

Exercise #1

Atomic Masses

1. The average mass of pennies minted after 1982 is 2.50 g and the average mass of pennies minted before 1982 is 3.00 g. In a sample that contains 90.0% new and 10.0% old pennies, what is the overall average mass of pennies in this sample? (Answer: 2.55 g)

2. A mass spectrometer computed the atomic mass ratio of fluorine to carbon-12 as 1.58320-to-1. If the atomic mass of carbon-12 is 12 *amu* (exactly), determine the atomic mass of fluorine in *amu*. (Answer: 18.9984 *amu*)

3. Natural boron is composed of two isotopes: 19.78% boron-10 (atomic mass = 10.0129 *amu*) and 80.22% boron-11 (atomic mass = 11.0093 *amu*). What is the average atomic mass of naturally occurring boron? (Answer: 10.81 *amu*)

4. Magnesium has three natural isotopes with the following masses and natural abundances:
 ^{24}Mg : abundance = 79.00%; atomic mass = 23.9850 *amu*;
 ^{25}Mg : abundance = 10.00%; atomic mass = 24.9858 *amu*;
 ^{26}Mg : abundance = 11.00%; atomic mass = 25.9826 *amu*.
Calculate the average atomic mass of naturally occurring magnesium.
(Answer: 24.30 *amu*)

5. Chlorine has two naturally occurring isotopes with the following atomic masses: ^{35}Cl = 34.9689 *amu* and ^{37}Cl = 36.9659 *amu*. If the average atomic mass of chlorine is 35.453 *amu*, calculate the percent abundances of isotopes ^{35}Cl and ^{37}Cl in nature?
(Answer: 75.76% isotope ^{35}Cl and 24.24% isotope ^{37}Cl)

Exercise #2

Counting by Mass

- (a) What is the mass of one silicon atom in *amu* and in gram?

(b) What is the total mass of one trillion silicon atoms in *amu* and in gram?

(c) What is the total mass of 6.022×10^{23} silicon atoms in *amu* and in gram?
(Give the answers in 4 significant figures)

(d) How many silicon atoms are present in a 5.00-g sample of pure silicon? Can a sample of silicon weigh 5.00 *amu*? Why or why not.

(Answers: (a) 28.09 *amu*; 4.664×10^{-23} g; (b) 2.809×10^{13} *amu*; 4.664×10^{-11} g;
(c) 1.692×10^{25} *amu*; 28.09 g; (d) 1.07×10^{23} atoms; *None* – less than atomic mass)

- The atomic mass of carbon is 12.01 *amu* and the atomic mass of silicon is 28.09 *amu*. (a) What mass of silicon contains the same number of atoms as there are carbon atoms in 2.50 g of carbon? (b) What mass of carbon contains as many atoms as there are silicon atoms in 5.00 g of silicon? (c) How many atoms are present in each sample?
(Answer: (a) 5.85 g Si; (b) 2.14 g C; (c) 1.25×10^{23} atoms of each)
- There are approximately 5.5 millions red blood cells per cubic inch in a healthy adult and an average adult has approximately 5.0 L of blood. (a) How many red blood cells (RBC) does an average adult have? (b) If a person donates 1.0 pint of whole blood per visit to the Red Cross, how many RBC does he/she give away? (c) Suppose that the blood of an average adult male contains a total of 2.8 g of iron. How many iron atoms are present in each RBC? (d) The red blood cells contain protein known as hemoglobin, which gives the cells the red color. This red color is due to the “heme” group in the protein that contains Fe-atoms. If there are four (4) iron atoms per hemoglobin molecule, what is the average number of hemoglobin molecules per RBC? (1 inch = 2.54 cm; 1 pint = 473 mL)
(Answer: (a) 1.7×10^9 RBC; (b) 1.6×10^8 RBC; (c) 1.8×10^{13} Fe-atoms/RBC;
(d) 4.5×10^{12} hemoglobin molecules per RBC)

Exercise #3

Percent Composition, Empirical Formula, and Molecular Formula

1. A sample of sodium carbonate was found to contain 11.50 g sodium, 3.00 g carbon, and 12.00 g oxygen. (a) Calculate the percent composition (by mass) of sodium carbonate. (b) Determine the empirical formula of sodium carbonate.
(Answer: (a) 43.40% Na; 11.32% C, and 45.28% O; (b) Empirical formula = Na_2CO_3)

2. When 0.424 g of finely divided iron is burned and completely converted into its oxide, 0.606 g of a reddish brown oxide is obtained. (a) Determine the empirical formula of the oxide. (b) Write a balanced equation for the reaction of iron and molecular oxygen based on this empirical formula.
(Answer: Empirical formula = Fe_2O_3 ; $4\text{Fe} + 3\text{O}_2 \rightarrow 2\text{Fe}_2\text{O}_3$)

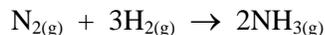
3. One of the chlorofluorocarbon (CFC) compounds used in the refrigeration unit has the following compositions: 18.07% Carbon, 28.59% Fluorine, and 53.34% Chlorine, by mass. (a) Determine the empirical formula of the compound. (b) What is the molecular formula of the compound if the molecular mass is 133 *amu*?
(Answer: Empirical formula = CClF ; molecular formula = $\text{C}_2\text{Cl}_2\text{F}_2$)

4. A compound is composed of carbon, hydrogen, oxygen, and nitrogen. When a 1.505-g sample of the compound is completely combusted, it yields 2.230 g of CO_2 and 1.065 g of H_2O . In a separate reaction, 2.500 g of the compound is reduced and yields 0.393 g of N_2 gas. (a) Calculate the mass percent of carbon, hydrogen, nitrogen, and oxygen, respectively, in the compound. (b) Determine the empirical formula of the compound.
(Answer: 75.91% C; 6.36% H, and 17.73% N; empirical formula = $\text{C}_5\text{H}_5\text{N}$)

Exercise #4

Reaction Stoichiometry

1. Ammonia is produced from the reaction with hydrogen according to the following equation:

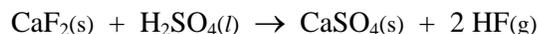


- (a) If 25 N₂ molecules are reacted with 60 H₂ molecules in a sealed container, which molecule will be completely consumed?
(b) Which molecules will be in excess and how many of these molecules are unreacted?
(c) How many NH₃ molecules are formed?
(d) According to the above equation, If 118 g of nitrogen gas is reacted with 31.5 g of hydrogen gas, which reactant will be completely consumed at the end of the reaction? How many grams of the excess reactant will remain (unreacted)? How many grams ammonia will be produced when the limiting reactant is completely reacted and the yield is 100%?
(e) How many grams of nitrogen gas are required to react with 31.5 g of hydrogen gas?
- (Answer: (a) H₂ is completely consumed; (b) 5 N₂ molecules in excess; (c) 40 NH₃ molecules;
(d) N₂ is completely consumed; 6.0 g of H₂ in excess; 143 g NH₃ produced;
(e) 146 g of N₂ needed to react with 31.5 g of H₂)

2. In a reaction to produce ammonia, the reactor is charged with N₂ and H₂ gases at flow rates of 805 g and 195 g per minute, respectively, at 227°C.
- (a) Determine the limiting reactant.
(b) What is the rate (in g/min) for the production of ammonia at this temperature if :(i) the yield is 100%; (ii) the yield is 95.0%?
(c) If this reaction produce 915 g of NH₃, calculate the percentage yield.

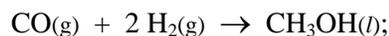
(Answer: (a) N₂ is the limiting reactant; (b) 979 g of NH₃/min at 100%; 930.g NH₃ at 95.0%;
(c) 93.5% yield)

3. Hydrogen fluoride is prepared by the reaction of calcium fluoride with concentrated sulfuric acid according to the following equation:



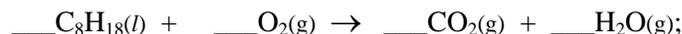
- (a) In a particular reaction, 98.5 g of calcium fluoride was reacted with 138 g of concentrated sulfuric acid. How many grams of HF were formed if the yield is 100%? (b) If the reaction produced 46.0 grams of HF, what is the percentage yield? (Concentrated sulfuric acid is 98.0%, by mass, in H₂SO₄)
- (Answer: (a) 50.5 g; (b) 91.3%)

4. Methanol is produced by the following reaction:



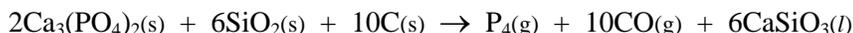
How many grams of CO and H₂, respectively, are needed to produce 1.00 gallon of methanol if the reaction has a percentage yield of 95.0%? (1 gall = 3.7854 L; density of methanol = 0.790 g/mL)
(Answer: 2.75 x 10³ g CO and 396 g H₂)

5. Balance the following equation that represents the complete combustion of octane in gasoline.



How many kilograms of CO₂ are produced when 1.00 L of octane (C₈H₁₈, density = 0.692 g/mL) is completely combusted and the reaction has 95.0% yield efficiency?
(Answer: 2.13 kg of CO₂)

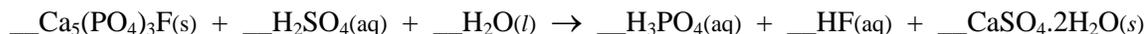
6. Phosphorus is produced from phosphate rocks, Ca₃(PO₄)₂, using the following reaction:



- (a) How many kilograms of phosphorus can be produced from 1.00 metric tonne of Ca₃(PO₄)₂ if the yield is 91.0%? (Assume the other reactants are in excess.) (1 metric tonne = 1000 kg)
(b) How many kilograms of CO and CaSiO₃, respectively, are produced as by-products?

(Answers: (a) 182 kg of P₄; (b) 411 kg of CO and 1020 kg of CaSiO₃)

7. (a) Balance the following equation:



When calcium phosphate fluoride, Ca₅(PO₄)₃F, is reacted with concentrated sulfuric acid and water according to above equation (after it is balanced), phosphoric acid, H₃PO₄, hydrofluoric acid, HF, and calcium sulfate dehydrate, CaSO₄·2H₂O, are produced. (b) How many kilograms of each product are produced when 908 kg of Ca₅(PO₄)₃F are completely reacted? Assume the other reactants are in excess and the reaction has 100% yield?

(Answer: (b) 529 kg of H₃PO₄; 36.0 kg of HF, and 1550 kg of CaSO₄·2H₂O)