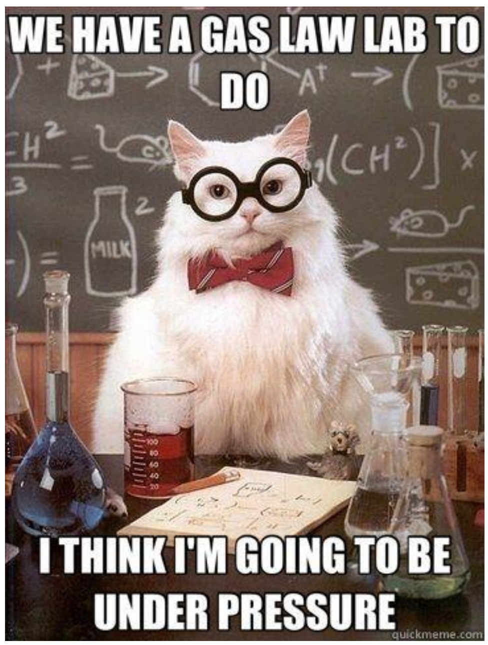
Name:

Regents Chemistry:

Notes: Unit 8 Gases



Name:

KEY IDEAS

- The concept of an ideal gas is a model to explain the behavior of gases. A real gas is most like an ideal gas when the real gas is at low pressure and high temperature. (3.4a)
- Kinetic molecular theory (KMT) for an ideal gas states that all gas particles: are in random, constant, straight-line motion, are separated by great distances relative to their size; the volume of the gas particles is considered negligible; have no attractive forces between them; have collisions that may result in the transfer of energy between particles, but the total energy of the system remains constant. (3.4b)
- Kinetic Molecular Theory expresses the relationship between pressure, volume, temperature, velocity, and frequency and force of collisions among gas molecules. (3.4c)
- Equal volumes of different gases at the same temperature and pressure contain an equal number of particles. (3.4e)

PROCESS SKILLS

- Use kinetic molecular theory (KMT) to explain the relationships among temperature, pressure, and volume of a substance. (3.4)
    - Explain the gas law in terms of KMT (The concept of an ideal gas is a model to explain the behavior of gases. (3.4 i)
    - Solve problems, using the combined gas laws (3.4 ii)
    - Convert temperature in Celsius degrees (°C) to kelvins (K) and kelvins to degrees Celsius (3.4 iii)
    - A real gas is most like an ideal gas when the real gas is at low pressure and high temperature. (3.4a)
- Interpret vapor pressure curves (Table H)

Vocabulary:

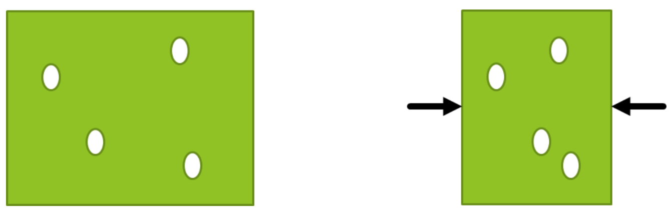
Word	Definition
Absolute Zero	The lowest possible temperature; the temperature at which all particle movement stops; -273°C or 0 K.
Avogadro's Hypothesis	Equal volumes of two ideal gases under the same conditions of temperature and pressure will contain equal number of molecules.
(Normal) Boiling Point	The temperature at which a phase change between liquid and gas occurs at 1 atm or 101.3 kPa; the temperature at which the vapor pressure of a liquid is equal to the atmospheric pressure.
Direct Relationship	A relationship where the increase of the independent variable results in the increase of the dependent variable.
Equilibrium	The condition that exists when the rates of two opposing changes are equal.
Evaporating	The transition of the surface molecules of a liquid into a gas below the boiling point.
Gas	A phase of matter characterized by the complete dissociation of matter particles from each other with the distances between the particles very large in comparison to the size of the particles and no attractive forces between them.
Ideal Gas	A gas in which the molecules are infinitely small and far apart, the molecules travel with a straight-line motion, all collisions have no net loss of energy (elastic), there are no attractive forces between molecules and the speed of the molecules is directly proportional to the Kelvin temperature. Gases are most ideal at high temperature and low pressure.
Indirect Relationship	A relationship where the increase of the independent variable results in the decrease of the dependent variable, or vice versa.
Kinetic Molecular Theory (KMT)	A model used to explain the behavior of gases in terms of the motion of their particles.
Pressure	Force exerted over an area.
Temperature	The average kinetic energy of a sample or system.
Vapor-Liquid Equilibrium	A system where the rate of evaporation equals the rate of condensing.

Objective:

- ***Describe the behavior of ideal gases based on the Kinetic Molecular Theory***
- ***Differentiate between ideal and real gases***
- ***Determine when real gases behave most like ideal gases.***

Gases:

- Few and far apart
- Constantly moving (faster if hotter)
- Can be compressed (take shape & volume of container)



Most affected by changes in temperature and pressure (compared with liquid & solid)

KINETIC MOLECULAR THEORY: Explains behavior of "Ideal" Gas

IDEAL GASES
• Particles move in straight line, random motion • Particles are NOT attracted to each other • Particles have NO volume (negligible) • Have elastic collisions (transfer but don't lose energy) • Double the temperature (in Kelvin), double the speed!!

PRACTICE REGENTS QUESTION:

An assumption of the kinetic theory of gases is that the particles of a gas have

A. **little attraction for each other and a significant volume**
B. **little attraction for each other and an insignificant volume**
C. **strong attraction for each other and a significant volume**
D. **strong attraction for each other and an insignificant volume**

Real Gases aren't ideal, but they come close…

IDEAL GASES	REAL GASES
• Imaginary	• Actual gas, what we work with in lab
• Follows the gas laws	• Do not follow gas laws exactly
• Particles are NOT attracted to each other	• Particles DO attract each other (have some intermolecular forces of attraction)
• Particles have NO volume (negligible)	• Particles DO have some volume…atomic radii
• Particles move in straight line motion	• Particles DO not necessarily move in straight lines
• Have elastic collisions	• Non elastic collisions

Ideal Gases are PERFECT Gases:

No mass

No volume

No attractive forces

Gases behave **most IDEALLY** under conditions of:

_______________ **temperature** and _______________ **pressure** BECAUSE:

☐ particles are moving ____________________________

☐ particles are ____________________________________

WHY?

- Smaller, symmetrical particles most ideal: He and H_2

Lesson 1: Kinetic Molecular Theory: Ideal vs Real Gases

Gases **deviate (stray)** from ideal under conditions of:

_______________ **temperature** and _______________ **pressure** BECAUSE:

- ☐ particles are moving ____________________________
- ☐ particles are ____________________________________

WHY?

SUMMARY:

- **Ideal Gases are perfect gases. They have:**
  - ☐ No mass
  - ☐ No volume
  - ☐ No attractive forces
- **When will real gases behave as Ideal Gases?**
  - ☐ When they are spread out
  - ☐ Temperature is High
  - ☐ Pressure is Low

****REMEMBER **PLIGHT**

PRACTICE:
Under which conditions of temperature and pressure would He behave most like an ideal gas?
A) 50 K and 20 kPa
B) 50 K and 600 kPa
C) 750 K and 20 kPa
D) 750 K and 600 kPa

Objective:

- ***Determine the relationship between pressure and volume; volume and temperature; and pressure and temperature.***
- ***Compare amounts of gases in samples using Avogadro's Hypothesis.***

Nature of the Gas Phase:

- Particles are spread out; great space between them
- Random motion (until they collide with each other or container)
- Take shape and size of container

Changing temperature, volume, or
or pressure impacts on the others:

If decrease volume, _______ collisions

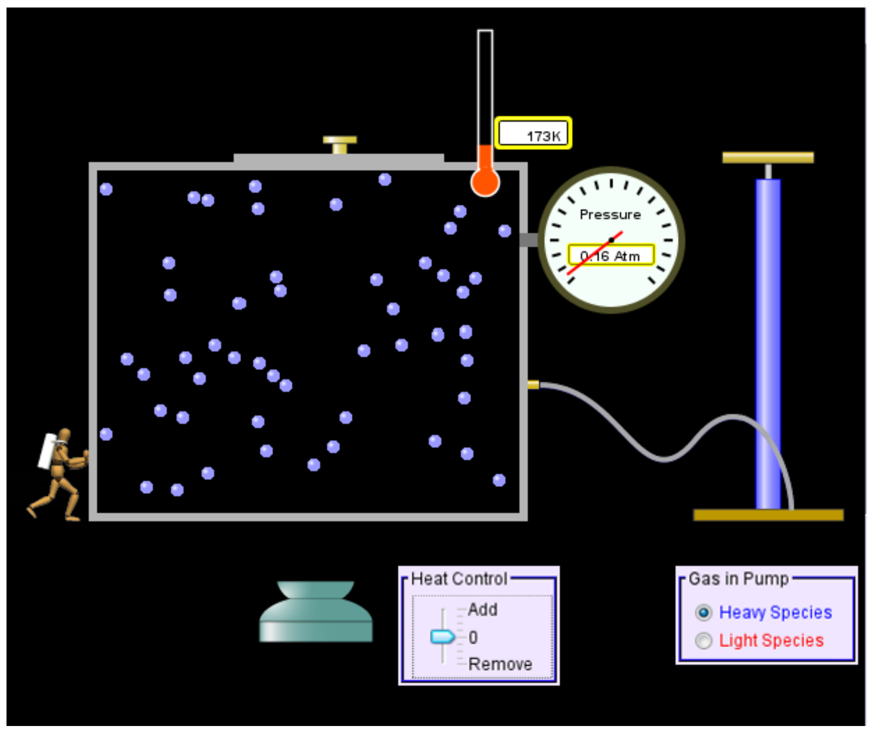
(____________ pressure).

If increase temperature (speed),

_________ collisions (_________ pressure).

If increase temperature (speed), volume

___________________.



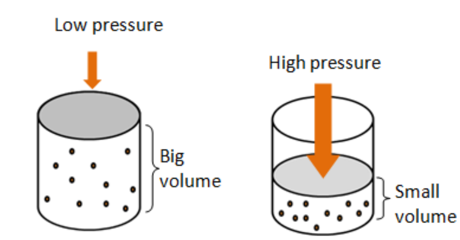
FACTORS AFFECTING PRESSURE

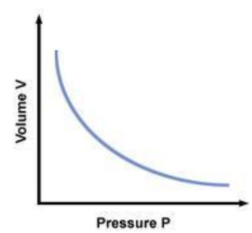
Amount of Gas (number of moles)	Increasing amount will increase Pressure and dec amount will dec pressure	Ex: adding more air to bicycle tires, car tires
Temperature	Increasing temp. will increase Pressure and dec temp will decrease pressure	Ex: Tires deflate in winter
Volume	Decreasing volume will increase P, increasing volume decreases P	Ex: press down on a balloon (decrease volume) and it pops

Gas Laws: ***A mathematical model to describe these relationships.***

PRESSURE VS. VOLUME: Boyle's Law ($P_1V_1 = P_2V_2$)

- As the **pressure** on a gas ______________, the **volume** of the gas ________________
- *(indirect relationship)*

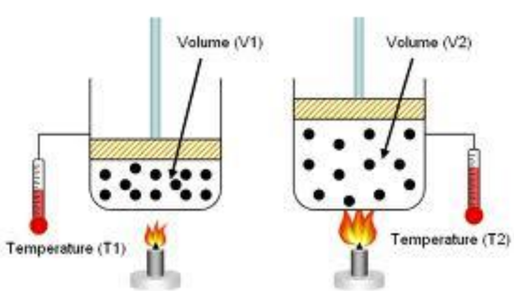




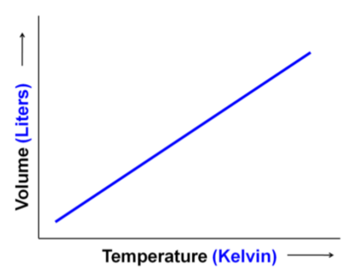
VOLUME VS. TEMPERATURE: Charles Law ($\frac{V_1}{T_1} = \frac{V_2}{T_2}$)

- When **Temperature** of a gas _______________, **Volume** _______________at constant pressure
- (*direct relationship)*

TEMPERATURE MUST BE IN KELVIN!!



-Lussac's law ($\frac{P_1}{T_1} = \frac{P_2}{T_2}$)



- When **Temperature** of a gas ______________, **Pressure** ________________ at constant volume
- *(direct relationship)*

TEMPERATURE MUST BE IN KELVIN!!

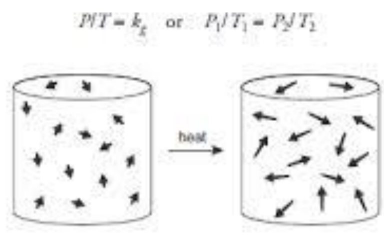
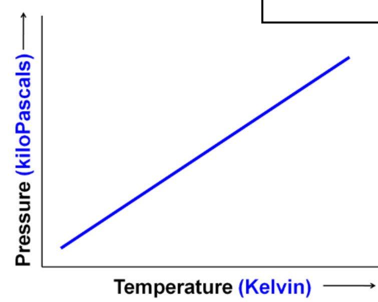


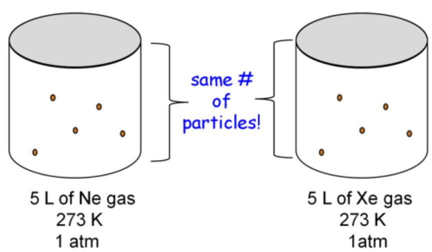
Figure 8.5 Pressure–temperature relationship for gases. As the temperature increases, the gas particles have greater kinetic energy (longer arrows) and collisions are more frequent and forceful.



AVOGADRO'S HYPOTHESIS:

- EQUAL VOLUMES of different gases at the same temperature and pressure contain EQUAL NUMBERS OF PARTICLES

EXAMPLE:
5 L of Ne gas at STP has the same number of molecules as 5 L of Xe gas at STP BECAUSE (same conditions, same volumes, same # of particles)



So, if given three of the four qualities below as being equal, the fourth will be as well…

- ▶ Amount (number of moles)
- ▶ Volume
- ▶ Temperature
- ▶ Pressure

EXAMPLE:

Which sample has the same number of particles as a 2L sample of Ne(g) at STP?

(a) 1L of Ne(g) at 273K and 1 atm
(b) 1L of CH_4(g) at 300K and 1 atm
(c) 2L of Ne(g) at 300K and 1 atm
(d) 2L of CH_4(g) at 273K and 1 atm

Choices (a) and (c) are the same gas as our sample, but Avogadro said we can ignore that!!

Match temperature, pressure, and volume – 273K and 1 atm (STP:Table A); 2L

Objective:

- ***Convert between pressure units (atm and kPa)***
- ***Convert from Celsius temperatures to Kelvin***
- ***Solve gas law problems using the combined gas law equation***

COMBINED GAS LAW

Located on Table T

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

P = pressure (kPa or atm)
V = volume (L, mL, cm^3)
T = temperature (K)

TEMPERATURE MUST BE IN KELVIN!!

HOW TO USE THE COMBINED GAS LAW EQUATION:

Make sure all temperatures are in **KELVIN !

** Make sure you use the same unit for BOTH volumes and BOTH pressures!

**** If one variable remains the same, leave it out of the equation!**

When solving combined gas law problems you may need to do the following conversions:

CONVERTING UNITS OF PRESSURE:

- set up a proportion (Table A)
- 1 atm = 101.3 kPa

EXAMPLE: What is the pressure in kPa of 0.92 atm?

$$\frac{0.92\ \text{atm}}{1\ \text{atm}} = \frac{x\ \text{kPa}}{101.3\ \text{kPa}}$$

x = (0.92)(101.3)

x = 93.2 kPa

CONVERTING UNITS OF TEMPERATURE:

- K = °C + 273 (Table T)
- Ex: What is 33.7°C equal to in Kelvins?

K = °C + 273

K = 33.7 + 273

= 306.7 K = 307 K

EXAMPLE:

A gas in a rigid container has a pressure of 3.5 atmospheres at 200K. Calculate the pressure at 273K**.**

“RIGID” = _______________ volume

Answer:

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

P_1 = **P_2 =**

V_1 = **V_2 =**

T_1 = **T_2 =**

EXAMPLE:

A 32.9L sample of a gas at constant pressure increases in temperature from 25 to 45°C. Should the volume increase or decrease? Calculate the new volume.

Answer:

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

P_1 = **P_2 =**

V_1 = **V_2 =**

T_1 = **T_2 =**

EXAMPLE:

A 45 mL sample of gas at standard pressure is heated from 20.°C to 50.°C. The pressure of the gas increases to 107.9 kPa. What is the new volume of the gas?

Answer:

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

P_1 = **P_2 =**

V_1 = **V_2 =**

T_1 = **T_2 =**

Additional Work Space

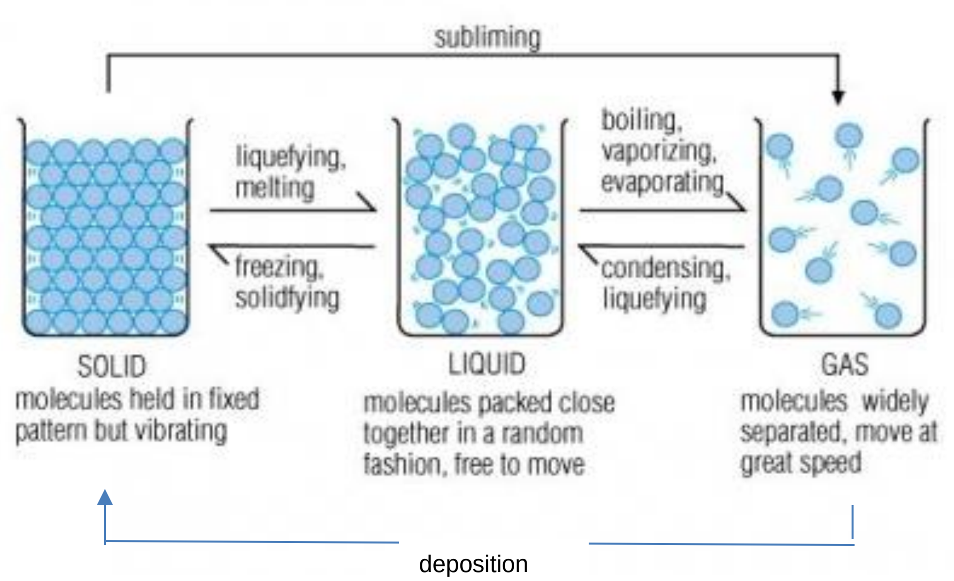
Lesson 4: Vapor Pressure and Boiling Point

Objective:

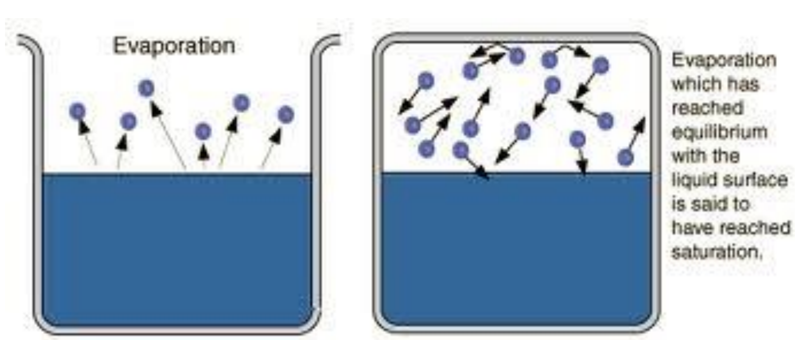
- ***Describe the relationship between intermolecular forces and vapor pressure***
- ***Differentiate between evaporation and boiling***
- ***Describe the relationship between pressure and boiling point***
- ***Determine the vapor pressure or boiling point of a substance using Table H***

What we already know:

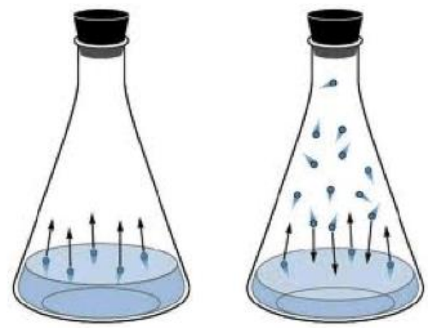
Liquid to Gas transition (vaporization) requires particles to separate (break their connections):



EVAPORATION: Molecules at the _______________ of liquid gain enough energy to overcome their IMF's and change to gas which causes pressure to build up above liquid (vapor pressure)



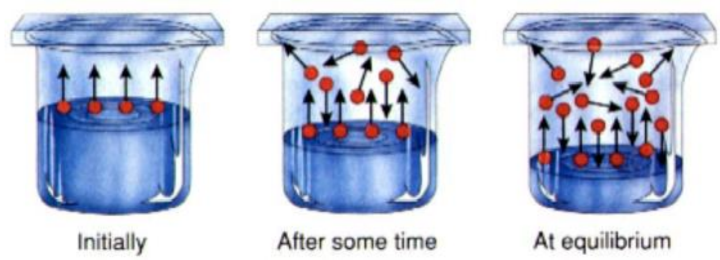
VAPOR PRESSURE: The pressure exerted by vapor (gas) above a liquid at equilibrium



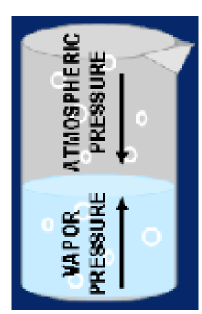
The higher the temperature, the ______________ the vapor pressure

LIQUID-VAPOR EQUILIBRIUM: Some of the gas particles condense and then we find <u>both evaporating and condensing occurs at the same rate.</u> [IN A CLOSED SYSTEM!]

Rate of Evaporation = Rate of Condensation



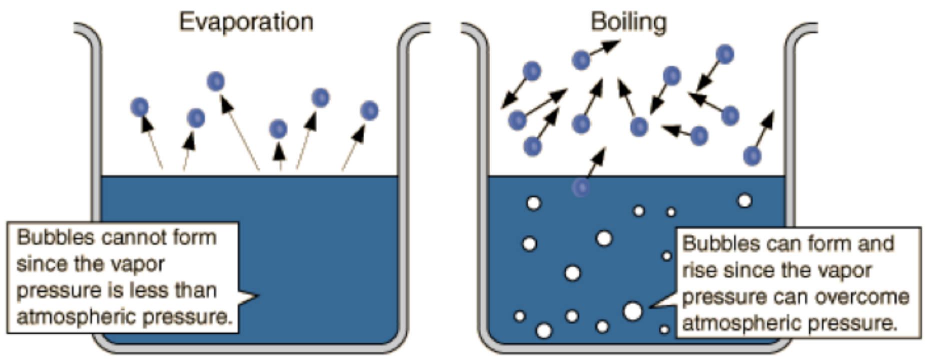
BOILING: Boiling occurs when the **vapor pressure** becomes **equal** to or greater than the **atmospheric pressure**. Allows vaporization *THROUGHOUT* the sample *(the bubbles you observe).*



At standard pressure (normal atmospheric pressure), the temperature where this occurs is called the <u>normal boiling point</u>.

EVAPORATION vs BOILING:

- Evaporation occurs on the surface
- Boiling occurs throughout the sample



VAPOR PRESSURE, BOILING POINT, AND ATTRACTIVE FORCES (IMF'S):

Vaporization occurs when heat energy overcomes attractive forces between molecules, so the

_________________ the intermolecular force, the ___________________ the vapor pressure, and vice versa!

IMF	Effect on Vapor Pressure and Boiling point	Reason
The stronger the IMF	The lower the vapor pressure The higher the boiling pt	Takes **MORE** energy to break the forces of attraction (IMF's) between particles
The weaker the IMF	The higher the vapor pressure The lower the boiling pt	Takes **LESS** energy to break the forces of attraction (IMF's) between particles

PRESSURE EFFECTS ON BOILING POINT:

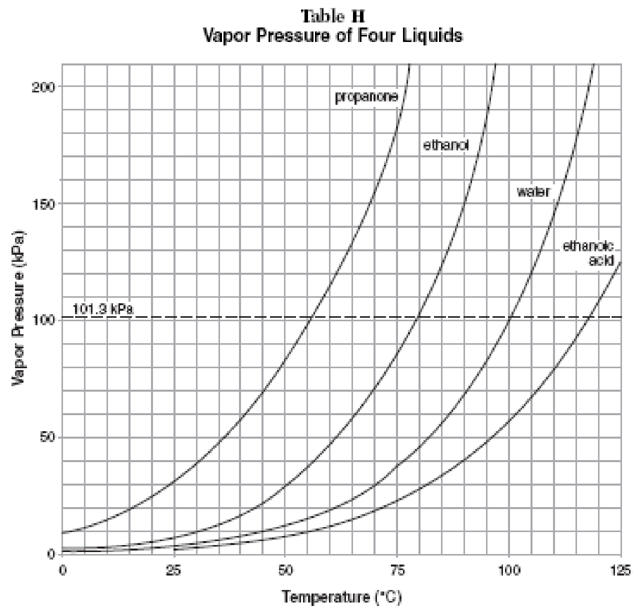
Because boiling requires vapor pressure = to atmospheric pressure, *A CHANGE IN ATMOSPHERIC PRESSURE CHANGES THE BOILING POINT* (temperature).

The lower the pressure pushing down on the liquid, the lower the vapor pressure needed to match it, hence the lower the temperature where this occurs (boiling point).

This is why at altitude, cooking pasta will take longer!!

TABLE H: VAPOR PRESSURE and TEMPERATURE

- Note the axes intervals:
  - Temperature by ____°C
  - Vapor Pressure by _____kPa



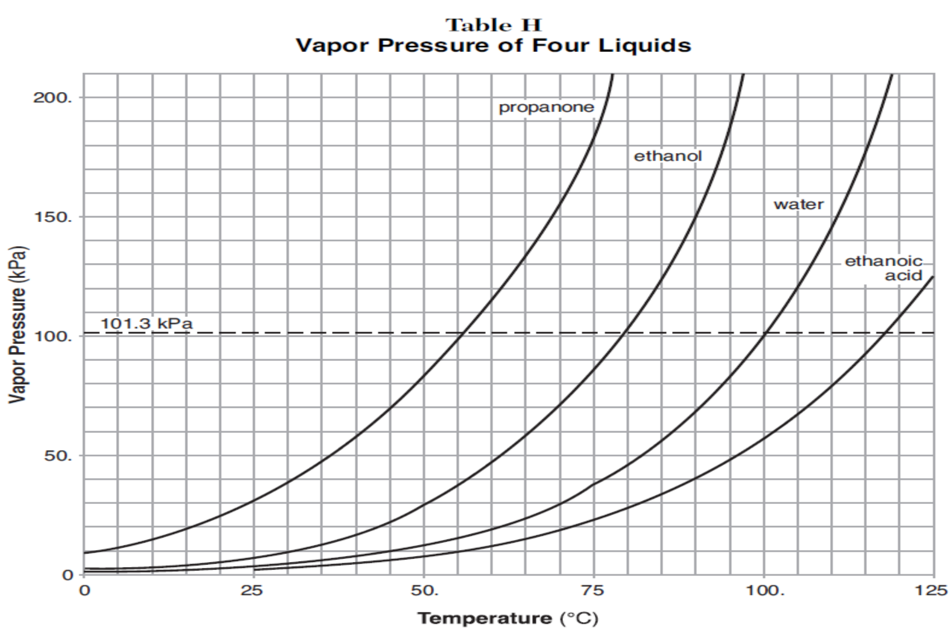
- Note the four substances
- The lower the Vapor Pressure, the greater the IMF

_______________has weakest IMF
_______________has strongest IMF

- The dotted line represents standard pressure and therefore normal boiling point

USING TABLE H:

EXAMPLE: What is the vapor pressure of ethanol at 40°C?



EXAMPLE: At what temperature will water boil at at pressure of 30. kPa?