Chemistry 112
Second Hour Exam

Name:_____
(4 points)

Please show all work for partial credit
All problems worth 12 points

Starting with a harder problem.
1. (12 points) I have discovered a new element with an atomic mass of 113.2 amu. I know there are two isotopes for this element. One isotope has a mass of 112.9 amu and the other has a mass of 113.8 amu. What is the natural abundance of each of these isotopes?
If X is the fraction of atoms with mass 112.9 and
Y is the faction of atoms with mass 113.8, then:

X+Y =1 And X(112.9) + Y(113.8) = average atomic mass = 113.2

Two equations with two unknowns. Rearrange equation X+Y=1 to X=1-Y
And substitute this into the other equation:

(1-Y)112.9 + Y(113.8) = 113.2
112.9 -112.9Y + 113.8Y = 113.2
112.9 + .9Y =113.2
.9Y = 113.2-112.9 ; .9Y = .3; Y=.3/.9 = **.33333 = fraction of 113.8 or 33.3%**
X + Y =1
X=1-Y = 1-.33333; X=**.666666 = fraction 112.9 or 66.6%**

Hopefully an easier problem.
2A. (6 points) What is the % composition for each element in Calcium nitrite.

Calcium nitrite is $Ca(NO_2)_2$
Mass Ca = 40.08
Mass N = 2(14.01) = 28.02
Mass O = 4(16) = 64
Total mass = 132.1 g/mol

% Ca = (40.08/132.1) x 100% = 30.3%
% N = (28.02/132.1))x100% = 21.11%
% O = (64/132.1) x100% = 48.45%

2B. (6 points) How many nitrogen atoms are in 5 ng of Calcium nitrite?

$$5ng\ Ca(NO_2)_2 \times \frac{1x10^{-9}\,g}{ng} \times \frac{1\,mol\ Ca(NO_2)_2}{132.1g\ Ca(NO_2)_2} \times \frac{2\ mole\ N}{1\ mole\ Ca(NO_2)_2} \times \frac{6.022 \times 10^{23}\ atoms\ N}{1\ mole\ N} = 4.56 \times 10^{13} atom$$

3. (12 points) Define the following terms:

Empirical formula - A chemical formula that expresses the ratio of each atom to another in molecule, but not the exact number of each atom in a molecule.

Avogadro's number 6.022×10^{23} things, actually it is the number of atoms in 12g of ^{12}C.

Percent yield (Actual yield / theoretical yield) x 100%

amu Atomic mass unit, the mass of a proton or neutron.

Weak electrolyte An ionic substance that only ionizes slightly so it doesn't carry much current in aqueous solution.

Strong acid An substance that ionizes completely to produce H^+ ions in solution.

4. (12 points) I want to generate 10 grams of Cr_2S_3 using the reaction:

$$16\ Cr(s) + 3\ S_8(s) \rightarrow 8\ Cr_2S_3(s)$$

Assuming the reaction only has a 20% yield, how much Cr(s) and S_8(s) do I need?

% yield = Actual/Theoretical x 100%
20% = 10g/Xg x 100%; 20/100 = 10/X; 0.2=10/X; X=10/0.2 ; X = 50
so need 50g yield

$$50\ g\ Cr_2S_3 \times \frac{1\ mole\ Cr_2S_3}{200.21 g\ Cr_2S_3} \times \frac{16\ mole\ Cr}{8\ mole\ Cr_2S_3} \times \frac{52.0 g\ Cr}{mole\ Cr} = 25.93 g\ Cr$$

$$50\ g\ Cr_2S_3 \times \frac{1\ mole\ Cr_2S_3}{200.21 g\ Cr_2S_3} \times \frac{3\ mole\ S_8}{8\ mole\ Cr_2S_3} \times \frac{256.56 g\ S_8}{mole\ S_8} = 24.03 g\ S_8$$

5. (12 points) What are the rules we use to predict the solubility of salts in water?

1. Most nitrate salts are soluble
2. Most Alkali metal and ammonium salts are soluble
3. Cl^-, Br^- and I^- salts are usually soluble except Ag^+, Pb^{2+} , and Hg_2^{2+}
4. Most Sulfates are soluble except Ba^{2+}, Pb^{2+}, Hg_2^{2+}, and Ca^{2+}
5. Hydroxides are only slightly soluble except Na and K that are completely soluble
6. S^{2-}, CO_3^{2-}, CrO_4^{2-} and PO_4^{3-}salts are only slightly soluble

6A. (4 points) What is the molar concentration of each of the ions you get when you dissolve 1 g of H_2SO_4 in 150 mLs of water?

$H_2SO_4 \rightarrow 2H^+ (aq) + SO_4^{2-}(aq)$

1 g H_2SO_4 x (1 mole/98.096 g) = .0102 moles H_2SO_4

.0102 moles H_2SO_4 x (2 moles H^+/1 mole H_2SO_4) = .0204 moles H^+
.0204 moles H^+ / .150L = **.136M H^+**

.0102 moles H_2SO_4 x (1moles SO_4^{2-}/1 mole H_2SO_4) = .0102 moles SO_4^{2-}
.0104 moles H^+ / .150L = **.068M SO_4^{2-}**

B. (8 points) How much Iron(III) hydroxide do I need to neutralize the above Sulfuric acid solution?

$3H_2SO_4 (aq)+ 2Fe(OH)_3 (s) = 6H_2O (l)+ Fe_2(SO_4)_3(s)$

.0102 moles H_2SO_4 x (2 moles $Fe(OH)_3$/3 moles H_2SO_4) = .0068 moles $Fe(OH)_3$

.0068 moles $Fe(OH)_3$ x 106.874 g/mol = .726 g $Fe(OH)_3$

7. Find the oxidation state for each element in the following compounds or elements

S_8(s) (elemental form of sulfur)
S=0

NO_2^- (aq)
O= -2
-1 = 2(O) + 1(N) : -1 = 2(-2) +1(N) : -1 = -4 +N: **N=+3**

Magnesium sulfate
$MgSO_4$ when ionized gives $Mg^{2+} + SO_4^{2-}$
Mg=+2
O=-2
-2 = S + 4(O) : -1 = S +4(-2) : -1 = S-8 : -1+8 = S : **S=+7**

Carbon tetrafluoride
CF_4
F= -1
0 = C + 4(F) : 0 = C + 4(-1) : 0=C - 4 : 0+4=C: **C=+4**

8 Balance the following redox reactions
In acid or neutral conditions

$H^+(aq) + Cr_2O_7^-(aq) + C_2H_5OH(l) \rightarrow Cr^{3+}(aq) + CO_2(g) + H_2O(l)$

$Cr_2O_7^- \rightarrow Cr^{3+}$	$C_2H_5OH \rightarrow CO_2$
$Cr_2O_7^- \rightarrow 2Cr^{3+}$	$C_2H_5OH \rightarrow 2CO_2$
$Cr_2O_7^- \rightarrow 2Cr^{3+} + 7H_2O$	$3H_2O + C_2H_5OH \rightarrow 2CO_2$
$14H^+ + Cr_2O_7^- \rightarrow 2Cr^{3+} + 7H_2O$	$3H_2O + C_2H_5OH \rightarrow 2CO_2 + 12H^+ + 12\ e^-$
$14H^+ + Cr_2O_7^- + 7e^- \rightarrow 2Cr^{3+} + 7H_2O$	$3H_2O + C_2H_5OH \rightarrow 2CO_2 + 12H^+ + 12\ e^-$
x12	x7
$168\ H^+ + 12Cr_2O_7^- + 84e^- \rightarrow 24Cr^{3+} + 84H_2O$	$21H_2O + 7C_2H_5OH \rightarrow 14CO_2 + 84H^+ + 84e^-$

$168\ H^+ + 12Cr_2O_7^- + 84e^-\ 21H_2O + 7C_2H_5OH \rightarrow 14CO_2 + 84H^+ + 84e^- + 24Cr^{3+} + 84H_2O$
$84\ H^+ + 12Cr_2O_7^- + 7C_2H_5OH \rightarrow 14CO_2 + 24Cr^{3+} + 63H_2O$
$84\ H^+(aq) + 12Cr_2O_7^-(aq) + 7C_2H_5OH(l) \rightarrow 14CO_2(g) + 24Cr^{3+}(aq) + 63H_2O(l)$

In BASIC conditions

$CN^-(aq) + MnO_4^-(aq) \rightarrow CNO^-(aq) + MnO_2(s)$

$CN^- \rightarrow CNO^-$	$MnO_4^- \rightarrow MnO_2$
$H_2O + CN^- \rightarrow CNO^-$	$MnO_4^- \rightarrow MnO_2 + 2H_2O$
$H_2O + CN^- \rightarrow CNO^- + 2H^+$	$4H^+ + MnO_4^- \rightarrow MnO_2 + 2H_2O$
$H_2O + CN^- \rightarrow CNO^- + 2H^+ + 2e^-$	$3e^- + 4H^+ + MnO_4^- \rightarrow MnO_2 + 2H_2O$
x3	X2
$3H_2O + 3CN^- \rightarrow 3CNO^- + 6H^+ + 6e^-$	$6e^- + 8H^+ + 2MnO_4^- \rightarrow 2MnO_2 + 4H_2O$

$3H_2O + 3CN^- + 6e^- + 8H^+ + 2MnO_4^- \rightarrow 2MnO_2 + 4H_2O + 3CNO^- + 6H^+ + 6e^-$

$3CN^- + 2H^+ + 2MnO_4^- \rightarrow 2MnO_2 + 1H_2O + 3CNO^-$
$3CN^- + 2H^+ + 2OH^- + 2MnO_4^- \rightarrow 2MnO_2 + 1H_2O + 3CNO^- + 2\ OH^-$
$3CN^- + 2H_2O + 2MnO_4^- \rightarrow 2MnO_2 + 1H_2O + 3CNO^- + 2\ OH^-$
$3CN^- + H_2O + 2MnO_4^- \rightarrow 2MnO_2 + 3CNO^- + 2\ OH^-$
$3CN^-(aq) + H_2O(l) + 2MnO_4^-(aq) \rightarrow 2MnO_2(s) + 3CNO^-(aq) + 2\ OH^-(aq)$