SOLUTIONS

19.49 & 20.43

19.49 (a) $\Delta T = \frac{Q}{nC_V} = \frac{1.52\times10^4\,J}{2.5\times20.76\,J/K} = 293\,K$

$T_1 = 293 + 293 = 586\,K$

$pV = nRT \quad 2(586\,K) = 1172\,K$

$T_C = T_K - 273 = 1172K - 273K = \boxed{899\,^\circ C}$

(b) $W = nR\Delta T = 2.5mol \times 8.314\,J/mol\cdot K\,(1172K - 586K) = \boxed{1.22\times10^4\,J}$

(c) $Q = nC_p(T_2 - T_1) = 2.5mol \times 29.07\,J/mol\cdot K\,(1172 - 586K) = \boxed{4.26\times10^4\,J}$

(d) $\Delta U = nC_V\Delta T = 2.5mol \times 20.76\,J/mol\cdot K\,(1172 - 293K) = \boxed{4.56\times10^4\,J}$

20.43 a) $T_K = T_C + 273 = 327^\circ C + 273 = 600K$

$\frac{P_aV_a}{T_a} = \frac{P_bV_b}{T_b}$ so $T_a = \frac{1}{3}\times600K = 200K$

$P_aV_b = nRT_b \quad V_b = \frac{nRT_b}{P_b} = \frac{2mol \times 8.81\,J/mol\cdot K \times 600K}{3\times10^5\,Pa} = 0.0332\,m^3$

$V_C = V_b\frac{P_b}{P_C} = 0.0332\,m^3 \times 3 = 0.0997\,m^3$

$Q_{ab} = nC_V\Delta T = 2mol \times \frac{3}{2} \times 8.31\,J/mol\,K \cdot 400K = 9.97\times10^3\,J$

$Q_{BC} = nRT_b\ln\frac{V_C}{V_b} = 2mol \times 8.314\,J/mol\cdot K \times 600K \times \ln 3 = 1.10\times10^4\,J$

$Q_{in} = Q_{AB} + Q_{BC} = 1.1\times10^4\,J + 0.998\times10^4\,J = \boxed{2.08\times10^4\,J}$

$Q_{out} = Q_{CA} = nC_V\Delta T = 2.00$ [redacted] $\times \frac{5}{2} \times 8.314 \times 4.00\,J = \boxed{1.66\times10^4\,J}$

b) $Q = \Delta U + W = W$

$Q = Q_{in} - Q_{out} = 2.08\times10^4\,J - 1.66\times10^4\,J = 0.42\times10^4\,J$

$\eta = \frac{W}{Q_{in}} = \frac{0.42\times10^4}{2.08\times10^4} \times 100\% = \boxed{20.1\%}$

(c) $\eta = 1 - \frac{T_C}{T_H} = 1 - \frac{200}{600} = \boxed{67\%}$