Problem Set 3: Atoms & Moles KEY

$N_A = 6.022 \times 10^{23}$ units/mol

1. How many entities are present in each of the following:
   a. 3.21 mol argon atoms

   $3.21 \text{ mol Ar atoms} \times \frac{6.022 \times 10^{23} \text{ atoms}}{1 \text{ mol}} = 1.93 \times 10^{24}$ Ar atoms

   b. 1.3×10^{-12} mol marbles

   $1.3 \times 10^{-12} \text{ mol marbles} \times \frac{6.022 \times 10^{23} \text{ marbles}}{1 \text{ mol}} = 7.8 \times 10^{11}$ marbl

   c. ~~Nitrogen~~ Carbon atoms in 2.0 g of trinitrotoluene (TNT), $C_7H_5N_2O_6$

   $2.0 \text{ g TNT} \times \frac{1 \text{ mol}}{213.13 \text{ g}} \times \frac{7 \text{ mol C}}{1 \text{ mol TNT}} \times \frac{6.022 \times 10^{23} \text{ atoms}}{1 \text{ mol}} = 4.0 \times 10^{22}$ C atoms

   MW: C = 12.01 × 7 = 84.07
   H = 1.0079 × 5 = 5.0395
   N = 14.01 × 2 = 28.02
   O = 16.00 × 6 = 96.00
   213.13 g/mol

2. Fill in the blanks in the table (one column per element or ion)

Symbol	^{58}Ni	$^{59}Co^{2+}$	^{20}Ne	X
# protons	28	27	10	
# neutrons	58-28 = 30	59-27 = 32	10	
# electrons	28	25	10	

3. Naturally occurring uranium consists of two isotopes, whose masses and abundances are shown below.

Isotope	Abundance	Mass
^{235}U	0.720%	235.044 amu
^{238}U	99.275%	238.051 amu

Only ^{235}U can be used as fuel in a nuclear reactor, so uranium for use in the nuclear industry must be enriched in this isotope. If a sample of enriched uranium has an average atomic mass of 235.684 amu, what percentage of ^{235}U is present?

atomic mass = Σ(isotope mass)(abundance)

$x + y = 1$

$y = 1 - x$

(alternatively $x = 1 - y$)

235.684 amu = (235.044 amu)(x) + (238.051 amu)(y)

235.684 amu = 235.044x + 238.051(1−x)

235.684 amu = 235.044x + 238.051 − 238.051x

−2.367 am = −3.007x

x = 0.79

79% ^{235}U

4. I have two pennies—one dated 1977 and the other dated 1999. I was asked if each penny contained the same number of copper atoms. The logical answer is yes (you would at least expect it to be close). The real answer is no. They look the same, but the 1977 penny weighs 3.11 g and the 1999 penny weighs 2.5 g. I looked into this and found out that the penny underwent a change in ~1982. Prior to 1982 the penny was roughly 95% copper and now it is only 2.5% copper (the rest is zinc). How many copper atoms are there in each of my pennies?

$3.11 g \cdot 0.95 = 2.95 g\ Cu \times \frac{1\ mol\ Cu}{63.55\ g\ Cu} \times \frac{6.022\times10^{23}\ atoms}{1\ mol\ Cu} = 2.80\times10^{22}$ Cu atoms

$2.5 g \times 0.025 = 0.0625 g\ Cu \times \frac{1\ mol\ Cu}{63.55\ g\ Cu} \times \frac{6.022\times10^{23}\ atoms}{1\ mol\ Cu} = 5.9\times10^{20}$