Chemistry 5 Test 1

Name:____

You **must** show your work to receive credit

PERIODIC TABLE OF THE ELEMENTS

1A	2A	3B	4B	5B	6B	7B	8B			1B	2B	3A	4A	5A	6A	7A	8A
1 **H** 1.008																	2 **He** 4.003
3 **Li** 6.941	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** 65.39	31 **Ga** 69.72	32 **Ge** 72.61	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** 132.9	56 **Ba** 137.3	57 **La** 138.9	72 **Hf** 178.5	73 **Ta** 181.0	74 **W** 183.8	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** 226.0	89 **Ac** 227.0	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (264)	108 **Hs** (265)	109 **Mt** (268)									

metals nonmetals

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** 231.0	92 **U** 238.0	93 **Np** 237.0	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)

A few Constants

Avagadro's Number, $N = 6.022*10^{23}$ Gas constant, R = 0.08206 L atm/K mole

A set of solubility rules

I. Soluble compounds
   A. All Na^+, K^+, and NH_4^+ compounds are soluble.
   B. All NO_3^-, $C10_4^-$, $C10_3^-$, and $C_2H_3O_2^-$ compounds are soluble.
   C. All SO_4^{2-} compounds are soluble except: Ca^{2+}, Sr^{2+}, Ba^{2+}, and Pb^{2+}.
   D. All Cl^-, Br^{--}, and I^- compounds are soluble except: Ag^+, Hg^{2+}, and Pb^{2+}.

II. Insoluble compounds
   All O^{2-}, OH^-, and S^{2-} compounds are insoluble except: Na^+, K^+, NH_4^+, Ca^{2+}, Sr^{2+}, and Ba^{2+}. Metal sulfides are the least soluble followed by H_2S; hydroxides are only slightly more soluble than sulfides.

III. The compounds of anions not mentioned in any of the preceding rules are probably insoluble except when combined with Na^+, K^+, or NH_4^+.

   Examples: CrO_4^{2-}, CO_3^{2-}, PO_2^-, PO_3^- AsO_3^-, SO_3^{2-}, etc.

IV. Covalent compounds are generally insoluble, water is an exception.

1. Name the following compounds:

a. K_3P **potassium phosphide**

b. OF_2 **oxygen difluoride or monoxygen difluoride**

c. $CuSO_3$ **copper(II) sulfite**

d. HBr **hydrogen bromide, or, if in water, hydrobromic acid**

2. Write the formula for the following compounds

a. Ammonia **NH_3**

b. aluminium sulfide **Al_2S_3**

c. magnesium perbromate **$Mg(BrO_4)_2$**

d. mercury (I) manganate **Hg_2MnO_4**

3. Predict products, assign oxidation states, complete and balance the following reactions. If these are metathesis reactions, also show the direction of the reaction. Justify your answers by showing all your work.

a. the metathesis reaction between :

i. mercury (II) nitrate and sodium carbonate
ii. hydrofluoric acid and sodium chloride

+1 +5 -2		+1 +4 -2		+2 +4 -2		+1 +5 -2
$Hg(NO_3)_2$	+	**Na_2CO_3**	→	**$HgCO_3$**	+	**$2NaNO_3$**
Salt		salt		salt		salt
hd		hd		hd		hd
sol		sol		**insol**		sol

HF	+	**NaCl**	←	**HCl**	+	**NaF (Na & H are +1, F & Cl are -1)**
wa		salt		sa		salt
sd		hd		hd		hd
sol?		sol		sol		sol

+! +7 -2 +1 -1 +2 +5 -2

b. $KMnO_4$ + HCl → $Mn(ClO_3)_2$ you may chose to rewrite the product as Mn^{2+} & ClO_3^{1-}

$6(\ 8H^+ + 5e^- + KMnO_4 \rightarrow Mn^{2+} + K^+ + 4H_2O)$

$5(\ 3H_2O + HCl \rightarrow ClO_3^- + 7H^+ + 6e^-)$

$13H^+ + 6\ KMnO_4 + 5HCl \rightarrow 6Mn^{2+} + 6K^+ + 9H_2O + 5ClO_3^-$

4. If ,in problem #3b, we started out with 1.00 liters of 0.067 M potassium permanganate solution and dissolved 5.60 L hydrogen chloride (at 273 K and 1.00 atm pressure) in this solution, how many grams of manganese (II) chlorate could we isolate?

Please rebalance your equation on this page before solving the problem.

$KMnO_4$ + HCl → $Mn(ClO_3)_2$

$2(13H^+ + 6\ KMnO_4 + 5HCl \rightarrow 6Mn^{2+} + 6K^+ + 9H_2O + 5ClO_3^-)$ to give

$26H^+ + 12\ KMnO_4 + 10HCl \rightarrow 7Mn^{2+} + 12K^+ + 9H_2O + 5Mn(ClO_3)_2$

limiting reagent: M*V = moles permanganate = 0.067mole
n = PV/RT & solve, or, at STP, 22.4L = I mole
so 5.60L/22.4L/mol = 0.25 mole
mole ratio is 5:6, so 0.067 moles permanganate would require 0.0558 moles of HCl and the permanganate is the limiting reagent. ALSO, we only use 5/12 of the manganese in the chlorate salt. 7/12 is not isolated as the chlorate.

Therefore, we get 0.067 * 5/12, or 0.0279 moles of manganese (II) chlorate
g = moles * molar mass = (0.0279 * 222.)g = 6.20 grams (NOTE, sig figs may change these numbers slightly!)

b. If we were able to recover 0.0867 grams of manganese (II) chlorate what would the percent yield of manganese (II) be?

%yield = 100 * grams recovered/theoretical yield = 100* 0.0867/5.61 = 1.54%

5. Nitrogen and silicon form two binary compounds with the following compositions:

Compound	Mass % N	Mass % Si
1	33.28	66.72
2	39.94	60.06

a. compute the mass of silicon that combines with 1.000 gram of nitrogen in each case.

b. Show that these compounds satisfy the law of multiple proportions. If the second compound has a molar mass of 140.3 g/mole what are the formulas of the two compounds?

a.

Case 1

$$\frac{33.28}{1} = \frac{66.72}{X} \qquad X = \frac{66.72}{33.28} = 2.004 = 2\,\mathbf{g} \;\; \textbf{or 2.004g}$$

Max 4 significant figures. Is rounding OK for this problem?

Case 2

$$\frac{39.94}{1} = \frac{60.06}{X} \qquad X = \frac{60.06}{39.94} = 1.504 = 1.5\,\mathbf{g} \;\textbf{or 1.504g}$$

b.

M= 140.3 g/mole

N = 14.01g/mole

Si = 28.09g/mole

mass% = Molar mass* particles → particles = mass%/ Molar mass

For compound2: $\chi_N = \frac{39.94}{14.01} = \mathbf{2.850}$

$\chi_{Si} = \frac{60.06}{28.09} = \mathbf{2.138}$

Cross link: N/Si = 2.850/2.138 = 1.333/1 = 4/3

4*14.01= 56.04

3*28.09 = 84.27 → resulting in 140.3 molar mass.

The formula of the second compound is $\mathbf{Si_3N_4}$

Compound1:

$\chi_N = \frac{33.28}{14.01} = \mathbf{2.375}$

$\chi_{Si} = \frac{66.72}{28.09} = \mathbf{2.375}$ **→ resulting in 1:1 ratio.**

SiN, $\mathbf{Si_2N_2}$**,** $\mathbf{Si_3N_3}$**…**

6. In 1783 the French physicist Jacques Charles supervised and took part in the first human flight in a hydrogen balloon. Such balloons rely on the low density of hydrogen relative to air for their buoyancy. In Charles balloon ascent the hydrogen was produced by the reaction of aqueous sulfuric acid and iron filings (powdered iron).

a. What volume of hydrogen is produced at 300 K and 1.00 Atm when 300 kg of sulfuric acid is consumed in this reaction?
b. What would be the radius of a spherical balloon filled by this amount of hydrogen? (The volume of a sphere is: $V = 4/3 * pi * r^3$)
c. What would the radius be when the balloon reached an altitude where the air pressure was 0.750 atm and the temperature had dropped 50 degrees C? (please show the equation(s) you used to find this.)

a. **$H_2SO_4 + Fe \rightarrow FeSO_4 + H_2$**

300,000g **X L = 7.53*10^{4}Liters**

?/98.1g/mole **?22.4 L/mole*(300/273)**

3.06*10^3 moles → 3.06*10^3 moles (1:1 mole ratio)

b. **r = cube root(3*V*Π/4) = 2.62 meters**

c. **r = 2.71 meters (7.53*10^4*(1/.75)*(250/300 gives new volume and resolve as in b)**

Extra: Would the balloon, filled as described, lift Charles into the air? A reasonable guess of the mass of the unfilled balloon is 60 kg. A simple "yes" or "no" answer is not acceptable.

No. "lift" is the difference in mass of air displaced and displacing object. Air is about 20% oxygen and 80% nitrogen, so 1 "mole" of air has a mass of about 29. grams. We have 3.06*10^3 moles of hydrogen which would displace an equal amount of air. Masses of the two volumes are 6.12 kg and 88.7 kg, giving a lift of about 82.5 kg. Balloon massed 60 kg, so the system can only lift about 22 kg, or a young child.