$E = mc^2$

1. Complete the table:

Symbol from the equation	What it standards for	Unit	Value
		m/s	3×10^8
	mass		—----------
		J	—----------

2. If a cute furry animal with a mass of 2.5 kg were to be completely annihilated, what amount of energy would be released?

3. The bomb which devastated Hiroshima released 63 TJ of energy. How much mass was converted to energy in the explosion? (T = tera, the prefix for 10^{12})

Optional follow up for those of you who like maths!

4. a) If all the energy in question 3 came from the fission of uranium-235 atoms, and each U-235 fission releases (on average) 3.2×10^{-11} J, how many atoms of U-235 underwent fission in the Hiroshima explosion?

b) If the mass of one atom of U-235 is approximately 3.9×10^{-25} kg, show the total mass of U-235 in the bomb is less than 1 kg.

Solutions, with a little help from ChatGPT for clarity!

1. Complete the table:

Symbol from the equation	What it standards for	Unit	Value
c	Speed of light	m/s	3 x 10^8
m	mass	kg	----------
E	energy	J	----------

2.

ChatGPT

To calculate the energy released through complete annihilation, you can use Einstein's mass-energy equivalence principle, given by the equation $E = mc^2$, where E is the energy, m is the mass, and c is the speed of light (approximately $3 \times 10^8 \, \text{m/s}$).

Given the mass of the cute furry animal ($m = 2.5 \, \text{kg}$), the energy (E) released would be:

$$E = 2.5 \, \text{kg} \times (3 \times 10^8 \, \text{m/s})^2$$

$$E \approx 2.25 \times 10^{17} \, \text{J}$$

So, if the cute furry animal were completely annihilated, approximately 2.25×10^{17} joules of energy would be released.

3. The relationship between energy (E), mass (m), and the speed of light (c) is described by Einstein's famous equation, $E=mc^2$

Here, E is the energy, m is the mass, and c is the speed of light (approximately 3 x 10^8 meters per second).

If you have an energy release of 63 terajoules (63 TJ), you can use the equation to find the mass converted to energy:

$E = mc^2$

Rearrange the equation to solve for mass (m):

$m = E / c^2$

Now, plug in the values:

$m = (63\ TJ) / (3 \times 10^8\ m/s)^2$

$m = (63 \times 10^{12}\ J) / (9 \times 10^{16}\ m^2/s^2)$

$m = 6.99 \times 10^{-4}\ kg$

So, if 63 terajoules of energy is released, approximately 0.000699 kilograms of mass would be converted to energy.

4(a)
To find the number of atoms of U-235 that underwent fission, you can use the following relationship:

$$\text{Total energy released} = \text{Energy per fission} \times \text{Number of fissions}$$

Let's denote:

- E_{total} as the total energy released (63 TJ),
- $E_{\text{per fission}}$ as the energy released per fission (3.2 × 10^-11 J), and
- Number of fissions as N_{fissions}.

The equation becomes:

$$E_{\text{total}} = E_{\text{per fission}} \times N_{\text{fissions}}$$

Solving for N_{fissions}:

$$N_{\text{fissions}} = \frac{E_{\text{total}}}{E_{\text{per fission}}}$$

Plug in the given values:

$$N_{\text{fissions}} = \frac{63 \times 10^{12}\ \text{J}}{3.2 \times 10^{-11}\ \text{J/fission}}$$

Calculate the result:

$$N_{\text{fissions}} \approx 1.96875 \times 10^{24}$$

So approximately **2 x 10^{24} atoms** of Uranium 235 underwent fission.

b) 2 x 10^{24} atoms each with mass 3.9×10^{-25} kg gives **0.78 kg**

Here's the working according to ChatGPT:

To multiply 2×10^{24} by 3.9×10^{-25}, you can multiply the numerical parts and add the exponents.

$$(2 \times 10^{24}) \times (3.9 \times 10^{-25}) = (2 \times 3.9) \times 10^{(24-25)}$$

Calculating the numerical part gives:

$$2 \times 3.9 = 7.8$$

And the exponent is the difference of the exponents:

$$10^{(24-25)} = 10^{-1}$$

So, the result is:

$$7.8 \times 10^{-1}$$

Which is equivalent to 0.78.