

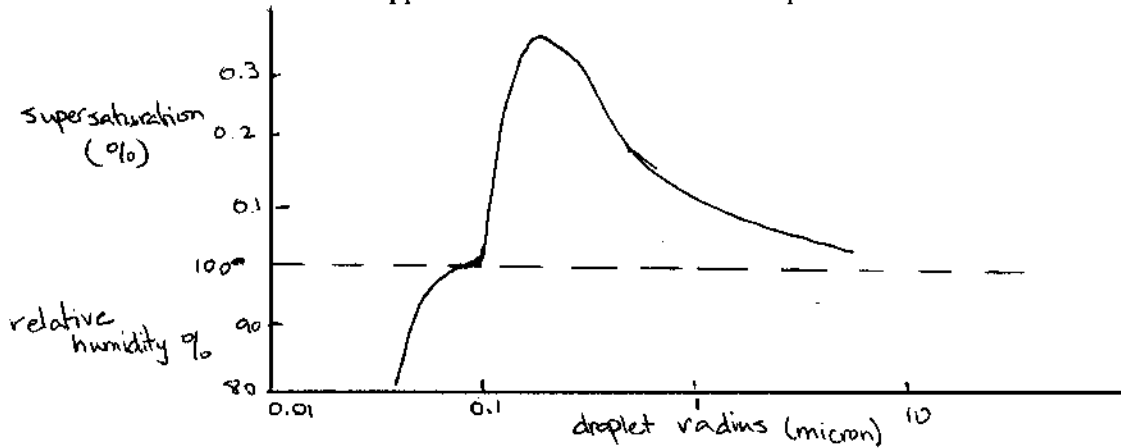
**MSC 409 Midterm Spring 2006 (100 points total)**

Multiple choice except for 12& 14. Circle the right answer. 2 points each.

1. It is possible for condensation to occur on very small liquid cloud droplets because of the (curvature, solute) effect.
2. Cloud seeding is effective for dispersing fogs consisting of (ice needles, supercooled water droplets, water droplets above freezing).
3. Cloud condensation nuclei exist in (higher, lower, similar) concentrations in the atmosphere to ice nuclei.
4. Cloud condensation nuclei in marine air are (more, less, similarly) numerous to those in continental air.
5. The saturation vapor pressure over an ice surface is (higher, lower) than that over a water surface.
6. Fog is likely when (warm air flows over a cold water surface, cold air flows over a warm water surface).
7. In an adiabatic liquid water cloud, cloud droplet size (decreases, increases, doesn't change) with increasing height.
8. For a given supersaturated environment in a warm cloud, the rate of increase in the radius of a large droplet by condensation is (greater than, smaller than, the same as) that of a small droplet.
9. For a given environment in a warm cloud, the rate of increase in the radius of a large drop by collision is (greater than, smaller than, the same as) that of a small drop.
10. Snowflakes are an example of ice crystal growth occurring through (deposition, riming, aggregation).
11. Which one of the following substances is most unique to lightning: carbon dioxide molecules, snowflakes, supercooled water droplets, graupel.
12. Why is the liquid water content higher up in a Cumulus cloud is typically less than the maximum adiabatic liquid water content ?
13. A typical radius for an aerosol particle capable of serving as a cloud condensation nucleus is (10, 0.001, 0.1) micron.
14. Air at 700 hPa and 10C has a density of \_\_\_\_\_  $\text{kg m}^{-3}$
15. The biggest difference between water and ice saturation pressures occurs at (0, -15, -30) Celsius.

**Problems** Make an attempt on all of them. Showing work, units, values of (relevant) constants helps you get partial credit. Can show work without showing the final number if you don't have a calculator.

1 (10 pts). The relative humidity of a chamber is 95%. If a solution droplet of radius 1 micron is placed in the chamber, show on the Kohler curve below how the supersaturation over this droplet will change as the radius  $r$  of the droplet changes, as it comes to equilibrium with the air in the chamber. What will be the approximate final radius of the droplet. ?



2. A drop with a radius  $r$  of 100 micron falls through a cloud with a uniform liquid water content (LWC) of  $0.3 \text{ g m}^{-3}$ . The cloud is 3 km thick.

a. (5 pts) What is the cloud liquid water path in  $\text{g m}^{-2}$  ?

b. (10 pts) If the drop experiences a drag force given by  $2k\pi r^2 v$ , where  $v$  is the speed of the drop, what is the terminal (equilibrium) fallspeed of the drop when the radius  $r$  is 100 micron ?  $k = 1 \text{ kg s}^{-1} \text{ m}^{-2}$ .

c. (10 pts) If the drop collects smaller cloud droplets with a collection efficiency  $E$  of 0.7, how long will it take for the drop to reach a radius of 1 mm ? The equation for the mass growth is given by  $dM/dt = \pi r^2 v \text{LWC} \cdot E$ .