CHEM 302
Assignment #4

Answers the following questions and submit solutions to <u>even numbered questions ONLY</u> in a neat and well organized manner, including dimensional analysis, where appropriate. Reference data and information sources.

Due: Tuesday, December 5rd, 2017

1. Calculate the thickness of the Earth's atmosphere that contains 99% of the air molecules. If a model of the Earth were the size of a basketball (diameter = 24 cm), how thick would the atmosphere be?

2. A coal-burning power station burns 8,500 tonnes of coal per day.
a) Calculate the sulfur content of coal if the flue gas contains 1700 ppm_v of SO_2.
b) What mass of lime is needed per day to react with this sulfur dioxide?
c) What mass of CaSO4 is produced per year during this process?

3. A one compartment home of 400 m^3 has a ventilation rate of 0.30 air changes per hour with its doors and windows closed. Carbon monoxide is produced from a kerosene heater at a rate 1 g per hour. How long will it take before the indoor concentration exceeds the toxic action threshold level of 1.00 ppm_v? When the outside concentration of a pollutant is negligible, it can be shown that;

$$\ln\left(1-\frac{[X]_t}{[X]_{ss}}\right) = -k_e t$$

4. The planet Venus has a surface temperature of about 460°C and a surface pressure of 92 atmospheres. The mixing ratios for **CO_2** and **N_2** are 96.5% and about 3.5%, respectively.
(i) Calculate the density of surface 'air' on Venus.
(ii) The mixing ratio of **SO_2** on Venus is 150 ppm_v. Determine the number density and the partial pressure for this gas on the surface.

5. Given that the gasoline is about 85% by mass carbon and has a density of about 0.75 kg/L, estimate the adjusted 'life cycle' cost that would need to be added to a liter of gasoline that would offset the cost associated with carbon capture and sequestration (CCS) at $200/tonne of $\mathbf{CO_2}$.

6. It has recently been suggested that nitrogen trifluoride (a solvent used in the manufacture of new LCD monitors) has the potential to be a significant 'greenhouse' gas[1]. What is meant by the term '*Global Warming Potential'* and what information would you need in order to estimate the global warming potential of NF_3? What additional information is relevant to determine if this gas actually makes a significant contribution to global warming?

7. Information about the average chemical composition and energy content of the three major fossil fuels and global consumption rates are summarized below.[2]

	Average composition	Percent combustible of total	Worldwide consumption in 1980 (x 10^{18} J/yr)	Energy content
Petroleum	$CH_{1.5}$	98% (w/w)	135	43 x 10^6 J/kg
Natural Gas	$CH_{3.6}$	88% (v/v)	60	3.9 x 10^7 J/m^3 (STP)
Coal	$CH_{0.8}$	75% (w/w)	90	29.3 x 10^6 J/kg

a) What mass of $\mathbf{CO_2}$ was released to the atmosphere in 1980 from fossil-fuel burning?
b) Rank these fossil fuels based on the mass of $\mathbf{CO_2}$ released per Joule of energy produced.

8. How much would the Earth's atmospheric temperature change for 1.5% increase from their current value in each of the following:
i) 'greenhouse effect', ΔE
ii) solar irradiance constant
iii) Earth's *albedo*

9. Describe what is meant by '*radiative forcing*' in the context of global climate change. Provide an example of at least one positive and one negative feedback loop in the global climate system.

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[1] For more information of this issue see M.J. Prather and J. Hsu, *NF_3, the greenhouse gas missing from Kyoto*, Geophysical Res. Letters, 35, L12810, **2008** and Velders et al., *The large contribution of projected HFC emissions to future climate forcing*, Proceedings of the National Academy of Science, 106, 10949, **2009**.

[2] Adapted from **Consider a Spherical Cow: A Course in Environmental Problem Solving**, John Harte, University Science Books, Mill Valley, CA, 1988.