Today, we will:

- Continue example problem from last time – EFs from combustion chemistry
- Do some example problems
- Discuss how to *measure* emission rates and calculate EFs

Example: EFs from combustion of natural gas (assume it is all methane) (continued)

Given: Natural gas is burned in a power plant. There is no APCS. Exhaust gases go up the stack at $T = 500$ K and $P = 100$ kPa.

(a) To do: Estimate the mol fraction, mass fraction, mass concentration, and molar concentration of CO_2 going up the stack. Give all answers to 3 significant digits.

(b) To do: Estimate (from first principles and chemistry) the EF of CO_2 emitted by burning methane, and compare with EPA's published EFs for burning natural gas (NG).

Solution (continued from last class): We had,

Chemical equation:

$$CH_4 + a(O_2 + 3.76\ N_2) \rightarrow bCO_2 + cH_2O + dN_2$$

Solve for the molar coefficients: $a = 2$, $b = 1$, $c = 2$, $d = 3.76a = 7.52$. So, the equation is

$$CH_4 + 2(O_2 + 3.76\ N_2) \rightarrow CO_2 + 2H_2O + 7.52N_2$$

Notice that *all* the carbon in the fuel is converted to carbon dioxide in the products.

Our estimated EF was $\boxed{EF = 2740 \frac{\text{kg } CO_2}{\text{Mg } CH_4}}$. Let's compare to published EFs of

$\boxed{EF = 53 \frac{\text{kg } CO_2}{\text{thousand SCF NG}}}$ and $\boxed{EF = 120{,}000 \frac{\text{lbm } CO_2}{10^6 \text{ SCF NG}}}$

Example: EFs and APCSs (Air Pollution Control Systems) in parallel

Given: On an average day, a chemical plant generates 40.0 Mg of a product, and in the process emits an air pollutant. The uncontrolled emission factor for the air pollutant is EF = 5.3 kg/Mg. The plant has in place an APCS with a removal efficiency E = 89.%.

(a) To do: Calculate the amount of the air pollutant actually emitted into the atmosphere on in one typical day. Give your answer in kg to two significant digits.

Solution:

(b) To do: The government regulation gets more strict, and the plant is allowed to emit only 10 kg of the air pollutant per day. Calculate the minimum efficiency of a second APCS that is to be put in series with the existing one in order to meet the new regulation.

Solution:

Example: Emissions from a natural gas power plant

Given: A power plant burns natural gas (NG), and produces electricity at a rate of 860 MW (on average over the course of a year).

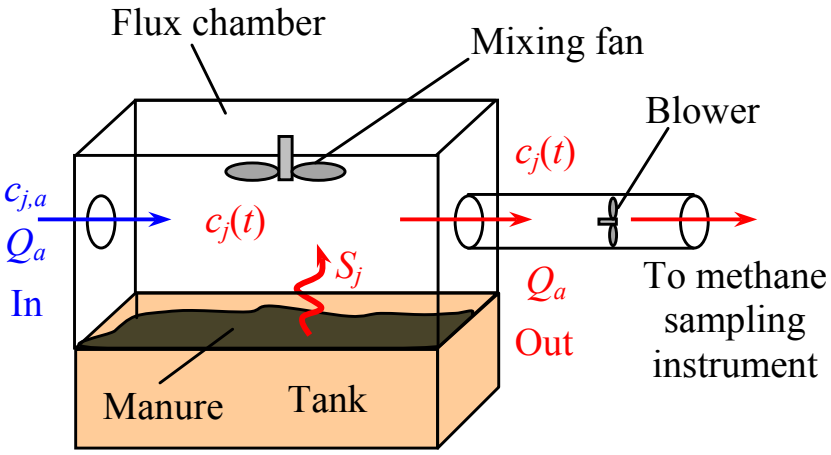
To do: Estimate (to 2 digits) how many million tons of CO_2 are emitted by this power plant per year.

Solution: First look up the EF of CO_2 emissions in an NG plant: EF = 1135 lbm CO_2/MWh.

Example: Methane from a Manure Tank

Given: Methane (CH_4) is emitted from a 2 m × 1 m manure tank in a barn. A flux chamber is built on top of the tank to measure the emission rate. The following quantities are measured:

- $c_{j,a}$ = 0.0020 mg/m^3 (ambient mass concentration of CH_4 in the barn)
- Q_a = 0.18 m^3/s (bulk air flow rate into the flux chamber)
- $c_{j,ss}$ = 1.5 mg/m^3 (steady-state mass concentration of CH_4 leaving the flux chamber)



To do: Generate an emission factor, EF, for methane from a manure pile.

Solution: