Activity Answer

From the *Quark Recipe Rules*, students will likely infer that they should:

- only use 1st generation (up and down) quarks in their recipe.
- use more than one quark to build a proton and neutron.
- build a proton with a net integer charge of 1; and a neutron with 0 charge.
- use the smallest number of quarks possible to meet the stated criteria.

This information should help students discover through trial and error the composition of quarks necessary to describe a proton and a neutron: The proton should contain two up quarks and one down quark; the neutron should contain one up quark and two down quarks.

Check to ensure that student recipes use the lowest number of quarks possible—three. This concept is identical to that of the Least Common Multiple in mathematics. To create a neutral atom, three electrons would be needed in an atom containing three protons and four neutrons.

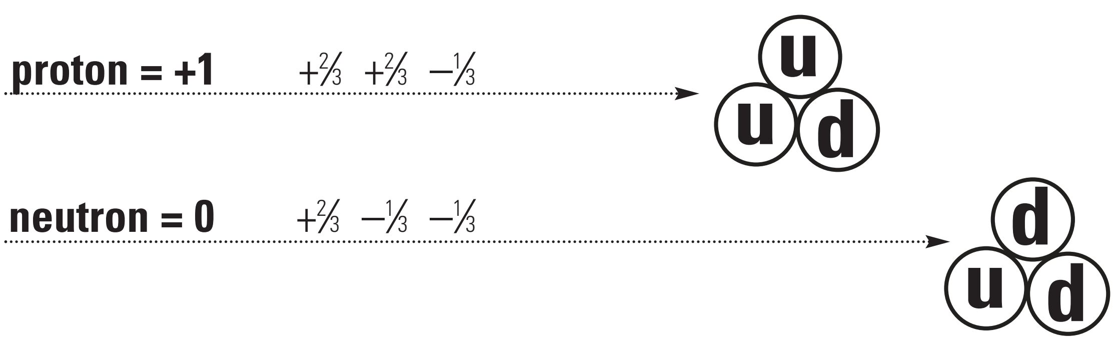
You may want to note to students that while antimatter particles are part of the basic building blocks in our universe, and have been identified by particle detectors, they are not observed very much in the everyday world. That's because when matter and antimatter meet, they annihilate each other. The resulting energy, however, is not lost; it can rematerialize as new particles and antiparticles.

Physicists theorize that at the time of the big bang, matter and antimatter were created in identical amounts. So why didn't the matter and antimatter annihilate each other and end the universe as we know it? Part of the answer may be that an asymmetry in the weak force occasionally converts antimatter into matter. But some physicists believe that this effect accounts for only some of the imbalance. New theories predict additional sources for asymmetry for which physicists continue to search.

One of the few places where matter and antimatter occur outside of a particle accelerator is in the medical imaging technique known as Positron Emission Tomography (PET).

In PET, positrons (the antimatter partner of electrons) are created by the decay of radioactive nuclei. The process works by first attaching a radioactive element to a natural body substance (glucose is commonly used) and injecting it into a patient. After the targeted area absorbs the substance, the radioactive nuclei undergo beta plus decay and the positrons that are created collide almost immediately with the electrons they encounter. The mass of both particles is converted into two gamma rays that travel outward and away from each other in exact opposite directions.

Gamma ray detectors that surround the patient register and measure these events. After algorithms are applied to the data, an image is constructed that shows areas where radioactivity is concentrated. These areas indicate signs of metabolic activity, giving clues to where tumors are or providing information about physiologic function to help diagnose disease.



Web Connection
Find out more about elementary particles—such as their mass, charge, and spin properties—in *Elementary Particles* at **www.pbs.org/nova/elegant/**