

Chemical Reactions

Sept. 20



Carbon: $x_1 = x_3$

Hydrogen: $4x_1 = 2x_4$

Oxygen: $2x_2 = 2x_3$

$$\begin{matrix} x_1 & x_2 & x_3 & x_4 \\ \begin{bmatrix} 1 & 0 & -1 & 0 \\ 4 & 0 & 0 & -2 \\ 0 & 2 & -2 & 0 \end{bmatrix} \end{matrix}$$

$$\begin{bmatrix} 1 & 0 & 0 & -1/2 \\ 0 & 1 & 0 & -1 \\ 0 & 0 & 1 & -1/2 \end{bmatrix}$$

$x_4 = t$

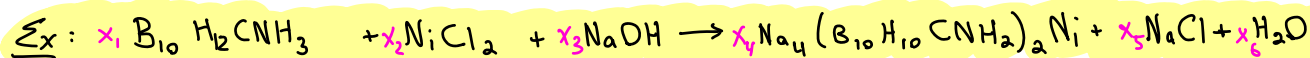
$x_3 = \frac{1}{2}t$

$x_2 = t$

$x_1 = \frac{1}{2}t$

$$\begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{bmatrix} = t \begin{bmatrix} 1/2 \\ 1 \\ 1/2 \\ 1 \end{bmatrix}$$

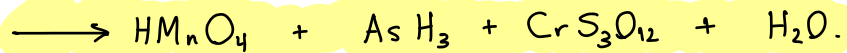
take 'simple' value of t
say $t=2$



$$\begin{matrix} \text{B:} \\ \text{H:} \\ \text{C:} \\ \text{N:} \\ \text{Ni:} \\ \text{Cl:} \\ \text{Na:} \\ \text{O:} \end{matrix} \begin{matrix} x_1 & x_2 & x_3 & x_4 & x_5 & x_6 \\ \begin{bmatrix} 10 & 0 & 0 & -20 & 0 & 0 \\ 15 & 0 & 1 & -24 & 0 & -2 \\ 1 & 0 & 0 & -2 & 0 & 0 \\ 1 & 0 & 0 & -2 & 0 & 0 \\ 0 & 1 & 0 & -1 & 0 & 0 \\ 0 & 2 & 0 & 0 & -1 & 0 \\ 0 & 0 & 1 & -4 & -1 & 0 \\ 0 & 0 & 1 & 0 & 0 & -1 \end{bmatrix} \end{matrix}$$

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & -1/3 \\ 0 & 1 & 0 & 0 & 0 & -1/6 \\ 0 & 0 & 1 & 0 & 0 & -1 \\ 0 & 0 & 0 & 1 & 0 & -1/6 \\ 0 & 0 & 0 & 0 & 1 & -1/3 \end{bmatrix}$$

$$\begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \\ x_6 \end{bmatrix} = \begin{bmatrix} t/3 \\ t/6 \\ t \\ t/6 \\ t/3 \\ t \end{bmatrix}$$



FOR YOU!

Dimensional Analysis

$$T_{\text{turkey}} = f(m, t, k, c, \rho) T_o$$

temperature of the turkey $^{\circ}\text{C}$ (points to T_{turkey})
 mass (points to m)
 time (points to t)
 Thermal Conductivity (points to k)
 specific heat capacity (points to c)
 density (points to ρ)
 oven temperature $^{\circ}\text{C}$ (points to T_o)
 must be 'dimensionless' no units. (bracketed under k, c, ρ)

Buckingham Π Theorem: # variables - # units = # of ways to group variables for f .

$$[m] = \text{kg}$$

$$[J] = \frac{\text{kg} \cdot \text{m}^2}{\text{s}^2}$$

$$[t] = \text{s}$$

$$[K] = \frac{\text{W}}{\text{m} \cdot \text{K}} = \left(\frac{\text{kg} \cdot \text{m}^2}{\text{s}^3} \right) / \text{m} \cdot \text{K} = \frac{\text{kg} \cdot \text{m}}{\text{s}^3 \cdot \text{K}}$$

$$[c] = \frac{\text{J}}{\text{kg} \cdot \text{K}} = \left(\frac{\text{kg} \cdot \text{m}^2}{\text{s}^2} \right) / \text{kg} \cdot \text{K} = \frac{\text{m}^2}{\text{s}^2 \cdot \text{K}} \quad \text{kg, s, m, K}$$

$$[\rho] = \frac{\text{kg}}{\text{m}^3}$$

$$(5 - 4) = 1$$

$$f(m^{x_1} t^{x_2} K^{x_3} c^{x_4} \rho^{x_5}) = f\left(\text{kg}^{x_1} \text{s}^{x_2} \left(\frac{\text{kg} \cdot \text{m}}{\text{s}^3 \cdot \text{K}}\right)^{x_3} \left(\frac{\text{m}^2}{\text{s}^2 \cdot \text{K}}\right)^{x_4} \left(\frac{\text{kg}}{\text{m}^3}\right)^{x_5}\right)$$

$$\text{kg: } x_1 + x_3 + x_5 = 0$$

$$\text{s: } x_2 - 3x_3 - 2x_4 = 0$$

$$\text{m: } x_3 + 2x_4 - 3x_5 = 0$$

$$\text{K: } -x_3 - x_4 = 0$$

$$\begin{bmatrix} 1 & 0 & 1 & 0 & 1 \\ 0 & 1 & -3 & -2 & 0 \\ 0 & 0 & 1 & 2 & -3 \\ 0 & 0 & -1 & -1 & 0 \end{bmatrix}$$

$$\begin{bmatrix} 1 & 0 & 0 & 0 & -2 \\ 0 & 1 & 0 & 0 & 3 \\ 0 & 0 & 1 & 0 & 3 \\ 0 & 0 & 0 & 1 & -3 \end{bmatrix}$$

$$T_t = \frac{t \cdot K}{m^{2/3} c p^{1/3}} T_0$$

$$R = \frac{T_0}{T_t} \text{ a constant}$$

$$t = \underbrace{\frac{c p^{1/3}}{R K}}_{C_t} m^{2/3}$$

C_t
the 'turkey'
constant.

$$\begin{aligned} x_1 &= 2a \\ x_2 &= -3a \\ x_3 &= -3a \\ x_4 &= 3a \\ x_5 &= a \end{aligned}$$

$$\begin{aligned} a &= -\frac{1}{3} \\ \text{so that} \\ x_2 &= 1 \end{aligned}$$

$$\begin{cases} x_1 = 2/3 \\ x_2 = 1 \\ x_3 = 1 \\ x_4 = -1 \\ x_5 = -1/3 \end{cases}$$

$$\text{SO... } t = C_t \cdot m^{2/3}$$

$$C_t \approx 0.55$$