CHE 203
HW # 8 SOLUTION

1) $W_{12} = 0$, $W = W_{23} = -P_2(V_3 - V_2) = -R(T_3 - T_2)$

But $T_3 = T_1$ so $W = R(T_2 - T_1)$ — (a)

Also $W = RT_1 \ln\left(\frac{P}{P_1}\right)$ — (b)

equating (a) and (b), implies that:

$$\ln\left(\frac{P}{P_1}\right) = \frac{T_2 - T_1}{T_1}$$

$T_1 = 800\,K$
$T_2 = 350\,K$
$P_1 = 4$ bar

$$\Rightarrow P = P_1 \exp\left[\frac{T_2 - T_1}{T_1}\right] = 4 \times \exp(-0.5625) = 2.279 \text{ bar}$$

$\therefore$ $P = 2.279$ bar

2) $B = -242.5\ cm^3/mol$, $C = 25{,}200\ cm^6/mol^2$

$T = 373.15\,K$, $P_1 = 1$ bar, $P_2 = 55$ bar

$B' = \frac{B}{RT}$, $C' = \frac{C - B^2}{R^2T^2}$

a) Solve virial equation for initial V

Guess: $V_1 = \frac{RT}{P_1}$ Given $\frac{P_1 V_1}{RT} = 1 + \frac{B}{V_1} + \frac{C}{V_1^2}$

$V_1 = \text{Find}(V_1)$ $V_1 = 30{,}780\ cm^3/mol$

Solve virial equation for final V.

Guess : $V_2 = \frac{RT}{P_2}$ Given $\frac{P_2 V_2}{RT} = 1 + \frac{B}{V_2} + \frac{C}{V_2^2}$

$V_2 = \text{Find}(V_2)$, $V_2 = 241.33 \text{ cm}^3/\text{mol}$

$$W = -\int_{V_1}^{V_2} P\,dV \quad \text{---} \quad (1.3)$$

Eliminate P from equation (1.3) by the virial equation :

$$\Rightarrow \quad W = -RT \int_{V_1}^{V_2} \left[1 + \frac{B}{V} + \frac{C}{V^2}\right] \cdot \frac{1}{V}\, dV$$

$W = 12.62 \text{ KJ/mol}$

b) Eliminate dV from equation (1.3) by the virial equation in P :

$$dV = RT\left[\frac{-1}{P^2} + C'\right] dP$$

$$\Rightarrow W = -RT \int_{P_1}^{P_2} \left(\frac{-1}{P} + C'P\right) dP$$

$W = 12.6 \text{ KJ/mol}$

Note: The answers to (a) & (b) differ because the relations between the two sets of parameters are exact only for infinite series.

3) $T = 348.15\ K$, $P = 15\ bar$, $R = 8.314\ J/mol \cdot K$

a) $B = -194\ cm^3/mol$, $C = 15{,}300\ cm^6/mol^2$

Guess $V = \frac{RT}{P}$ Given $\frac{PV}{RT} = 1 + \frac{B}{V} + \frac{C}{V^2}$

$V = Find(V)$ $V = 1722\ cm^3/mol$

$Z = \frac{PV}{RT}$ $\Rightarrow$ $Z = 0.893$

b) $T_c = 318.7\ K$, $P_c = 37.6\ bar$ $\omega = 0.286$

$T_r = \frac{T}{T_c}$, $P_r = \frac{P}{P_c}$, $B_0 = 0.083 - \frac{0.422}{T_r^{1.6}}$

$B_1 = 0.139 - \frac{0.172}{T_r^{4.2}}$, $Z = 1 + (B_0 + \omega B_1)\frac{P_r}{T_r}$

$\Rightarrow$ $Z = 0.899$. $V = \frac{Z \cdot RT}{P}$, $V = 1734\ cm^3/mol$

c) $a = \frac{0.42748\, R^2 T_c^{2.5}}{P_c}$, $b = \frac{0.08664\, RT_c}{P_c}$

Given $P = \frac{RT}{V-b} - \frac{a}{T^{0.5}V(V+b)}$

$V = Find(V)$, $V = 1714\ cm^3/mol$

$Z = \frac{PV}{RT}$ $\Rightarrow$ $Z = 0.888$

4)

$T = 298.15\ K$, $P = 2.43\ bar$, $V_{vap.} = 16\ m^3$

$T_c = 425.1\ K$, $P_c = 37.96\ bar$, $\omega = 0.200$

$T_r = \frac{T}{T_c}$, $P_r = \frac{P}{P_c}$, $mol = 58.123\ gm$,

$R = 8.314\ J/mol.K$, $B_0 = 0.083 - \frac{0.422}{T_r^{1.6}}$

$B_1 = 0.139 - \frac{0.172}{T_r^{4.2}}$

$V = \frac{RT}{P} + \left(B_0 + \omega B_1\right) R \cdot \frac{T_c}{P_c}$

$m_{vap.} = \frac{V_{vap.}}{V} \Rightarrow m_{vap} = 98.2\ kg$