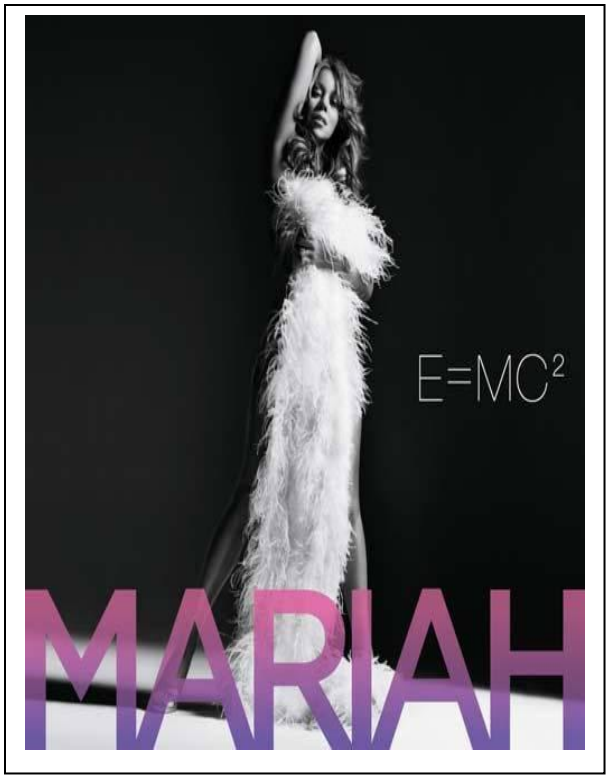

Einstein's formula $E = mc^2$ is almost legendary, and sometimes appears even on T-shirts or even Mariah Carey's pop music album cover! But what does the formula really mean?

It means that, what we consider to be energy in its many forms (like light and heat), which we measure in Joules, can also be considered equivalent to mass in its many forms (like grains of sand or mountains), which we measure in units of kilograms!

The problem is that it takes a LOT of energy to make a kilogram of mass! That's why we never see matter suddenly just appearing out of nowhere in our daily lives. That little formula says that 1 kilogram of mass, m, is exactly equal to 9.0×10^{16} Joules of energy, E. That's the energy released by just one, 20 megaton hydrogen bomb!

The formula depends on the speed of light-squared, c^2, to do the conversion from energy units (E in Joules) to matter units (m in kilograms). If c = 300 million meters/sec, we have the simpler formula: E(Joules) = 9×10^{16} x (mass in kilograms). Use this formula to perform the following conversions using a calculator, and providing answers to 2 significant figures in scientific notation:

Problem 1 1-proton mass = 1.6726×10^{-27} kg equals ---------- Joules

Problem 2 1 Joule of Energy = ---------- kilograms

Problem 3 1 electron Volt = 1.6×10^{-19} Joules = ---------- kilograms

Problem 4 1 neutron = 1.6749×10^{-27} kg equals ---------- Joules

Problem 5 1 deuterium nucleus (1 proton+1 neutron) = 3.3444×10^{-27} kg equals ---------- Joules

Problem 6 What is: A) The difference in mass between a single proton plus a single neutron, and the deuterium nucleus? B) The difference in energy? C) The difference in Volts?

Answer Key

Problem 1 1-proton mass = 1.6726×10^{-27} kg

$9 \times 10^{16} \times 1.6726 \times 10^{-27}$ kg = 1.505×10^{-10} Joules

Problem 2 1 Joule of Energy = $1 / (9 \times 10^{16})$ = 1.1×10^{-17} kilograms

Problem 3 1 electron Volt = 1.6×10^{-19} Joules = 1.8×10^{-36} kilograms

Problem 4 1 neutron = 1.6749×10^{-27} kg equals 1.507×10^{-10} Joules

Problem 5 1 deuterium nucleus (1 proton+1 neutron) = 3.3444×10^{-27} kg

= 3.010×10^{-10} Joules

Problem 6 What is:

A) The difference in mass between a single proton plus a single neutron, and the deuterium nucleus?

$(1.6726 \times 10^{-27}$ kg + 1.6749×10^{-27} kg) - 3.3444×10^{-27} kg = 3.1×10^{-30} kg

B) The difference in energy?

$(1.505 \times 10^{-10}$ Joules + 1.507×10^{-10} Joules) - 3.010×10^{-10} Joules = 2.0×10^{-13} Joules

C) The difference in Volts?

Answer: Since 1 volt = 1.8×10^{-36} kilograms

3.1×10^{-30} kg x $(1 \text{ Volt} / 1.8 \times 10^{-36}$ kg) = 1.7 million Volts or 1.7 MeV.

A more accurate calculation yields 2.2 MeV