2. Przeliczanie stężeń

Tabela 2.1 Stężenia

Stężenie	Faza gazowa	Faza ciekła	Jednostka
Koncentracja molowa	$C_{Ag} = n_A / V$	$C_{Ac} = n_A / V$	$kmol_A/m^3$
Ułamek/udział molowy	$y_A = n_A / n$	$x_A = n_A / n$	$kmol_A/kmol$
Ułamek/udział masowy	$\bar{y}_A = m_A / m$	$\bar{x}_A = m_A / m$	kg_A/kg
Stosunek molowy	$Y_A = n_A / n_B$	$X_A = n_A / n_B$	$kmol_A/kmol_B$
Stosunek masowy	$\bar{Y}_A = m_A / m_B$	$\bar{X}_A = m_A / m_B$	kg_A/kg_B
Ciśnienie cząstkowe	p_A	–	Pa

Tabela 2.2 Przeliczniki stężeń dla gazów

	p_A	C_A	$\bar{y}_A$	y_A	Y_A	$\bar{Y}_A$
$p_A =$	–	$C_A RT$	$P\,\bar{y}_A \frac{M}{M_A}$	$y_A P$	$\frac{PY_A}{1+Y_A}$	$\frac{P\bar{Y}_A M_B}{M_A + \bar{Y}_A M_B}$
$C_A =$	$\frac{p_A}{RT}$	–	$\bar{y}_A \frac{\rho}{M_A}$	$\frac{y_A \rho}{M}$	$\frac{Y_A}{1+Y_A}\frac{\rho}{M}$	$\frac{\bar{Y}_A}{1+\bar{Y}_A}\frac{\rho}{M_A}$
$\bar{y}_A =$	$\frac{p_A}{P}\frac{M_A}{M}$	$C_A \frac{M_A}{\rho}$	–	$y_A \frac{M_A}{M}$	$\frac{Y_A M_A}{Y_A M_A + M_B}$	$\frac{\bar{Y}_A}{1+\bar{Y}_A}$
$y_A =$	$\frac{p_A}{P}$	$C_A \frac{M}{\rho}$	$\bar{y}_A \frac{M}{M_A}$	–	$\frac{Y_A}{1+Y_A}$	$\frac{\bar{Y}_A M_B}{M_A + \bar{Y}_A M_B}$
$Y_A =$	$\frac{p_A}{P-p_A}$	$\frac{MC_A}{\rho - MC_A}$	$\frac{\bar{y}_A}{1-\bar{y}_A}\frac{M_B}{M_A}$	$\frac{y_A}{1-y_A}$	–	$\bar{Y}_A \frac{M_B}{M_A}$
$\bar{Y}_A =$	$\frac{p_A}{P-p_A}\frac{M_A}{M_B}$	$\frac{C_A M_A}{\rho - C_A M_A}$	$\frac{\bar{y}_A}{1-\bar{y}_A}$	$\frac{y_A}{1-y_A}\frac{M_A}{M_B}$	$Y_A \frac{M_A}{M_B}$	–

Tabela 2.3 Przeliczniki stężeń dla cieczy

	C_A	$\bar{x}_A$	x_A	X_A	$\bar{X}_A$
$C_A =$	–	$\bar{x}_A \frac{\rho}{M_A}$	$\frac{x_A \rho}{x_A M_A + (1-x_A)M_B}$	$\frac{X_A \rho}{X_A M_A + M_B}$	$\frac{\bar{X}_A}{1+\bar{X}_A}\frac{\rho}{M_A}$
$\bar{x}_A =$	$C_A \frac{M_A}{\rho}$	–	$\frac{x_A M_A}{x_A M_A + (1-x_A)M_B}$	$\frac{X_A M_A}{X_A M_A + M_B}$	$\frac{\bar{X}_A}{1+\bar{X}_A}$
$x_A =$	$\frac{C_A M_B}{C_A M_B + \rho - C_A M_A}$	$\frac{\bar{x}_A M_B}{\bar{x}_A M_B + (1-\bar{x}_A)M_A}$	–	$\frac{X_A}{1+X_A}$	$\frac{\bar{X}_A M_B}{M_A + \bar{X}_A M_B}$
$X_A =$	$\frac{C_A M_B}{\rho - C_A M_A}$	$\frac{\bar{x}_A}{1-\bar{x}_A}\frac{M_B}{M_A}$	$\frac{x_A}{1-x_A}$	–	$\bar{X}_A \frac{M_B}{M_A}$
$\bar{X}_A =$	$\frac{C_A M_A}{\rho - C_A M_A}$	$\frac{\bar{x}_A}{1-\bar{x}_A}$	$\frac{x_A}{1-x_A}\frac{M_A}{M_B}$	$X_A \frac{M_A}{M_B}$	–

Znane zależności:

$p_A V = n_A RT$ (r. Clapeyrona)

$p_A = y_A p$

$p = p_A + p_B$ (prawo Daltona)

$n = \frac{m}{M}$

$\rho = \frac{m}{V} = \frac{M}{V_m}$

Zad. Wyprowadź zależności:

a) $Y_a(y_a)$

$Y_a = \frac{n_a}{n_b} = \frac{n_a}{n - n_a} \frac{1/n}{1/n} = \frac{y_a}{1 - y_a}$

b) $\bar{y}_a(p_a)$

$\bar{y}_a = \frac{m_a}{m}$; $p_a V = n_a RT$; $m_a = n_a M_a$ stąd:

$p_a V = \frac{m_a}{M_a} RT$ oraz $pV = \frac{m}{M} RT$

Dzielimy powyższe wyr. prze siebie i otrzymujemy:

$\frac{p_a}{p} = \frac{m_a M}{m M_a}$ stąd $\frac{m_a}{m} = \bar{y}_a = \frac{p_a}{p} \frac{M_a}{M}$

c) $C_a(\bar{y}_a)$

$C_a = \frac{n_a}{V} = \frac{n_a \rho}{m} = \frac{m_a}{M_a} \frac{\rho}{m} = \bar{y}_a \frac{\rho}{M_a}$

d) $C_a(\bar{Y}_a)$

$C_a = \frac{n_a}{V} = \frac{n_a \rho}{m} = \frac{m_a}{M_a} \frac{\rho}{m} = \frac{m_a}{m_a + m_b} \frac{\rho}{M_a} \frac{m_b}{m_b} = \frac{\bar{Y}_a}{\bar{Y}_a + 1} \frac{\rho}{M_a}$

e) $Y_a(p_a)$

$Y_a = \frac{n_a}{n_b} = \frac{n_a}{n - n_a} = \frac{n_a / n}{1 - n_a / n} = \frac{y_a}{1 - y_a} = \frac{p_a / p}{1 - p_a / p} = \frac{p_a}{p - p_a}$

f) $p_a(Y_a)$

$p_a = y_a P = \frac{n_a / n_b}{n_a / n_b + n_b / n_b} P = \frac{Y_a}{1 + Y_a} P$

g) $\bar{Y}_a(y_a)$

$$\bar{Y}_a = \frac{m_a}{m_b} = \frac{n_a M_a / n}{(n/n - n_a/n)M_b} = \frac{y_a M_a}{(1-y_a)M_b}$$

h) $\bar{x}_a(C_a)$

$$\bar{x}_a = \frac{m_a}{m} = \frac{n_a M_a}{V\rho} = C_a \frac{M_a}{\rho}$$

i) $y_a(C_a)$

$$y_a = \frac{n_a}{n} = \frac{n_a}{m/M} = \frac{n_a M}{\rho V} = C_a \frac{M}{\rho}$$

j) $x_a(\bar{x}_a)$

$$x_a = \frac{n_a}{n} = \frac{m_a/M_a}{m_a/M_a + m_b/M_b}\frac{m}{m} = \frac{\bar{x}_a/M_a}{\bar{x}_a/M_a + (1-\bar{x}_a)/M_b}\frac{M_a M_b}{M_a M_b} = \frac{\bar{x}_a M_b}{\bar{x}_a M_b + (1-\bar{x}_a)M_a}$$

k) $y_a(\bar{Y}_a)$

$$y_a = \frac{n_a}{n} = \frac{m_a/M_a}{m_a/M_a + m_b/M_b}\frac{m_b}{m_b} = \frac{\bar{Y}_a/M_a}{\bar{Y}_a/M_a + 1/M_b}\frac{M_a M_b}{M_a M_b} = \frac{\bar{Y}_a M_b}{\bar{Y}_a M_b + M_a}$$

l) $C_a(y_a)$

$$C_a = \frac{n_a}{V} = \frac{n_a}{nM/\rho} = y_a \frac{\rho}{M}$$

ł) $\bar{x}_a(x_a)$

$$\bar{x}_a = \frac{m_a}{m} = \frac{n_a M_a}{n_a M_a + n_b M_b}\frac{n}{n} = \frac{x_a M_a}{x_a M_a + x_b M_b} = \frac{x_a M_a}{x_a M_a + (1-x_a)M_b}$$

m) $C_a(\bar{x}_a)$

$$C_a = \frac{n_a}{V} = \frac{m_a/M_a}{V} = \frac{m_a \rho}{M_a m} = \bar{x}_a \frac{\rho}{M_a}$$