**Investigating Ozone Lab Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**INTRODUCTION:**

Chlorofluorocarbons (CFCs) are compounds used mainly as coolants in refrigerators and air conditioners. When CFCs escape, they are mixed by air motions in the atmosphere and transported into the stratosphere. There, they absorb ultraviolet radiation. This extra energy breaks the bonds holding these compounds together, releasing an atom of chlorine. The chlorine atom then pulls away the third oxygen atom in an ozone molecule, breaking the weak bond that joins it to the rest of the molecule. The chlorine and oxygen form a molecule that also has weak bonds, making it unstable. Because the chlorine-oxygen atom is unstable, it is easy for free atoms of oxygen (O) to pull away the oxygen atom, forming O2 and releasing the chlorine to destroy more ozone. This process and slightly more complicated ones are depleting the protective “ozone umbrella” in the stratosphere. The chlorine is not used up, and it can continue to destroy ozone.

**PROCEDURE:**

1. **Making CFCl3**—One of the simplest CFC molecules is CFCl3. It is one atom of carbon, one atom of fluorine, and three atoms of chlorine. To make a model of CFCl3, use three pieces of green candy to represent chlorine, a big marshmallow to represent carbon, and one pink piece of candy to represent fluorine. Toothpicks will represent the bonds between the atoms.
	1. Stick (3) toothpicks into the big white marshmallow, forming a three-legged stool with the legs evenly spread apart.
	2. Attach a green marshmallow to the free end of each toothpick.
	3. Stand the “stool” on the table and gently push down on the big marshmallow until the green pieces have slid apart enough that the big marshmallow candy is suspended about two inches above the table.

 **CFC**

* 1. With your “stool” sitting on the table, insert a toothpick vertically into the top of the marshmallow and attach a pink marshmallow to the free end of the toothpick.

This is a rough model of a CFCl3 molecule. **Sketch and Label**.

1. **Making Ozone**—In the stratosphere, O2 molecules can combine with third oxygen to create ozone. This happens when energy from UV radiation breaks the bond between the two oxygen atoms in an O2 molecule. This free oxygen (O) then bond with the other O2 molecules and forms O3 or ozone. O3 is able to absorb high levels of UV radiation.

 **Ozone**

* 1. Use three orange marshmallows (oxygen) to form the ozone molecule. Connect them with two toothpicks (bonds) to form a triangle. Set aside the “free oxygen” atom for later use.

This is a rough model of an ozone molecule. **Sketch and Label.**

1. **Modeling Ozone Destruction**—Place your CFCl3 and your model of ozone on your “atmosphere” paper. Your CFCl3 atom will originate in the troposphere and will float up into the stratosphere. Be sure your ozone is placed in the correct layer of the atmosphere.

 **BOX 1**

When UV radiation hits a CFC molecule, the molecule releases chlorine. Pull off one green “chlorine atom” from your CFCl3 model to show this process (remove the bond from the chlorine and the CFC).

**Sketch what you see in Box 1.**

 **BOX 2**

The free chlorine atom destroys an ozone molecule by attracting one of the oxygen atoms away from the ozone molecule. Remove one of the oxygen atoms and its toothpick “bond” from the

ozone molecule and attach it to the free chlorine.

**Sketch what you see in Box 2.**

 **BOX 3**

The chlorine-oxygen molecule just formed has a very weak bond (it is an unstable molecule). Use the extra orange marshmallow to represent a free atom of oxygen. This can attract the other oxygen atom away from the chlorine. Remove the oxygen and its toothpick “bond” from the chlorine-oxygen molecule and connect it to the “free” oxygen atom.

**Sketch what you see in Box 3.**

**QUESTIONS:**

1. How is the chlorine atom freed from the CFCl3 molecule? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. At the end of this process, is the chlorine atom attached to anything? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. Explain how the chlorine from one CFC atom can destroy millions of ozone molecules. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
4. At the end of the process, what molecule is formed when the “free” oxygen bonds with the oxygen from the chlorine-oxygen atom? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
5. How do O2 and O3 compare in their ability to absorb ultraviolet radiation? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_