Thermodynamics Homework #3

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1) $dU = TdS - PdV + \mu dN$

a) $dV = dN = 0$ for C_V by definition.

$\Rightarrow dU = TdS \Rightarrow \frac{dU}{dT} = T\frac{dS}{dT} \Rightarrow \boxed{C_V = T\left(\frac{dS}{dT}\right)_{V,N}}$

b) $dP = dN = 0$ for C_P by definition

$dU = TdS - PdV + dH - TdS - VdP = dH - PdV$

$\Rightarrow \frac{dU}{dT} = \frac{dH}{dT} - P\frac{dV}{dT} \Rightarrow \boxed{C_P = \frac{dH}{dT} - P\frac{dV}{dT}}$

2) $\Delta G = \Delta H - T\Delta S$, $T = 298K$

$N_3 + 3H_2$) $G_0 = 0 + 3\cdot 0 = 0$ kJ

$H_0 = 0 + 3\cdot 0 = 0$ kJ

$S_0 = 191.61\ J/K + 3\cdot 130.68\ J/K = 583.65\ J/K$

$2NH_3$) $G_1 = 2\cdot(-16.45\ kJ) = -32.90$ kJ

$H_1 = 2(-46.11\ kJ) = -92.11$ kJ

$S_1 = 2(192.45\ J/K) = 384.90\ J/K$

$\Delta G = \Delta H - T\Delta S = (H_1 - H_0) - T(S_1 - S_0)$

$= -92.11\ kJ - (298\ K)(-198.75\ J/K)$

$= -92.11\ kJ + 59.23\ kJ$

$= \boxed{-32.88\ kJ}$

$\Delta G = G_1 - G_0$

$= \boxed{-32.90\ kJ}$

3) $\overset{(g)}{CH_4} + \overset{(g)}{2O_2} \rightarrow \overset{(l)}{2H_2O} + \overset{(g)}{CO_2}$, $T = 298K$

H_0: $-74.81\,kJ + 2(0)$	H_1 : $2(-285.83kJ) - 393.51\,kJ$
G_0: $-50.72\,kJ + 2(0)$	G_1 : $2(-237.13kJ) - 394.36\,kJ$

a) $\Delta H = H_1 - H_0 = -890.36\,kJ/mol$

$\Delta G = G_1 - G_0 = -817.90\,kJ/mol$

b) $W = -\Delta G = 817.90\,kJ/mol \cdot 1mol = \boxed{817.90\,kJ}$

c) $Q = -\Delta H = 890.36\,kJ/mol \cdot 1mol = \boxed{890.36\,kJ}$ Exothermic

d) $W = nFV$, $n = 8mol\,e^-$, $F = 96.485\,\frac{kJ}{V\,mol\,e^-}$

$$V = \frac{W}{nF} = \frac{817.90\,kJ}{(8mol\,e^-)(96.485\,\frac{kJ}{mol\,e^-\,V})} = \boxed{1.0596V}$$