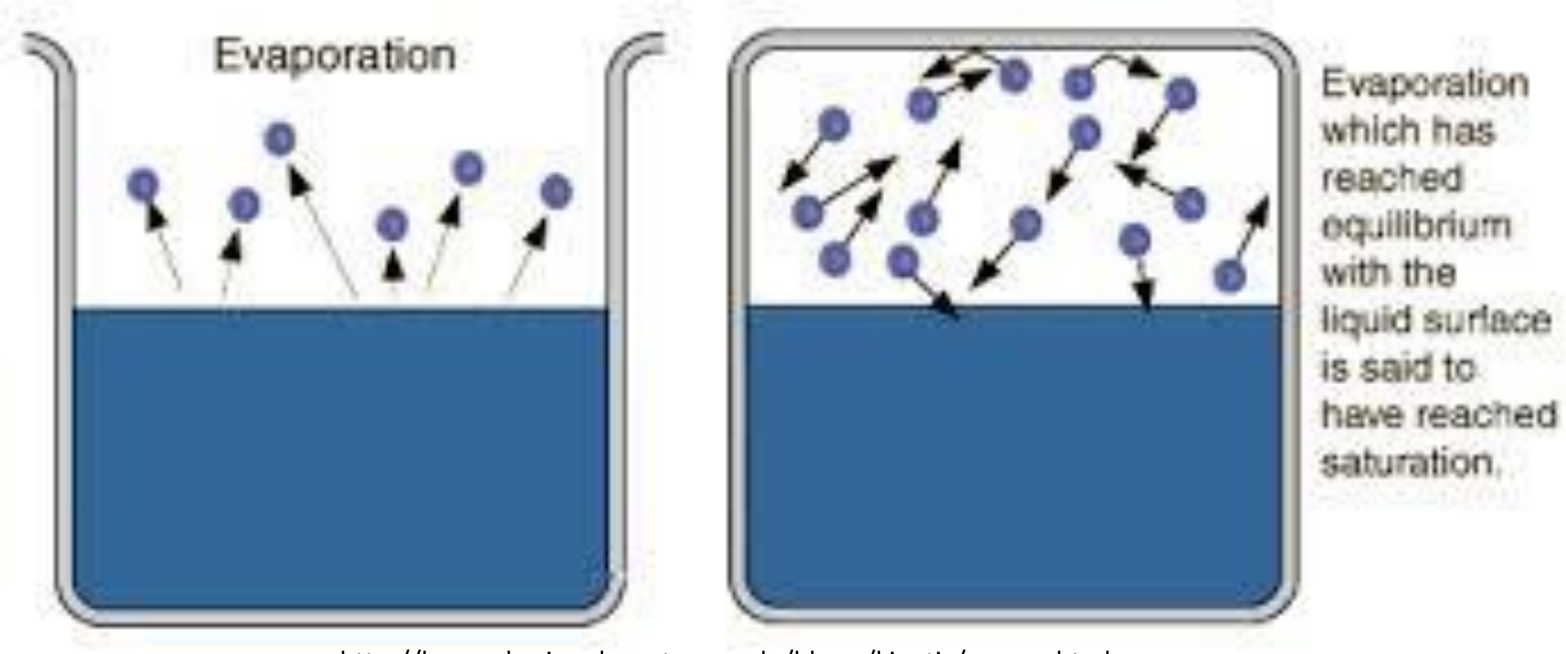
Vapour Pressure



http://hyperphysics.phy-astr.gsu.edu/hbase/kinetic/vappre.html

Outcomes:

- Operationally define vapour pressure

Vapour Pressure:

Recall that in order for a liquid to **VAPORIZE**, it must overcome the **FORCE** of the **ATMOSPHERIC PRESSURE**.

Vapour Pressure (P_{vap})

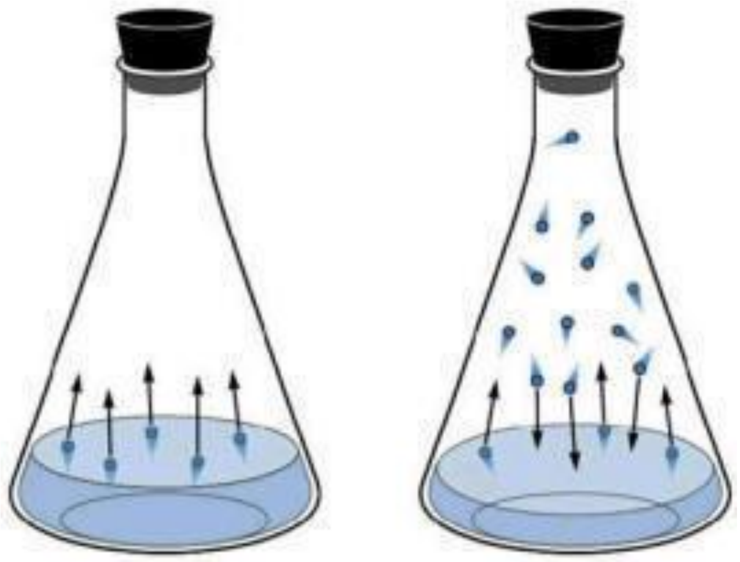
- Is the pressure of the **VAPOUR** of a **SOLID** or **LIQUID** in **EQUILIBRIUM** with the solid or liquid state.
- Is a **PHYSICAL PROPERTY** that can be **MEASURED**
- When you heat a liquid, you **INCREASE** the P_{vap} causing boiling.
- In order for **BOILING** to occur:

$$P_{vap} \geq P_{atm}$$

- This means that the **LOWER** the **PRESSURE** of the **ATMOSPHERE**, the **LOWER** the **BOILING POINT**.

Boiling Point of Water		
Sea Level (101 kPa)	Banff (84.5 kPa)	**Mt. Everest (33.7 kPa)**
100 °C	**95 °C**	**70 °C**

Vapour Pressure:



In a **SEALED** container:

http://www.teachnlearnchem.com/Vapor%20Pressure%20and%20Boiling%20Point.htm

- **LIQUID** molecules will **EVAPORATE**, but can also hit the surface and become **LIQUID AGAIN**.
- **RATE** of **VAPORIZATION** will depend on **TEMPERATURE**.
  - If **TEMPERATURE** is **CONSTANT**, **RATE** of vaporization will stay **CONSTANT**, and the rate of **CONDENSATION** will **INCREASE**.

Eventually: ***Liquid ←→ Vapour***

- At this point vapour molecules exert a pressure called **EQUILIBRIUM VAPOUR PRESSURE** by colliding with the walls of the container.

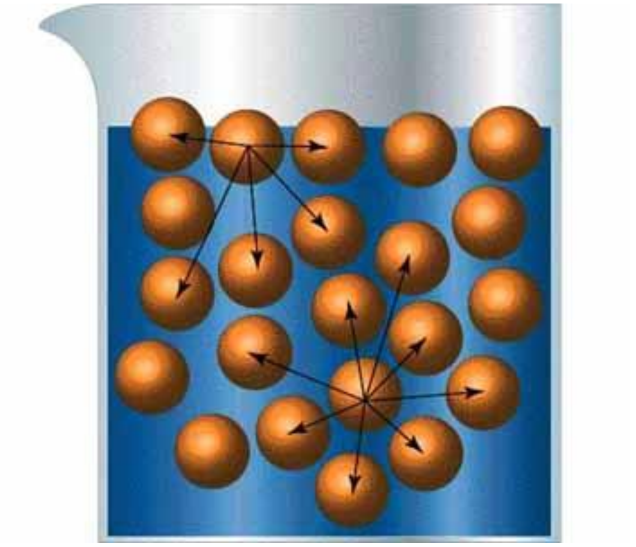
Factors Affecting Rate of Evaporation:

Influence on Rate of Vaporization

We have learned that **SURFACE MOLECULES** are more likely to escape as vapour. This is because there are more molecules surrounding the interior molecules. Several factors influence the rate of vaporization:

1. Intermolecular Forces

- Polar substances have **STRONGER IMF'S** holding them together, therefore have **LOWER VAPOUR PRESSURES**.
- **MORE FORCES** means its **HARDER** for the molecules to **ESCAPE** to the gas phase

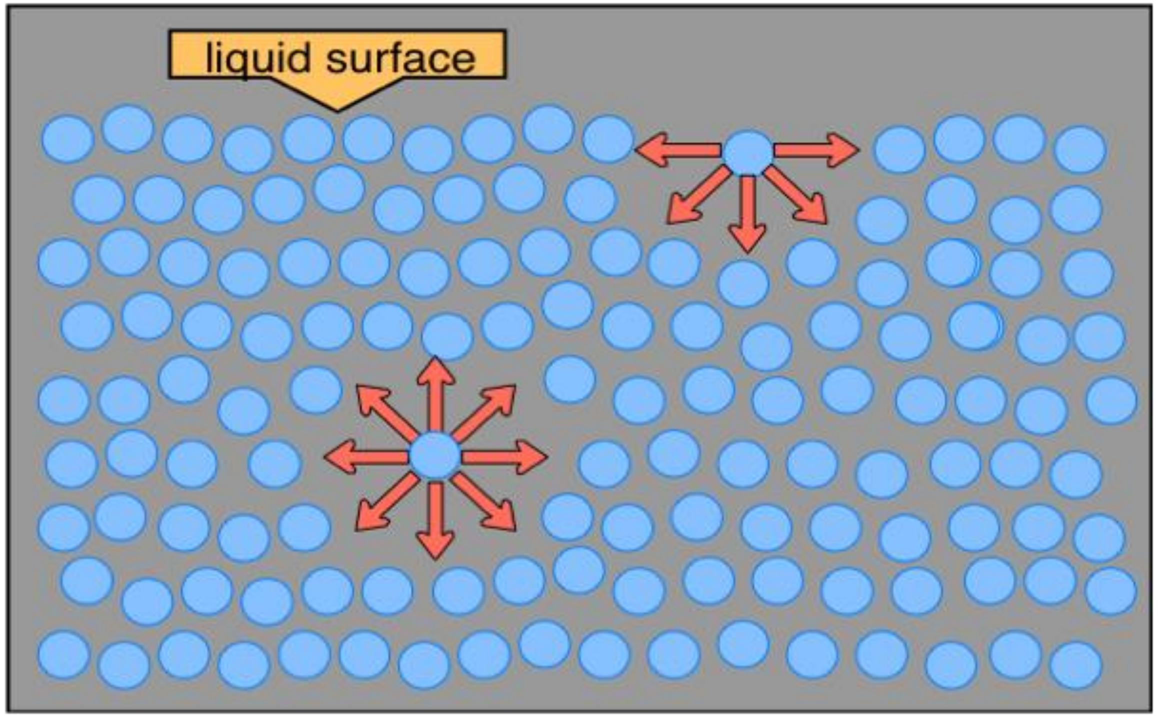


https://socratic.org/questions/how-are-intermolecular-bonds-and-viscosity-related

Factors Affecting Rate of Evaporation:

2. Surface area

- **SURFACE** molecules are the **MOST LIKELY** to **ESCAPE** since they have **LESS FORCES** holding them in the liquid phase:

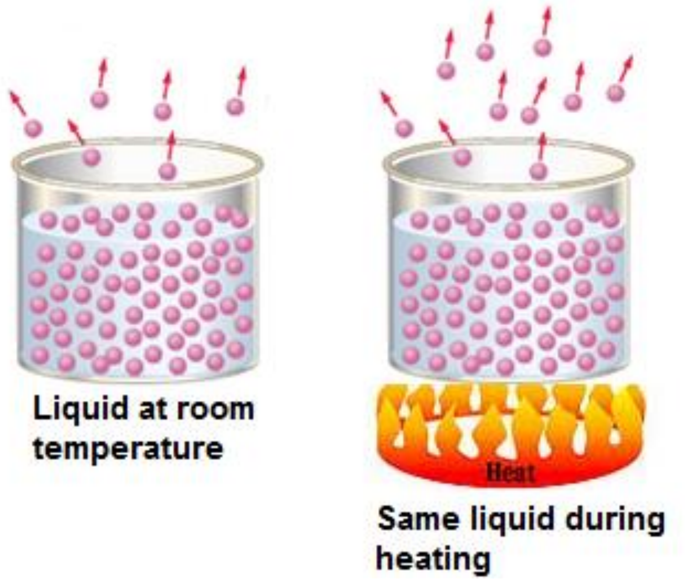


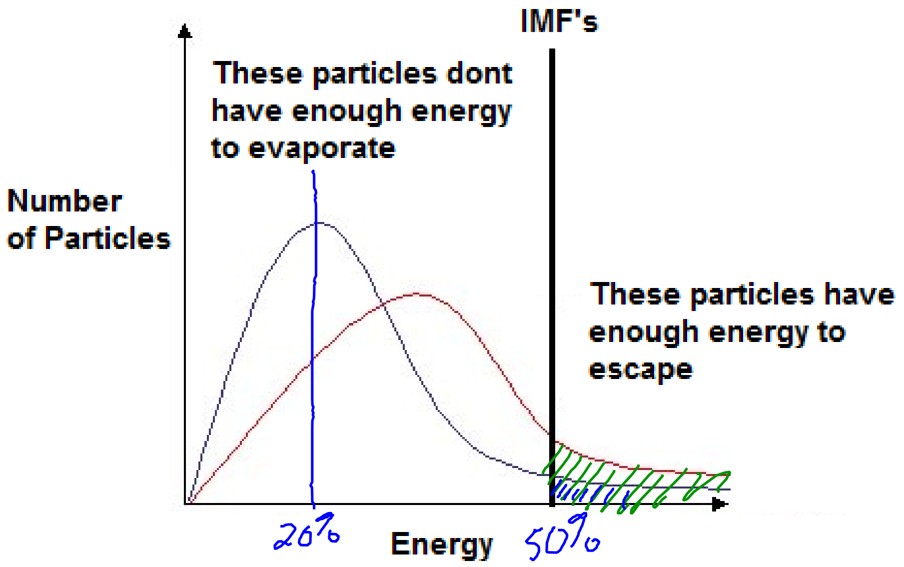
- If we **INCREASE** surface area of a liquid, we **INCREASE** the **RATE** of vapourization (more molecules can escape).

Factors Affecting Rate of Evaporation:

3. Temperature

- **TEMPERATURE** increases kinetic **ENERGY** of the molecules, allowing more to escape, **INCREASING** vapour **PRESSURE**.

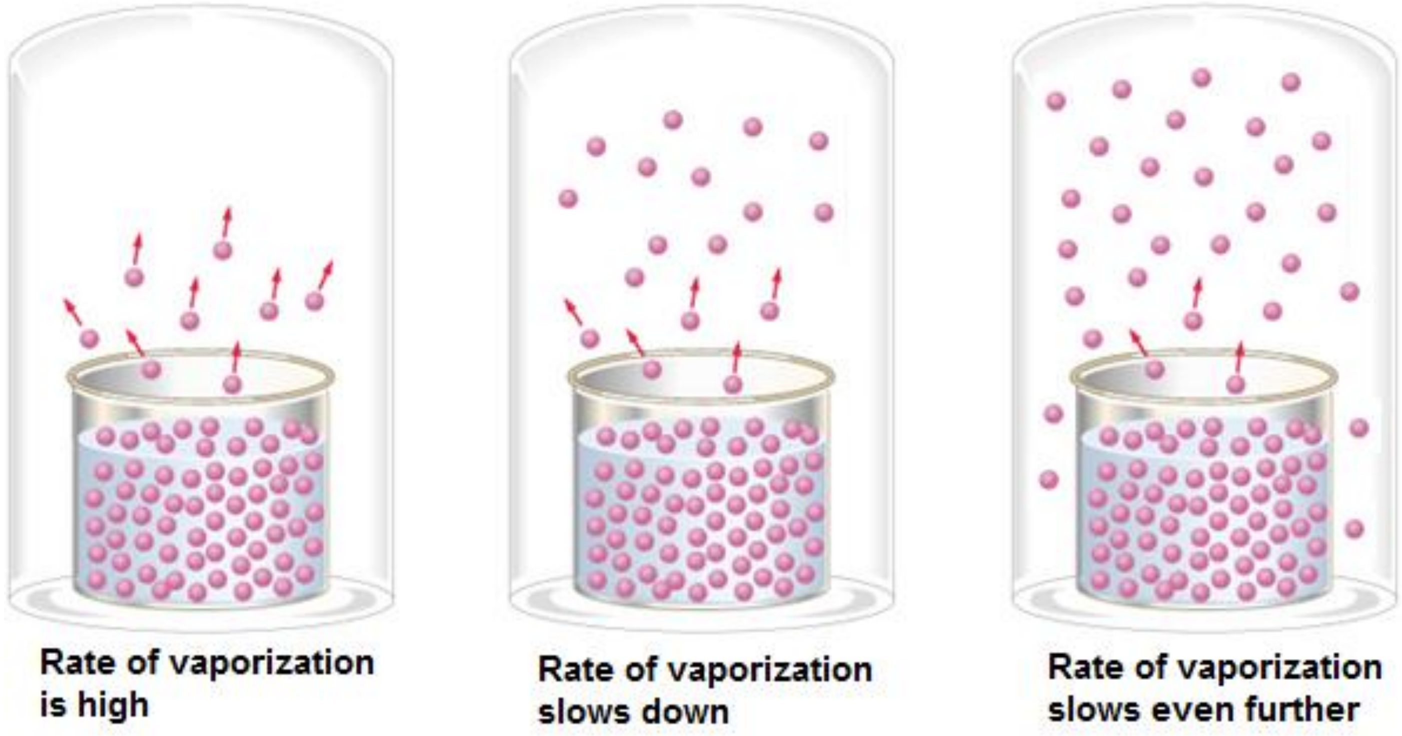




Factors Affecting Rate of Evaporation:

4. Concentration of vapour molecules above liquid

- More vapour = **LESS ROOM** for new **VAPOUR** molecules, hence **LESS VAPOURIZATION**.

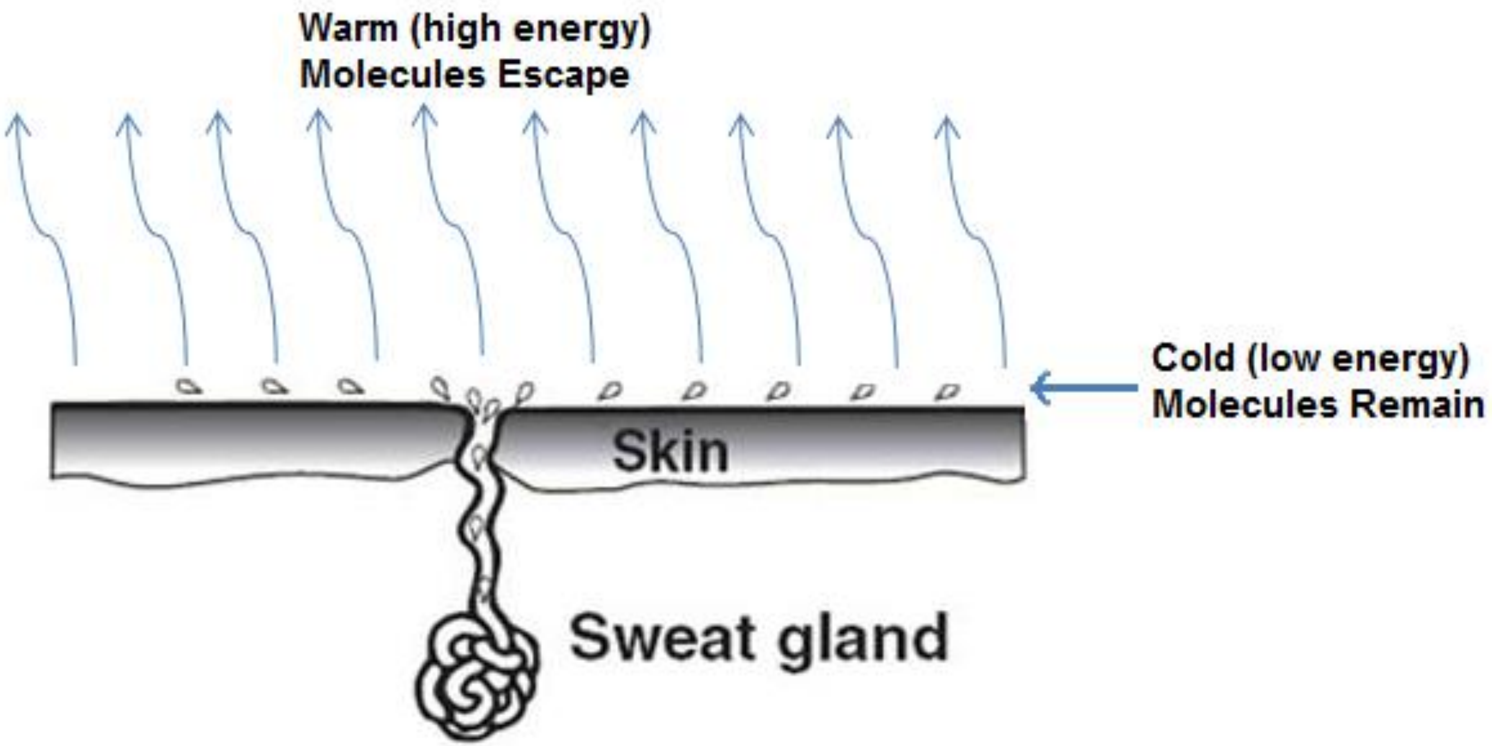


http://dluetgens.com/vapor_pressure_equilibrium.html

Evaporative cooling:

Vaporization is a **COOLING** process…

→ Sweat that evaporates has a higher **KINETIC ENERGY** than sweat that **REMAINS**, therefore remaining sweat has a **LOWER TEMPERATURE**.



http://pahs.pasd.com/common/pages/DisplayFile.aspx?itemId=2966486

Simple Cooling Devices:

Evaporative Cooling

- When **EVAPORATION** occurs, particles with the **HIGHEST KINETIC ENERGIES** are **ESCAPING** into the gas phase.
- Molecules left behind have **LOWER** kinetic **ENERGIES**, causing a **DECREASE** in the **AVERAGE** kinetic **ENERGY** of particles in the **LIQUID**.
- The **DECREASE** in kinetic **ENERGY** is observed as a **DECREASE** in **TEMPERATURE** → ***evaporative cooling*.**

This principle was used before refrigerators by people in warm climates. They would put liquids in porous clay pots which allowed evaporation through the clay, leaving the cooler molecules behind. The clay would also insulate the liquid from outside heat.

Effect on Climate:

Moderating Effects of Large Bodies of Water…

- In the fall, as the temperature drops below that of an ocean or large lake, the water gives up its energy (heat) to the atmosphere, moderating the drop in air temperature.
- In the summer, as the temperature rises, an ocean or lake will absorb the heat, moderating the rise in air temperature.
- It takes an exchange of a tremendous amount of energy to heat or cool an ocean, causing a gradual drop/rise in both air and water temperature.

Effect on Climate:

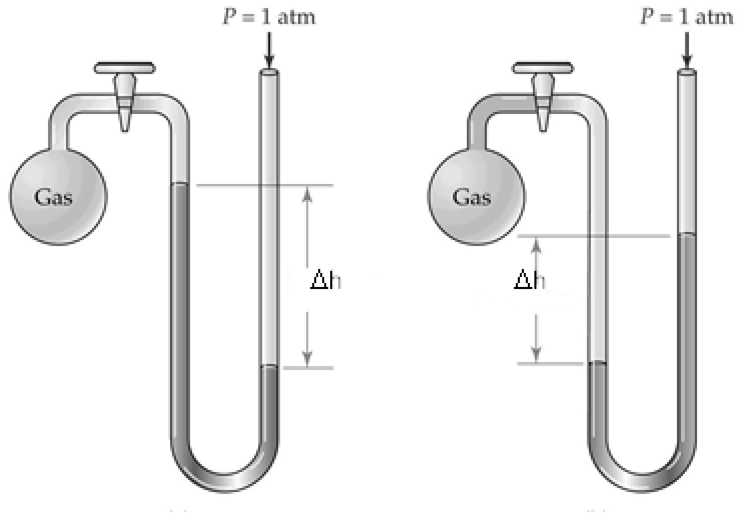
The land absorbs heat from the Sun more quickly than the water does. The air over the land becomes warmer as some of this absorbed heat is radiated back into the air. The warmer air begins to rise, and the cooler air over the water moves in to take its place.

As the Sun goes down, the land cools off quickly, but the water does not. The water radiates some of its stored heat into the air, and this warmed air begins to rise. The cooled air over the land moves in to take the place of the rising warm air over the water.

Measuring Vapour Pressure:

We measure vapour *pressure using* an **OPEN-END MANOMETER.**

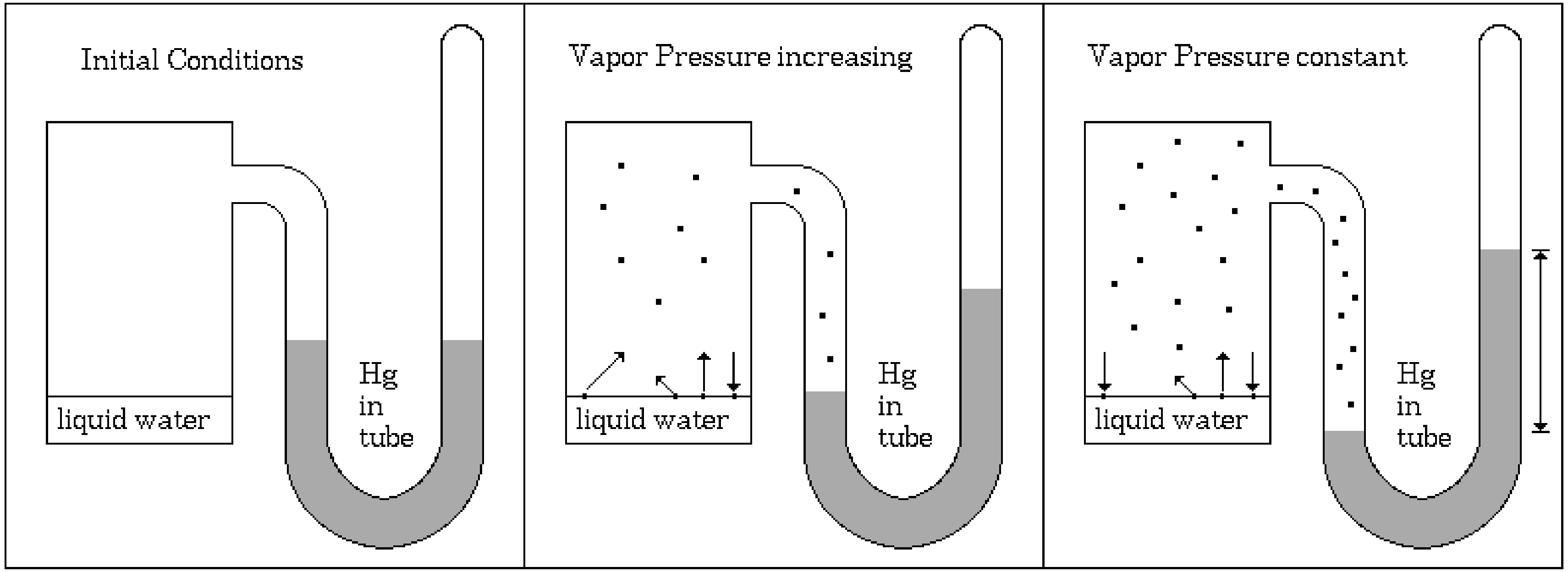
The **MANOMETER** works by comparing the pressure of the **VAPOUR** to that of the **ATMOSPHERE**.



One end of a "**U-TUBE**" is connected to a vessel containing the **GAS**, and the other is open to the **ATMOSPHERE**. The u-tube contains a **KNOWN VOLUME** of liquid (usually **MERCURY**).

Δh is the **DIFFERENCE** between the **HEIGHT** of mercury in **EACH SIDE** of the u-tube, measured in **mmHg**.

Measuring Vapour Pressure Using a Manometer



Measuring Vapour Pressure:

We can find the **PRESSURE** of the **GAS** by **ADDING** or **SUBTRACTING** Δ*h* from the actual **ATMOSPHERIC** pressure.

There are three conditions possible with a manometer:

1. $P_{vap} = P_{atm}$

   - ***Level of mercury will be equal on both sides of the "u-tube". (Δh = 0)***

2. $P_{vap} > P_{atm}$

   - ***Mercury on right will be higher than Mercury on left.***

$$P_{vap} = P_{atm} + \Delta h$$

3. $P_{vap} < P_{atm}$

   - ***Mercury on left will be higher than Mercury on right.***

$$P_{vap} = P_{atm} - \Delta h$$

Converting Pressure Units:

We will have to be able to convert between different pressure units. Remember the units for standard pressure:

1atm = 101.3kPa = 760mmHg

Example Conversions:

Convert the following to the other two pressure units:

a. 650mmHg $\times \frac{1 \text{ atm}}{760 \text{ mmHg}} = 0.855 \text{ atm}$

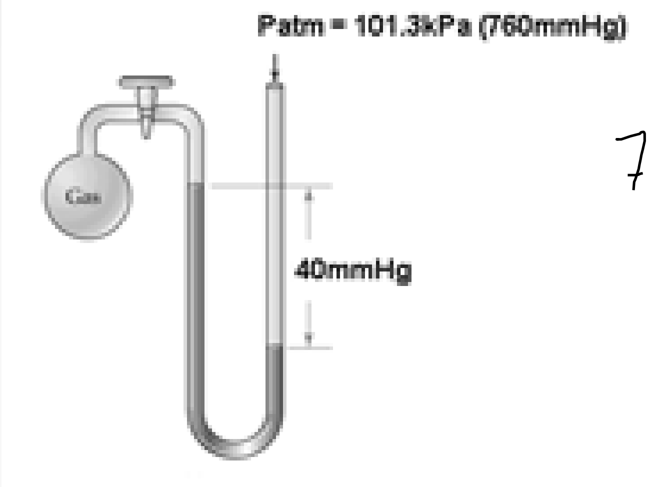
$650 \text{ mmHg} \times \frac{101.3 \text{ kPa}}{760 \text{ mmHg}} = 86.64 \text{ kPa}$

b. 110.5kPa $\times \frac{1 \text{ atm}}{101.3 \text{ kPa}} = 1.09 \text{ atm}$

$110.5 \text{ kPa} \times \frac{760 \text{ mmHg}}{101.3 \text{ kPa}} = 829.02 \text{ mmHg}$

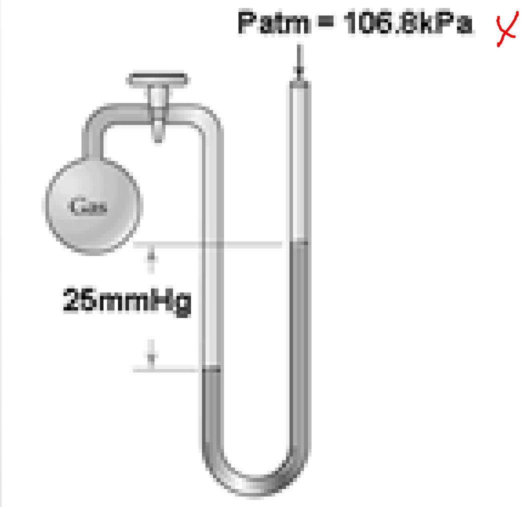
Reading a Manometer Examples:

1. Assuming the valve is open, what is the pressure of the gas in kilopascals?



$$760\,mmHg - 40\,mmHg = 720\,mmHg \times \frac{101.3\,kPa}{760\,mmHg} = 95.97\,kPa$$

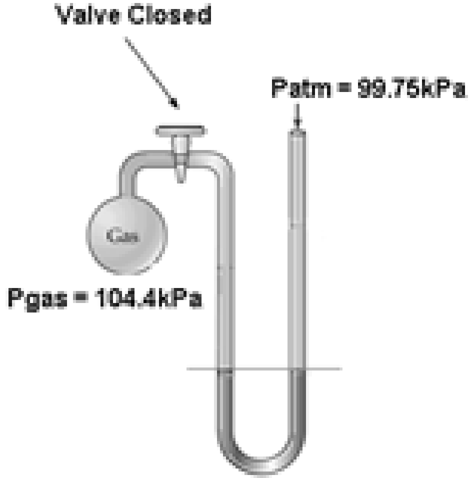
2. Determine the pressure of the gas in mmHg and kPa.



$$\times \frac{760\,mmHg}{101.3\,kPa} = 801.26\,mmHg + 25 = 826.26\,mmHg \times \frac{101.3\,kPa}{760\,mmHg} = 110.13\,kPa$$

Reading a Manometer Examples:

3. When the valve in the manometer to the right is opened, will the mercury in the right arm of the U-tube move up or down?



$P_{gas} > P_{atm}$

4. After the mercury stops moving in the manometer from question #3, what will be the difference in height (Δh) in the two arms of the tube?

$P_{gas} - P_{atm} = \Delta H$

$\Delta H = 4.65\ kPa \times \frac{760\ mmHg}{101.3\ kPa} = 34.88\ mmHg$