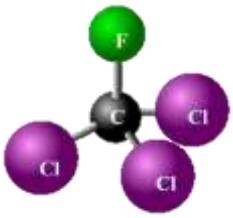
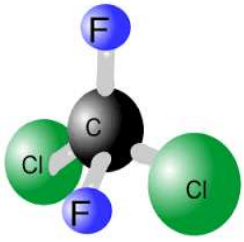
Student Sheet 1

MATH APPLICATION ACTIVITY: THE NUMBERS GAME

INTRODUCTION: *Chlorofluorocarbons (CFCs)* described as "miracle chemicals" have no natural sources. They were first manufactured in the 1930s, and industries soon found a wide variety of applications for them due to their chemical non-reactivity and heat-absorbing properties. CFCs have been used as refrigerants in air conditioners and refrigerators, in aerosol spray cans, in manufacturing foams and as cleaning agents in the manufacture of electronics. One U.S. chemical industry gave them the trade name of ***freon*** and the term has since become a household word.



A numbering system was created by the Du Pont Chemical Company in the early 1930s, and is still the standard method for naming chlorofluorocarbons (CFCs). The system is known as the ***Rule of 90***. Chlorofluorocarbons, such as dichlorodifluoromethane (CCl_2F_2), and trichlorofluorocarbon (CCl_3F), were given the nicknames CFC-12 and CFC-11, respectively, so that they could be remembered more easily. Chemically, CFCs are a part of a group of compounds called ***halocarbons*** (carbon- and halogen-containing compounds). CFCs are halocarbons that contain only the elements ***carbon, chlorine,*** and ***fluorine.*** The most common CFCs are small molecules containing only one or two carbon atoms. For example, a common refrigerant has the chemical formula of CCl_2F_2, which in industry-invented shorthand is known as ***CFC-12.***



In order to get the ***chemical structure*** of a chlorofluorocarbon from its common name, the Rule of 90 states that you would add 90 to the number at the end of the name. In the case of CFC-12, add 90+12 to get 102. The hundreds place, the one in this example, represents the number of carbon atoms in the molecule. The tens place, the 0, represents the number of hydrogen atoms in the molecule, and the ones place represents the number of fluorine atoms in the molecule. According to the rule of 90, CFC-12 has 1 carbon atom, 0 hydrogen atoms, and 2 fluorine atoms.

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The final part of the rule of 90 has to do with to the need of carbon to form four bonds. If, after assigning hydrogen and fluorine atoms to it, the carbon atom still requires more bonds to reach the required four, those bonds will be to chlorine atoms. So far, the one carbon atom of CFC-12 has only formed two bonds, both with fluorine atoms. Thus the remaining two bonds must be chlorine atoms. Therefore, CFC-11's chemical formula is CCl_3F.

Student Sheet 3

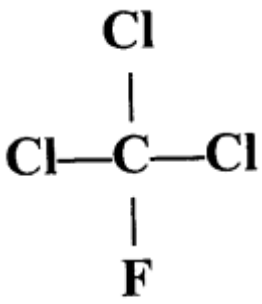
PART 1: DATA TABLE: GENERIC CFC AND HCFC FORMULAS

NAME	CODE #	CODE # +90	# C/H/F	2(N) +2-H+F	#Cl	FORMULA
CFC-10						
CFC-11						
CFC-12						
CFC-13						
CFC-14						
HCFC-21						
HCFC-22						
HCFC-23						
HCFC-30						
HCFC-32						
HCFC-40						
CFC-112						
CFC-113						
CFC-114						
CFC-115						
CFC-116						
HCFC-123						
HCFC-140						
HCFC-143						
HCFC-160						
HCFC-161						

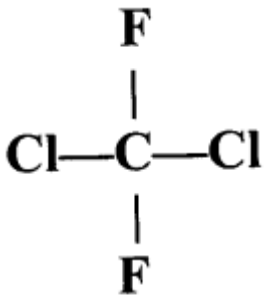
Student Sheet 4

PART II: ANALYSIS

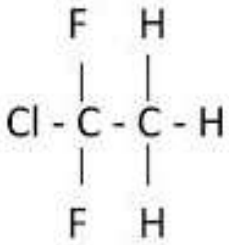
1. What are the natural sources of CFCs?
2. Why were they considered "miracle chemicals"?
3. When were CFCs developed? Why?
4. What chemical properties of CFCs made them so useful?
5. Name the most common uses for CFCs.
6. What industry name for CFC is still popular?
7. What influenced the development of the numbering system for CFCs? Who developed them? When? How did this system prove useful?
8. What larger group of chemicals do CFCs belong to?
9. What are the elements found in CFC compounds?
10. Describe a common CFC molecule.
11. What is the shorthand for CCl_2F_2?
12. Briefly explain how to find the chemical formula of a CFC.
13. What number of carbon bonds do carbon atoms require?
14. Find the chemical formula for the CFC molecules shown below. Show your work for each solution.



Freon-11



Freon-12



HCFC – 142b

MATH APPLICATION: THE RULE OF 90

Part I: The chemical formulas for individual chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs), such as CFC- 11 , can be arrived at by using a simple mathematical process. Use the steps below to complete DATA TABLE #1.

Step 1: Add 90 to the code number (the 11 in CFC-11 is the code number).

$$90 + 11 = 101$$

Step 2: The 3 resulting digits-101- correspond, respectively to the number of carbon, hydrogen and fluorine atoms present in one molecule. In this case there would be:

1- carbon 0-hydogen 1-fluorine

Step 3: The number of chlorine atoms in the compound can be found by subtracting the number of non-carbon atoms (hydrogen and fluorine) from 2n + 2, where n= the number of carbon atoms.

#Cl = [2 (n) + 2] - # of non-carbon atoms (H + F)
#Cl = [2 (1) + 2] – 0 + 1
Cl= [2 + 2] - 1
Cl = 4 - 1
Cl = 3

Step 4: The formula for CFC -11 calls for: 1 carbon (C), 1 Fluorine (F) and 3 chlorine (Cl) forming $CFCl_3$.