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 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 = $6.022\text{x}10^{23}\ ^{\text{units}}/_{\text{mol}}$
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 = $1.6605\text{x}10^{-24}$ g
Masses of subatomic particles:
- Proton 1.00728amu = $1.6726\text{x}10^{-24}$ g
- Neutron 1.00866amu = $1.6749\text{x}10^{-24}$ g
- Electron 0.000549amu = $9.1094\text{x}10^{-28}$ g

Density of Water = $1.000^{g}/_{mL}$
R = $0.08206\ ^{L\bullet atm}/_{mol\bullet K}$
PV=nRT
1 calorie = 4.184 J = 0.001Calorie
h = $6.626\text{x}10^{-34}$ Jsec
$\lambda = {}^{h}/_{mv}$
1 J = 1 kg $(^{m}/_{sec})^2$

$c = \lambda\nu = 3.00\text{x}10^{8}\ ^{m}/_{sec}$
$E_{photon} = h\nu$

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	57 **La** 138.91	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	89 **Ac** 227.03	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (262)	108 **Hs** (265)	109 **Mt** (266)	110 (269)	111 (272)	112 (277)		114		116		

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	71 **Lu** 174.97
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)	103 **Lr** (260)

Score

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

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

2. The specific heat capacity of a substance is:
   a. The amount of energy required to increase the temperature of one pound of the substance one degree Celsius
   b. The amount of energy required to increase the temperature of one gram of the substance one degree Fahrenheit
   c. 4.184 $^{J}/_{g\cdot °C}$
   d. The amount of energy required to increase the temperature of one mole of the substance one degree Celsius
   e. **The amount of energy required to increase the temperature of one gram of the substance one degree Celsius**

3. Each of the following describes an ***exothermic*** process *except*:
   a. Chemical bonds are formed
   b. ΔH is negative
   c. **The system absorbs heat from the surroundings**
   d. The reactants have a higher energy than the products of a reaction
   e. The system releases heat to the surroundings

4. Which of the following is ***not*** a possible set of quantum numbers?
   a. $n = 3$, $\ell = 2$, $m_\ell = 2$
   b. $n = 3$, $\ell = 0$, $m_\ell = 0$
   c. **$n = 2$, $\ell = 2$, $m_\ell = -1$**
   d. $n = 2$, $\ell = 1$, $m_\ell = -1$
   e. $n = 1$, $\ell = 0$, $m_\ell = 0$

5. Write out the correct electron configuration for a phosphorus atom (6pts)

$1s^2 2s^2 2p^6 3s^2 3p^3$

Score

Multiple Choice Calculations: (10pts each)

6. Chromium(III) oxide (Cr_2O_3) can be converted to aluminum metal by the following reaction:

$$2\ Cr_2O_3(s) \rightarrow 4\ Cr(s) + 3\ O_2(g)$$

What is $\Delta H^o_{reaction}$ for this process? ($\Delta H_f^o = -1139.7\ ^{kJ}/_{mol}$ for Cr_2O_3.)

a. 2279.4 $^{kJ}/_{mol}$
b. 1139.7 $^{kJ}/_{mol}$
c. -569.85 $^{kJ}/_{mol}$
d. -1139.4 $^{kJ}/_{mol}$
e. -2279.4 $^{kJ}/_{mol}$

7. The specific heat capacity of liquid water is $4.184^{J}/_{g\cdot{}^oC}$. How much energy is required to heat 108.92g of liquid water from 34.68ºC to 51.37ºC?

a. $2.3016\text{x}10^{-3}$ J
b. 434.48 J
c. 7606.0 J
d. 15.804 kJ
e. 23.410 kJ

8. A red laser pointer emits light with a wavelength of 635nm. What is the energy of a single photon of light from a red laser pointer?

a. $4.21\text{x}10^{-40}$ J
b. $3.13\text{x}10^{-28}$ J
c. $1.99\text{x}10^{-25}$ J
d. $3.13\text{x}10^{-19}$ J
e. $4.7244\text{x}10^{5}$ J

9. Palmitic acid ($C_{16}H_{32}O_2$) is a saturated fatty acid found in palm oil that melts at 60.48ºC. How much energy is required to melt 41.825g of stearic acid at 60.48ºC? ($\Delta H^o_{fusion} = 163.93\ ^{J}/_{g}$ for palmitic acid)

a. 0 J
b. 3.9194 J
c. 26.738 J
d. 6856.4 J
e. $4.1467\text{x}10^{5}$ J

10. You have determined that $\Delta H^o_{reaction}$ for the following reaction is $-311.2^{kJ}/_{mol}$.

$$3\ Ca(OH)_2(s) + 2\ H_3PO_4(s) \rightarrow Ca_3(PO_4)_2(s) + 6\ H_2O(l)$$

What is $\Delta H^o_{reaction}$ for the reaction:

$$2\ Ca_3(PO_4)_2(s) + 12\ H_2O(l) \rightarrow 6\ Ca(OH)_2(s) + 4\ H_3PO_4(s)$$

a. -622.4 $^{kJ}/_{mol}$
b. -311.2 $^{kJ}/_{mol}$
c. 155.6 $^{kJ}/_{mol}$
d. 311.2 $^{kJ}/_{mol}$
e. 622.4 $^{kJ}/_{mol}$

Score

Problems:

11. Pentane burns according to the following equation:

$$C_5H_{12}(g) + 8\,O_2(g) \rightarrow 5\,CO_2(g) + 6\,H_2O(g)$$

You perform an experiment in which you burn 18.246g of pentane and determine that the reaction generated 827.5kJ of heat. Based upon this experiment, what is the value of ΔH_f^o for pentane? (20pts)

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

Starting with the generic equation we'll use to calculate ΔH^o_{rxn}:

$$\Delta H^o_{rxn} = 1\{-\Delta H^o_f(C_5H_{12}(g))\} + 8\{-\Delta H^o_f(O_2(g))\} + 5\{\Delta H^o_f(CO_2(g))\} + 6\{\Delta H^o_f(H_2O(g))\}$$

The problem gives us information to calculate the heat of the reaction, ΔH^o_{rxn} :

$$\Delta H^o_{rxn} = \frac{-827.5\text{kJ}}{(18.246\text{g } C_5H_{12})\left(\frac{1\text{mol } C_5H_{12}}{72.150\text{g } C_5H_{12}}\right)\left(\frac{1\text{mol rxn}}{1\text{mol } C_5H_{12}}\right)} = -3272\,\frac{\text{kJ}}{\text{mol rxn}}$$

{NOTE: The negative sign is included because the problem states that the reaction generates heat, therefore it is exothermic.}

Using the ΔH^o_f numbers provided in the problem, we can plug in to the ΔH^o_{rxn} expression:

$$-3272\,^{kJ}/_{mol\ rxn} = 1\{-\Delta H^o_f(C_5H_{12}(g))\} + 8\{0\,^{kJ}/_{mol}\} + 5\{-393.509\,^{kJ}/_{mol}\} + 6\{-241.818\,^{kJ}/_{mol}\}$$

Solving for the unknown:

$$\Delta H^o_f(C_5H_{12}(g)) = -146\,^{kJ}/_{mol}$$

12. Which has the shorter deBroglie wavelength, the fastest recorded tennis serve, or the fastest recorded badminton smash? The mass of a standard tennis ball is 57g and the fastest serve was measured at 73.14 $^{m}/_{sec}$ in 1931 by "Big Bill" Tilden. A badminton shuttlecock has a mass of 4.9g and the fastest smash was measured at 92.22 $^{m}/_{sec}$ in 2005 by Fu Haifeng. Show your work. {Note: those speeds are 163 and 206mph. Yikes!} (16pts)

This problem involves plugging values into the deBroglie relationship:

$$\lambda = \frac{h}{mv}$$

For the tennis serve:

$$\lambda = \frac{6.626\text{x}10^{-34}\,\frac{\text{kg}\bullet\text{m}^2}{\text{sec}}}{(0.057\text{kg})(73.14\,\frac{\text{m}}{\text{sec}})} = 1.6\text{x}10^{-34}\text{ m}$$

For the badminton smash:

$$\lambda = \frac{6.626\text{x}10^{-34}\,\frac{\text{kg}\bullet\text{m}^2}{\text{sec}}}{(0.0049\text{kg})(92.22\,\frac{\text{m}}{\text{sec}})} = 1.5\text{x}10^{-33}\text{ m}$$

The tennis serve has the shorter deBroglie wavelength. If you think about these wavelengths, they are both incredibly small, so there is no macroscopically observable wave character to the flight of a tennis ball or a shuttlecock.

Score

13. The specific heat capacity of gold is 0.128 $^{J}/_{g\bullet^\circ C}$ and the specific heat capacity of iron is 0.449 $^{J}/_{g\bullet^\circ C}$. You have heated a 51.294g block of iron to 49.318ºC and placed it on a gold block at 21.516ºC. When the system reaches thermal equilibrium, the temperature of the gold and iron blocks are 34.468ºC. If the system is perfectly insulated, what was the mass of the gold block in grams? (20pts each)

The assumption that the system is perfectly insulated implies that all of the energy lost by the iron block is transferred to the gold block. Finding the energy lost by the iron block:

$E_{iron} = (0.449\ ^{J}/_{g\bullet^\circ C})(51.294g\ Fe)(14.850^\circ C)$

And the energy gained by the gold block:

$E_{gold} = (0.128\ ^{J}/_{g\bullet^\circ C})(x\ g\ Au)(12.952^\circ C)$

Setting these energies equal:

$(0.449\ ^{J}/_{g\bullet^\circ C})(51.294g\ Fe)(14.850^\circ C) = (0.128\ ^{J}/_{g\bullet^\circ C})(x\ g\ Au)(12.952^\circ C)$

$x = 206g\ Au$

14. You have been studying a series of reactions:

A → B → C → D

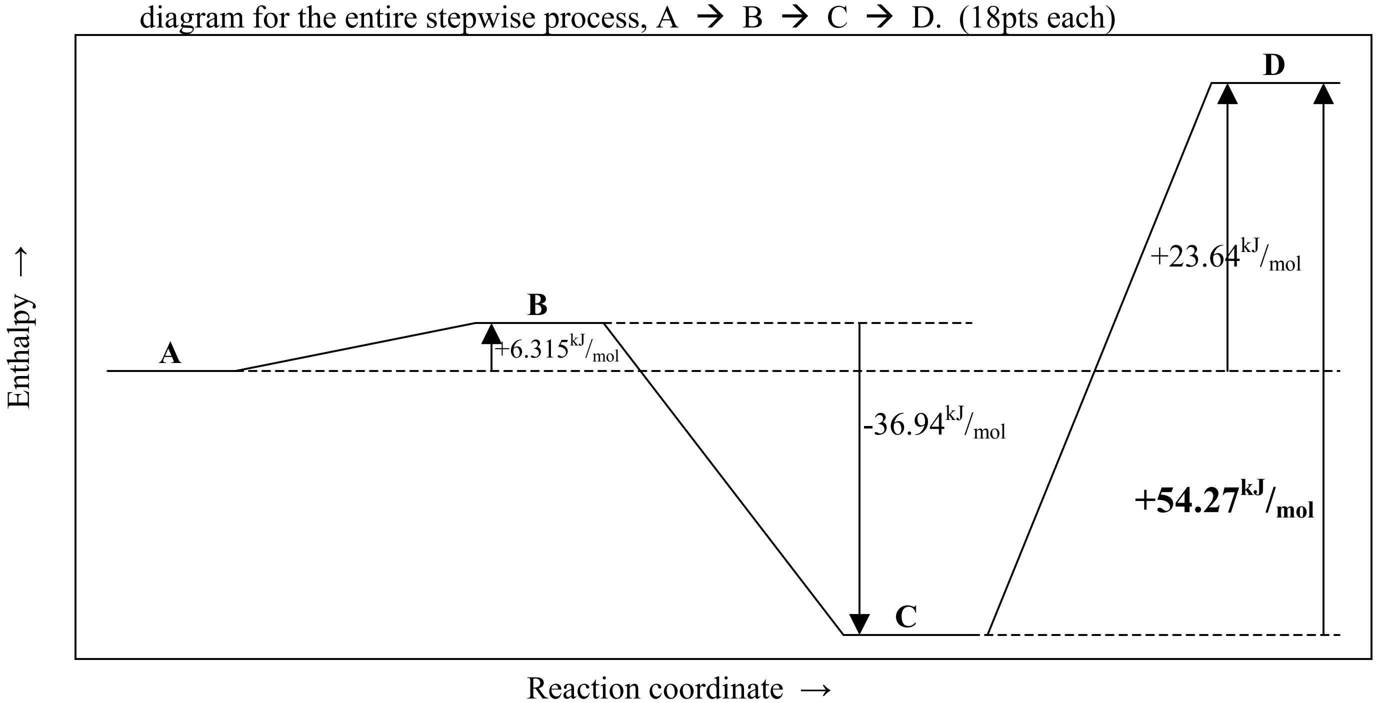
So far, you have determined the following ΔH°_{rxn} values:

A → B +6.315 $^{kJ}/_{mol}$

B → C -36.94 $^{kJ}/_{mol}$

And ΔH°_{rxn} for the whole process (A → D) is +23.64 $^{kJ}/_{mol}$.

What is ΔH°_{rxn} for the reaction C → D? Draw a qualitatively correct reaction coordinate diagram for the entire stepwise process, A → B → C → D. (18pts each)



Score