Chem 106 Exam 2. January 17, 2003.
Name_____

Useful information: $\Delta H = \Delta w + q$, $\Delta G = \Delta H - T\Delta S$, $\Delta H_{rxn} = \sum \Delta H_{products} - \sum \Delta H_{reagents}$, q=s x m x ΔT, q = C x ΔT, s = 4.18 J/g•ºC for water, $\Delta G = \sum \Delta G_{products} - \sum \Delta G_{reagents}$

(1)(4 pts) Calculate the value of ΔH (in kJ·mol^{-1}) for the reaction

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

	Bond Energies (kJ·mol^{-1})
H–H	435
N_N	946 (in N_2 triple bond)
N–H	389

(A) 2340 kJ of heat absorbed

(B) 213 kJ of heat absorbed

(C) 2340 kJ of heat evolved

(D) 83 kJ of heat evolved

(2)(4 pts) In which process is entropy decreased?

(A) dissolving sugar in water

(B) expanding a gas

(C) evaporating a liquid

(D) freezing water

(3)(4 pts)

Compound	ΔG_f^0 (kJ·mol^{-1})
$SO_2(g)$	–301
$SO_3(g)$	–372
$O_{2(g)}$	0

What is ΔG^0 for this reaction at 298 K?

$$2SO_2(g) + O_2(g) \quad 2SO_3(g)$$

(A) –142 kJ (B) –200 kJ (C) –744 kJ (D) 142 kJ

(4)(4 pts) At 298 K, is this reaction endothermic or exothermic, and what is the value of ΔH?

Compound and State	ΔH_f^0 (kJ·mol^{-1})	ΔG_f^0 (kJ·mol^{-1})
$CO_2(g)$	–393	–393
$CaO(s)$	–636	–603
$CaCO_3(s)$	–1210	–1130

At 298 K, the reaction represented by

$$CaCO_3(s) \text{ ---> } CaO(s) + CO_2(g) \text{ is}$$

(A) exothermic with ΔH = +181 kJ

(B) endothermic with ΔH = –181 kJ

(C) endothermic with ΔH = +134 kJ

(D) endothermic with ΔH = +181 kJ

(5)(4 pts) A certain reaction has negative values of both ΔH and ΔS. Therefore, the reaction

(A) must be spontaneous at all temperatures.

(B) cannot be spontaneous at any temperature.

(C) will be spontaneous only at low temperatures.

(D) will have a positive free energy at any temperature.

(6)(4 pts) What is the sign of ΔH and ΔS?

For this process at 25 °C:

$$H_2O(g) \text{ ---> } H_2O(l)$$

(A) ΔH is negative and ΔS is negative.

(B) ΔH is negative and ΔS is positive.

(C) ΔH is positive and ΔS is positive.

(D) ΔH is positive and ΔS is negative.

(7)(4 pts) How much heat must be absorbed to heat a 45 kg car engine (made of iron) from 25 ºC to operating temperature (95 ºC)? The specific heat of iron is 0.45 J/g•ºC.

(8)(4 pts) Butane (C_4H_{10}) (1.0 g) and 5000 psi of O_2 was placed in a bomb calorimeter. If the initial temperature of the calorimeter was 25 ºC and the final temperature was 31 ºC, what is ΔH for the reacdtion below. The heat capacity for the calorimeter is 6,800 J/ºC.

$C_4H_{10(l)} + 6.5O_2$ ------> $4CO_{2(g)} + 5H_2O_{(l)}$ $\Delta H = ?$

(9) The Haber process is used commercially to manufacture ammonia.

$$3\ H_{2(g)} + N_{2(g)} \text{ ----> } 2NH_{3(g)}$$

Using the tables of thermodynamic data on the back of this exam,
(a) is this process spontaneous or nonspontaneous at 25 ºC?

(b)At what temperature is this process in equilibrium?

(10)(4 pts) Calculate the ΔH for the following reaction using the information below.

$KClO_3 + PCl_3 \rightarrow 3POCl_3 + KCl \quad \Delta H = ?$

Useful information

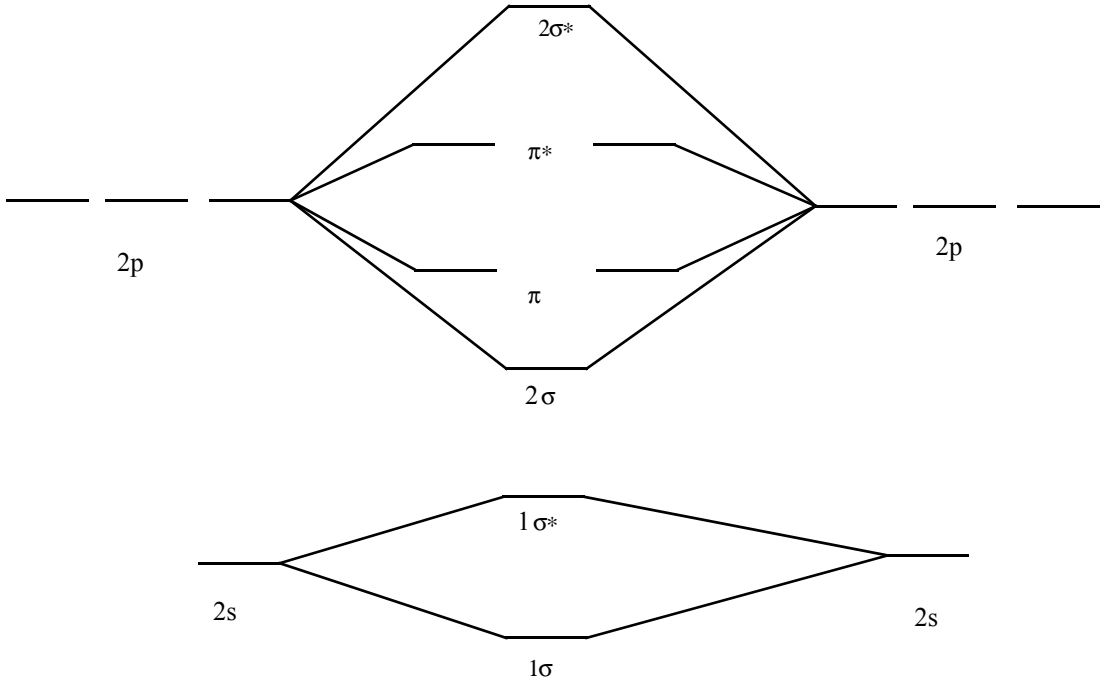
$KCl + 0.5O_2 \rightarrow KClO_3 \qquad \Delta H = 39.0$ kJ

$0.75P_4 + 1.5O_2 + 4.5Cl_2 \rightarrow 4POCl_3 \qquad \Delta H = -1234$

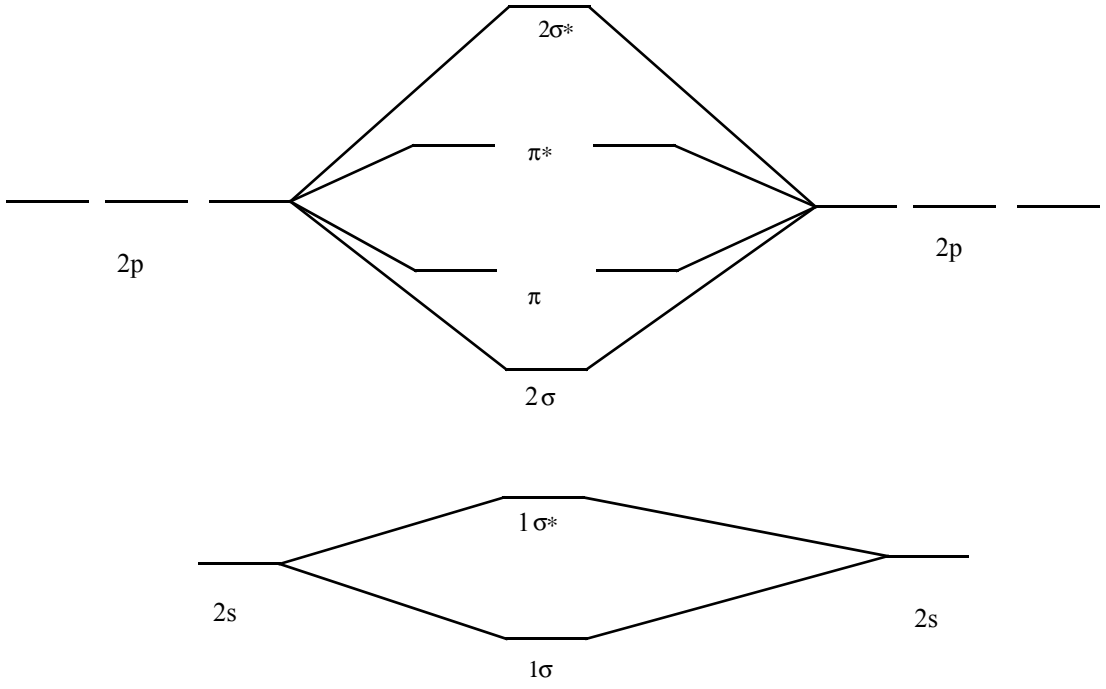
$0.75P_4 + 4.5Cl_2 \rightarrow 3PCl_3 \qquad \Delta H = -861$ kJ

(11)(4 pts) If a reaction has a positive ΔH and a positive ΔS, under what conditions is it spontaneous and why?

(12)(5 pts) Using the MO diagrams below, fill in the electrons for F_2 and CO. What is the bond order for each of these molecules? Which molecule has the strongest bond and why?



(a) F_2



(b) CO

(c) What are the bond orders, which one has a stronger bond, and why?

Extra Credit:(5 pts) If 25.00 g of $NH_4Cl_{(s)}$ is added to 100.0 g of water at 45.0 ºC, what is the final temperature of the solution. Assume that s = 3.98 J/g•ºC for the solution.

$$NH_4Cl_{(s)} \text{ -----> } NH_4^+{}_{(aq)} + Cl^-{}_{(aq)} \quad \Delta H = 28.1 \text{ kJ}$$