Supernova, Ozone, Earth

Subject: Chemistry, Astronomy

Grade Level: 9th – 11th

Rational or Purpose: The purpose of this activity is to increase students' understanding of supernova and ozone. The teacher will explain how the ozone layer protects us from harmful radiation caused by the creation of supernova.

Materials:

Post-assessment quiz
Electromagnetic spectrum

Lesson Duration: 50 minutes

TEKS Objectives:
§112.45. Chemistry.
(c) (11a-c)

§112.48. Astronomy.
(c) (6b) (7a) (10a)

Background Information:
The following is a picture of a supernova:

Supernovas originate from a stellar explosion. During the explosion, huge amounts of radiation and energy are emitted from the star. The radiation emitted consists of mainly gamma-rays, a high frequency, high energy radiation that can cause skin cancer in humans. If the explosion happens close enough (less than 100 light years) to the earth, the strong radiation could deplete the entire ozone layer in our atmosphere. This

destruction will expose humans and other organisms to direct harmful solar and cosmic radiation. Without the protection of ozone layer, we are susceptible to a wide variety of negative effects caused by radiations, such as skin cancer, overproduction of Vitamin D, and accelerated cellular mutations, etc.

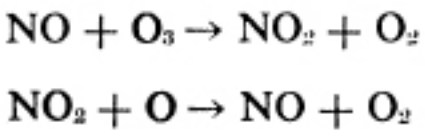
Procedure

1. Teacher will show some pictures of supernovae to the students.

2. Explain the cause of supernova formation, and the constituents of the emitted radiation. In this lesson, teacher will focus on the properties of gamma rays emitted from supernova.

3. Discuss the light spectrum (attached). Answer the following question using the picture: “Why aren’t UV, X-ray, and gamma rays able to penetrate Earth’s atmosphere? What blocks these forms of radiation from passing into our atmosphere?”

4. Show the following key reaction that cause the depletion of ozone:



$$NO + O_3 \rightarrow NO_2 + O_2$$

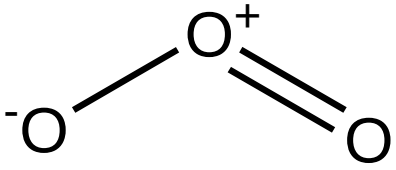
$$NO_2 + O \rightarrow NO + O_2$$

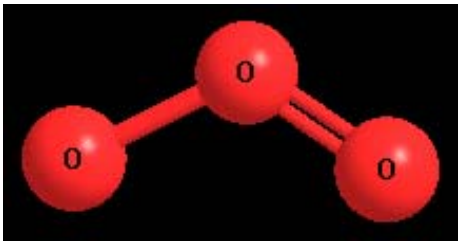
   This is an example of chain reaction: *one reaction causes the formation of a product, which will be the reactant in another reaction*. For Chemistry classes, this is a good example of La Chatelier’s principle that shows how depletion of products drives the reaction in forward direction.

5. To conclude the lesson, assess their knowledge about the hole in the ozone layer with probing questions, such as, “*Why is ozone so important to us and other living organism?”* The purpose of the discussion is to lead them to think about how to decrease the destruction of ozone layer and ways to protect the ozone layer.

6. Since the students may not have complete chemical knowledge of ozone, it is important to emphasize the following main ideas:

   a. O_3 is the chemical name for ozone.
   b. The chemical structure of ozone is shown in the following diagram:





c. The major chemical compounds that accelerate the depletion of ozone layer are nitric oxides (e.g. NO, NO_2, or generally written as NO_x).
d. The nature of the ozone depletion reaction by nitric oxides is catalytic, meaning that a small amount of nitric oxides is enough to initiate the reaction and causes a considerable degree of damage to the ozone layer. For example, consider the example for earlier in the lesson:

$$NO + O_3 \rightarrow NO_2 + O_2$$

$$NO_2 + O \rightarrow NO + O_2$$

The NO on the product side of the second reaction becomes the reactant of the first reaction. Therefore only a catalytic amount of NO is needed to deplete ozone.
e. One major source of NO in the atmosphere is that produced from combustion in the jet engines of a plane.
f. Strong radiation emitted from interstellar bodies can also initiate the depletion process.

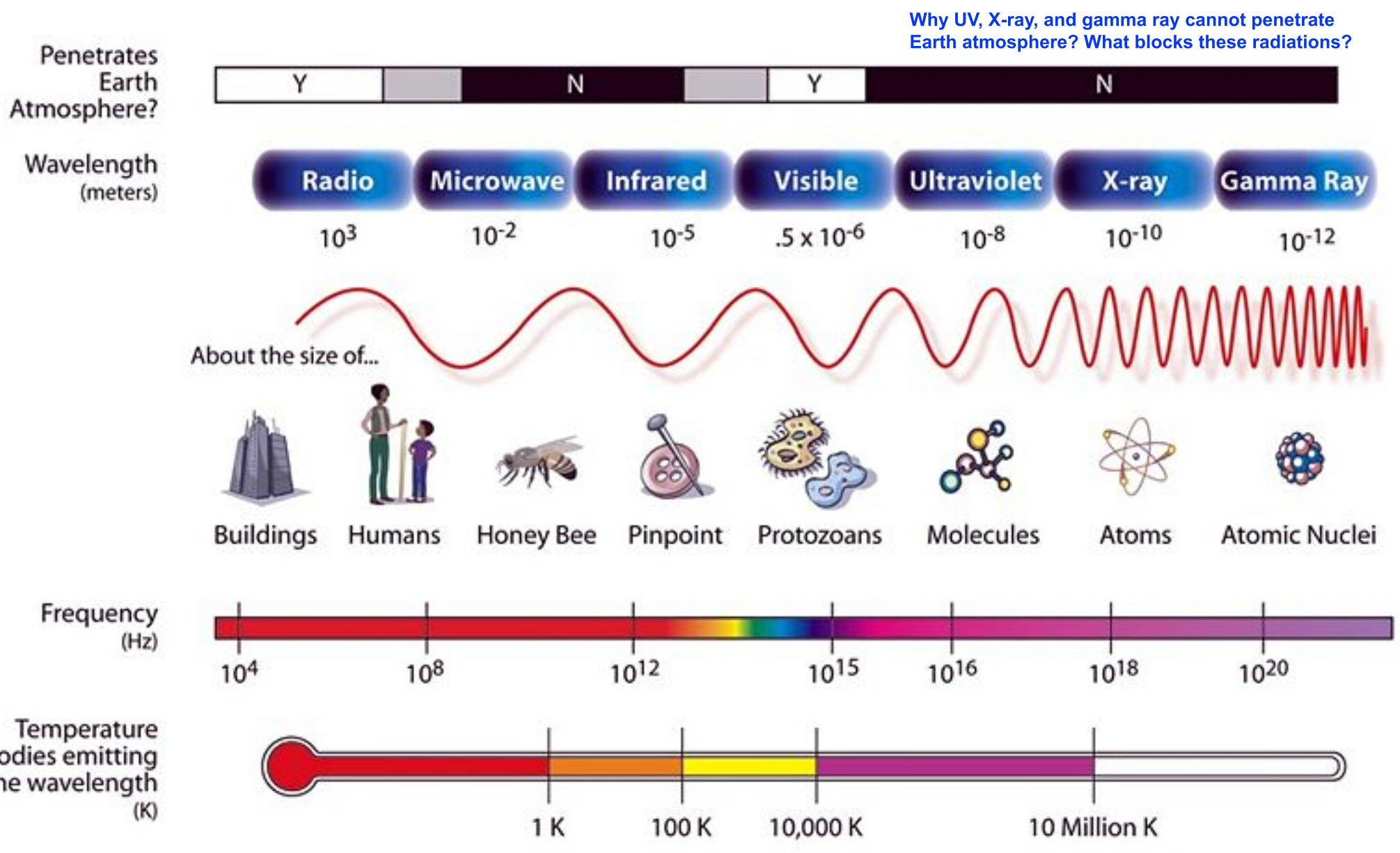
7. Ask the students to think about the adverse effects of ozone depletion. Be sure to incorporate the following ideas into the class discussion:

a. Ozone protects living organisms by reflecting and blocking the penetration of harmful radiation entering into the Earth's atmosphere.
b. The primary threat of overexposure to harmful radiation such as UV, x-ray, and gamma rays, is the abnormal mutation of skin cells, which may eventually become skin cancer cells.
c. Appropriate amount of exposure of ultra-violet (UV) radiation helps to produce vitamin D in our bodies. However, overexposure to UV will cause overproduction of vitamin D. If our bodies accumulate excessive amount of vitamin D, it becomes toxic to us. (Because Vitamin D, which is not water-soluble it cannot be excreted out of our bodies through our metabolic system.)
d. Cell death rate will also be accelerated by the overexposure of harmful radiations.

8. Post-assessment: Quiz is attached with this lesson plan.

THE ELECTROMAGNETIC SPECTRUM

Why UV, X-ray, and gamma ray cannot penetrate Earth atmosphere? What blocks these radiations?



Source: NASA

Name: _____ Date: _____

Class Section: _____

Supernova, Ozone, Earth

Quiz

1. What are the THREE strongest types of radiation in the electromagnetic spectrum?

   a. _____

   b. _____

   c. _____

2. Refer to the above question, can these types of radiation penetrate Earth atmosphere? Provide an explanation for your answer.

   _____

   _____

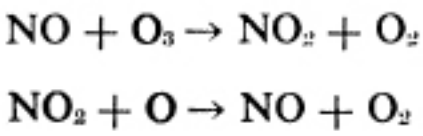
   _____

   _____

3. What is the major source of NO_x in the atmosphere?

   _____

4. Look at the following reactions:



$$NO + O_3 \rightarrow NO_2 + O_2$$

$$NO_2 + O \rightarrow NO + O_2$$

   These two reactions are called a chain reaction. What is a chain reaction?

   _____

   _____

5. How much NO (nitric oxide) is needed to deplete ozone (O_3)? Why?

_____

_____

6. We discussed a specific principle while describing the chain reaction seen in question #4. Name the principle and briefly describe the mechanism of the principle.

_____

_____

_____

_____

7. In the lesson, we discussed some adverse effects of overexposure of harmful radiation. Explain briefly TWO of the adverse effects mentioned in class.

   a. _____

   _____

   _____

   b. _____

   _____

   _____

8. **(Extra Credit)** In the space below, draw the chemical structure of ozone. Be sure to include the correct charge at the corresponding atoms.