A prime assumption of this problem is piston is massless. Although in thermodynamics we assume quasi-static processes, here the velocity of piston will vary with distance, which means it will have some acceleration. Hence, the assumption of massless piston becomes mandatory to solve the problem. After that it's very easy.

$PA = kx$. When piston is stopped, $\frac{dQ}{dt} = nC_v r_0$. Also, heat absorbtion rate must be constant.

$$nC_v r_0 = nC_v \frac{dT}{dt} + (PAv)$$

Also,

$$PAv + (Ax)\frac{dP}{dt} = nR\frac{dT}{dt}.$$

Now, since $PA = kx$, $A\frac{dP}{dt} = kv$.

$$kxv + kxv = nR\frac{dT}{dt}$$

So, $$2kl_0 v = nR\frac{dT}{dt}$$

Going back to 1st law eqn,

$$nC_v r_0 = C_v\left[\frac{2kl_0 v}{R}\right] + kl_0 v$$

$$kl_0 v = \frac{nC_v r_0}{1+\frac{2C_v}{R}} = \frac{\frac{3nRr_0}{2}}{1+6/2}$$

$$\boxed{v = \frac{3nRr_0}{8kl_0}}$$