

Exam #1

Name Key(20) 1. Matching (use a letter only once)A small change in entropy,  $dS$ , is defined as f.Raoult's Law is d.The expression for  $\Delta G_{\text{mix}}$  is n.At constant T and P, and only P,V-work,  $\Delta S_{\text{univ}}$  equals h. $\Delta S$  for a phase transition is p. $\Delta S$  for heating a substance at constant volume is c. $\Delta S$  is j (negative or positive) for freezing of a liquid.The statistical definition of entropy is m.The molar Gibbs free energy is called the b.The vapor pressure of a liquid varies with temperature according to l.

$R = 8.314 \text{ J/mol-K}$

$R = 1.987 \text{ cal/mol-K}$

$R = 0.08206 \text{ L-atm/mol-K}$

$N_A = 6.02 \times 10^{23}$

a.  $-R(n_A \ln X_A + n_B \ln X_B)$

b. chemical potential

c.  $C_V \ln(T_2/T_1)$

d.  $P_A = X_A P_A^*$

e.  $\int C_p dT/T$

f.  $dq_{\text{rev}}/T$

g. activation potential

h.  $-\Delta G/T$

i.  $S = n_A \ln X_A$

j. negative

k.  $\mu_A(l) = \mu_A^*(l) + RT \ln X_A$

l.  $\ln P = -\Delta \bar{H}_{\text{vap}}/RT + \text{const.}$

m.  $S = k_B \ln W$

n.  $RT(n_A \ln X_A + n_B \ln X_B)$

o. positive

p.  $\Delta H/T$

q.  $C_p dT$

r.  $P = nRT/V$

s.  $\Delta H - T\Delta S$

t.  $nR \ln(V_2/V_1)$

(10) 2. Use the expression for  $\Delta G_{\text{mix}}$  at constant T, and the relationship between  $\Delta G$  and  $\Delta S$  at constant T, to find  $\Delta S_{\text{mix}}$ .

$$\Delta G = \Delta H - T\Delta S$$

$$\Delta H_{\text{mix}} = 0$$

$$\Delta G_{\text{mix}} = -T\Delta S_{\text{mix}}$$

$$\Delta G_{\text{mix}} = RT(n_A \ln X_A + n_B \ln X_B)$$

$$\Delta S_{\text{mix}} = -R(n_A \ln X_A + n_B \ln X_B)$$

(15) 3. Assume you know the entropy of ice at 0 K. Give the series of equations you would use to determine the entropy of water vapor at 150 °C.

$$S_{\text{vap}}^{\circ}(150^{\circ}\text{C}) = S^{\circ}(0\text{K}) + \int_0^{T_f} \frac{C_p(\text{s})dT}{T} + \frac{\Delta H_{\text{fus}}}{T_f} + \int_{T_f}^{T_b} \frac{C_p(\text{l})dT}{T} + \frac{\Delta H_{\text{vap}}}{T_b} + \int_{T_b}^{150^{\circ}\text{C}} \frac{C_p(\text{g})dT}{T}$$

(25) 4. At 1 atm pressure the molar heat of vaporization of ethanol is 39.3 kJ/mol, and the boiling point is 78.3 °C; K = 273 + °C. Calculate for 1 mole of ethanol:

a.  $\Delta S$  and  $\Delta G$ .

and constant P

$\Delta S = q_{\text{rev}}/T$ , vaporization at the boiling point is equilibrium and reversible so  $q_{\text{rev}} = \Delta H_{\text{vap}}$

$$\Delta S = \frac{39.3 \text{ kJ/mol}}{351.3 \text{ K}} = \frac{0.112 \text{ kJ}}{\text{mol-K}}$$

$$\Delta G_{\text{vap}} = \Delta H_{\text{vap}} - T\Delta S_{\text{vap}} = \Delta H_{\text{vap}} - T(\Delta H_{\text{vap}}/T) = 0$$

b. q, w, and  $\Delta U$ .

$$q = q_p = \Delta H_{\text{vap}} = 39.3 \text{ kJ/mol}$$

$$w = -P(\bar{V}_g - \bar{V}_l) \text{ with } \bar{V}_l \approx 0; w = -P\bar{V}_g = -RT = -8.314 \times 351.3 = -2.92 \text{ kJ/mol}$$

$$\Delta U = q_p + w = 39.3 - 2.92 = 36.4 \text{ kJ}$$

(10) 5. A solution consists of 10 grams of urea ( $\text{NH}_2\text{CONH}_2$ ) in 500 grams of water. What is the molality of the solution?

$$\text{MW} = 60 \text{ g/mole}$$

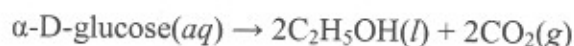
$$n = 10 \text{ g} / 60 \text{ g/mole} = 0.167 \text{ moles}$$

$$\text{molality} = \frac{0.167 \text{ moles}}{0.5 \text{ kg}} = 0.333 \text{ molal}$$

(5) 6. Give a statement of the Third Law of Thermodynamics.

The entropy of a perfect crystal at 0 K is zero.

(15) 7. Consider the reaction



and the information

	$\Delta H_f^\circ$ (kJ/mol)	$\Delta G_f^\circ$ (kJ/mol)
$\alpha\text{-D-glucose(aq)}$	-1274.5	-910.6
$\text{C}_2\text{H}_5\text{OH(l)}$	-277.0	-174.2
$\text{CO}_2\text{(g)}$	-393.5	-394.4

Calculate  $\Delta S_r^\circ$  for the reaction.  $T = 298 \text{ K}$ .

$$\Delta H_r^\circ = 2 \times (-393.5) + 2 \times (-277.0) - (-1274.5) = -66.5 \text{ kJ}$$

$$\Delta G_r^\circ = 2 \times (-394.4) + 2 \times (-174.2) - (-910.6) = -226.6 \text{ kJ}$$

$$\Delta G_r^\circ = \Delta H_r^\circ - T \Delta S_r^\circ$$

$$\Delta S_r^\circ = \frac{\Delta H_r^\circ - \Delta G_r^\circ}{T} = \frac{-66.5 + 226.6}{298} = 537 \text{ J/K}$$

Positive  $\Delta S_r^\circ$  expected since products are more random.