Moles and Molecules

A molecule is the smallest possible unit of a compound. It consists of two or more atoms chemically bonded together.

A molecule of hydrogen fluoride, HF, is made up of 1 hydrogen atom bonded to 1 fluorine atom. Since a hydrogen atom weighs 1.0 amu and a fluorine atom weighs 19.0 amu, 1 molecule of HF weighs 1.0 amu + 19.0 amu = 20.0 amu.

A molecule of carbon tetrafluoride, CF_4 , is made up of 1 carbon atom bonded to 4 fluorine atoms. Each carbon atom weighs 12.0 amu and each fluorine atom weighs 19.0 amu so 1 CF_4 molecule weighs 1×12.0 amu + 4×19.0 amu = 88.0 amu. This number, 88.0, is called the molecular weight (or molecular mass) of CF_4. It is obtained by adding the atomic weights of all the atoms in the compound.

The molecular weight of a compound is the sum of all the atomic weights in a molecule. Just like atomic weights are the relative masses of atoms relative to carbon-12, which is assigned a mass of 12.00000, molecular weights are relative masses of molecules relative to the mass of a carbon-12 atom. For example, the molecular weight of C_2H_5Cl is 2×12.01 + 5×1.008 + 1×35.45 = 64.51 .

One mole of molecules is 6.022×10^{23} molecules. One mole of HF is 6.022×10^{23} molecules of HF. Since each HF molecule (weighing 20.0 amu) is 20.0 times as heavy as a hydrogen atom (weighing 1.0 amu), 1 mole of HF molecules must weigh 20.0 times as much as 1 mole of H atoms. Since 1 mole of H atoms weigh 1.0 g, then 1 mole HF molecules must weigh 20.0 g.

So just like for atoms: 1 mole H = 6.022×10^{23} atoms H = 1.0 g H (the atomic weight in grams)
1 mole HF = 6.022×10^{23} molecules HF = 20.0 g HF (the molecular weight in grams)
Likewise 1 mole CF_4 = 6.022×10^{23} molecules CF_4 = 88.0 g CF_4

Also 1 mole CF_4 = 6.022×10^{23} molecules CF_4 = 6.022×10^{23} atoms C + 4×6.022×10^{23} atoms F, since each molecule of CF_4 contains 1 atom of C and 4 atoms of F.
So 1 mole CF_4 = 1 mole C + 4 moles F = 12.0 g C + 4×19.0 g F = 88.0 g CF_4

Try the following problems:

1. 3 molecules of CF_4 contains how may atoms of carbon and how may atoms of fluorine?
2. 3.00 moles CF_4 contains how many moles of fluorine and how many grams of fluorine?
3. 3.00 grams CF_4 contains how many molecules of CF_4 and how many grams of carbon?
4. 3.00×10^{22} molecules of SnF_4 contain how many grams of SnF_4 and how many moles of fluorine?
5. 3.00 g IF_7 contain how many atoms of I, how many moles of IF_7, and how may grams of F?

Answers:

1. 3 atoms C , 12 atoms F 2. 12.0 mol F , 228.0 g F
3. 2.05×10^{22} molecules CF_4 , 0.409 g C 4. 9.70 g SnF_4 , 0.199 mol F
5. 6.95×10^{21} atoms I , 0.0115 mole IF_7 , 1.54 g F

Selected Solutions:

1. 3 molec CF_4 = ? atoms C

$$3 \text{ molec } CF_4 = 3 \text{ molec } CF_4 \times \frac{1 \text{ atom C}}{1 \text{ molec } CF_4} = 3 \text{ atoms C}$$

2. 3.00 mol CF_4 = ? g F

$$3.00 \text{ mol } CF_4 = 3.00 \text{ mol } CF_4 \times \frac{4 \text{ mol F}}{1 \text{ mol } CF_4} \times \frac{19.0 \text{ g F}}{1 \text{ mol F}} = 228.0 \text{ g F}$$

3. 3.00 g CF_4 = ? molec CF_4 mw = 12.01 + 4x19.00 = 88.01

$$3.00 \text{ g } CF_4 = 3.00 \text{ g } CF_4 \times \frac{6.022\text{x}10^{23} \text{ molec } CF_4}{88.01 \text{ g } CF_4} = 2.05\text{x}10^{22} \text{ molec } CF_4$$

4. $3.00\text{x}10^{22}$ molecules SnF_4 = ? g SnF_4 mw = 118.71 + 4×19.00 = 194.7

$$3.00\text{x}10^{22} \text{ molec } SnF_4 = 3.00\text{x}10^{22} \text{ molec } SnF_4 \times \frac{194.7 \text{ g } SnF_4}{6.022\text{x}10^{23} \text{ molec } SnF_4} = 9.70 \text{ g } SnF_4$$

$$= 3.00\text{x}10^{22} \text{ molec } SnF_4 \times \frac{1 \text{ mol } SnF_4}{6.022\text{x}10^{23} \text{ molec } SnF_4} \times \frac{4 \text{ mol F}}{1 \text{ mol } SnF_4} = 0.199 \text{ mol F}$$

5. $$3.00 \text{ g } IF_7 = 3.00 \text{ g } IF_7 \times \frac{1 \text{ mol I}}{259.9 \text{ g } IF_7} \times \frac{6.022\text{x}10^{23} \text{ atoms I}}{1 \text{ mol I}} = 6.95\text{x}10^{21} \text{ atoms I}$$

$$3.00 \text{ g } IF_7 = 3.00 \text{ g } IF_7 \times \frac{1 \text{ mol } IF_7}{259.9 \text{ g } IF_7} = 0.0155 \text{ mol } IF_7$$

$$3.00 \text{ g } IF_7 = 3.00 \text{ g } IF_7 \times \frac{7 \text{ mol F}}{259.9 \text{ g } IF_7} \times \frac{19.00 \text{ g F}}{1 \text{ mol F}} = 1.54 \text{ g F}$$