Workshop #12: Vapor Pressure

The stronger the intermolecular forces that exist between liquid molecules, the less likely they will escape into the vapor phase. Boiling point (which you explored in Workshop #11) and vapor pressure are both good measures of intermolecular forces. In the following problem set, you will analyze some provided "experimental" data in order to calculate the vapor pressure of a liquid.

Vapor pressure is defined as the pressure of a vapor that is in equilibrium with its liquid. It is controlled by 2 factors:

1. temperature – the higher the temperature, the greater kinetic energy the liquid molecules possess; therefore, they vaporize more readily, hence increasing the vapor pressure.

2. molar heat of vaporization, ΔH_{vap} – the energy required to change a liquid to a gas at its boiling point. The stronger the intermolecular forces, the harder it is to pull liquid molecules apart, and therefore the higher its ΔH_{vap}, which decreases its vapor pressure.

The Clausius-Clapeyron Equation relates the three quantities vapor pressure, ΔH_{vap}, and temperature according to the equation:

$$\ln VP = -\frac{\Delta H_{vap}}{RT} + B$$

Notice this equation fits the slope-intercept form $y = mx + b$, so if ln VP is plotted against $1/T$, a straight line results with $-\Delta H_{vap}/R$ as the slope. You will use this equation and the provided "experimental" data to calculate an unknown liquid's ΔH_{vap} and its boiling point at a particular temperature. Consider the following:

	Temperature, t, (in °C)	Heights of Manometer Mercury Levels (in mm)		Vapor Pressure (in mmHg or torr)
		open to atm	atm + VP trapped on gas side	
1.	1.2	250	228	_____
2.	21.1	265	205	_____
3.	40.0	297	142	_____

4. Boiling Point: 76 °C   Barometric Pressure: 752 torr

Name: _____   Section: _____

Now fill in the following table to prepare for the graph:

t, °C	T, Kelvin	1 / T, K⁻¹	VP, mmHg	ln VP
1.2				
21.1				
40.0				

Graph ln VP vs. 1 / T on Microsoft Office Excel® (see Experiment #2 in this lab manual for directions on using Excel®). According to the Clausius-Clapeyron equation, the slope is equal to $-\Delta H_{vap}$ / R. Using R = 8.314 x 10⁻³ kJ / mole·K, calculate ΔH_{vap} for the liquid:

slope = $\Delta y/\Delta x = \Delta(lnVP)/\Delta(1/T)$ = _____ = $-\Delta H_{vap}/R$ (rearrange to solve for ΔH_{vap})

SHOW CALCULATION:

Therefore, ΔH_{vap} = _____ kJ / mole

From the graph, you can also calculate what the liquid's boiling point should be at the "experimental" barometric pressure. Recall that boiling point is the temperature where the vapor pressure is equal to the atmospheric pressure.

"Experimental" barometric pressure _____ mmHg
(= the VP needed for boiling)

ln (barometric pressure)   _____

1 / T at this vapor pressure   _____ K⁻¹ (from the graph)

T at this pressure   _____ K

t at this pressure   _____ °C (= the predicted boiling point)

"Experimental" boiling point   _____ °C

Make sure to submit your properly labeled graph when submitting this Workshop!