

**Chemistry for Earth Scientists**  
**Practical 1: Atomic Theory and Stoichiometry**  
**(Worked Solutions)**

*Use the unit-factor method to solve all of these problems (no matter how easy!)*

1. How many seconds in a year?

Solution:

$$1 \text{ year} \times \frac{365 \text{ days}}{\text{year}} \times \frac{24 \text{ hours}}{\text{day}} \times \frac{60 \text{ min}}{\text{hour}} \times \frac{60 \text{ secs}}{\text{min}} = 3.1536 \times 10^7 \text{ seconds}$$

2. How many inches are in a kilometer? There are 5280 feet/mile, 12 inches/foot and 0.62 miles/km.

$$1 \text{ km} \times \frac{0.62 \text{ mile}}{\text{km}} \times \frac{5280 \text{ ft}}{\text{mile}} \times \frac{12 \text{ inches}}{\text{foot}} = 3.9 \times 10^4 \text{ inches}$$

3. You are having a party and want to invite 15 people. Each person will need 4 slices of pizza. Each pizza costs £16 and has 12 slices. How much will this cost?

Solution:

$$15 \text{ people} \times \frac{4 \text{ slices}}{\text{person}} \times \frac{1 \text{ Pizza}}{12 \text{ slices}} \times \frac{£16}{\text{Pizza}} =$$

4. A rock contains 20 ppm Au. This is the same as 20 mg Au per kg of rock. How many kg of rock are needed to get 1 g of Au?

$$1 \text{ g Au} \times \frac{1 \text{ kg rock}}{20 \text{ mg Au}} \times \frac{1000 \text{ mg}}{1 \text{ g}} =$$

5. An ore contains 10 g Au per 1000 kg. Gold is worth \$1500 an ounce. How many kg of ore must be mined to get £1,000,000? There are 28 g/ounce and \$1.6/£.

Solution:

$$£1,000,000 \times \frac{1 \text{ oz Au}}{\$1500} \times \frac{28 \text{ g Au}}{\text{oz Au}} \times \frac{\$1.6}{£} \times \frac{1000 \text{ kg Ore}}{10 \text{ g Au}} =$$

6. Petrol costs £1.50 per litre. There are 4.5 litres/gallon (imperial). How many euros will it cost you to drive 800 kilometers given that your car gets 30 miles to the gallon and there are 1.45 euros/ £. There are 1.6 km/mile.

Solution:

$$800 \text{ km} \times \frac{1 \text{ mile}}{1.6 \text{ km}} \times \frac{1 \text{ gallon}}{30 \text{ miles}} \times \frac{4.5 \text{ litres}}{\text{gallon}} \times \frac{\text{£}1.50}{\text{litre}} \times \frac{1.45 \text{ euros}}{\text{£}} =$$

7. There are 300 “calories” (actually, kcal) per pint of beer. Upon coming to Bristol, Fred is starting to drink, on average, two pints a day. A rule of thumb is that if he consumes 3500 excess calories, he will generate 1 pound of excess body fat. How much weight will Fred gain in his first year of University?

$$1 \text{ year} \times \frac{365 \text{ days}}{\text{year}} \times \frac{2 \text{ beers}}{\text{day}} \times \frac{300 \text{ kcal}}{\text{beer}} \times \frac{1 \text{ lb fat}}{3500 \text{ kcal}} = 63 \text{ lbs}$$

(Note: he doesn't gain this much because, as is weight increases, is calorie needs increase)

8. How many ng of Pb are in  $1.0 \times 10^{-9}$  moles of lead? The atomic mass of lead is 208.0 grams/mole.

Solution:

$$1.0 \times 10^{-9} \text{ moles Pb} \times \frac{208 \text{ g Pb}}{\text{mol Pb}} \times \frac{1 \text{ ng}}{10^{-9} \text{ g}} = 208 \text{ ng}$$

9. A solution contains 100 mg Pb/kg water. What is the concentration of Pb in moles Pb/kg water? Again, there are 207.2 grams Pb/mole Pb.

$$\frac{100. \text{ mg Pb}}{\text{kg water}} \times \frac{1 \text{ mole Pb}}{207.2 \text{ g Pb}} \times \frac{1 \text{ g}}{1000 \text{ mg}} = 4.83 \times 10^{-4} \text{ moles Pb/kg water}$$

10. 50 grams of NaCl are dissolved in 1 kg of water. What is the concentration of NaCl in moles/kg water? There are 58.0 g NaCl/mole NaCl.

$$\frac{50. \text{ g NaCl}}{\text{kg water}} \times \frac{1 \text{ mole NaCl}}{58.0 \text{ g NaCl}} = 0.86 \text{ moles NaCl/kg water}$$

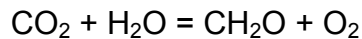
11. In the simple elemental gas phase, oxygen exists as the O<sub>2</sub> molecule. At 1 bar pressure, a mole of O<sub>2</sub> molecules has a volume of 22.4 litres. Given that there are  $6.022 \times 10^{23}$  O<sub>2</sub> molecules in a mole, how much volume in (Å<sup>3</sup>)

is available for each O<sub>2</sub> molecule? Note that there are 1000 cm<sup>3</sup> in a liter and 10<sup>8</sup> Å/cm.

Solution:

$$\frac{22.4 \text{ liters}}{\text{mole}} \times \frac{1 \text{ mole}}{6.022 \times 10^{23} \text{ molecules}} \times \frac{1000 \text{ cm}^3}{\text{liter}} \times \frac{(10^8 \text{ Å})^3}{\text{cm}^3} = 3.72 \times 10^4 \text{ Å}^3$$

12. How much biomass (CH<sub>2</sub>O) in kg would be produced if we removed all the CO<sub>2</sub> from the atmosphere via photosynthesis:



The concentration of CO<sub>2</sub> in the atmosphere is 200 mg/kg, the volume of the atmosphere is 8.14 x 10<sup>18</sup> m<sup>3</sup> and the density of the atmosphere is about 0.5 kg/m<sup>3</sup>.

Solution:

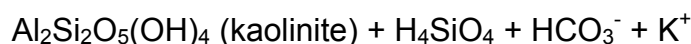
$$\frac{200 \text{ mg CO}_2}{\text{kg Atmos.}} \times \frac{0.5 \text{ kg Atmos.}}{\text{m}^3 \text{ Atmos.}} \times 8.14 \times 10^{18} \text{ m}^3 \text{ Atmos.} \times \frac{1 \text{ mole CH}_2\text{O}}{1 \text{ mole CO}_2}$$

$$\times \frac{30 \text{ g CH}_2\text{O}}{\text{mole CH}_2\text{O}} \times \frac{1 \text{ mole CO}_2}{44 \text{ g CO}_2} \times \frac{1 \text{ g}}{1000 \text{ mg}} \times \frac{1 \text{ kg}}{1000 \text{ g}} =$$

13. How many grams of CO<sub>2</sub> do we generate from burning 1 kg of coal (assume pure carbon). There are 12 grams of carbon in 44 g of CO<sub>2</sub>.

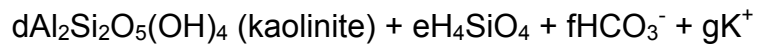
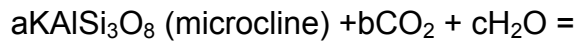
$$1.0 \text{ kg C} \times \frac{1000 \text{ g}}{\text{kg}} \times \frac{44. \text{ g CO}_2}{12. \text{ g C}} = 3.7 \times 10^3 \text{ g CO}_2$$

14. Balance the following reaction for the weathering of feldspar (microcline):



Now, calculate how many moles of CO<sub>2</sub> will be consumed by the weathering of 1 kg of microcline. The atomic masses of Si, Al, K and O are 28.0, 27.0, 39.1 and 16.0 grams/mole, respectively.

Solution:



$$\text{K: } a = g$$

$$\text{Al: } a = 2d$$

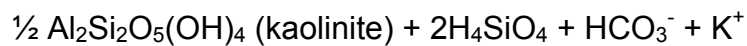
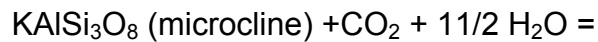
$$\text{Si: } 3a = 2d + e$$

$$\text{O: } 8a + 2b + c = 9d + 4e + 3f$$

$$\text{C: } b = f$$

$$\text{H: } 2c = 4d + 4e + f$$

We have 7 unknowns and 6 equations. Set  $a = 1$  to get  $g = 1$  and  $d = \frac{1}{2}$  and  $e = 2$ . We then get  $8 + c = \frac{9}{2} + 8 + f$  and  $2c = 2 + 8 + f$  to give  $c = \frac{11}{2}$  and  $f=1$  and  $b = 1$



$$1\text{kg Feld.} \times \frac{1 \text{ mole Feld.}}{278.1 \text{ g Feld.}} \times \frac{1000\text{g Feld.}}{\text{kg Feld.}} \times \frac{1 \text{ moles CO}_2}{\text{mole Feld.}} = 3.6 \text{ moles CO}_2$$