LESSON MAKER PRO

Mass Energy Exchange

Calculate how much mass and energy can change form.

HIGH SCHOOL · HS-PSII-10.3

HS-PSII-10.3 "Qualitatively compare and contrast how particle interactions, fission, and fusion can convert matter into energy and energy into matter and calculate the relative amounts of matter and energy in such processes."

NAME _____ DATE _____

THE CONVERSION RULE

When rest mass becomes energy, use $E = mc^2$, where $c^2 = 9 \times 10^{16}$ J/kg. To find how much rest mass can form from energy, divide the energy by c^2. Convert grams to kilograms before calculating: 1 g = 0.001 kg.

WORKED EXAMPLE

A process converts 7 g of rest mass into energy. How much energy is released?

1. Convert the mass: 7 g = 0.007 kg.
2. Use $E = mc^2$: $E = 0.007 \text{ kg} \times 9 \times 10^{16}$ J/kg.
3. Multiply: $E = 6.3 \times 10^{14}$ J.

Answer: 6.3×10^{14} J

PRACTICE 6 problems

1 A particle and its antiparticle have a combined rest mass of 1 g. If all that rest mass becomes energy when they meet, how much energy is released?

ANSWER _____

2 Fission in a batch of reactor fuel reduces its rest mass by 3 g. How much energy is released?

ANSWER _____

3 Fusion reduces the total rest mass of a reactor's fuel by 6 g. How much energy is released?

ANSWER _____

4 In many high-energy particle collisions, 3.6×10^{14} J becomes the rest mass of new particles. What total rest mass forms, in grams?

ANSWER _____

5 A fission power station releases 4.5×10^{14} J. How many grams of rest mass were converted into energy?

ANSWER _____

6 Across many particle collisions, 7.2×10^{14} J of energy becomes new particles' rest mass. What total rest mass forms, in grams?

ANSWER _____

APPLY IT Show your work

1 A proposed fusion-powered spacecraft converts 10 g of rest mass into energy during a trip. How much energy does it release?

WORK SPACE

ANSWER _____

2 Your phone's battery stores an additional 36,000 J when you charge it. If all that energy stays in the battery, by how much does its mass increase?

WORK SPACE

ANSWER _____

CHALLENGE One step up

A fusion system releases 1.8×10^{15} J, while a fission system releases 9×10^{14} J. How many more grams of rest mass does fusion convert into energy? If all the fusion energy later becomes new particles' rest mass, how many grams form? Ignore energy losses.

WORK SPACE AND ANSWER

Mass Energy Exchange

PART 1 · PRACTICE

#	PROBLEM	ANSWER
1	A particle and its antiparticle have a combined rest mass of 1 g. If all that rest mass becomes energy when they meet, how much energy is released?	**9×10^{13} J**
2	Fission in a batch of reactor fuel reduces its rest mass by 3 g. How much energy is released?	**2.7×10^{14} J**
3	Fusion reduces the total rest mass of a reactor's fuel by 6 g. How much energy is released?	**5.4×10^{14} J**
4	In many high-energy particle collisions, 3.6×10^{14} J becomes the rest mass of new particles. What total rest mass forms, in grams?	**4 g**
5	A fission power station releases 4.5×10^{14} J. How many grams of rest mass were converted into energy?	**5 g**
6	Across many particle collisions, 7.2×10^{14} J of energy becomes new particles' rest mass. What total rest mass forms, in grams?	**8 g**

PART 2 · APPLY IT

1. **9×10^{14} J** Convert 10 g to 0.01 kg. Then multiply 0.01 kg by 9×10^{16} J/kg.
2. **4×10^{-13} kg** Divide 36,000 J by 9×10^{16} J/kg. The stored energy increases the battery's mass by 4×10^{-13} kg.

CHALLENGE

Fusion converts 10 g more rest mass than fission. The fusion energy could form 20 g of new particles' rest mass.

Accept equivalent scientific notation. Charging the phone increases its mass through stored energy, not by creating new particles.