PAN Lesson Plans

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Background: The lesson plans cover three days and are part of a larger unit covering radiation, nuclear fission, fusion and nuclear power. Students will have an understanding of what radiation is, the first family of radiation, and isotopes. The lesson plans will begin after learning what an isotope is but before learning about radioactive tracers.

Day One

Objective: NGSS HS.PS.SPM a) Structure and properties of matter

NGSS HS.PS.NP a) Nuclear processes

NGSS HS.PS.IF d) Interaction of forces

Materials: Marble set, chart of the nuclides, lab worksheet (base on JINA Marble lesson pages 3-7)

Lesson: Lesson is based on learning how isotopes are created, which are stable or not stable and how to read a chart of the nuclides. Begin by reviewing the knowledge they have about radiation and the 3 main decays. From there move into what an isotope is, review how they are different from an atom. Explain how to read the chart of the nuclides and have students build the different Be isotopes, looking at where they fall on the chart. Then students will build several differ isotopes based on the lab worksheet working in small groups and recording different information and naming the isotopes. Finish by having them go through the 3 main decays of an isotope and look at differences in the nucleus based on the decay.

Wrap-up: Students will fill out an exit slip with the following information as well as completed lab worksheets.

Tell me one WOW! thing from the lesson:

Tell me one thing that caused a problem for you today:

Tell me something that you still find confusing:

Day Two

Objective: NGSS HS.PS.SPM b) Structure and properties of matter

NGSS HS.PS.IF d) Interaction of forces

Materials: Fragmentation Box, marble sets, chart of the nuclides, lab worksheet (based on JINA Marble lab pages 8 -11)

Lesson: Complete the lab worksheet following the instructions to build the fragmentation box. Complete the entire lab making sure to record each isotope created and collecting all of the needed data. Collect all of the class data on the board to compare and talk about stable and unstable isotopes, rare and common isotopes based on stability.

Wrap-up: Class discussion about what types of isotopes are stable vs. which ones are unstable. Exit slip will have the students answer:

Why are some isotopes more stable than others?

Why can some isotopes exist forever but others can't exist at all?

Day Three

Objective: NGSS HS.PS.IF e) Interaction of forces

Materials: NSCL virtual tour, PAN poster

Lesson: Explain to students what the NSCL is and show them how it works using the virtual tour. Show them the PAN poster and explain what I did over the summer. Conclude with why rare isotope research and nuclear physics is so important and what new frontiers have been opened or advanced based on work done at the NSCL.

Conclusion

Roll into current lessons on radioactive tracers, medical isotopes and rare isotope use in everyday life.

Isotope Lab

Adapted from the JINA Learn Nuclear Science with Marbles

Materials: Each group needs to have 2 sets of marbles, one chart of the nuclides

Directions:

Each member of the group needs to practice taking off and putting on the marbles from the magnet. Make sure you have 6 yellow marbles and 6 green marbles per magnet.

Yellow = protons, heavy positive charge

Green= neutron, heavy no charge

1. Created a C-12 isotope, draw what it looks like below: label the number of p+ and n.

2. Now create a Be-9 isotope
    a. p+ =
    b. n =

3. Remove one neutron and name the isotope.

4. Create a second Be-9 isotope, add one neutron and name.

5. Compare the two isotopes, do they look the same? Will they have the same chemical properties?

6. Now take the smaller isotope and create Be-6, compare it to the isotope you have left.

7. Build an isotope that has 3 protons and 6 neutrons, name it.

8. Build a Be-10 isotope. Exchange one neutron for a proton and an electron. This is a Beta-minus decay. Name the isotope created.

9. Look at the chart of the nuclides, in which direction did the isotope move from the original?

10. Does this isotope have more or less energy than it started with? Explain your answer.

11. Now create a Be-7 by swapping a proton for a neutron and a positron. Name the new isotope.

12. Look at the chart of the nuclides, in which direction did the isotope move from the original?

13. Does this isotope have more or less energy than it started with? Explain your answer.

14. Now build a Be-8 isotope and have it undergo alpha decay, releasing 2 p+ and 2n. Name the isotope.

15. Isotopes can also undergo a capture process. It is possible for them to capture a free electron, turning one of its protons into a neuron! They can also capture a neutron inside of a supernova creating a new element!

Fragmentation Box Experiment

Adapted from the JINA Learn Nuclear Science with Marbles

Put the fragmentation box together so it looks like the demonstration model.

a. Test the fragmentation box by dropping a single yellow marble from the lowest opening (low energy opening). Record what you observe.

b. Now predict what will happen when dropping the same marble from the top opening (high energy opening).

c. Record what actually happens and explain why.

d. Build a C-12 nucleus and hang it from the nail centered in the wire mesh close to the opening. This is the target nucleus. Predict what will happen if you hit the target nucleus with a low energy beam (one yellow marble).

e. Now try the low energy beam and record your results.

f. Predict what will happen if you use a high energy beam.

g. Now try the high energy beam, after resetting the target and record your results.

h. Now reset the target and build a He-4 beam. Predict what will happen if this beam hits the target.

i. Try the He-4 beam at low energy and record the results.

j. Reset the target and predict the He-4 beam at high energy hitting the target.

k. Try the He-4 beam at high energy results.

l. Try moving your nucleus target farther away from the opening and record what happens.

m. Now try moving the target closer and record what happens.

n. You will be moving the target offset from center. Move your target to one side of the opening so that it is less than half of the opening. Most beams are no head on collisions, more glancing like this.

o. Drop the He-4 beam from low energy and record how that is different from a high energy beam.

p. Record the next 10 observations of high energy beam He-4, remembering to reset the nucleus target each time. You will need to record the proper isotope name of each collision.

q. Record your results on the board.