This equation can be transformed by defining a new dependent variable, $\alpha(x, y, z)$, where

$$X_a = \exp(-\alpha) \tag{7}$$

In terms of this new variable Equation (6) becomes

$$\nabla^2\alpha = 0 \tag{8}$$

Thus the transformation of Equation (7) has reduced the problem to that of finding solutions to the Laplace equation. Equation (7) also allows transformation of the boundary conditions. It should be noted that the condition $X_a = 0$ ($X_b = 1$) cannot be handled, since this implies an infinite value of α. This is to be expected, since the basic equations lose their meaning in this case. The condition $X_b = 1$ applies, for example, to the case where gas b is supplied by a boiling liquid, a process which is not diffusion controlled.

EXAMPLE

As an example of the application of the transformation given here consider the classic Stefan problem. An evaporating liquid b is contained at the bottom of a constant area column of height h located in an environment of gases a and b. In this case Equation (6) reduces to

$$\left[\frac{dX_a}{dz}\right]^2 - X_a\frac{d^2X_a}{dz^2} = 0 \tag{9}$$

In terms of α this becomes

$$\frac{d^2\alpha}{dz^2} = 0 \tag{10}$$

and the solution is

$$\alpha = \alpha_o + \frac{\alpha_h - \alpha_o}{h}\,z \tag{11}$$

where $\alpha_o = -\ln x_{a_o}$ and $\alpha_h = -\ln x_{a_h}$. Equation (11) is readily reduced to the expression which Stefan (2) first obtained by means of a direct application of Fick's law:

$$\frac{1-X_b}{1-X_{b_o}} = \left[\frac{1-X_{b_h}}{1-X_{b_o}}\right]^{z/h} \tag{12}$$

NOTATION

α = parameter defined by Equation (7)
C = molar concentration, g.-moles/cc.
D = diffusion coefficient, sq.cm./sec.
h = length of diffusion path, cm.
$\bar{N}$ = molal flux, g.-moles/sq.cm. sec.
$\bar{v}^*$ = molal average velocity, cm./sec.
t = time, sec.
X = mole fraction
(x, y, z) = Cartesian coordinates

Subscripts

a = parameter for gas a
b = parameter for gas b
h = boundary condition at $z = h$
o = boundary condition at $z = o$

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Comments on Simplified Method for the Predictions of Multicomponent Adsorption Equilibria from Single Gas Isotherms

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The method presented by Kidney and Myers (*1*) is a refined way to predict the multicomponent adsorption, if the mutual interactions for the adsorbed molecules are ideal. In the chemisorption, however, the interaction is not always ideal, and sometimes the mutual enhancements of adsorptions have to be expected, as evidenced in the systems of hydrogen-nitrogen on iron (*2*) and hydrogen-carbon monoxide on zinc oxide + copper chromate (*3*). It has also been reported (*4*) that the simultaneous chemisorption of mixed gases is unpredictable from the single gas adsorption of their components.

The ideal adsorbed solution theory was confirmed by Kidney and Meyers for physisorption data. We would like to point out that the use of this theory is limited to the physical adsorption, since it can not predict the mutual enhancement of the adsorption of gases.

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