EGEE 470
Exam #2

Read the statements carefully and indicate whether they are true or false. For full credit (if correct) or partial credit (if incorrect), summarize how you arrived at your conclusions. If necessary, make reasonable assumptions and justify them.

T  Benzene is a primary air pollutant.

T  If the concentration of CO₂ in the atmosphere is 800 mg/m³, it exceeds 400 ppm.

\[
\text{437 ppm (NTP) } = 293 \text{ K, atm} \\
\text{407 ppm (STP) } = 273 \text{ K, atm}
\]

T  If the AP-42 factor for NOx emissions from a 500 MW(th) boiler (efficiency=40%) that uses natural gas (1000 BTU/scf) is 190 lb/10⁶ scf, the amount emitted exceeds 100 g/s.

\[
\text{190 lb} \quad 4508 \quad 10^6 \text{scf} \quad 500 \text{kJ} \quad (\text{kJ}) \quad \frac{6 \text{ BTU}(\text{ch})}{1 \text{kJ}} \quad = 0.4 \text{ BTU}(\text{ch}) = 101 \text{ g/s} \quad ? \quad \text{And if Eff = 90%?}
\]

F  For a coal-fired power plant (10,000 BTU/lb) whose NOx emissions are 20 kg/Mg, the minimum required efficiency of the NOx removal device exceeds 80% if the NSPS limit is 0.70 lb NO₂/10⁶ BTU(ch).

\[
\frac{\text{20 lb NO}_2}{\text{10,000 BTU/lb}} = 1.98 \frac{\text{lb NO}_2}{\text{10}^6 \text{BTU}(\text{ch})} \\
\Rightarrow \text{Min eff} = \frac{1.98 - 0.7}{1.98} = 65\% \quad (\text{If 20 kg NO}_2/\text{Mg, then 46%.})
\]

T  If the pressure at a certain height above ground is 0.50 atm for ‘standard’ atmosphere, that predicted using the neutral (dry, adiabatic) pressure gradient will exceed 0.50 atm.
Temperature inversion in the lower atmosphere (say, up to 500 m above ground) is more often observed at night than during the day.

See handout "\( \frac{dT}{dz} \) = Diurnal cycle"

If the dispersion coefficient is 20 m and the average (turbulent) 'diffusivity' of air is 0.1 \( m^2/s \), the characteristic (averaging) time in the Gaussian plume model does not exceed 1 h.

\[
T = \frac{0.5 \sigma_z^2}{K_x} \approx 0.6 \text{ h}
\]

When the wind speed is 10 m/s, the stack diameter is 2 m and the exhaust gas flow rate is 100 \( m^3/s \), the buoyancy and momentum length scales are of the same order of magnitude if the ambient and exhaust gas temperatures are 280 and 400 K.

\[
L_b = \frac{V_s (d_s/z)^2}{V_s} \left( \frac{T_s - T_a}{k} \right) = 0.13 \text{ m}
\]

\[
\frac{L_m}{L_b} = 24 > 10
\]

\[
L_m = 3.2 \text{ m}
\]

If the radon flux into a basement of a house (20x20x8 ft) is 0.5 pCi/m\(^2\)/s and the basement ventilation rate is 0.1 h\(^{-1}\), the steady-state radon concentration in the basement will not exceed the EPA-recommended limit of 4 pCi/L.

\[
C_{ss} = \frac{S/V}{Q + k} = 18 \text{ pCi L}^{-1}
\]

\[
\frac{S}{V} = 1.3 \times 10^{-8} \text{ m}^3/\text{m}^3 \text{ h}
\]

\[
C_{ss} = 1.2 \times 10^{-7} \text{ m}^3/\text{m}^3
\]

Under the worst-case scenario on a clear night, the Gaussian plume model predicts that the ground-level concentration of PM (average diameter=0.01 mm), emitted at 100 g/s in a rural location at an effective stack height of 250 m, will not exceed 0.030 mg/m\(^3\).

Clear night \( \Rightarrow \) D-F \( \equiv \) Worst case scenario: \( D = 6 \text{ m/s} \)

-neglect \( \nabla T \) (relatively small particles)

\[
C_{GL} \approx 0.009 \text{ mg/m}^3
\]

13 km

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