Avogadro's Number and the Mole

1. What number of iron atoms, each weighing 55.847 u, is necessary to get 55.847 g of Fe?

   This is the definition of Avogadro's number.

2. What quantity (in moles) of atoms of titanium are in 53.99 g of Ti? How many atoms is this?

$$n = 53.99\text{g} \times \frac{1\text{ mol}}{47.88\text{ g}} = 1.128\text{ mol Ti}$$

$$N = 1.1276\text{ mol} \cdot 6.022 \times 10^{23}\ {}^{\text{atoms}}\!/\!_{\text{mol}} = 6.79 \times 10^{23}\text{ atoms Ti}$$

3. (On-your-own problem) At \$450/oz (1 oz = 32 g), how much is 1.0 million atoms (1.0 x 10^6 atoms) of gold worth (in dollars)?

$$Amount = 1.0 \times 10^{6}\text{atoms Au}\left(\frac{1\text{mol}}{6.022 \times 10^{23}\text{ atoms}}\right)\left(196.97\,\tfrac{\text{g}}{\text{mol}}\right)\left(\frac{1\text{ oz}}{32\text{ g}}\right)\left(\frac{\$450}{\text{oz}}\right)$$

$$Amount = \$4.6 \times 10^{-15} \quad \text{not very much (not very many atoms)}$$

4. (Another take-home problem) Show that since 6.022 x 10^{23} atoms is 1 mol, that 6.022 x 10^{23} u is 1.00 g

5. How many atoms of iron are in 0.0255 mol of Fe? What mass, in g, is represented by 0.0255 mole of iron?

$$N = 0.0255 \text{ mol Fe} \cdot 6.022 \times 10^{23} \tfrac{\text{atoms}}{\text{mol}} = 1.54 \times 10^{23} \text{atoms Fe}$$

$$m = 0.0255 \text{ mol Fe} \times 55.847 \text{ g/mol} = 1.42 \text{ g Fe}$$

6. One molecule of CO_2 has a mass of 44.010 u. How many moles of CO_2 are in 15.01 g of the gas? How many molecules is this?

$$M = 44.010 \text{ g/mol}$$

$$n = 15.01 \text{ g } CO_2 \times \frac{1 \text{ mol}}{44.010 \text{ g}} = 0.3411 \text{ mol } CO_2$$

$$N = 0.3411 \text{ mol } CO_2 \cdot 6.022 \times 10^{23} \text{ molecules/mol } 2.054 \times 10^{23} \text{ molecules}$$

7. How many atoms of hydrogen are contained in 0.123 g of water?

$$M_{H_2O} = 18.015 \text{ g/mol}$$

$$N_H = 0.123 \text{ g } H_2O \times \frac{1 \text{mol } H_2O}{18.015 \text{ g } H_2O} \times \frac{2 \text{ mol H}}{1 \text{ mol } H_2O} \times 6.022 \times 10^{23} \text{ atoms/mol} = 8.22 \times 10^{21} \text{ atoms H}$$

8. (Another take-home...yes, another one) How many nitrogen atoms are in 1.50 g of the fertilizer ammonium phosphate, $(NH_4)_3PO_4$?

(The answer is 1.82×10^{22} atoms of N, I think)

$$M_{(NH_4)_3PO_4} = 149.09 \text{ g/mol}$$

$$N_N = 1.50 \text{ g } (NH_4)_3PO_4 \times \frac{1 \text{ mol}}{149.09 \text{ g}} \times \frac{3 \text{ mol N}}{1 \text{ mol } (NH_4)_3PO_4} \times \left(6.022 \times 10^{23} \text{ atom/mol}\right) = 1.82 \times 10^{22} \text{ atoms N}$$