Quiz II
CH 353 Sumer 2010
Vanden Bout
Name: KEY

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

$R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$ $R = 8.314 \times 10^{-2} \text{ L bar K}^{-1} \text{ mol}^{-1}$ $R = 8.206 \times 10^{-2} \text{ L atm mol}^{-1} \text{ K}^{-1}$

$1 \text{ cal} = 4.184 \text{ J}$ $1 \text{ atm} = 1.01325 \text{ bar}$ $T/K = T/°C + 273.15$

$1 \text{ atm-L} = 101.325 \text{ J}$ $1 \text{ bar-L} = 100 \text{ J}$

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 isothermal process, ΔS_{SYS} can never decrease.   isothermal
                                                                          compression IG

T (F)   For a reversible phase transition, $\Delta H = 0$
                        for phase transition ΔH is never zero

T (F)   A process that doubles the number of microstates of system will double the entropy of
        the system. $S = \cancel{k\#} k \ln \underline{\Omega}$

(T) F   Dropping an eraser from a height of three feet to the floor leads to an increase in the
        entropy of the Universe.

T (F)   The standard entropy of an element in its standard state at 298.15 K and 1 bar is zero.

            $S = 0$ for pure subst in perfect xtal at $T = 0 K$

2A. For each of the following note what you would expect for the entropy of the system, surroundings, and total (12 points)

A container of liquid honey (the system) sitting in your kitchen (the surroundings) crystallizes

ΔS_{SYS} Increase   (Decrease)   Stay the Same   No Way to Know

ΔS_{SURR} (Increase)   Decrease   Stay the Same   No Way to Know

ΔS_{TOTAL} (Increase)   Decrease   Stay the Same   No Way to Know

1 mole of an ideal gas initially at a pressure of 10 bar, expanding isothermally against a constant external pressure of 1 bar until mechanical equilibrium is reached. irrev.

ΔS_{SYS} (Increase)   Decrease   Stay the Same   No Way to Know

ΔS_{SURR} Increase   (Decrease)   Stay the Same   No Way to Know

ΔS_{TOTAL} (Increase)   Decrease   Stay the Same   No Way to Know

2B. 25 g of solid water at a temperature at temperature of 0°C are brought into contact with a constant temperature bath of 50°C until it is completely converted to liquid water at 0°C. What is $\Delta_{Total}S$ for this process?

$C_{P,solid} = 36$ J K^{-1} mol^{-1}
$C_{P,liquid} = 75.3$ J K^{-1} mol^{-1}
$\Delta_{FUS}H° = 6.02$ kJ mol^{-1}

$$H_2O\,(s, 0°c) \longrightarrow H_2O\,(\ell, 0°c)$$

$$\Delta S_{sys} = \frac{\Delta_{fus}H \times n}{273.15} = \frac{(6,020\ J\ mol^{-1})(\frac{25}{18}\ mol)}{273.15\ K}$$

$$\Delta S_{sys} = +30.6\ JK^{-1}$$

$$\Delta_{svrr}S = \frac{-\Delta_{fus}H \times n}{323.15} = -25.9\ JK^{-1}$$

$$\Delta_{Total}S = \Delta S_{sys} + \Delta S_{svrr} = +4.7\ JK^{-1}$$

$\Delta_{SYS}S$ for temperature change = __+30.6 JK^{-1}__ (13 pts)

$\Delta_{SYS}S$ for volume change = __+4.7 JK^{-1}__ (13 pts)

3. (50 points)

Data at 298. Enthalpy in kJ mol^{-1}, entropy and heat capacities in J K^{-1} mol^{-1}

	$\Delta_f H^\circ$	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

What are ΔS_{sys}, ΔS_{surr}, ΔS_{total} when 10 g of solid carbon are reacted with excess hydrogen gas at a constant temperature of 400K. You can assume the reaction goes to completion and that all heat capacities are independent of temperature.

400k $C(s) + 2H_2(g) \longrightarrow CH_4(g)$

298k $C(s) + 2H_2(g) \longrightarrow CH_4(g)$
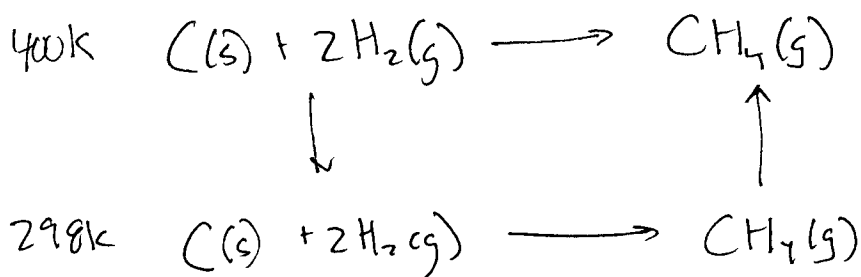
$$\Delta_R H^\circ (400) = \Delta_R H^\circ (298) + \Delta C_P (400 - 298)$$

$$= -74,800 + [35.3 - 8.73 - 2(28.8)](102\,k)$$

$$= -74,800 - 3165 = -77,965 \text{ J mol}^{-1}$$

$$\Delta_R S^\circ (400) = \Delta_R S^\circ + \Delta C_P \ln\left(\frac{400}{298}\right)$$

$$= \left(186.3 - 5.74 - 2(130.7) + (-31)\ln\left(\frac{400}{298}\right)\right)$$

$$= -80.84 \; \ast - 9.12 = -89.9 \text{ J K}^{-1}\text{ mol}^{-1}$$

$$\Delta_{SYS}S = \Delta_R S^\circ \times n = (-89.9)\left(\frac{10}{12}\right) = -75 \text{ J K}^{-1}$$

$\Delta_{SYS}S = \underline{-75 \text{ J K}^{-1}}$

$\Delta_{SURR}S = \underline{+162.4 \text{ J K}^{-1}}$

$\Delta_{TOTAL}S = \underline{+87.4 \text{ J K}^{-1}}$

$$\Delta_{SURR}S = \frac{-q}{T_{SURR}} = \frac{-\Delta_R H \times n}{T}$$

$$= \frac{(+77965)\left(\frac{10}{12}\right)}{400} = +162.4$$

$$\Delta S_{TOTAL} = -75 + 162.4 = 87.4$$

4. (50 points)

1 mole of an ideal gas, $C_{V,M}=(3/2)R$, is initially at 1 bar and 300 K. In a process that is neither isothermal nor adiabatic, the gas is simultaneously compressed by a constant external pressure of 2 bar and brought into thermal contact with a constant temperature heat bath at 500 K. What are ΔS_{TOTAL} for this process?

$$V_f = \frac{nRT_f}{P_f} = \frac{nR\frac{5}{3}T_i}{2T_i} = \frac{5}{6}V_i$$

$$\Delta_{SYS}S = nR\ln\left(\frac{V_f}{V_i}\right) + C_v\ln\left(\frac{T_f}{T_i}\right)$$

$$= (1)(R)\ln\left(\frac{\frac{5}{6}V_i}{V_i}\right) + (1.5R)\ln\left(\frac{500}{300}\right)$$

$$= -.18R + .77R = +0.58R$$

$$\boxed{\Delta S_{sys} = +4.87\ JK^{-1}}$$

$$\Delta_{SURR}S = \frac{-q_{actual}}{500} \qquad q = \Delta U - w$$

$$\Delta U = C_v\Delta T = (1)(1.5R)(200) = 300R = 2494.2\ J$$

$$w = -P_{ex}\Delta V = -\left(2\frac{R_i}{P_i}\right)\left(\frac{5}{6}V_i - V_i\right) = +\left(\frac{1}{3}\right)P_iV_i = \frac{1}{3}nRT_i$$

$$= \frac{1}{3}(1)R(300) = 100R = 831.4\ J$$

$$q = \Delta U - w = 1662.8\ J$$

$\Delta_{SYS}S = \underline{+4.87\ JK^{-1}}$

$\Delta_{SURR}S = \underline{-3.32\ JK^{-1}}$

$\Delta_{TOTAL}S = \underline{+1.55\ JK^{-1}}$

$$\boxed{\Delta S_{SURR} = \frac{-1662.8}{500} = -3.32\ JK^{-1}}$$

$$\boxed{\Delta S_{TOTAL} = +4.87 - 3.32 = +1.55}$$