Diffusion & Osmosis - Exercise 4

Objectives

-Define: Solvent, Solute, and Solution
-Define: Diffusion, Selectively permeable membrane, Osmosis, and Dialysis
-Understand rule of thumb: Concentration will always go from higher concentration to lower concentration.
-Know how Hypertonic, Hypotonic, Isotonic effect the bags (cells) in the osmosis experiment.
-Know how to calculate the cumulative percent weight of change.
-Understand Brownian Movement.
-Effect of Temperature on Rate of Diffusion on the crystal of potassium permanganate at different temperatures (Celsius).
-Understand the effect of particle weight and Size on the Rate of Diffusion.
-Understand Dialysis which is diffusion across a selectively permeable membrane base on size of the molecule.

Solvent: The dissolving agent of a solution; often water.

Solute : A substance that is dissolved in solution (salt, sugar, etc).

Solution: A homogenous liquid mixture of two or more substances.

Diffusion: The passive movement of matter; the spontaneous tendency of a substance to move down its *concentration*, pressure, or temperature gradient. Matter essentially moves (or diffuses) from an area of higher free energy to an area of lower free energy until equilibrium is achieve. In biology, **the most common type of diffusion is down a *concentration* gradient from higher to lower concentration**.

Selectively permeable membrane: Some substances can cross the membrane while others cannot. Several factors contribute to this selectable **(pore size, electric charge, etc.).** The cell membrane is a severely permeable membrane, and therefore it regulates the passage of substances into and out of the cell.

Osmosis: The diffusion of water (or some other solvent) across a selective permeable membrane; water diffuses to a hypertonic area. When water enters or leaves the cell it is usually accomplished by osmosis. **Osmosis: Special case of diffusion of water (High to low)**

Key: Where's there more concentration the water is going to move to. The only thing that moves is water (solvent) and not the solute (sugar).

Dialysis: The diffusion of a solute across a selectively permeable membrane. **Dialysis can be used to separate a mixture of dissolved substances on the bases of their size**.

- All cells are bathed in an aqueous mixture, and this fluid, sometimes referred to as the extracellular fluid (ECF), is very important to the cell.

- Passive processes do not require an expending of energy on the part of the cell, its driven by natural physical means that utilize the free energy.

- Many of the physical processes that you will study occur in both living and nonliving systems, and these processes play important roles in the maintenance of living systems. Physical processes and chemical reaction are the basis of life itself (homeostasis).

- The energy available to do work in a system is called **free energy**. The amount of free energy in a system is directly affected by concentration, pressure and temperature.

- Molecules may move from higher to lower concentration, from higher to lower pressure, or form higher to lower temperature. This passive movement is called **diffusion**. The difference between the higher concentration, pressure, or temperature and the lower concentration, pressure, or temperature is referred to as the **gradient**.

- Matter essentially move (or diffuses) from an area of higher free energy to an area of lower free energy until equilibrium has reached. Diffusion of matter can take place in air or liquid and can occur across cell membranes.

- Most common type of diffusion in biological systems is known as **Osmosis**. This is special type of diffusion whereby a solvent (water) diffuses across a selectively permeable membrane. When water enters or leaves a cell, it is usually accomplished by osmosis.

Membrane structure results in selective permeability

- A cell must exchange materials with its surroundings, a process controlled by the plasma membrane
- Hydrophobic molecules
  - Are lipid soluble and can pass through the membrane rapidly
- Polar molecules
  - Do not cross the membrane rapidly
- Transport proteins
  - Allow passage of hydrophilic substances across the membrane

Osmosis

- Osmosis is the diffusion of a liquid solvent (water) through a selectively permeable membrane. The solvent is usually water. The membrane in a living system is the cellular membrane (phosolipid bilayer).
- **In osmosis, TALKING ABOUT BEAKER FLUID WITH RESPECT TO CELL.**

- Took 4 bags that contained water (solvent) and variable concentration levels of sugar (sucrose) which is known as the solute.

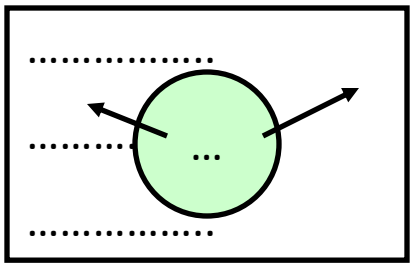
- Note: The surface of bag is made of an artificial membrane composed of cellulose that has microscopic pores in it.

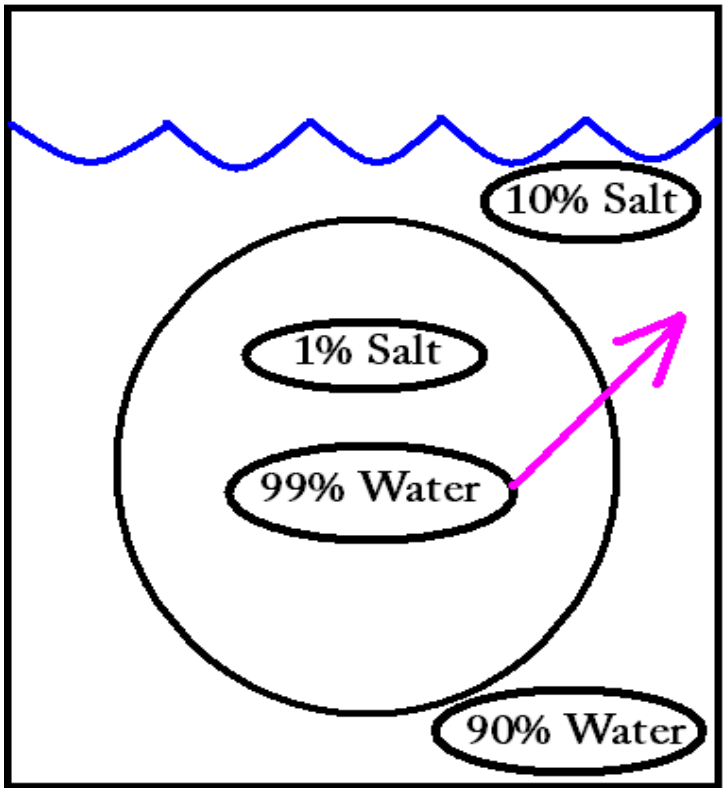
- **Each bag was placed in a beaker of liquid. The bags represented the model of a cell, and each beaker represents the extracellular fluid (ECF).**

Hypertonic

Hypertonic: Water comes out of the cell, so the cell loses weigh and eventually the cell shrivels.

- If a solution is hypertonic
  - The concentration of solutes outside is greater than it is inside the cell
  - Water will diffuse to equilibrium
  - The cell will lose water



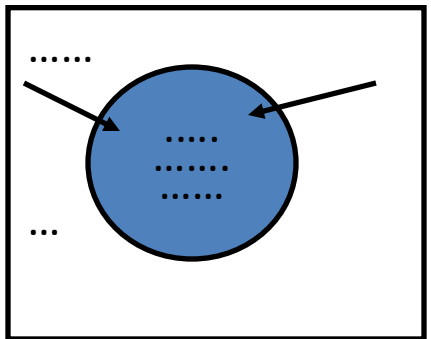


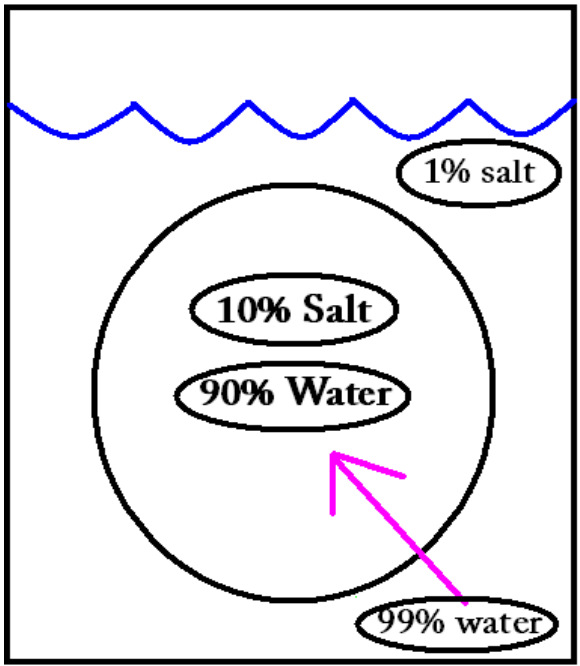
Hypotonic

Hypotonic: Water goes inside of the cell, so the weight of the cell increases, and eventually bursts.

Why doesn't this happen to plant cells? **Plant cells have a cell wall which is really resistant, and it also has a vacuole to takes water out of it.**

- If a solution is hypotonic
  - The concentration of solutes outside is less than it is inside the cell
  - Water will diffuse to equilibrium
  - The cell will gain water



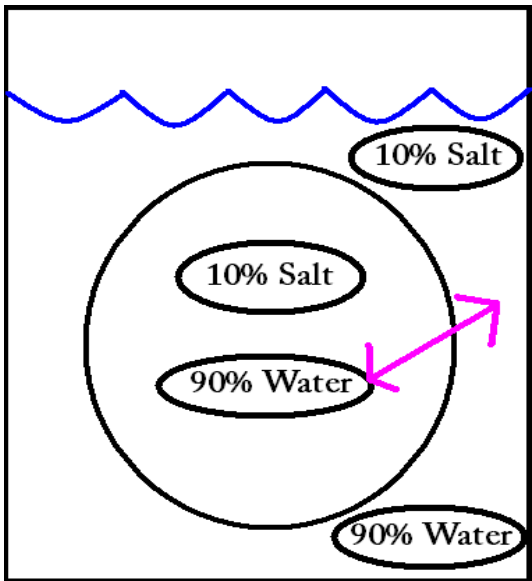


Isotonic

Isotonic: Water can diffuse, but its going to go back and forth and Stay in equilibrium.

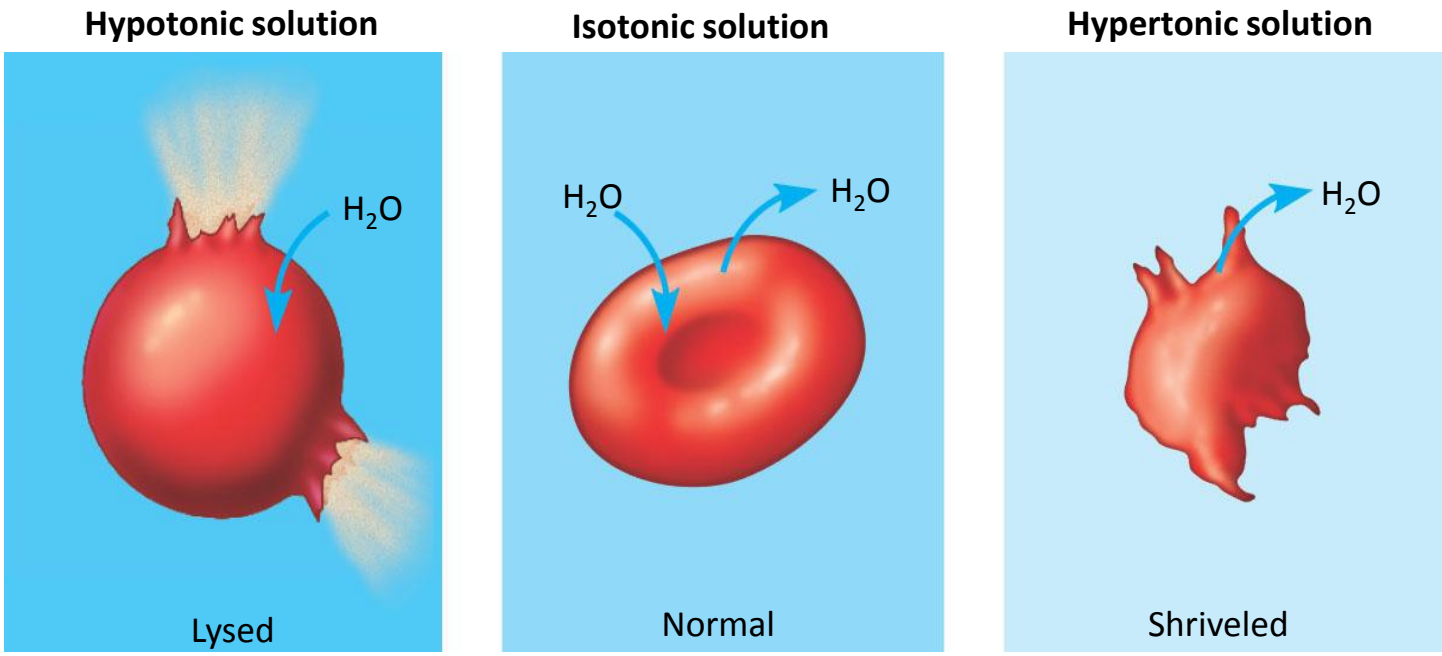
Is there any movement in an isotonic solution? **Yes, there's movement at the same rate (speed), but there's no net gain or lost in the bag (cell) , this solution is in equilibrium.**

- If a solution is isotonic
  - The concentration of solutes is the same as it is inside the cell
  - Water STILL DIFFUSES, but does not accumulate



Water balance in cells without walls

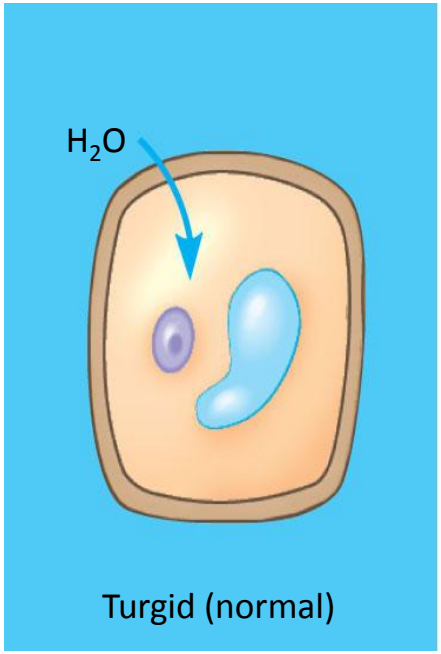
(a) **Animal cell.** An animal cell fares best in an isotonic environment unless it has special adaptations to offset the osmotic uptake or loss of water.

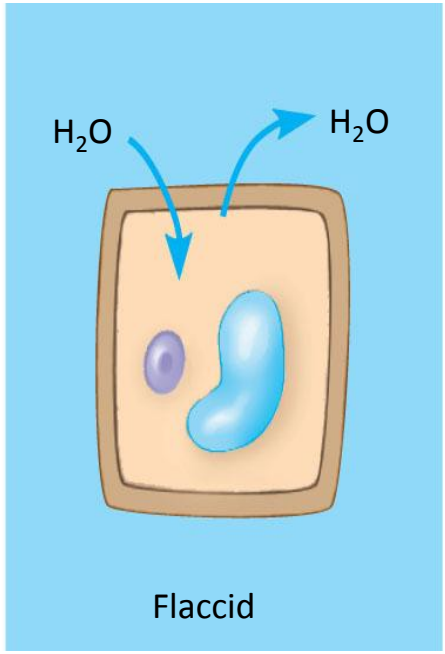


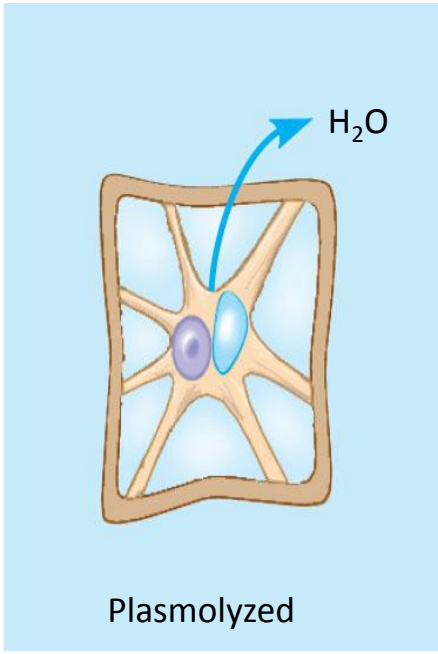
Water balance in cells with walls

(b)

Plant cell. Plant cells are turgid (firm) and generally healthiest in a hypotonic environment, where the uptake of water is eventually balanced by the elastic wall pushing back on the cell.







- **Rule of thumb: Water will ALWAYS go to where there's more solute (salt, sugar, etc) whether in the cell or in the beaker. The solvent (water) is the ONLY thing that is moving to reach equilibrium.**

- **Note: The bigger the gradient, the faster you go.**

- The higher the concentration of the solute, the lower the concentration of the water and vice versa.

- Remember that the water will diffuse down the free energy gradient of water, not the free energy gradient of the solute (sucrose)

Calculating Cumulative Percent Weight Change

Example: Initial weight of bag x (at 0 minutes) = 12.7 grams

Weight of bag x at 30 minutes = 13.6 grams

The cumulative percentage increase is then:

$$\frac{13.6 - 12.7}{12.7} \times 100 = +7.1\%$$

After the experiment was conducted for a period of 45 minutes of intervals of 15 minutes. You calculated the percentage change in weight for each of the bag, and computed that into a percent into a **cumulative percent change in weight**.

Formula: $\frac{\text{Final weight (g) - Initial Wright (g)}}{\text{Initial Wright (g)}} \times 100 =$

NOTE: This could be a negative value because your Bag (cell) is losing water (Hypertonic).

%

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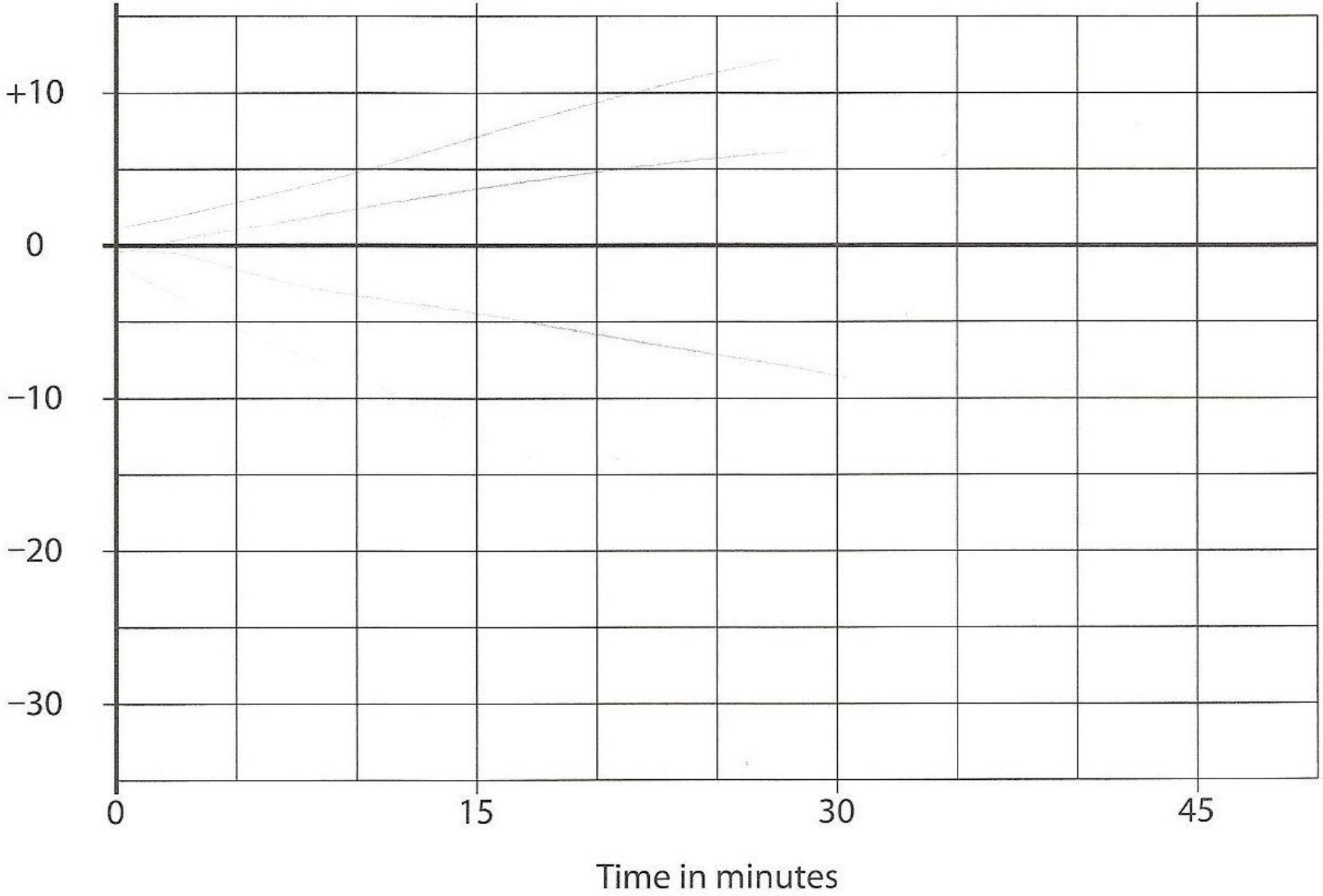
Plot the percentage change in weight verses time for each of the four bags on the graph below:



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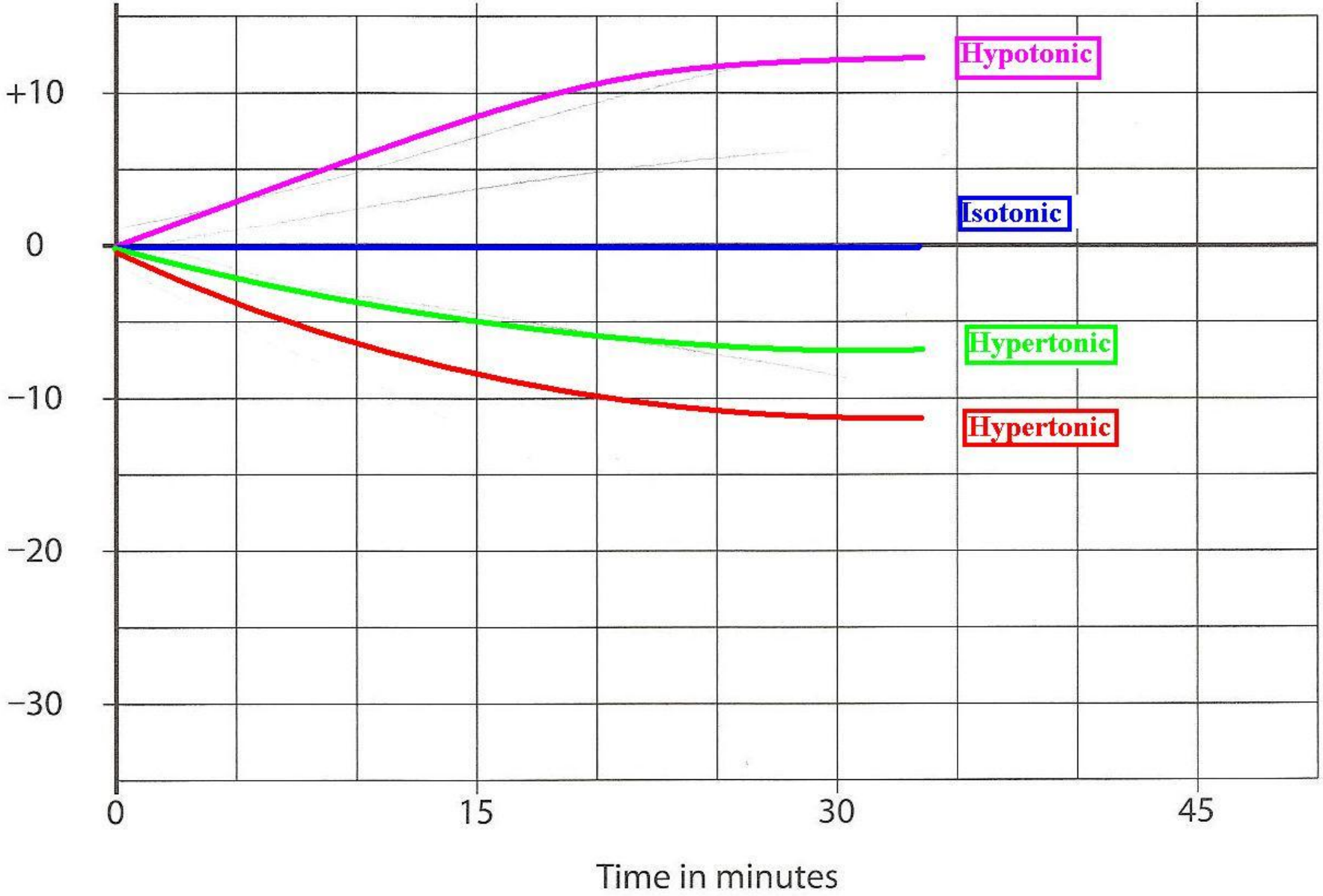

Questions

- 6. Four dialysis tubing bags were filled with the following solutions listed on the table below and closed off. **Each of the bags were placed in separate beakers that contained 40% sucrose.** The bags were weight every 15 minutes for 45 minutes. The dialysis tubing that was used in permeable to water but not to sucrose.

BAG	SOLUTION IN BAG	SOLUTION IN THE BEAKER
Bag # 1	Contains 0% sucrose	40% Sucrose
Bag # 2	Contains 40% sucrose	40% Sucrose
Bag # 3	Contains 60% sucrose	40% Sucrose
Bag# 4	Contains 20% sucrose	40% Sucrose

- In the table below, describe the expected weight changes, if an , for each of the four bags after 45 minutes. Answer by saying one of the following. The bag will gain weight slowly; The bag will gain weight rapidly; The bag will lose weight slowly; The bag will lose weight rapidly. The bag will not change in weight.

- State whether the bag is hypertonic, isotonic, or hypotonic to the beaker.

Questions

BAG	GENERAL WEIGHT CHANGES	HYPER, ISOTONIC, OR HYPO
Bag #1	**The bag will lose weight quickly.**	**Hypertonic**
Bag #2	**The bag will not change in weight, but there's movement.**	**Isotonic**
Bag #3	**The bag will gain weight slowly.**	**Hypotonic**
Bag #4	**The bag will lose weight slowly.**	**Hypertonic**

Questions

- 4. A dialysis bag, permeable to water and not permeable to sucrose, filled with 30% sucrose solution and was placed in a beaker full of water. The bag's initial weight was 15g, and after 15 minutes it became 17g. Calculate the percent change in weight of the dialysis bag.

- 5. A dialysis bag, permeable to water and not permeable to sucrose, filled with water was place 30% sucrose solution. The bag's initial weight was 15g, and after 15 minutes it became 17g. Calculate the percent change in weight of the dialysis bag. After 45 minutes it was found the same bag weighted 20 g. What Is the cumulative percent change in weight of the bag at that point?

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$$\frac{17 - 15}{15} \times 100 = 13\%$$

$$\frac{20 - 15}{15} \times 100 = 33.33\%$$

- Why do we use percentages to calculate the rate of change in dialysis bag - why is this a good thing?

- Why do we use percentages to calculate the rate of change in dialysis bag - why is this a good thing? **It shows a better difference in change in weight (grams).**

Molecular Motion - Brownian Movement

- The random movement of particles suspended in a fluid; caused by collisions with the molecules that make up the fluid (most often collision with water molecules).

- Heat causes molecules to move about at **random**, with those in gases moving most rapidly, followed by those in liquids, and then in solids.

- You observed the movement of visible particle of **carmine dye**, which are bombarded by the movement of invisible water molecules in which the dye particles are suspended.

- What was the purpose of the carmine dye in this experiment?

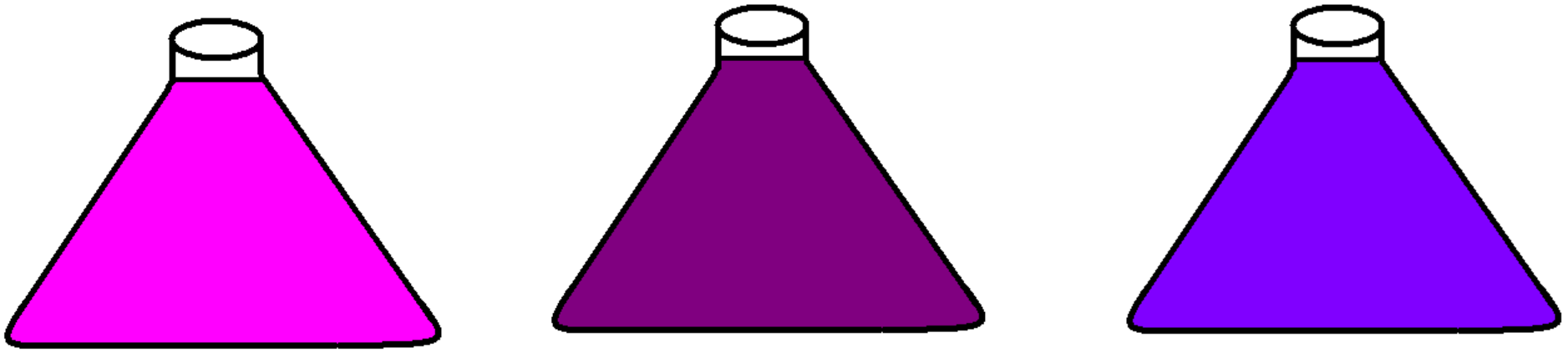
Effect of Temperature on Rate of Diffusion

- Matter has free energy and is in constant random motion. If certain areas or regions of molecules are more concentrated, are under higher pressure, or are at a higher temperate than other areas or regions, the molecules will move down the free energy gradient from higher to lower concentration, pressure or temperature.. The passive movement is called diffusion an area of high concentration to an area of lower concentration. **This experiment involves concentration differences.**

- **A crystal of potassium permanganate was added into each of three vessels of water which are being held at different temperatures (Celsius).**

- Note: The crystals are soluble in water and product a colored solution.
- Ice (about 4^{O})
- Room Temperature (20^{O})
- Hot Water Bath (75^{O})

Effect of Temperature on Rate of Diffusion



Ice (about 4^{O})

Room Temperature (20^{O})

Hot Water Bath (75^{O})

The goal was to see at what temperature to see which diffuses the fastest at a certain temperature by putting the crystal (potassium permanganate) dissolved in.

Effect of Particle Weight and Size on the Rate of Diffusion

- Normally molecules weight and particle size are strongly correlated.

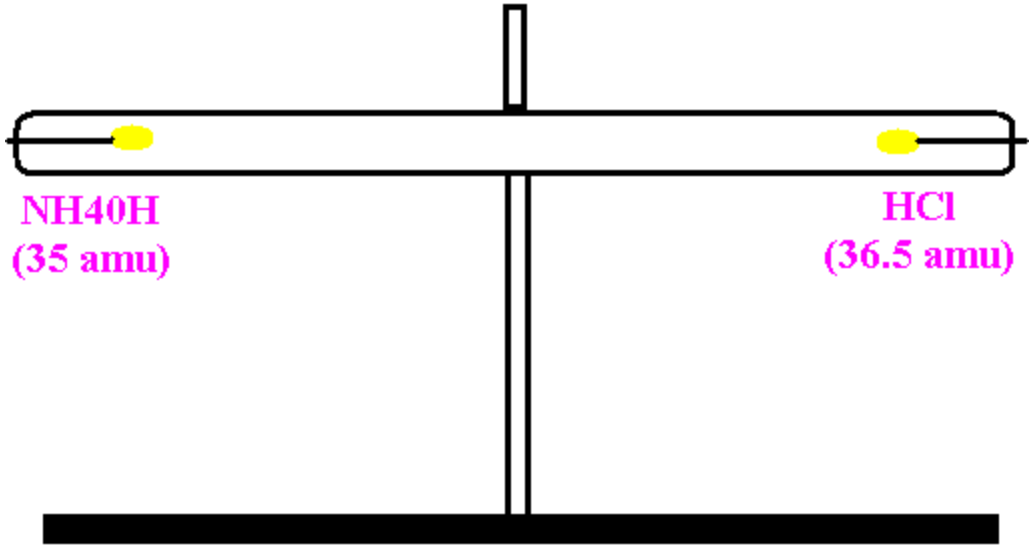
There was a tube and put two cotton swabs and put into each end of the tube. On one side of the tube HCl was place, and in the other end NH40H at the same time. HCl weighs 35 amu and NH40H weighs 36.5 amu.

So then they were allow to diffuse in the air inside of the tube for several minutes. When these ions collide H and OH collided they formed a water vapor H2O. And when NH4 and Cl collided it formed a white precipitate salt (NH4Cl) that will make rings inside the tube.

Rule of thumb: If the molecule is heavier, meaning has a higher amu mass it is slower, and vice versa. Think of this diffusion as a fat guy versus a skinny guy. The skinny guy is going to quicker, so he will go farther in the tube versus the fat guy who is slower. So when the two guys meet at a certain point there going to collide and form a ring.

Effect of Particle Weight and Size on the Rate of Diffusion

Indicate on the drawing below at what points NH4Cl salt originally precipitated



(NH40H) Ammonium hydroxide:

(NH4) Ammonium: weights - 18 amu
(OH) Hydroxide: weights - 17 amu

18+17 = 35 amu

HCl) Hydrochloric acid:

(H) Hydrogen: weights - 1 amu
(Cl) Chloride: weights - 35.5 amu

1+35.5 = 36.5 amu

Based on this data, where would the ring form and why?

Effect of Particle Weight and Size on the Rate of Diffusion

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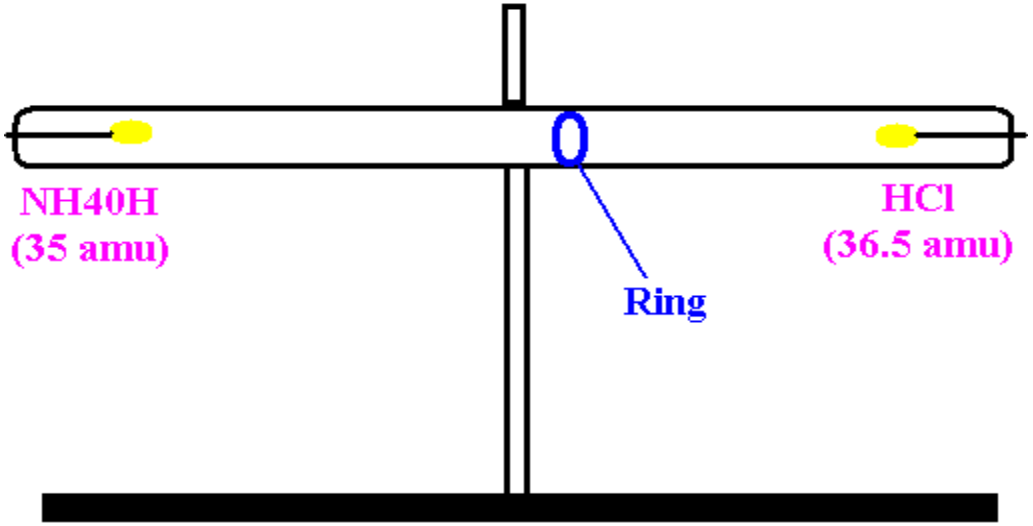

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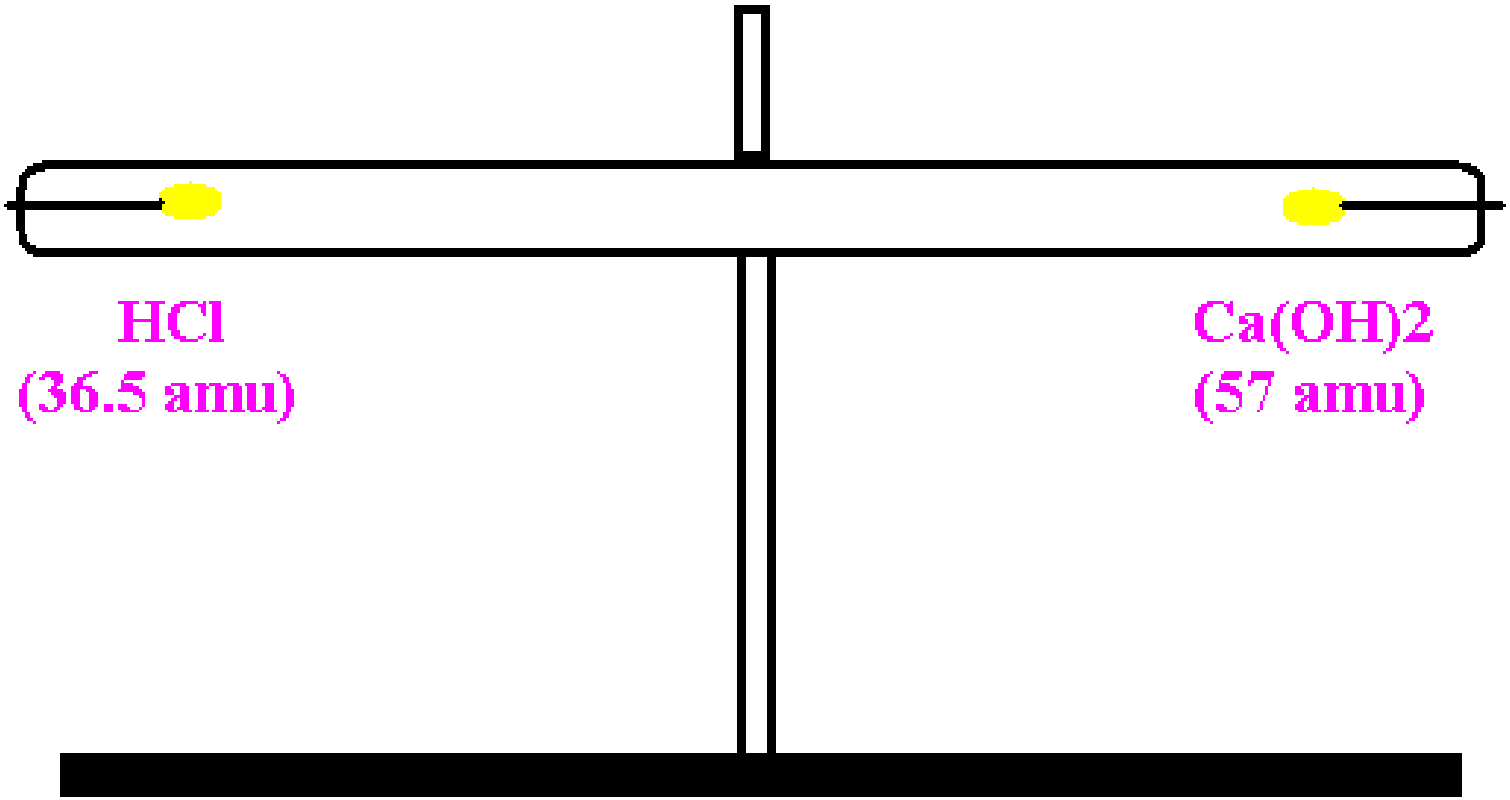
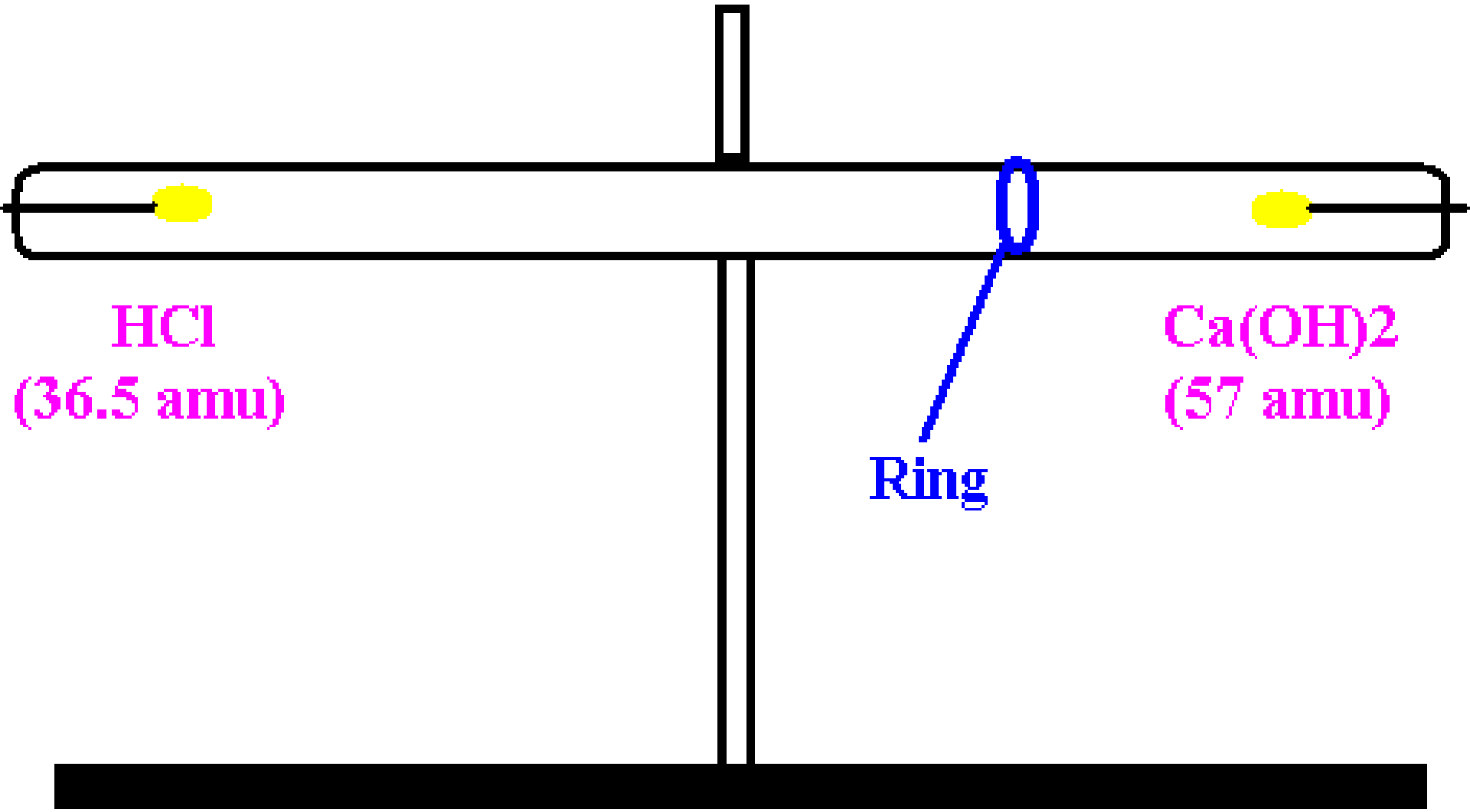


Where does the ring form?


HCl
(36.5 amu)
Ca(OH)2
(57 amu)
Ring

Diffusion across a selectively Permeable Membrane
Dialysis

- Cells and some organelles are surround by a membrane which the passage of substances into or out of the cell or organelles. The characteristics of the membrane makes it **selectively permeable (some substance can cross the membrane while others cannot)**. Several different factors contribute to this selectivity **(pore size, electric charge, solubility, transport proteins embedded in the membrane, etc).**

But in this experiment you studied the pore size effects on the permeability.

- You used dialysis tubing (an artificial membrane) as a model of a selectively permeable membrane. The dialysis tubing has small microscopic pores which prohibit the passage of large molecules through it, but allow small sized molecules and atoms to pass.

- **Dialysis: This is the diffusion of a solute (salt, sugar) through a differentially permeable membrane. This is specialize type of diffusion.**

- Dialysis can be used to separate a mixture of dissolved substance on the basis of their particle sizes.

- **<u>Separated these two. If something can cross the bag, your going to get color change. If nothing can cross the bag, there's going to be no color change</u>.**

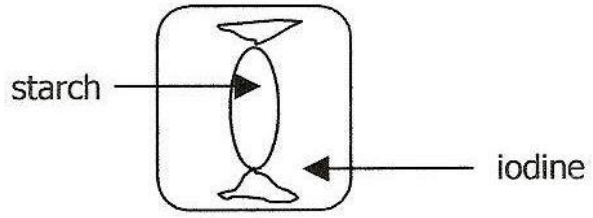
Dialysis: This is the diffusion of a solute (salt, sugar) through a differentially permeable membrane. This is specialize type of diffusion.

Dialysis can be used to separate a mixture of dissolved substance on the basis of their particle sizes.

Pour about 10 to 15 ml of starch solutions into the bag.

Fill a beaker about one quarter full of iodine solution and submerge the bag in the iodine.

Note: Iodine is brownish red.
Note: Starch is Milky/clear



Substance & Location	Original Color	Color after 5 minutes
Iodine in the beaker	Brownish Red	Brownish Red
Starch in the bag	Milky/Clear	Light Blue

Questions

- 1. Define osmosis:

- 2. How does dialysis differs from osmosis?

- 3. If a 50% sucrose solution is separated from a 20% sucrose solution by a membrane that does not allow sucrose to pass through, in which direction the movement of water will take place.

a) There will be no net movement of water
b) Water will move into 50% sucrose solution from 20% sucrose solution.
c) Water will move into 20% sucrose solution from 50% sucrose solution.
d) In this case only dialysis will take place.

Questions

- 1. Define osmosis: **The diffusion of water (or some other solvent) across a selective permeable membrane hyp, hyper, iso. Special case of diffusion of water (Higher concentration to lower concentration).**

- 2. How does dialysis differs from osmosis? **In dialysis water has to go through a selectively permeable membrane that's specific to a substance size, but in osmosis its concentration of gas, molecules, water from higher to lower concentration and water is the solvent moving, and only water.**

- 3. If a 50% sucrose solution is separated from a 20% sucrose solution by a membrane that does not allow sucrose to pass through, in which direction the movement of water will take place.

a) There will be no net movement of water
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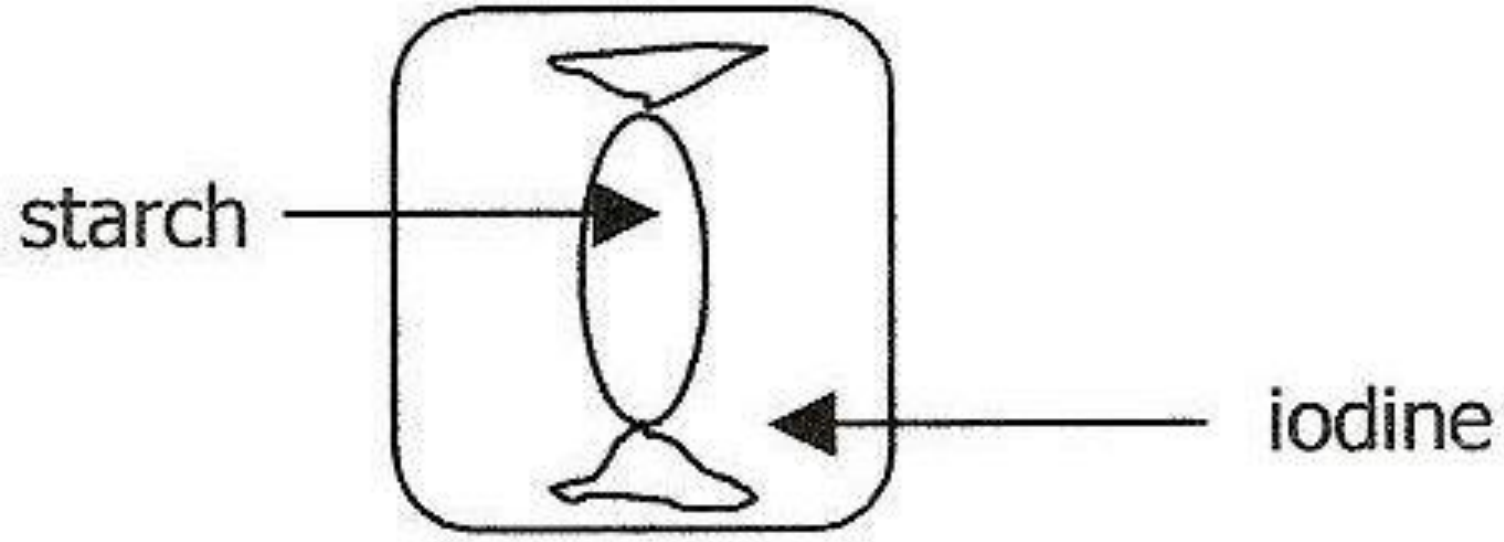
Questions

- 7. _____ diffused into the _____ as seen by the _____ color (inside/outside) of the bag.

- 8. This happens because _____has a smaller _____ _____ than _____.



Questions

- 7. **Iodine** diffused into the **starch** as seen by the **dark blue** color (**inside**/outside) of the bag.

- 8. This happens because **iodine** has a smaller **molecular molecules** than **starch**.