10. Molarity (M)

Molarity = Moles per Liter (moles/L or mol/L) = moles of solute per liter of solution = molar concentration

n = CV
n = number of moles of solute
C = concentration of solution
V = volume of solution

<u>Example1</u> If 30 grams of NaOH are dissolved and then diluted to 2.0 L with water, what is the molar concentration (molarity) of the solution?

<u>Example2</u> How do you make 300 ml of a 0.10 mole/L solution of KCl?

Starting Material	Preliminary Calculation	Procedure
Solute and water have to be turned into a solution of known concentration.	moles = CV, if C is in moles/L	1. **W**eigh the calculated amount of solid. 2. **D**issolve in beaker containing less than the desired amount of solvent. 3. **T**ransfer to a volumetric flask. 4. **A**dd water to dilute to the mark with solvent and mix. Remember **WDTA**= We don't trust aliens.

Exercises

1. In 100 mL of a solution, there are 3.0 g of NaCl. Find the molarity.
2. In 2.0 L of a solution, there are 3.0 g of KF. Find the molarity.
3. How many grams of KBr are needed to prepare 2.5 L of a 0.25 mole/L solution?
4. How many grams of $Ca(ClO)_2$ are needed to prepare 2.0 L of a 0.45 mole/L solution?
5. What is the volume of a solution containing 3.0 grams of HNO_3 if the concentration is 0.10 mole/L.
6. Explain how you would actually prepare 3.0 L of a 0.2 mole/L Na Br solution in the lab.

$n = CV$ or $C = \frac{n}{V}$

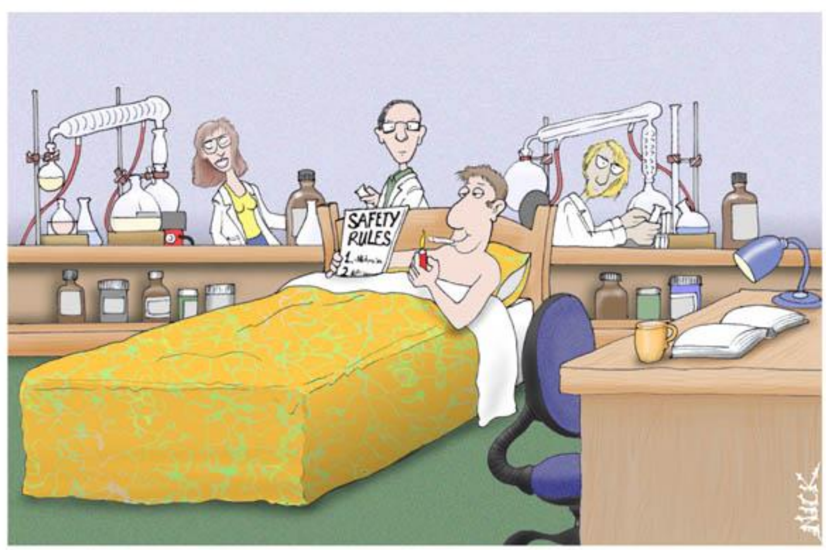
n = moles of solute
C = concentration (moles/L= molarity)

7. In 10.0 mL of a certain solution, there are 0.050 g of KF. Find the molarity of the solution (moles/L)
8. In 2.0 L of a solution, there are 3.0 g of KF. Find the molarity.
9. How many grams of NaCl are needed to prepare 1.5 L of a 0.20 mole/L solution?
10. How many grams of $LiNO_3$ are needed to prepare 500 ml of a 0.10 mole/L solution?
11. What is the volume of a solution containing 3.0 grams of HCl if the concentration is 0.50 mole/L.

12. Explain how you would actually prepare 2.0 L of a 0.2 mole/L $MgCl_2$ solution in the lab.

13. Find the **error** in the student's procedure. Explain why.

    1. The student weighed 0.10 grams of a solid to make 0.10 L of a solution.
    2. He transferred the solid into a beaker.
    3. He added less than 100 ml of water and stirred.
    4. He used more water to make sure that he got all of the solution out of the beaker as he transferred it into a second beaker.
    5. He added water to the 100 ml line and then carefully mixed.



Recent Advances in Science, #32:

Dr Ed Henderson demonstrates that it IS possible for someone to become too familiar with the safety rules.

More Molarity: Preparing a Solution from Another Solution Using Dilution

Starting Material	**Preliminary Calculation**	**Procedure**
An already prepared solution has to be diluted to create a less concentrated solution	$C_1V_1 = C_2V_2$ C_1= concentration of original solution V_1 = volume actually used from original C_2 = final concentration of the newly prepared solution V_2 = volume of the new solution (*it is total of the original volume and the volume of water added*)	1. **P**ipette the calculated amount (V_1)into a volumetric flask of size V_2. 2. **T**ransfer to a volumetric flask of volume V_2. 3. **A**dd water and mix. **Remember:** **PTA= Parents' Teachers Association**

<u>Example 1</u> A student needs to make 300 mL of a 2.0 g/L solution of HCl from a 5.0 g/L solution. How does he go about doing it?

<u>Example 2</u> You want to prepare 500 mL of a 0.60 g/L solution. Only a 10.0 ml pipette is available. To use that volume, how concentrated should your original solution be?

Example 3 — 0.25 L of a 3 g/L solution are on the counter. How much of the solution should he dilute to 0.30 L to make a 2 g/L solution?

Combining Stochiometry With Concentration

Example 4 — How many ml of a 0.10 M NaOH solution are needed to neutralize 200.0 ml of a 0.50 M H_2SO_4 solution?

$$H_2SO_{4(aq)} + 2\ NaOH_{(aq)} \rightarrow Na_2SO_{4(aq)} + 2\ H_2O_{(l)}$$

Example 5 — If it took 35.25 ml of a $Ca(OH)_2$ solution to neutralize 0.98 g of H_3PO_4, what was the molarity of the alkaline solution used?

$$2\ H_3PO_{4(aq)} + 3\ Ca(OH)_{2\ (aq)} \rightarrow Ca_3(PO_4)_{2(s)} + 6\ H_2O_{(l)}$$

Exercises

1. A technician needs 2.0 L of a 1.8 g/L solution of HNO_3. Sitting on the counter is concentrated HNO_3 (10 g/L). How much of the 10 g/L solution should he carefully dilute to 2.0 L ?

2. You want to prepare 250 mL of a 0.50 g/L solution from a 2.0 g/L solution. How many mL should you pipet from the 2.0 g/L solution?

3. a. 0.75 L of a 4 g/L solution are on the counter. How much of the solution should he dilute to 0.10 L to make a 1 g/L solution?

   b. *Outline the lab procedure.*

4. A 25.0 mL pipette is available. You want to end up with 300 mL of a 3.0 g/L solution. How concentrated should your original solution be if 25.0 mL will be used for dilution.

5. To 50 ml of a 3g/L solution, a student added 250 ml of water. What was the final concentration of the solution?

6. How much water should be added to 20 .0 mL of a 6.5 g/L solution in order to create a 2.8 g/L solution?

7. What is the concentration of a solution created by adding 200 mL of water to 1.5 L of a 3.0 mole/L solution?

8. In 100 mL of a solution, there are 3.0 g of NaCl. Find the molarity.

9. How many grams of KBr are needed to prepare 2.5 L of a 0.25 g/L solution?

10. How many grams of $Ca(ClO)_2$ are needed to prepare 2.0 L of a 0.45 g/L solution?

11. Explain how you would actually prepare 3.0 L of a 0.2 g/L Na Br solution in the lab.

$C_1V_1 = C_2V_2$ problems

12. In the laboratory, there are 4 L of HCl with a concentration of 1.0 g/L. Using this concentrated acid, you must prepare a 500 mL solution of HCl with a 0.01g/L.

    Explain how you would prepare this solution.
    SHOW YOUR WORK.

13. Using 300 mL of a 2.0 g/L solution of copper sulfate, $CuSO_4$, a student must prepare a 0.50 g/L solution of copper sulfate.

    What volume of H_2O must be added to prepare the 0.50 g/L solution?

    Show all your work.

14. You are given 60 mL of a 45 g/L aqueous solution and asked to dilute it to obtain a concentration of 30 g/L.

    What is the volume of the resulting solution?

    A) 22.5 mL
    B) 40 mL
    C) 90 mL
    D) 105 mL

15. A beaker contains 200 mL of a 60 g/L solution. A student added 400 mL of water to this solution.

    What is the concentration of the diluted solution?

16. If it took 35.25 ml of a 0.10 M $Ca(OH)_2$ solution to neutralize H_3PO_4, what volume of water was produced by the reaction? Assume a density of 1.00 g/ml for water.

$$2\ H_3PO_{4(aq)} \quad + \quad 3\ Ca(OH)_{2\ (aq)} \rightarrow Ca_3(PO_4)_{2(s)} \quad + \quad 6\ H_2O_{(l)}$$

11. Toxicology and Ecotoxicology

DEFINITIONS

1. Toxic Dose: is the lowest dosage per unit of weight (typically stated in milligrams of poison per kilogram of body weight = mg/kg) of a substance known to have produced signs of toxicity in an animal. **Toxicity** is the degree to which something is able to produce illness or damage to an exposed organism.

Example 1: Experiments have shown that 0.075 g of Tylenol (acetaminophen) has toxic effects on 500 gram rats. What is tylenol's toxic dose in mg/kg, also known as a ppm?

2. Lethal Dose: represents a dose (usually recorded as dose per kilogram of subject body weight) at which a given *percentage* of subjects will die.

   Often used is the $LD_{50:}$= a dose at which 50% of subjects will die.

Example 2: 50% of 250 g rats die after ingesting 0.0845g of Tylenol. Calculate LD_{50} for Tylenol.

Example 3: A 36 kg dog arrives at a vet's clinic. Its owner caught him eating rat poison. You see from the box of rat poison that the owner brings with him that **the poison is cholecalciferol 0.075%**, and that each of the 50 place packs weighs 30 grams. The owner found the other 3 place packs he had put out intact, and 46 packs remain in the box. Half of one packet was ingested.

Will the dog start to experience symptoms soon?[1] Will the dog die?

toxic dosage = **2 mg/kg = 0.002 of poison/kg of body mass**

lethal dosage of cholecalciferol =**13 mg/kg = 0.013 g/kg**

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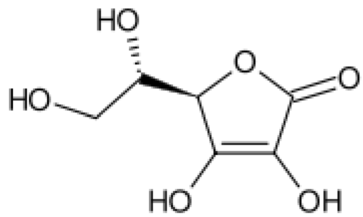
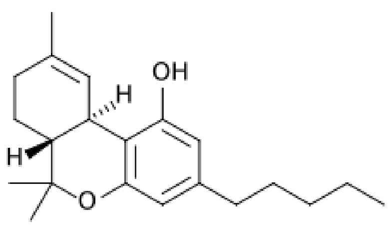
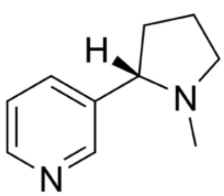
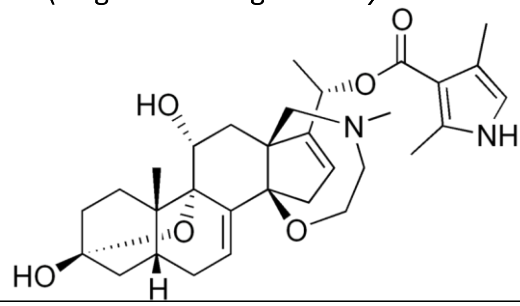
[1] (**It ingested 0.312 mg/kg = 0.000312 g/kg)**

Examples of LD 50

Substance	LD_{50} in rats	
	Grams of substance/kg of body mass	Percent of body mass
Vitamin C (ascorbic acid=C_6H_8O6) 	11.9 g/kg	1.19
Grain alcohol (C_2H_6O)	7.06 g/kg	0.706
Table Salt (NaCl)	3 g/kg	0.3
Tetrahydrocannabinol ($C_{21}H_{30}O_2$) 	1.270 g/kg	0.1270
Nicotine($C_{10}H_{14}N_2$) 	0.050 g/kg	0.005
Batrachotoxin($C_{31}H_{42}N_2O_6$) (frogs from the genus *Phyllobates* 	(2 to 7)X 10^{-6} g/kg	0.0000002
Polonium 210 ^{210}Po	1.0 X 10^{-8} g/kg	1.0 X 10^{-9} %
Botulinum toxin ($C_{6760}H_{10447}N_{1743}O_{2010}S_{32}$)	1.0 X 10^{-9} g/kg	1.0 X 10^{-10} %

<u>Example 4</u>: Through inhaling smoke, the average smoker takes in 1 to 2 mg of nicotine per cigarette.(Let's use an average of 1.5) How many cigarettes would a 50 kg teenager have to smoke in order to experience a lethal dose?[2] Refer to the LD_{50} table on the previous page.

3. **<u>Contaminant</u>:** A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful effects to humans or other organisms. For example if **mercury** is above 0.002 mg/L of drinking water it is considered to be a contaminant. Short-term exposure to levels above this concentration can lead to kidney damage. Long term effects include damage to the brain and chromosomes.

<u>Types of contaminants</u>: Microbes ~ Radionuclides ~ Inorganics ~ Volatile Organics ~ Other Gases

<u>Example 5</u>: Give examples of each type:

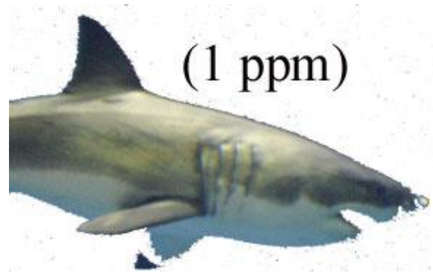
[2] 1666 cigarettes

4. **<u>Bioconcentration</u>** refers to the uptake of a chemical from the environment to the organism's tissues so that the concentration in its body tissues is greater than in surrounding environment. The degree to which a contaminant will concentrate in an organism is expressed as a bioconcentration factor (BCF), which is defined as the concentration of a chemical in an organism's tissues divided by the exposure concentration.

<u>Example 6:</u> What does a BCF factor of 100 mean?

<u>Example 7:</u> If the algae in water average 0.03 ppm of a certain toxin, and if the bioconcentration factor is 25, what is the concentration of that toxin in the water itself?

5. **<u>Bioaccumulation</u>** occurs in the food chain when organisms absorb a toxic substance at a rate greater than that at which the substance is lost. There is subsequently a greater risk of chronic poisoning, even if environmental levels of the toxin are very low. For example, though mercury is only present in small amounts in seawater, it is absorbed by algae (in the form of methyl mercury). It is efficiently absorbed, but only very slowly excreted by organisms. Bioaccumulation results in buildup in the *fatty tissue* of successive trophic levels: zooplankton, small nekton, larger fish etc. Anything which eats these fish also consumes the higher level of mercury the fish have accumulated. This process explains why predatory fish such as swordfish and sharks or birds like osprey and eagles have higher concentrations of mercury in their tissue than could be accounted for by direct exposure alone. For example, herring contains mercury at approximately 0.01 mg/ kg and shark contains mercury at greater than 1 mg/ kg.


(0.01ppm) →


Example 8: a) By what factor did bioaccumulation increase the amount of mercury if we compare herrings to sharks?

b) Why is 1 ppm = 1 mg/kg ?

Example 9: Organize the predators and prey into a pyramid (with the predator that no one eats on top) using the following concentrations of a pesticide that binds to body fat.

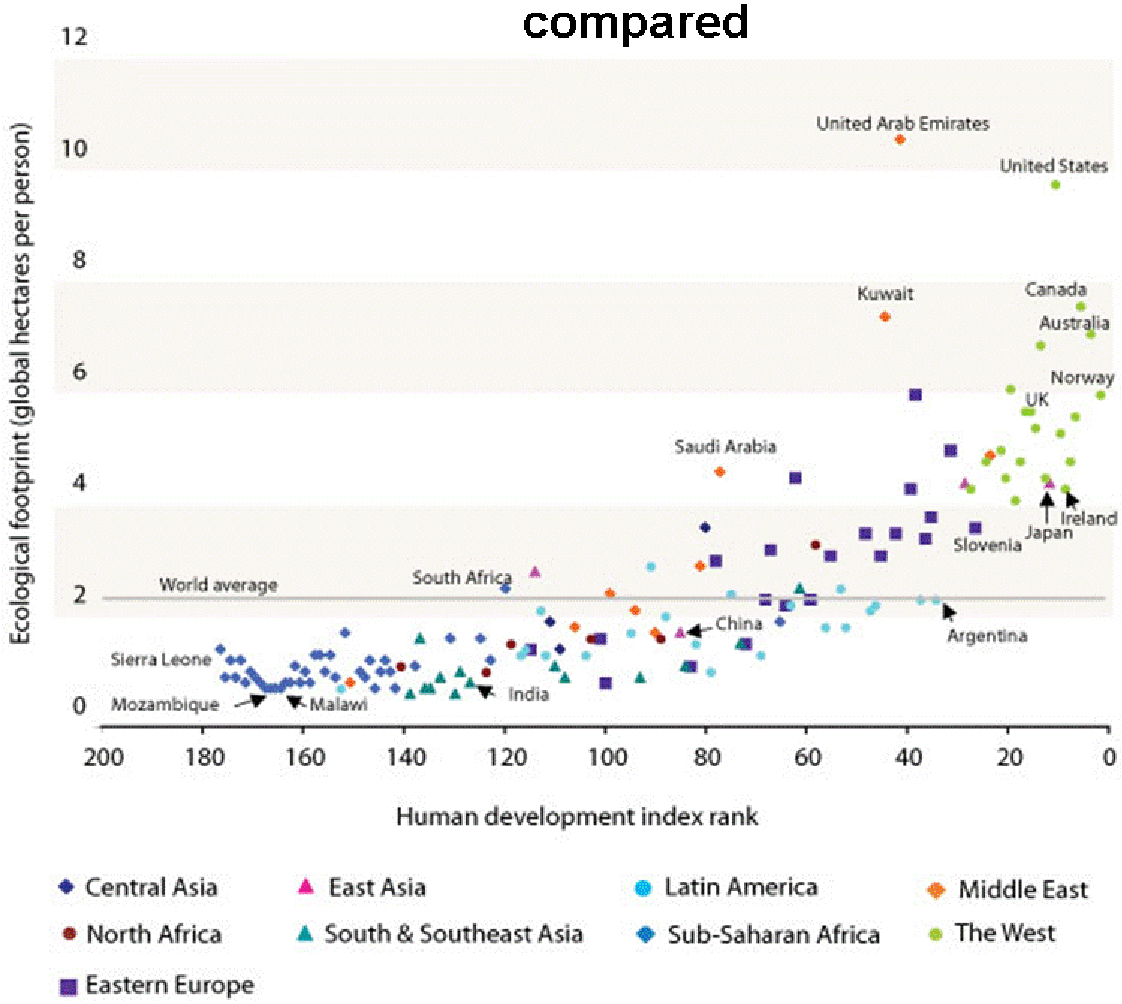
Osprey 3 ppm; copepod 0.50 ppm; volvox 0.20 ppm; fish 1 ppm

12. Ecological Footprint

Ecological footprint (*EF*) analysis tries to measure human demand on the Earth's ecosystems and natural resources.(includes water, energy and raw materials like copper, zinc, iron) Using this assessment, it is possible to estimate how many planet Earths it would take to support humanity if everybody lived a given lifestyle.

In most high-income nations, fossil fuel makes up more than 50 percent of the ecological footprint. This carbon footprint is based on estimating the land area and plants, such as new forests, needed to sequester (recapture) the CO_2 released from burning fossil fuels.

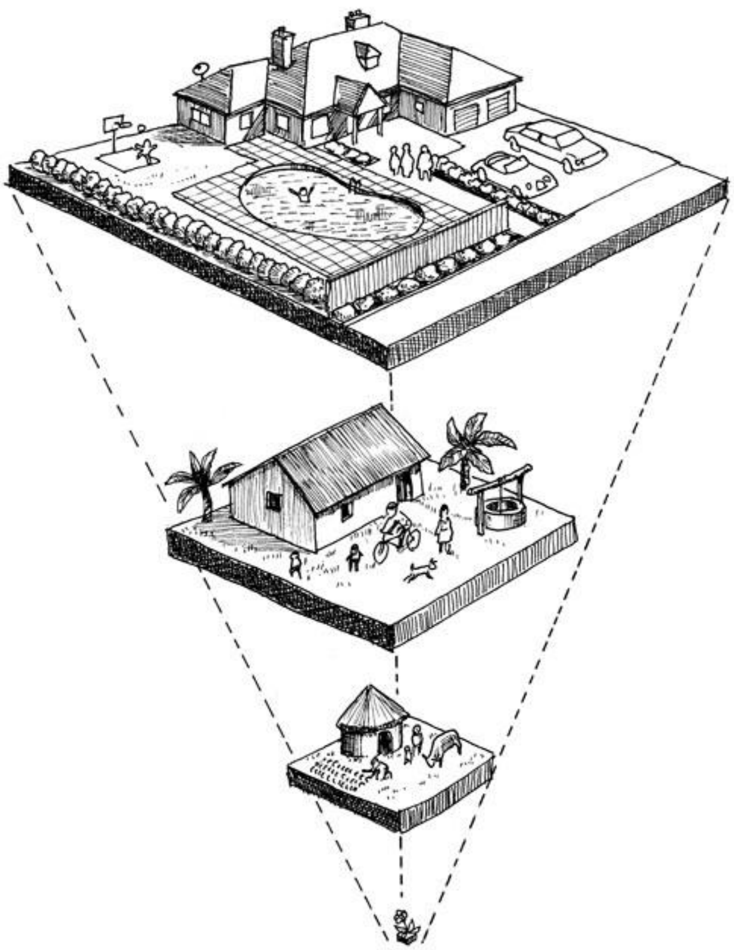
Human Welfare and Ecological Footprints compared



Source: Global Footprint Network (2006); United Nations Development Programme (2006).]

Example 10: a) Which 5 countries create the largest ecological footprint?

b) Which two countries are technologically advanced but yet manage to create a lower footprint. How do they manage?



Example 11: What lifestyles reduce the ecological footprint?

Exercises

1. Calculate the toxic dose in mg/kg.

a. 0.15 g of acetaminophen has toxic effects on a 1 kg rat.
b. A minimum of 1 gram of lincomycin (antibacterial drug) has toxic effects a 400 gram mouse.

2. What is the difference between a lethal dose and a toxic dose?

3. What is an LD_{50}?

4. Calculate the LD_{50} in mg/kg for THC, marijuana's active ingredient, if 127 g of THC will kill 50% of men weighing 100 kg

5. Rabbits feeding on lettuce growing above a cadmium dump have become ill. The LD_{50} for cadmium is 75 mg/kg. On average, the rabbits weigh 2 kg. If the lettuce contains 0.01 % cadmium, and each rabbit ate about 125 g of the contaminated lettuce, how close did they come to LD_{50}?

6. Secured bottle caps and locked medicine cabinets in the home can prevent tragic accidents. How many 500mg Advil tablets can become toxic for a 12 kg toddler? Ibuprofen(Advil) toxic dose = 400mg/kg

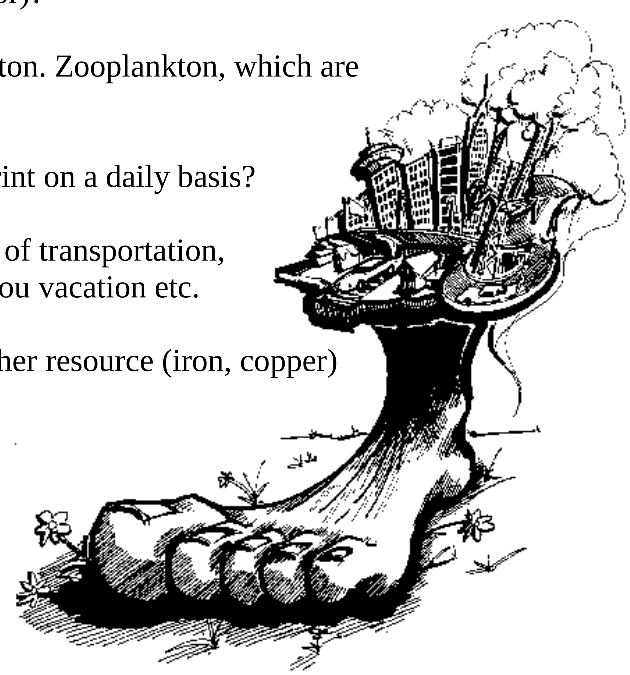
7. Do some research and find three water contaminants <u>not</u> mentioned in class.

8. A herring has a concentration of 0.01 mg of mercury per kg of body mass. The water it swims in has a concentration of only 0.0002 mg/kg.
a) Compared to sea water, how much more concentrated is the mercury in the herring? (In other words, what is the BCF factor)?
b) How did it bioaccumulate in the food chain? (Herrings eat small fish and zooplankton. Zooplankton, which are eaten by small fish, eat algae.)

9. How can you create a smaller ecological footprint on a daily basis?

Hint: think of the food you eat, your means of transportation, how you consume energy in your home, how you vacation etc.

Be specific with regard to energy, water and other resource (iron, copper) demands.



Extra Toxicology Problems

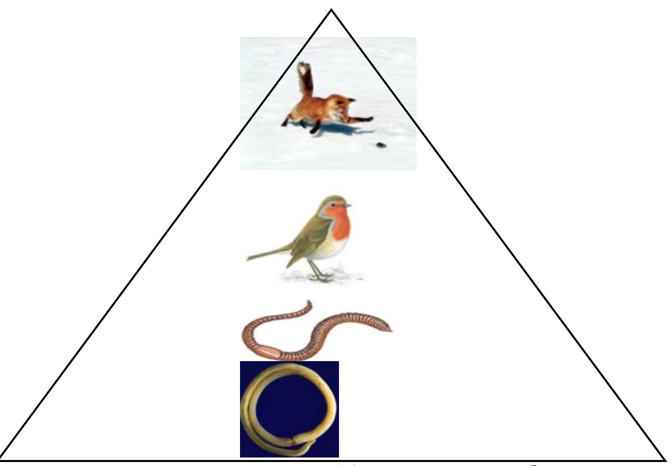
1. What is the toxic dose of a pill in mg/kg if a 100 kg patient begins to get sick after ingesting only 2 pills each 0.010 g in mass?

2. The LD_{50} for grain alcohol is 7060 mg/kg. An 85 kg man was found dead with an empty jug of vodka next to him. If the density of grain alcohol is 0.80g/ml, and the vodka is 40% alcohol, what is the least amount of vodka* that was in the jug?

3. If the bioconcentration factor is 120, and if we find 120 ppm of methyl mercury in a fish, what is the concentration of the toxin in the water?

4. a) Place the following organisms in a food pyramid. The ppm are the parts per million of cadmium ion found in various organisms.

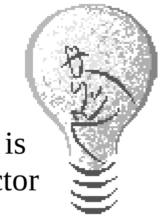
earthworm	0.30 ppm	fox	2.5 ppm	robin	1.0 ppm
roundworms	0.01 ppm				



b) How is bioaccumulation related to how you obtained your answer in a) ?

5. Briefly explain what each of the following are, and then explain why they would reduce our ecological footprint.

a) using NaOH to remove carbon dioxide from the air.
b) solar shingles
c) wind turbines
d) hybrid cars
e) hydroelectricity



13. Strength of Electrolytes

This depends on what percent of the original molecule splits into ions. If the percent is high, the molecule will be a **strong electrolyte**. Otherwise it will be a poorer conductor of electricity and is considered to be a **weak electrolyte**.

<u>Example 1</u>: Give examples of each type of electrolyte.

<u>Example 2</u>: What accounts for why an electrolyte is either weak or strong? Draw a diagram at the level of molecules to reveal what's going on in each case.

Exercises

1. Only 5% of acetic acid molecules become H^+ ions.
   a) Is acetic acid a weak electrolyte?
   b) Give an expected physical property of acetic acid.

2. Write ionic equations for each of the following:

a) $Na_2SO_{4(s)} \rightarrow$

b) $K_2S_{(s)} \rightarrow$

c) $MgCO_{3(s)} \rightarrow$

d) $Ba(NO_3)_{2(s)} \rightarrow$

3. Use the following solubility rules to identify the precipitate and also complete and balance the precipitation equations)

a) $Na_2SO_{4(aq)} + AgNO_{3(aq)} \rightarrow$

b) $Li_3PO_{4(aq)} + CuCl_{2(aq)} \rightarrow$

c) $MgCl_{2(aq)} + (NH_4)_2CO_{3(aq)} \rightarrow$

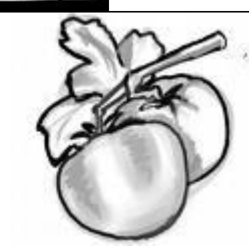
Solubility Rules for Ionic Compounds in Water

Anion	+	Cation	=	Solubility
Any negative ion	+	Li^+, Na^+, K^+, Rb^+, or Cs^+	=	Soluble
Any negative ion	+	Ammonium (NH_4^+)	=	Soluble
Nitrate (NO_3^-)	+	Any positive ion	=	Soluble
Acetate (CH_3COO^-)	+	Ag^+ or Hg_2^{+2}	=	Insoluble
	+	Any other positive ion	=	Soluble
Cl^-, Br^-, or I^-	+	Ag^+, Pb^{+2}, Hg_2^{+2}, or Cu^+	=	Insoluble
	+	Any other positive ion	=	Soluble
Sulfate (SO_4^{-2})	+	Ag^+, Pb^{+2}, Ca^{+2}, Sr^{+2}, Ba^{+2}, or Ra^{+2}	=	Insoluble
	+	Any other positive ion	=	Soluble
Sulfide (S^{-2})	+	Li^+, Na^+, K^+, Rb^+, Cs^+, or NH_4^+	=	Soluble
	+	Be^{+2}, Mg^{+2}, Ca^{+2}, Sr^{+2}, Ba^{+2}, or Ra^{+2}	=	Soluble
	+	Any other positive ion	=	Insoluble
Hydroxide (OH^-)	+	Li^+, Na^+, K^+, Rb^+, Cs^+, NH_4^+ or Ba^{+2}	=	Soluble
	+	Any other positive ion	=	Insoluble
PO_4^{-3}, CO_3^{-2} or SO_3^{-2}	+	Li^+, Na^+, K^+, Rb^+, Cs^+, or NH_4^+	=	Soluble
	+	Any other positive ion	=	Insoluble

14. pH : A Closer Look

$[H^+] = 10^{-pH}$, where $[H^+]$= concentration of H^+ in moles of H^+ per litre of solution

Based on this formula, fill out the amount of H^+ for pH= 0 to 14.

pH	$[H^+]$	**Examples**
0		
1		 Stomach acid comes in at pH = 1.4
2		
3		
4		
5		 Rain from unpolluted skies is at pH = 5.6
6		 Tomatoes love a pH range of 6.2 to 6.8
7		
8		 8.2= good for brushing teeth
9		

10		
11		
12		
13		
14		

Example 1 Compare pH = 3 to pH = 7 based on the amount of $[H^+]$.

Example 2 What would be the pH of rain that is 100 times more acidic than normal?

Example 3 **a)**What is the value of log 0.01? (A log or logarithm is an exponent needed to create the value being logged.)

b) Use that concept and the formula $[H^+] = 10^{-pH}$ to derive a formula for pH.

Example 4 Find the pH of a solution with a concentration of 0.75 M of H^+.

Example 5 Where does the very small amount of H^+ come from if you a basic solution, which has mostly OH^-?

Exercises

1. What is the $[H^+]$ at a pH of 6?

2. Where does the $[H^+]$ come from if we a basic solution at pH = 8?

3. Compare pH = 3 to pH = 7 based on the amount of $[H^+]$. How many times more concentrated is the pH = 3 solution?

4. a) What would be the pH of rain that is 10 times more acidic than normal (normal pH = 5.6) ?

b) What atmospheric gas forms an acid and lowers the pH of rain from 7 to 5.6?

5. a) Look up the definition of buffer.

b) Soil is said to be a good buffer. What would happen to the pH of soil if it received a small amount of acid? Of base?

6. Find the pH of a solution with $[H^+]$ = 0.0035 M.

7. If solution A is 3.67 times more acidic than solution B, which is at pH = 3.90, what is the pH of solution A?