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Chapter 11 Einstein's Formula Practice Worksheet

Everything in the universe can be categorized as either matter or energy. Einstein worked to establish a relationship between the amount of matter (mass) making up an object and the amount of energy it contains. He derived the famous $E = mc^2$ to relate energy and mass.

$$\mathbf{E = m \cdot c^2}$$

E is energy (Joules)
m is mass of the substance (kilograms)
c is speed of light, 3×10^8 m/s

Einstein's formula does not mean you can take an object such as a rock and easily convert its mass into energy. Einstein thought of mass as the measure of the energy contained in an object. Getting the energy from an object's mass is another matter.

Processes during which we can observe mass becoming energy include radioactive decay and nuclear reactions. Radioactive decay occurs when the nuclei of atoms in a radioactive substance release energy in the form of radiation. The mass of the substance gradually decreases. Nuclear reactions involve the splitting of nuclei (fission) or the combining of nuclei (fusion). Mass is converted into energy during these reactions.

1. How much energy is contained in matter with a mass of 1 gram (0.001 kg)?

2. How much energy is contained in the mass of a 60 kg person?

3. Radioactive carbon-14 decays into nitrogen-14. A piece of carbon-14 that originally had a mass of 1 kg is later found to have a mass of 0.9999 kg. How much energy was released?

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4. Nuclear fusion creates energy in the sun. During this process, hydrogen atoms combine to create helium. The mass of the helium created is less than the mass of the hydrogen from which it was made. The lost mass is converted to radiant energy.

    a. The sun loses 4.3×10^9 kg of mass every second. How much energy is released in one second?

    b. What is the power of the sun in Watts?

    c. How much mass does the sun lose each year?

    d. How much energy is released in one year?

    e. Because Earth is so far from the sun, we receive only one-half of one billionth of the sun's energy. How much energy do we get from the sun in one year?

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5. The annual energy consumption for the world totals approximately 4×10^{20} J.

    a. How much mass would have to be converted to energy on the sun to provide this much energy?

    b. Based on your answers to question 4, do we get enough energy from the sun to be able to meet our energy needs?