

40 Exam  
Too High  
66 Low  
Median 92

Chemistry – 4311  
October 28, 2009

Exam #2

Name Key

(20) 1. Matching (use a letter only once)

The e law of thermodynamics states that energy is conserved.

The change in  $q$  for heating a pure solid at constant pressure is given by s.

The enthalpy  $H$  is defined as h.

When a substance is heated at constant pressure, its entropy change is given by c.

$\Delta S$  for mixing two gases is given by l.

When a liquid freezes, heat is p.

The entropy change for a phase transition is r.

The k law of thermodynamics says that the entropy of the universe increases for spontaneous processes.

For an adiabatic process n is zero

If a process at constant  $T$  and  $P$  is non-spontaneous,  $\Delta G$  is d than zero.

**Gas Law Constants:**

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

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

$R = 0.0821 \text{ L-atm/mol-K}$

- a. absorbed
- b. zeroth
- c.  $C_p \ln(T_2/T_1)$
- d. greater
- e. first
- f.  $nR \ln(P_1/P_2)$
- g.  $nRT \ln(V_1/V_2)$
- h.  $H = U + PV$
- i.  $\Delta U$
- j.  $w$
- k. second
- l.  $-R(n_A \ln x_A + n_B \ln x_B)$
- m.  $H = q + w$
- n.  $q$
- o. third
- p. released
- q.  $R(n_A x_A + n_B x_B)$
- r.  $\Delta H_w/T_w$
- s.  $\int C_p dT$
- t. less

(5) 2. For a certain process the system gains 20 kJ of heat and does 10 kJ of work. What is  $\Delta U$ ?

$$q = +20 \text{ kJ}$$

$$w = -10 \text{ kJ}$$

$$\Delta u = q + w = 20 - 10 \\ = 10 \text{ kJ}$$

(20) 3. One mole of an ideal gas, initially at 27 °C and 1 atm pressure, is heated and allowed to expand at constant pressure until the final temperature is 327 °C.  $C_v = 20.8 \text{ J/mol-K}$  and  $C_p = 29.1 \text{ J/mol-K}$ , and both are constant over the temperature range.

a. Calculate the initial and final volumes of the gas.

$$V_1 = \frac{RT}{P} = 0.0821 \times 300 = 24.6 \text{ L}$$

$$V_2 = 0.0821 \times 600 = 49.3 \text{ L}$$

b. Calculate the work for this process.

$$w = -P \Delta V = -R \Delta T = -8.314 \times 300 = -2,490 \text{ J} \\ = -2.49 \text{ kJ}$$

$$w = -24.6 \text{ L-atm}$$

c. Calculate  $\Delta U$  for this process.

$$\Delta u = C_v \Delta T = 20.8 \times 300$$

$$\Delta u = 6,240 \text{ J} = 6.24 \text{ kJ}$$

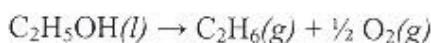
d. Determine  $q$  and  $H$  for this process.

$$q_p = \Delta H = 29.1 \times 300 = 8,730 \text{ J} \\ = 8.73 \text{ kJ}$$

e. Calculate  $\Delta S$  for this process.

$$\Delta S = C_p \ln \frac{T_2}{T_1} = 29.1 \times \ln \frac{600}{300} = 20.2 \text{ J/K}$$

(20) 4. Consider the reaction:



with the following thermodynamic information (25 °C is the standard state):

Molecule	$\Delta H_f^\circ$ (kJ/mol)	$S^\circ$ (J/mol-K)
$\text{C}_2\text{H}_5\text{OH}(l)$	-276.98	160.67
$\text{C}_2\text{H}_6(g)$	-84.68	229.60
$\text{O}_2(g)$	0	205.14

Calculate  $\Delta H^\circ$ ,  $\Delta S^\circ$ , and  $\Delta G^\circ$  for this reaction.

$$\textcircled{+7} \Delta H^\circ = -84.68 - (-276.98) = \boxed{192.3 \text{ kJ}}$$

$$\textcircled{+9} \Delta S^\circ = \frac{1}{2}(205.14) + 229.60 - 160.67$$

$$= \boxed{171.5 \text{ J/K}} \quad \textcircled{+6} \Delta G^\circ = 192.3 - 298 \times 171.5 \times 10^{-3} = \boxed{141.2 \text{ kJ}}$$

(20)5. Consider the reversible, isothermal, constant pressure freezing of 1 mol of water at 0 °C.  $\Delta H_{\text{fusion}} = 6.007 \text{ kJ/mol}$ .

a. What is  $\Delta H$  for this process?

$$\textcircled{+4} \Delta H = -6.007 \text{ kJ}$$

b. What is  $q$  for this process?

$$\textcircled{+4} q_p = \Delta H = -6.007 \text{ kJ}$$

c. What is  $\Delta S$  for this process?

$$\textcircled{+5} \frac{-6007 \text{ J}}{273 \text{ K}} = -22.0 \text{ J/K}$$

d. What is  $\Delta G$  for this process?

$$\textcircled{+5} 0 \quad \text{constant } T, P \text{ and eq.}$$

e. Why is it an excellent approximation to assume the work  $w$  is zero, so that  $\Delta U$  equals  $q$ ?

$$\textcircled{+2} w = -P_{\text{ex}} [V_s - V_l], \quad V_s \approx V_l \\ w \approx 0$$

(5) 6. Two reactions are coupled. If  $\Delta G_r$  for one reaction is -20 kJ and  $\Delta G_r$  is 5 kJ for the second, what is  $\Delta G_r$  for the coupled reactions?

$$\Delta G_{\text{overall}} = -20 \text{ kJ} + 5 \text{ kJ} = -15 \text{ kJ}$$

(10) 7. Write T or F after each of the following:

T a.  $\Delta U = q + w$

T b. Isothermal, reversible work:  $-nRT \ln(V_2/V_1)$

F c.  $G = H + TS$

T d.  $dS = dq_{\text{rev}}/T$

T, F e.  $\ln(P_2/P_1) = -(\Delta H_{\text{vap}}/R)(T_1^{-1} - T_2^{-1})$