CHMY 361

Exam 1

Sept. 16, 2014, 7:55-8:55 AM

4 x 6 note card

100 points in 9 questions on 4 pages including Tables 2.3 and A.5

For full credit show all work and put correct units on final answers. Note: information that is not needed may be present in some problems.

(12 pts) 1. If a system composed of unknown material goes from state 1 to state 2 such that:

$$P_1 = 5$$
 bar, $V_1 = 20$ L, and $T_1 = 300$ K

$$P_2 = 2$$
 bar, $V_2 = 30$ L, and $T_2 = 250$ K

heat given off by the system = 10 kJ, work done on the system = 15 kJ

Find ΔU , ΔH , q, and w, using the First Law of Thermodynamics, and definitions of q and w used by our text book. If insufficient information is given to find some of these, please indicate what is missing.

$$\Delta U = 3 + W$$

$$\Delta H = \Delta U + P_2V_2 - P_1V_1$$

$$= 5k_1 + \left[2(30) - 5(20)\right] L bar \times \frac{100J}{L ban}$$

$$= 5000 J + (60 - 100) \times 100 J$$

$$= 5000 J + (60 - 100) \times 100 J$$

(6 pts) 2. Under what conditions is $\Delta H = q$?

(16pts)3. (a) Consider the *isothermal* expansion of 2 moles of ideal gas from $V_1 = 25$ L to $V_2 = 75$ L at 300 K. $C_v = 20$ J mol⁻¹ K⁻¹ and $C_p = 29$ J mol⁻¹ K⁻¹. The external pressure is held constant at 2 bar during the process. Calculate q, w, ΔU , ΔH , ΔS , and ΔS_{surr} for this process.

bar during the process. Calculate q, w, 20, 21, 25, and 25 sum for this process.

$$W = -pext \ \Delta V = -2bex \times (75-25) L \times 100 T \qquad q + 10,000 T$$

$$= -100 \ Lbar \times 100 T \qquad w - 10,000 T$$

$$\Delta S = -\frac{Q}{T} = -\frac{10000}{300} = -33.3 \ J/k$$

$$\Delta S = \frac{q}{T} = -\frac{q}{T} = -\frac{10000}{7} = -33.3 \ J/k$$

$$\Delta S = \frac{q}{T} = -\frac{q}{T} = -\frac{10000}{7} = -33.3 \ J/k$$

$$= 2 \times 8.3(45) \ln 3$$

$$\Delta S_{sur} = -33.3 \ J/k$$

$$\Delta S_{sur} = -33.3 \ J/k$$

(b) Is the process in part (a) allowed according to the Second Law of Thermodynamics? Explain your answer.

(14 pts) 4. In the cylinder of a diesel engine, the fuel + air mixture is ignited solely by the temperature rise caused by adiabatic compression. (It is adiabatic because there is not time for heat to conduct out of the cylinder during the compression.)
What will be q, w, ΔU, ΔH, ΔS, and ΔS_{surr} for 3 moles of an ideal diatomic gas (C_{p,m} = 7/2 R) if its temperature increases by 500 K during the compression, assuming the expansion is reversible and adiabatic?

the expansion is reversible and adiabatic?
$$C_{V,m} = C_{V,m} = C$$

 ΔS_{surr}

(10 pts) 5. If the molar concentration of
$$O_2$$
 gas is 0.2 M and that of N_2 gas is 0.8 M in a closed container at T=300 K, what is its partial pressure of the N_2 ?

Fat
$$T=300 \text{ K}$$
, what is its partial pressure of the N_2 ?

$$P_{N_2} = [N_2]RT = 0.8 \text{ mol} 0.083145 \text{ Lber} \times 300 \text{ K}$$

$$= 19.95 \text{ bar}$$

$$= 19.95 \text{ bar} \times 10^5 \text{ Pa} = 1.995 \times 10^5 \text{ Pa}$$
6. Define "vapor pressure" of a liquid.

(11 pts) 6. Define "vapor pressure" of a liquid.

(11 pts) 7. Write the balanced chemical reaction whose $\Delta_r H^0 = \Delta_f H^0$ for NO₂ (g).

(10 pts) 8. With the aid of the Bond Dissociation table below, explain why the N_2 gas of the atmosphere is does not catch on fire when we light a match in it. Assume the chemical reaction for the burning is $N_2 + O_2 \rightarrow 2NO$. (D for N-O is 630 kJ.mol.)

(10 pts) 9. The vapor pressure of $H_2O(1)$ at 298 K is 0.0313 atm. At what temperature will water boil in a vessel in which the air pressure is 0.0313 atm?

TABLE A.5 Inorganic Compounds* (cont.)

HCO ₃ (aq)	TABLE A.5 IIIOI ga	inc compounds (corre.)		*
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		$\Delta_{\xi}H_{-}(kJ \text{ mof }^{-1})$	5 (JK ⁻¹ mol ')	∆,G (kJ mol ¹)
Fe(s) 0 27.28 0 Fe ₂ O ₃ (s) -824.2 87.40 -742.2 H ₂ (s) 0 130.79 0 H ₂ O(s) -241.82 188.93 -228.73 H ₂ O(s) -241.82 188.93 -228.73 H ₂ O(s) -225.83 69.91 -237.13 H ⁺ (aq) 0 0 0 OH (aq) -229.99 -10.75 -157.244 H ₂ O ₂ (aq) -191.17 143.9 -134.03 H ₂ S(s) -20.63 205.90 -33.56 H ₂ S(s) -20.63 205.90 -33.56 H ₂ S(s) -735.13 298.8 -653.37 N ₂ (s) 0 191.72 0 NH ₃ (s) -46.11 192.56 -16.78 NH ₃ (s) -46.11 192.56 -16.78 NH ₄ (aq) -132.51 113.4 -79.31 NO(s) 90.25 210.87 86.55 NO ₂ (s) 33.18 240.17 <th< th=""><td>HCO₃¬(aq)</td><td>-691.99</td><td>91.2</td><td>-586.77</td></th<>	HCO₃¬(aq)	-691.99	91.2	-586.77
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	CO ₃ ²⁻ (aq)	-677.14	-56.9	-527.81
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	Fe(s)	0	27.28	0
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$Fe_2O_3(s)$	-824.2	87.40	-742.2
$H_2O(l)$ -285.83 69.91 -237.13 $H^+(aq)$ 0 0 0 $OH^-(aq)$ -229.99 -10.75 -157.244 $H_2O_2(aq)$ -191.17 143.9 -134.03 $H_2S(g)$ -20.63 205.90 -33.56 $H_2S(g)$ -20.63 205.90 -33.56 $H_2S(g)$ -20.63 205.90 -33.56 $H_2S(g)$ 0 191.72 0 $NH_2(g)$ 0 191.72 0 $NH_3(g)$ -46.11 192.56 -16.78 $NH_3(g)$ -46.11 192.56 -16.78 $NH_3(g)$ -46.11 192.56 -16.78 $NH_3(g)$ -380.29 111.3 -265.50 $NH_4(aq)$ -132.51 113.4 -79.31 $NO(g)$ 33.18 240.17 51.47 $NO_2(g)$ 33.18 240.17 51.47 $NO_3(aq)$ -205.0 146.40 -108.74 $Na^+(aq)$ -240.12 59.0 -2	$H_2(g)$	0	130.79	0
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$H_2O(g)$	-241.82	188.93	-228.73
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	H ₂ O(0)	-285.83	69.91	-237.13
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	H+(aq)	0	0	0
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	OH (aq)	-229.99	-10.75	-157;244
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$H_2O_2(aq)$	-191.17	143.9	-134.03
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	H ₂ S(g)	-20.63	205.90	-33.56
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	"19" S. Toller and Commercial States and Dec.		298.8	-653.37
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$N_2(g)$	0	191.72	0
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	NH ₃ (g)	-46.11	192.56	-16.78
NO(g) 90.25 210.87 86.55 NO ₂ (g) 33.18 240.17 51.47 NO ₃ ⁻ (aq) -205.0 146.40 -108.74 Na ⁺ (aq) -240.12 59.0 -261.90 NaCl(s) -411.15 72.13 -384.14 NaCl(aq) -407.27 115.5 -393.13 NaOH(s) -425.61 64.46 -379.49 O ₂ (g) 0 205.25 0 O ₃ (g) 142.7 239.04 163.4 S(rhombic) 0 31.80 0 SO ₂ (g) -296.83 248.33 -300.19	NH ₃ (aq)	-80.29	1113	-26.50
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	The particular of the property and the property of the property of	-132.51	THE RESERVE OF THE PARTY OF THE	-79.31
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	And agreed hour half the sail processes and the		210.87	86.55
Na+(aq) -240.12 59.0 -261.90 NaCl(s) -411.15 72.13 -384.14 NaCl(aq) -407.27 115.5 -393.13 NaOH(s) -425.61 64.46 -379.49 O2(g) 0 205.25 0 O3(g) 142.7 239.04 163.4 S(thombic) 0 31.80 0 SO2(g) -296.83 248.33 -300.19	Name of the state	enature restricts and the second	2.5. 5.7	51.47
NaCl(s) -411.15 72.13 -384.14 NaCl(aq) -407.27 115.5 -393.13 NaOH(s) -425.61 64.46 -379.49 $O_2(g)$ 0 205.25 0 $O_3(g)$ 142.7 239.04 163.4 S(rhombic) 0 31.80 0 $SO_2(g)$ -296.83 248.33 -300.19	and the second of the second	e control into a refer to a	146.40	-108.74
NaCl(aq) -407.27 115.5 -393.13 NaOH(s) +425.61 64.46 -379.49 O2(g) 0 205.25 0 O3(g) 142.7 239.04 163.4 S(rhombic) 0 31.80 0 SO2(g) -296.83 248.33 -300.19	PATRASSecur Internation and Religious Co. 1. In the concerns	NAMES AND	CASSA IN REPORT CONTRACTOR AND A SECURITION OF ANY AND AND AND ANY AND	-261.90
NaOH(s) -425.61 64.46 -379.49 $O_2(g)$ 0 205.25 0 $O_3(g)$ 142.7 239.04 163.4 S(rhombic) 0 31.80 0 $SO_2(g)$ -296.83 248.33 -300.19	Controlled the state of the control of the control of the state of the	Control of the Contro		-384.14
$O_2(g)$ 0 205.25 0 $O_2(g)$ 142.7 239.04 163.4 $O_3(g)$ 31.80 0 $O_2(g)$ 205.25 0 $O_2(g)$ 248.33 -300.19	table. A refer for discussion as in section	. 10	and the second second	-393.13
O3(g) 142.7 239.04 163.4 S(rhombic) 0 31.80 0 SO2(g) -296.83 248.33 -300.19	the comment of the second	-425.61	64.46	-379.49
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$SO_3(g)$ -395.72 256.87 -371.22	A CHAMBER OF BUILDING TO SERVICE AND	ಶಿಕ್ಷಣಗಳು ಕಾರ್ಯಕ್ಕೆ ಬಿಕ್ಕುಗಳು		
	$SO_3(g)$	395.72	256.87	-371.22

Table 2.3 Bond Dissociation Energies

Bond	D (kJ mol ⁻¹
c-c	359
C=C	611
C = C	827
С—н	411
C-N	303
c-o	361
c=0	709
c-s	294
N-H	383
о—н	452
s—н	359
н—н	436.0
N = N	945.4
0=0	498.3
C (graphite)	716.7
S (rhombic sulf	277.0

^{*} Standard thermodynamic values at 25°C (298.15 K) and 1 bar pressure. Values for ions refer to an aqueous solution at unit activity on the molarity scale. Standard enthalpy of formation, $\Delta_{\rm f}H^{\circ}$, third-law entropies. S° , and standard Gibbs free energy of formation, $\Delta_{\rm f}G^{\circ}$, are given.

[†] The standard state for all ions and for species labeled (aq) is that of a solute on the molarity scale. (Data from The NBS Tables of Thermodynamic Properties, D. D. Wagman et al., eds., J. Phys. Chem. Ref. Data, 11, Suppl. 2 (1982), corrected to 1 bar pressure.)