Aluminum: Saving Energy to Make More

GRADE LEVEL: 9-12

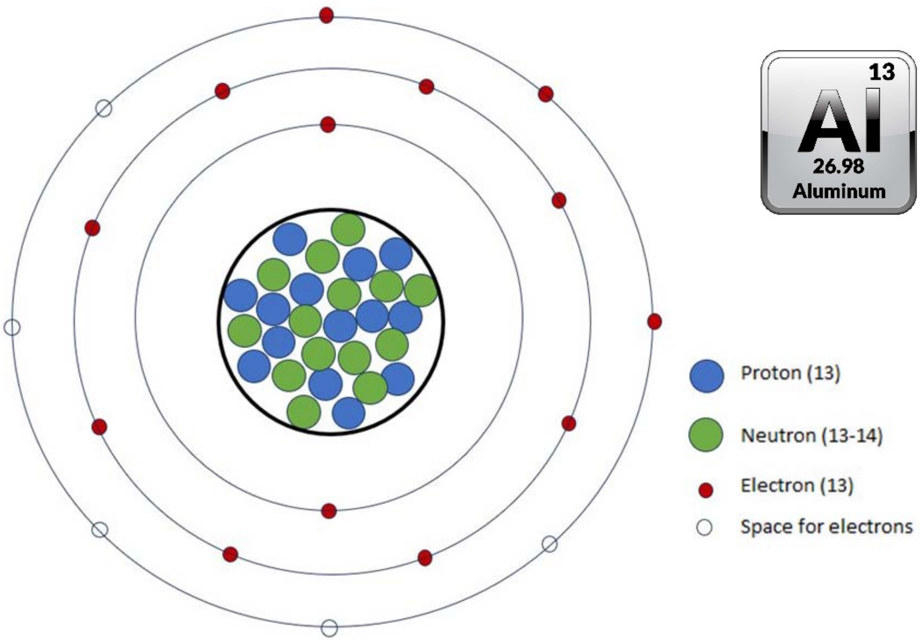
INTRODUCTION:

Aluminum is the most common metal in the Earth's crust (8% of the Earth's crust). Aluminum demand is expected to double over the next 25 years, as more lightweight aluminum is used in electric cars and other green energy applications. Aluminum has hundreds of uses, from aircraft and vehicle parts to building material, beverage cans, wrapping foil, and just about any application where a lightweight metal is needed.

Although aluminum is a common, natural metal, it isn't found as a native metal. It is found combined with other elements in minerals. Bauxite ore is a sedimentary rock that consists of aluminum minerals. A large amount of energy is required, however, in processing to remove the other elements from the minerals in the bauxite to make pure aluminum metal.

Wendi Cooksey is a metallurgical engineer. She enjoys conducting this activity for students and teachers whenever she can and wants them to understand the important science behind metallurgy. She explains that there are three stages in aluminum production: 1) the surface mining of bauxite, 2) which is then refined to alumina (aluminum oxide), 3) then converted to aluminum metal through a process requiring an electric current. Two percent of the world's energy goes to aluminum production. Aluminum production is also the largest carbon emission producer of all metals, though this has been nearly cut in half in North America over the past 30 years due to increased recycling and technological improvements. Aluminum is infinitely recyclable.

Why does it take so much energy to produce aluminum? The answer is in its atomic structure. Looking at the aluminum atom, it has 13 protons and 14 neutrons in the nucleus with 13 electrons surrounding them. Although the aluminum atom is neutrally charged, its outer (valence) shell has room for five more electrons. This is why it forms minerals with other atoms, often oxygen or silicon, but also why it takes so much energy to break the strong bonds in those minerals.



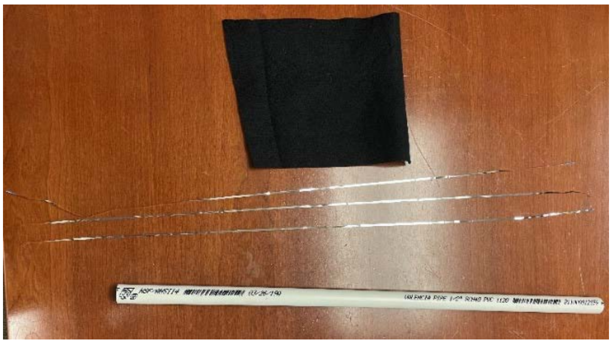
The recycling of aluminum requires only 5% of the energy that is needed to process bauxite ore for that same amount of aluminum. This activity shows the surface chemistry of aluminum atoms demonstrating the importance of recycling aluminum for a much lower carbon footprint. **Not recycling an aluminum can is equivalent to filling that can half full of gasoline and dumping it onto the ground.**

Statistics source: Aluminum.org (The Aluminum Association)

ENERGETIC ALUMINUM ACTIVITY

LEARNING OUTCOMES:

Students will conduct an experiment to illustrate the reason that it takes a great deal of energy to process aluminum.



MATERIALS NEEDED:

- 24-inch PVC pipe (3/4" diameter), one (1) per student or student group or just one (1) for the teacher if being conducted as a classroom demonstration
- Piece of felt cloth for each PVC pipe being used
- Three (3) strands of silver Christmas tinsel per PVC pipe (synthetic tinsel needs to be coated with aluminum)

PROCEDURE:

1. Tie a knot in the middle of three strands of tinsel.
2. Fold the bundle in half at the knot and tie another knot 4 inches from the first knot using all the pieces (this will make an orb when puffed up).
3. Trim off excess pieces below the knot.
4. Rub PVC pipe with felt until static electricity can be heard.
5. Holding the tinsel orb in one hand and the PVC in the other, show how the aluminum tinsel is attracted to the pipe.
6. Recharge the PVC with the felt by rubbing it again then toss the tinsel orb into the air.
7. Quickly **tap** the PVC to the tinsel then immediately move the pipe below the orb and control the orb movement by moving the pipe.

Practice these steps until it works well for you. Be patient with your practicing.

Why does the orb puff up?
Electrons jumped to the tinsel from the charged PVC pipe, making all the tinsel strands repel each other (puffing the orb) and repelling the extra electrons on the PVC.

What happened when you tapped the PVC pipe to the tinsel orb?
Static electricity was generated by taking electrons from the felt cloth onto the pipe. You can see that the aluminum is attracted to the excess electrons on the PVC pipe. Tossing up the tinsel and tapping it with the charged pipe allowed electrons to rush over to the aluminum. The pipe and tinsel now repel each other as they are both covered with excess electrons. This tendency is the reason that it takes a great deal of energy to process aluminum from bauxite. The next activity is an illustration of how to save much of that energy by recycling.

CALCULATING CANS ACTIVITY

LEARNING OUTCOMES:

Students will calculate the amount of aluminum cans used annually, exemplifying the magnitude of this number by using distance to the moon.
Students will calculate the amount of energy that could be saved if all the aluminum cans are recycled, using the energy in gasoline to illustrate this.

PROCEDURE:

Givens:
Aluminum cans that are used every year: 180 billion
Aluminum can dimension 12 cm height
Distance to the moon and back: 769,000 km
Statistics: Aluminum.org (The Aluminum Association)
Energy in a gallon of gas: 33.7 kW per gallon
Source: energyeducation.ca/encyclopedia/Miles_per_gallon_gasoline_equivalent

Calculations:

____________ x ______cm/can = ____________________cm
number of cans   can height   height of all cans end to end

__________________cm x __________km/100,000 cm= ____________km
height of all cans end to end   convert to km   height of cans in km

__________km÷____________________km = _____________________
height of cans   distance to the moon and back   Number round trips to the moon

Image not to scale!

Calculations:

____________ x ½ x ______gallons = ________________________gallons
number of cans can volume amount of gallons in all these half cans

________________kWh x ______________ = __________________kWh
energy in a gallon of gas gallons in all half cans energy saved if all recycled

DISCUSSION:

What do these calculations say about the energy saved by recycling cans?

The US is recycling 50% of its aluminum cans. How could this be improved?

Why could recycling cans reduce emissions?

Even more aluminum will be needed for green energy uses such as electric vehicles. What are the possibilities for dealing with this need?

Extension Activity: Contact your local solid waste or recycling company and learn how long the time lapse is between when an aluminum drink can is put in a recycling bin in your community until that aluminum might reappear as a new drink can on a shelf in your local store.