Mercury Lake

a) The water volume of the lake is the product of its length, width, and depth. $5km * 2km * 100m = 1km^3$
b) The total mercury mass of the lake is the product of the water volume and the mercury concentration. $1km^3 * \frac{0.001mg}{L} = 1000kg$
c) Residence time is the average amount of time a substance spends in a system. It is calculated as the system's capacity to hold the substance divided by the flow of the substance through the system. The concentration of the substance in the system and system size remain constant under steady state conditions. $\frac{1000kg}{0.0005mg/L*2*10^{12}L/yr} \approx 1yr$ One year is the time it takes to cycle 1000kg of mercury through the system.
The amount of mercury in the lake can be expressed as a differential equation

$$\frac{dH}{dt} = rc - \frac{rH}{V},\ H(0) = 1000kg$$

where H represents the total amount of mercury in the lake
r is the water flux rate
c is the concentration of mercury in the input water
V is the volume of the lake
d) $3 * \frac{1km^3}{2*10^{12}L/yr} \approx \frac{3}{2}yr$
e) $10km^3$; $10000kg$; $10yr$; $15yr$ Increasing the volume of the system by a factor of 10x with all other factors held constant causes the other metrics to increase by a factor of 10. A longer residence times means that it takes longer to naturally remove pollutants.

Latent and Sensible Heat Flux

a) Sensible heat flux is flow of heat through air flow, combined with the displacement of cooler air. Latent heat flux is the flow of heat through evaporation of subsequent condensation of water. Sensible heat flux's sole effect is the change of temperature, while latent heat involves energy changes during constant temperature phase changes. Figure 1.4 in the text shows that latent heat flux ($80Wm^{-2}$) is approximately five times greater than sensible heat flux ($17Wm^{-2}$).
b) $L = 596\frac{cal}{g} - (\frac{0.56cal}{g*^oC} * T) = \frac{593.2cal}{g}$
$10tons = 9.0718\times10^6 grams$
Latent heat of vaporization for 10 tons of water at 5ºC is $9.0718\times10^6 grams * \frac{593.2cal}{g} = 5.38 * 10^9 cal$
c) $\frac{5.38}{1.42} = 3.8$ barrels of oil
d) $3140km^2 * 5cm = 1.57 * 10^{14}cm^3$
$1.57 * 10^{14}g * \frac{593.2cal}{g} = 9.31 * 10^{16}cal$
$\frac{9.31*10^{16}cal}{1.42*10^9 cal/barrel} = 6.56 * 10^7 barrels$

Dust deposition

a) The airborne dust would end up in the Atlantic Ocean basin. An example of this dust reaching across the ocean can be found here: `http://now.msn.com/saharan-dust-cloud-makes-way-from-africa-to-texas`
b) Dust from the Gobi Desert would be deposited into the Pacific by the Westerlies.
c) $\frac{4km}{500cm/yr} = 800yr$

Solar Radiation

a) There is more radiation at the lower latitiudes than at the higher latitudes because sunlight strikes the Earth at a more oblique angle at the higher latitudes so, lower latitudes receive more light per unit area than do higher ones. Heat is transported from low to high latitudes through sensible and latent heat flux. These are defined above. Heat is transferred through both air and water (surface and thermohaline) circulation.
b) The Gulf Stream is a wind driven surface current which brings warm water from the lower latitudes to the higher latitudes, where the water sinks to form the NADW, driven by thermohaline circulation. The Gulf Stream's flow brings warm water to Europe and Eastern NA, which warms the climate. If this circulation system were to shut down, the climate in these regions would cool down.