Environmental Engineering May 2005
Comprehensive Exam R. Harley

CEE 218A – Air Quality Engineering

1,3-butadiene is an alkene with four carbon atoms and two carbon-carbon double bonds (CH_2=CH–CH=CH_2). It is emitted as a product of incomplete combustion in gasoline engine exhaust.

(a) Write but do not solve an appropriate steady-state version of the atmospheric diffusion equation for butadiene transport and reaction downwind of a long and busy highway with perpendicular wind direction. Show terms that are zero/negligible by omitting them or crossing them out.

(b) Derive an appropriate plume formula for the ground-level concentration downwind of an infinite line source with perpendicular wind direction. Start with the Gaussian plume formula for a point source with reflection at the ground:

$$C(x,y,0) = \frac{2Q}{2\pi\sigma_y\sigma_z u}\exp\left(-\frac{y^2}{2\sigma_y^2}\right)\exp\left(-\frac{H^2}{2\sigma_z^2}\right)$$

In the above formula, Q is the point source emission rate (g/s) and *H* is the effective release height. Note the probability density function for a Gaussian distribution,

$$p(y) = \frac{1}{\sigma_y\sqrt{2\pi}}\exp\left(-\frac{y^2}{2\sigma_y^2}\right)$$

(c) Sketch concentration profiles of butadiene at x=1 km downwind for the crosswind (y) and vertical (z) coordinate directions. Make two separate plots. You do not need to show numerical values.

(d) The main atmospheric loss process for butadiene is reaction with the hydroxyl radical. Show the <u>first step only</u> of the reaction with butadiene.

(e) Given a pseudo-first order loss rate of butadiene (k = 1 h^{-1}), show how to adjust your answer to part (b) above to account for reaction.

(f) Assuming the above parts apply to midday conditions, explain how/why calculated answers to (b) and (e) would be different under nighttime conditions.

Scoring: a – 2, b – 2, c – 2, d – 1, e – 1, f – 2 points.