Radioactivity 2

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Comparing deflection of α particles and β - particles in an Electric field

* Compare in terms of "masses"

$m_\alpha = 4u = 4 \times (1.66 \times 10^{-27})$ kg.

$m_\beta = m_e = 9.11 \times 10^{-31}$ Kg

$$\boxed{m_\alpha \approx 2000 \times m_\beta}$$

Since m_α is greater ∴ it has more inertia hence difficult to deflect ∴

$$\boxed{\text{deflection of } \alpha < \text{deflection of } \beta}$$

* Compare in terms of "Charges"

$q_\alpha = +2e$

$q_\beta = -1e$

$$\boxed{q_\alpha = 2 \times q_\beta}$$

Since more charge ∴ more deflection hence

$$\boxed{\text{deflection of } \alpha > \text{deflection of } \beta}$$

* OVERALL Comparision

The effect of mass OUTWEIGHS the effect of charge b/c

$m_\alpha = 2000 \times m_\beta$

$q_\alpha = 2 \times q_\beta$

hence on an overall basis

$$\boxed{\text{deflection of } \alpha < \text{deflection of } \beta}$$

* Compare in terms of "Speed"

V_α = 10% of speed of light

V_β = 90 - 99% of speed of light.

Since α travels slower than β $\therefore$ Electric field gets ample amount of time to apply an electric force on an α-particle; whereas in case of β, since they have a higher speed, they will quickly pass through the Electric field not giving ample time to the field to apply a significant force

$$\boxed{\text{deflection of } \alpha > \text{deflection of } \beta}$$

* Compare acceleration of α with acceleration of β as they enter the same Electric field.

Q:: $\frac{a\alpha}{a\beta}$ = find

$$F = ma$$
$$Eq = ma$$
$$a = E \cdot \frac{q}{m}$$
$$\boxed{a \propto q/m}$$

ratio of $\frac{\text{Charge}}{\text{mass}}$

$$\frac{a\alpha = \frac{q\alpha}{m\alpha}}{a\beta = \frac{q\beta}{m\beta}}$$

$$\frac{a\alpha}{a\beta} = \frac{q\alpha}{m\alpha} \times \frac{m\beta}{q\beta}$$

$$\frac{a\alpha}{a\beta} = \frac{+2e}{4u} \times \frac{(9.11 \times 10^{-31})}{-1e}$$

$$\frac{a\alpha}{a\beta} = \frac{2}{4(1.66 \times 10^{-27})} \times \frac{(9.11 \times 10^{-31})}{1}$$

$$\frac{a\alpha}{a\beta} = \frac{2.74 \times 10^{-4}}{1}$$

* Calculations where Energy is provided in units of eV (electron-volt) rather than units of Joules.

Q What is eV ?
Alternate unit for Energy.

Calories KWh J
eV

$$\boxed{1\,\text{eV} = 1.6 \times 10^{-19}\,\text{J}}$$

Not given in Exams.

$$\boxed{1\,\text{KWh} = 3600{,}000\,\text{J}}$$

An α particle requires 9.4×10^{-13} J to ionize an air molecule
In a certain situation an α particle is travelling with 31 eV of Energy
Cal. the # of ions of air molecules which can be produced by this α particle per unit length ?

Ans $1\,\text{eV} = 1.6 \times 10^{-19}\,\text{J}$

$\therefore 31\,\text{eV} = 5.0 \times 10^{-18}\,\text{J}$

↳ Total Energy of an α particle

Step ②

$$\frac{5.0 \times 10^{-18} J}{9.4 \times 10^{-13} J}$$

$$= \boxed{5.3 \times 10^{-6}}$$

↳ Total # of ions produced

Step ③

$$\frac{5.3 \times 10^{-6}}{4.5 \times 10^{-2} m}$$

$$= \boxed{1.2 \times 10^{-4}} m^{-1}$$

↳ # of ions produced per unit length.

4.5×10^{-2} ??

* α particles travel a range of 4 - 5 cm in Air. hence I took an average value i.e 4.5 cm ∴ (4.5×10^{-2} m)