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CHEM 110 – Dr. McCorkle – Exam #2 ***KEY***

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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 IB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1	1 H 1.01																	2 He 4.00
2	3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
3	11 Na 22.99	12 Mg 24.31	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIIIB	9 VIIIB	10 VIIIB	11 IB	12 IB	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
4	19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.92	34 Se 78.97	35 Br 79.90	36 Kr 83.80
5	37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.95	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 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.29
6	55 Cs 132.91	56 Ba 137.33	57 La * 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.85	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)
7	87 Fr (223)	88 Ra (226)	89 Ac ** (227)	104 Rf (267)	105 Db (268)	106 Sg (271)	107 Bh (270)	108 Hs (277)	109 Mt (276)	110 Ds (281)	111 Rg (280)	112 Cn (285)	113 Uut (284)	114 Fl (289)	115 Uup (288)	116 Lv (293)	117 Uus (294)	118 Uuo (294)

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

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

1. What is the molarity of a solution containing 5.0 moles of KCl in 2.0 L of solution?
   A) 2.5 *M* B) 1.0 *M* C) 5.0 *M* D) 10. *M* E) 2.0 *M*

2. What is the molarity of a KCl solution made by diluting 75.0 mL of a 0.200 M solution to a final volume of 100. mL?
   A) 0.267 *M* **B) 0.150 *M*** C) 0.200 *M* D) 6.67 *M* E) 0.100 *M*

3. Calculate the mass of solute present in 150.0 g of a 3.50% solution.
   A) 0.0233 g B) 2.33 g **C) 5.25 g** D) 52.5 g E) 4290 mL

4. How many formula units are in 53.2 g of $(NH_4)_2CrO_4$?
   A) 5.81×10^{-25} B) 1.34×10^{-20} C) 4.87×10^{27} **D) 2.11×10^{23}** E) 2.39×10^{23}

5. What mass in grams of phosphorus is in 72.4 g of $Zn_3(PO_4)_2$?
   A) 0.0121 g B) 2.90 g C) 5.80 g **D) 11.6 g** E) 13.9 g

For questions 6-9, consider the following redox reaction:

$$\mathbf{HNO_3}\textbf{\textit{(aq)}} + \mathbf{HI}\textbf{\textit{(aq)}} \rightarrow \mathbf{NO}\textbf{\textit{(g)}} + \mathbf{I_2}\textbf{\textit{(s)}} + \mathbf{H_2O}\textbf{\textit{(l)}}$$

6. Which element was oxidized?
   A) H B) N C) O **D) I**

7. Which element was reduced?
   A) H **B) N** C) O D) I

8. Which substance is the oxidizing agent?
   A) HNO_3 B) HI C) NO D) I_2 E) H_2O

9. Which substance is the reducing agent?
   A) HNO_3 **B) HI** C) NO D) I_2 E) H_2O

Calculations – 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.

10. Write formulas for the following compounds: [2 points each]

a. diselenium tetrachloride **Se_2Cl_4**

b. hyposulfurous acid **H_2SO_2**

c. cobalt(III) chlorite **$Co(ClO_2)_3$**

d. zinc phosphide trihydrate **$Zn_3P_2 \cdot 3H_2O$**

e. tin(IV) dichromate **$Sn(Cr_2O_7)_2$**

f. calcium cyanide **$Ca(CN)_2$**

g. pentaiodine nonaselenide **I_5Se_9**

h. lead(IV) perbromate **$Pb(BrO_4)_4$**

i. uranium(VI) nitride **UN_2**

j. hydroselenic acid **$H_2Se(aq)$**

11. Name the following compounds: [2 points each]

a. $BaSeO_3 \cdot 5H_2O$ **barium selenite pentahydrate**

b. P_6O_{10} **hexaphosphorus decaoxide**

c. $HMnO_4$ [acid name] **permanganic acid**

d. $Pt(HSO_4)_2$ **platinum(II) hydrogen sulfate OR platinum(II) bisulfate**

e. $BiBO_3$ **bismuth(III) borate**

f. RaO_2 **radium peroxide**

g. $Cu_2C_2O_4$ **copper(I) oxalate**

h. Cl_3F_7 **trichlorine heptafluoride**

i. $NiBr_3 \cdot ½H_2O$ **nickel(III) bromide hemihydrate**

j. HIO [acid name] **hypoiodous acid**

12. Determine the percentage of chromium in $Ni(Cr_2O_7)_3$. [3 points]

Molar mass = 706.69 g/mol

$$\%\mathbf{Cr} = \frac{\mathbf{6 \times Cr}}{\mathbf{Ni(Cr_2O_7)_3}} \times \mathbf{100} = \frac{\mathbf{6 \times 52.00}}{\mathbf{706.69}} \times \mathbf{100} = \frac{\mathbf{312}}{\mathbf{706.69}} \times \mathbf{100} = \mathbf{44.1\%}$$

13. Consider the following reaction:

$$2\ H_3PO_4(aq) + Al_2(CO_3)_3(s) \rightarrow\ 3\ H_2O(l) + 3\ CO_2(g)\ +\ 2\ AlPO_4(s)$$

When 75.0 mL of 3.5 *M* H_3PO_4 reacts with excess $Al_2(CO_3)_3$, what mass in grams of CO_2 can be produced? [5 points]

$$\mathbf{75.0\ mL} \times \frac{\mathbf{10^{-3}\ L}}{\mathbf{1\ mL}} \times \frac{\mathbf{3.5\ mol\ H_3PO_4}}{\mathbf{1\ L}} \times \frac{\mathbf{3\ mol\ CO_2}}{\mathbf{2\ mol\ H_3PO_4}} \times \frac{\mathbf{44.01\ g}}{\mathbf{1\ mol\ CO_2}} = \mathbf{17\ g}$$

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

$$\_\_\_\_\_\ C_{12}H_{22}O_{11}(s) + \underline{12}\ O_2(g) \rightarrow \underline{12}\ CO_2(g) + \underline{11}\ H_2O(g)$$

a. 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? [6 points]

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

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

b. How many grams of the excess reagent will remain? [4 points]

$$\mathbf{13.8\ g\ CO_2} \times \frac{\mathbf{1\ mol\ CO_2}}{\mathbf{44.01\ g}} \times \frac{\mathbf{1\ mol\ C_{12}H_{22}O_{11}}}{\mathbf{12\ mol\ O_2}} \times \frac{\mathbf{342.34\ g}}{\mathbf{1\ mol\ C_{12}H_{22}O_{11}}} = \mathbf{8.95\ g\ used}$$

$$\mathbf{10.0\ g - 8.95\ g = 1.05\ g\ remain}$$

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

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

15. Dianabol is one of the anabolic steroids that has been used by some athletes to increase the size and strength of their muscles, often with serious side effects. In one experiment, 14.765 g of Dianabol is burned, and 43.257 g CO_2 and 12.395 g H_2O are formed. In a second experiment, the molar mass of Dianabol is found to be approximately 300 g/mol. What is the molecular formula for Dianabol? [8 points]

$$43.257\ \text{g CO}_2 \times \frac{1\ \text{mol CO}_2}{44.01\ \text{g}} \times \frac{1\ \text{mol C}}{1\ \text{mol CO}_2} = 0.98289\ \text{mol C}$$

$$12.395\ \text{g H}_2\text{O} \times \frac{1\ \text{mol H}_2\text{O}}{18.02\ \text{g}} \times \frac{2\ \text{mol H}}{1\ \text{mol H}_2\text{O}} = 1.3757\ \text{mol H}$$

$$0.98289\ \text{mol C} \times \frac{12.01\ \text{g}}{1\ \text{mol C}} = 11.80\ \text{g C}$$

$$1.3757\ \text{mol H} \times \frac{1.01\ \text{g}}{1\ \text{mol H}} = 1.389\ \text{g H}$$

$$14.765\ \text{g total} - 11.80\ \text{g C} - 1.389\ \text{g H} = 1.576\ \text{g O}$$

$$1.576\ \text{g O} \times \frac{1\ \text{mol O}}{16.00\ \text{g}} = 0.0985\ \text{mol O}$$

$$\frac{\text{C}_{0.98289\ \text{mol}}}{0.0985\ \text{mol}}\text{H}\ \frac{1.3757}{0.0985\ \text{mol}}\ \frac{\text{O}_{0.0985\ \text{mol}}}{0.0985\ \text{mol}} = C_{10}H_{14}O_1$$

$$\frac{\text{molar mass}}{\text{empirical mass}} = \frac{300\ \text{g/mol}}{150\ \text{g/mol}} = 2$$

$$(C_{10}H_{14}O_1) \times 2 = C_{20}H_{28}O_2$$

16. A 10.00 mL sample of sulfurous acid requires 14.75 mL of 0.100 *M* potassium hydroxide to titrate to the equivalence point. Determine the molarity of the sulfurous acid sample. *(Hint: Write a balanced equation.)* [6 points]

$$\mathbf{H_2SO_3}\textit{(aq)} + \mathbf{2\ KOH}\textit{(aq)} \rightarrow \mathbf{K_2SO_3}\textit{(aq)} + \mathbf{2\ H_2O}\textit{(l)}$$

$$\mathbf{14.75\ mL} \times \frac{\mathbf{10^{-3}\ L}}{\mathbf{1\ mL}} \times \frac{\mathbf{0.100\ mol\ KOH}}{\mathbf{1\ L}} \times \frac{\mathbf{1\ mol\ H_2SO_3}}{\mathbf{2\ mol\ KOH}} = \mathbf{7.3\underline{7}5 \times 10^{-4}\ mol\ H_2SO_3}$$

$$\mathbf{10.00\ mL} \times \frac{\mathbf{10^{-3}\ L}}{\mathbf{1\ mL}} = \mathbf{0.01000}\ \boldsymbol{L}$$

$$\mathbf{M} = \frac{\mathbf{mol\ solute}}{\mathbf{L\ solution}} = \frac{\mathbf{7.3\underline{7}5 \times 10^{-4}\ mol\ H_2SO_3}}{\mathbf{0.01000\ L}} = \mathbf{0.0738\ M}$$

17. 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]

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

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

18. Write the balanced full chemical equation, complete ionic equation, and net ionic equation for the reaction between titanium(IV) sulfate and lead(II) acetate. Be sure to include physical states.

a. Full Chemical Equation: [4 points]

$Ti(SO_4)_2(aq) + 2\ Pb(C_2H_3O_2)_2(aq) \rightarrow Ti(C_2H_3O_2)_4(aq) + 2\ PbSO_4(s)$

b. Complete Ionic Equation: [4 points]

$\cancel{Ti^{4+}(aq)} + 2\ SO_4^{2-}(aq) + 2\ Pb^{2+}(aq) + \cancel{4\ C_2H_3O_2^{-}(aq)} \rightarrow \cancel{Ti^{4+}(aq)} + \cancel{4\ C_2H_3O_2^{-}(aq)} + 2\ PbSO_4(s)$

c. Net Ionic Equation: [2 points]

$2\ SO_4^{2-}(aq) + 2\ Pb^{2+}(aq) \rightarrow 2\ PbSO_4(s)$

Reduce to…

$SO_4^{2-}(aq) + Pb^{2+}(aq) \rightarrow PbSO_4(s)$

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

Ti^{4+} and $C_2H_3O_2^{-}$

Extra Credit Joke: What TV show does cesium and iodine love watching together? [2 points]

CSI

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	$q = m \times C \times \Delta T$
Avogadro's # = 6.022×10^{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)