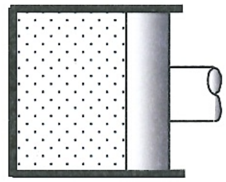
Example

A piston-cylinder contains 1.5 kg of air. Initially, the air is at 150 kPa and 20°C. The air is compressed in an *isobaric process* (and that means...) until the volume is 1 m³. Assume that air is an **ideal gas with constant specific heats**. If the compression is quasistatic,



(a) find the work into the system, in kJ, and
(b) the heat transfer into the system, in kJ.

a) WORK IS *Compression - expansion work*:

$$W_{12} = -\int_1^2 P\,d\forall = -P\int_1^2 d\forall = -P\forall\Big|_1^2 = -P\left[\forall_2 - \forall_1\right]$$

↑ ISOBARIC

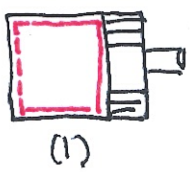
AT (1) $P_1\forall_1 = mRT_1 \Rightarrow \forall_1 = \dfrac{mRT_1}{P_1} = \dfrac{(1.5\text{ kg})\left(0.287\ \frac{\text{kJ}}{\text{kg}\cdot\text{K}}\right)(20°\text{C} + 273)}{150\text{ kPa}}\left\langle\dfrac{\text{kJ}}{\text{kPa}\cdot\text{m}^3}\right\rangle$

$= 0.84\text{m}^3$

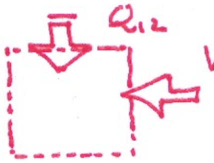
$$W_{12} = -150\text{ kPa}\left[1\text{ m}^3 - 0.84\text{m}^3\right] = -23.9\text{ kPa}\cdot\text{m}^3$$

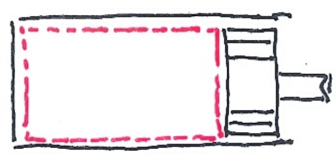
$$= \boxed{23.9\text{ kJ OUT}}$$

b) C.O.E. (1) TO (2) *Finite time*



(1)





(2)

$$\frac{dE}{dt}_{sys} = \dot{Q} + \dot{W} + \cancel{\ }_0 - \cancel{\ }_0$$

CLOSED SYSTEM

$$\int_{E_1}^{E_2} dE_{sys} = \int_{t_1}^{t_2}\dot{Q}\,dt + \int_{t_1}^{t_2}\dot{W}\,dt$$

$E_2 - E_1 = Q_{1\to2} + W_{1\to2}$ ONLY U IMPORTANT $U_2 - U_1 = Q_{12} + W_{1\to2}$

$$m(u_2 - u_1) = Q_{12} + W_{12}$$

$$m\,c_v(T_2 - T_1) = \text{"} \quad \text{"}$$

$$Q_{12} = m\,c_v(T_2 - T_1) - W_{12}$$

NEED T_2

$$P_2 V_2 = mRT_2 \qquad T_2 = \frac{P_2 V_2}{mR} = \frac{(150\ \text{kPa})(1.0\ \text{m}^3)}{(1.5\ \text{kg})(0.287\ \frac{\text{kJ}}{\text{kg}\cdot\text{K}})}$$

$$= 348.4\ \frac{\text{kPa}\cdot\text{m}^3}{\text{kg}\cdot\frac{\text{kJ}}{\text{kg}\cdot\text{K}}}\left(\frac{\text{kJ}}{\text{kPa}\cdot\text{m}^3}\right)$$

$$= 348.4\ \text{K}$$

$$Q_{12} = 1.5\ \text{kg}\cdot 0.713\ \frac{\text{kJ}}{\text{kg}\cdot\text{K}}\cdot(348.4 - 293)\ \text{K}$$

$$- (-23.9\ \text{kJ})$$

$$= \boxed{83.2\ \text{kJ}}$$