Quiz II

CH 353 Sumer 2008
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Name: KEY

Carefully read all the problems. The exam should have 4 questions on 6 pages. The first page has potentially useful information. The last page is for extra writing space.

$R = 8.314\ J\ K^{-1}\ mol^{-1}$ $R = 8.314x10^{-2}\ L\ bar\ K^{-1}\ mol^{-1}$ $R = 8.206x10^{-2}\ L\ atm\ mol^{-1}\ K^{-1}$

1 cal = 4.184 J 1 atm = 1.01325 bar T/K = T/°C + 273.15

1 atm-L = 101.325 J 1 bar-L = 100 J

Please sign at the bottom to certify that you have worked on your own.
I certify that I have worked the following exam without the help of others, and that the work I am turning in is my own.

Signed: --
Signature Date

1. True/False Circle either T or F for each statement (10 points each)

(T) F For an cyclic process, ΔS_{SURR} can never decrease. $\Delta S_{sys} = 0$ $\Delta S_{TOTAL} \geq 0$

T (F) A process is always spontaneous if $\Delta G = 0$. must be const T & P

(T) F If a solid sublimes at constant temperature and pressure, then $\Delta S_{Surr} < 0$. $\Delta H_{sub} > 0$

(T) F For an adiabatic compression of an ideal gas, ΔT is always > 0. $\Delta U = C_v \Delta T = w \therefore > 0$

(T) F The total entropy change of the universe for the process of an acorn falling from a tree to the ground is > 0.

It happens

2. Short Answer (25 points each)

Given the following, what is the standard Gibb's energy of formation for CH_4 gas at 298? Data at 298. Enthalpy in kJ mol^{-1}, entropy and heat capacities in J K^{-1} mol^{-1}

	$\Delta_f H°$	S°	C_P
CH_4(g)	-74.8	186.3	35.3
C(s)	0	5.74	8.73
H_2(g)	0	130.7	28.8

$\Delta_f S° = 186.3 - 2(130.7) - 5.74$

$= -80.84$ K^{-1} mol^{-1}

$C(s) + 2H_2 \longrightarrow CH_4(g)$

$\Delta_f G° = \Delta_f H° - T\Delta_f S°$

$\Delta_f G° = -74{,}800 \text{ J mol}^{-1} - 298(-80.84) = -50.7$ J mol^{-1}

Explain why $\Delta G < 0$ at constant T and P is the same as $\Delta S_{Total} > 0$. (You should use some know relations of state functions in your explanation. Specifically why must T and P be constant for the relationship to hold)

$\Delta S_{TOTAL} = \Delta S_{sys} + \Delta_{surr} S > 0$

if P const $q = \Delta H$

at const T $\Delta_{surr} S = \frac{-q}{T} = -\frac{\Delta H_{sys}}{T}$

$\Delta S_{sys} - \frac{\Delta H_{sys}}{T} > 0$

$\therefore \Delta G_{sys} < 0$

3. (50 points)

2 moles of an ideal gas ($C_{V,M} = 3/2R$) are initially at 300 K and a pressure of 1 atm.

First: The gas is compressed isothermally against a constant external pressure of 2 atm.

Second: The gas is expanded adiabatically in a process that causes the final temperature to be 120 K and the pressure to be 0.5 atm.

210 This should have been 210K!

What is ΔS_{total} for this entire process?

$$\Delta S_{sys} = nR\ln\left(\frac{V_f}{V_i}\right) + C_v\ln\left(\frac{T_f}{T_i}\right)$$

$$= 2R\ln\left(\frac{nRT_f}{P_f} \Big/ nRT_i/P_i\right) + 3R\ln\left(\frac{T_f}{T_i}\right)$$

$$= 2R\ln\left(\frac{120}{.5} \Big/ \frac{300}{1}\right) + 3R\ln\left(\frac{120}{300}\right)$$

$$= -3.71 + -22.85 = -26.56\ JK^{-1}$$

$$\Delta S_{surr} = \frac{-q}{T}$$

$$\Delta S_{surr,1} = \frac{-q_1}{300}$$

$\Delta U = 0 \quad q = -w = +P_e(V_f - V_i)$

$q = P_f V_f - \frac{P_f}{P_i} P_i V_i$

$q = nRT - 2nRT = -nRT$

$$\Delta S_{surr,1} = nR = 16.63$$

$$\Delta S_{surr,2} = 0 \quad \text{(adiabatic)}$$

$$\Delta S_{TOTAL} = -10\ !$$

4. (50 points)

In an insulated (adiabatic) thermos you place 10 g of ice with a temperature of 0°C into 10 g of liquid water with a temperature of 25°C. The system is held at a constant pressure of 1 bar.

$C_{P,solid} = 36\ J\ K^{-1}\ mol^{-1}$
$C_{P,liquid} = 75.3\ J\ K^{-1}\ mol^{-1}$
$\Delta_{FUS}H° = 6.02\ kJ\ mol^{-1}$
$S°\ (H_2O,\ liq,\ 298K) = 70\ J\ K^{-1}\ mol^{-1}$

10g (s, 0°)

q to melt all

$\Delta_{fus}H° = 6.02 \times \frac{10}{18}$

$= 3344 J$

What is the final temperature of the water in the thermos?

cool all H_2O to 0°

$(75.3) \times (\frac{10}{18})(-25) = 1045$ J

$T_f = 0°C$

NOT ALL ICE MELTS.

For this process, what ΔS for the system, surrounding, and total

$q_{ice} = -q_{H_2O}$

$n \times 6{,}020 = -(75.3) \times \frac{10}{18}(-25)$

$n = \frac{1045.8}{6020} = 0.17$ moles ice melt $< \frac{10}{18}$ not all

melting $\Delta S_{ice} = \frac{\Delta_{fus}H \times n}{273} = \frac{1045.8}{273} = +3.8\ JK^{-1}$

liq cooling $\Delta S_{liq} = C_p \ln\left(\frac{T_f}{T_i}\right) = 75.3 \times \frac{10}{18} \ln\left(\frac{273}{298}\right) = -3.66$

$\Delta S_{sys} = 3.8 - 3.66 = +0.13\ JK$

(note: this is a lot like the two blocks problem on the hw except there is a phase change).

$\Delta S_{surr} = 0$ $\Delta S_{TOTAL} = \Delta S_{sys} = +0.13$

$P = 2 \qquad T = 300$

$P_f = .5 \qquad T_f = ?$

$C_v \Delta T = -P_f (V_f - V_i)$

$3R(T_f - T_i) = -nRT_f + \frac{P_f}{P_i} nRT_i$

$\cancel{3R}(T_f - T_i) = -\cancel{3R}\, T_f + \left(\frac{1}{4}\right) \cancel{3R}\, T_i$

$T_f - T_i = -T_f + .25\, T_i$

$2T_f = 1.25\, T_i \qquad 190$

$T_f = \frac{1.25}{2} T_i = \underline{187.5}\,!$

$\neq 120\text{ K}.$