31.19 An ideal gas expands from a pressure of $90psia$ to $15psia$. The density decreases from $0.4\frac{lb_m}{ft^3}$ to $0.04\frac{lb_m}{ft^3}$. The internal energy decreases from $150\frac{Btu}{lb_m}$ to $50\frac{Btu}{lb_m}$. What is the change in enthalpy during the expansion process?

A. $-128\frac{Btu}{lb_m}$

B. $-72\frac{Btu}{lb_m}$

C. $72\frac{Btu}{lb_m}$

D. $128\frac{Btu}{lb_m}$

Recall the definition of Specific Enthalpy as shown on the first page of the Thermodynamics chapter in the Reference Handbook.

$$h = u + Pv$$

Adapt the equation to produce an expression for the difference between two enthalpies at different states.

$$\Delta h = \Delta u + \Delta (Pv) = (u_2 - u_1) + [P_2 v_2 - P_1 v_1]$$

Recognize the specific volume, v, is the inverse of the density, ρ, which is given before both states. Substitute into the expression.

$$\Delta h = (u_2 - u_1) + \left[\frac{P_2}{\rho_2} - \frac{P_1}{\rho_1}\right]$$

All inputs are given. Substitute and solve, converting units where necessary. Notice the final answer is given in $\frac{Btu}{lb_m}$ which is the *intensive* property of *specific enthalpy*. No mass has been given so it would not be possible to calculate the *extensive* property of enthalpy, $H = mh$. Therefore, it is implied that the question is seeking the *specific* enthalpy.

$$\Delta h = \left(50\frac{Btu}{lb_m} - 150\frac{Btu}{lb_m}\right) + \left[\frac{\left(15\frac{lb_f}{in^2}\right)\left(\frac{144in^2}{ft^2}\right)}{\left(0.04\frac{lb_m}{ft^3}\right)\left(\frac{778ft\cdot lb_f}{Btu}\right)} - \frac{\left(90\frac{lb_f}{in^2}\right)\left(\frac{144in^2}{ft^2}\right)}{\left(0.4\frac{lb_m}{ft^3}\right)\left(\frac{778ft\cdot lb_f}{Btu}\right)}\right] = -72.2\frac{Btu}{lb_m}$$

Answer B