

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 non-multiple choice 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 = $1.000^{\text{g}}/\text{mL}$

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

$PV = nRT$

1 calorie = 4.184 J = 0.001 Calorie

$h = 6.626 \times 10^{-34}$ Jsec

$\lambda = h/mv$

$1 \text{ J} = 1 \text{ kg (m/sec)}^2$

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

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

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	71 Lu 174.97	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	103 Lr (260)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 Ds (269)	111 Rg (272)	112 Cn (277)	113	114	115	116	117	118				

57 La 138.91	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
89 Ac 227.03	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)

Multiple Choice: Circle the letter of the most correct response. (5pts 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 any 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
 - $4.184 \text{ J/g}^{\circ}\text{C}$
 - 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
- Which of the following describes an *endothermic* process?
 - Chemical bonds are formed
 - The reactants have a higher energy than the products of a reaction
 - The system absorbs heat from the surroundings
 - ΔH is negative
 - The system liberates heat to the surroundings
- Which of the following is *not* a possible set of quantum numbers for an electron?
 - $n = 1, \ell = 2, m_{\ell} = +1, m_s = +1/2$
 - $n = 2, \ell = 0, m_{\ell} = 0, m_s = +1/2$
 - $n = 3, \ell = 1, m_{\ell} = -1, m_s = -1/2$
 - $n = 3, \ell = 2, m_{\ell} = +2, m_s = -1/2$
 - $n = 4, \ell = 3, m_{\ell} = -2, m_s = +1/2$

For each of the following, write out a correct electron configuration. You may use noble gas shorthand notation for species below the 2nd row of the Periodic Table. (7pts each)

- Arsenic (At.# = 33)
- Bromide ion (At.# = 35)
- Molybdenum(III) ion (At.# = 42)

Problems:

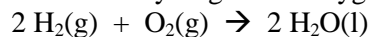
8. The specific heat capacity of limestone is $0.908 \text{ J/g}\cdot\text{C}$. How much energy is needed to heat 25.00kg of limestone from 19.61°C to 23.94°C ? (15pts)

Answer 8:

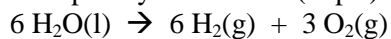
9. How much energy is required to vaporize 964.28g of ethanol at its boiling point (78.37°C)?
($\Delta H^\circ_{\text{vaporization}} = 38.56 \text{ kJ/mol}$ for ethanol) (15pts)

Answer 9:

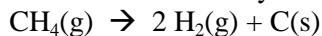
10. You have determined that $\Delta H^\circ_{\text{reaction}}$ for the reaction of hydrogen and oxygen to produce liquid water is -571.66 kJ/mol .



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

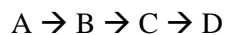


11. One potential source of hydrogen gas for use as a fuel is methane by the following reaction:

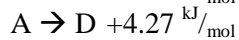
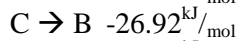
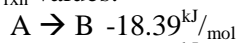


What is $\Delta H^\circ_{\text{reaction}}$ for this process? $\{\Delta H^\circ_{\text{f}} = -74.87 \text{ kJ/mol}$ for $\text{CH}_4(\text{g})\}$ How many kJ of energy must be transferred to produce 15.00g of $\text{H}_2(\text{g})$? Is the energy transferred *in* or *out* of the system? Explain. (20pts)

12. You have been studying a series of reactions:



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



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

13. You have burned 25.00g of liquid cyclopentane $\{C_5H_{10}(l)\}$ in excess oxygen to produce carbon dioxide and water. If all of the energy from this reaction is transferred to a 41.93kg block of nickel initially at 6.38°C , what is the final temperature of the nickel block? (The specific heat capacity of $\text{Ni}(s)$ is $0.461 \text{ J/g}^{\circ}\text{C}$) (25pts)

Material	ΔH_f° (kJ/mol)
$C_5H_{10}(l)$	-105.77
$CO_2(g)$	-393.509
$H_2O(g)$	-241.818