

# 1 The Equivalence of Mass and Energy

The Einstein relation

$$E = mc^2 \quad (1)$$

is a statement of the facts that a given mass can be converted into a specific amount of energy in some form and that a given amount of energy can be converted into a specific amount of mass. The process of nuclear fusion in which two deuterium nuclei (deuterons) fuse under a sufficiently hot and high pressure environment to form a helium nucleus (alpha particle)



yields the energy

$$\Delta E = (2m_D - m_{He})c^2. \quad (3)$$

For  $m_D = 3.34 \times 10^{-27} kg$ ,  $m_{He} = 6.64 \times 10^{-27} kg$  and  $c = 3 \times 10^8 m/s$ , the energy released by one such fusion event is

$$\Delta E = 3.6 \times 10^{-12} J = \frac{3.6 \times 10^{-12} J}{1.6 \times 10^{-19} J/eV} = 2.25 \times 10^7 eV = 22.5 MeV. \quad (4)$$

Fusion of one mole ( $6.02 \times 10^{23}$ ) deuterium molecules ( $D_2$ ) yields

$$2.2 \times 10^{12} J = \frac{2.2 \times 10^{12} J}{3.6 \times 10^6 J/kWhr} = 6.1 \times 10^5 kWhr \quad (5)$$

of energy.