

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

$c = \lambda\nu = 3.00 \times 10^8$ 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 = 1.6605×10^{-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)²

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|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|
| 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. (5pts. per question)

- The First Law of Thermodynamics states that:
 - Energy cannot be created or destroyed
 - Potential energy is a measure of the speed of molecular movement
 - Kinetic energy is stored in chemical bonds
 - 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 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
 - $4.184 \text{ J/g}\cdot^\circ\text{C}$
 - 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

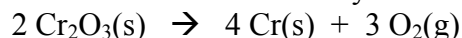
- Each of the following describes an *exothermic* process *except*:
 - Chemical bonds are formed
 - ΔH is negative
 - The system absorbs heat from the surroundings
 - The reactants have a higher energy than the products of a reaction
 - The system releases heat to the surroundings

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

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

Multiple Choice Calculations: (10pts each)

6. Alumina (Al_2O_3) can be converted to aluminum metal by the following reaction:

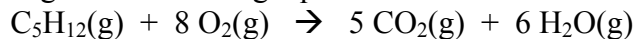


What is $\Delta H^\circ_{\text{reaction}}$ for this process? ($\Delta H^\circ_{\text{f}} = -1139.7 \text{ kJ/mol}$ for Cr_2O_3 .)

- 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 $4.184 \text{ J/g}\cdot^\circ\text{C}$. How much energy is required to heat 108.92g of liquid water from 34.68°C to 51.37°C ?
- a. $2.3016 \times 10^{-3} \text{ J}$
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. $4.21 \times 10^{-40} \text{ J}$
b. $3.13 \times 10^{-28} \text{ J}$
c. $1.99 \times 10^{-25} \text{ J}$
d. $3.13 \times 10^{-19} \text{ J}$
e. $4.7244 \times 10^5 \text{ J}$
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°C . How much energy is required to melt 41.825g of stearic acid at 60.48°C ? ($\Delta H^\circ_{\text{fusion}} = 163.93 \text{ J/g}$ for palmitic acid)
- a. 0 J
b. 3.9194 J
c. 26.738 J
d. 6856.4 J
e. $4.1467 \times 10^5 \text{ J}$
10. You have determined that $\Delta H^\circ_{\text{reaction}}$ for the following reaction is -311.2 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 kJ/mol
b. -311.2 kJ/mol
c. 155.6 kJ/mol
d. 311.2 kJ/mol
e. 622.4 kJ/mol

Problems:

11. Pentane burns according to the following equation:



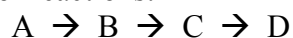
You perform an experiment in which you burn 18.246g of pentane and determine that the reaction generated 827.5kJ of heat. Based upon this experiment, what is the value of ΔH_f° for pentane? (20pts)

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

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)

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 iron to 49.318°C and placed it on a gold block at 21.516°C . When the system reaches thermal equilibrium, the temperature of the gold and iron blocks are 34.468°C . If the system is perfectly insulated, what was the mass of the gold 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)