

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 = 6.022×10^{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 = 1.6605×10^{-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

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)

Multiple Choice: Circle the letter of the most correct response. (6pts. per question)

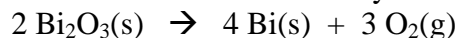
- The First Law of Thermodynamics states that:
 - Kinetic energy is stored in chemical bonds
 - Energy cannot be created or destroyed
 - Potential energy is a measure of the speed of molecular movement
 - Electrostatic energy is another name for electricity
 - An element in its “normal” state has no energy
- 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 pound 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 gram 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
 - ΔH is negative
 - The system liberates heat to the surroundings
 - The reactants have a higher energy than the products of a reaction
 - The system absorbs heat from 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
 - ΔH for a reaction

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

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

Multiple Choice Calculations: (12pts each)

6. Bismuth(III) oxide (Bi_2O_3) can be converted to bismuth by the following reaction:

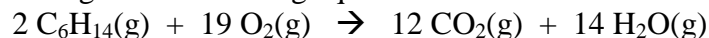


What is $\Delta H^\circ_{\text{reaction}}$ for this process? ($\Delta H^\circ_{\text{f}} = -573.9 \text{ kJ/mol}$ for Bi_2O_3 .)

- a. $+1147.8 \text{ kJ/mol}$
b. $+573.9 \text{ kJ/mol}$
c. $+287.0 \text{ kJ/mol}$
d. -287.0 kJ/mol
e. -573.9 kJ/mol
f. -1147.8 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 150.0g of liquid water from 26.813°C to 12.193°C ?
- a. $1.683 \times 10^4 \text{ J}$
b. $9.176 \times 10^3 \text{ J}$
c. $7.652 \times 10^3 \text{ J}$
d. 4.184 J
e. $1.91 \times 10^{-3} \text{ J}$
8. Propane (C_3H_8) is often stored and transported in its liquid form. How much energy is required to boil 428.37g of propane at its boiling point (-42°C)? ($\Delta H^\circ_{\text{vaporization}} = 15.7 \text{ kJ/mol}$ for propane)
- a. 6725 kJ
b. 659 kJ
c. 153 kJ
d. 1.62 kJ
e. 0.0367 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 kJ/mol
e. -98.26 kJ/mol
f. -196.52 kJ/mol

Problems: (22pts each)

10. Hexane burns according to the following equation:

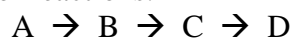


You perform an experiment in which you burn 9.842g of hexane and determine that the reaction generated 442.83kJ of heat. Based upon this experiment, what is the value of ΔH_f° for hexane?

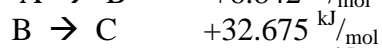
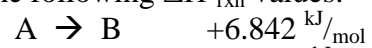
Material	ΔH_f° (kJ/mol)
CO ₂ (g)	-393.509
H ₂ O(g)	-241.818

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°C and dropped it into a beaker of ethylene glycol at 21.516°C . When the system reaches thermal equilibrium, the temperature of the graphite and ethylene glycol is 18.619°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 -11.923 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, $A \rightarrow B \rightarrow C \rightarrow D$.