Chm142 KEY Sample Midterm Exam Chapters 1-5 Dr. Trail

Please write legibly and **only in blue, black or pencil.** Use only the space provided and **show all your calculations**. Best of luck! Significant figures count !

1. (4 pts) Name the following compounds (limited to binary metal and nonmetal (thallium = Tl)

Al_2Se_3 **aluminum selenide** AgI **silver iodide (not a type II)**

B_3C_4 **triboron tetracarbide** P_2S_5 **diphosphorus pentasulfide**

2. (4 pts) Give the chemical formulas for the following compounds (1 pt each)

magnesium bromide $MgBr_2$ disulfur tetranitride S_2N_4

sodium oxide Na_2O water H_2O

3. (8 pts)

Circle the mostly likely oxidation state for the following:

Ba	+2	F	-1	Al	+3	Cs	+1
Xe	0	N	+5	N	-3		

4. **(8 pts)** Perform the following calculations. Provide the result with correct number of significant figures **ALL STEPS MUST BE SHOWN FOR CREDIT**

$12.2*10^{102} + 3.8*10^{104} =$ $3.9*10^{104}$

$(7.20*10^{101}) \div (2.00000*10^{-102}) + 12.12333*10^{201} = 3.60*10^{203} + 12.12333*10^{201} = 3.72*10^{203}$

5. **(12 points)** Please perform the following unit conversions (16 oz = 1 pound (lb), 5280 feet = 1 mile, 10^{10} Å=1 m)) **(WORK MUST BE SHOWN OR NO CREDIT)**

$$12.2\text{ g} = 12.2\text{ g}\left(\frac{1\text{ lb}}{453.6\text{ g}}\right)\left(\frac{16\text{ oz}}{1\text{ lb}}\right) = \mathbf{0.430\text{ oz}}$$

$$75\text{ cm/sec} = \left(\frac{75\text{ cm}}{\text{sec}}\right)\left(\frac{60\text{ sec}}{1\text{ min}}\right)\left(\frac{60\text{ min}}{1\text{ hr}}\right)\left(\frac{1\text{ in}}{2.54\text{ cm}}\right)\left(\frac{1\text{ ft}}{12\text{ in}}\right)\left(\frac{1\text{ mile}}{5280\text{ ft}}\right) = \mathbf{1.7\text{ mph}}$$

$3\text{ in}^3\ H_2O\ (20^oC) = 3\text{ in}^3\left(\frac{2.54\text{ cm}}{1\text{ in}}\right)^3\left(\frac{1.00\text{ g}}{\text{cm}^3}\right) = 49.2$ or **50 g** (1 s.f.) notice the use of density to covert from volume to mass

$$1.5\text{x}10^{-8}\text{ km}^3 = 1.5\text{x}10^{-8}\text{ km}^3\left(\frac{10^3\text{ m}}{1\text{ km}}\right)^3\left(\frac{10^{10}\text{ Å}}{1\text{ m}}\right)^3 = \mathbf{1.5*10^{31}\text{Å}^3}$$ remember to cube everything in the ( )

6. **(5 pts)** Please determine the number of significant figures in each of the following numbers:

NUMBER	NUMBER OF SIGNIFICANT FIGURES
$10*10^{-35}$	1
0.000201	3
12	2
0.0003030	4
10000.	5

7. **(3 pts)** Please determine how many electrons, protons and neutrons are present in isotope shown below (Seaborgium – a.k.a. Unh – unilhexium)

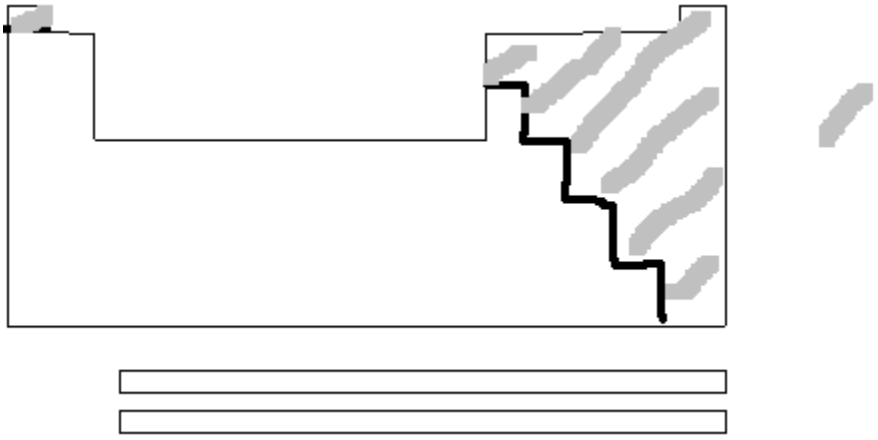
$^{266}Sg^{+6}$

# of electrons _____ **106-6 = 100 e**

# of protons _____ **106 p**

# of neutrons _____ **266-106 = 160 n**

8. **(2 points)** Below you see outline of Periodic table. Please mark region (regions) where you can find **metals** and **non-metals.**



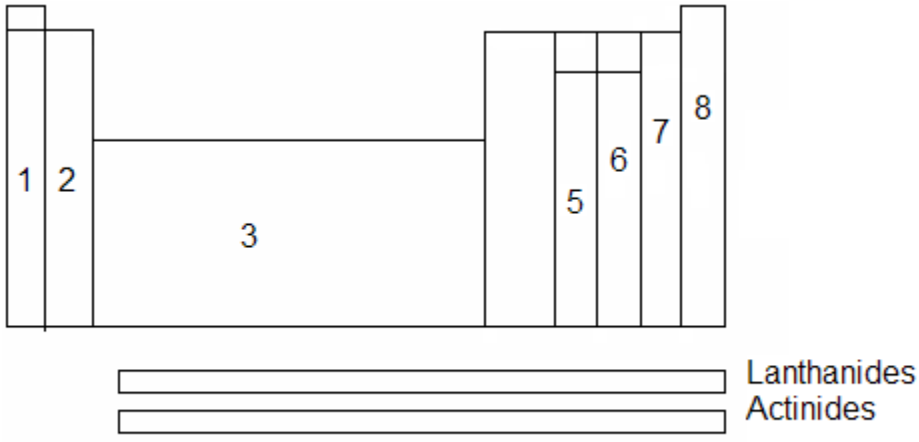
Grey = non-metals

.....

dfdsfasdfasdfasdfasdfasdasdf

9. **(10 points)** label the noble gases, alkaline earth metals, alkali metals, transition metals, f-metals, pnictogens, and chalcogens

1) alkali metals
2) alkaline earth metals
3) transition metals
4) f-metals
5) pnictogens
6) chalcogens
7) halogens
8) noble gases



10. **(3 points)** Please decide if the following is a homogeneous or heterogeneous sample. If you think it could be either answer, then provide an explanation and I will consider it.

	homogeneous	heterogeneous
Gasoline	HOMO	
14 k gold	HOMO	
Muscle tissue		HETERO

11. **(4 pts)** Please determine if the following processes are chemical or physical:

	Physical	Chemical
Fog forms when warm air crosses cold snow.	PHYS	
An egg is cooked on a hot skillet		CHEM
Ink on paper runs when wet	PHYS	
A soda can left in a freezer explodes	PHYS	

12. **(11 pts)** Some chemical History

a) (2 pts)What did Aristotle contribute to the atomic theory of Democritus? (these ideas persisted for almost 2000 years before they were finally rejected). Please describe his theory.

Four earthly elements (earth, wind, fire, air) and one heavenly element (ether – things like spirit).

b) (2 pts) Which model was Rutherford attempting to prove when he conducted his experiments with gold foil and alpha particles ?

J. J. Thomson's Plum-Pudding Model of the Atom

c) (2) What did Rutherford's gold foil/alpha particle experiment show?

That the atom was mostly empty space – 99.99% of the mass and all of the positive charge in a miniscule nucleus (the nuclear atom)

d) (2) Who conducted experiments with a cathode ray tube and determined the charge/mass ratio of the electron?

J. J. Thomson

13. (8 pts) A government agency randomly chooses a gas station to check it's one gas pump. Gas was pumped into a container until the pump read 10.00 gallons. The same pump was tested 10 times this way and the volumes were verified with the following results (i.e. the first data point, the pump said 10.00, the verification indicated the correct value to be 10.02 gallons)

10.02 gal	9.97 gal	10.00 gal	9.92 gal	10.07 gal
9.95 gal	10.00 gal	9.95 gal	10.01 gal	10.02 gal

a) What can you conclude about the accuracy of the pump? **It's fairly accurate since the average is roughly 10.0 gallons (9.991 gallons)**

b) What can you conclude about the precision of the pump? **The average is 9.99 and ranges from a low of 9.92 to a high of 10.07 (which is +/- 0.8 of the average). 0.8 divided by 9.99x100 is about 4% - that seems a bit high since a 4% error of a $50 gasoline bill would be pretty big ($2!). So I'll accept not precise as an answer here if you did this rough approximation. If you know how to calculate the standard deviation, you get a stdev of 0.04 That's about an 0.4% error. Do you think a 0.4% error on a $50 gasoline bill is reasonable (20 cents)? That's arguable. I think it is probably considered o.k. so I would accept either precise or not precise with some argument from you supporting your answer.**

14. (10 pts) Show how the following data illustrate the Law of Multiple Proportions:

	Mass of chlorine that combines with 1 g of sulfur		
Compound A	4.42 g	A:C = 2:1	B:C = 3:1 B:A = 3:2
Compound B	6.63 g		
Compound C	2.21 g	so possible formulas are A = SCl_2	B = SCl_3 C = SCl

15. **(10 pts)** You want to make fiber to help make sweaters to keep the world warm. You are considering building a chemical plant that will occupy 2300 acres and will produce 1.5 billion pounds each year of a plastic that will be spun into fibers to make sweaters.

If one sweater needs 3 lb of this fiber, then how many sweaters a year can be built at the plant?

$\frac{(1\text{ sweater})(1\text{ lb fiber})}{(3\text{ lb fiber})(1\text{ lb plastic})}\left(\frac{1.5*10^9\text{ lb plastic}}{\text{year}}\right) = 0.5*10^9$ sweaters/year (you don't have to do the middle conversion if you understand it)

Greenpeace approaches you and asks you to consider raising sheep instead to provide a natural alternative to the synthetic fiber. One sheep when sheared produces 9 pounds of wool a year. Again, you need 3 lb of this fiber to make one sweater. How many sheep do you need to make the same number of sweaters as the chemical plant?

$\frac{(\text{one sheep})(1\text{ lb wool})(3\text{ lb fiber})}{(9\text{ lbs wool})(1\text{ lb fiber})(1\text{ sweater})}0.5*10^9\text{ sweaters} = 167*10^6$ sheep (I'm keeping extra sig figs until the end of the problem)

Sheep can be raised to a maximum of 5 sheep per acre. How many acres do you need to equal the output of the chemical plant?

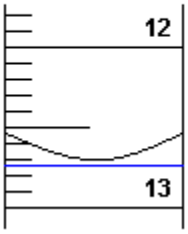
$\frac{(1\text{ acre})}{(5\text{ sheep})}(167*10^6\text{ sheep}) = 33*10^6$ acres

How much land will you have to buy and convert to grazing land for your sheep?:

10 football fields	(	~1 acre)
same size as chemical plant	(	~3,000 acres)
City of Chicago	(	~150,000 acres)
Kane County	(	~2,500,000 acres)
State of Illinois	**(**	**~37,000,000 acres)**
U.S.	(	~2,000,000,000 acres)

16. (4 pts)

MEASUREMENT WITH A BURET



12.73 mL

Chapter 3 questions:

17. Copper ore consists of two isotopes of masses 62.93 amu and 64.93 amu with abundances of 69.09% and 30.91%, respectively. What is the average atomic mass of copper?

a)63.55 62.93(.6909) + 64.93(.3091) = 63.55

b)78.03

c)63.5593

d)69.39

e)69.55

18. What is the mass of one atom of carbon 12 (^{12}C) in grams?

a)12.0 g

b)12.0000000 g (infinite sig. figs)

c) 6.0 g

d)1.99 x 10^{-23} g

e) 1.06 x 10^{-22} g

1 atom C(1 mole C)(12.000g C)
(6.02x10^{23} atoms C)(1 mole C)

19. Suppose the reaction $Ca_3(PO_4)_2 + 3H_2SO_4 = 3CaSO_4 + 2H_3PO_4$ is carried out starting with 103 g of $Ca_3(PO_4)_2$ and 75.0 g of H_2SO_4. How much phosphoric acid will be produced?

a)74.9 g

b)50.0 g

c)112 g

d)32.5 g

e)97.6 g

compound	molar masses
$Ca_3(PO_4)_2$	310.
H_2SO_4	98.1
H_3PO_4	98.0

103gCAP(1 mol CAP) = 0.332 mol CAP
(310.g CAP)

75.0g H_2SO_4(1 mol H_2SO_4) = 0.764 mol H_2SO_4
(98.1 g H2SO4)

have 0.332 mole CAP which needs (0.332mol CAP)(3 mol H2SO4) = 0.996 mol H2SO4
have 0.764 mole H2SO4 (1 mol CAP)

So there isn't enough H2SO4 present to react with all of the CAP so H2SO4 is the limiting reagent.

0.996 mol H2SO4 (2 mole H3PO4)(98.0 g H3PO4) = 49.9 g H3PO4 produced (0.1 difference due to choice of
(3 mole H2SO4)(1 mole H3PO4) molar masses)

20. $NaHCO_3$ is the active ingredient in baking soda. How many grams of oxygen are in 1.35 g of $NaHCO_3$? (84.0 g/mol)

a) 0.0463 g
b) 0.0849 g
c) 0.258 g
d) 0.579 g
e)0.771 g

1.35 g NaHCO3(1 mol NaHCO3) (3 mol O) (16 g O) = 0.771 g O
(84.0 g NaHCO3)(1 mol NaHCO3)(1 mol O)

21. For which compound does 0.256 mole weigh 12.8 g? want molar mass (grams per mole)

a)C_2H_4O 44 g/mol
b)CO_2 44 g/mol
c)CH_3Cl 50 g/mol
d)C_2H_6 30 g/mol
e) none of these

12.8 g = 50.0 g/mol - now check out molar masses
0.256 mole

22. In which of the following does nitrogen have an oxidation state of +3?

a) HNO_3 +5
b) NO_2 +4
c) N_2O +1
d) NH_4Cl -3
e) $NaNO_2$ +3

23. 10 pts Vitamin C contains the elements C, H, and O. It is known to contain 40.9% C and 4.58% H by mass. The molar mass of vitamin C has been found to be in the neighborhood of 180. Determine the molecular formula for vitamin C:

	g/mol	moles	/3.41	*3 (to clear the fraction)
C 40.9 g	12.0	3.41	1.00	3
H 4.58 g	1.01	4.53	1.33	4
O 54.5 g	16.0	3.41	1.00	3

$C_3H_4O_3$ = 88 g/mol (empirical molar mass)
so if M.W. is about 180, then there must be two empirical units (180/88 is about 2)

O = 100-H-C = 54.5 g O

$C_6H_8O_6$ is molecular formula and molar mass is 176 g/mol

24. (8 pts) Iron is biologically important in the transport of oxygen by red blood cells from the lungs to the various organs of the body. In the blood of an adult human, if one red blood cell contains approximately 1.20×10^{12} iron atoms, and there are approximately 2.90 grams of iron in the blood, calculate the number of red blood cells in the average adult human. (molar mass (Fe) = 55.85 g)

answer needs units of RBC per human

$\frac{1.20\times10^{12}\text{ Fe atoms}}{\text{RBC}}$ $\frac{2.90\text{ g Fe}}{\text{human}}$ so $\frac{(2.90\text{g Fe})(1\text{ mol Fe})(6.02\times10^{23}\text{ Fe atoms})(1\text{ RBC})}{(\text{human})\ (55.8\text{ g Fe})(1\text{ mol Fe})\ (1.20\times10^{12}\text{ Fe atoms})}$ 1

$= 2.61\times10^{10}$ RBC's per Fe atom

25. Gold has a density 19.3 g/cm^3 Gold forms cubic crystals where the smallest repeating unit is a cube containing 4 gold atoms. One mole of gold has a mass of 197 g. One mole of gold has 6.02 x 10^{23} atoms of gold. Using this information, determine the length of one side of this cubic box in Angstroms (10^{10}Å = 1 m)

$\frac{19.3\text{ g Au}}{\text{cm}^3}\ \frac{1\text{ mol Au atoms}}{197\text{ g}}\ \frac{6.02\text{x}10^{23}\text{ Au atoms}}{1\text{ mol Au atoms}}\ \frac{1\text{ cube}}{4\text{ Au atoms}}$ = cubes per cm3 oops, should have flipped everything over.

$1.47\text{x}10^{22}$ cubes per cm^3 Rather than rewriting everything, I can flip the whole thing over by using the 1/x buttons (or x^{-1} button).

$\frac{6.78\text{x}10^{-23}\text{ cm}^3}{\text{cube}}$ That's the volume per one cube. Take the cubed root and get the length of a side.

$4.08\text{x}10^{-8}\text{ cm}\ \frac{1\text{ m}}{10^2\text{ cm}}\ \frac{10^{10}\text{ Å}}{1\text{ m}} = 4.08\text{ Å}$

26. (4 pts) The interaction between solute particles and water molecules, which tends to cause a salt to fall apart in water, is called

a) hydration.
b) polarization.
c) dispersion.
d) coagulation.
e) conductivity.

27. (5 pts) A white powder is added to deionized water and is found to dissolve. Can you think of a test you could conduct to determine if the white powder is an ionic or covalent material? Please describe how you would do this.

Using an approved device (i.e. don't try this at HOME!!!!), see if a D.C. electrical current flows through it (remember the demo where dissolved salts caused the lightbulb to light up?). If ions form in solution, the they will help complete the circuit causing the bulb to light up. If the material is covalent, it will dissolve to form molecules – not ions, so it will not support an electrical current.

28. (6 pts) What mass of calcium chloride, $CaCl_2$ (111 g/mol), is needed to prepare 150.0 mL of a 1.56 M solution?

$\frac{(1.56\text{ mol})(111\text{ g})}{\text{L soln}}\ \frac{(0.150\text{ L})}{(1\text{ mol})} = 26.0\text{ g CaCl2}$

29. (4 pts) Circle **ALL** of the incorrectly paired answers (more than 1 possible answer)

a) HF – strong acid
b) HNO_3 – weak acid
c) NaOH – strong base
d) HBr – strong acid
e) NH_3 – strong base

30. (4 pts) The scientist who discovered the essential nature of acids through solution conductivity studies:

e) Arrhenius – Swedish

31. (5 pts) Identify the oxidation states of all of the elements in the following compounds.

CeO_2 $(NH_4)_2S$ (CeP is Ce **+3** and P **-3**)

Ce **+4** O **-2** N **-3** H **+1** S **-2**

32-34 calcium nitrate, $Ca(NO_3)_2$ is mixed with ammonium sulfide $(NH_4)_2S$

32. (4 pts) Write the molecular equation (hint, most sulfides are insoluble)

$Ca(NO_3)_2(aq) + (NH_4)_2S(aq) \rightarrow CaS(s) + 2NH_4NO_3(aq)$

33. (2 pts) Write the complete ionic equation

$Ca^{+2}(aq) + 2NO_3^{1-}(aq) + 2NH_4^{+1}(aq) + S^{-2}(aq) \rightarrow CaS(s) + 2NH_4^{+1}(aq) + + 2NO_3^{1-}(aq)$

34. (4 pts) Write the net ionic equation

$Ca^{+2}(aq) + S^{-2}(aq) \rightarrow CaS(s)$

35. (5 pts) Which of the following aqueous solutions contains the greatest number of ions?

a) 200.0 mL of 0.10 M NaCl
b) 200.0 mL of 0.10 M $CaCl_2$
c) 400.0 mL of 0.10 M sucrose

You must show work showing why your answer is correct

0.2L(0.1mol/L)(2 moles ions/1 mol NaCl) = 0.040 moles ions
0.2L(0.1mol/L)(3 moles ions/1 mol NaCl) = 0.060 moles ions
0.4L(0.1mol/L)(0 moles ions/1 mol NaCl) = ZERO moles ions

36. (5 pts) The following reactions are examples of
$Hg(s) + 1/2O_2(g) \rightarrow HgO(s)$
$BaO(s) + H_2SO_3(aq) \rightarrow BaSO_3(aq) + H_2O(l)$
$(NH_4)_2S(aq) + Cu(NO_3)_2(aq) \rightarrow 2NH_4NO_3(aq) + CuS(s)$

a) precipitation reactions.
b) redox, acid-base, and precipitation, respectively.
c) precipitation (two) and acid-base reactions, respectively.
d) redox reactions.
e) none of these

37. (8 pts) Balance the following oxidation-reduction reaction in acid using the half-reaction method:

$Fe^{3+} + SnO \rightarrow Fe^{2+} + SnO_2$

Split into the half reactions. Balance everything except O's and H's. Balance O by adding H2O, Balance H by adding H+, balance charge. Now add together so that the electrons cancel.

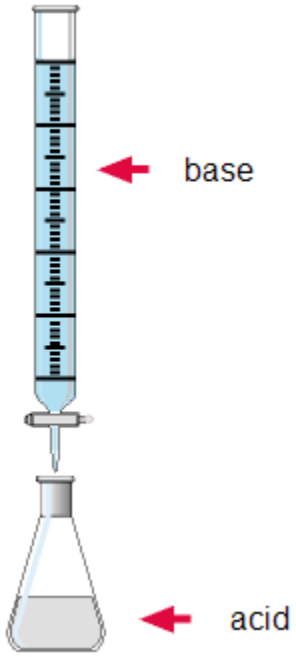
$Fe^{+3} + 1\ e^- \rightarrow Fe^{+2}$ $H_2O + SnO \rightarrow SnO_2 + 2H^+ + 2\ e^-$

$2(Fe^{+3} + 1\ e^- \rightarrow Fe^{+2})$ $H_2O + SnO \rightarrow SnO_2 + 2H^+ + 2\ e^-$

$2Fe^{+3} + SnO + H_2O \rightarrow 2Fe^{+2} + SnO_2 + 2H^+$

38. (6 pts) What mass of NaOH (40.0 g/mol) is required to react exactly with 25.0 mL of 1.0 M H_2SO_4?

$0.025\ L\ H_2SO_4 \left(\frac{1.0\ mol\ H_2SO_4}{L\ soln}\right) \left(\frac{2\ mol\ H^+}{1\ mol\ H_2SO_4}\right) \left(\frac{1\ mol\ OH^-}{1\ mol\ H^+}\right) \left(\frac{40.0\ g\ NaOH}{1\ mol\ NaOH}\right) = 2.0\ g$



39. (5 pts) How many grams of sulfuric acid (H_2SO_4 - 98.0 g/mol) are in 1.0 L of 1.00 M H_2SO_4?

a) 98 g
b) 98.0 g
c) 49 g
d) 49.0 g
e) 2.0×10^2 g.

1.0 L (1.00 mole/L)(98.0 g/mol) = 98 g (2 sig figs)

Chapter Six Questions

R = 8.314 J/K*mol $\Delta E = q + w$ $w = -P\Delta V$ $q = m*Cs*\Delta T$

1. (8 pts) A gas is compressed in a cylinder from 6.0L to 1.0 L at 3.0 atm of pressure while the transferring 22.0 J of heat to the outside.

Determine the following (from the point of view of the system)

q = -22.0 Joules (heat left the system so it is negative)

$w = -p\Delta V = -3.0atm(V2-V1) = -3.0atm(-5.0L) = 15\ L*atm*\left(\frac{101.3\ J}{L*atm}\right) = 1520$ Joules (1500 Joules)

$\Delta E = q + w = -22.0 + 1520 = 1498$ Joules or 1500 Joules (2 sig figs)

2. (6 pts) Consider a wax candle burning. Comment on the signs for q and w for the system

sign why?

q – heat is leaving the system so negative

w – a solid is reacting to form gases – so the volume is increasing, pushing back the atmosphere, hence doing work to the environment (work is leaving the system, so negative).

3. (10 pts) 30.0 g of pure water at 290. K is mixed with 100. g of gold at 330. K. What will the equilibrium temperature be? (C_{Au} = 6.07 cal*mol^{-1}*K^{-1})

first, convert CAu into cal/g/K 6.07 cal/(mol*K)*(1 mol Au/197 g Au) = 0.0308 cal/(mol*K)

the heat flows from the gold to the water until the temperatures equalize. So q(gold) = -q(water)

$q=mS\Delta T = 30.0g\left(\frac{1.00\ cal}{g*K}\right)(T_2-290\ K) = -100.g\left(\frac{0.0308\ cal}{g*K}\right)(T_2-330K)$

$30.0T_2 - 8700 = -3.08T_2 + 1020$ $33.1T_2 = 9720$ $T_2 = 294$ K

4. (6 pts) $R = 8.314\ J*K^{-1}*mol^{-1}$ and $R = 0.08206\ L*atm*K^{-1}*mol^{-1}$

From these versions of the gas constant, determine the conversion factor between L*atm and Joules (use the units to set the problem up !)

$\frac{8.314\ J}{K*mol} = \frac{0.08206\ L*atm}{K*mol}$ 1 L*atm = 101.3 J

5. (6 pts) List any four energy sources used in the U.S. in decreasing order of usage (i.e. the one we rely most on list first, and then the second most, etc). We mentioned at least 7.

#1 Petroleum/Natural Gas

#2 Nuclear

#3 Coal

#4 Hydroelectric (wind, wood, and solar are tiny)

6. (4 pts) Which of the following energy sources accounts for a significant percentage of Illinois' energy?

a) wind power (windmills) b) nuclear power c)solar power

7. (12 pts) The first step to converting natural gas into low sulfur diesel fuel is by the water shift reaction:

$CH_4 + H_2O \rightarrow CO + 3H_2$ (all reactions given are balanced)

Express the enthalpy change for this process using the following reactions:

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ -890 kJ
$H_2 + 1/2O_2 \rightarrow H_2O$ –286 kJ
$CO + 1/2O_2 \rightarrow CO_2$ –283 kJ

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ -890 kJ
$CO_2 \rightarrow CO + 1/2O_2$ +283 kJ
$3H_2O \rightarrow 3H_2 + 3/2O_2$ +858 kJ

$CH_4 + H_2O \rightarrow CO + 3H_2$ + 251 kJ = ΔH_{rxn}

8. (8 pts) Write the chemical equation for the standard enthalpy of combustion of Al

ΔH_{rxn} or $\Delta H_{comb}(Al)$ $2Al(s) + 3/2O_2(g) = Al_2O_3(s)$

Write the chemical equation for the standard enthalpy of formation of Al_2O_3

ΔH_{rxn} or $\Delta H_f(Al)$ $2Al(s) + 3/2O_2(g) = Al_2O_3(s)$

Comment on these enthalpies: $\Delta H_{comb}(Al_2O_3)$ and $\Delta H_f(Al_2O_3)$ THEY ARE THE SAME!