

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 = $1.000 \frac{\text{g}}{\text{mL}}$

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

$PV = nRT$

1 calorie = 4.184 J = 0.001 Calorie

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
 - Electrostatic energy is another name for electricity
 - An element in its “standard” 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 1°C
 - The amount of energy required to increase the temperature of one gram of the substance 1°C
 - 4.184 J/g°C
 - The amount of energy required to increase the temperature of one pound of the substance 1°C
 - The amount of energy required to increase the temperature of one gram of the substance 1°F
- Each of the following describes an *endothermic* process *except*:
 - Chemical bonds are broken
 - The reactants have a lower energy than the products of a reaction
 - The system absorbs heat from the surroundings
 - ΔH is positive
 - The system liberates heat to the surroundings
- Is each of the following processes endothermic or exothermic? (3pts each)

Splitting water to form H ₂ (g) and O ₂ (g)	<i>Endothermic</i>	<i>Exothermic</i>
Burning butane in air	<i>Endothermic</i>	<i>Exothermic</i>
Boiling liquid methanol	<i>Endothermic</i>	<i>Exothermic</i>
Freezing water	<i>Endothermic</i>	<i>Exothermic</i>

Problems:

5. Beryllium oxide (BeO) can be converted to strontium metal by the following reaction:



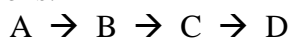
What is $\Delta H^\circ_{\text{reaction}}$ for this process? ($\Delta H^\circ_f = -609.4 \text{ kJ/mol}$ for BeO.) How many kJ of energy must be transferred to produce 15.00g of Be(s)? Is the energy transferred *in* or *out* of the system? Explain. (20pts)

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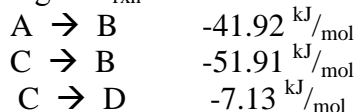
6. The specific heat capacity of liquid water is $4.184 \text{ J/g}\cdot\text{C}$. How much energy is needed to heat 450.0g of liquid water from 8.61°C to 35.92°C ? (20pts)

7. How much energy is released when 800.0g of water is condensed at its boiling point (100°C)? ($\Delta H^\circ_{\text{vaporization}} = 40.64 \text{ kJ/mol}$ for water) (15pts)

9. You have been studying a series of reactions:



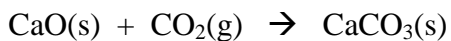
So far, you have determined the following $\Delta H^\circ_{\text{rxn}}$ values:



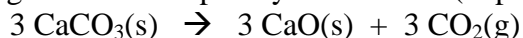
What is $\Delta H^\circ_{\text{rxn}}$ for the overall reaction, $\text{A} \rightarrow \text{D}$? Is $\text{A} \rightarrow \text{D}$ endothermic or exothermic? Draw a qualitatively correct reaction coordinate diagram for the entire stepwise process, $\text{A} \rightarrow \text{B} \rightarrow \text{C} \rightarrow \text{D}$. (20pts)

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8. You have determined that $\Delta H^\circ_{\text{reaction}}$ for the reaction of calcium oxide with carbon dioxide gas is -178.3 kJ/mol .



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



10. You have burned 25.00g of methane gas $\{\text{CH}_4(\text{g})\}$ in excess oxygen to produce carbon dioxide and water. If all of the energy from this reaction is transferred to a 38.18kg block of iron initially at 11.64°C , what is the final temperature of the iron block? (The specific heat capacity of Fe(s) is $0.451 \text{ J/g}\cdot^\circ\text{C}$) (30pts)

Material	ΔH_f° (kJ/mol)
$\text{CH}_4(\text{g})$	-74.61
$\text{CO}_2(\text{g})$	-393.509
$\text{H}_2\text{O}(\text{g})$	-241.818