VISUAL PHYSICS ONLINE

Special Relativity

Question 1

A particular radioactive isotope loses 5×10^{2} J of energy. Calculate its resultant loss of mass.

Question 2

An electron with a rest mass of 9.11×10^{-31} kg is travelling at 0.999c. Determine the relativistic mass of the electron.

Question 3

Energy is radiated by the Sun at the rate of about 3.92×10^{26} W. Find the corresponding decrease in the Sun's mass for every second that it radiates.

Question 4

A π^0 travels at a speed of 0.80 c. What is the kinetic energy of the π^0 particle. compare the classical and relativistic answers.

$$\pi^0 \quad m = 2.4 \times 10^{28}\ kg$$

Question 5

The energy required or released in nuclear reactions is due to the change in mass between the reactants (initial particles) and products (final particles). Calculate the energy released in the nuclear reaction for the decay of uranium atom into thorium atom and an helium atom.

m_{U} = 232.03714

m_{Th} = 228.02873 u

m_{He} = 4.00260 u

1 u = 1.6605x10^{-27} kg

Answer 1

5.6×10^{-15} kg

Answer 2

2.04×10^{-29} kg

Answer 3

ΔE = 3.92×10^{26} J

Δm = 4.36×10^{9} kg

Answer 4

$$c = 3.0\times10^{8}\ \text{m.s}^{-1}$$
$$m = 2.4\times10^{28}\ \text{kg}$$
$$v = 0.80\,c = (0.80)\left(3.0\times10^{8}\right)\ \text{m.s}^{-1} = 3.0\times10^{8}\ \text{m.s}^{-1}$$

Classical

$$E_K = \tfrac{1}{2}mv^2 = 6.9\times10^{-12}\ \text{J}$$

Relativistic

$$E = \gamma mc^2 \qquad E = E_K + mc^2$$
$$E_K = E - mc^2 = \gamma mc^2 - mc^2 = (\gamma - 1)mc^2$$
$$E_K = 1.4\times10^{-11}\ \text{J}$$

The classical value is about half the value of the relativistic value (the classical value is wrong).

Answer 5

Initial mass

$m_U = 232.03714\,\text{u}$

Final mass

$$m_{Th} + m_{He} = \left(228.02873 + 4.00260\right)\,\text{u} = 232.03133\ \text{u}$$

Mass defect

$$\Delta m = \left(232.03133 - 232.03714\right)\ \text{u} = -0.0058\ \ \text{u}$$

The mass decreases as the mass of the final particles is less than the mass of the initial particles. The decrease in mass corresponds to the kinetic energy of the final particles after the decay, as energy/mass must be conserved.

Energy as kinetic energy of products

$$1\ \text{u} = 1.6605 \times 10^{-27}\ \text{kg}$$
$$E = \Delta m\, c^2 = \left(1.6605 \times 10^{-27}\right)\left(0.0058\right)\left(3 \times 10^8\right)\ \text{J} = 8.68 \times 10^{-13}\ \ \text{J}$$
$$1\ \text{MeV} = 1.602 \times 10^{-19}\ \text{J}$$
$$E = 5.4\ \text{MeV}$$