South Dakota School of Mines and Technology
Department of Materials and Metallurgical Engineering

MET 320 HQ 1 MI 220
9:00 AM Oct 10, 2008

CLOSED BOOK & NOTES - NO CALCULATORS. SHOW ALL WORK ON THIS SHEET.
Turn in only this sheets with the problems on them. Keep or discard all other paper.

CLOSED BOOK and NOTES

- NO CALCULATORS
- Algebraic Answers Preferred
- Leave R in the equation but write out its value to achieve proper units.

UNITS (Algebraic answers should be left in a form to obtain these units

- q, w, U, and H [=] Joules
- S [=] J/K
- V[=]Liters
- T [=] K
- P [=] atm

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NO QUESTIONS ANSWERED CONCERNING THE EXAM

If there seems to be an error state clearly a reasonable correction/assumption and proceed.

4 Questions
Questions 2 and 4 have two parts: a) and b)

1. Two mole of ideal monatomic gas at 300 K are adiabatically compressed from 5 L to 1 L. Find the q, w, ΔU, ΔH, ΔS, and final T for the process. (20 points)

$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{R/Cv=R/(2/3*R)=2/3}$$

R = 8.31 J / (K * gmole) for all problems

$$T_2 = T_1\left(\frac{V_1}{V_2}\right)^{2/3} = 300K\left(\frac{5}{1}\right)^{2/3} = 300K*5^{2/3}$$

$$\Delta T = (300K*5^{2/3} - 300)K = 300(5^{2/3} - 1)K$$

$$\Delta U = n*Cv*\Delta T = 2(gmole)*1.5R*300(5^{2/3} - 1)*K$$

$$\Delta H = n*Cp*\Delta T = 2(gmole)*2.5R*300(5^{2/3} - 1)*K$$

$$q_{\mathrm{Rev}} = 0$$

$$w = -\Delta U$$

$$\Delta S = \int dS = \int \frac{dq}{T}\Big)_{\mathrm{Rev}} = 0$$

2. a) Two moles of an ideal diatomic gas at 400 K are isothermally and reversibly expanded from 3 L to 10 L. Find q, w, ΔU, ΔH, ΔS, and the final P for the process. (20 points)

$$T_2 = T_1 = 400K \qquad R_{gl} = 0.08205L*atm/(gmole*K) \qquad \textit{for all problems}$$

$$P_2V_2 = P_1V_1 \qquad P_2 = nRT/V_2 = 2gmoles*R_{gl}*400K/10L = 80(K*gmoles/L)*R_{gl}$$

$$\Delta U = n*Cv*\Delta T = 0$$

$$\Delta H = n*Cp*\Delta T = 0$$

$$w_{Max} = q_{\mathrm{Rev}} = \int_1^2 PdV = nRT\int_1^2 \frac{dV}{V} = nRT\int_1^2 d\ln V = nRT\ln\frac{V_2}{V_1} = 800R\ln\frac{10}{3} = -800(gmoles/K)R\ln 0.3$$

$$\Delta S = \int dS = \int \frac{dq}{T}\Big)_{\mathrm{Rev}} = \frac{1}{T}\int dq\Big)_{\mathrm{Rev}} = \frac{q_{\mathrm{Rev}}}{T} = nR\ln\frac{V_2}{V_1} = nR\ln\frac{10}{3} = -nR\ln 0.3 = -2(gmoles)R\ln 0.3$$

b) Rework part “a” assuming only 10% of the maximum work is performed during the expansion. (10 points)

$$T_2 = T_1 = 400K$$

$$P_2 = same : State\,Function$$

$$\Delta U = same : State\,Function, \quad \Delta H = same : State\,Function, \quad \Delta S = same : State\,Function$$

$$w = q = 0.1*w_{Max} = 0.1nRT\ln\frac{P_1}{P_2} = 80R\ln\frac{1}{10} = -80(gmoles*K)R\ln 10$$

3. Two moles of ideal monatomic gas at 305 K and 10 atm (V = 5.0 L) are compressed along a straight-line path on a P-V plot to 305 K and 1 L. Find w, q, ΔU, ΔH, ΔS, and the final P. (25 points)

$T_2 = T_1 = 305K \qquad P_2 = P_1 V_1 / V_2 = 10\,atm(5/1) = 50\,atm$

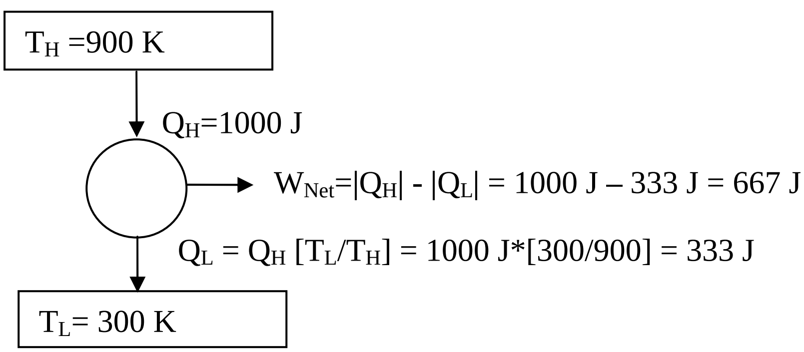
$\Delta U = n*Cv*\Delta T = 0 \qquad \Delta H = n*Cp*\Delta T = 0$

$$w_{Max} = q_{Rev} = \int_1^2 PdV = Area\,of\,Trapezoid = (P_1+P_2)/2*(V_2-V_1) = (P_1+P_2)/2*nRT(1/P_2-1/P_1)$$

$$= (P_1+P_2)/2*nRT(1/P_2-1/P_1) = nRT\left[\frac{10+50}{2}\right]*\left[\frac{1}{50}-\frac{1}{10}\right] = -1,464Rgmoles*K$$

$$\Delta S = \int dS = \int \frac{dq}{T}\Big)_{Rev} = \frac{1}{T}\int dq\Big)_{Rev} = \frac{q_{Rev}}{T} = nR\ln\frac{V_2}{V_1} = -2R(\ln 5)gmoles \qquad (State\,Function)$$

4. a) A Carnot-cycle heat engine is operating between two heat sinks at 627 °C and 27°C. What is the maximum theoretical work that can be produced from 1,000 Joules of heat? (15 points)



b) How much work would be required to move 1000 BTU’s of heat from a home at 295 K to the outdoors at 310 K assuming theoretical efficiency? (10 points)