

A hydrogen atom moving at speed v collides with another hydrogen atom kept at rest. Find the minimum value of v for which one of the atoms may get ionized.

The mass of a hydrogen atom = 1.67×10^{-27} kg.

The hydrogen atoms after collision move with speeds v_1 and v_2 .

$$mv = mv_1 + mv_2 \quad \dots(1)$$

$$\frac{1}{2}mv^2 = \frac{1}{2}mv_1^2 + \frac{1}{2}mv_2^2 + \Delta E \quad \dots(2)$$

$$\text{From (1) } v^2 = (v_1 + v_2)^2 = v_1^2 + v_2^2 + 2v_1v_2$$

$$\text{From (2) } v^2 = v_1^2 + v_2^2 + 2\Delta E/m$$

$$= 2v_1v_2 = \frac{2\Delta E}{m} \quad \dots(3)$$

$$(v_1 - v_2)^2 = (v_1 + v_2)^2 - 4v_1v_2$$

$$\Rightarrow (v_1 - v_2) = v^2 - 4\Delta E/m$$

For minimum value of 'v'

$$v_1 = v_2 \Rightarrow v^2 - (4\Delta E/m) = 0$$

$$\Rightarrow v^2 = \frac{4\Delta E}{m} = \frac{4 \times 13.6 \times 1.6 \times 10^{-19}}{1.67 \times 10^{-27}}$$

$$\Rightarrow v = \sqrt{\frac{4 \times 13.6 \times 1.6 \times 10^{-19}}{1.67 \times 10^{-27}}} = 7.2 \times 10^4 \text{ m/s.}$$