

# 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 =  $6.022 \times 10^{23}$  units/mol

$c = \lambda\nu = 3.00 \times 10^8$  m/sec

$32.00^\circ\text{F} = 0.000^\circ\text{C} = 273.15\text{K}$

$E_{\text{photon}} = h\nu$

1 foot = 12 inches

1 inch = 2.54cm (exactly)

1 pound = 453.6 g = 16 ounces

1 amu =  $1.6605 \times 10^{-24}$  g

Masses of subatomic particles:

Proton  $1.00728\text{amu} = 1.6726 \times 10^{-24}$  g

Neutron  $1.00866\text{amu} = 1.6749 \times 10^{-24}$  g

Electron  $0.000549\text{amu} = 9.1094 \times 10^{-28}$  g

Density of Water =  $1.000^{\text{g}}/\text{mL}$

$R = 0.08206$  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)<sup>2</sup>

1 <b>H</b> 1.0079																2 <b>He</b> 4.0026	
3 <b>Li</b> 6.941	4 <b>Be</b> 9.0122											5 <b>B</b> 10.811	6 <b>C</b> 12.011	7 <b>N</b> 14.007	8 <b>O</b> 15.999	9 <b>F</b> 18.998	10 <b>Ne</b> 20.180
11 <b>Na</b> 22.990	12 <b>Mg</b> 24.305											13 <b>Al</b> 26.982	14 <b>Si</b> 28.086	15 <b>P</b> 30.974	16 <b>S</b> 32.066	17 <b>Cl</b> 35.453	18 <b>Ar</b> 39.948
19 <b>K</b> 39.098	20 <b>Ca</b> 40.078	21 <b>Sc</b> 44.956	22 <b>Ti</b> 47.88	23 <b>V</b> 50.942	24 <b>Cr</b> 51.996	25 <b>Mn</b> 54.938	26 <b>Fe</b> 55.847	27 <b>Co</b> 58.933	28 <b>Ni</b> 58.69	29 <b>Cu</b> 63.546	30 <b>Zn</b> 65.39	31 <b>Ga</b> 69.723	32 <b>Ge</b> 72.61	33 <b>As</b> 74.922	34 <b>Se</b> 78.96	35 <b>Br</b> 79.904	36 <b>Kr</b> 83.80
37 <b>Rb</b> 85.468	38 <b>Sr</b> 87.62	39 <b>Y</b> 88.906	40 <b>Zr</b> 91.224	41 <b>Nb</b> 92.906	42 <b>Mo</b> 95.94	43 <b>Tc</b> (98)	44 <b>Ru</b> 101.07	45 <b>Rh</b> 102.91	46 <b>Pd</b> 106.42	47 <b>Ag</b> 107.87	48 <b>Cd</b> 112.41	49 <b>In</b> 114.82	50 <b>Sn</b> 118.71	51 <b>Sb</b> 121.76	52 <b>Te</b> 127.60	53 <b>I</b> 126.90	54 <b>Xe</b> 131.29
55 <b>Cs</b> 132.91	56 <b>Ba</b> 137.33	57 <b>La</b> 138.91	72 <b>Hf</b> 178.49	73 <b>Ta</b> 180.95	74 <b>W</b> 183.84	75 <b>Re</b> 186.21	76 <b>Os</b> 190.23	77 <b>Ir</b> 192.22	78 <b>Pt</b> 195.08	79 <b>Au</b> 196.97	80 <b>Hg</b> 200.59	81 <b>Tl</b> 204.38	82 <b>Pb</b> 207.2	83 <b>Bi</b> 208.98	84 <b>Po</b> (209)	85 <b>At</b> (210)	86 <b>Rn</b> (222)
87 <b>Fr</b> (223)	88 <b>Ra</b> 226.03	89 <b>Ac</b> 227.03	104 <b>Rf</b> (261)	105 <b>Db</b> (262)	106 <b>Sg</b> (263)	107 <b>Bh</b> (262)	108 <b>Hs</b> (265)	109 <b>Mt</b> (266)	110 <b>(269)</b>	111 <b>(272)</b>	112 <b>(277)</b>		114		116		

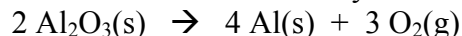
58 <b>Ce</b> 140.12	59 <b>Pr</b> 140.91	60 <b>Nd</b> 144.24	61 <b>Pm</b> (145)	62 <b>Sm</b> 150.36	63 <b>Eu</b> 151.97	64 <b>Gd</b> 157.25	65 <b>Tb</b> 158.93	66 <b>Dy</b> 162.50	67 <b>Ho</b> 164.93	68 <b>Er</b> 167.26	69 <b>Tm</b> 168.94	70 <b>Yb</b> 173.04	71 <b>Lu</b> 174.97
90 <b>Th</b> 232.04	91 <b>Pa</b> 231.04	92 <b>U</b> 238.03	93 <b>Np</b> 237.05	94 <b>Pu</b> (244)	95 <b>Am</b> (243)	96 <b>Cm</b> (247)	97 <b>Bk</b> (247)	98 <b>Cf</b> (251)	99 <b>Es</b> (252)	100 <b>Fm</b> (258)	101 <b>Md</b> (258)	102 <b>No</b> (259)	103 <b>Lr</b> (260)

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

- The First Law of Thermodynamics states that:
  - Electrostatic energy is another name for electricity
  - An element in its “normal” state has no energy
  - Energy cannot be created or destroyed
  - Potential energy is a measure of the speed of molecular movement
  - Kinetic energy is stored in chemical bonds
  
- The specific heat capacity of a substance is:
  - The amount of energy required to increase the temperature of one mole of the substance one degree Celsius
  - The amount of energy required to increase the temperature of one gram of the substance one degree Celsius
  - $4.184 \text{ J/g}\cdot^\circ\text{C}$
  - The amount of energy required to increase the temperature of one pound of the substance one degree Celsius
  - The amount of energy required to increase the temperature of one gram of the substance one degree Fahrenheit
  
- Each of the following describes an *exothermic* process *except*:
  - Chemical bonds are formed
  - The reactants have a higher energy than the products of a reaction
  - The system releases heat to the surroundings
  - $\Delta H$  is negative
  - The system absorbs heat from the surroundings
  
- Which of the following is *not* a possible set of quantum numbers?
  - $n = 1, \ell = 0, m_\ell = 0$
  - $n = 2, \ell = 1, m_\ell = -1$
  - $n = 2, \ell = 2, m_\ell = -1$
  - $n = 3, \ell = 0, m_\ell = 0$
  - $n = 3, \ell = 2, m_\ell = 2$
  
- Write out the correct electron configuration for a sulfur atom (6pts)

**Multiple Choice Calculations:** (10pts each)

6. Alumina ( $\text{Al}_2\text{O}_3$ ) can be converted to aluminum metal by the following reaction:

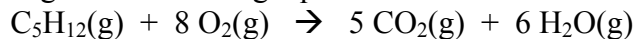


What is  $\Delta H^\circ_{\text{reaction}}$  for this process? ( $\Delta H^\circ_f = -1675.7 \text{ kJ/mol}$  for  $\text{Al}_2\text{O}_3$ .)

- a.  $-3351.4 \text{ kJ/mol}$   
b.  $-1675.7 \text{ kJ/mol}$   
c.  $-837.85 \text{ kJ/mol}$   
d.  $1675.7 \text{ kJ/mol}$   
e.  $3351.4 \text{ kJ/mol}$
7. The specific heat capacity of liquid water is  $4.184 \text{ J/g}\cdot^\circ\text{C}$ . How much energy is required to heat 126.49g of liquid water from  $10.34^\circ\text{C}$  to  $61.92^\circ\text{C}$ ?  
a. 32.77 kJ  
b. 27.30 kJ  
c. 5.472 kJ  
d. 1559 J  
e.  $6.413 \times 10^{-4} \text{ J}$
8. A green laser pointer emits light with a wavelength of 512nm. What is the energy of a single photon of light from a green laser pointer?  
a.  $5.86 \times 10^5 \text{ J}$   
b.  $3.88 \times 10^{-19} \text{ J}$   
c.  $1.99 \times 10^{-25} \text{ J}$   
d.  $3.88 \times 10^{-28} \text{ J}$   
e.  $3.39 \times 10^{-40} \text{ J}$
9. Palmitic acid ( $\text{C}_{16}\text{H}_{32}\text{O}_2$ ) is a saturated fatty acid found in palm oil that melts at  $60.48^\circ\text{C}$ . How much energy is required to melt 50.612g of stearic acid at  $60.48^\circ\text{C}$ ? ( $\Delta H^\circ_{\text{fusion}} = 163.93 \text{ J/g}$  for palmitic acid)  
a.  $5.0179 \times 10^5 \text{ J}$   
b. 8296.8 J  
c. 3.2390 J  
d. 0.30874 J  
e. 0 J
10. You have determined that  $\Delta H^\circ_{\text{reaction}}$  for the following reaction is  $-311.2 \text{ kJ/mol}$ .  
$$3 \text{Ca}(\text{OH})_2(\text{s}) + 2 \text{H}_3\text{PO}_4(\text{s}) \rightarrow \text{Ca}_3(\text{PO}_4)_2(\text{s}) + 6 \text{H}_2\text{O}(\text{l})$$
  
What is  $\Delta H^\circ_{\text{reaction}}$  for the reaction:  
$$2 \text{Ca}_3(\text{PO}_4)_2(\text{s}) + 12 \text{H}_2\text{O}(\text{l}) \rightarrow 6 \text{Ca}(\text{OH})_2(\text{s}) + 4 \text{H}_3\text{PO}_4(\text{s})$$
  
a.  $622.4 \text{ kJ/mol}$   
b.  $311.2 \text{ kJ/mol}$   
c.  $155.6 \text{ kJ/mol}$   
d.  $-311.2 \text{ kJ/mol}$   
e.  $-622.4 \text{ kJ/mol}$

**Problems:**

11. Pentane burns according to the following equation:



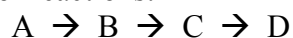
You perform an experiment in which you burn 12.913g of pentane and determine that the reaction generated 585.6kJ of heat. Based upon this experiment, what is the value of  $\Delta H_f^\circ$  for pentane? (20pts)

Material	$\Delta H_f^\circ$ (kJ/mol)
CO <sub>2</sub> (g)	-393.509
H <sub>2</sub> O(g)	-241.818

12. Which has the longer 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)

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

14. You have been studying a series of reactions:



So far, you have determined the following  $\Delta H^\circ_{\text{rxn}}$  values:



And  $\Delta H^\circ_{\text{rxn}}$  for the whole process ( $\text{A} \rightarrow \text{D}$ ) is  $+23.64 \text{ kJ/mol}$ .

What is  $\Delta H^\circ_{\text{rxn}}$  for the reaction  $\text{C} \rightarrow \text{D}$ ? Draw a qualitatively correct reaction coordinate diagram for the entire stepwise process,  $\text{A} \rightarrow \text{B} \rightarrow \text{C} \rightarrow \text{D}$ . (18pts each)