Chem 150 – Exam 3a *Name:* _____
Fall 2011

Chemistry 150 Exam 3

Be sure to put your name on each page. This page can be removed from your exam so that you will have a Periodic Table handy throughout the exam, it does not need to be turned in. Show all your work for non-multiple choice problems which require any sort of calculation, no credit will be given for answers without work shown. If you have shown a significant amount of work or multiple drawings for a problem, draw a box around what you consider your final answer.

Avogadro's Number = 6.022×10^{23} units/mol
$32.00^{o}F = 0.000^{o}C = 273.15K$
1 foot = 12 inches
1 inch = 2.54cm (exactly)
1 pound = 453.6 g = 16 ounces
1 amu = 1.6605×10^{-24} g
Masses of subatomic particles:
Proton 1.00728amu = 1.6726×10^{-24} g
Neutron 1.00866amu = 1.6749×10^{-24} g
Electron 0.000549amu = 9.1094×10^{-28} g
Density of Water = $1.000\ g/mL$
$R = 0.08206\ L \cdot atm/mol \cdot K$
PV=nRT
1 calorie = 4.184 J = 0.001Calorie

$h = 6.626 \times 10^{-34}$ Jsec
$\lambda = h/mv$
$1\ J = 1\ kg\ (m/sec)^2$
$c = \lambda\nu = 3.00 \times 10^{8}\ m/sec$
$E_{photon} = h\nu$

1 **H** 1.0079																	2 **He** 4.0026
3 **Li** 6.941	4 **Be** 9.0122											5 **B** 10.811	6 **C** 12.011	7 **N** 14.007	8 **O** 15.999	9 **F** 18.998	10 **Ne** 20.180
11 **Na** 22.990	12 **Mg** 24.305											13 **Al** 26.982	14 **Si** 28.086	15 **P** 30.974	16 **S** 32.066	17 **Cl** 35.453	18 **Ar** 39.948
19 **K** 39.098	20 **Ca** 40.078	21 **Sc** 44.956	22 **Ti** 47.88	23 **V** 50.942	24 **Cr** 51.996	25 **Mn** 54.938	26 **Fe** 55.847	27 **Co** 58.933	28 **Ni** 58.69	29 **Cu** 63.546	30 **Zn** 65.39	31 **Ga** 69.723	32 **Ge** 72.61	33 **As** 74.922	34 **Se** 78.96	35 **Br** 79.904	36 **Kr** 83.80
37 **Rb** 85.468	38 **Sr** 87.62	39 **Y** 88.906	40 **Zr** 91.224	41 **Nb** 92.906	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.29
55 **Cs** 132.91	56 **Ba** 137.33	71 **Lu** 174.97	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.84	75 **Re** 186.21	76 **Os** 190.23	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** 226.03	103 **Lr** (260)	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (262)	108 **Hs** (265)	109 **Mt** (266)	110 **Ds** (269)	111 **Rg** (272)	112 **Cn** (277)	113	114	115	116	117	118

57 **La** 138.91	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.36	63 **Eu** 151.97	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.94	70 **Yb** 173.04
89 **Ac** 227.03	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** 237.05	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (258)	101 **Md** (258)	102 **No** (259)

Score

Multiple Choice: Circle the letter of the most correct response. (5pts. per question)

1. The First Law of Thermodynamics states that:
   a. Kinetic energy is stored in chemical bonds
   b. Electrostatic energy is another name for electricity
   c. An element in its "standard" state has no energy
   d. Energy cannot be created or destroyed
   e. Potential energy is a measure of the speed of molecular movement

2. The specific heat capacity of any substance is:
   a. The amount of energy required to increase the temperature of one mole of the substance 1°C
   b. The amount of energy required to increase the temperature of one gram of the substance 1°C
   c. 4.184 $^{J}/_{g\bullet^{o}C}$
   d. The amount of energy required to increase the temperature of one pound of the substance 1°C
   e. The amount of energy required to increase the temperature of one gram of the substance 1°F

3. Each of the following describes an ***endothermic*** process *except*:
   a. Chemical bonds are broken
   b. The reactants have a lower energy than the products of a reaction
   c. The system absorbs heat from the surroundings
   d. ΔH is positive
   e. The system liberates heat to the surroundings

Problems:

4. The specific heat capacity of wood is $1.76^{J}/_{g\bullet^{o}C}$. How much energy is needed to heat 450.0g of wood from 7.61ºC to 29.19ºC? (15pts)

Answer 4:

$q = (1.76^{J}/_{g\bullet^{o}C})(450.0g)(29.19\text{-}7.61°C) = 1.71x10^{4}$ J

5. How much energy is released when 800.0g of acetone is frozen at its freezing point (-94ºC)? ($\Delta H^{o}_{fusion} = 5.691\ ^{kJ}/_{mol}$ for acetone) (15pts)

Answer 5:

$E = (5.691\ ^{kJ}/_{mol})(1mol / 58.079g)(800.0g) = 78.39kJ$

Score

6. You have determined that $\Delta H^o_{reaction}$ for the reaction of copper(II) ions with ammonia is -28.16 $^{kJ}/_{mol}$.

$$Cu^{2+}(aq) + 4\ NH_3(aq) \rightarrow [Cu(NH_3)_4]^{+2}(aq)$$

What is $\Delta H^o_{reaction}$ for the following reaction? Explain your answer. (15pts)

$$2\ [Cu(NH_3)_4]^{+2}(aq) \rightarrow 2\ Cu^{2+}(aq) + 8\ NH_3(aq)$$

Reverse and double → +56.32 $^{kJ}/_{mol}$

7. One potential source of hydrogen gas for use as a fuel is water by the following reaction:

$$2\ H_2O(l) \rightarrow 2\ H_2(g) + O_2(g)$$

What is $\Delta H^o_{reaction}$ for this process? {ΔH_f^o = -285.83 $^{kJ}/_{mol}$ for $H_2O(l)$} How many kJ of energy must be transferred to produce 15.00g of $H_2(g)$? Is the energy transferred *in* or *out* of the system? Explain. (20pts)

ΔH_{rxn} = +571.66 $^{kJ}/_{mol}$

(15.00g $H_2(g)$)(1mol H_2 / 2.016g H_2) (1mol rxn / 2 mol H_2) (571.66 $^{kJ}/_{mol}$) = 2126.7kJ in

8. You have been studying a series of reactions:

$$A \rightarrow B \rightarrow C \rightarrow D$$

So far, you have determined the following ΔH^o_{rxn} values:

A → B +13.38 $^{kJ}/_{mol}$
C → B +19.61 $^{kJ}/_{mol}$
D → A -8.13 $^{kJ}/_{mol}$

What is ΔH^o_{rxn} for the the third step, C → D? Is C → D endothermic or exothermic? Draw a qualitatively correct reaction coordinate diagram for the entire stepwise process, A → B → C → D. (20pts)

(+8.13 $^{kJ}/_{mol}$) = (+13.38 $^{kJ}/_{mol}$) + (-19.61 $^{kJ}/_{mol}$) + ($\Delta H°${C → D})
$\Delta H°${C → D} = +14.36 $^{kJ}/_{mol}$

Score

9. You have burned 25.00g of ethane gas {$C_2H_6(g)$} in excess oxygen to produce carbon dioxide and water. If all of the energy from this reaction is transferred to a 39.67kg block of copper initially at 6.38°C, what is the final temperature of the copper block? (The specific heat capacity of Cu(s) is $0.385^{J}/_{g\bullet°C}$) (25pts)

Material	**ΔH_f^o ($^{kJ}/_{mol}$)**
$C_2H_6(g)$	-84.68
$CO_2(g)$	-393.509
$H_2O(g)$	-241.818

$2\ C_2H_6(g) + 7\ O_2(g) \rightarrow 4\ CO_2(g) + 6\ H_2O(g)$
$2(84.68) + 4(-393.509) + 6(-241.818) = -2855.58\ ^{kJ}/_{mol}$
$(25.00g)(1mol\ ethane / 30.069g)\ (1mol\ rxn / 2mol\ ethane)\ (2855.58\ ^{kJ}/_{mol}) = 1187kJ$

$1187kJ = (0.000385)(39670g)(\Delta T)$
$\Delta T = 77.72°C$
$T_{final} = 6.38+77.72 = 84.10°C$

10. You have reacted 5.382L of oxygen at 37.32°C and 0.912atm with 250.0mL of 0.773M sodium thiocyanate solution by the following reaction:

$$a\ NaSCN(aq) + b\ O_2(g) \rightarrow c\ NaCN(aq) + d\ SO_3(g)$$

How much heat is transferred by this reaction? Is the reaction endothermic or exothermic? (25pts)

Material	**ΔH_f^o ($^{kJ}/_{mol}$)**
$Na^{+1}(aq)$	-240.12
$SCN^{-1}(aq)$	-22.92
$CN^{-1}(aq)$	-183.62
$SO_3(g)$	-395.72

$2\ NaSCN(aq) + 3\ O_2(g) \rightarrow 2\ NaCN(aq) + 2\ SO_3(g)$
$2\ Na^+(aq) + 2\ SCN^{-1}(aq) + 3\ O_2(g) \rightarrow 2\ Na^+(aq) + 2\ CN^{-1}(aq) + 2\ SO_3(g)$
$2(+22.92) + 2(-183.62) + 2(-395.72) = -1112.84\ ^{kJ}/_{mol}$
Exothermic

$\{(5.382L)(0.912atm) / (0.08206)(310.47K)\}\ (1mol\ rxn / 3mol\ O_2)\ (1112.84\ ^{kJ}/_{mol}) = 71.5kJ$ heat released
$\{(0.2500L)(0.773mols\ SCN^{-1} / L)\}\ (1mol\ rxn / 2mol\ SCN^{-1})\ (1112.84\ ^{kJ}/_{mol}) = 108\ kJ$ heat released

Oxygen is limiting, 71.5kJ heat released

Score