

# 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 =  $6.022 \times 10^{23}$  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 = 0.001 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<br><b>H</b><br>1.0079   |                           |                           |                           |                           |                           |                           |                           |                           |                           |                           |                           |                           |                           |                           |                           |                           | 2<br><b>He</b><br>4.0026  |                          |                          |                           |                           |
| 3<br><b>Li</b><br>6.941   | 4<br><b>Be</b><br>9.0122  |                           |                           |                           |                           |                           |                           |                           |                           |                           |                           |                           |                           |                           |                           | 5<br><b>B</b><br>10.811   | 6<br><b>C</b><br>12.011   | 7<br><b>N</b><br>14.007  | 8<br><b>O</b><br>15.999  | 9<br><b>F</b><br>18.998   | 10<br><b>Ne</b><br>20.180 |
| 11<br><b>Na</b><br>22.990 | 12<br><b>Mg</b><br>24.305 |                           |                           |                           |                           |                           |                           |                           |                           |                           |                           |                           |                           |                           |                           | 13<br><b>Al</b><br>26.982 | 14<br><b>Si</b><br>28.086 | 15<br><b>P</b><br>30.974 | 16<br><b>S</b><br>32.066 | 17<br><b>Cl</b><br>35.453 | 18<br><b>Ar</b><br>39.948 |
| 19<br><b>K</b><br>39.098  | 20<br><b>Ca</b><br>40.078 | 21<br><b>Sc</b><br>44.956 | 22<br><b>Ti</b><br>47.88  | 23<br><b>V</b><br>50.942  | 24<br><b>Cr</b><br>51.996 | 25<br><b>Mn</b><br>54.938 | 26<br><b>Fe</b><br>55.847 | 27<br><b>Co</b><br>58.933 | 28<br><b>Ni</b><br>58.69  | 29<br><b>Cu</b><br>63.546 | 30<br><b>Zn</b><br>65.39  | 31<br><b>Ga</b><br>69.723 | 32<br><b>Ge</b><br>72.61  | 33<br><b>As</b><br>74.922 | 34<br><b>Se</b><br>78.96  | 35<br><b>Br</b><br>79.904 | 36<br><b>Kr</b><br>83.80  |                          |                          |                           |                           |
| 37<br><b>Rb</b><br>85.468 | 38<br><b>Sr</b><br>87.62  | 39<br><b>Y</b><br>88.906  | 40<br><b>Zr</b><br>91.224 | 41<br><b>Nb</b><br>92.906 | 42<br><b>Mo</b><br>95.94  | 43<br><b>Tc</b><br>(98)   | 44<br><b>Ru</b><br>101.07 | 45<br><b>Rh</b><br>102.91 | 46<br><b>Pd</b><br>106.42 | 47<br><b>Ag</b><br>107.87 | 48<br><b>Cd</b><br>112.41 | 49<br><b>In</b><br>114.82 | 50<br><b>Sn</b><br>118.71 | 51<br><b>Sb</b><br>121.76 | 52<br><b>Te</b><br>127.60 | 53<br><b>I</b><br>126.90  | 54<br><b>Xe</b><br>131.29 |                          |                          |                           |                           |
| 55<br><b>Cs</b><br>132.91 | 56<br><b>Ba</b><br>137.33 | 71<br><b>Lu</b><br>174.97 | 72<br><b>Hf</b><br>178.49 | 73<br><b>Ta</b><br>180.95 | 74<br><b>W</b><br>183.84  | 75<br><b>Re</b><br>186.21 | 76<br><b>Os</b><br>190.23 | 77<br><b>Ir</b><br>192.22 | 78<br><b>Pt</b><br>195.08 | 79<br><b>Au</b><br>196.97 | 80<br><b>Hg</b><br>200.59 | 81<br><b>Tl</b><br>204.38 | 82<br><b>Pb</b><br>207.2  | 83<br><b>Bi</b><br>208.98 | 84<br><b>Po</b><br>(209)  | 85<br><b>At</b><br>(210)  | 86<br><b>Rn</b><br>(222)  |                          |                          |                           |                           |
| 87<br><b>Fr</b><br>(223)  | 88<br><b>Ra</b><br>226.03 | 103<br><b>Lr</b><br>(260) | 104<br><b>Rf</b><br>(261) | 105<br><b>Db</b><br>(262) | 106<br><b>Sg</b><br>(263) | 107<br><b>Bh</b><br>(262) | 108<br><b>Hs</b><br>(265) | 109<br><b>Mt</b><br>(266) | 110<br><b>Ds</b><br>(269) | 111<br><b>Rg</b><br>(272) | 112<br><b>Cn</b><br>(277) | 113                       | 114                       | 115                       | 116                       | 117                       | 118                       |                          |                          |                           |                           |

|                           |                           |                           |                           |                           |                           |                           |                           |                           |                           |                           |                           |                           |                           |
|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|
| 57<br><b>La</b><br>138.91 | 58<br><b>Ce</b><br>140.12 | 59<br><b>Pr</b><br>140.91 | 60<br><b>Nd</b><br>144.24 | 61<br><b>Pm</b><br>(145)  | 62<br><b>Sm</b><br>150.36 | 63<br><b>Eu</b><br>151.97 | 64<br><b>Gd</b><br>157.25 | 65<br><b>Tb</b><br>158.93 | 66<br><b>Dy</b><br>162.50 | 67<br><b>Ho</b><br>164.93 | 68<br><b>Er</b><br>167.26 | 69<br><b>Tm</b><br>168.94 | 70<br><b>Yb</b><br>173.04 |
| 89<br><b>Ac</b><br>227.03 | 90<br><b>Th</b><br>232.04 | 91<br><b>Pa</b><br>231.04 | 92<br><b>U</b><br>238.03  | 93<br><b>Np</b><br>237.05 | 94<br><b>Pu</b><br>(244)  | 95<br><b>Am</b><br>(243)  | 96<br><b>Cm</b><br>(247)  | 97<br><b>Bk</b><br>(247)  | 98<br><b>Cf</b><br>(251)  | 99<br><b>Es</b><br>(252)  | 100<br><b>Fm</b><br>(258) | 101<br><b>Md</b><br>(258) | 102<br><b>No</b><br>(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 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
- 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
  - $\Delta H$  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 2<sup>nd</sup> row of the Periodic Table. (7pts each)

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

**Problems:**

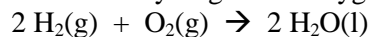
8. The specific heat capacity of limestone is  $0.908 \text{ J/g}\cdot\text{C}$ . How much energy is needed to heat 25.00kg of limestone from  $17.61^\circ\text{C}$  to  $25.94^\circ\text{C}$ ? (15pts)

*Answer 8:*

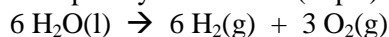
9. How much energy is required to vaporize 947.39g of ethanol at its boiling point ( $78.37^\circ\text{C}$ )? ( $\Delta H^\circ_{\text{vaporization}} = 38.56 \text{ kJ/mol}$  for ethanol) (15pts)

*Answer 9:*

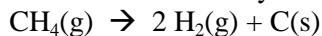
10. You have determined that  $\Delta H^\circ_{\text{reaction}}$  for the reaction of hydrogen and oxygen to produce liquid water is  $-571.66 \text{ kJ/mol}$ .



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

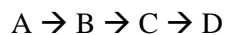


11. One potential source of hydrogen gas for use as a fuel is methane by the following reaction:

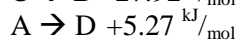
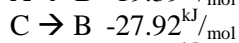
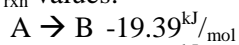


What is  $\Delta H^\circ_{\text{reaction}}$  for this process?  $\{\Delta H^\circ_{\text{f}} = -74.87 \text{ kJ/mol}$  for  $\text{CH}_4(\text{g})\}$  How many kJ of energy must be transferred to produce 15.00g of  $\text{H}_2(\text{g})$ ? Is the energy transferred *in* or *out* of the system? Explain. (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 39.41kg block of nickel initially at  $6.59^{\circ}\text{C}$ , 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       | $\Delta H_f^{\circ}$ (kJ/mol) |
|----------------|-------------------------------|
| $C_5H_{10}(l)$ | -105.77                       |
| $CO_2(g)$      | -393.509                      |
| $H_2O(g)$      | -241.818                      |