CHM 1040 **FINAL EXAM** **Apr. 25, 2013**

Last Name (printed): Key **First Name (printed):** _____

Access ID (ex. xx1234) _____ **Section: 002 003 004 005 006 007 008 009 010 011**

Signature: _____

Please write your answers neatly in the spaces provided. Please use a blue or black ink pen. You may use a non-programmable calculator. You must show your work to receive full credit. Include units in your work and answer if needed and pay attention to significant figures. Place a box around your final answer. There are 36 questions, some with multiple parts. The periodic table is at the end. You may detach it.

Academic Integrity Pledge

During the exam I will
- turn off my cell phone and put it away (out of sight and not on my person)
- close all books, notebooks, etc. and put them under the seat in which I sit
- keep my eyes down and focused on my own paper
- keep my answers covered
- sit in the area assigned to my section

During the exam I will not
- have any papers other than those provided
- have any writing on my clothing or person or desk
- talk to anyone other than the instructor

I will stop writing when time is called.

I will hand in my paper when told to do so.

I understand that the ***minimum consequence*** of any behavior contrary to this pledge is that I will receive a ***zero on this exam*** that will not be replaced by the percent earned on my final exam.

Name (sign)_____

Scoring

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Total:

R = 0.08206 L atm/mol K
1 mol of any gas at STP occupies 22.4 L
1 atm = 760 mm Hg
1 atm = 101,325 Pa = 101.3 kPa
1 atm = 760 torr
STP is 1 atm and 273 K

Questions 1-8 are worth 4 points each.

1. Classify each of the following as a pure substance or a mixture. If it is a pure substance, classify it as an element of a compound. If it is a mixture, classify it as homogeneous or heterogeneous.

helium gas pure substance, element

chocolate chip cookie mixture, heterogeneous

silver chloride pure substance, compound

coffee mixture, homogeneous

2. Determine whether each of the following changes is physical or chemical.

A balloon filled with hydrogen gas explodes upon contact with a spark. chemical

The liquid propane in a barbecue evaporates away because the user left the valve open. physical

3. When 56.0 J of heat are added to 11.0 g of a liquid, its temperature rises from 10.4 °C to 12.7 °C. What is the heat capacity of the liquid? $\Delta T = 12.7 - 10.4 = 2.3$

$Q = s m \Delta T$

$$s = \frac{Q}{m \Delta T} = \frac{56.0}{(11.0)(2.3)} = 2.2 \text{ J/g°C}$$

4. Would you expect the following elements to gain or lose electrons in chemical changes.

potassium lose

sulfur gain

fluorine gain

copper lose

5. Write the electron configuration for each of the following elements in the ground state. You may use the noble gas abbreviation.

Cl $1s^2 2s^2 2p^6 3s^2 3p^5$ or $[Ne] 3s^2 3p^5$

Mn $[Ar] 4s^2 3d^5$

6. Write the full electron configuration for each of the following ions. Do not use a Noble gas abbreviation.

Ca^{2+} $1s^2 2s^2 2p^6 3s^2 3p^6$

Se^{2-} $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6$

7. Describe the bonding in each of the following. Use words such as ionic, non-polar covalent, or polar covalent.

HBr (g) polar covalent

MgF_2 ionic

8. Complete and balance the following equation:

$2\ HCl\ (aq) + Ba(OH)_2\ (aq) \rightarrow BaCl_2 + 2H_2O$

The remaining questions are worth 6 points each.

9. Name the following compounds:

a. $LiIO_4$ lithium periodate

b. $FeCl_3$ iron (III) chloride

c. PBr_3 phosphorus tribromide

d. Cu_2SO_3 copper(I) sulfite

e. Ag_3PO_4 silver phosphate

f. HNO_2 nitrous acid

10. Write formulas for the following compounds:

a. magnesium acetate $Mg(C_2H_3O_2)_2$

b. ammonium nitrate NH_4NO_3

c. potassium permanganate $KMnO_4$

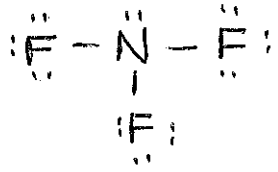
d. calcium hydroxide $Ca(OH)_2$

e. cobalt(II) hydrogen carbonate $Co(HCO_3)_2$

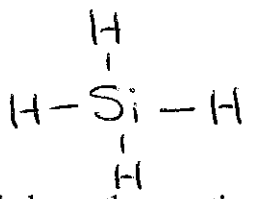
f. nickel(II) acetate $Ni(C_2H_3O_2)_2$

11. Draw a reasonable Lewis structure for each of the following. Be sure to include unshared pairs of electrons where necessary. **Describe the molecular shape (geometry).**

NF_3



SiH_4



tetrahedral

12. Write and balance the equation showing the reaction between copper metal and aqueous sulfuric acid to form aqueous copper (II) sulfate, sulfur dioxide gas and water.

$$Cu(s) + 2H_2SO_4 \rightarrow CuSO_4(aq) + SO_2(g) + 2H_2O$$

13. Write and balance the equation showing the reaction between nitrogen monoxide gas and hydrogen gas to form nitrogen gas and water vapor.

$$2NO(g) + 2H_2(g) \rightarrow N_2(g) + 2H_2O$$

14. BALANCE and CLASSIFY the following reactions. Use the standard choices: combination, decomposition, oxidation (combustion), single replacement (redox), double replacement - precipitation (DRP) or double replacement - neutralization (DRN).

$2\ C_3H_7OH\ (l) + 9\ O_2\ (g) \rightarrow 6\ CO_2\ (g) + 8\ H_2O\ (g)$ oxidation combustion

$2\ Co(NO_3)_3\ (aq) + 3\ (NH_4)_2S\ (aq) \rightarrow Co_2S_3\ (s) + 6\ NH_4NO_3\ (aq)$ double replace, ppt

15. Calculate the number of atoms in 8.095 grams of calcium. Ca = 40.08 amu

$$8.095\ g\ Ca \left(\frac{1\ mol\ Ca}{40.08\ g\ Ca}\right)\left(\frac{6.022 \times 10^{23}\ atoms}{mol}\right) = 1.216 \times 10^{23}\ atoms$$

16. How many moles are in 1.54 g of Zinc? Zn = 65.38 amu

$$1.54\ g\ Zn \left(\frac{1\ mol\ Zn}{65.38\ g}\right) = 0.0236\ mol\ Zn$$

17. What is the mass (in grams) of 1.640 moles of K_2SO_3?
K = 39.10 amu, S = 32.07 amu, O = 16.00 amu

$2(39.10) = 78.20$
$32.07 = 32.07$
$3(16.00) = 48.00$
$158.27\ g/mol$

$$1.640\ mol \left(\frac{158.27\ g}{mol}\right) = 259.6\ g$$

18. What is the molarity of a solution that is 321 g of $CaCl_2$ with a total volume of 1.45 L?
Ca = 40.08, Cl = 35.45 $CaCl_2 = 110.98\ g/mol$

$$\frac{321\ g}{110.98\ g/mol} = 2.89\ mol \qquad M = \frac{mol}{L} = \frac{2.89\ mol}{1.45\ L}$$

$= 1.99\ M$

19. What mass in grams of solute does the following sample contain: 173 mL of 1.24 M KBr.
K = 39.10, Br = 79.90

0.173 L

$$1.24\ \frac{mol}{L}\left(0.173\ L\right) = 0.21452\ mol\left(\frac{119.00\ g}{mol}\right) = 25.5\ g$$

20. If 75 mL of 0.211 M NaOH is diluted to a final volume of 125 mL, what is the concentration of NaOH in the diluted solution?

$$M_1V_1 = M_2V_2$$
$$(0.211)(75) = M_2(125)$$
$$0.127 = M_2$$

21. A compound (that smells like pineapple) is analyzed and found to contain 62.04 % carbon, 10.41 % hydrogen and 27.55 % oxygen (by mass). Calculate the empirical formula of this compound.
Atomic masses: C = 12.01 amu, H = 1.008 amu, O = 16.00 amu

$$62.04\ g\ C\left(\frac{mol\ C}{12.01\ g}\right) = 5.166\ mol\ C \div 1.722 = 3$$

$$10.41\ g\ H\left(\frac{mol\ H}{1.008\ g}\right) = 10.327\ mol\ H \div 1.722 = 6$$

$$27.55\ g\ O\left(\frac{mol\ O}{16.00\ g}\right) = 1.722\ mol\ O \div 1.722 = 1$$

$$C_3H_6O$$

22. Given the following balanced equation for the reaction:

$$2\ KI + Hg(NO_3)_2 \rightarrow HgI_2 + 2\ KNO_3$$

Calculate the mass (in grams) of potassium iodide required to yield 2.78 g of mercury(II) iodide precipitate. Molar masses: KI = 166.00 g/mol; HgI_2 = 454.39 g/mol

$$2.78\ g\ HgI_2\left(\frac{mol\ HgI_2}{454.39\ g\ HgI_2}\right)\left(\frac{2\ mol\ KI}{1\ mol\ HgI_2}\right)\left(\frac{166.00\ g\ KI}{mol\ KI}\right) =$$

$$2.03\ g\ KI$$

23. Given the following balanced equation for the reaction:

$5\ C + 2\ SO_2 \rightarrow CS_2 + 4\ CO$

What is the theoretical yield (in grams) of CS_2 when 8.50 g of carbon are combined with 8.50 g of SO_2? Masses: C = 12.01 amu; SO_2 = 64.07 g/mol; CS_2 = 76.15 g/mol

$$8.50\ g\ C\left(\frac{mol\ C}{12.01\ g\ C}\right)\left(\frac{1\ mol\ CS_2}{5\ mol\ C}\right)\left(\frac{76.15\ g\ CS_2}{mol\ CS_2}\right) = 10.8\ g\ CS_2$$

$$8.50\ g\ SO_2\left(\frac{mol\ SO_2}{64.07\ g\ SO_2}\right)\left(\frac{1\ mol\ CS_2}{2\ mol\ SO_2}\right)\left(\frac{76.15\ g\ CS_2}{mol\ CS_2}\right) = \boxed{5.05\ g\ CS_2}$$

24. Given the following balanced equation for the reaction:

$2\ NaN_3\ (s) + spark \rightarrow 2\ Na + 3\ N_2$

In the event of a car crash, the unstable compound in an air bag, NaN_3 decomposes explosively and fills the air bag with nitrogen gas in about 30 seconds. If an air bag contains 150.0 g of NaN_3, what is the volume of nitrogen gas produced at STP? Molar masses: NaN_3 = 65.02 g/mol; N_2 = 28.02 g/mol

$$150.0\ g\ NaN_3\left(\frac{mol\ NaN_3}{65.02\ g}\right)\left(\frac{3\ mol\ N_2}{2\ mol\ NaN_3}\right) = 3.460\ mol\ N_2$$

$$3.460\ mol\ N_2\left(\frac{22.4\ L}{1.00\ mol}\right) = 77.50\ L$$

25. What pressure of hydrogen gas at 3.20 L volume and 22.0 °C could be produced by the reaction of 2.00 g of Al with excess HCl by the reaction: $2\ Al + 6\ HCl \rightarrow 2\ AlCl_3 + 3\ H_2\ (g)$?

$T = 295\ K$

$$2.00\ g\ Al\left(\frac{mol\ Al}{26.98\ g\ Al}\right)\left(\frac{3\ mol\ H_2}{2\ mol\ Al}\right) = 0.111\ mol\ H_2$$

$PV = nRT$

$$R = \frac{nRT}{V} = \frac{(0.111\ mol\ H_2)\left(0.08206\ \frac{L\,atm}{mol\,K}\right)(295\ K)}{3.20\ L}$$

$$= 0.840\ atm$$

$$\frac{V_1P_1}{T_1} = \frac{V_2P_2}{T_2}$$

26. A gas occupies 340 mL at 273 K and 0.625 atm. What final temperature would be required to increase the pressure to 1.00 atm, the volume being held constant?

$T_1 = 273\ K$

$P_1 = 0.625\ atm$

$T_2 = ?$

$P_2 = 1.00\ atm$

$$\frac{P_1}{T_1} = \frac{P_2}{T_2} \qquad T_2 = \frac{P_2T_1}{P_1}$$

$$= \frac{(1.00)(273)}{0.625} = 437\ K$$

27. Assuming that the pressure and quantity of a gas sample remain constant, what will the final volume of a 4.86 L sample of a gas originally at 281 °C be when heated to 400 °C?

$V_1 = 4.86\ L$

$V_2 = ?$

$T_1 = 554\ K$

$T_2 = 673\ K$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \qquad V_2 = \frac{V_1T_2}{T_1}$$

$$= \frac{(4.86)(673)}{554}$$

$\boxed{V_2 = 5.90\ L}$

28. How many moles of nitrogen gas will occupy a volume of 1.25 L at a pressure of 1.00 atm and a temperature of 200 °C?

$P = 1.00\ atm$

$T = 473\ K$

$V = 1.25\ L$

$n = ?$

$$PV = nRT$$

$$n = \frac{PV}{RT} = \frac{(1.00\ atm)(1.25\ L)}{\left(0.08206 \frac{L\ atm}{mol\ K}\right)(473\ K)}$$

$$= 0.0322\ mol$$

29. How many mL of 0.00850 M $Ca(OH)_2$ solution are needed to react with 20.0 mL of 0.0120 M H_3PO_4 solution? Use the balanced equation: $2\ H_3PO_4 + 3\ Ca(OH)_2 \rightarrow Ca_3(PO_4)_2 + 6\ H_2O$

$H_3PO_4 = 97.99$ g/mol; $Ca(OH)_2 = 74.10$ g/mol

$20.0\ mL$ ↓ $X\ mL$

$0.0120\ M$ $0.00850\ M$

$$(0.0200\ L)\left(\frac{0.0120\ mol\ H_3PO_4}{L}\right)\left(\frac{3\ mol\ Ca(OH)_2}{2\ mol\ H_3PO_4}\right)\left(\frac{L\ Ca(OH)_2}{0.00850\ mol}\right)$$

$$= 0.0424\ L$$

$$\text{or } 42.4\ mL$$

30. Commercial preparation of the once-popular dry cleaning solvent carbon tetrachloride (CCl_4) was by the reaction $CS_2 + 2\ S_2Cl_2 \rightarrow CCl_4 + 6\ S$. How many grams of S_2Cl_2 are needed to prepare 38.4 grams of carbon tetrachloride. The molar masses are: CS_2 = 76.143 g/mol; S_2Cl_2 = 135.025 g/mol; CCl_4 = 153.822 g/mol; and S = 32.066 g/mol

$$38.4\text{g } CCl_4 \left(\frac{\text{mol } CCl_4}{153.822\text{g}}\right)\left(\frac{2\text{mol } S_2Cl_2}{1\text{mol } CCl_4}\right)\left(\frac{135.025\text{ g } S_2Cl_2}{\text{mol } S_2Cl_2}\right) =$$

$$67.4\text{ g } S_2Cl_2$$

31. When aqueous solutions of silver nitrate and magnesium chloride are mixed, silver chloride precipitates. Calculate the mass of AgCl formed when 1.25 L of 0.0500 M $MgCl_2$ and 5.25 L of 0.0250 M $AgNO_3$ are mixed.

AgCl = 143.35 g/mol

$$2\ AgNO_3 + MgCl_2 \rightarrow 2\ AgCl\ (s) + Mg(NO_3)_2$$

5.25 L
0.0250 M
↓
0.131 mol
excess

1.25 L
0.0500 M
↓
0.0625 mol

$$0.0625\text{ mol } MgCl_2 \left(\frac{2\text{mol AgCl}}{1\text{mol } MgCl_2}\right)\left(\frac{143.35\text{g AgCl}}{\text{mol AgCl}}\right) = 17.9\text{ g AgCl}$$

32. What mass of K_3PO_4 is needed to react with 555 mL of 0.250 M HCl? Useful molar masses are K_3PO_4 = 212.265 g/mol; HCl = 36.461 g/mol.

$$3\ HCl + K_3PO_4 \rightarrow H_3PO_4 + KCl$$

$$(0.555\text{ L})\left(\frac{0.250\text{ mol HCl}}{\text{L HCl}}\right)\left(\frac{1\text{mol } K_3PO_4}{3\text{ mol HCl}}\right)\left(\frac{212.265\text{g } K_3PO_4}{\text{mol } K_3PO_4}\right)$$

$$= 9.82\text{ g } K_3PO_4$$

33. The following reaction forms 11.1 g of Ag (s): $2\ Ag_2O(s) \rightarrow 4\ Ag(s) + O_2\ (g)$
What volume of gas forms if it is collected over water at a temperature of 25 °C and a total pressure of 0.989 atm? The vapor pressure of water at 25 °C is 0.0313 atm. Ag = 107.9 g/mol

$$11.1\text{ g Ag}\left(\frac{1\text{ mol Ag}}{107.9\text{ g Ag}}\right)\left(\frac{1\text{ mol } O_2}{4\text{ mol Ag}}\right) = 0.0257\text{ mol } O_2$$

$P_T = P_{H_2O} + P_{O_2}$

$0.989\text{ atm} = 0.0313\text{ atm} + P_{O_2}$

$0.9577 = P_{O_2}$

$PV = nRT \qquad V = \frac{nRT}{P}$

$$V = \frac{(0.0257)(0.08206)(298)}{0.9577}$$

$$= 0.656\text{ L}$$

34. Calcium oxalate, CaC_2O_4, is very insoluble in water. What mass of sodium oxalate, $Na_2C_2O_4$, is required to precipitate the calcium ion from 37.5 mL of 0.104 M $CaCl_2$ solution? The reaction is:
$Na_2C_2O_4 + CaCl_2 \rightarrow CaC_2O_4 + 2\ NaCl$ $\qquad Na_2C_2O_4 = 133.99$ g/mol

$$(0.0375\text{ L})\left(0.104\frac{\text{mol } CaCl_2}{\text{L}}\right)\left(\frac{1\text{ mol } Na_2C_2O_4}{1\text{ mol } CaCl_2}\right)\left(\frac{133.99\text{ g } Na_2C_2O_4}{\text{mol}}\right)$$

$$= 0.523\text{ g } Na_2C_2O_4$$

35. What volume of H_2 gas, measured at 37 °C and 0.971 atm, can be obtained by reacting 4.00 g zinc metal with 150. mL of 0.250 M HCl? The equation follows. The molar masses are: Zn = 65.38 g/mol; HCl = 36.458 g/mol; $ZnCl_2$ = 136.28 g/mol; H_2 = 2.016 g/mol

$Zn(s) + 2\ HCl\ (aq) \rightarrow ZnCl_2(aq) + H_2\ (g)$

$$4.00\text{ g Zn}\left(\frac{\text{mol Zn}}{65.38\text{ g}}\right)\left(\frac{1\text{ mol } H_2}{1\text{ mol Zn}}\right) = 0.06118\text{ mol } H_2$$

$$0.150\text{ L}\left(\frac{0.250\text{ mol}}{\text{L}}\right)\left(\frac{1\text{ mol } H_2}{2\text{ mol HCl}}\right) = 0.01875\text{ mol } H_2$$

lesser amt

$PV = nRT$

$$V = \frac{nRT}{P} = \frac{(0.01875)(0.08206)(310)}{0.971} = 0.491\text{ L}$$

36. Balance the following equations.

Al_2S_3 (s) + 6 H_2O (l) → 3 H_2S (g) + 2 $Al(OH)_3$ (s)

3 PbO + 2 NH_3 → 3 Pb + N_2 + 3 H_2O

2 N_2H_4 + N_2O_4 → 3 N_2 + 4 H_2O

2 C_4H_{10} + 13 O_2 → 8 CO_2 + 10 H_2O

4 NO_2(g) + 2 H_2O(l) + O_2(g) → 4 HNO_3(aq)

2 BF_3(g) + 3 H_2O(g) → B_2O_3 + 6 HF (g)

Extra Credit (5 points):
Ammonium carbonate decomposes upon heating according to the following balanced equation.
$(NH_4)_2CO_3$ (s) → 2 NH_3 (g) + CO_2 (g) + H_2O (g)
Calculate the total volume of gas produced at 22 °C and 1.02 atm by the complete decomposition of 15.55 g of ammonium carbonate. $(NH_4)_2CO_3$ = 96.094 g/mol

$$15.55\,g\,(NH_4)_2CO_3\left(\frac{1\,mol}{96.094\,g}\right) = 0.162\,mol\,(NH_4)_2CO_3$$

gives
0.324 mol NH_3
0.162 mol CO_2
0.162 mol H_2O
0.648 mol gas

$$PV = nRT$$

$$V = \frac{nRT}{P} = \frac{(0.648)(0.08206)(295)}{1.02\,atm}$$

$$= 15.4\,L$$

WAYNE STATE UNIVERSITY

Department of Chemistry

Periodic Table of the Elements

1 IA	2 IIA	3	4	5	6	7	8	9	10	11	12	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1 **H** 1.008																	2 **He** 4.003
3 **Li** 6.9419	4 **Be** 9.012											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
11 **Na** 22.99	12 **Mg** 24.31											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.07	17 **Cl** 35.45	18 **Ar** 39.95
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** 65.38	31 **Ga** 69.72	32 **Ge** 72.59	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.94	43 **Tc** [98]	44 **Ru** 101.1	45 **Rh** 102.9	46 **Pd** 106.4	47 **Ag** 107.9	48 **Cd** 112.4	49 **In** 114.8	50 **Sn** 118.7	51 **Sb** 121.8	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.3
55 **Cs** 132.90	56 **Ba** 137.3	57 **La** 138.9	72 **Hf** 178.5	73 **Ta** 180.9	74 **W** 183.9	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.1	79 **Au** 197.0	80 **Hg** 200.6	81 **Tl** 204.4	82 **Pb** 207.2	83 **Bi** 209.0	84 **Po** [209]	85 **At** [210]	86 **Rn** [222]
87 **Fr** [223]	88 **Ra** 226	89 **Ac** [227]	104 **Rf** [261]	105 **Db** [262]	106 **Sg** [263]	107 **Bh** [264]	108 **Hs** [265]	109 **Mt** [268]	110 **Ds** [271]	111 **Rg** [272]	112 **Uub**	113 **Uut**	114 **Uuq**	115 **Uup**		117 Uuo	

58 **Ce** 140.1	59 **Pr** 140.9	60 **Nd** 144.2	61 **Pm** [145]	62 **Sm** 150.4	63 **Eu** 152.0	64 **Gd** 157.3	65 **Tb** 158.9	66 **Dy** 162.5	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0	71 **Lu** 175.0
90 **Th** 232.0	91 **Pa** [231]	92 **U** 238.0	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** [260]