# Announcements – Lecture IV – Thursday, Feb 1st

1. Class Web Site: https://genchem.chem.umass.edu – Under Spring, click on Chem 112 – the click on my picture!

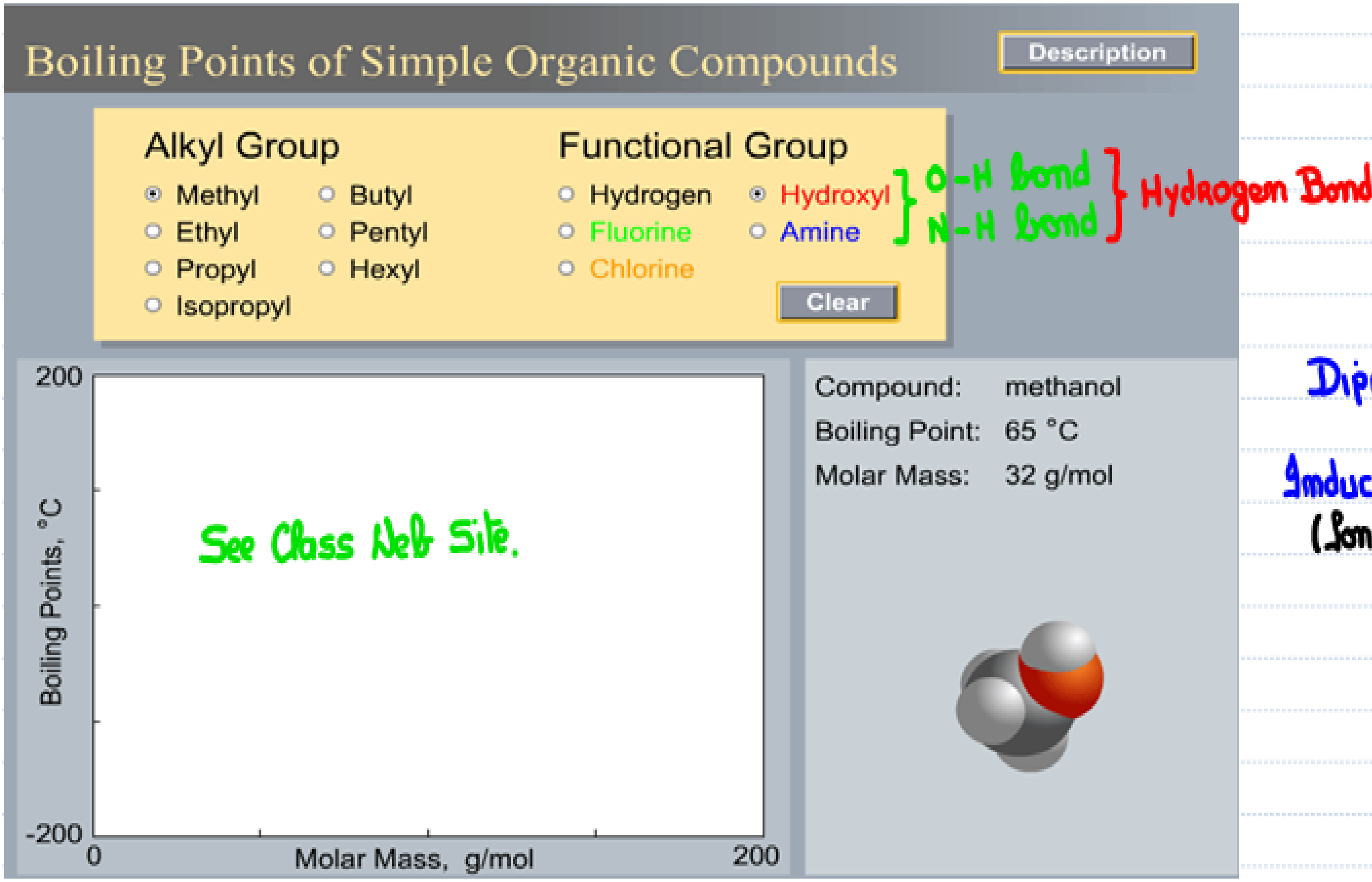
2. Clicker for Credit: Starts today!

3. Quiz 1: Will be collected in class on Tuesday, Feb 6th.

# 11.4 The Nature of Intermolecular Forces

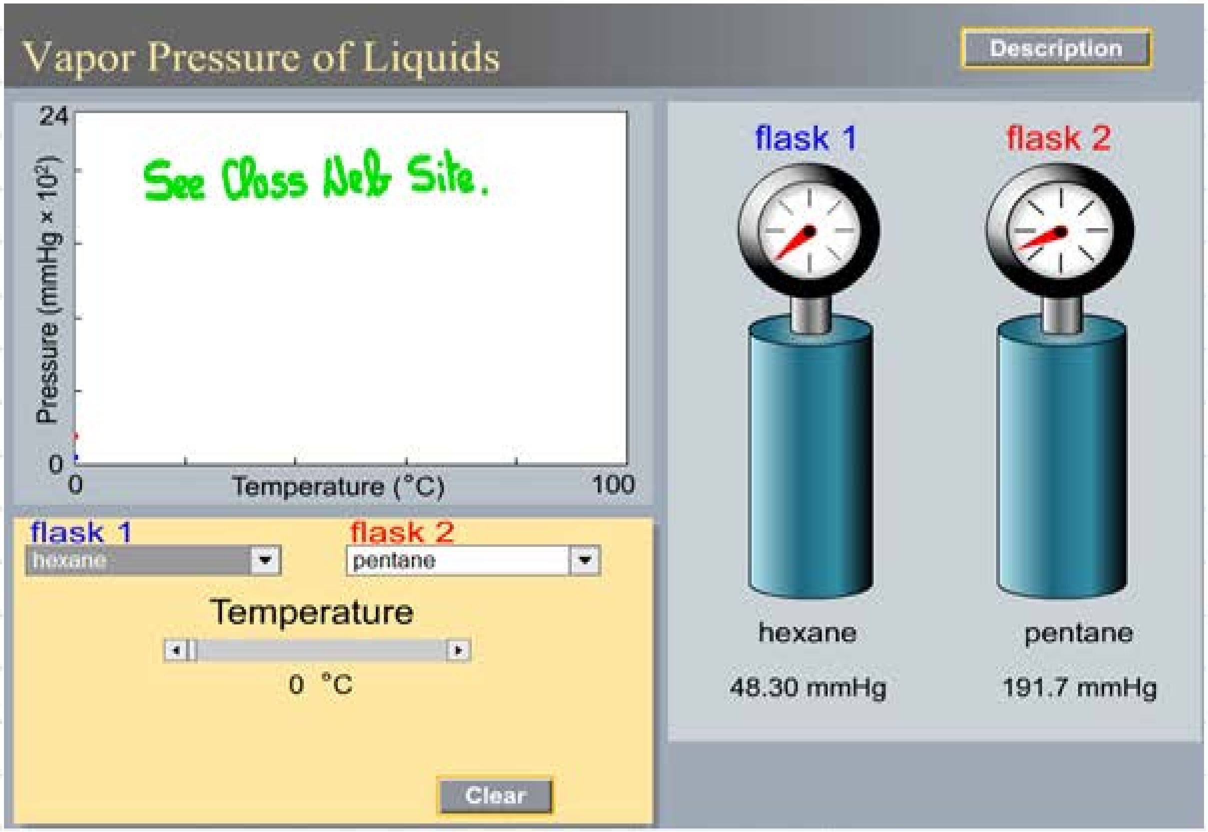
## London Dispersion Forces – Stronger than you might think

*Boiling Points of Simple Organic Molecules*




Dipole - Dipole
vs
Induced Dipole - Induce Dipole
(London Dispersion Forces)

# 11.2 Vapor Pressure




VP = Vapor Pressure.

a) VP Vs T

b) VP Vs Molar Mass (non-polar)

c) VP in polar molecules Vs
VP in non-polar molecules.

## 11.2 Vapor Pressure

### Heat of Vaporization

The amount of heat required to convert a liquid to a gas: $\Delta H^\circ_{vap}$

Which of the following molecules would you expect to have the smallest $\Delta H^\circ_{vap}$

1. $CH_3OH$
2. $C_2H_6$ ✓
3. $C_4H_{10}$

Why?

Non-polar with a smaller Molar Mass than $C_4H_{10}$ which is also non-polar. $CH_3OH$ is polar.

# 11.2 Vapor Pressure

## Relationship Between P, T, and $\Delta H^\circ_{vap}$ – Clausius-Clapeyron Equation

$$\ln P = \frac{-\Delta H^\circ_{vap}}{RT} + C$$

$\Delta H^\circ_{vap}$ = Heat of Vaporization.
$R$ = 8.314 $J.mol^{-1}.K^{-1}$ (Ideal Gas Constant)

a) GRAPHICALLY:

Plot: $\ln P$ vs $\frac{1}{T}$ : T must be in K

$$\text{Slope} = \frac{-\Delta H^\circ_{vap}}{R}$$

b) QUANTITATIVELY:

$$\ln P_1 = \frac{-\Delta H^\circ_{vap}}{RT_1} + C \qquad \ln P_2 = \frac{-\Delta H^\circ_{vap}}{RT_2} + C$$

$$\ln P_2 - \ln P_1 = \frac{-\Delta H^\circ_{vap}}{RT_2} + C + \frac{\Delta H^\circ_{vap}}{RT_1} - C$$

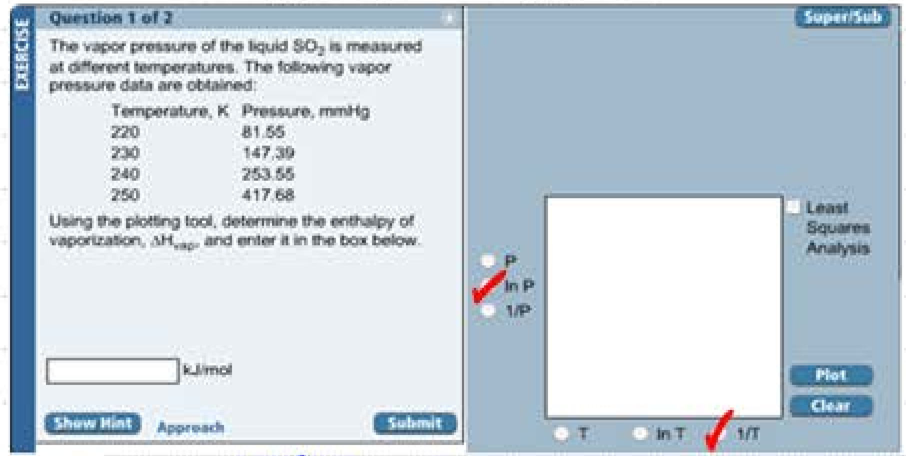
$$\ln P_2 - \ln P_1 = \frac{\Delta H^\circ_{vap}}{RT_1} - \frac{\Delta H^\circ_{vap}}{RT_2}$$

$$\ln \frac{P_2}{P_1} = \frac{\Delta H^\circ_{vap}}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

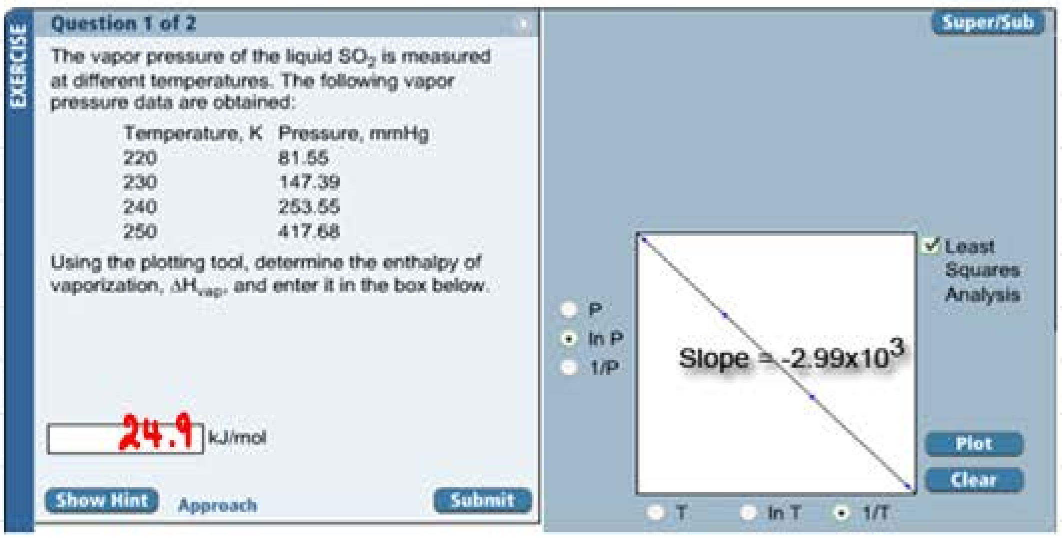
# 11.2 Vapor Pressure

## Clausius-Clapeyron Equation – Graphical Method

Determine enthalpy of vaporization graphically




Determine enthalpy of vaporization graphically




$$-\frac{\Delta H^{o}_{vap}}{R} = \text{slope}$$

$$= -2.99 \times 10^{3}$$

$$-\Delta H^{o}_{vap} = -2.99 \times 10^{3} \, (8.314)$$

$$= -2.49 \times 10^{4} \text{ J.mol}^{-1}$$

$$\Delta H^{o}_{vap} = 2.49 \times 10^{4} \text{ J.mol}^{-1}$$

$$= 24.9 \text{ kJ.mol}^{-1}$$

# 11.2 Vapor Pressure

## Clausius-Clapeyron Equation – Quantative

From the following vapor pressure data for heptane, an estimate of the molar heat of vaporization of $C_7H_{16}$ is

| P, mm Hg | T, Kelvins |
|---|---|
| 100 | 315 |
| 400 | 351 |

$$\ln \frac{P_2}{P_1} = \frac{\Delta H^\circ_{vap}}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

$P_1 = 100$ $T_1 = 315$

$P_2 = 400$ $T_2 = 351$

$$\ln \frac{400}{100} = \frac{\Delta H^\circ_{vap}}{R}\left(\frac{1}{315} - \frac{1}{351}\right)$$

$$\ln 4 = \frac{\Delta H^\circ_{vap}}{R}(3.26 \times 10^{-4})$$

$$1.39 = \frac{\Delta H^\circ_{vap}(3.26 \times 10^{-4})}{R}$$

$$\Delta H^\circ_{vap}(3.26 \times 10^{-4}) = 1.39 \times 8.314$$

$$\Delta H^\circ_{vap} = \frac{1.39 \times 8.314}{3.26 \times 10^{-4}}$$

$$= 3.54 \times 10^4 \text{ J.mol}^{-1}$$

OR

$$35.4 \text{ kJ.mol}^{-1}$$

## 13.1 Quantitative Expressions of Concentration

### Units of Concentration – Molarity, Molality, Mole Fraction, Weight %

Solution = Solute + Solvent

↳ that which is present in the greatest amount.

**Molarity:** only one you met in Chem 111.

$$M = \frac{\text{Moles of solute}}{\text{Volume of solution in L}}$$

Drawback: We know nothing quantity wise about the solvent.

**Mole Fraction:**

$$X = \frac{\text{moles of solute}}{\text{moles of solute + moles of solvent}}$$

**Molality:**

$$m = \frac{\text{moles of solute}}{\text{mass of solvent (kg)}}$$

Drawback: We know nothing quantity wise about the solution.

**Weight %**

$$\text{Wt \% A} = \left(\frac{\text{mass A}}{\text{mass A + mass B + ...}}\right)100$$