1. (20 pts) Using HERP data from the link on the course website, let’s compare the risk of drinking coffee to that of taking a sleeping pill with active ingredient phenobarbital. Note: There is more than one entry for coffee – you must add all of the HERP values to get the total risk.
   (a) Estimate the mass (in units of g) of coffee a person would have to drink every day in order to have the same risk of cancer as a person who takes one of these sleeping pills every evening.
   (b) A “cup” of coffee is not 8 ounces, but 6 ounces, for some odd reason. Approximating the density of coffee as the same as that of water, how many cups of coffee were used in the HERP table as a typical “dose”? Your answer should be much smaller than one cup. Why do you think the HERP value is based on such a small amount of coffee?
   (c) How many (6 ounce) cups of coffee must a person drink every day of his/her life to have the same risk of cancer as a person who takes one of these sleeping pills every evening?
   (d) Estimate the actual risk of dying from cancer for either of these behaviors (taking one sleeping pill per day, or drinking the amount of coffee that gives the same risk, as calculated in Part (a)). Discuss.

2. (15 pts) This is a very open-ended question. Note: In homework questions like this, where you are looking things up, always cite your reference(s). Do some searching (Internet, books, journals,…) and write a brief (limit to a paragraph or two, please) analysis about the air that we breathe in our homes. Look for answers to questions like these: Is the air in a typical home harmful to breathe? Which harmful chemicals (or particulate matter) are most prevalent in typical house air? Is indoor air quality getting better or worse? Should we be concerned about the air we breathe in our homes?

3. (35 pts) Look up the NIOSH Pocket Guide to Chemical Hazards on the Internet [there is a link from the ME 405 website in the tab called Links], and do the following:
   (a) Print the MSDS (now called SDS) for the chemical hexachloroethane. What is its chemical formula, its official chemical name, and its CAS number? [Hint: Scroll down on the list of chemicals starting with H to see this list in alphabetical order.]
   (b) Look at the synonyms or trade names for this chemical. Why do you think some of them have “hex” in them?
   (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 SDS is rounded to 4 significant digits. Write M for this molecule to 6 significant digits. Hint: The interactive periodic table of the elements (also on the Links tab 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? Assume that the tank is ventilated one way (gas can escape from the tank, but no gas can enter the tank).
   (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 the class notes, convert the PEL value to mass concentration c_j in units of mg/m³ for STP conditions (101.325 kPa and 25°C). Show all unit conversions. Give your answer to 3 significant digits. Compare your result to the value listed on the SDS. Are they the same? If not, explain why the two results differ.
   (g) Repeat when the gas mixture is at 95.0 kPa and 59.0°C. Give your answer to 3 significant digits. Compare your result to the value listed on the SDS. 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 hexachloroethane (same chemical as previous problem) is flowing in a duct at approximately STP conditions. The molar concentration of this chemical in the duct is 10.0 mol/m³. The total volume flow rate of the mixture is 0.0750 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 21 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 0.650 kPa. The pressure and temperature of the ideal gas mixture are 96.0 kPa and 30.0°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.