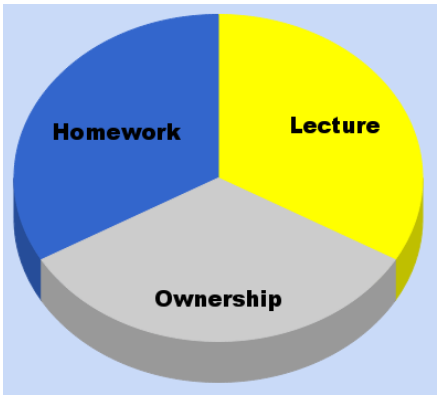
CHEM 121 – Worksheet 15 – Fall 2015

Monday Name: _____

Wednesday Name: _____



Directions: You may not complete this prior to class: by all means use it as a study guide. As usual, the first 50 minutes you'll be working on this without notes, with your partner[s] and with a non-programmable calculator. The next 10 minutes you may use your notes (this might include hard copies of the 5 links Dr. Carman emailed to you). The final 25 minutes is time spent at the board.

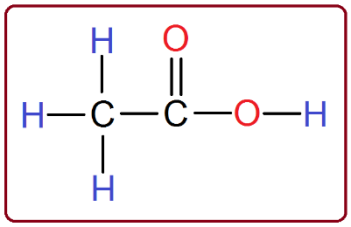
You may find this table of help:

Average Bond Energies (kJ/mol)

Single Bonds						Multiple Bonds	
H—H	432	N—H	391	I—I	149	C=C	614
H—F	565	N—N	160	I—Cl	208	C≡C	839
H—Cl	427	N—F	272	I—Br	175	O=O	495
H—Br	363	N—Cl	200			C=O*	745
H—I	295	N—Br	243	S—H	347	C≡O	1072
		N—O	201	S—F	327	N=O	607
C—H	413	O—H	467	S—Cl	253	N=N	418
C—C	347	O—O	146	S—Br	218	N≡N	941
C—N	305	O—F	190	S—S	266	C≡N	891
C—O	358	O—Cl	203			C=N	615
C—F	485	O—I	234	Si—Si	340		
C—Cl	339			Si—H	393		
C—Br	276	F—F	154	Si—C	360		
C—I	240	F—Cl	253	Si—O	452		
C—S	259	F—Br	237				
		Cl—Cl	239				
		Cl—Br	218				
		Br—Br	193				

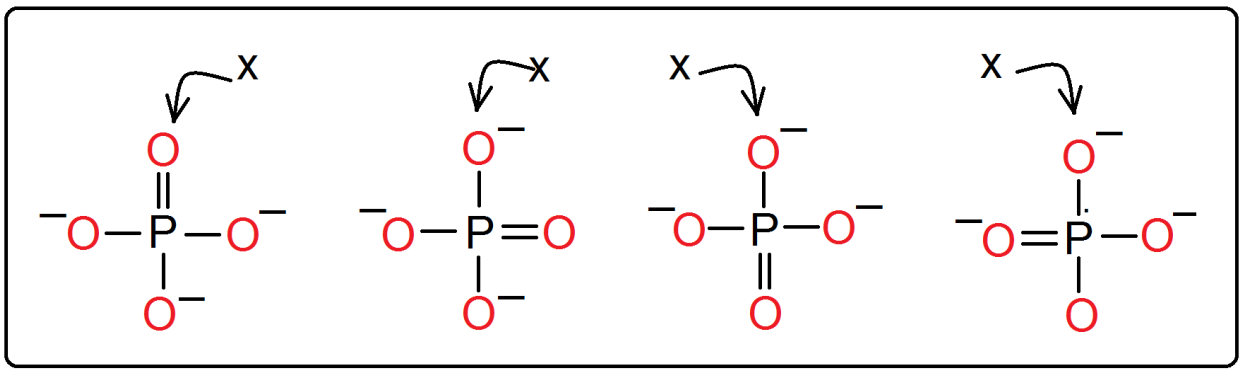
*C=O(CO_2) = 799

1) Using the above table, determine the ΔE for the following reaction: $CH_3OH + C{\equiv}O \rightarrow HC_2H_3O_2$. $HC_2H_3O_2$ has the following structure:



Here's something that will let you comingle Lewis Structures (lab) with Thermochemistry (reading) in your spare time: http://science.uvu.edu/ochem/index.php/alphabetical/q-r/resonance-theory/

2) According to resonance theory, each bond in the phosphate ion (PO_4^{3-}) is consistent with the observation that the four bonds in the phosphate ion have the same bond length. Given that the P–O bond energy is 376.6 kJ/bond and that the P=O bond energy is 460.2 kJ/bond, determine the bond energy for the O labeled "X" in the diagram, below.



You may find the following table of assistance in the next problems:

Heat of Formation Values

ΔH_f° (kJ/mol) (concentration of aqueous solutions is 1*M*)

Substance	ΔH_f°	Substance	ΔH_f°	Substance	ΔH_f°	Substance	ΔH_f°
Ag(s)	0	CsCl(s)	−443.04	H_3PO_4(aq)	−1279.0	NaBr(s)	−361.062
AgCl(s)	−127.068	Cs_2SO_4(s)	−1443.02	H_2S(g)	−20.63	NaCl(s)	−411.153
AgCN(s)	146.0	CuI(s)	−67.8	H_2SO_3(aq)	−608.81	$NaHCO_3$(s)	−950.8
Al_2O_3	−1675.7	CuS(s)	−53.1	H_2SO_4(aq)	−814.0	$NaNO_3$(aq)	−447.48
$BaCl_2$(aq)	−871.95	Cu_2S(s)	−79.5	$HgCl_2$(s)	−224. 3	NaOH(s)	−425.609
$BaSO_4$	−1473.2	$CuSO_4$(s)	−771.36	Hg_2Cl_2(s)	−265.22	Na_2CO_3(s)	−1130.7
BeO(s)	−609.6	F_2(g)	0	Hg_2SO_4(s)	−743.12	Na_2S(aq)	−447.3
$BiCl_3$(s)	−379.1	$FeCl_3$(s)	−399.49	I_2(s)	0	Na_2SO_4(s)	−1387.08
Bi_2S_3(s)	−143.1	FeO(s)	−272.0	K(s)	0	NH_4Cl(s)	−314.4
Br_2	0	FeS(s)	−100.0	KBr(s)	−393.798	O_2(g)	0
CCl_4(l)	−128.2	Fe_2O_3(s)	−824.2	$KMnO_4$(s)	−837.2	P_4O_6(s)	−1640.1
CH_4(g)	−74.81	Fe_3O_4(s)	−1118.4	KOH	−424.764	P_4O_{10}(s)	−2984.0
C_2H_2(g)	226.73	H(g)	217.965	LiBr(s)	−351.213	$PbBr_2$(s)	−278.7
C_2H_4(g)	52.26	H_2(g)	0	LiOH(s)	−484.93	$PbCl_2$(s)	−359.41
C_2H_6(g)	−84.68	HBr(g)	−36.40	Mn(s)	0	SF_6(g)	−1220.5
CO(g)	−110.525	HCl(g)	−92.307	$MnCl_2$(aq)	−555.05	SO_2(g)	−296.830
CO_2(g)	−393.509	HCl(aq)	−167.159	$Mn(NO_3)_2$(aq)	−635.5	SO_3(g)	−454.51
CS_2(l)	89.70	HCN(aq)	108.9	MnO_2(s)	−520.03	SrO(s)	−592.0
Ca(s)	0	HCHO	−108.57	MnS(s)	−214.2	TiO_2(s)	−939.7
$CaCO_3$(s)	−1206.9	HCOOH(l)	−424.72	N_2(g)	0	TlI(s)	−123.5
CaO(s)	−635.1	HF(g)	−271.1	NH_3(g)	−46.11	UCl_4(s)	−1019.2
$Ca(OH)_2$(s)	−986.09	HI(g)	26.48	NH_4Br(s)	−270.83	UCl_5(s)	−1059
Cl_2(g)	0	H_2O(l)	−285.830	NO(g)	90.25	Zn(s)	0
Co_3O_4(s)	−891	H_2O(g)	−241.818	NO_2(g)	33.18	$ZnCl_2$(aq)	−488.19
CoO(s)	−237.94	H_2O_2(l)	−187.8	N_2O(g)	82.05	ZnO(s)	−348.28
Cr_2O_3(s)	−1139.7	H_3PO_4(l)	−595.4	Na(s)	0	$ZnSO_4$(aq)	−1063.15

3) Using the above table, determine the $\Delta H_f°$ for the following reaction: NH_3 (g) + HCl (g) $\rightarrow$ NH_4Cl (s) ($\Delta H_f°$ for NH_4Cl (s) = -314.43 kJ/mol).

4) If you had 18.25 grams of gaseous hydrogen chloride in #3, how much heat was actually generated in the formation of ammonium chloride by the reaction?

5) In advance of your week 10 experiment (Born Haber Cycles and Hess' Law), calculate the ΔH for the reaction CaC_2 (s) + $2H_2O$ (l) $\rightarrow$ $Ca(OH)_2$ (l) + C_2H_2 (g) given the following data:

Reaction	ΔH (kJ)
Ca(s) + ½ O2 $\rightarrow$ CaO (s)	-635.5
Ca(s) + 2C (graphite) $\rightarrow$ CaC_2 (s)	-62.8
CaO(s) + H_2O (l) $\rightarrow$ $Ca(OH)_2$ (l)	-653.1
C_2H_2 (g) + 2.5 O_2 $\rightarrow$ $2CO_2$ (g) + H_2O (l)	-1300
C(graphite) + O_2 (g) $\rightarrow$ CO_2(g)	-393.5

6) Your bicycle tire is flat and you need to fill it with air. If the air is at 1 atm and your bicycle tire holds 4.5 L at 80 psi, how much air do you need to pump into your tire?

7) At full expiration a rabbit's lungs hold 2.4 L of air at 765 mm Hg. At full inspiration, the intrapulmonary pressure is 750 mm Hg. How large is the volume of the rabbit's lungs at full inspiration?

8) A hot air balloon at deflation has a volume of 5 L at 760 mm Hg. After inflation, the balloon has a volume of 450 L. What is the pressure of the hot air in the balloon?

9) As you drive along in your automobile, the air in your tires (and the tires, too) heats up. If you started a 500 mile trip at 10°C with 50 L of air in your tires, what volume would be occupied by air in your tires at the end of the trip when the air temperature is 40°C?

10) The air in a deflated hot air balloon occupies 5 L at 5°C. What is the volume of the air in the balloon at 60°C?

11) Air that we breathe in has to be heated for breathing ease. If we breathe in air at 10°C and the temperature in the lungs is 37°C with a volume of 6 L, how much air did we breathe in?

12) A gas at 300 Torr and 5°C occupies 350 mL. How many mol of gas is/are present in this volume?

13) If 0.8 mol of a gas exerts 4 atm of pressure at 75°C, how much volume does it occupy?

14) 0.8 mol of a gas occupies 50 L at 25°C. How much pressure does this gas exert against the walls of its container?

15) A sample of NH_3 has a mass of 3.04 g and occupies a volume of 4 L at STP (0°C and 760 mm Hg). What is the molecular weight of NH_3?

16) The total pressure of a mixture of gases (CO_2, O_2 and CH_4) is 1800 Torr. The pCO_2 is 500 Torr and the pO_2 is 600 Torr. What is the pCH_4?

17) Air is collected at a barometric pressure of 600 mm Hg. If the primary gases in the air are N_2, O_2 and H_2O and the pN_2 is 400 mm Hg and the pO_2 is 160 mm Hg, what is the pH_2O?

18) Compare the rate of diffusion of each pair of gases:

A. Cl_2 with H_2

B. Br_2 with H_2

C. O_2 with N_2

D. I_2 with O_2

E. I_2 with F_2

F. CH_4 with O_2

G. CH_4 with N_2

H. CH_4 with air (MW = 29)

I. H_2S with air