can combine to form $H_2O$ with the release of a great deal more energy than was put in initially. The initial activation energy can be provided by applying an electric spark to a mixture of $H_2$ and $O_2$, breaking a few of these molecules into H and O atoms. The resulting explosive release of energy when these atoms combine to form $H_2O$ quickly provides the activation energy needed for further reactions, so additional $H_2$ and $O_2$ molecules are broken up and recombined to form $H_2O$.

The potential-energy diagrams for ionic bonds can have similar shapes. In NaCl, for example, the $Na^+$ and $Cl^-$ ions attract each other at distances a bit larger than some $r_0$, but at shorter distances the overlapping of inner electron shells gives rise to repulsion. The two atoms thus are most stable at some inter-mediate separation, $r_0$, and there often is an activation energy.

Sometimes the potential energy of a bond looks like that of Fig. 29–10. In this case, the energy of the bonded molecule, at a separation $r_0$, is greater than when there is no bond $(r = \infty)$. That is, an energy *input* is required to make the bond (hence the binding energy is negative), and there is energy release when the bond is broken. Such a bond is stable only because there is the barrier of the activation energy. This type of bond is important in living cells, for it is in such bonds that energy can be stored efficiently in certain molecules, particularly ATP (adenosine triphosphate). The bond that connects the last phosphate group (designated Ⓟ in Fig. 29–10) to the rest of the molecule (ADP, meaning adenosine diphos-phate, since it contains only two phosphates) has PE of the shape shown in Fig. 29–10. Energy is stored in this bond. When the bond is broken (ATP → ADP + Ⓟ), energy is released and this energy can be used to make other chemical reactions "go."
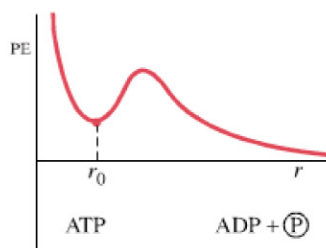
**FIGURE 29–10** Potential-energy diagram for the formation of ATP from ADP and phosphate (Ⓟ).

In living cells, many chemical reactions have activation energies that are often on the order of several eV. Such energy barriers are not easy to overcome in the cell. This is where enzymes come in. They act as *catalysts*, which means they act to lower the activation energy so that reactions can occur that other-wise would not. Enzymes act by distorting the bonding electron clouds, so that the initial bonds are easily broken.

*Enzymes act to lower activation energy*

## *29–3 Weak (van der Waals) Bonds

Once a bond between two atoms or ions is made, energy must normally be supplied to break the bond and separate the atoms. As mentioned in Section 29–1, this energy is called the *bond energy* or *binding energy*. The binding energy for covalent and ionic bonds is typically 2 to 5 eV. These bonds, which hold atoms together to *form* molecules, are often called **strong bonds** to distinguish them from so-called "weak bonds." The term **weak bond**, as we use it here, refers to an attachment *between* molecules due to simple electrostatic attraction—such as *between* polar molecules (and not *within* a polar molecule, which is a strong bond). The strength of the attachment is much less than for the strong bonds. Binding energies are typically in the range 0.04 to 0.3 eV—hence their name "weak bonds."