"NUCLEAR WAR"

A GAME ABOUT RADIOACTIVE DECAY

This game is not about atomic bombs or real war. This is a card game about alpha, beta, and gamma radioactive decay. The game format is loosely based on the classic card game "War" in which the players challenge each other, card by card, with the higher numbers and royal suits winning each round. In this game, you try to get rid of your unstable nucleus cards by using the three kinds of decay. The winner is the first person (or team) to get rid of their unstable nuclei.

BACKGROUND INFORMATION:

Large, unstable atoms (such as the nuclei of naturally occurring radioactive elements like radium, actinium, polonium, and uranium, and also radioactive isotope byproducts from fission reactors) do their best to become more stable. Their nuclei are very large and often contain a non-ideal ratio of protons to neutrons. By either getting rid of some of its neutrons and/or protons, or by changing neutrons into protons (or vice versa), an atom can become more stable. When an atom's nucleus shifts to become more stable, this is called ***radioactive decay***. There are three basic kinds of decay.

Alpha decay: The nucleus ejects an ***alpha particle***, which is made of 2 neutrons and 2 protons. (This particle happens to be identical to the nucleus of a helium atom.) Alpha particles cannot penetrate very deeply. A sheet of paper can stop them! Therefore, they are not very dangerous as long as they stay outside your body. However, if they get inside of you they can do a lot of damage to your cells.

Beta decay: Beta decay involves electrons. A ***beta particle*** is a high-energy electron; it has more energy than an alpha particle. A beta particle can go right through a sheet of paper, but can be stopped by a sheet of aluminum foil.

There are three basic types of beta decay:

1) **Regular beta decay**: This is when a neutron turns into a proton and emits a ***beta particle***. Also emitted, along with the beta particle, is an extremely tiny particle called an **anti-neutrino**. This particle was first discovered using mathematics. When physicists added up the numbers for the shift in mass and energy that happened during beta decay, there was a tiny bit of mass missing. According to the laws of physics, mass cannot be created or destroyed. Thus, this missing bit of mass had to have gone somewhere. The physicists guessed that another tiny particle was being emitted. This particle was actually observed for the first time in 1970.
2) **Reverse beta decay:** This is when a proton become a neutron and a ***positron*** is ejected. A positron is a positively charged electron. This doesn't mean it becomes a proton—it stays an electron, but carries a positive charge. (Seems strange, but it's true!) Also emitted at the same time is a ***neutrino***, the positively charged counterpart to the anti-neutrino.
3) **Electron capture:** This is sometimes called inverse beta decay. The nucleus captures one of the electrons in the atom's inner orbitals and it combines with a proton to become a neutron. (You could think of it as the positive and negative charges canceling out.) When electron capture happens, an electron from an outer orbital often drops down to fill the empty place left by the captured electron. This sudden drop in energy causes the emission of a photon (usually an x-ray or gamma ray). On rare occasions, other things can be emitted, too, but that is outside the scope of this game.

Gamma decay: This type of decay usually happens immediately after another type of decay. When a nucleus shifts to become more stable, there is usually extra energy that has to be released. It is often released in the form of a gamma ray. Gamma rays are high-energy x-rays. (Both gamma rays and x-rays are types of electromagnetic energy, as are light rays, radio waves and microwaves.) Gamma rays have a lot of energy and are very harmful to living cells. They can be stopped by lead, or by a meter of concrete.

Sometimes it takes multiple decays for an unstable atom to become stable, but eventually (after anywhere from a split second to several billion years) it will become stable and will no longer be radioactive. In the process, it may have changed into an entirely different element! For example, when uranium is finished decaying, it ends up as lead. This is because protons were lost in the decay processes, and when the number of protons changes, the identity of the element changes. If the number of neutrons changes, the element's identity stays the same, but its atomic mass changes, making it into a different ***isotope*** of that element.

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PURPOSE OF THIS GAME: To become familiar with the three basic types of decay.

(NOTE: This is NOT a complete, all-inclusive discussion of radioactive decay! This game has a very limited purpose. The author of this game is assuming that the students are using other instructional materials, as well.)

OBJECT OF THE GAME: To be the first person (or team) to get rid of all your UNSTABLE NUCLEUS cards.

NUMBER OF PLAYERS: 2 or more (For more than 2 players, form 2 teams, but don't have any more than 6 players per team.)

TIME REQUIRED: A round only takes 5-15 minutes, depending on the "luck of the draw." Play as many rounds as your class time allows.

YOU WILL NEED:

- Copies of the board game pages (1 copy of the board per 2 players)
- Copies of the cards, printed onto card stock
  (For every 2 players, you will need 2 copies of CARD PAGE 1, and 1 copy of CARD PAGE 2. For example, for 6 players, you will need 6 copies of PAGE 1 and 3 copies of PAGE 2.)
- Tape or glue stick, and scissors

SET UP:

Cut apart all the cards. Put 2 UNSTABLE NUCLEUS cards into the deck (a few more if you are playing with a large group), but keep the rest of the UNSTABLE NUCLEUS cards apart. Shuffle the deck well. Trim the board pages and put the halves together using glue stick or tape.

Give each player, or pair of players, a decay board. It is ideal for each player to have their own decay board, but since color copies can be expensive, the game will work just fine if you have one board per pair of players. (If necessary, even four players could share a board.)

Go over the background information with the players and take a few minutes to look at the decay board and discuss each kind of decay.

INSTRUCTIONS FOR 2 PLAYERS:

Each player starts out with 2 UNSTABLE NUCLEUS cards. These cards are placed on the table in front of each player. They will not be part of their "hand" of cards. The object of the game is to get rid of these cards by giving them to your opponent.

The players then take turns drawing cards. (These are the cards that will be held in hand, but secrecy is not important, so they could also be set out in front of the players.) As soon as a player accumulates the right combination of cards for a type of decay, the player may lay those cards down on the appropriate squares on the decay board, then give one of his UNSTABLE NUCLEUS cards to his opponent. The player who just received an extra nuclei card will hope to immediately lay down decay cards so he can give it back. After a series of turns, one player will ultimately end up with all the nuclei cards. The player with no cards

left wins that round.

Note that with gamma decay, only one card is required. This helps to speed up the game. You don't want a round to last any more than 5-10 minutes. A round might be over in as little as 1-2 minutes.

The Pb (lead) card is used to block the opponent from moving an UNSTABLE NUCELUS card. (This card was invented by my students. They wanted to add another feature to the game, so they suggested a Pb card. They liked the idea that Pb can block all radtaion.) When a Pb card is drawn, the player sets it out next to his UNSTABLE NUCLEUS card(s). When the opponent completes a decay and tries to move a nuclei card over, the Pb can block them. However, the Pb can't be used more than once (unless you need to recycle all the cards to replenish the draw pile).

Adjusting the length of the game:

You can make the game last longer by giving each player 3 or 4 UNSTABLE NUCLEUS cards to start with.

Playing multiple rounds:

This game is designed to go very quickly so that you will have time to play mulitple rounds. Each player should get a chance to win a round.

Ending the game quickly:

With just two players, you probably won't have a problem resolving the game quickly, but if you do, see the "Sudden Death" rule at the end of the instructions for more than 2 players.

INSTRUCTIONS FOR MORE THAN 2 PLAYERS:

Divide your players into 2 teams. Give each player 1 or 2 UNSTABLE NUCLEUS cards, depending on how long you want each round to last. (In my class we had 6 players on each team and each player had only 1 card to start. The first round lasted 10 minutes, the second 15 minutes. The third round lasted much longer and we had to use the Sudden Death rule listed below. If you are playing with more than 4 players, give each player only 1 card to start, unless you want a long game.) If you have an odd number of players, the team with fewer players will have to take an additional UNSTABLE NUCLEUS card, so that each team has the same number of cards to get rid of. The extra card can go to an individual player, or they can be set out between the players, available to anyone on that team.

Draw piles: You can have multiple draw piles if your students are stretched out in line (as in the pictures on the following page) or you can have just one big one.

TIP: It is helpful to have some kind of visible dividing line going down the middle, diving the two teams. In my class, I put a strip of masking tape down the middle of the table. It is surprisingly easy to have cards shift around so that you loose track of which side it was on! If you are playing on a carpeted floor, a long piece of rope or yarn might work nicely.

All members of the team will go at once. Someone (parent or teacher?) will say "Team One, go!" and all of the members will draw a card. Then, 'Team Two, go!" and they all draw a card. Letting everyone on a team play at once maximizes everyone's playing time and minimizes wasted time. (This also leads to a lot of conversation, cooperation, and positive social interaction among the players, too!)

When someone collects the correct cards for a type of decay, those cards are then "discarded" onto the decay board (lay each card on the appropriate square), and their UNSTABLE NUCLEUS card is moved over to the opponent's side. (On some turns, you might have two or three team members who can move cards.) The first team to get rid of all their UNSTABLE NUCLEUS cards wins.

OPTION: You can have all the UNSTABLE NUCLEUS cards be joint property so that anyone with a set of decay cards can move any of the UNSTABLE NUCLEUS across, or you may choose to keep track of which cards belong to which person. My group choose the latter, because they were stretched out so far along a table. We used a rule that said when someone got rid of their UNSTABLE NUCLEUS card, they could then

use their turn to put one of their cards (either from their existing hand, or a fresh draw) out on the table near the draw pile for anyone on their team to use. That way, at the beginning of each turn, players could choose to either pick up one of the available cards, or draw one from the draw pile. (Using this method of play, the players can cooperate a bit, making it more of a team game.)

The Pb (lead) card is used to block the opponent from moving an UNSTABLE NUCLEUS card. (This card was invented by my students. They wanted to add another feature to the game, so they suggested a Pb card. They liked the idea that Pb can block all radiation.) When a Pb card is drawn, the player sets it out by the UNSTABLE NUCLEUS card(s). When the opponent completes a decay and tries to move a nuclei card over, the Pb can block them. However, the Pb can't be used more than once. After it has blocked that move, the Pb card is removed from game (unless you need to recycle all the cards to replenish the draw pile).

"Sudden Death"

If you have a round that is going on too long, you may end the game quickly by using the "Sudden Death" rule. This rule says that instead of moving an UNSTABLE NUCLEUS card to the opponent's side, you simply turn it over and it goes out of play. The first team to have all their nucleus cards turned over wins.

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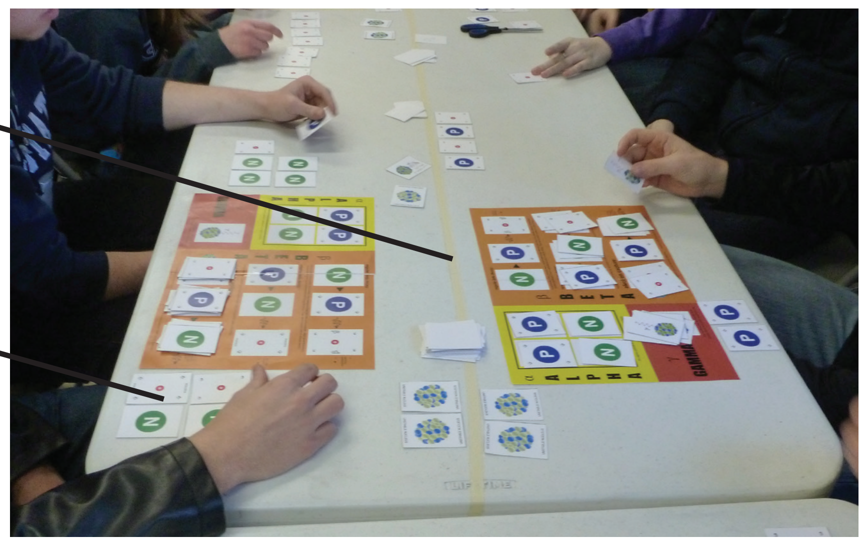
FINAL NOTE: You are ultimately in charge of how the game runs! If you want to change the rules to suit your particular situation, go right ahead. Do what works best for you. (For example, you might want to remove the extra UNSTABLE NUCLUES cards from the draw pile, or add more Pb cards. Or, you may think of your own creative twist to the game!)

I put tape along the center line so cards would not get mixed up.

Players don't have to hold all their cards in their hand. They can put them out on the table. My students had a lot of fun looking at each other's cards and joking about having too many of one type of card. It made the game more fun to see everyone's cards.



You can have more than one draw pile for a large group.

ALWAYS REMEMBER THAT THE PURPOSE OF THE GAME is to become very familiar with the different types of decay. As long as this happens, the game is a success no matter how you play it!

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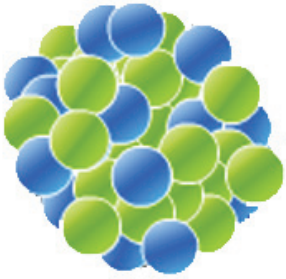
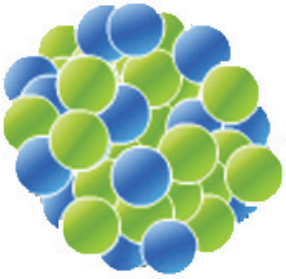
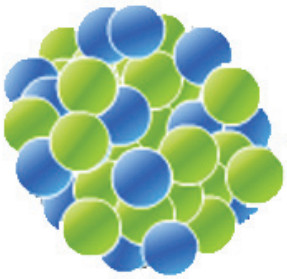
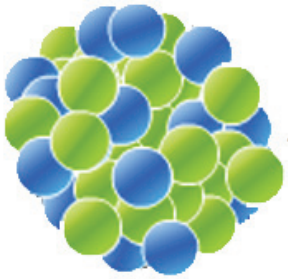
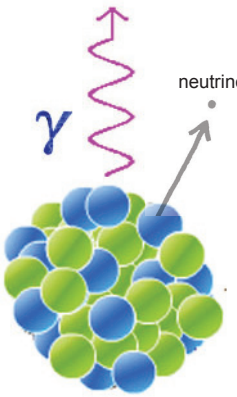
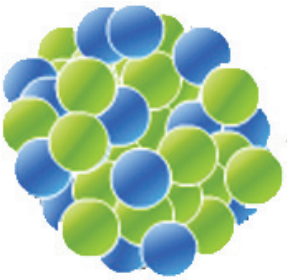
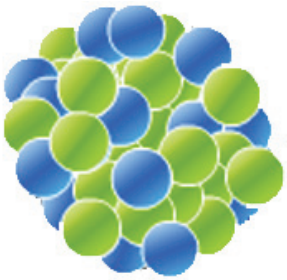
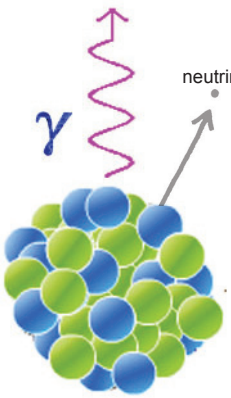
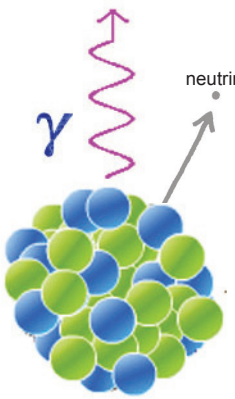
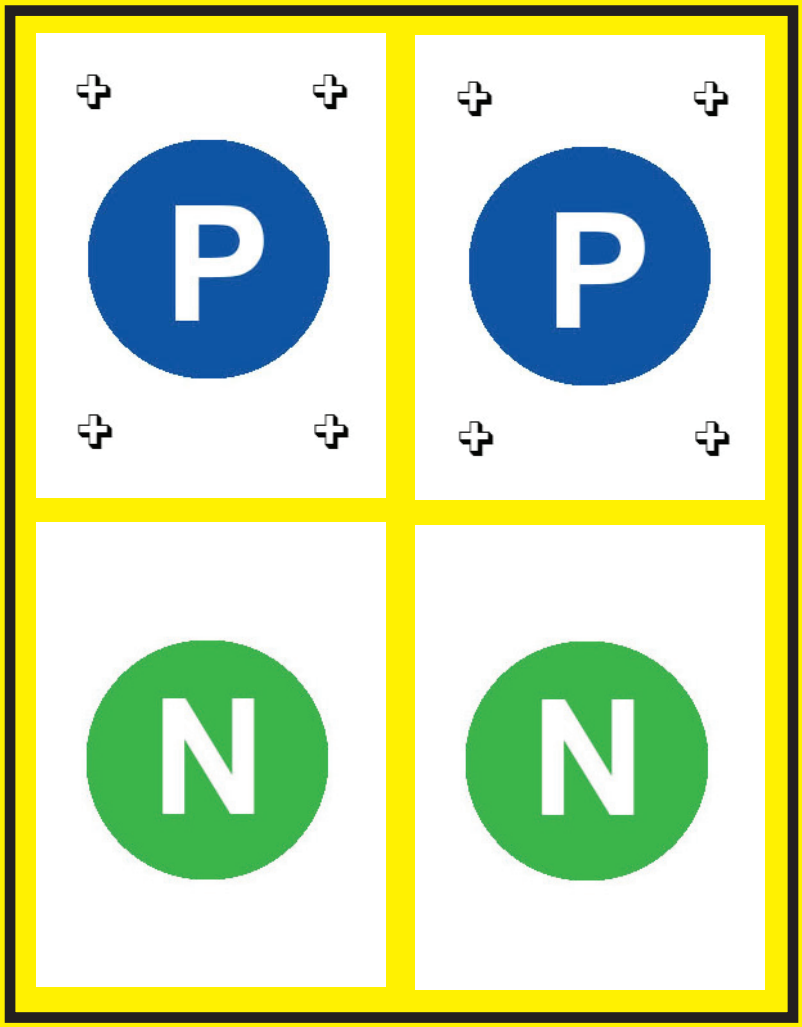
e	e	UNSTABLE NUCLEUS  UNSTABLE NUCLEUS	UNSTABLE NUCLEUS  UNSTABLE NUCLEUS
β e ϑ	β e ϑ	UNSTABLE NUCLEUS  UNSTABLE NUCLEUS	UNSTABLE NUCLEUS  UNSTABLE NUCLEUS
Pb (lead) *One-time protection from an unstable nuclei* *One-time protection from an unstable nuclei* (lead) **Pb**		UNSTABLE NUCLEUS  UNSTABLE NUCLEUS	UNSTABLE NUCLEUS  UNSTABLE NUCLEUS
POSITRON e POSITRON			POSITRON e POSITRON

α ALPHA



An alpha particle is identical to a helium nucleus.

β BETA

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A neutron tur
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A proton turn

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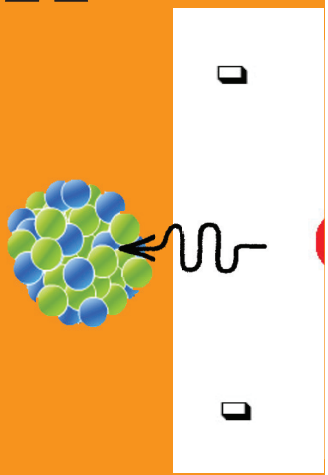
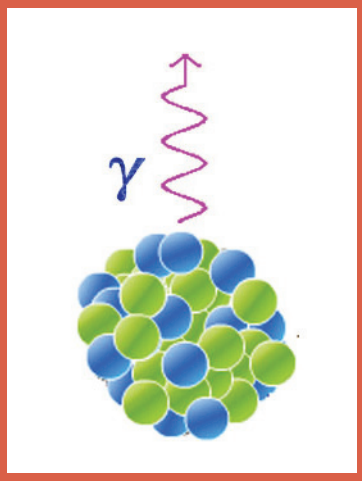


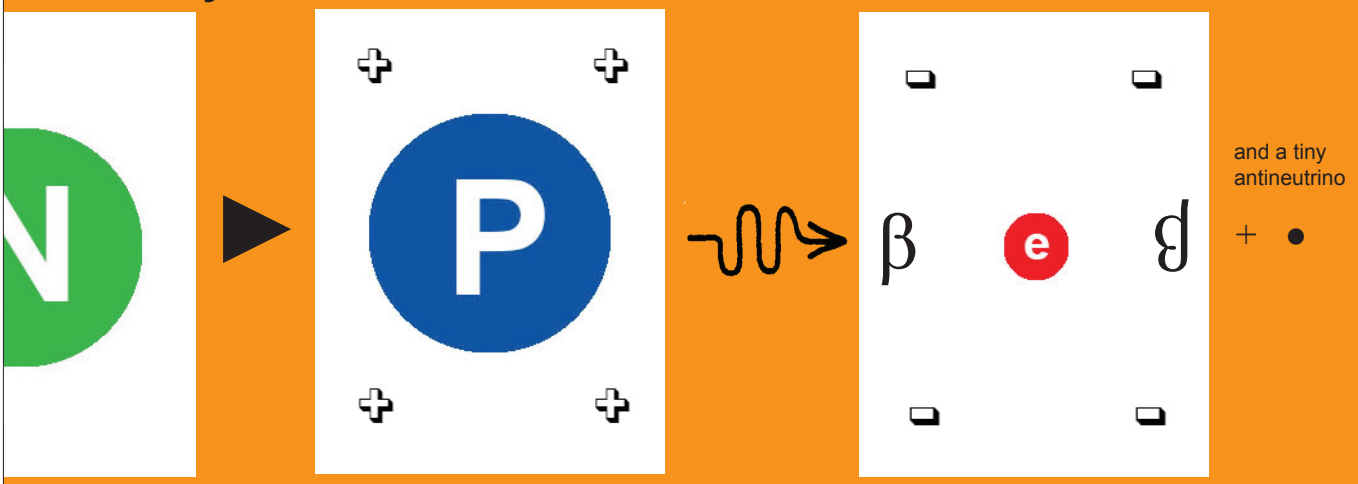
The nucleus

γ GAMMA



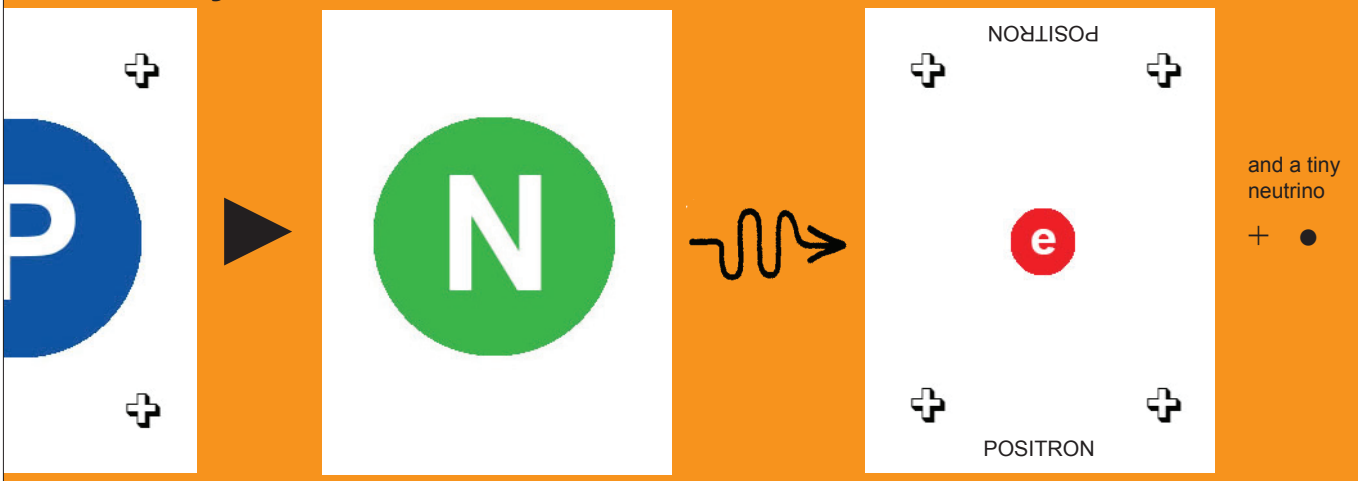
The nucleus has a change in its energy level and emits a gamma ray.

beta decay:



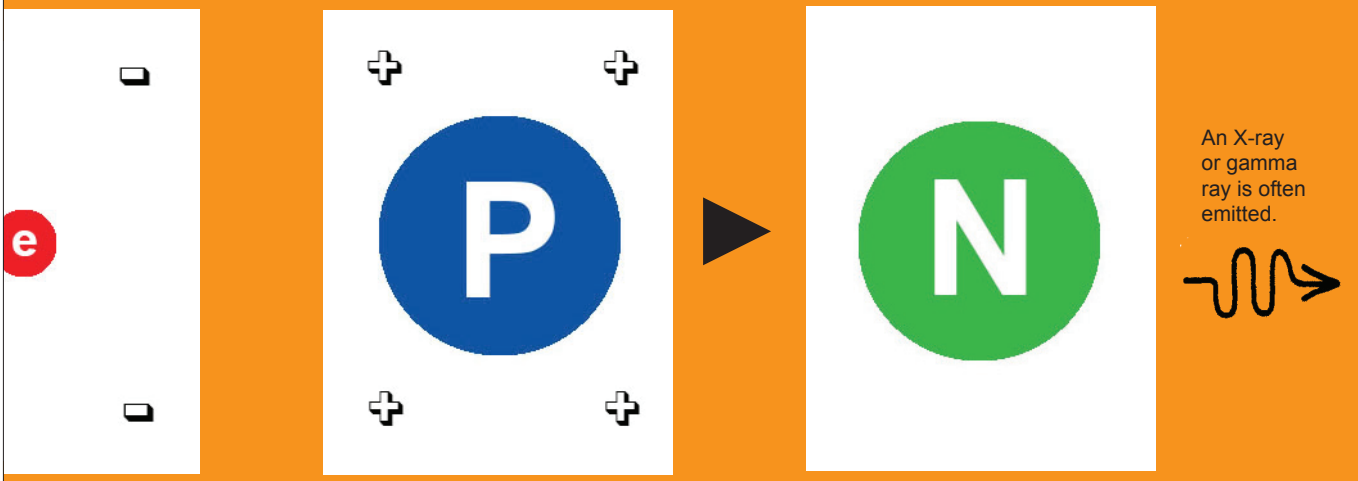
ns into a proton, and a emits a high-energy electron (and also a tiny particle called an antineutrino).
N and P are in alphabetical order in regular decay. They are in reverse order in reverse decay.)

beta decay:



s into a neutron, and emits a positron (and also a tiny particle called a neutrino).

ron capture:



captures one of its own inner electrons. A proton turns into a neutron, and a photon is emitted.