

$$n=1$$

$$C_{v,m} = 12.5 \frac{\text{J}}{\text{mol K}}$$

$$C_{p,m} = 20.8 \frac{\text{J}}{\text{mol K}}$$

جوابی تمرین ①

$$\textcircled{a} \quad q_h = 234 \text{ J}$$

$$W = 534 \text{ J}$$

$$\Delta U = q_h + W = 234 + 534 = 768 \text{ J}$$

$$\textcircled{b} \quad q_c = -106 \text{ J}$$

$$W = -242 \text{ J}$$

$$\Delta U = q_c + W = -106 - 242 = -348 \text{ J}$$

$$\textcircled{c} \quad W=0 \quad \Delta U = C_v \Delta T = n C_{v,m} \Delta T = (1)(12.5)(100) = 1250 \text{ J}$$

$$\textcircled{d} \quad q_p = C_p \Delta T = n C_{p,m} \Delta T = (1)(20.8)(100) = 2080 \text{ J}$$

$$\textcircled{e} \quad W = -P_{\text{ext}} \Delta V = -(2.5 \times 10^5 \text{ Pa})(0.75 \times 10^{-3} \text{ m}^3) = -187.5 \text{ J}$$

$$\textcircled{f} \quad \Delta H = q_p \Rightarrow q_p = -678 \text{ J}$$

$$\Delta U = -407 \text{ J}$$

$$\Delta U = q_p + W \rightarrow W = \Delta U - q_p = -407 + 678 = 271 \text{ J}$$

جواب نمبر ②

$$P_1 V_1^\gamma = P_2 V_2^\gamma \Rightarrow \frac{P_2}{P_1} = \left(\frac{V_1}{V_2}\right)^\gamma$$

$$\Rightarrow \left(\frac{V_1}{V_2}\right) = \left(\frac{P_2}{P_1}\right)^{\frac{1}{\gamma}}$$

$$\left(\frac{T_2}{T_1}\right) = \left(\frac{V_1}{V_2}\right)^{\gamma-1}$$

$$\Rightarrow \frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} \quad \gamma = \frac{5}{3} = 1.66$$

$$P_1 = 6 \text{ atm} = 6 \times 10^5 \text{ Pa}$$

$$P_2 = 1 \text{ atm} = 1 \times 10^5 \text{ Pa}$$

$$\Rightarrow \frac{T_2}{T_1} = \left(\frac{1 \times 10^5}{6 \times 10^5}\right)^{\frac{1.66-1}{1.66}} = 0.49 \approx 0.5$$

$$T_2 = 0.5 T_1 \Rightarrow$$

دما نصف ہو گا۔

$$p v^\gamma = c \Rightarrow d(p v^\gamma) = 0$$

$$dp v^\gamma + p d(v^\gamma) = 0$$

$$dp v^\gamma + p \gamma v^{\gamma-1} dv = 0$$

$$dp v^\gamma = -p \gamma v^{\gamma-1} dv$$

$$\Rightarrow \frac{dp}{p} = -\gamma \frac{dv}{v} \quad \gamma > 1$$

$$\Rightarrow \left|\frac{dp}{p}\right| = \gamma \left|\frac{dv}{v}\right| \rightarrow \left|\frac{dp}{p}\right| > \left|\frac{dv}{v}\right|$$

جواب نمبر ③

④ جواب آیرن
 ⑤ آنتالپی ثابت است.

جواب آیرن ⑤

$$P_1 = 690 \text{ kPa}$$

$$T_1 = 260^\circ\text{C} = 533.15 \text{ K}$$

$$P_2 = 210 \text{ kPa}$$

$$T_2 = 40^\circ\text{C} = 313.15 \text{ K}$$

$$\left(\frac{T_2}{T_1}\right) = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}$$

$$\left(\frac{313.15}{533.15}\right) = \left(\frac{210}{690}\right)^{\frac{\gamma-1}{\gamma}}$$

$$\Rightarrow (0.6) = (0.3)^{\frac{\gamma-1}{\gamma}} \Rightarrow \ln 0.6 = \left(\frac{\gamma-1}{\gamma}\right) \ln 0.3$$

$$\Rightarrow \gamma (\ln 0.6 - \ln 0.3) = -\ln 0.3$$

$$\Rightarrow \gamma = \frac{-\ln 0.3}{\ln 0.6 - \ln 0.3} = \frac{1.2}{0.7} = 1.71$$

$$W = - \int P dv = - \int c v^{-\gamma} dv = -c \frac{v^{-\gamma+1}}{-\gamma+1} \Big|_{v_1}^{v_2}$$

$$W = \frac{c v_2^{1-\gamma} - c v_1^{1-\gamma}}{\gamma-1} = \frac{P_2 v_2 - P_1 v_1}{\gamma-1}$$

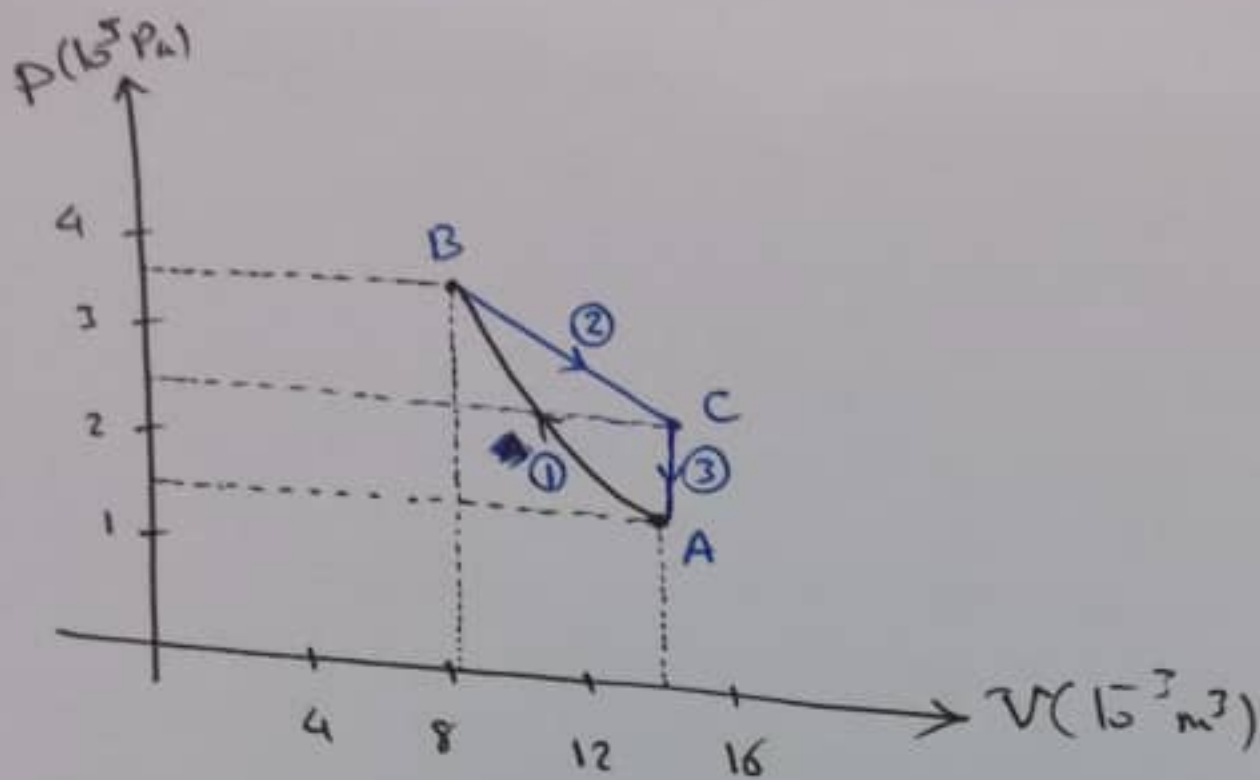
برابر کار از آیرن $PV = nRT \Rightarrow W = \frac{nR(T_2 - T_1)}{\gamma-1}$

$$\Rightarrow \frac{W}{n} = \frac{R(T_2 - T_1)}{\gamma-1} = \frac{8.314(313.15 - 533.15)}{1.71-1}$$

$$= -2520.4 \frac{\text{J}}{\text{mol}}$$

کاره که هر مول از گاز انجام دهد.

جواب برین ⑥:



$$P_A = 1.5 \times 10^5 \text{ Pa}$$

$$V_A = 0.014 \text{ m}^3$$

$$P_B = 3.6 \times 10^5 \text{ Pa}$$

$$V_B = 8.3 \times 10^{-3} \text{ m}^3 = 0.0083 \text{ m}^3$$

$$P_C = 2.4 \times 10^5 \text{ Pa}$$

$$V_C = V_A$$

① در شکل بالا مسیر رسم شده است

② کار W_2 برابر است با مساحت زیر نمودار در مرحله ②

$$|W_2| = \text{مساحت نوزنقه}$$

$$|W_2| = \frac{1}{2} \times (\text{مجموع دو قاعده}) \times \text{ارتفاع}$$

$$|W_2| = \frac{1}{2} (3.6 + 2.4) \times 10^5 \times (0.014 - 0.0083)$$

$$|W_2| = 0.0171 \times 10^5 \text{ J} = 1.7 \text{ kJ}$$

$$W_2 = -1.7 \text{ kJ}$$

صورت اینست داریم

جواب سوال 7

$$m = 2.5 \text{ kg}$$

$$\text{state 1: } P_1 = 125.0 \text{ kPa}$$

$$\text{state 2: } V_2 = 50 \text{ L} = 50 \times 10^{-3} \text{ m}^3 ; P_2 = P_1$$

$$\text{state 3: } V_3 = V_2 = 50 \times 10^{-3} \text{ m}^3 ; P_3 = 225.0 \text{ kPa}$$

$$\text{state 2} \quad v_g = \frac{V_g}{m} = \frac{50 \times 10^{-3}}{2.5} = 20 \times 10^{-3} = 0.02 \frac{\text{m}^3}{\text{kg}}$$

از جدول مربوط به آب اشباع اطلاعات زیر را استخراج کنید:

$$P = 125 \text{ kPa} \quad v_f = 0.001048 \quad v_{fg} = 1.37385$$

$$P = 225 \text{ kPa} \quad v_f = 0.001064 \quad v_{fg} = 0.71765$$

$$\text{state 2: } P_2 = P_1 = 125 \text{ kPa} \quad v_g = \frac{V_2}{m} = 0.02 \frac{\text{m}^3}{\text{kg}}$$

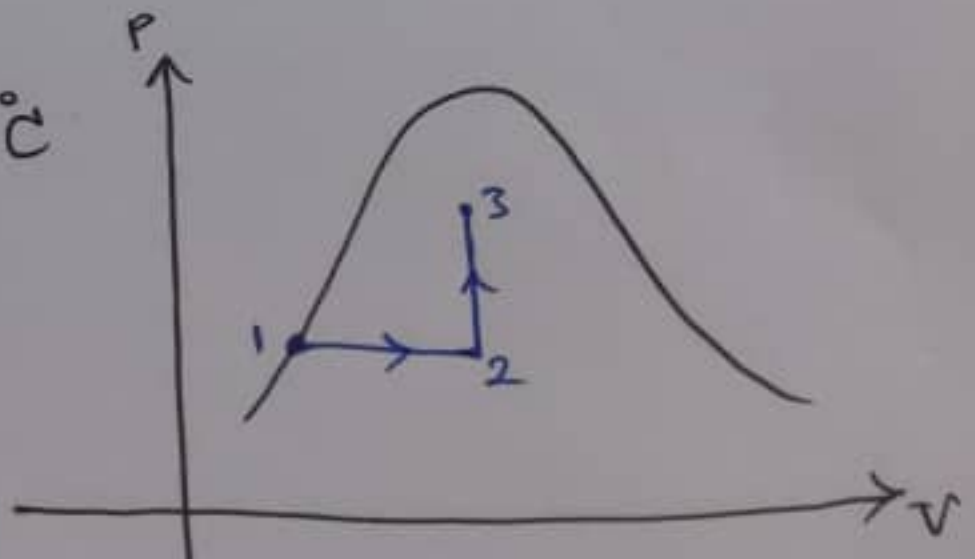
$$x_2 = \frac{v_g - v_f}{v_{fg}} = \frac{0.02 - 0.001048}{1.37385} = 0.0137$$

$$\text{state 3: } V_3 = V_2 \Rightarrow v = 0.02 \frac{\text{m}^3}{\text{kg}}$$

$$P_3 = 250 \text{ kPa}$$

$$x_3 = \frac{v - v_f}{v_{fg}} = \frac{0.02 - 0.001064}{0.71765} = 0.0263$$

برای رسیدن به درخت $\Rightarrow T_3 = 124^\circ \text{C}$
250 kPa



جواب تمرین ⑤ :

$$m = 5 \text{ kg}$$

$$P_1 = 500 \text{ kPa}$$

$$T_1 = 500 \text{ K}$$

$$P_2 = 230 \text{ kPa}$$

$$\bar{c}_v = 0.742 \frac{\text{kJ}}{\text{kg K}} = 0.742 \times 10^3 \frac{\text{J}}{\text{kg K}}$$

$$\gamma = 1.4$$

$$\text{عزایته می شود} \Rightarrow \left(\frac{T_2}{T_1}\right) = \left(\frac{V_1}{V_2}\right)^{\gamma-1} \quad (1)$$

$$P_1 V_1^\gamma = P_2 V_2^\gamma \Rightarrow \frac{V_1}{V_2} = \left(\frac{P_2}{P_1}\right)^{\frac{1}{\gamma}} \quad (2)$$

$$(1), (2) \Rightarrow \frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}$$

$$T_2 = T_1 \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} = (500) \left(\frac{230}{500}\right)^{\frac{1.4-1}{1.4}} = 400.73 \text{ K}$$

$$\Delta U = c_v \Delta T = m \bar{c}_v \Delta T = (5) (0.742 \times 10^3) (400.73 - 500)$$

$$= -368.3 \times 10^3 \text{ J} = -368.3 \text{ kJ}$$

$$\text{قانون اول} \quad \Delta U = q + W \quad \begin{array}{l} \text{بی طرفی} \\ \xrightarrow{\quad} \\ q = 0 \end{array} \quad W = \Delta U = -368.3 \text{ kJ}$$

جواب سؤال 9

$$P_1 = 1 \text{ atm} = 1.0325 \times 10^5 \text{ Pa}$$

$$T_1 = 20^\circ\text{C} = 293.15 \text{ K}$$

$$V_1 = 1000 \text{ cm}^3 = 1000 \times 10^{-6} \text{ m}^3 = 10^{-3} \text{ m}^3$$

$$T_2 = 260^\circ\text{C} = 533.15 \text{ K}$$

$$P_2 = P_1 = P \text{ فناء ثابت اس}$$

$$\bar{C}_p = 1.005 \frac{\text{kJ}}{\text{kg K}}$$

$$M = 28.97 \times 10^{-3} \frac{\text{kg}}{\text{mol}}$$

$$P_1 V_1 = n R T_1 \Rightarrow n = \frac{P_1 V_1}{R T_1} = \frac{(1.0325 \times 10^5)(10^{-3})}{(8.314)(293.15)} = 0.042 \text{ mol}$$

$$m = n M = 0.042 \times 28.97 \times 10^{-3} = 1.27 \times 10^{-3} \text{ kg}$$

$$\Delta U = q_p + W$$

$$q_p = C_p \Delta T = m \bar{C}_p \Delta T = (1.27 \times 10^{-3})(1.005)(533.15 - 293.15)$$

$$q_p = 306.3 \text{ J}$$

$$W = -\int P_{\text{ext}} dv = -\int P dv = -P \int dv = -P \Delta V$$

$$W = -P(V_2 - V_1)$$

$$\begin{aligned} P_1 V_1 &= n R T_1 \\ P_2 V_2 &= n R T_2 \end{aligned} \xrightarrow{P_1 = P_2} \frac{V_1}{V_2} = \frac{T_1}{T_2}$$

$$\rightarrow V_2 = \left(\frac{T_2}{T_1}\right) V_1 = 18.19 \times 10^{-3}$$

$$W = -P(V_2 - V_1) = -(1.0325 \times 10^5)(18.19 - 1) \times 10^{-3} = -82.98 \text{ J}$$

$$\Delta U = q_p + W = 306.3 - 82.98 = 223.2 \text{ J}$$

• جواب آئین 19 :

$$U = 3.56 p v + 84$$

$$m = 3 \text{ kg}$$

$$P_1 = 500 \text{ kPa}$$

$$V_1 = 0.22 \text{ m}^3$$

$$P_2 = 100 \text{ kPa}$$

$$pV^{1.2} = \text{constant} \Rightarrow pV^{1.2} = c$$

$$\Delta U = U_2 - U_1 = 3.56 (P_2 v_2 - P_1 v_1)$$

$$\begin{aligned} \Delta u = m \Delta U &= 3.56 (P_2 (m v_2) - P_1 (m v_1)) \\ &= 3.56 (P_2 V_2 - P_1 V_1) \end{aligned}$$

$$P_1 V_1^{1.2} = P_2 V_2^{1.2} \rightarrow V_2 = V_1 \left(\frac{P_1}{P_2} \right)^{\frac{1}{1.2}} = 0.22 \left(\frac{500}{100} \right)^{\frac{1}{1.2}} = 0.841 \text{ m}^3$$

$$\Rightarrow \Delta u = 3.56 \left((100 \times 10^3)(0.841) - (500 \times 10^3)(0.22) \right) = -92.2 \text{ kJ}$$

$$W = - \int_{V_1}^{V_2} P dV = - \int_{V_1}^{V_2} \frac{c}{V^{1.2}} dV = -c \int_{V_1}^{V_2} \frac{dV}{V^{1.2}} = \frac{c}{0.2} V^{-0.2} \Big|_{V_1}^{V_2}$$

$$= \frac{c V_2^{-0.2} - c V_1^{-0.2}}{0.2} = \frac{P_2 V_2 - P_1 V_1}{0.2}$$

$$= \frac{(100 \times 10^3)(0.841) - (500 \times 10^3)(0.22)}{0.2} = -129.5 \text{ kJ}$$

$$\text{قانون اول} \quad \Delta u = q + W \Rightarrow q = \Delta u - W = -92.2 \text{ kJ} + 129.5 \text{ kJ}$$

$$= 37.3 \text{ kJ}$$

کار الکتریکی $P_{el} = \frac{W_{el}}{\Delta t}$ توان الکتریکی

جواب ۱۱

$P_{el} = VI$
 ↓ ↓
 ولتاژ جریان

$V = 120 \text{ volt}$ $I = 2 \text{ A}$

$\Delta t = 6 \text{ min} = 360 \text{ s}$

$\Rightarrow \frac{W_{el}}{\Delta t} = VI \Rightarrow W_{el} = VI \Delta t$

$\Rightarrow W_{el} = VI \Delta t = (120)(2)(360) = 86.4 \text{ kJ}$

کار الکتریکی بالا به سیستم وارد می شود.

$P_1 = 350 \text{ kPa}$

حجم مولی $M = 28.01 \frac{\text{kg}}{\text{kmol}} = 28.01 \times 10^{-3} \frac{\text{kg}}{\text{mol}}$

$V_1 = 0.3 \text{ m}^3$

$q_h = -3000 \text{ J}$

$T_1 = 35^\circ \text{C} = 308.15 \text{ K}$

$P_1 V_1 = n R T_1 \Rightarrow n = \frac{P_1 V_1}{R T_1} = \frac{(350 \times 10^3)(0.3)}{(8.314)(308.15)} = 41 \text{ mol}$

$n = \frac{m}{M} \Rightarrow m = n M = (41 \text{ mol}) \times (28.01 \times 10^{-3} \frac{\text{kg}}{\text{mol}})$
 $= 1148 \times 10^{-3} \text{ kg} = 1.148 \text{ kg}$

موازنه $\Delta u = q + w = q_h + (w_{el} + w_{exp})$

$w_{exp} = -P \Delta V$
 فشار ثابت.

کار انبساطی کار الکتریکی

$\Delta u = q + w_{el} - P \Delta V \Rightarrow \Delta u + P \Delta V = q + w_{el}$

$\Rightarrow \Delta u + \Delta P V = q + w_{el} \Rightarrow \Delta(u + P V) = q + w_{el}$

$\Rightarrow \Delta H = q + w_{el}$ $\Delta H = c_p \Delta T = m \bar{c}_p \Delta T = m \bar{c}_p (T_2 - T_1)$

$\Rightarrow m \bar{c}_p (T_2 - T_1) = q + w_{el} = (-3000) + (86.4 \times 10^3)$

$\Rightarrow (1.148)(1.039)(T_2 - 308.15) = 83.4 \times 10^3 \Rightarrow T_2 = 377.9 \text{ K}$

$$\Delta H_{rx}^{\circ} = \sum \Delta H_f^{\circ}(\text{products}) - \sum \Delta H_f^{\circ}(\text{reactants})$$

$$\Delta H_{rx}^{\circ} = 3\Delta H_f^{\circ}(\text{H}_2\text{O}) + 7\Delta H_f^{\circ}(\text{CO}_2) - \Delta H_f^{\circ}(\text{C}_7\text{H}_6\text{O}_2) - \frac{15}{2}\Delta H_f^{\circ}(\text{O}_2)$$

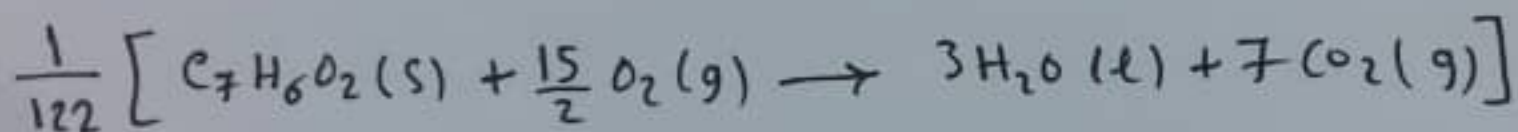
$$\Delta H_{rx}^{\circ} = 3(-286) + 7(-393.5) - (1)(-386) - \frac{15}{2}(0) = -3227 \text{ kJ mol}$$

$$m = 1 \text{ gr}$$

$$M = 122 \frac{\text{gr}}{\text{mol}}$$

$$\rightarrow n = \frac{m}{M} = \frac{1}{122} \text{ mol}$$

بنابراین وقتی یک گرم اسیدرانی واکنش به صورت زیر اصلاح می شود



یعنی به علاوه واکنش ضرب $\frac{1}{122}$ افزان می شود.

$$\Delta H = n \Delta H_{rx}^{\circ} = \left(\frac{1}{122} \text{ mol}\right) (-3227 \text{ kJ mol}) = \frac{-3227}{122} \text{ kJ} = -26.45 \text{ kJ}$$

$$\text{constant } p \rightarrow q_p = \Delta H = -26.45 \text{ kJ}$$

$$W = -P\Delta V$$

$$W = -P\Delta V = RT \Delta n_{\text{gas}}$$

$$= -(8.314)(298) \left(\frac{-1}{244}\right) = 10 \text{ J}$$

$$\Delta u = q_p + W = -26.45 \text{ kJ}$$

$$PV = nRT$$

$$D(PV) = \Delta(nRT)$$

$$P\Delta V = RT \Delta n_{\text{gas}}$$

$$\Delta n_{\text{gas}} = n_2 - n_1$$

$$\Delta n_{\text{gas}} = \frac{1}{122} \left[7 - \frac{15}{2} \right] = \frac{1}{122} \left(-\frac{1}{2}\right)$$

$$V = 1.0 \text{ m}^3 \quad V_1 = V_2 = V$$

$$P_1 = 0.25 \text{ MPa}$$

$$T_1 = 50^\circ\text{C} = 323.15 \text{ K}$$

$$T_2 = 325^\circ\text{C} = 598.15 \text{ K}$$

$$M = 32 \frac{\text{gr}}{\text{mol}}$$

$$P_1 V_1 = n R T_1 \implies n = \frac{P_1 V_1}{R T_1} = \frac{(0.25 \times 10^6)(1.0)}{(8.314)(323.15)} = 95.1 \text{ mol}$$

$$m = n M = (95.1)(32) = 3043 \text{ gr} = 3.043 \text{ kg}$$

$$\begin{array}{l} P_1 V_1 = n R T_1 \\ P_2 V_2 = n R T_2 \end{array} \quad \xrightarrow{V_1 = V_2} \quad \frac{P_1}{P_2} = \frac{T_1}{T_2}$$

$$\implies P_2 = \left(\frac{T_2}{T_1}\right) P_1 = \left(\frac{598.15}{323.15}\right)(0.25 \text{ MPa})$$

$$P_2 = 0.4627 \text{ MPa}$$

$$P_1 = P_2 = 0.2 \text{ MPa}$$

$$P_3 = P_4 = 0.5 \text{ MPa}$$

$$x_2 = 0.3$$

کلیتاً $W = W_{1 \rightarrow 2} + W_{2 \rightarrow 3} + W_{3 \rightarrow 4}$
 حجم ثابت است

$$W_{1 \rightarrow 2} = P_1 (V_2 - V_1)$$

$$W_{3 \rightarrow 4} = P_2 (V_4 - V_3)$$

حجم مخصوص $v = \frac{V}{m} \rightarrow V = v m$

$$W_{1 \rightarrow 2} = P_1 m (v_2 - v_1)$$

$$W_{3 \rightarrow 4} = P_2 m (v_4 - v_3)$$

$$W = W_{1 \rightarrow 2} + W_{3 \rightarrow 4} = m P_1 (v_2 - v_1) + m P_2 (v_4 - v_3)$$

$$\bar{W} = \frac{W}{m} = P_1 (v_2 - v_1) + P_2 (v_4 - v_3)$$

\bar{W} کار بر واحد حجم

state 1: $v_1 = v_f = 0.001061 \frac{\text{m}^3}{\text{kg}}$

بر اساس جدول

state 2: $v_2 = v_f + x_2 (v_g - v_f)$

$$= (0.001061) + 0.3 (0.88467 - 0.001061) = 0.2665 \frac{\text{m}^3}{\text{kg}}$$

state 3: $v_3 = v_2 = 0.2665 \frac{\text{m}^3}{\text{kg}}$

state 4: $v_4 = v_g = 0.37483$

بر اساس جدول

$$\bar{W} = (0.2 \times 10^6) (0.2665 - 0.001061) + (0.5 \times 10^6) (0.37483 - 0.2665)$$

$$= 107.2 \frac{\text{kJ}}{\text{kg}}$$

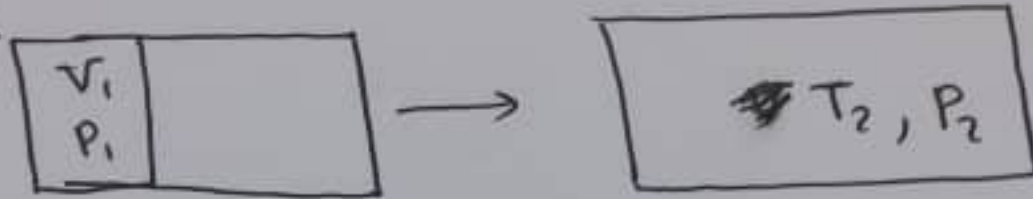
$$V_1 = 0.01 \text{ m}^3$$

$$P_1 = 0.8 \text{ MPa}$$

$$T_2 = 200^\circ\text{C} = 473.15 \text{ K}$$

$$P_2 = 400 \text{ kPa}$$

$$V_2 = ?$$

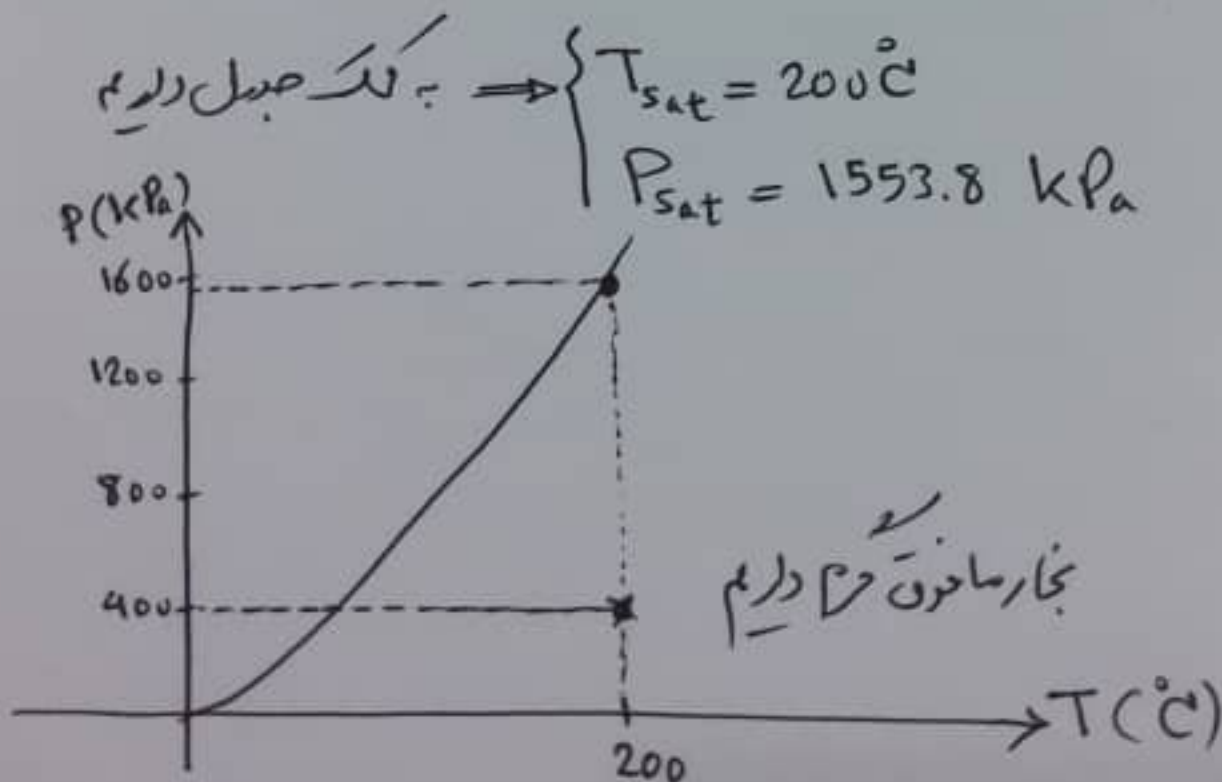


State 1: آب مایع اشباع داریم

$$v_1 = v_f (P_{\text{sat}} = 0.8 \text{ MPa}) = 0.001115 \frac{\text{m}^3}{\text{kg}}$$

$$v_1 = \frac{V_1}{m} \Rightarrow m = \frac{V_1}{v_1} = \frac{0.01 \text{ m}^3}{0.001115 \frac{\text{m}^3}{\text{kg}}} = 8.969 \text{ kg}$$

state 2: $T_2 = 200^\circ\text{C}$



$$v_2 = v(200^\circ\text{C}, 400 \text{ kPa}) = 0.53422 \frac{\text{m}^3}{\text{kg}} \quad \text{برای آب جدول}$$

$$v_2 = \frac{V_2}{m} \rightarrow V_2 = m v_2 = (8.969 \text{ kg})(0.53434) = 4.79 \text{ m}^3$$