How to Solve Problems Using the Clausius – Clapeyron Equation

$\ln(P_2/P_1) = (\Delta H_{vap}/R)(1/T_1 - 1/T_2)$

Notice: It is a natural log (ln) function as shown but may be written as a log function.
There are parentheses around the pressure variables.
The ΔH_{vap} is the enthalpy of vaporization of the liquid.
The gas constant R is 8.31J/molK not 0.08206 Latm/molK.
The difference of the reciprocals of the Kelvin temperatures is $1/T_1 - 1/T_2$.

Problems normally come in one of three forms:

1. Given the vapor pressures at two different temperatures, solve for ΔH_{vap}.
2. Given a boiling point and a ΔH_{vap} , solve for the vapor pressure at a different temperature.
3. Given the vapor pressure at one temperature and the ΔH_{vap} , solve for the vapor pressure at a different temperature.

Problem type 1. is the easiest to solve mathematically. Problem types 2. and 3. are the actually same. Why? If you are given a boiling point, assume that T_1 is the given boiling point and that P_1 is 760T unless otherwise noted.

Remember!!! USE KELVIN TEMPERATURES ONLY!

Solving Type 1 Problems

Problem: The vapor pressure of water at 20°C is 17.5Torr. What is the ΔH_{vap} of water?

Remember that boiling points give you a P and T for the substance, so you actually have two pressures and two temperatures, even though the problem appears to not give you enough information. (You should know the boiling point of water at 760T.)

P_1 = 760T	P_2 = 17.5T	R = 8.31 J/mol K
T_1 = 100°C = 373K	T_2 = 20°C = 293K	ΔH_{vap} = ?

(It doesn't matter which is P_1/T_1 or P_2/T_2 as long as the temperatures and pressures stay together.)

$\ln(17.5T/760T) = (\Delta H_{vap} / 8.31 J/molK)(1/373K - 1/293K)$

$\ln(0.0230) \times 8.31 J/molK = \Delta H_{vap} (0.00268K - 0.00341K)$

$(-3.77 \times 8.31 J/molK) / -0.000730K = \Delta H_{vap} = 42{,}900 J/mol$ (Actually 40.67 kJ/mol but there is round-off error)

Solving Type 2 and 3 Problems

Problem: Naphthalene (mothballs) has a B.P. of 218°C and a ΔH_{vap} = 43.3 kJ/mol. What is the vapor pressure of naphthalene at room temperature (25.0°C)?

P_1 = 760T (From boiling point) P_2 = ?
T_1 = 218°C = 491K T_2 = 25.0°C = 298K
ΔH_{vap} = 43,300 J/mol (Must convert from kJ to joules because R is in joules.)
R = 8.31 J/molK

$\ln(P_2/760T) = (43{,}300 J/mol / 8.31 J/molK)(1/491K – 1/298K)$

$\ln(P_2/760T) = 5210/K \times (0.00204K – 0.00336K)$

$\ln(P_2/760T) = -6.88$ (You can't multiply both sides by 760T to solve because it is inside the ( ).)

Take the antiln of both sides.

$\text{antiln}(\ln(P_2/760T)) = \text{antiln}(-6.88)$ (The antiln of lnX = X, the antiln of Y = e^Y)

$P_2/760T = e^{-6.88} = 0.00103$

$P_2 = 0.00103 \times 760T = 0.781$Torr

Math to Remember

ln x = 2.303log x (Whenever you see 2.303 in a formula it means it was converted from a natural logarithm (ln) function. You may use whichever you prefer.)
The number of places past the decimal in the log or ln determines the number of sig figs in the answer.

If x = 1000 then log x = log(1000) = log(10^3) = 3.0 (1 sig fig in 1000)

If x = 1000 then ln x = ln(1000) = 6.9078 ($e^{6.9078}$) = 1000 (e = 2.718281828….)

If log x = 2.5 then x = $10^{2.5}$ = 316.23 (Actually if you follow sig fig rules the answer is 300)

If log x = 0.267 then x = $10^{0.267}$= 1.85 (3 sig figs)

If log x or ln x is a negative number then x is less than 1.

log x = -1.6 then x = $10^{-1.6}$ = 0.025118 or 0.02 with 1 sig fig.

If ln x = 6.30 then x = $e^{6.30}$ = 544.6 = 540 with 2 sig figs.

If ln x = -4.72 then x = $e^{-4.72}$ = 0.0089 with 2 sig figs.

If ln(a/b) or log(a/b) is positive then a/b > 1. If ln(a/b) or log(a/b) is negative then a/b < 1.