Exponential Growth and the Aurora

Overview:

Students compare the atmospheric molecular density to the appearance of the aurora and identify the lower limit of the aurora.

Objectives:

The student will:
- compare the density of gas molecules in the atmosphere to the appearance of the aurora; and
- identify the lower altitude limit of the aurora.

Materials:

- Colored pencils
- Highlighters
- VISUAL AID: “Photographs by Jan Curtis”
- STUDENT WORKSHEETS: “Exponential Growth and Color Intensity”

Activity Procedure:

1. Distribute STUDENT WORKSHEET: “Exponential Growth and Color Intensity” and display VISUAL AID: “Photographs by Jan Curtis.” It is important to monitor the students as they draw their aurora to make sure they include the element of the fading quality the higher up the aurora goes.
2. Allow students to continue on with the worksheet. When they are finished, discuss their answers to the questions.

Answers to Student Worksheet:

1. *Answers will vary, however the student’s drawing should replicate one of the drawings on the VISUAL AID with more intense color at the bottom of the auroral curtain.*
2. *Answers will vary, however the student’s answer should reflect that the part of the aurora that is closest to Earth’s surface is the most intense in color. The aurora fades as it gains distance from Earth’s surface.*
3. *Answers will vary, however the student’s answer should reflect that the graph shows there are fewer molecules as altitude increases and the color fades in the picture as altitude increases.*
4. *If color intensity increases as the density of gas molecules increases, then the aurora should be the brightest at ground level.*
5. *The altitude of 100 kilometers should be highlighted all the way across the graph.*
6. 10^{13} *molecules per cubic centimeters (or 10,000,000,000,000)*

Exponential Growth and the Aurora

Teacher Information:

The colors and shapes of the auroral display appear brighter closer to Earth than they do farther away. The factors that affect the way in which auroras appear to us are very complex. Two of the major factors are the density of gas molecules at the height where auroras occur, and energy.

In certain conditions, the energy created by the collision between Earth's magnetic field and the solar wind is such that it builds up and shoots charged particles into the polar regions of Earth's ionosphere, the top layer of the atmosphere. The strength of this energy determines how deep in the ionosphere the charged particles are pushed and as a result, the potential for brighter aurora.

As altitude increases, the density of the gas molecules decreases exponentially, thereby contributing to the fading quality of the colors. Energy causes the charged particles to hit gas molecules in the ionosphere. Because there are more gas molecules near Earth's surface than farther away, the auroral display is brightest at its lowest possible altitude, 100 kilometers.

The speed at which the particles enter the atmosphere determines how deep they will travel. Particles travel through space at very high speeds. When they hit our atmosphere they experience friction, as if someone suddenly applied the brakes. The particles that enter the atmosphere with the highest amount of energy generally create aurora down to 100 kilometers from Earth's surface.

Name: ____________________________________

Exponential Growth and Color Intensity

Directions: The range of color within the auroral curtain is a result of several factors. Follow the instructions for each task and answer each question below to learn about these factors.

1. Examine the pictures of the aurora on the VISUAL AID. Then use colored pencils to draw one of the auroral pictures in the box below. Use shading to show the color intensity of the aurora.

2. Describe the intensity of the arc's color in terms of distance from Earth's surface.

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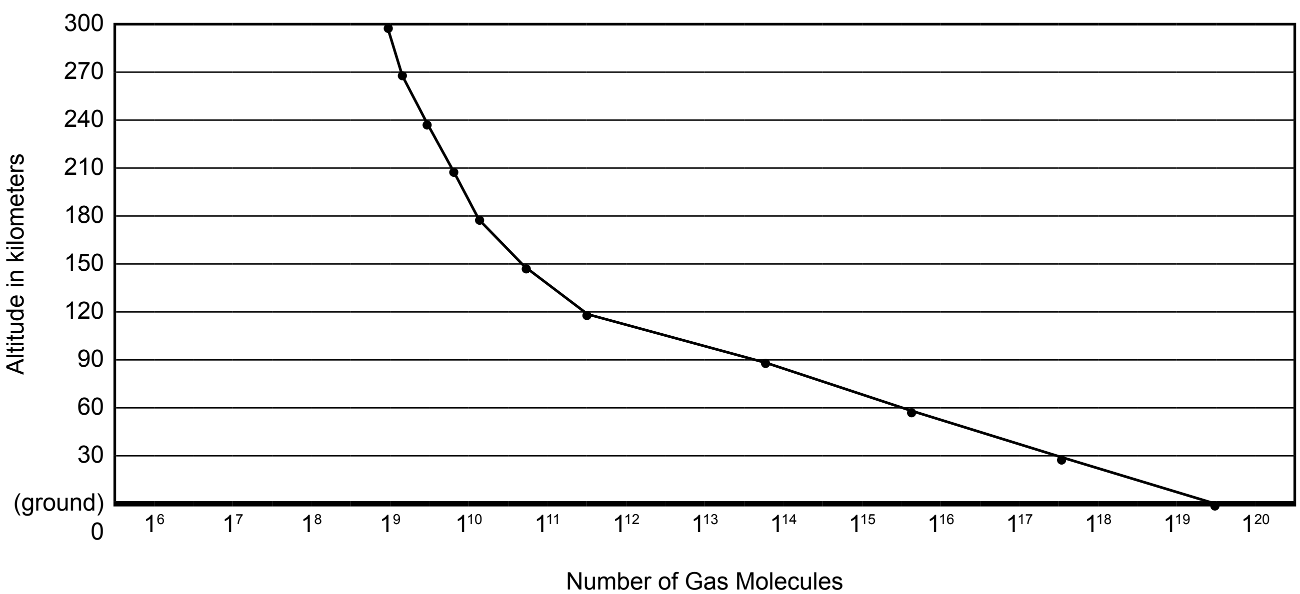
The graph below plots the number of gas molecules per cubic centimeter at different altitudes in the atmosphere. Remember, in exponential form, 10^9 molecules is another way of writing 1,000,000,000 molecules.



Exponential Growth and Color Intensity

3. Compare the graph shown above to the picture of the aurora. What is the relationship between them?

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4. If color intensity increases as the density of gas molecules increases, then where on the graph would the color be the brightest?

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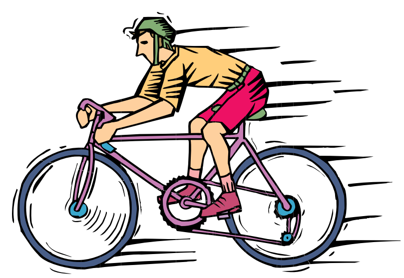
So, why aren't auroras at ground level?

Imagine riding a bike at a fairly fast speed on dirt. What happens when you suddenly apply the brakes? A skid mark is left on the ground. If you go even faster and apply the brake, you leave a longer skid mark.

This is similar to what happens to the particles that create the aurora. The particles travel through space at great speeds. When they enter our atmosphere, they slow down, as if someone applied a brake. While the particles "skid," they interact with molecules to create the light of the aurora.



The particles that enter the atmosphere with the highest amount of energy generally create aurora down to 100 kilometers from Earth's surface.

5. Use a highlighter to identify the minimum height for the aurora on the graph.

6. What is the approximate density of gas molecules at the minimum altitude of the aurora?

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