Mass (u)	14.0065	14.0031	93.8945	139.892	234.9935
B.E (MeV)	99.54	101.44	810.50	1164.75	
B.E/A		7.25	8.62		

Quiz Atomic nucleus Duration: 20min

1) Define the binding energy of a nucleus.
2) Write the expression of the binding energy of a nucleus ${}^{A}_{Z}X$ as a function of Z, A, m_P, m_n, m_X and the speed of light in vacuum c.
3) Calculate, in MeV, the binding energy of the uranium 235 nucleus.
4) Complete the table by calculating the missing values of $\frac{BE}{A}$
5) Give the name of the most stable nucleus in the above table. Justify your answer.

Quiz Atomic nucleus Duration: 20min

$m_n = 1.0087u;\ m_p = 1.0073u$;1 u = 931.5 MeV/$c^2$. $^{235}_{92}U$

1) Define the binding energy of a nucleus.

The binding energy of a nucleus is the minimum energy needed in order to break the nucleus into its nucleons

2)Write the expression of the binding energy of a nucleus $^{A}_{Z}X$ as a function of Z, A, m_P, m_n, m_X and the speed of light in vacuum c.

$$B.E = \Delta mc^2 = \left[Zm_p + (A - Z)m_n - m_X\right]c^2$$

$m_n = 1.0087u;\ m_p = 1.0073u$;1 u = 931.5 MeV/$c^2$. $^{235}_{92}U$

3)Calculate, in MeV, the binding energy of the uranium 235 nucleus.

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

$$\Delta m = [92 \times 1.0073 + 143 \times 1.0087] - 234.9935$$

$$\Delta m = [92.6716 + 144.2441] - 234.9935$$

$$\Delta m = 236.9157 - 234.9935$$

$$\Delta m = 1.9222\text{u}$$

Quiz Atomic nucleus Duration: 20min

$m_n = 1.0087u;\ m_p = 1.0073u;$1 u = 931.5 MeV/$c^2$. $^{235}_{92}U$

$\Delta m = 1.9222\text{u}$ ⇒ $\Delta m = 1.922 \times 931.5$

$$\Delta m = 1790.343 MeV/c^2$$

$$B.E = \Delta m c^2$$

$$B.E = 1790.343 \frac{MeV}{\cancel{c^2}} \times \cancel{c^2}$$

$$B.E = 1790.343 MeV$$

Quiz Atomic nucleus Duration: 20min

$m_n = 1.0087u;\ m_p = 1.0073u$;1 u = 931.5 MeV/$c^2$.

4)Complete the table by calculating the missing values of $\frac{BE}{A}$

Nucleus	$^{14}_{6}C$	$^{14}_{7}N$	$^{94}_{38}Sr$	$^{140}_{54}Xe$	$^{235}_{92}U$
Mass (u)	14.0065	14.0031	93.8945	139.892	234.9935
B.E (MeV)	99.54	101.44	810.50	1164.75	1790.3434
B.E/A	7.11	7.25	8.62	8.32	7.62

5) **Give the name of the most stable nucleus in the above table. Justify your answer.**

The nucleus that has greater binding energy per nucleon is more stable.

Referring to the table we conclude strontium (Sr) is the most stable nucleus.

The End