Ocean in Motion 5: CFCs in the Ocean - A Cool Tool.

A. Overview

1. Ocean in Motion - Chemicals as Tracers

We will look at the CFCs as an example of tracers that chemical oceanographers use to track ocean waters and calculate their age. We will briefly describe their chemistry, sources, and sinks. We will go through an exercise that is also available on the World Wide Web called "CFCs: A Cool Tool for Oceanographers", to calculate the age of a water sample. Simple mathematics and linear graphical solutions will be used. Values will be read from line graphs and used in simple calculations. Simple chemical structures and an investigation of the ozone layer are the subjects of related exercises. *(Web page will be a link from the Project Oceanography homepage; http://www.marine.usf.edu/pjocean/).*

2. Contents of packet

Your packet contains copies of the following activities:

I. CFC Worksheet
II. CFC-12 Graph
III. CFC-12 History Lesson
IV. Ozone Exercise
V. "Rule of 90"

B. Program Preparation

1. Focus Points

- Gases in the atmosphere and the ocean
  - a. relationship of concentrations in both
  - b. quantity parts per trillion (ppt)
- CFCs
  - a. reactivity with ozone in upper atmosphere
  - b. non-reactive characteristic in ocean
- CFCs as ocean tracers
  - a. what chemical properties make it useful
  - b. used to date the age of water
- Sources and sinks of dissolved matter in the ocean
- Understanding simple line graphs

2. Program Preparation

A. What are the sources and sinks for the following things found in the ocean? (There may be more than one of each.) Are they found naturally, or because of human activities?

a. oxygen

b. freshwater

c. radioactive chemicals

B. Words to know:

tracer- an identifiable substance as a dye or radioactive isotope, that can be followed through the course of a mechanical
or biological process , providing information on the pattern of events in the process.

source- point of origin; a thing or place something comes from.

sink- point of final destination; the place that something concentrates for final destination

stable- maintaining equilibrium; resistant to change

solubility- the quality or condition of being able to dissolve in a given solvent

inert- totally unreactive, chemically inactive

molecule- a small particle with a nucleus and electrons bound together by electrostatic and electromagnetic forces

internet-an electronic communication network linking computers all over the world for transfer of mail, data and other information

atom- smallest unit of material consisting of dense, central, positively charged nucleus surrounded by a system of electrons equaling the number of protons

World Wide Web- an electronic communication network linking computers all over the world with a device used to easily navigate through databases for information. Used for private, government, academic, and commercial purposes with a software called a web browser to compile information, movies, and sound.

Web Browser- software used to navigate the World Wide Web

C. Showtime

1. Broadcast Topics

This broadcast will link into discussions on chemical tracers, age of water, CFCs, where CFCs come from, and simple understanding of line graphs.

a. Overview from Earlier Broadcasts

Chemical Tracers are like 'dyes' that help us 'see' ocean circulation. They are chemical species that are dissolved in the ocean water that tell us something about the origin or history of the water that we find them in. They may have been added on purpose ('deliberate' tracers, as in dye experiments), but some of the most useful have simply been accumulating in the ocean naturally.

b. Sources and Sinks

We have to understand the 'sources' and 'sinks' of the chemical tracers before they become useful tools.

Sources = where the chemical comes from

Sinks = how they are ultimately removed from the ocean

D. Activities

1. Moving on

Associated Exercises:

I. CFC Worksheet

II. CFC-12 Graph

III. CFC-12 History Lesson

Train Your Brain

IV. Ozone Exercise

V. CFCs and 'The Rule of 90'

Key concepts for activities I - III:

1. solubility of chemicals at different temperatures
2. proper interpretation of linear graphs
3. changes in CFC concentrations through the century

Classroom Discussion Questions:

1. What is the age of the water?

2. How does CFC solubility react in water when the temperature decreases?

3. How much CFC-12 was in the atmosphere when you were born?

Teacher's Guide for Discussion Questions:

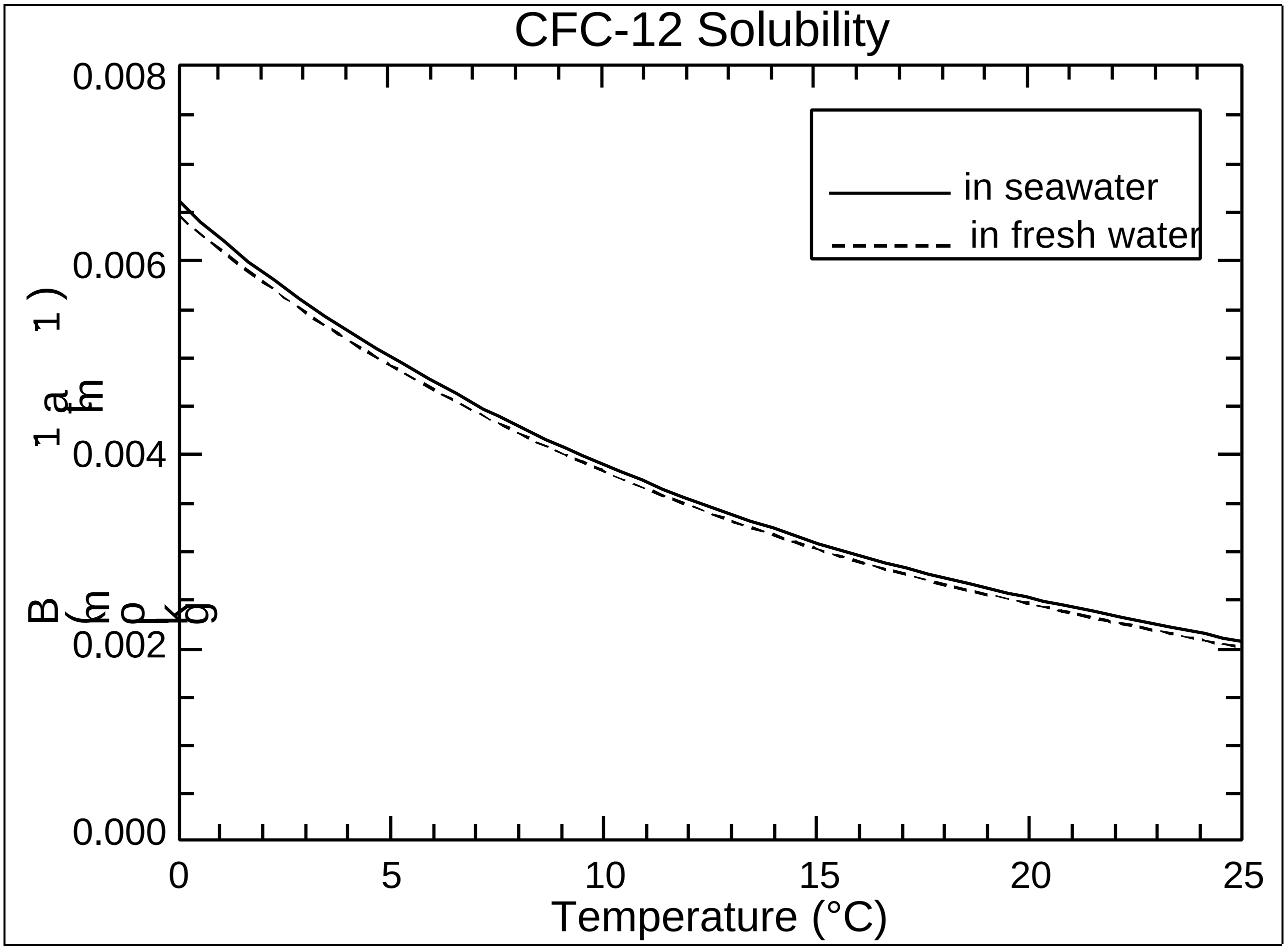
1. The age of the water is 31 years. Follow the teachers copy in the packet to calculate the age of the water because the symbolism is confusing.

2. The solubility of CFC in the water increases with decreasing temperature. If you are daring, you might demonstrate this with a bottle of carbonated beverage. The solubility of gases increase with decreasing temperature, thus more bubbles in a shaken bottle of carbonated drink.

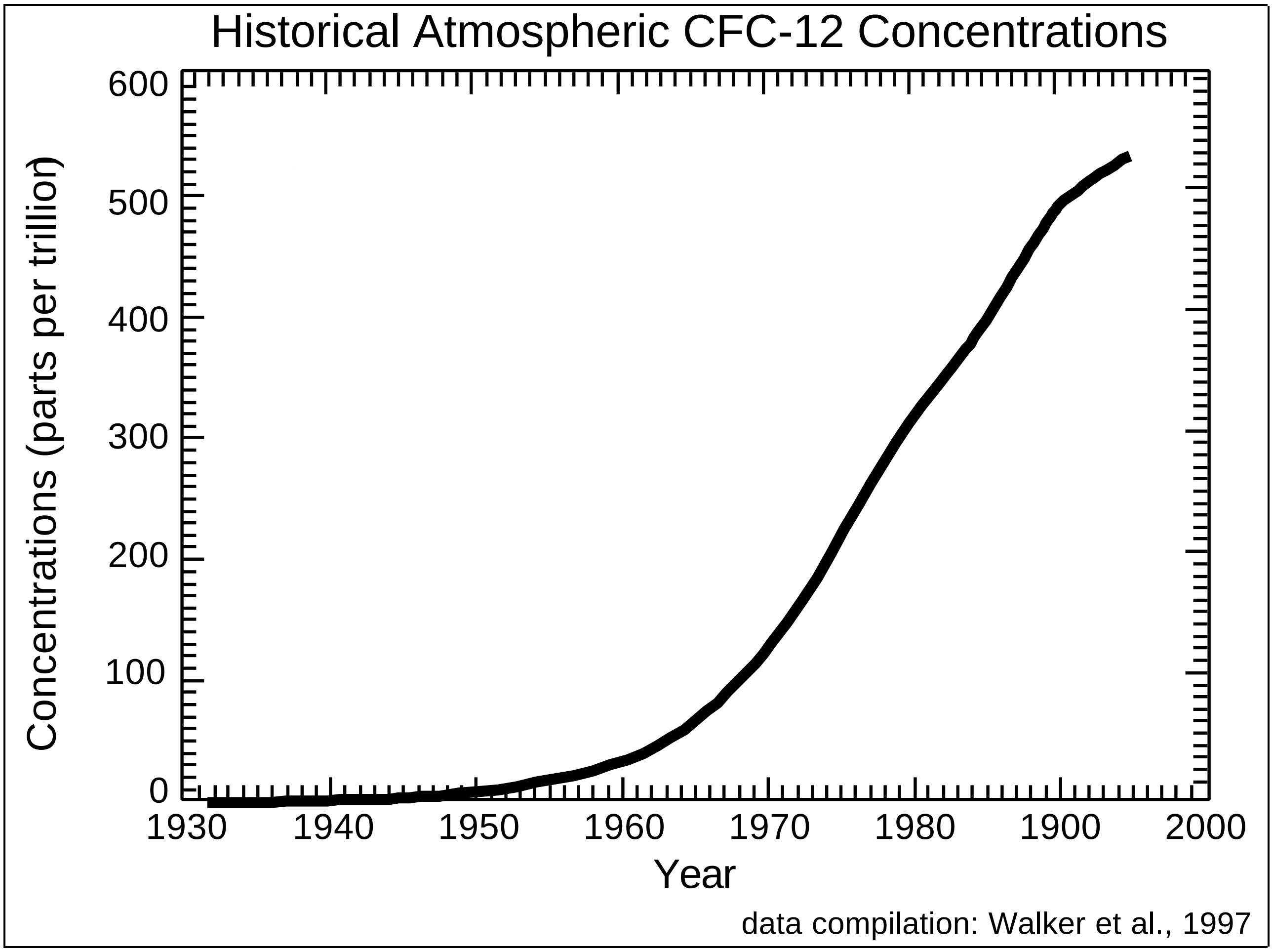
3. This answer depends on the age of your class.

Solution: Current year minus birth year.

Activity I. CFC-12 Solubility graph to use with worksheet



Activity II. CFC-12 Graph



2. Train your brain

Associated Exercises

IV. Ozone Exercise

V. "Rule of 90"

Key Concepts:

1. Ozone Layer acts as a protector to the earth.
2. Destruction of the Ozone Layer and why.
3. Difference between HFCs and CFCs

Classroom Discussion Questions:

1. There are no additional Classroom Discussion Questions to go with this activity, because it is a discussion activity.

2. Why do you think that 'Rule of 90' works? Is it applicable other compounds?

Teacher's Guide for Additional Activities:

1. Have your students utilize the resources that were listed on the Ozone Exercise, and make a list of ways that they might change things around their home to help protect the ozone layer.
2. Have the students follow through the 'Rule of 90'. Utilize this rule for compounds not listed.

Activity IV. Ozone Exercise

What do you know about ozone?

- Where is the ozone layer?
- What does he ozone layer protect the earth (and its inhabitants) from?
- How do we measure the ozone layer?
- What is causing the hole in the ozone layer?
- How big is the ozone hole? Is it changing?
- In many applications we can use HFCs instead of CFCs. What atoms do you think these molecules are made of? Why might they be better for the ozone layer?

To help you answer these questions, you might find the following resources helpful.

⇒United Nations Ozone Secretariat: http://unep.unep.no/unep/secretar/ozone/

⇒Data and images of the ozone hole: Goddard Space Flight Center
http://jwocky.gsfc.nasa.gov/. Click on 'Today's Ozone', or go to the 'Multimedia option' to see animations of the ozone hole observations.

⇒World Meteorological Organization, total ozone maps of the Northern Hemisphere.
http://www.wmo.ch/web/arep/nhoz.html

⇒Cagin, S. and P.Dray, 'Between Earth and Sky: How CFCs changed our world and threatened the ozone layer', 512 pp., Pantheon Press, New York, 1993

⇒United States Environmental Protection Agency Stratospheric Ozone Protection Hotline.
1-800-296-1996 (10am - 4pm EST)

Activity V. CFCs and 'The Rule of 90'

Freon-12 is a trade name (like Pepsi or Reebok) that belongs to the DuPont Chemical Company. It is a lot easier to say and remember then nickname **Freon-12** than it is to use the correct long name, **dichlorodifluorocarbon**. However the full name of the CFC molecule is used by chemists because it describes the composition *(what atoms it is made up of*) and structure (*how they are connected*).

For a long time, the DuPont coding scheme was a trade secret. Now, it is well known and using simple addition and subtraction you can figure out the composition of a CFC molecule from the DuPont code number.

Follow the '*Rule of the 90*". It goes like this:

1. Take the code number, and add 90 to it

$$\begin{array}{r} 12 \\ \underline{+90} \\ 102 \end{array}$$

2. You get a 3 digit number, where

C = 1

H = 0

F = 2

The first digit tells you the number of **carbon** atoms, in this case: 1 **C** atom

The second digit tells you the number of **hydrogen** atoms, in this case:

0 **H** atoms

The third digit tells you the number so **fluorine** atoms, in this case: 2 **F** atoms

You calculate the number of chlorine atoms as follows:

Each **C** atom has to have 4 other atoms connected to it 1x**C**x4 =4

Subtract the atoms of **H** and **F** that we have already counted, in this case

(0x**H**) + (2x**F**) = 2, 4-2=2

So, there are 2 atoms required, i.e. there are 2 **Cl** atoms in Freon-12

Classroom Discussion Questions:

Here are some more for you to figure out:

1. Freon-11
2. Freon-141
3. Freon-113 (a good solvent, used for cleaning computer chips)
4. Freon-22 (a non-ozone replacement for Freon-11)
5. Freon-134 (a replacement for Freon-12)
6. Methane is simply one carbon with four hydrogens attached. Following the 'Rule of 90', what would be the code number for methane?

Teacher's Guide for Classroom Discussion Questions:

1. $CFCl_3$
2. $C_2H_3FCl_3$
3. $C_2F_2Cl_3$
4. $CHClF_2$
5. $C_2H_2 F_4$
6. Freon-50