(Student Page)

Activity Five:
The Rules of the Game

Scientists in every field devise rules that explain what they have observed. They then use these rules to interpret new observations. This activity will give you the chance to discover rules, called *conservation laws*, that play a crucial role in the study of particle physics.

The most common type of observation in particle physics is called an *event*. An event is similar to a chemical reaction in chemistry, in the sense that one set of particles is formed from another.

The following particle charts can help you identify the types and charges of particles in a number of events given below. As indicated, each particle can have an electrical charge of +1, -1, or 0.

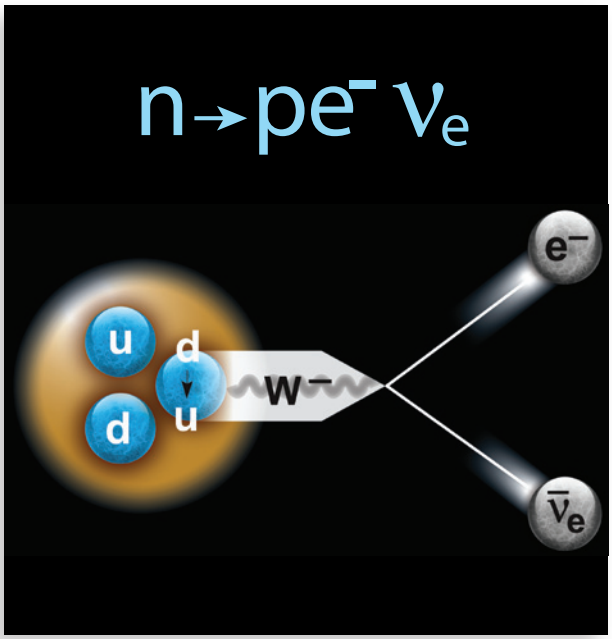
Note that antiparticles are denoted by a bar over the name of the particle (e.g., p-bar = antiproton, nu-bar sub-e = antielectron -- neutrino); or simply by the charges (e^- = electron, e^+ = positron = antielectron); pi$^+$ and pi$^-$ are particle and antiparticle, and similarly K^+ and K^-. An antiparticle has the same mass as its corresponding particle, but the opposite value for all charges.

BARYONS		MESONS		LEPTONS		PHOTON	
Symbol	Charge	Symbol	Charge	Symbol	Charge	Symbol	Charge
p	+1	π^+	+1	e^-	-1	γ	0
$\bar{p}$	-1	π^-	-1	e^+	+1		
n	0	π^0	0	ν_e	0		
Δ	0	K^+	+1	$\bar{\nu}_e$	0		
		K^-	-1				
		K^0	0				

Two sets of particle events are shown in the table below. The set in the left column consists only of events that are known to take place, and the set in the right column consists only of events that are believed not to take place (they've never been observed). By examining the two sets, along with the preceding chart of particles, we must determine what quantities are or are not conserved in these particle physics events. These are the "rules of the game" played by nature.

All of the quantities whose conservation can be deduced from the following events can be found by counting. All such quantities are conserved in every "observed" event, but at least one of these quantities is not conserved in each "unobserved" event. Assume that the incoming particles have sufficient energy to generate the outgoing particles.

OBSERVED EVENTS				UNOBSERVED EVENTS			
1.	n	$\rightarrow$	$p + e^- + \bar{\nu}_e$	11.	$n + p$	$\rightarrow$	$p + p$
2.	$\pi^+ + n$	$\rightarrow$	$p + \pi^0$	12.	p	$\rightarrow$	$\pi^+ + \pi^0$
3.	$\pi^- + p$	$\rightarrow$	$n + \pi^- + \pi^+$	13.	p	$\rightarrow$	$\pi^+ + \pi^-$
4.	$\pi^- + p$	$\rightarrow$	$p + \pi^0 + \pi^-$	14.	$\pi^+ + n$	$\rightarrow$	$K^+ + K^0$
5.	Δ	$\rightarrow$	$p + \pi^-$	15.	Δ	$\rightarrow$	$\pi^+ + \pi^- + \pi^0$
6.	Δ	$\rightarrow$	$n + \pi^0$	16.	Δ	$\rightarrow$	$K^+ + K^-$
7.	$n + p$	$\rightarrow$	$p + p + \pi^-$	17.	$\pi^0 + n$	$\rightarrow$	$\pi^+ + \pi^-$
8.	$p + p$	$\rightarrow$	$p + n + \pi^+$	18.	$\pi^0 + n$	$\rightarrow$	$p + \bar{p}$
9.	$e^+ + e^-$	$\rightarrow$	$p + \bar{p}$	19.	Δ	$\rightarrow$	$n + \pi^0 + \nu_e$
10.	$e^+ + e^-$	$\rightarrow$	$\gamma + \gamma$	20.	π^-	$\rightarrow$	$e^- + \gamma$



1. What is meant when we say that a quantity is "conserved?"

_____

_____

_____

2. What quantities or numbers of object types are conserved?

a)_____

b)_____

c)_____

3. What is an "event" in particle physics?

_____

_____

_____

4. Which of the above events are decays?

_____

_____

5. For each of the unobserved events, indicate what is not conserved (there may be more than one answer).

Event #:

11: _____ 16: _____

12: _____ 17: _____

13: _____ 18: _____

14: _____ 19: _____

15: _____ 20: _____