78. It is straightforward to show, from Eq. 20-11, that for any process that is depicted as a straight line on the pV diagram, the work is

$$W_{\text{straight}} = \left(\frac{p_i + p_f}{2}\right) \Delta V$$

which includes, as special cases, $W = p\Delta V$ for constant-pressure processes and $W = 0$ for constant-volume processes. Also, from the ideal gas law in ratio form (see Sample Problem 1), we find the final temperature:

$$T_2 = T_1 \left(\frac{p_2}{p_1}\right)\left(\frac{V_2}{V_1}\right) = 4T_1 \ .$$

(a) With $\Delta V = V_2 - V_1 = 2V_1 - V_1 = V_1$ and $p_1 + p_2 = p_1 + 2p_1 = 3p_1$, we obtain

$$W_{\text{straight}} = \frac{3}{2}(p_1 V_1) = \frac{3}{2} nRT_1$$

where the ideal gas law is used in that final step.

(b) With $\Delta T = T_2 - T_1 = 4T_1 - T_1 = 3T_1$ and $C_V = \frac{3}{2}R$, we find

$$\Delta E_{\text{int}} = n\left(\frac{3}{2}R\right)(3T_1) = \frac{9}{2} nRT_1 \ .$$

(c) The energy added as heat is $Q = \Delta E_{\text{int}} + W_{\text{straight}} = 6nRT_1$.

(d) The molar specific heat for this process may be defined by

$$C_{\text{straight}} = \frac{Q}{n\Delta T} = \frac{6nRT_1}{n\,(3T_1)} = 2R \ .$$