

# 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

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

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 =  $1.000^{\text{g}}/\text{mL}$

$R = 0.08206 \text{ L}\cdot\text{atm}/\text{mol}\cdot\text{K}$

$PV = nRT$

1 calorie = 4.184 J = 0.001Calorie

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. (6pts. per question)

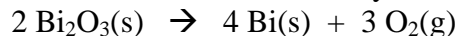
- The First Law of Thermodynamics states that:
  - Kinetic energy is stored in chemical bonds
  - Electrostatic energy is another name for electricity
  - An element in its “normal” state has no energy
  - Energy cannot be created or destroyed
  - Potential energy is a measure of the speed of molecular movement
- 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
  - $4.184 \text{ J/g}\cdot\text{C}$
  - 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 absorbs heat from the surroundings
  - $\Delta H$  is negative
  - The system liberates heat to the surroundings
- Which of the following processes/quantities is *not* a state function?
  - Change in longitude
  - Change in latitude
  - The number of stairs you must step on to get from the front of SL104 to the lab
  - The difference in altitude between the front of SL104 and the lab
  - $\Delta H$  for a reaction

5. Is each of the following processes endothermic or exothermic? (4pts each)

Splitting water to form $\text{H}_2(\text{g})$ and $\text{O}_2(\text{g})$	<i>Endothermic</i>	<i>Exothermic</i>
Burning methane in air	<i>Endothermic</i>	<i>Exothermic</i>
Freezing diesel fuel	<i>Endothermic</i>	<i>Exothermic</i>
Boiling water	<i>Endothermic</i>	<i>Exothermic</i>

**Multiple Choice Calculations:** (12pts each)

6. Bismuth(III) oxide ( $\text{Bi}_2\text{O}_3$ ) can be converted to bismuth by the following reaction:

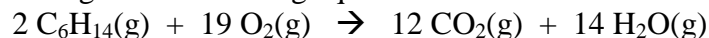


What is  $\Delta H^\circ_{\text{reaction}}$  for this process? ( $\Delta H_f^\circ = -573.9 \text{ kJ/mol}$  for  $\text{Bi}_2\text{O}_3$ .)

- a.  $-1147.8 \text{ kJ/mol}$   
b.  $-573.9 \text{ kJ/mol}$   
c.  $-287.0 \text{ kJ/mol}$   
d.  $+287.0 \text{ kJ/mol}$   
e.  $+573.9 \text{ kJ/mol}$   
f.  $+1147.8 \text{ kJ/mol}$
7. The specific heat capacity of liquid water is  $4.184 \text{ J/g}^\circ\text{C}$ . How much energy is released by cooling  $150.0 \text{ g}$  of liquid water from  $26.813^\circ\text{C}$  to  $12.193^\circ\text{C}$ ?  
a.  $1.91 \times 10^{-3} \text{ J}$   
b.  $4.184 \text{ J}$   
c.  $7.652 \times 10^3 \text{ J}$   
d.  $9.176 \times 10^3 \text{ J}$   
e.  $1.683 \times 10^4 \text{ J}$
8. Propane ( $\text{C}_3\text{H}_8$ ) is often stored and transported in its liquid form. How much energy is required to boil  $428.37 \text{ g}$  of propane at its boiling point ( $-42^\circ\text{C}$ )? ( $\Delta H^\circ_{\text{vaporization}} = 15.7 \text{ kJ/mol}$  for propane)  
a.  $0.0367 \text{ kJ}$   
b.  $1.62 \text{ kJ}$   
c.  $153 \text{ kJ}$   
d.  $659 \text{ kJ}$   
e.  $6725 \text{ kJ}$
9. You have determined that  $\Delta H^\circ_{\text{reaction}}$  for the following reaction is  $+98.26 \text{ kJ/mol}$ .
- $$2 \text{A}(\text{g}) + 8 \text{B}(\text{g}) \rightarrow 4 \text{C}(\text{g}) + 6 \text{D}(\text{g})$$
- What is  $\Delta H^\circ_{\text{reaction}}$  for the reaction:
- $$2 \text{C}(\text{g}) + 3 \text{D}(\text{g}) \rightarrow \text{A}(\text{g}) + 4 \text{B}(\text{g})$$
- a.  $-196.52 \text{ kJ/mol}$   
b.  $-98.26 \text{ kJ/mol}$   
c.  $-49.13 \text{ kJ/mol}$   
d.  $+49.13 \text{ kJ/mol}$   
e.  $+98.26 \text{ kJ/mol}$   
f.  $+196.52 \text{ kJ/mol}$

**Problems:** (22pts each)

10. Hexane burns according to the following equation:

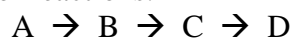


You perform an experiment in which you burn 8.762g of hexane and determine that the reaction generated 397.61kJ of heat. Based upon this experiment, what is the value of  $\Delta H_f^\circ$  for hexane?

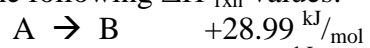
Material	$\Delta H_f^\circ$ (kJ/mol)
CO <sub>2</sub> (g)	-393.509
H <sub>2</sub> O(g)	-241.818

11. The specific heat capacity of graphite is  $0.715 \text{ J/g}\cdot^\circ\text{C}$  and the specific heat capacity of ethylene glycol (a component of antifreeze) is  $2.38 \text{ J/g}\cdot^\circ\text{C}$ . You have cooled a 38.64g block of graphite to  $1.394^\circ\text{C}$  and dropped it into a beaker of ethylene glycol at  $21.516^\circ\text{C}$ . When the system reaches thermal equilibrium, the temperature of the graphite and ethylene glycol is  $19.827^\circ\text{C}$ . If the system is perfectly insulated, how many grams of ethylene glycol were in the beaker?

12. 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 ( $A \rightarrow D$ ) is  $-6.96 \text{ kJ/mol}$ .

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