Worksheet: Determine Antoine constants for saturation pressure

Name(s)_____

This experiment measures the saturation pressure (vapor pressure) of a single component over a range of temperatures by injecting sufficient liquid into an evacuated tank at constant temperature to obtain vapor-liquid equilibrium. The constants in the Antoine equation are determined from a series of temperature/pressure measurements. The Clausius-Clapeyron equation is used to obtain the heat of vaporization.

Student learning objectives

1. Be able to describe how saturation pressure changes with temperature.
2. Be aware of how saturation pressure can be measured.
3. Know how to use Excel Solver to determine parameters when fitting data to a model.

Equipment

- A spherical tank in a constant-temperature bath. The tank has a port through which liquid is injected. The pressure gauge on the tank reads absolute pressure. The tank has a pressure relief valve to avoid pressures above the tank rating.
- A vacuum pump attached to the tank allows the tank to be evacuated.
- A heater and temperature controller in the tank allows the temperature to be adjusted.
- A beaker of the liquid and a liquid syringe.

Questions to answer before starting experiment

Given a limited temperature range for experiments because of the pressure rating of the tank, how should the temperatures chosen for measurement be distributed? That is, should the temperatures be equally spaced in the range or weighted more to higher or lower temperatures? Explain why.

Before starting

Evacuate the tank so that the pressure gauge reads zero absolute pressure.

Select a molecule (A, B, C, D, E) to inject from the dropdown menu. Note that the Antoine constants are only good over a temperature range.

Liquid injected _____

Temperature range _____

Measure saturation pressures

Select the amount of liquid to inject: _____ mL.

Pick the first temperature to make measurements.

Inject liquid with the syringe, allow the tank to equilibrate, and read pressure from the pressure gauge. How can you determine if you are at vapor-liquid equilibrium (VLE)?

Pick another temperature (keeping in mind what part of the temperature ranges measurements should be made) and repeat measurements until sufficient data are obtained to yield accurate Antoine constants. Record the data in the table below. How can you confirm you are at VLE at the higher temperatures?

Temperature (°C)	Pressure (bar)

Determine Antoine constants

Use Excel Solver to fit the saturation pressure (P_i^{sat}, bar) versus temperature (T, °C) data in the table to Antoine's equation.

$$logP_i^{sat} = A - \frac{B}{T + C}$$

Determine the values of the Antoine parameters (A, B, C).

A = _____

B = _____

C = _____

Plot ln P_1^{sat} versus inverse absolute temperature and use the Clausius-Clapeyron equation to estimate the heat of vaporization (ΔH_{vap}, kJ/mol) of the molecule.

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

where R is the ideal gas constant.

ΔH_{vap} = _____ +/- _____

Questions to answer

1. Are the measurements valid if the tank is at high pressure (or low temperature) so that the gas phase is not ideal? Explain.

2. What are possible sources of error in the measurements?

3. From tables in the literature, can you guess the identity of the molecule?

4. What safety measures would you employ if making this measurement in the laboratory?