1. (15 pts) Using HERP data from the course website, let’s compare the risk of eating celery to that of taking a sleeping pill with active ingredient phenobarbital.
   (a) Estimate the mass (in units of kg) of celery a person would have to eat every day in order to have the same risk of cancer as a person who takes one of these sleeping pills every evening.
   (b) Calculate the percentage of celery mass calculated in Part (a) to the mass of an average human male, which is about 70 kg. Is this a large amount or a small amount of celery?
   (c) Estimate the actual risk of dying from cancer for either of these behaviors (taking one sleeping pill per day, or eating the amount of celery that gives the same risk, as calculated in Part (a)). Discuss.

2. (20 pts) A smoker typically inhales smoke from one cigarette over an elapsed (integrated) period of time equal to 20 s at an average volumetric flow rate of 5.0 L/min. The number concentration of smoke particles in the inhaled air from the cigarette is $1.2 \times 10^{15}$ particles/m$^3$. For simplicity, assume that the smoke particles are spherical with a uniform diameter ($D_p$) of 0.19 µm (microns) and a density ($\rho_p$) of 800 kg/m$^3$. Hint: In case you don’t recall, the volume of a sphere is $\pi D_p^3/6$.
   (a) Calculate the mass concentration of smoke particles inhaled by the smoker (in mg/m$^3$). Note: Use units or dimensions to help you come up with an equation for your calculation. Get used to using units in this way – it is very useful.
   (b) Consider a nonsmoker in a room with smokers. The average smoke concentration in the room is 0.32 mg/m$^3$. Assume that the nonsmoker inhales air at an average volumetric flow rate of 4.0 L/min. Calculate how long (in hours) the nonsmoker would have to remain in the room in order to inhale a mass of smoke equivalent to smoking one cigarette (in other words, both people get the same dose of smoke). Discuss; namely, what does this imply about “secondhand” smoke?

3. (35 pts) Look up the NIOSH Pocket Guide to Chemical Hazards on the Internet [there is a link from the course website in the tab called Links or References], and do the following:
   (a) Print the Safety Data Sheet for the chemical 3-Hydroxytoluene. What is its chemical formula, its official or most common chemical name, and its CAS number?
   (b) List the synonyms or trade names for this chemical.
   (c) What is the molecular weight ($M$ or $MW$) and the boiling point ($BP$) in °C of this chemical? (Be sure to include units and unit conversions where necessary.) Add up the molecular weights for each atom in the molecule and verify that the molecular weight is correct, showing your work. Note that the molecular weight on the safety data sheet is rounded to 3 or 4 significant digits. Write $M$ for this molecule to 6 significant digits. Hint: An interactive periodic table of the elements (also on our website) comes in handy for finding exact molecular weights of individual elements.
   (d) What is the vapor pressure of this substance at normal atmospheric conditions? If a sufficient amount of this substance were put into a container of air at atmospheric pressure (101.325 kPa) such that after a long time, the air above the chemical became saturated with the chemical, what would be the partial pressure of the chemical in kPa? What would be the partial pressure of the air in kPa? [Note: Assume that the container can expand or vent slightly as the liquid chemical evaporates such that the overall pressure inside the container remains atmospheric at all times.]
   (e) What is the OSHA time-weighted average (TWA) permissible exposure limit (PEL) in parts per million? What is the NIOSH TWA REL (recommended exposure level) in parts per million? Which is safer, a chemical with a low PEL or a high PEL? Explain. Compare the PEL of this chemical to that of ethanol – namely, is this chemical more or less hazardous than ethanol? Explain.
   (f) Using the conversion equation provided in class, convert the PEL value to mass concentration $c_j$ in units of mg/m$^3$ for STP conditions (101.325 kPa and 25°C). Give your answer to 3 significant digits. Compare your result to the value listed on the safety data sheet. Are they the same? If not, explain why the two results differ.
   (g) Repeat for a case when the gas mixture is at 90.0 kPa and 49.0°C. Give your answer to 3 significant digits. Compare your result to the value listed on the safety data sheet. Are they the same? If not, explain why the two results differ.

Note: There is another page.
4. (15 pts) A mixture of air and 3-Hydroxytoluene (same chemical as in the previous problem) is flowing in a duct at approximately STP conditions. The molar concentration of this chemical in the duct is 8.55 mol/m³. The total volume flow rate of the mixture is 0.0550 m³/s.

(a) Estimate the mass flow rate of the chemical in the duct (in units of g/s and also in units of lbm/min). Give all answers to three significant digits, which is appropriate for the given information.

(b) Calculate the mol fraction of the chemical in ppm. If workers were exposed to this gas mixture for 8 hours, would OSHA be concerned? Explain. Why would we normally not be concerned about exposure in this situation?

(c) If the duct is vented to the atmosphere with no pollution control device, estimate how many tons of the chemical are discharged into the atmosphere in a year, assuming that the plant runs 22 hours per day, 7 days per week (1 ton mass = 2000 lbm). Note: Use 365.25 days in a year for your calculations, which is the average year counting leap years.

5. (15 pts) Methanol vapors and air are mixed. The partial pressure of the methanol is 0.750 kPa. The pressure and temperature of the ideal gas mixture are 96.0 kPa and 25.0°C respectively. From its chemical formula, calculate its molecular weight to 5 significant digits. Give all the rest of the answers to 3 significant digits. Calculate the mol fraction (PPM), the mass concentration (mg/m³) and the molar concentration (mol/m³) of the methanol vapors.