$\vec{g}^{\circ} = -19,73 \text{ kJ/mol}$.

2) Obtener entalpía

Ecuación 1

Partiendo de $\left(\frac{\partial u}{\partial v}\right)_T = T\left(\frac{\alpha}{k}\right) - P$

$$\left(\frac{\partial h}{\partial T}\right) = v - T\left(\frac{\partial v}{\partial T}\right)_P$$

Definición de entalpía: $h = U + PV$

Derivando respecto a la presión manteniendo constante a T

$$\left(\frac{\partial h}{\partial T}\right)_P = \left(\frac{\partial u}{\partial P}\right)_T + P\left(\frac{\partial v}{\partial P}\right)_T + v$$

$$\left(\frac{\partial v}{\partial P}\right)_T = \left(\frac{\partial u}{\partial v}\right)_T \cdot \left(\frac{\partial v}{\partial P}\right)_T$$

sustituimos → $\left(\frac{\partial h}{\partial P}\right)_T = \left(\frac{\partial u}{\partial v}\right)_T \left(\frac{\partial v}{\partial P}\right)_T + P\left(\frac{\partial v}{\partial P}\right)_T + v$

Sacamos factor común → $\left(\frac{\partial h}{\partial P}\right)_T = \left[\left(\frac{\partial u}{\partial v}\right)_T + P\right]\left(\frac{\partial v}{\partial P}\right)_T + v$

Ahora utilizando la expresión del encerrado:

$$\left(\frac{\partial u}{\partial v}\right)_T = T\frac{\alpha}{k} - P$$

por tanto → $\left(\frac{\partial u}{\partial v}\right)_T + P = T\frac{\alpha}{k}$

sustituimos $\left(\frac{\partial h}{\partial P}\right)_T = T\frac{\alpha}{k}\left(\frac{\partial v}{\partial P}\right)_T + v$

Recordando que: $k = \frac{-1}{v}\left(\frac{\partial v}{\partial P}\right)_T$

$\left(\frac{\partial v}{\partial P}\right)_T = -kv$ ↓ despejamos

↓ sustituimos en nuestra expresión

$\left(\frac{\partial h}{\partial P}\right)_T = T\left(\frac{\alpha}{k}\right)(-kv) + v$

$\left(\frac{\partial h}{\partial P}\right)_T = -T\alpha v + v$

↓

sacamos factor común

$$\left(\frac{\partial h}{\partial P}\right)_T = v(1 - T\alpha)$$

Usamos el coeficiente de expansividad térmica

$$\alpha = \frac{1}{v}\left(\frac{\partial v}{\partial T}\right)_P$$

Despejamos para v

$$\alpha v = \left(\frac{\partial v}{\partial T}\right)_P$$

Sustituyendo obtenemos → $\left(\frac{\partial h}{\partial P}\right)_T = v - T\left(\frac{\partial v}{\partial T}\right)_P$

Ecuación 2

(2) Proceso isotérmico $T_1 = T_2$

$v_2 = 2v_1$ → el volumen se duplica

Ecuación de van der Waals

$$P = \frac{RT}{v - b} - \frac{a}{v^2}$$

$$\left(\frac{\partial u}{\partial v}\right)_T = T\left(\frac{\partial P}{\partial T}\right) - P$$

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Derivamos la ecuación de van der Waals respecto a T

$$P = \frac{RT}{v-b} - \frac{a}{v^2}$$

Derivamos respecto a T y mantenemos v cte

$$\left(\frac{\partial P}{\partial T}\right)_v = \frac{R}{v-b}$$

Sustituimos en la ecuación de ΔV

$$\left(\frac{\partial v}{\partial v}\right)_T = T \cdot \frac{R}{v-b} - \left(\frac{RT}{v-b} - \frac{a}{v^2}\right)$$

$$\downarrow$$

$$\left(\frac{\partial u}{\partial v}\right)_T = \frac{RT}{v-b} - \frac{RT}{v-b} + \frac{a}{v^2}$$

$$\downarrow$$

$$\left(\frac{\partial u}{\partial v}\right)_T = \frac{a}{v^2}$$

Integramos para obtener la ecuación de variación de energía interna

$$du = \frac{a}{v^2}\, dv$$

$$\Delta U = u_2 - u_1 = \int_{v_1}^{v_2} \frac{a}{v^2}\, dv$$

$$\Delta V = \int_{v_1}^{v_2} a \cdot v^{-2}\, dv = a \cdot \left[\frac{-1}{v_2} + \frac{1}{v_1}\right]$$

$v_2 = 2v_1$

$$\Delta U = a \cdot \left(-\frac{1}{2v_1} + \frac{1}{v_1}\right) = a\left(\frac{1}{2v_1}\right)$$

$$u_2 - u_1 = \frac{a}{2v_1}$$

Ejercicio 3

③ Compresión del aire

$P_1 = 100 kPa$ $\quad \Delta s = -0,3844 kJ/(kg\,K)$

$T_1 = 290,15 K$

$T_2 = 330,15 K$

$$R = \frac{R_u}{M} = \frac{8,314}{28,91} = 0,2870 kJ/kg\,K$$

$$\Delta s = c_p \ln\left(\frac{T_2}{T_1}\right) - R \ln\left(\frac{P_2}{P_1}\right)$$

$$-0,384 = 1,055 \ln\left(\frac{330,15}{290,15}\right) - 0,287 \ln\left(\frac{P_2}{100}\right)$$

$$-0,384 = 1,005 \cdot 0,12915 - 0,287 \ln\frac{P_2}{100}$$

$$-0,3844 = 0,129 - 0,287 \ln\frac{P_2}{100}$$

$$-0,15420 = -0,287 \ln\left(\frac{P_2}{100}\right)$$

$$\ln\left(\frac{P_2}{100}\right) = 1,7917$$

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$$\frac{P_2}{100} = e^{1,791} \Rightarrow \boxed{P_2 = 600 KPa}$$

④ $v = 2 m^3$
$T = 329,35 K$
$m_T = 10,84 Kg$
} Masa molar de la acetona = $58,08 kg/mol$

$$P = \frac{RT}{v-b} - \frac{a\alpha}{v(v+b)+b(v-b)}$$

$$a = 0,457 \frac{R^2 T_c^2}{P_c} \qquad \alpha = [1 + k(1-\sqrt{T_r})]^2$$

$$b = 0,0778 \frac{RT_c}{P_c} \qquad T_r = \frac{T}{T_c}$$

$$k = 0,37464 + 1,54 \omega - 0,2699 \omega^2$$

Para la acetona usamos $\Rightarrow T_c = 508,1 K$
$P_c = 4,70 MPa$
$\omega = 0,307$

Calculo de la presión de saturación $\Rightarrow \int^L = \int^V$
↓
Equilibrio líquido - vapor

Para Peng-Robinson $\Rightarrow \phi^L_i = \phi^V_i$
|
$\phi^L = \phi^V$

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$P_{sat} = 101,007\ kPa$

Factores de compresibilidad

↓

Raíz ⊖ → líquido → $z_L = 0,003227$

Raíz ⊕ → vapor → $z_0 = 0,970388$

$PV = zRT$

↓

$V = \frac{zRT}{P}$

$V_L = \frac{0,003227 \cdot 8,314 \cdot 329,35}{101,007}$

$= 0,00008749\ m^3/mol$

$V_V = \frac{0,970388 \cdot 8,314 \cdot 329,35}{101,007} = 0,26308\ m^3/mol$

Calculamos los moles totales de la columna

$n_T = \frac{m_T}{M} = \frac{10,84}{58,08} = 0,18664\ kmol$

$n_T = 186,64\ mol$

$V_m = \frac{V}{n_T} = \frac{a}{186,64} = 0,001716\ m^3/mol$

$V_m = (1-B)\,V_L + B\,V_V$

$B = \frac{nV}{n_T}$

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$$V_m = V_L - B V_L + B V_V$$

$$V_m - V_L = B(V_V - V_L)$$

$$B = \frac{V_m - V_L}{V_V - V_L} = \frac{0{,}010716 - 0{,}000087449}{0{,}026308 - 0{,}000087449}$$

$$= 0{,}40535$$

$m_g = B \cdot m_T = 0{,}40535 \cdot 10{,}84 = 4{,}394\,kg$

Calculamos la masa de vapor en ebullición

$m_T = m_L + m_V$; $m_L = m_T - m_V = 6{,}446\,kg$