# DO NOT OPEN

## UNTIL INSTRUCTED TO DO SO

*CHEM 140 – Dr. McCorkle – Exam #4A* ***KEY***

While you wait, please complete the following information:

**Name:** _____

**Student ID:** _____

*Turn off cellphones and stow them away. No headphones, mp3 players, hats, sunglasses, food, drinks, restroom breaks, graphing calculators, programmable calculators, or sharing calculators. Grade corrections for incorrectly marked or incompletely erased answers will not be made.*

# Periodic Table of the Elements

| PERIOD | GROUP 1 IA | 2 IIA | 3 IIIB | 4 IVB | 5 VB | 6 VIB | 7 VIIB | 8 VIIIB | 9 VIIIB | 10 VIIIB | 11 IB | 12 IIB | 13 IIIA | 14 IVA | 15 VA | 16 VIA | 17 VIIA | 18 VIIIA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1<br>H<br>1.01 | | | | | | | | | | | | | | | | | 2<br>He<br>4.00 |
| 2 | 3<br>Li<br>6.94 | 4<br>Be<br>9.01 | | | | | | | | | | | 5<br>B<br>10.81 | 6<br>C<br>12.01 | 7<br>N<br>14.01 | 8<br>O<br>16.00 | 9<br>F<br>19.00 | 10<br>Ne<br>20.18 |
| 3 | 11<br>Na<br>22.99 | 12<br>Mg<br>24.31 | 3<br>IIIB | 4<br>IVB | 5<br>VB | 6<br>VIB | 7<br>VIIB | 8<br>VIIIB | 9<br>VIIIB | 10<br>VIIIB | 11<br>IB | 12<br>IIB | 13<br>Al<br>26.98 | 14<br>Si<br>28.09 | 15<br>P<br>30.97 | 16<br>S<br>32.07 | 17<br>Cl<br>35.45 | 18<br>Ar<br>39.95 |
| 4 | 19<br>K<br>39.10 | 20<br>Ca<br>40.08 | 21<br>Sc<br>44.96 | 22<br>Ti<br>47.88 | 23<br>V<br>50.94 | 24<br>Cr<br>52.00 | 25<br>Mn<br>54.94 | 26<br>Fe<br>55.85 | 27<br>Co<br>58.93 | 28<br>Ni<br>58.69 | 29<br>Cu<br>63.55 | 30<br>Zn<br>65.39 | 31<br>Ga<br>69.72 | 32<br>Ge<br>72.61 | 33<br>As<br>74.92 | 34<br>Se<br>78.97 | 35<br>Br<br>79.90 | 36<br>Kr<br>83.80 |
| 5 | 37<br>Rb<br>85.47 | 38<br>Sr<br>87.62 | 39<br>Y<br>88.91 | 40<br>Zr<br>91.22 | 41<br>Nb<br>92.91 | 42<br>Mo<br>95.95 | 43<br>Tc<br>(98) | 44<br>Ru<br>101.07 | 45<br>Rh<br>102.91 | 46<br>Pd<br>106.42 | 47<br>Ag<br>107.87 | 48<br>Cd<br>112.41 | 49<br>In<br>114.82 | 50<br>Sn<br>118.71 | 51<br>Sb<br>121.75 | 52<br>Te<br>127.60 | 53<br>I<br>126.90 | 54<br>Xe<br>131.29 |
| 6 | 55<br>Cs<br>132.91 | 56<br>Ba<br>137.33 | 57<br>La *<br>138.91 | 72<br>Hf<br>178.49 | 73<br>Ta<br>180.95 | 74<br>W<br>183.85 | 75<br>Re<br>186.21 | 76<br>Os<br>190.23 | 77<br>Ir<br>192.22 | 78<br>Pt<br>195.08 | 79<br>Au<br>196.97 | 80<br>Hg<br>200.59 | 81<br>Tl<br>204.38 | 82<br>Pb<br>207.2 | 83<br>Bi<br>208.98 | 84<br>Po<br>(209) | 85<br>At<br>(210) | 86<br>Rn<br>(222) |
| 7 | 87<br>Fr<br>(223) | 88<br>Ra<br>(226) | 89<br>Ac **<br>(227) | 104<br>Rf<br>(267) | 105<br>Db<br>(268) | 106<br>Sg<br>(271) | 107<br>Bh<br>(270) | 108<br>Hs<br>(277) | 109<br>Mt<br>(276) | 110<br>Ds<br>(281) | 111<br>Rg<br>(280) | 112<br>Cn<br>(285) | 113<br>Nh<br>(284) | 114<br>Fl<br>(289) | 115<br>Mc<br>(288) | 116<br>Lv<br>(293) | 117<br>Ts<br>(294) | 118<br>Og<br>(294) |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| * | 58<br>Ce<br>140.12 | 59<br>Pr<br>140.91 | 60<br>Nd<br>144.24 | 61<br>Pm<br>(145) | 62<br>Sm<br>150.36 | 63<br>Eu<br>151.96 | 64<br>Gd<br>157.25 | 65<br>Tb<br>158.93 | 66<br>Dy<br>162.50 | 67<br>Ho<br>164.93 | 68<br>Er<br>167.26 | 69<br>Tm<br>168.93 | 70<br>Yb<br>173.05 | 71<br>Lu<br>174.97 |
| ** | 90<br>Th<br>232.04 | 91<br>Pa<br>231.04 | 92<br>U<br>238.03 | 93<br>Np<br>(237) | 94<br>Pu<br>(244) | 95<br>Am<br>(243) | 96<br>Cm<br>(247) | 97<br>Bk<br>(247) | 98<br>Cf<br>(251) | 99<br>Es<br>(252) | 100<br>Fm<br>(257) | 101<br>Md<br>(258) | 102<br>No<br>(259) | 103<br>Lr<br>(262) |

**Multiple Choice – Choose the answer that best completes the question. Use an 815-E Scantron to record your response. [2 points each]**

1. Classify the reaction $KClO_3(s) \rightarrow KCl(s) + O_2(g)$

   A) combination **B) decomposition** C) combustion
   D) single replacement E) double replacement

2. Classify the reaction $Zn(s) + 2\ HBr(aq) \rightarrow ZnBr_2(aq) + H_2(g)$

   A) combination B) decomposition C) combustion
   **D) single replacement** E) double replacement

3. Which of the following is evidence for a chemical reaction?

   A) change in physical state
   **B) change in color**
   C) change in mass
   D) change in shape
   E) all of the above

4. How many waffles can be made from 1 dozen eggs, assuming you have enough of all other ingredients?

   Given: 2 cups flour + 3 eggs + 1 tbs oil → 4 waffles

   A) 48 B) 12 C) 4 **D) 16** E) 1,000,000

5. What is the coefficient of phosphorus after balancing the following equation?

   $__P(s) + __O_2(g) \rightarrow __P_2O_5(s)$

   A) 1 B) 2 C) 3 **D) 4** E) 5

6. What are the coefficients for the following reaction when it is properly balanced?

   $___HCl + ___Mg \rightarrow ___MgCl_2 + ___H_2$

   **A) 2, 1, 1, 1** B) 2, 1, 2, 2 C) 1, 2, ½, 1
   D) 1, 1, 1, 2 E) none of the above

7. What are the coefficients for the following reaction when it is properly balanced?

   ___nitrogen monoxide + ___carbon monoxide → ___nitrogen +___carbon dioxide

   A) 2, 1, 1, 2 **B) 2, 2, 1, 2** C) 2, 2, 2, 1
   D) 1, 1, 2, 2 E) none of the above

8. What are the products from the following double-replacement reaction?

   $BaCl_2(aq) + K_2SO_4(aq) \rightarrow$

   A) $Ba_2SO_4(s)$ and $KCl(aq)$ B) $BaSO_4(s)$ and $K_2Cl_2(aq)$

   C) $Ba(SO_4)_2(s)$ and $KCl(aq)$ **D) $BaSO_4(s)$ and $KCl(aq)$**

   E) $BaS(s)$ and $KClO_4(aq)$

9. What are the products from the complete neutralization of phosphoric acid with aqueous lithium hydroxide?

   A) $LiHPO_4(aq)$ and $H_2O(l)$ B) $LiH_2PO_4(aq)$ and $H_2O(l)$

   C) $Li_2HPO_4(aq)$ and $H_2O(l)$ D) $Li_2PO_4(aq)$ and $H_2O(l)$

   **E) $Li_3PO_4(aq)$ and $H_2O(l)$**

10. What would be the formula of the precipitate that forms when $Pb(NO_3)_2(aq)$ and $K_2S(aq)$ are mixed?

    A) $K_2NO_3$ B) $K(NO_3)_2$ **C) PbS** D) $KNO_3$ E) $PbS_2$

11. How many moles of water are made from complete reaction of 1.4 moles of hydrogen gas? Given the reaction: $2\ H_2 + O_2 \rightarrow 2\ H_2O$

    A) 0.7 **B) 1.4** C) 2.1 D) 2.8 E) 5.6

12. Given that $4\ NH_3 + 5\ O_2 \rightarrow 4\ NO + 6\ H_2O$, if 3.00 mol $NH_3$ were made to react with excess of oxygen gas, how many moles of $H_2O$ would be formed?

    A) 1.50 B) 2.00 C) 3.00 **D) 4.50** E) 6.00

13. A tricycle factory uses the following items to produce one tricycle: 3 tires, 1 frame, and 2 pedals. If the factory has available 270 tires, 90 frames, and 170 pedals, which item would limit the amount of complete tricycles that can be assembled?

    A) tires B) frames **C) pedals**

    D) both tires & frames E) all three are limiting

**Calculations & Short Answers – Write your initials in the upper-right corner of every page that contains work. For full credit show all work and write neatly; give answers with correct significant figures and units. Place a box around your final answer.**

14. When iron metal is heated with oxygen gas it produces solid iron(III) oxide.

a. Write a balanced equation, including physical states. [2 points]

**$4\ Fe(s) + 3\ O_2(g) \rightarrow 2\ Fe_2O_3(s)$**

b. If 50.0 g of iron are reacted with 25.0 g of oxygen, what is the theoretical yield of iron(III) oxide in grams? [4 points]

$$50.0\ g\ Fe \times \frac{1\ mol\ Fe}{55.85\ g} \times \frac{2\ mol\ Fe_2O_3}{4\ mol\ Fe} \times \frac{159.70\ g}{1\ mol\ Fe_2O_3} = 71.5\ g\ Fe_2O_3$$

$$25.0\ g\ O_2 \times \frac{1\ mol\ O_2}{32.00\ g} \times \frac{2\ mol\ Fe_2O_3}{3\ mol\ O_2} \times \frac{159.70\ g}{1\ mol\ Fe_2O_3} = 83.2\ g\ Fe_2O_3$$

**Choose the smallest – 71.5 g $Fe_2O_3$ is the theoretical yield.**

c. What is the limiting reactant? [2 points]

**Fe**

d. When running this experiment in the lab, 49.7 g of iron(III) oxide was produced. What was the percent yield? [2 points]

$$\%\ yield = \frac{actual\ yield}{theoretical\ yield} \times 100 = \frac{49.7\ g}{71.5\ g} \times 100 = 69.5\%$$

15. Consider the following unbalanced equation for the combustion of sucrose, $C_{12}H_{22}O_{11}$:

$$_____\ C_{12}H_{22}O_{11}(s) + __\mathbf{12}__\ O_2(g) \rightarrow __\mathbf{12}__\ CO_2(g) + __\mathbf{11}__\ H_2O(g)$$

a. Balance the above equation. [2 points]

b. How many grams of $CO_2$ could be produced from the reaction of 10.0 g of $C_{12}H_{22}O_{11}$ and 10.0 g of $O_2$? [7 points]

$$\mathbf{10.0\ g\ C_{12}H_{22}O_{11} \times \frac{1\ mol\ C_{12}H_{22}O_{11}}{342.34\ g} \times \frac{12\ mol\ CO_2}{1\ mol\ C_{12}H_{22}O_{11}} \times \frac{44.01\ g}{1\ mol\ CO_2}}$$
$$\mathbf{= 15.4\ g\ CO_2}$$

$$\mathbf{10.0\ g\ O_2 \times \frac{1\ mol\ O_2}{32.00\ g} \times \frac{12\ mol\ CO_2}{12\ mol\ O_2} \times \frac{44.01\ g}{1\ mol\ CO_2} = 13.8\ g\ CO_2}$$

**Choose the smallest: 13.8 g $CO_2$ is the theoretical yield.**

c. What is the excess reactant? [2 points]

**$C_{12}H_{22}O_{11}$**

d. Determine the percent yield if the actual yield of $CO_2$ produced is 12.7 g. [2 points]

$$\mathbf{\%\ yield = \frac{actual\ yield}{theoretical\ yield} \times 100 = \frac{12.7\ g}{13.8\ g} \times 100 = 92.0\%}$$

16. Predict the products and write a balanced equation for the reaction between ammonium phosphate and calcium hydroxide. Be sure to include physical states: [5 points]

**$2\ (NH_4)_3PO_4(aq) + 3\ Ca(OH)_2(aq) \rightarrow Ca_3(PO_4)_2(s) + \cancel{6\ NH_4OH(aq)}$**

**$2\ (NH_4)_3PO_4(aq) + 3\ Ca(OH)_2(aq) \rightarrow Ca_3(PO_4)_2(s) + 6\ NH_3(g) + 6\ H_2O(l)$**

17. Write the balanced full chemical equation, complete ionic equation, and net ionic equation for the reaction between molybdenum(V) iodide and potassium carbonate. Be sure to include physical states.

a. Full Chemical Equation: [4 points]

**$2\ MoI_5(aq) + 5\ K_2CO_3(aq) \rightarrow Mo_2(CO_3)_5(s) + 10\ KI(aq)$**

b. Complete Ionic Equation: [4 points]

**$2\ Mo^{5+}(aq) + \cancel{10\ I^-(aq)} + \cancel{10\ K^+(aq)} + 5\ CO_3^{2-}(aq) \rightarrow Mo_2(CO_3)_5(s) + \cancel{10\ K^+(aq)} + \cancel{10\ I^-(aq)}$**

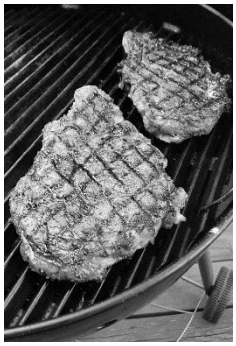
c. Net Ionic Equation: [2 points]

**$2\ Mo^{5+}(aq) + 5\ CO_3^{2-}(aq) \rightarrow Mo_2(CO_3)_5(s)$**

d. What are the spectator ions, if any? [2 points]

**$K^+$ and $I^-$**

18. After an exciting semester of chemistry, you decide to have a huge barbecue for the entire class. Before the party, you buy a new propane tank for your grill. After an entire day of grilling up steaks, pork chops, and bratwurst, you realize the tank is completely empty! Assuming the tank held 9.0 kg of propane ($C_3H_8$) when full, answer the following questions. (The reaction for the combustion of propane is below.)



$$C_3H_8(l) + 5\ O_2(g) \rightarrow 3\ CO_2(g) + 4\ H_2O(l) \qquad \Delta H_{rxn} = -2219.1\ kJ$$

a. How many kilojoules of energy did you generate while grilling? [4 points]

$$\mathbf{9.0\ kg\ C_3H_8 \times \frac{10^3\ g}{1\ kg} \times \frac{1\ mol\ C_3H_8}{44.11\ g} \times \frac{2219.1\ kJ}{1\ mol\ C_3H_8} = 4.5 \times 10^5\ kJ}$$

b. How many pounds of carbon dioxide did you release in to the atmosphere? [6 points]

$$\mathbf{9.0\ kg\ C_3H_8 \times \frac{10^3\ g}{1\ kg} \times \frac{1\ mol\ C_3H_8}{44.11\ g} \times \frac{3\ mol\ CO_2}{1\ mol\ C_3H_8} \times \frac{44.01\ g}{1\ mol\ CO_2} \times \frac{1\ lb}{453.6\ g} = 59\ lb\ CO_2}$$

19. July 20 was the 49th anniversary of man landing on the moon. To return to lunar orbit, Apollo 11's Lunar Module contained an Ascent stage with its own Ascent Propulsion System (APS) engine. It was powered by a propellant made of hydrazine, $N_2H_4$, combined with an oxidizer, $N_2O_4$, that reacted according to the following equation:

$$2\ N_2H_4(l) + N_2O_4(l) \rightarrow 3\ N_2(g) + 4\ H_2O(g) \quad \Delta H_{rxn} = -1049\ kJ$$

The average mass of propellant on an Apollo missions was 5,187 lb. Assuming it was a 50:50 mixture, what's the maximum amount of heat it could produce? [8 points]

**$50\%$ of $5,187$ lb $= 2593.5$ lb**

$$2593.5\ \text{lb}\ N_2H_4 \times \frac{453.6\ \text{g}}{1\ \text{lb}} \times \frac{1\ \text{mol}\ N_2H_4}{32.06\ \text{g}} \times \frac{1049\ \text{kJ}}{2\ \text{mol}\ N_2H_4} = 1.925 \times 10^7\ \text{kJ}$$

$$2593.5\ \text{lb}\ N_2O_4 \times \frac{453.6\ \text{g}}{1\ \text{lb}} \times \frac{1\ \text{mol}\ N_2O_4}{92.02\ \text{g}} \times \frac{1049\ \text{kJ}}{1\ \text{mol}\ N_2O_4} = 1.341 \times 10^7\ \text{kJ}$$

**Choose the smallest: $1.341 \times 10^7$ kJ of heat produced**

**Extra Credit:** Acid rain is especially damaging to statues made of limestone. What is the chemical formula of limestone? [2 points]

**$CaCO_3$**

**Formulas & Constants**
**(you may or may not need)**

1 inch = 2.54 cm (exact)

1 mile = 5280 ft ≈ 1.609 km

1 kg ≈ 2.205 lb

1 lb = 453.6 g; 1 lb = 16 oz

1 gal = 4 qt = 8 pt ≈ 3.785 L

1 L = 1000 $cm^3$

$T_K = T_{°C} + 273.15$

$T_{°F} = 1.8 \times T_{°C} + 32$

$T_{°C} = (T_{°F} - 32)/1.8$

1 cal = 4.184 J

1 Cal = 1000 cal

Avogadro's # = $6.022 \times 10^{23}$

**TABLE 4.1 Solubility Rules for Ionic Compounds in Water**

| Compounds Containing the Following Ions Are Generally Soluble | Exceptions |
|---|---|
| $Li^+$, $Na^+$, $K^+$, and $NH_4^+$ | None |
| $NO_3^-$ and $C_2H_3O_2^-$ | None |
| $Cl^-$, $Br^-$, and $I^-$ | When these ions pair with $Ag^+$, $Hg_2^{2+}$, or $Pb^{2+}$, the resulting compounds are insoluble. |
| $SO_4^{2-}$ | When $SO_4^{2-}$ pairs with $Sr^{2+}$, $Ba^{2+}$, $Pb^{2+}$, $Ag^+$, or $Ca^{2+}$, the resulting compound is insoluble. |
| **Compounds Containing the Following Ions Are Generally Insoluble** | **Exceptions** |
| $OH^-$ and $S^{2-}$ | When these ions pair with $Li^+$, $Na^+$, $K^+$, or $NH_4^+$, the resulting compounds are soluble. |
| | When $S^{2-}$ pairs with $Ca^{2+}$, $Sr^{2+}$, or $Ba^{2+}$, the resulting compound is soluble. |
| | When $OH^-$ pairs with $Ca^{2+}$, $Sr^{2+}$, or $Ba^{2+}$, the resulting compound is slightly soluble. |
| $CO_3^{2-}$ and $PO_4^{3-}$ | When these ions pair with $Li^+$, $Na^+$, $K^+$, or $NH_4^+$, the resulting compounds are soluble. |

## Scratch Page
**(to be handed in)**