Take Home Exam 03: Critical Radius for Nucleation of Water from the Vapor Phase

## Assigned: 09/01/2022

Due (as pdf by email) 09/04/2022 (Sunday)

•you will receive a simple letter grade for your report

•You may submit your answers in one of two ways:

1. For typed answers: as a .docx file (as is) or converted into a pdf file. (DO NOT SEND GOOGLE DOC)

For handwritten answers: Please scan as images, and group together into one pdf file. Or you may hand them manually to my office (ECME-212)

HW 03.1

(i) *Give the units for each of the parameters in the following equations*. The subscripts refer to the "volume" and the "surface".

 (1)

 (2)

If the vapor phase of H2O as the reference state, then  is the enthalpy of evaporation of water into the vapor (its value is 41 kJ mol–1).

(ii) We wish to transform Eqns (1) and (2) and rewrite them on a per-atom basis:

for example , which normally has units of J mol–1, becomes  , etc.

Write down the quantities in Eq. (2) on a per atoms basis, for example:

 Hint: play close attention to the units (the surface quantities are related to the number of atoms per unit surface area - how would you estimate that number).

HW03.2

The surface energy for water is J m–2. And  with units of J m–3 is related to supercooling below the Dew Point by

 as derived in class. We also derived that the critical radius for nucleation is given by



The Dew Point is the temperature where the atmospheric vapor pressure becomes equal to the thermodynamic vapor pressure of water. As shown in the graph below if the atmospheric vapor pressure is less than the thermodynamic vapor pressure, the humidity is less than 100%. As the temperature in the environment falls the thermodynamic vapor pressure becomes equal to the atmospheric pressure and the Dew Point is reached.

In the following analysis you may assume that the Dew Point is 15 oC or 288 K.

 kJ mol–1. (remember to convert into J mol–1).

You are asked to make a plot of  as a function of  (the supercooling) for a range of 1 to 15K.

Make another plot where  is plotted on a log10 scale, while the  remains on a linear scale.

Pick one value of  and calculate the number of atoms (actually water molecules) in the embryo of critical size.