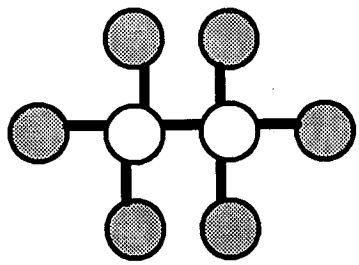
Teaching Activity: Formulas and Codes for Carbon Compounds

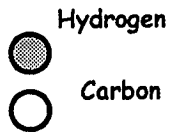
Introduction: In the *Periodic Table of the Elements* carbon (C) can be found in Group 4A with the other nonmetals. Its atoms form 4 *covalent bonds* in most stable molecules. A covalent bond is formed when two atoms share a pair of electrons. Sometimes a covalent bond is indicated by a dash between the atom: H - H or Cl - Cl. A compound composed of hydrogen and carbon atoms is called a *hydrocarbon.* The simplest hydrocarbon molecule of is methane, CH_4, which is a gas emitted into the air as a result of biological decay processes. Hydrocarbons in which the linkages are single bonds, are called *alkanes* (methane, ethane, pentane, etc.)

All alkanes with one or more of the hydrogen atoms substituted by halogens are stable. Other stable compounds of carbon can also be formed when any or all of the 4 hydrogen (H) atoms are replaced by halogen atoms. A *halogen* is a Group VIIA element and is very reactive. Fluorine is the most reactive, chlorine next and so on. Fluorine (F) and chlorine (Cl) are gases at room temperature, bromine (Br) is a liquid and iodine (I) is a solid. These carbon compounds are known as *chlorfluorocarbons (CFCs)* and examples are CH_2Cl_2, CF_2Cl_2 , CHF_2Cl. CH_3CFCl_2 and CH_2F - CF_3. If hydrogen is added to the compound in addition to the halogens, as in CFC replacement compounds, the compound is known as a *hydrochlorofluorocarbon* (HCFC). Examples are CH_3CL, and $C_2HCl_2F_3$.

Carbon atoms can combine with each other to form complex chains. The simplest chain has two carbon atoms held together by a single bond. Each C atom in this unit forms 3 other bonds, bringing the total number of bonds for each carbon to 4. If all of the 6 atoms joined to the carbon atoms are hydrogen (H), the gaseous compound C_2H_6, ethane, is formed. The formula for such compounds can be shown one carbon atom at a time so that the types of atoms bonded to the carbon can be displayed. Ethane can be written as CH_3CH_3, as CH_3 - CH_3, or as H_3C-CH_3 to show the carbon to carbon bond.

A molecule of ethane
C_2H_6





Objective:

- To understand the relationships between atoms in simple carbon compounds;
- To compute the number and types of atoms in CFC and HCFC compounds using their code numbers;]
- To arrive at the chemical formulas for CFC and HCFC compounds using the Rule of 90;

Important Terms: Chemical compound, atom, molecule, covalent bond, code number, alkane, CFC, HCFC, hydrocarbon, nonmetal, Periodic Table of the Elements, halogen;

Procedure:

1. Read over the **Introduction** with the class.
   - Be sure to check on vocabulary comprehension.
   - Draw some chemical structures on the board of other simple carbon compounds to reinforce the ideas in the **Introduction**.

2. Introduce the "Rule of 90".
   - Be sure that students understand that it can be applied to all CFC and HCFC compounds.
   - Go over each step carefully and give several examples of how the process works.

3. Instruct students to complete the Data Table using the information from the **Introduction** and the steps in the "Rule of 90".

4. Instruct students that when they have completed the **Data Table** they should complete the questions in the ***Analysis*** section.

Data Table: Generic CFC and HCFC Formulas

Part I: Data Table: Generic CFC and HCFC Formulas

Example	Code #	Code # - 90	# C/H/F	2(n) +2-H +F	#Cl	FORMULA
CFC-10	10	100	1 0 0	2 (1) + 2 - 0 + 0	4	CCl_4
CFC-11	11	101	1 0 1	2 (1) + 2 - 0 + 1	3	CCl_3F
CFC-12	12	102	1 0 2	2 (1) +2 - 0 + 2	2	CCl_2F_2
CFC-13	13	103	1 0 3	2 (1) +2 - 0 + 3	1	$CClF_3$
CFC-14	14	104	1 0 4	2 (1) +2 - 0 + 4	0	CF_4
HCFC-21	21	111	1 1 1	2 (1) +2 - 1 + 1	2	$CHCl_2F$
HCFC-22	22	112	1 1 2	2 (1) +2 - 1 + 2	1	$CHClF_2$
HCFC-23	23	113	1 1 3	2 (1) + 2 - 1 + 3	0	CHF_3
HCFC-30	30	120	1 2 0	2 (1) +2 - 2 + 0	2	CH_2Cl_2
HCFC-32	32	122	1 2 2	2 (1) + 2 - 2 + 2	0	CH_2F_2
HCFC-40	40	130	1 3 0	2 (1) + 2 - 3 + 0	1	CH_3Cl
CFC-112	112	202	2 0 2	2 (2) +2 - 0 + 2	4	$C_2Cl_4F_2$
CFC-113	113	203	2 0 3	2 (2) + 2 - 0 + 3	3	$C_2Cl_3F_3$
CFC-114	114	204	2 0 4	2 (2) + 2 - 0 + 4	2	$C_2Cl_2F_4$
CFC-115	115	205	2 0 5	2 (2) +2 - 0 + 5	1	C_2ClF_5
CFC-116	116	206	2 0 6	2 (2) +2 - 0 + 6	0	C_2F_6
HCFC-123	123	213	2 1 3	2 (2) + 2 - 1 + 3	2	$C_2HCl_2F_3$
HCFC-140	140	230	2 3 0	2 (2) + 2 - 3 + 0	3	$C_2H_3Cl_3$
HCFC-143	143	233	2 3 3	2 (2) +2 - 3 -3	0	$C_2H_3F_3$
HCFC-160	160	250	2 5 0	2 (2) + 2 - 5 + 0	1	C_2H_5Cl
HCFC-161	161	251	2 5 1	2 (2) + 2 -5 + 1	0	C_2H_5F

NOTE: When creating the chemical formula use the following sequence of elements: C - H- Cl - F

Student Activity Sheet: Formulas and Codes for Carbon Compounds

Introduction: In the *Periodic Table of the Elements* carbon (C) can be found in Group 4A with the other nonmetals. Its atoms form 4 *covalent bonds* in most stable molecules. A covalent bond is formed when two atoms share a pair of electrons. Sometimes a covalent bond is indicated by a dash between the atom: H - H or Cl - Cl. A compound composed of hydrogen and carbon atoms is called a *hydrocarbon.* The simplest hydrocarbon molecule of is methane, CH_4, which is a gas emitted into the air as a result of biological decay processes. Hydrocarbons in which the linkages are single bonds, are called *alkanes* (methane, ethane, pentane, etc.)

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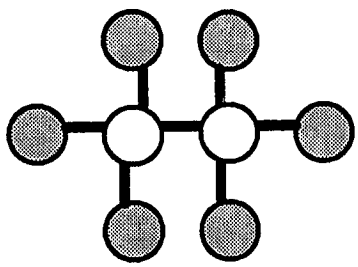

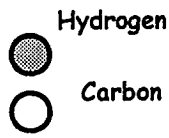

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Student Activity Sheet # 1

Math Application:
The "Rule of 90"

Part I: The chemical formulas for individual chlorofluorocarbons (CFCs) and (HCFCs) hydrochlorofluorocarbons, such as CFC-11, can be arrived at by using a simple mathematical process. Complete the spread sheet using the formula below and filling in the correct data.

Step 1. Adding 90 to their *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 - hydrogen 1 - fluorine.

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

$$\#Cl = [\ 2\ (n) + 2\ ] - \#\ \text{non-carbon atoms}\ (\ H + F\ )$$
$$\#\ Cl = [2\ (1) + 2] - 0 + 1$$
$$\#\ Cl = [\ 2 + 2] - 1$$
$$\#\ Cl = \ 4 - 1$$
$$\#\ Cl = 3$$

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

Part II: Complete the questions in the Analysis section.

Student Activity Sheet #2

Part I: Data Table: Generic CFC and HCFC Formulas

Example	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						

Part II: Analysis

1. What is the Periodic Table of the Elements? _____

_____

_____

2. How does carbon bond in most stable molecules? _____

_____

3. What is a covalent bond? _____

_____

Student Activity Sheet # 3

4. What is the name and chemical formula for the simplest hydrocarbon compound? _____

_____

5.What is an *alkane*? Give two examples. _____

_____

_____

6.What type of elements are generally substituted for hydrogen in alkanes? _____

7. Name three halogens. _____

8. Which are the 2 most reactive halogens? _____

9. What are type of carbon compounds have no hydrogen atoms? _____

10. What takes the place of the hydrogen? _____

11. What is the importance of hydrochlorofluorocarbons? _____

_____

12. What configuration do carbon atoms form when they combine? _____

13. How many bonds can each C atom form? _____

14. The prefix eth- means "two". How do you think ethane got its name? _____

_____

15. The prefix *penta-* means five (5). How do you think that *chloro-penta-fluoroethane* got its name? _____

16. What is the process called that allows you to compute the number of atoms in CFC and HCFC compounds? _____

17 What does the -n- represent in the formula? _____

18 What is the result of [2n + 2] - H + F? _____

19. What information does a chemical formula give you? _____

_____

20. Why are CFCs and HCFCs so important in atmospheric chemistry?_____

_____