Name:

What Do Soda and the Oceans Have in Common?

Student Activity Sheet

Learn About Henry's Law

As formulated in 1803 by William Henry, Henry's law states "At a constant temperature, the amount of a given gas that dissolves in a given type and volume of liquid is directly proportional to the partial pressure of that gas in equilibrium with that liquid." In other words, at a given temperature a gas will dissolve into a liquid to a degree that is determined by the balance between the undissolved gas and the and the dissolved gas in the liquid.

Henry's Law

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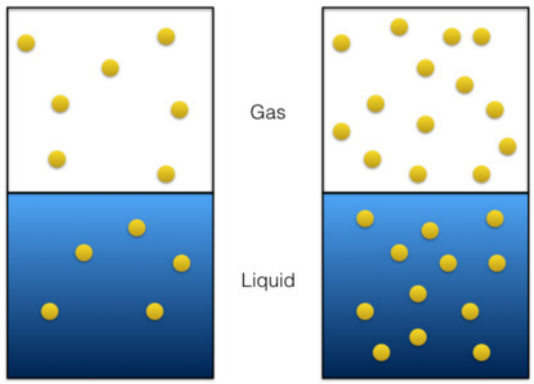


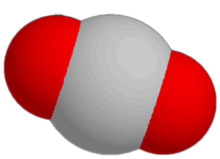
Let's take a look at Henry's law:

$$k = \frac{P_{gas}}{C_x}$$

Where k is a constant for each gas that can be looked up on a table, though when the temperature of a system changes so does the constant value of k. Pgas is the partial pressure of the gas in the parcel, and Cx is the concentration of the gas in the liquid solution. The concentration of the the gas in solution (solute) is directly proportional to the partial pressure of the gas above the liquid.

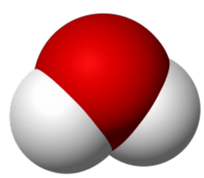
Molecular Process

Let's first consider how the process happens on a chemical level.



Carbon Dioxide Molecule

Carbon dioxide (CO_2) is made up of one oxygen atom and two carbon dioxide atoms. The atoms share the electron, but unevenly; the oxygen side of the molecule has a slight negative charge. CO_2 is a linear, symmetrical, molecule with a slight negative charge on either end, which is why it is a (weak) non-polar molecule.



Water Molecule

Water (H_2O) is made up of two hydrogen atoms and one oxygen atom. Again, the atoms share an electron, but not evenly. This uneven sharing of electrons give water molecules a slight positive charge near the two hydrogen atoms and a slight negative charge near the oxygen atom, which is called a polar molecule.

The positive charge, or electron rich, area of the water molecule attracts the negative charge, or electron deficient are of the carbon dioxide molecule allowing it to go into the solution.

To dissolve in the water, the CO_2 molecule must pass through the air-water-surface, where the CO_2 molecule gains an outer shell of the H_20 molecule. This process tranfers the molecule from the gaseous state to an aqueous solution.

Pressure

Any parcel of gas, or air for example, contains a mixture of gases, each of which has a partial pressure that contributes to the total sum of the pressure. The higher the concentration of a gas outside of the liquid, or partial pressure, the more gas of that gas will be able to go into solution.

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Watch these videos from Khan academy to learn about

- Partial Pressure
- Henry's Law
- CO_2 and O_2 Solubility

Temperature

Gas solubility is temperature dependent, gas can dissolve more readily in colder liquids. If you leave an opened bottle of soda on the counter it soon goes "flat", or all of the CO_2 leaves the solution, however if you leave your opened bottle of soda in the refrigerator, it will not go flat as quickly. This is because, even at the same pressure, the colder temperature allow for the gas to stay in the solution longer.

This is also true for ocean temperature and the solubility of gases such as CO_2. As discussed earlier, the colder the temperature is the more CO_2 can be dissolved, or colder ocean water can dissolve more CO_2 than warm ocean water. So in theory, colder water towards the poles can take up more CO_2 than warmer equatorial waters.

Scientists are concerned that increased CO_2 in the atmosphere could creates a positive feedback loop, a cycle in which the effects of a change in a system increase the magnitude of the change. For example, if ocean temperatures warm CO_2 could be released from solution, increasing the atmospheric concentrations leading to further heat trapping mechanisms, or at least slowing the rate of uptake by the oceans. The cycle continues to warm the atmosphere and the ocean.

Watch this video from the Science Learning Hub to learn about

- Southern Ocean Carbon Sink

Assessment

1. Choose the correct pair of words to fill in the blanks:

In Henry's law, "at a constant __________, the amount of a given gas that dissolves in a given type and volume of liquid is directly proportional to the __________ of that gas in equilibrium with that liquid."

a. pressure, solubulity
b. partial pressure, temperature
c. temperature, partial pressure
d. solubility, concentration

2. True or False: Gases are more soluble in cold water.

a. True
b. False

3. True or False: A gas such as CO_2 can molecularly dissolved in water because both the solute and solvent have polar bonds.

a. True
b. False

4. Why is better understanding of the role of the Southern Ocean so critical?

a. Because it drives warm waters to the surface that able to take up more $CO_{2.}$
b. Because it sets the overturning circulation for the global oceans, and determines the partitioning of heat and dissolved gases between the atmosphere and deep ocean.
c. Because much of the Earth's heat is stored in the ocean and released it into the atmosphere by the Southern Ocean.
d. Because anthropogenic CO_2 is not able to be taken up by oceans, but biogenic CO_2 is, particularly in the Southern Ocean.

5. How do you think climate change and warming of Earth's systems will affect the Southern Ocean? Check all that apply.

a. Warmer temperatures will decrease and slow the amount of gas that is dissolved into the ocean.
b. There will be a positive feedback loop which will release more CO_2 into the atmosphere, potentially worsening global warming.
c. There are still many scientific discoveries to be made enabling further research.
d. Through global ocean circulation, heat can be transported to all levels of the ocean affecting ecosystems far and wide.