Quiz 1—Environmental Measurements

CENG 340–Introduction to Environmental Engineering
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September 4, 2013

Name:

(Modified from Mihelcic and Zimmerman) Ice resurfacing machines (aka Zambonis) use internal combustion vehicles that give off exhaust containing carbon monoxide (CO) and nitrogen oxides (NO_x). The outdoor air-quality, 1-h standard of CO is set at 30 ppm_v. Average 1-h CO concentrations at Lynah Rink have been reported to be as high as 30 mg/m^3. Assume that the temperature and pressure at Lynah equal 25 ^{0}C and 1 atm, respectively. In addition, note that (1) temperature in Kelvin (K) = temperature in Celsius (^{0}C) + 273.15; (2) MW_C = 12 g/mole and MW_O = 16 g/mole; and (3) the ideal gas constant R = $8.205 \times 10^{-5} \frac{m^3 \times atm}{mole \times Kelvin}$.

1. Does the concentration of CO at Lynah violate the outdoor air quality standard (show your work) [6 points]? $MW_{CO} = 12+16 = 28$ g/mole ; $T = 25 + 273.15 = 298.15$ K

STEP 1: convert [CO] from mg/m^3 to $mole/m^3$

$[CO] = 30 \frac{mg}{m^3} \times \frac{1g}{1000mg} \times \frac{1 mole}{28g} = 1.07 \times 10^{-3} \frac{mole\ CO}{m^3\ air}$

STEP 2: convert [CO] from $mole/m^3$ to a volume fraction $\Rightarrow \frac{m^3_{CO}}{m^3_{air}}$

use $PV = nRT \Rightarrow V_{CO} = \frac{n_{CO} RT}{P_{air}}$ (n = moles)

$[CO] = 1.07 \times 10^{-3} \frac{mole\ CO}{m^3 \cdot air} \times \frac{RT}{P_{air}} = 1.07 \times 10^{-3} \frac{mole\ CO}{m^3_{air}} \times 8.205 \times 10^{-5} \frac{m^3 \cdot atm}{mole \cdot K} \times \frac{298.15 K}{1 atm} =$

Vol. fraction $[CO] = 2.6 \times 10^{-5} \frac{m^3\ CO}{m^3\ air}$

STEP 3: convert [CO] from volume fraction to ppmv

ppm_v = volum fraction $\times 10^6$

$[CO] = 2.6 \times 10^{-5} \frac{m^3_{CO}}{m^3_{air}} \times 10^6 \rightarrow [CO] = 26\ ppm_v$ < 30 ppm

Does not violate standard

2. Calculate the partial pressure (in units of atm) of CO in the rink [2 points].

$P_i = \frac{V_i}{V_{tot}} \times P_{tot} = \frac{V_{CO}}{V_{tot}} \times P_{tot} = 2.6 \times 10^{-5} \frac{m^3}{m^3} \times 1 atm = 2.6 \times 10^{-5}$ atm

Volume fraction

$P_{CO} = 2.6 \times 10^{-5}$ atm

3. Report the concentration of CO at Lynah in units of moles/L [2 points].

$[CO] = 1.7 \times 10^{-3} \frac{mole\ CO}{m^3\ air} \times \frac{1 m^3}{1000 L} = 1.7 \times 10^{-6} mole/L$

from part 1