Reading Zone 6

Read the following passage, marking in the margins your understanding of the larger issues, the important parts of each passage, and the facts that you think will be useful. There will be questions following the passage. *Do not time yourself.* When you start worrying about whipping through textbook material, you're missing the point. You can check your answers on page 242.

The concept of energy appears throughout every area of physics, and yet it is difficult to define in a general way just what energy is. Energy plays a central role in one of the fundamental natural laws called *conservation laws,* and looking at this role is as good a way as any to approach the question of what energy is. A conservation law always concerns a transformation or an interaction that occurs within some physical system or in a system and its surroundings. Some quantities that describe the state or condition of the system and surroundings may change during the transformation or interaction, but there may be one or more quantities that remain constant or are *conserved*. A familiar example is conservation of mass in chemical reactions. It has been established by a very large amount of experimental evidence that the total mass of the reactants in a chemical reaction is always equal to the total mass of all the products of the reaction. That is, the total mass is always the same after the reaction occurs as before. This generalization is called the principle of *conservation of mass,* and it is obeyed in all chemical reactions.

Something similar happens in collisions between bodies. For a body of mass m moving with speed v, we can define a quantity $\frac{1}{2}mv^2$, which we call the *kinetic energy* of the body. When two highly elastic or "springy" bodies (such as two hard steel ball bearings) collide, we find that the individual speeds change but that the total kinetic energy (the sum of the $\frac{1}{2}mv^2$ quantities for all the

colliding bodies) is the same after the collision as before. We say that kinetic energy is *conserved* in such collisions. This result doesn't tell us what kinetic energy *is,* but only that it is useful in representing a conservation principle in certain kinds of interactions.

When two soft, deformable bodies, such as two balls of putty or chewing gum, collide, experiment shows that kinetic energy is *not* conserved. However, something else happens; the bodies become *warmer*. Furthermore, it turns out to be possible to work out a definite relationship between the temperature rise of the material and the loss of kinetic energy. We can define a new quantity, which we may call *internal energy,* that increases with temperature in a definite way, so that the *sum* of kinetic energy and internal energy *is* conserved in these collisions.

The significant discovery here is that it is possible to extend the principle of conservation of energy to a broader class of phenomena by defining a new form of energy. This is precisely how the principle has developed. Whenever an interaction has been studied in which it seems that the total energy in all known forms is *not* conserved, it has been found possible to define a new form of energy so that the *total* energy, including the new form, is conserved. These new forms have included energy associated with heat, with elastic deformations, with electric and magnetic fields, and, in relativity theory, even with mass itself. Conservation of energy has the status, along with a small number of partners, of a *universal* conservation principle; no exception to its validity has ever been found.

1. The main question addressed by the passage is
   (A) What is conservation of energy?
   (B) What is an elastic deformation?
   (C) What is internal energy?
   (D) What happens in collisions between bodies?
   (E) What is energy?

2. Conservation of energy, as described in the passage, is exhibited in
   (A) two ball bearings colliding
   (B) reducing the speed of your car
   (C) turning off lights when not in use
   (D) resting after exercise
   (E) the conservation of mass in chemical reactions

3. Conservation of mass is mentioned in the passage because
   (A) chemistry and physics are related disciplines
   (B) chemistry is a sub-category of physics
   (C) it is the same as conservation of energy
   (D) it is a concept in chemistry that is similar to the conservation of energy in physics
   (E) it is necessary for an understanding of work and energy in physics

4. If a car were to slam into a large mound of wet clay, a probable result would be
   (A) a loss of energy
   (B) a loss of mass
   (C) a preservation of kinetic energy
   (D) a deformation of mass energy
   (E) a rise in clay temperature

5. In the passage, the term "elastic" means
   (A) steep
   (B) pliable
   (C) able to be stretched
   (D) hard and springy
   (E) heavy