INTRODUCTION TO ENVIRONMENTAL CHEMISTRY

SCE 201 TUTORIAL QUESTIONS

1) What is environmental Chemistry? Explain the following concepts as applied in atmospheric chemistry: mixing ratio, number density and partial pressure.
2) Discuss environmental segmentation and atmospheric stratification. Outline the main features of each segments above.
3) Compare and contrast the energy and material circulation among different segments of the environment.
4) Discuss the main features of the planetary atmosphere and the earth's atmosphere. What are the key characteristics of the planetary boundary layer?
5) Discuss atmospheric pressure, atmospheric mass and vertical pressure profile. Calculate the estimated atmospheric pressure and mass.
6) Compare and contrast the main sources of constant, variable and highly variable gases in the atmosphere.
7) Discuss atmospheric stability, adiabatic and atmospheric lapse rates, and latent heat transfers.
8) Discuss atmospheric oxidising power. Illustrate the chemistry of Co in the troposphere. Under what circumstances can it lead to accumulation are depletion of ozone in the troposphere.
9) Discuss the main features of green chemistry. Why do you think green chemistry is attracting more attention?
10) Discuss production scheme of nss from DMS oxidation following OH, NO_3, and halogens. Outline the influence of diurnal changes on DMS oxidation products.
11) Imagine a one-car garage with a volume of 40 m^3 and imagine that air in this garage has a residence time of 3.3 h. At what rate does the air leak into and out of this garage?
12) What is the Montreal Protocol? Explain the significance of this protocol to Atmospheric Chemistry.
13) Methane (CH_4) is a greenhouse gas (more on this later), and it enters (and leaves) Earth's atmosphere at a rate of about 500 million tonnes/year. If it has an atmospheric residence time of about 10 years, how much methane is in the atmosphere at any one time?
14) Given that the flow of oxygen into and out of Earth's atmosphere is 3×10^{14} kg/year, what is the residence time of oxygen in Earth's atmosphere?
15) Carbonyl sulfide (COS) is present as a trace gas in the atmosphere at a concentration of 0.51 ppb; its major source is from the oceans, from which it enters the atmosphere at a rate of 6×10^8 kg/year. What is the residence time (in years) of COS in the atmosphere?
16) Suppose a dye that is highly water soluble, nonvolatile, chemically stable, and nontoxic to be added to the lake at a rate of 6.0 kg of the solid per day. The lake has a volume of 2.8×10^6 m^3, and the average water flow rate of the river feeding the lake is 6.9×10^3 m^3/day. Once the dye becomes well mixed in the lake,
    a) estimate the dye's concentration in the lake's water.
    b) What if this same amount of dye was added in solution (rather than as a solid) and that the solution bringing this dye into the lake was flowing at $2.1 \times 10^3 m^3$/day? In this case, what would the concentration be?
17) What if 10% of this water evaporated? Would this change the concentration of the dye in the lake? What would its concentration be?
18) Discuss redox reactions in soil and aquatic environment. How do these processes affect air quality?

19) A sewage treatment plant is designed to process 9.3×10^6 L of sewage daily. What diameter (in feet) tank is required for the primary settling process if the residence time must be 7 h? Assume the tank is cylindrical and 2 m deep.
20) We are back to that closed one-car garage (volume = 40 m^3) with a badly adjusted lawnmower pumping out carbon monoxide at a flow rate of 11 g/h. Imagine that CO is lost from this garage by two processes: first, by simple mixing of clean air as it moves into and out of the garage, and second, by chemical decay of the CO. Let's assume that the residence time of the air in the garage is 3.3 h and that the rate constant for the chemical decay of the CO is $5.6 \times 10^{-5} s^{-1}$. Under these conditions, what will be the average steady-state concentration of CO in this garage?
21) Occasionally drinking water treatment plants will have "taste and odor" problems that result in a lot of complaints from their customers (after all, who wants smelly drinking water?). The compound that causes this problem is called geosmin. Assuming this compound has a chemical degradation rate constant of $6.6 \times 10^{-3}\ s^{-1}$ at what flow rate could a treatment plant with a tank volume of 2500 m^3 be operated if a 10-min water contact time is required?
22) The North American Great Lakes are a major ecological, industrial, and recreational resource. It turns out that the average lead concentration in the air over Lake Erie is 11 ng/m^3, and the annual flow of lead from the atmosphere into this lake is 21,000 kg/year. Given that the area of Lake Erie is 25,700 km^2, find the deposition velocity for lead into this lake.
23) Discuss the earth's radiation balance. Under what circumstance can man alter the earth's radiation balance by 0.1%. Is that currently feasible?
24) Given the small mass of hydrogen atoms (H_2) it should not come as a surprise to note that Earth has been losing H_2 at a flux of about 3×10^8 molecules per square centimeter per second for most of its history. Please estimate the mass of hydrogen lost (in tonnes) from the atmosphere each year.
25) Benzo[a]pyrene (BaP) is produced by the incomplete combustion of almost any fuel. This compound is a proven human carcinogen. BaP enters Lake Superior by two mechanisms: wet deposition (rain and snow falling into the lake) and dry deposition (particle fallout to the surface of the lake). The concentration of BaP on particles in the air over Lake Superior is 5 pg/m^3, and its concentration in rain over the lake is 2 ng/L. The area of Lake Superior is 8.21×10^4 km^2. What is the total flow of BaP from the atmosphere to Lake Superior?
26) Another bad lawnmower is being operated in a closed shed with a volume of 8 m_3. The engine is producing 0.7 g of CO per minute. The ventilation rate of this shed is 0.2 air changes per hour. Assuming that the air in the shed is well mixed and that the shed initially had no CO in it, how long would it take for the CO concentration to get to 8000 ppm?
27) In the course of producing nuclear weapons, an unnamed country had a small spill of promethium-147 ($_{147}$Pm) in September of 1989. This spill totalled 4.5 μCuries, covered a soil area of 5 m^2, and penetrated to a depth of 0.5 m. In August of 1997, the United Nations tested this site, and the concentration of Pm was found to be 0.222 micro curie. What is the half-life (in years) of $_{147}$Pm?
28) The concentrations of octachlorostyrene in trout in the Great Lakes have been measured over the years with the following results: 1986, 26 ppb; 1988, 18; 1992, 13; 1995, 12; 1998, 6.2; and 2005, 1.8. What is your best estimate of this compound's half-life (in years) in these fish?
29) Methane's average atmospheric concentration is 1.74 ppm (at 15°C and 1 atm), and the second-order rate constant for the reaction of CH_4 and OH is 3.6×10^{-15} cm^3 molecule"$_1$ s"$_1$. What is the flow rate (in Tg/year) of methane destruction by this reaction? Assume [OH] is always 9×10^5 molecules cm^{-3}.
30) The energy of the oxygen-to-oxygen bond in 0_2 is 4.92×10^5 J/mol. What is the maximum wavelength of light that could break this bond?
31) Discuss ozone chemistry in the troposphere. Comparing urban and rural environments, discuss the occurrence and distribution of ozone in the lower troposphere.
32) Compare and contrast greenhouse effect and global warming. Discuss the scientific concepts behind adverse effects of climate change and variability.