# Colligative Properties

Depend upon the concentration of a solution
Not the identity of the particles

# Colligative Properties

4 changes that result from mixing “something” into water

- Freezing point -  lowering (depression)
- Vapor pressure  - lowering
- Boiling point - elevation
- Osmotic pressure

Freezing Point of water 0°C (at 1 atm or 760 mmHg)

Can the Freezing point of water be changed?

If so……  How?

# Phase Diagram (for water)

# Interpreting a phase diagram

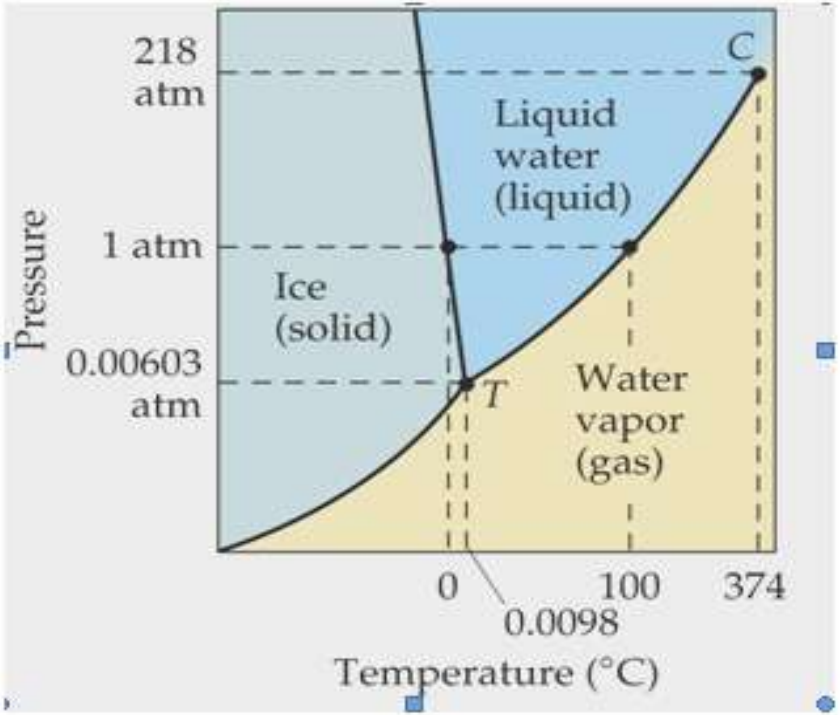
What would the freezing point of water be if it were under a lot of pressure?  217 atms?

-1C

The high pressure does not allow the water to expand in order to freeze.

This is what happens in ice skating.

- The weight of the person on the the sharp blade melts the ice temporarily so the skate glides on liquid water.



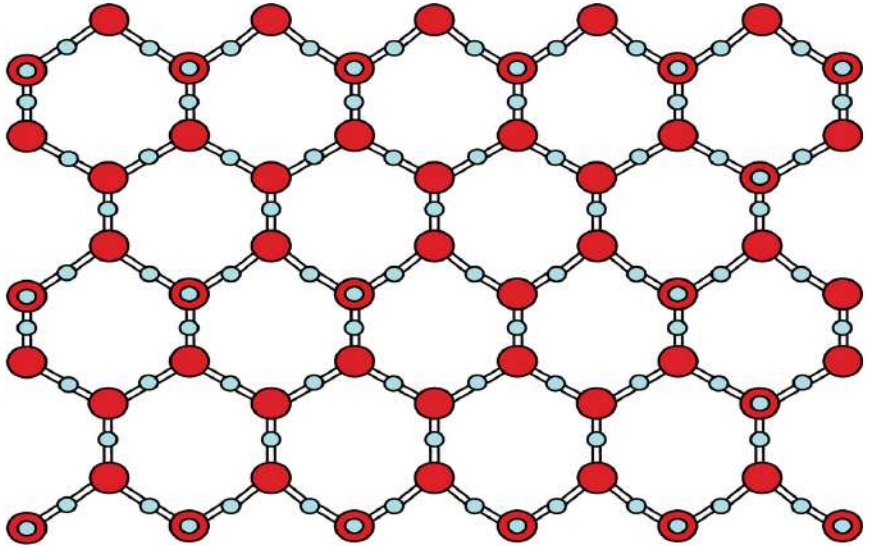
The Freezing point of water can be changed by changing the pressure.

Is there another way to change the freezing point of water?….
How?

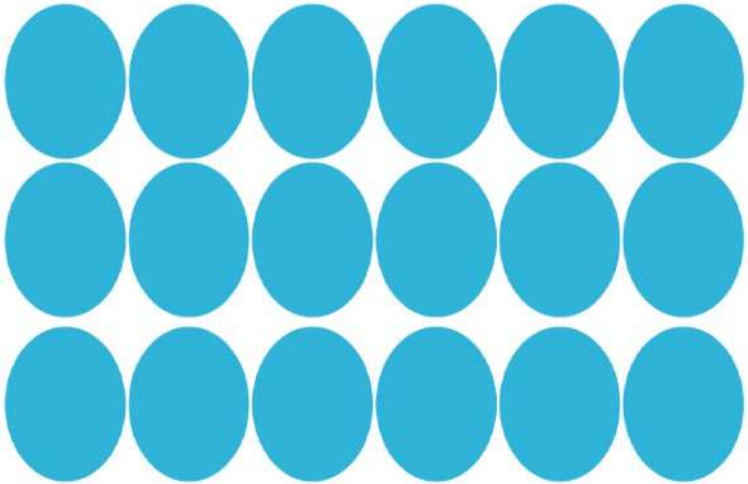
# During freezing, the molecules settle into a more organized structure.

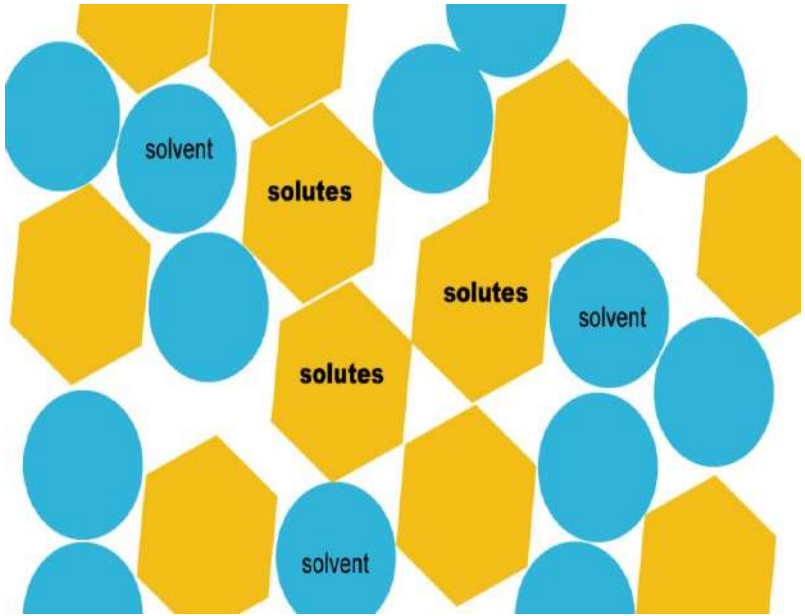
This diagram shows the expansion of

Water molecules in the frozen state.



The freezing point of a solution is always lower than that of a pure solvent.





The more particles added

→ the more interference in the organization of the solvent

→ the lower the temperature will be required for freezing

When dissolved in the water how many particles will be formed for each of the following solutes?

$MgCl_2$ NaCl $Na_3PO_4$ $C_6H_{12}O_6$

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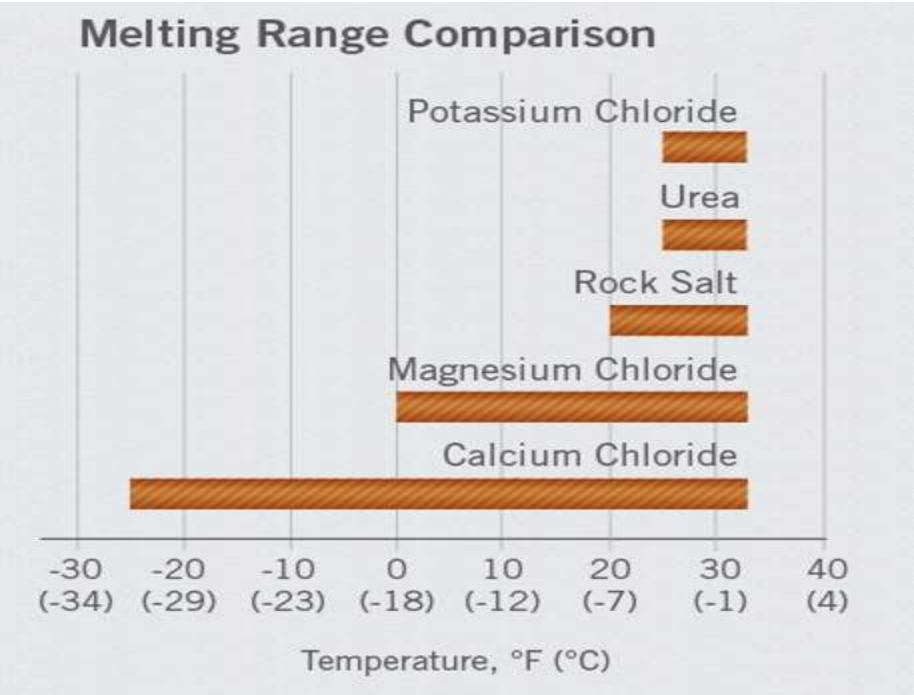
When dissolved in the water how many particles will be formed for each of the following solutes?

| $MgCl_2$ | NaCl | $Na_3PO_4$ | $C_6H_{12}O_6$ |
|---|---|---|---|
| 3 ions | 2 ions | 4 ions | 1 covalent compound |

# De-icing for the roads and sidewalks



# Homemade ice cream

Add salt to the ice.

The salt water solution will be colder than 0℃.

Rock salt　-7℃

Making is possible to freeze the milk/sugar solution

# The freezing point of water can be changed

A little …..  By  changing the pressure on the water

Or

By adding a solute to the water. The particles you add the more the freezing point changes.

Boiling Point of water 100℃ (at 1 atm or 760 mmHg)

Can the Boiling point of water be changed?

If so……  How?

# Interpreting a phase diagram

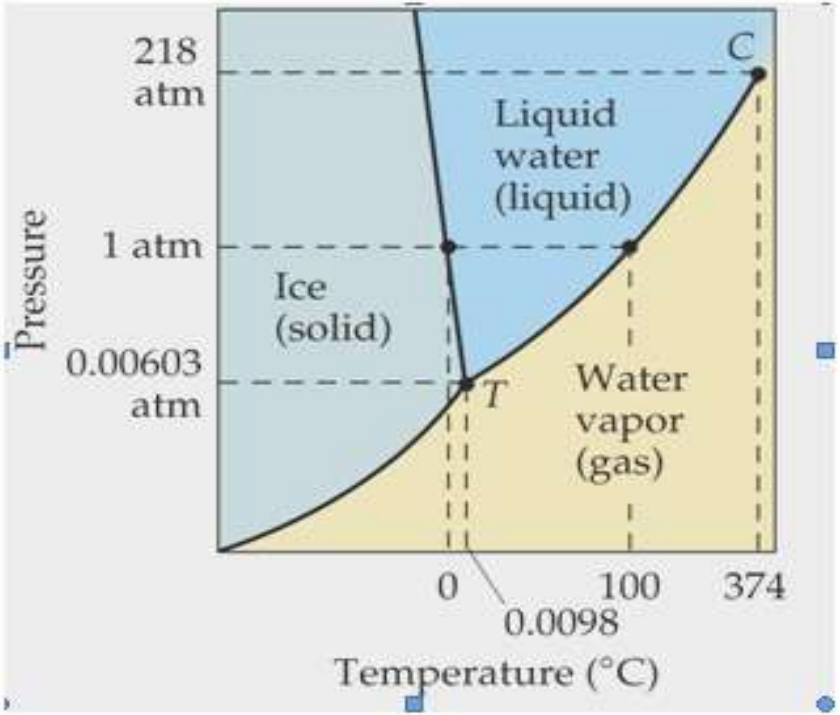
What would the boiling point of water be if it were under a lot of pressure?

218 atms?

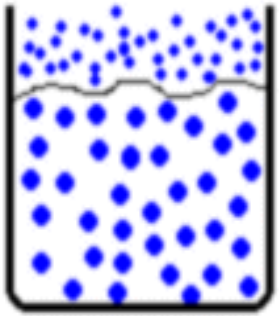
374C

By increasing the pressure on the surface of the liquid higher temperatures will be required to boil the substance.

Changing pressure can change the boiling point.



During boiling, the molecules escape from the liquid phase into the gas phase.

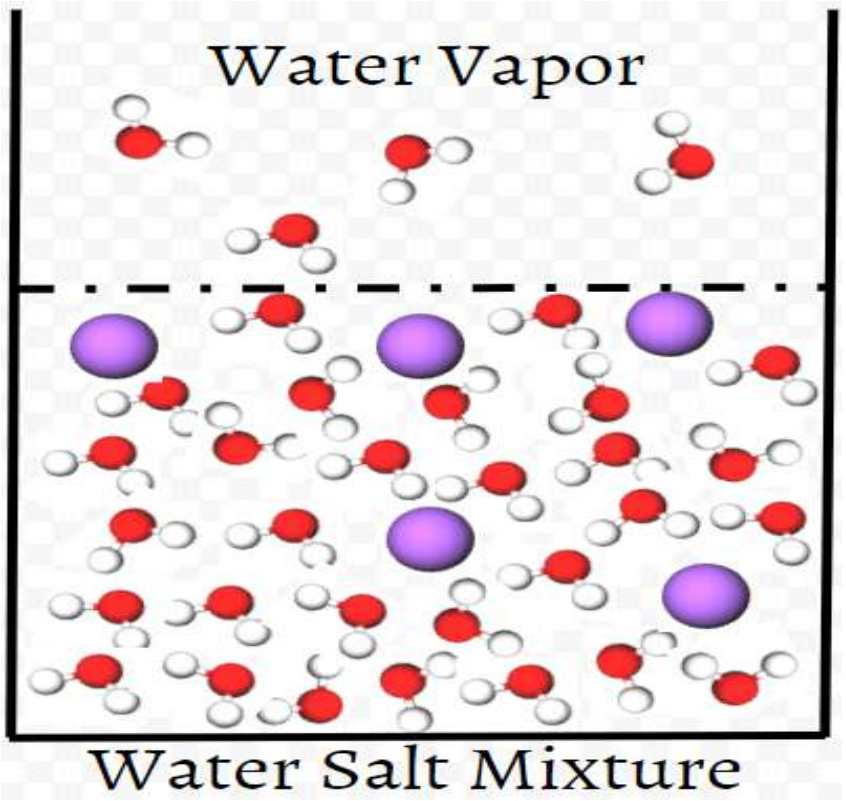


# The boiling point of a solution is always higher than that of a pure solvent.

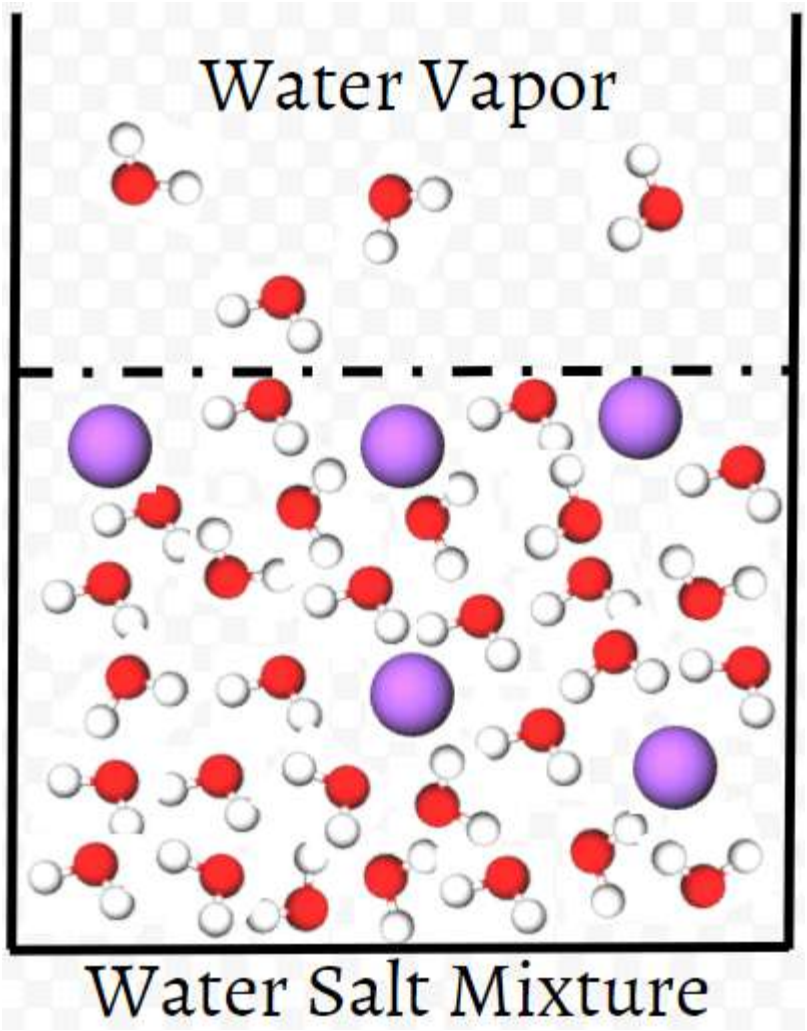
The particles are distributed throughout the solution.

They “get in the way” of the solvent particles when the solvent wants to evaporate.

Therefor,  the solution must be heated to a higher temperature to make it boil.



# Boiling point elevation



# Can you cook your spaghetti faster if you add salt to the water?

| Tablespoons of salt added to 1 cup of water | Boiling point ℃ Trial #1 | Boiling point ℃ Trial #2 | Boiling point ℃ Trial #3 | Boiling point ℃ Average |
|---|---|---|---|---|
| 0 | 100.5 | 100.3 | 100.6 | 100.5 |
| 1 | 102 | 101.8 | 102.2 | 102 |
| 2 | 103.5 | 103.4 | 103.7 | 103.5 |

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A lot of salt is required for a little change in cooking temperatures.

Probably not worth it.

# Antifreeze and your car radiator

To maintain an appropriate temperature for engine operation your car has a cooling system.

Antifreeze is pumped through the engine core, where it absorbs excess  heat.

The antifreeze runs through the radiator where  is dissipates the heat to the outside air.

# Antifreeze and your car radiator

A 50/50 mixture of water and ethylene glycol.
Boiling pt of 106℃

Freezing pt of -37℃

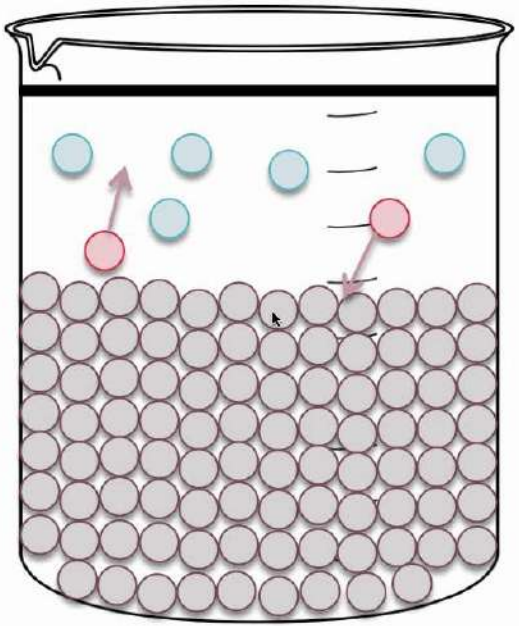
30/70 mixture of water ethylene glycol

Boiling pt of 113℃

Freezing pt of -55℃

# Vapor Pressure

When there is a lid on the container, the gas phase molecules are trapped… they are a vapor. The vapor creates a pressure!!



- Lid blocks exiting vapor
- Molecules in vapor phase collide with walls and cause a pressure
  - The vapor pressure!!
- Evap rate = Condense rate
  - An equilibrium!!
- Change T, change Evap rate, change $P_{vap}$
  - $P_{vap}$ is temperature dependent

# Vapor pressure of Water - temperature dependent

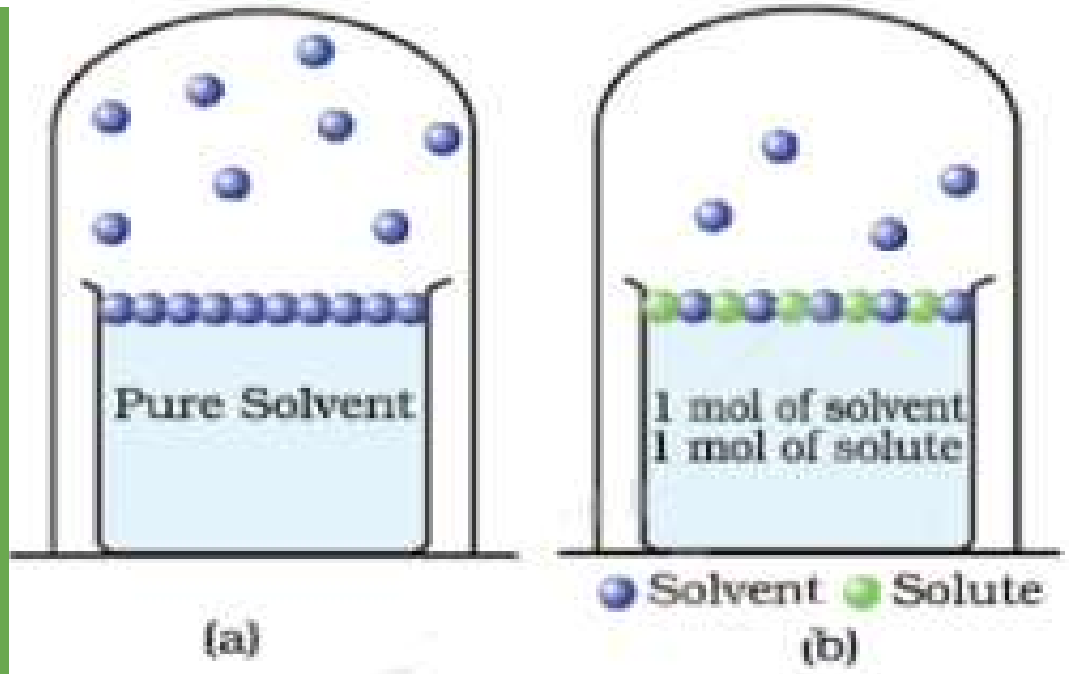
**TABLE 10.2** VAPOR PRESSURE OF WATER

| TEMPERATURE (°C) | PRESSURE (mm Hg) | TEMPERATURE (°C) | PRESSURE (mm Hg) |
|---|---|---|---|
| 5 | 6.5 | 55 | 118.0 |
| 10 | 9.2 | 60 | 149.4 |
| 15 | 12.8 | 65 | 187.5 |
| 20 | 17.5 | 70 | 233.7 |
| 25 | 23.8 | 75 | 289.1 |
| 30 | 31.8 | 80 | 355.1 |
| 35 | 41.2 | 85 | 433.6 |
| 40 | 55.3 | 90 | 525.8 |
| 45 | 71.9 | 95 | 633.9 |
| 50 | 92.5 | 100 | 760.0 |

# Solute  fewer particles are able to escape

The solute particles “get in the way” of the evaporating solvent.

Fewer particles evaporate --- resulting in a lower vapor pressure

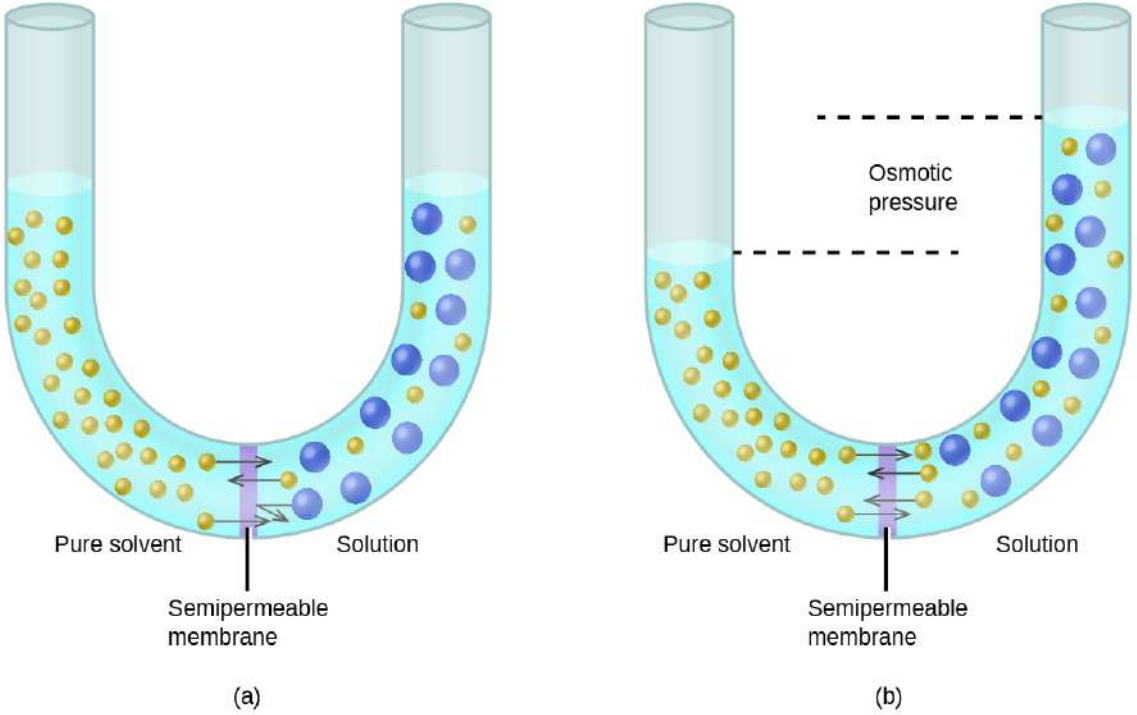


# Osmotic pressure

Pure solvent will flow into the solution.

The more particles the more solvent will flow,  to dilute the solution.

Your stomach is a semipermeable membrane. Be careful what you put into it.



# Summary

The freezing point of a liquid can be changed

→ by pressure changes → by adding particles

The boiling point of a liquid can be changed

→ by pressure changes → by adding a particles

The vapor pressure can be changed

Osmotic pressure can be changed

Several examples of everyday uses for freezing point depression and boiling point elevation.