. *A neutron moving with speed v makes a head-on collision with a hydrogen atom in ground state kept at rest. Find the minimum kinetic energy of the neutron for which inelastic (completely or partially) collision may take place. The mass of neutron = mass of hydrogen = $1{\cdot}67 \times 10^{-27}$ kg.*

Solution : Suppose the neutron and the hydrogen atom move at speeds v_1 and v_2 after the collision. The collision will be inelastic if a part of the kinetic energy is used to excite the atom. Suppose an energy ΔE is used in this way. Using conservation of linear momentum and energy,

$$mv = mv_1 + mv_2 \qquad \ldots \text{(i)}$$

and $$\frac{1}{2}mv^2 = \frac{1}{2}mv_1^2 + \frac{1}{2}mv_2^2 + \Delta E \qquad \ldots \text{(ii)}$$

From (i), $$v^2 = v_1^2 + v_2^2 + 2v_1v_2.$$

From (ii), $$v^2 = v_1^2 + v_2^2 + \frac{2\Delta E}{m}.$$

Thus, $$2v_1v_2 = \frac{2\Delta E}{m}.$$

Hence, $(v_1 - v_2)^2 = (v_1 + v_2)^2 - 4v_1v_2 = v^2 - \dfrac{4\Delta E}{m}$.

As $v_1 - v_2$ must be real,

$$v^2 - \frac{4\Delta E}{m} \geq 0$$

or, $$\frac{1}{2}mv^2 > 2\Delta E.$$

The minimum energy that can be absorbed by the hydrogen atom in ground state to go in an excited state is 10·2 eV. Thus, the minimum kinetic energy of the neutron needed for an inelastic collision is

$$\frac{1}{2} mv_{min}^{2} = 2 \times 10{\cdot}2 \text{ eV} = 20{\cdot}4 \text{ eV}.$$