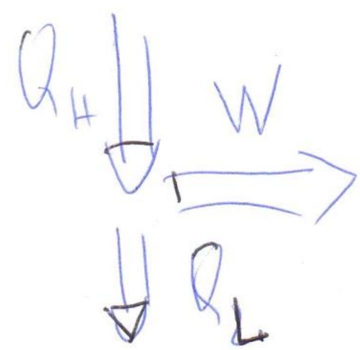
$W = 650\ J \rightarrow Q_L = 1270\ J;\ \varepsilon = ?$

63. . ORGANIZE AND PLAN The efficiency is the ratio between work done and heat used.
Known: $W = 650$ J; $Q_L = 1270$ J.
SOLVE The heat engine's efficiency is:

$$e = \frac{W}{Q_H} = \frac{(650\ \text{J})}{1920\ \text{J}} = 0.338 \approx 34\%$$

$$Q_H = W + Q_L = 1920\ \text{J}$$



90. ORGANIZE AND PLAN Because we can assume a constant temperature, we know from the ideal gas law that the product of pressure and volume is constant. The work can be calculated from the formula for an isothermal process.

Known: $P_D = 80$ mm Hg; $P_S = 125$ mm Hg; $d_D = 1.52$ mm; $T = 37°\text{C}$.

SOLVE (a) The product of pressure and volume is constant:

$$P_D V_D = P_S V_S = nRT, \quad T = \text{const}$$

Express the spherical volumes in terms of diameters and solve for the diameter at maximum pressure:

$$P_D \tfrac{\pi}{6} d_D^3 = P_S \tfrac{\pi}{6} d_S^3$$

$$d_S = \sqrt[3]{\frac{P_D}{P_S}} d_D = \sqrt[3]{\frac{(80 \text{ mm Hg})}{(125 \text{ mm Hg})}} (1.52 \text{ mm}) = 1.3 \text{ mm}$$

(b) The work done is calculated from the expression for work done in an isothermal process, and using the ideal gas law to substitute nRT for PV:

$$W = nRT \ln\left(\frac{V_D}{V_S}\right) = P_S V_S \ln\left(\frac{d_D^3}{d_S^3}\right) = \tfrac{\pi}{2} P_S d_S^3 \ln\left(\frac{d_D}{d_S}\right) = \tfrac{\pi}{2}(125 \text{ mm Hg})(1.3 \text{ mm})^3 \ln\left(\frac{(1.52 \text{ mm})}{(1.3 \text{ mm})}\right) = 8.8\ \mu\text{J}$$

1.013×10^5 Pa $= 760$ mm

REFLECT This is the work done per heart beat. If you assume a certain number of beats per minute, you can calculate the work done over a time period.
Note that we did not need to know the temperature of the gas bubble, only that the temperature was constant.

$1 \text{ mm} = 10^{-3}$ m

$$V_D = \frac{4}{3}\pi R_D^3 = \frac{4}{3}\pi\left(\frac{d_D}{2}\right)^3$$

$$V_S = \frac{4}{3}\pi\left(\frac{d_S}{2}\right)^3$$

$$\frac{V_D}{V_S} = \left(\frac{d_D}{d_S}\right)^3$$

$$P_S \cdot \frac{4}{3}\pi\frac{d_S^3}{2^3} = \frac{4}{3}\pi\frac{d_S^3}{8}$$

Also $\ln\left(\frac{d_D}{d_S}\right)^3 = 3 \cdot \ln\left(\frac{d_D}{d_S}\right)$

$$P_S \cdot \frac{\pi}{3 \times 2} d_S^3$$

$$P_S \frac{\pi}{2} d_S^3 \ln\left(\frac{d_D}{d_S}\right)$$