ENV-320: Physics and Chemistry of the Atmosphere

Exercise session for Clouds Lecture

20. Aerosol particles that attract water are called
a) hydrophobic
b) hydrophilic

21. Cloud condensation nuclei (CCN) are aerosol particles that nucleate water drops at supersaturations less than
a) 100%
b) 10%
c) 1%

22. Which of these aerosol particles are likely to act as cloud condensation nuclei (circle all that apply)
a) clay b) NaCl c) $(NH_4)_2SO_4$ d) AgI e) pollen f) sand

comment: clay may but not according to Köhler theory

23. The saturation vapor pressure over a solution is (less than, equal to, greater than) the vapor pressure over pure water.

24. The saturation vapor pressure over an electrolytic solution is (less than, equal to, greater than) the saturation vapor pressure over a non-electrolytic solution.

· electrolytes dissociate so the # of moles of effective ~~p~~ molecules goes up
non-electrolytes do not dissociate.

Combination of Kelvin's Law (#16, pure droplets with surface tension effects) with Raoult's Law (4.48) for solutions yields Kohler's equation:

$$\frac{e_s(r, m_{solt})}{e_s} = \left[1 - \frac{b}{r^3}\right] \exp\left(a/_r\right) \qquad (5.17)$$

where $a = 2\sigma_{lv}/(\rho_l R_v T)$. Use the Kohler curve below to estimate:

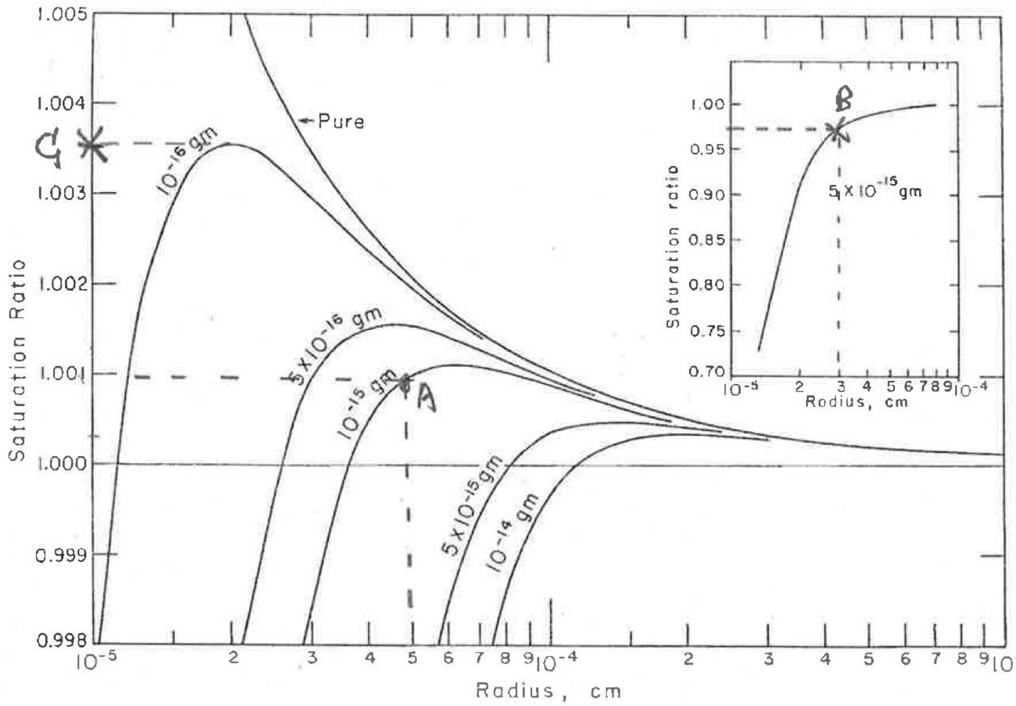

FIG. 2.4.—Curves of equilibrium saturation ratio of water droplets containing the stated mass of sodium chloride compared with Kelvin curve for pure water droplets. *Inset:* curve for 5×10^{-15} g NaCl on a compressed scale extended to the droplet size at which the given amount of NaCl would form a saturated salt solution in the droplet. All computations are made for a temperature of 25° C, but the values are very nearly the same at other atmospheric temperatures.

25. The radius of the droplet that will be in equilibrium on a NaCl particle of mass 10^{-15} g in air which is 0.1% supersaturated.

↳ $S = 1.001$ ⇒ point A ⇒ 5×10^{-5} cm radius.

26. The relative humidity of the air adjacent to a droplet of 0.3 microns with 10^{-15} g NaCl.

0.3×10^{-6} m = 0.3×10^{-4} cm = 3×10^{-5} cm ⇒ point B, $S = 0.975$ ⇒ 97.5% RH

27. The critical supersaturation required for a NaCl particle of mass 10^{-16} g to grow beyond the haze state.

point C ⇒ $S = 1.0035$ ⇒ $S = 0.35\%$ supersaturation.

28. Consider the droplet with radius r with a CCN consisting of 10^{-15} g NaCl in an environment with saturation ratio S, as indicated by point A. Is the droplet growing, evaporating, or in equilibrium? In equilibrium (left of the critical radius).

29. Consider the droplet with radius r with a CCN consisting of 10^{-15} g NaCl in an environment with saturation ratio S, as indicated by point B. Is the droplet growing, evaporating, or in equilibrium?

In equilibrium (RH < 100%, droplet size left of the critical point)