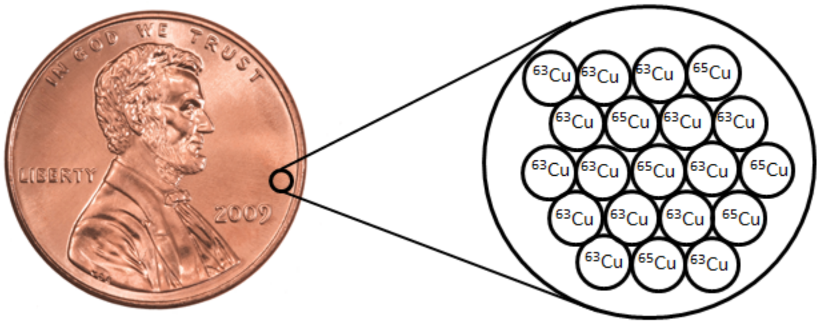
WKS 3-1 – Atomic Mass, Avogadro's Number & Molar Mass, Molecular Mass, Mass Spectrometry

Name: Answer Key

Isotopes of copper

Magnified 1 billion times (×10^9)



A. Does the sample contain identical atoms of copper?

No, the sample contains two different isotopes of copper, copper-63 and copper-65

B. Use the picture above to determine the percent of ^{63}Cu in the sample. What is the percent of ^{65}Cu?

^{63}Cu = 14 atoms   %^{63}Cu = 70%

^{65}Cu = 6 atoms   %^{65}Cu = 30%

C. What is the atomic mass of Cu from the periodic table? Is it closer to 63 amu or 65 amu?

63.55 amu is closer to 63 amu.

D. How does the picture above explain the answer to the previous question?

Since there are more copper-63 atoms, they will make a greater contribution to the weighted average. This is verified by the average atomic weight being closer to 63amu.

3.5 **The atomic masses of $^{35}_{17}Cl$ (75.53%) and $^{37}_{17}Cl$ (24.47%) are 34.968 amu and 36.956 amu, respectively Calculate the average atomic mass of chlorine.**

Avg. atomic mass of Cl = (34.968 amu)(0.7553) + (36.956 amu)(0.2447) = **35.45 amu**

3.6 **The atomic masses of $^{6}_{3}Li$ and $^{7}_{3}Li$ are 6.0151 and 7.0160 amu, respectively. Calculate the natural abundances of these two isotopes. The average atomic mass of Li is 6.941 amu.** (HINT: let x = fractional abundance of ^{6}Li. Thus, $1 - x$ = fractional abundance of ^{7}Li)

Average atomic mass of Li = 6.941 amu = x(6.0151 amu) + $(1 - x)$(7.0160 amu)

$6.941 = 1.0009x + 7.0160$

$1.0009x = 0.075$

$\mathbf{x = 0.075}$

$x = 0.075$ corresponds to a natural abundance of ^{6}Li of **7.5 percent**. The natural abundance of ^{7}Li is $(1 - x) = 0.925$ or **92.5 percent**.

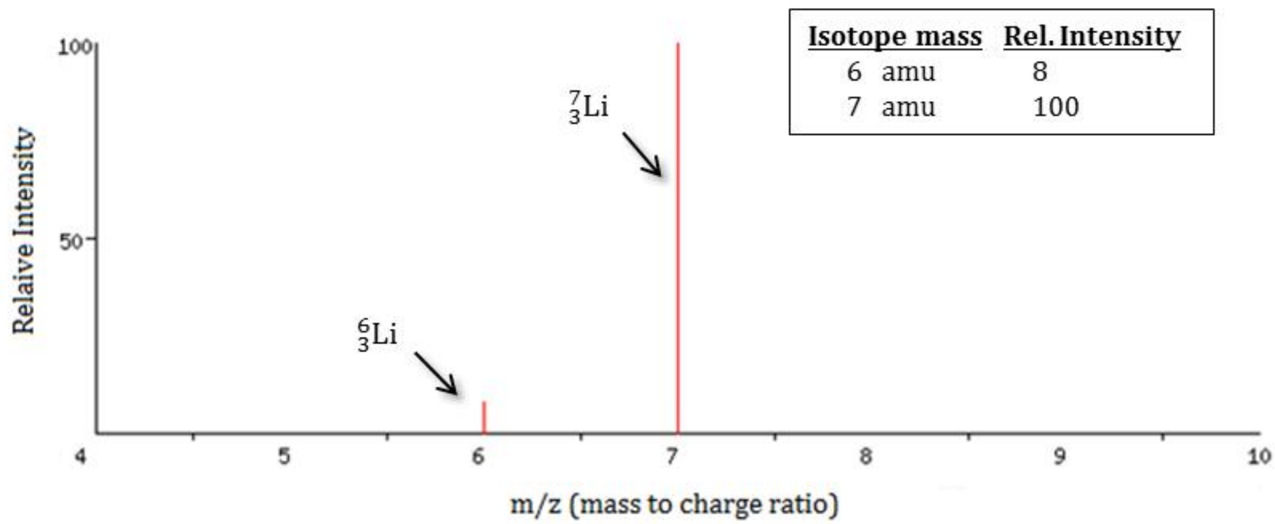
3.31 Describe the operation of a mass spectrometer.

A mass spectrometer shoots a beam of positively-ionized atoms or molecules through a magnetic field, separating the ions by mass (actually charge/mass ratio), and they are detected by a detector that measures a current for each ion that strikes it.

3.32 Describe how you would determine the isotopic abundance of an element from it mass spectrum.

By analyzing the mass peaks for each isotope, the total (integrated) current for each isotope is proportional to its abundance. Dividing the integrated current for each isotope by the total for all isotopes will give the fractional abundance for each isotope.

The graph below was produced when an element, lithium, was analyzed in a mass spectrometer. Use the graph to answer the questions below.



Isotope mass	Rel. Intensity
6 amu	8
7 amu	100

Mass spectrum of Lithium

E. According to the mass spectrum, how many isotopes of Lithium exist?

The mass spectrum represents two isotopes of lithium

F. Label the each peak with the nuclide symbol for each isotope

See spectrum above

G. Without performing any calculations, predict the approximate atomic mass for lithium. Explain the basis for your prediction.

Since there is a greater relative intensity for lithium-7, it will contribute much more to the average atomic mass. The mass should be closer to 7 amu, in a range between 6.9 amu to 7.0 amu.

H. Now calculate the average atomic mass of the element from the mass spectrum data. The height of each peak is the relative intensity, not the % abundance. You will first need to calculate the % abundance and then the average atomic mass.

a) What is the % of the intensity of each peak? $\left(\% = \frac{\text{Peak Intensity}}{\text{Total Intensity}} \times 100\%\right)$

$\text{Peak 1 } \% = \frac{8}{108} \times 100\% = 7.40\%$ $\quad\quad$ $\text{Peak 2 } \% = \frac{100}{108} \times 100\% = 92.6\%$

b) You've just determined the % abundance for each isotope of the element. Use this data and the isotope masses to calculate the average atomic mass of the element.

Average atomic mass = (6 amu)(.0740) + (7 amu)(0.926) = 6.93 amu

3.14 How many moles of cobalt (Co) atoms are there in 6.00 ×10⁹ (6 billion) Co atoms?

$$6.00\times10^{9}\text{ Co atoms} \times \frac{1\text{ mol Co}}{6.022\times10^{23}\text{ Co atoms}} = \boxed{\mathbf{9.96\times10^{-15}\text{ mol Co}}}$$

3.16 How may grams of gold (Au) are there in 15.3 moles of Au?

$$\textbf{? g Au} = 15.3\text{ mol Au} \times \frac{197.0\text{ g Au}}{1\text{ mol Au}} = \boxed{\mathbf{3.01\times10^{3}\text{ g Au}}}$$

3.18 What is the mass in grams of a single atom of each of the following elements?
(a) As:

$$\textbf{? g / As atom} = \frac{74.92\text{ g As}}{1\text{ mol As}} \times \frac{1\text{ mol As}}{6.022\times10^{23}\text{ As atoms}} = \boxed{\mathbf{1.244\times10^{-22}\text{ g / As atom}}}$$

(b) Ni:

$$\textbf{? g / Ni atom} = \frac{58.69\text{ g Ni}}{1\text{ mol Ni}} \times \frac{1\text{ mol Ni}}{6.022\times10^{23}\text{ Ni atoms}} = \boxed{\mathbf{9.746\times10^{-23}\text{ g / Ni atom}}}$$

3.20 How many atoms are present in 3.14 g of copper (Cu)?

$$\textbf{? atoms of Cu} = 3.14\text{ g Cu} \times \frac{1\text{ mol Cu}}{63.55\text{ g Cu}} \times \frac{6.022\times10^{23}\text{ Cu atoms}}{1\text{ mol Cu}} = \boxed{\mathbf{2.98\times10^{22}\text{ Cu atoms}}}$$

3.22 Which of the following has a greater mass: 2 atoms of lead or 5.1×10⁻²³ moles of helium?

$$2\text{ Pb atoms} \times \frac{1\text{ mol Pb}}{6.022\times10^{23}\text{ Pb atoms}} \times \frac{207.2\text{ g Pb}}{1\text{ mol Pb}} = \boxed{\mathbf{6.881\times10^{-22}\text{ g Pb}}}$$ *Greater Mass

$$5.1\times10^{-23}\text{ mol He} \times \frac{4.003\text{ g He}}{1\text{ mol He}} = \boxed{\mathbf{2.0\times10^{-22}\text{ g He}}}$$

3.24 Calculate the molar mass of the following substances:

(a) Li_2CO_3 = 2(6.941 g) + 12.01 g + 3(16.00 g) = **73.89 g/mol**

(b) CS_2 = 12.01 g + 2(32.07 g) = **76.15 g/mol**

(c) $CHCl_3$ = 12.01 g + 1.008 g + 3(35.45 g) = **119.37 g/mol**

(d) $C_6H_8O_6$ = 6(12.01 g) + 8(1.008 g) + 6(16.00 g) = **176.12 g/mol**

(e) KNO_3 = 39.10 g + 14.01 g + 3(16.00 g) = **101.11 g/mol**

(f) Mg_3N_2 = 3(24.31 g) + 2(14.01 g) = **100.95 g/mol**

3.26 How many molecules of ethane (C_2H_6) are present in 0.334 g of C_2H_6?

$$\textbf{? molecules of } \mathbf{C_2H_6} = 0.334\ \text{g } C_2H_6 \times \frac{1\ \text{mol } C_2H_6}{30.07\ \text{g } C_2H_6} \times \frac{6.022\times10^{23}\ C_2H_6\ \text{molecules}}{1\ \text{mol } C_2H_6}$$

$$= \boxed{\mathbf{6.69\times10^{21}\ C_2H_6\ molecules}}$$

3.28 Urea $[(NH_2)_2CO]$ is used for fertilizer and may other things. Calculate the number of N, C, O, and H atoms in 1.68×10^4 g of urea.

$$\textbf{? atoms of N} = 1.68\times10^4\ \text{g urea} \times \frac{1\ \text{mol urea}}{60.06\ \text{g urea}} \times \frac{6.022\times10^{23}\ \text{urea molecules}}{1\ \text{mol urea}} \times \frac{2\ \text{N atoms}}{1\ \text{molecule urea}}$$

$$= \boxed{\mathbf{3.37\times10^{26}\ N\ atoms}}$$

$$\textbf{? atoms of C} = 3.37\times10^{26}\ \text{N atoms} \times \frac{1\ \text{C atom}}{2\ \text{N atoms}} = \boxed{\mathbf{1.69\times10^{26}\ C\ atoms}}$$

$$\textbf{? atoms of O} = 3.37\times10^{26}\ \text{N atoms} \times \frac{1\ \text{O atom}}{2\ \text{N atoms}} = \boxed{\mathbf{1.69\times10^{26}\ O\ atoms}}$$

$$\textbf{? atoms of H} = 3.37\times10^{26}\ \text{N atoms} \times \frac{4\ \text{H atoms}}{2\ \text{N atoms}} = \boxed{\mathbf{6.74\times10^{26}\ H\ atoms}}$$

3.30 The density of water is 1.00 g/mL at 4°C. How many water molecules are present in 2.56 mL of water at this temperature?

$$\text{Mass of water} = 2.56\ \text{mL} \times \frac{1.00\ \text{g}}{1.00\ \text{mL}} = 2.56\ \text{g}$$

$$\textbf{? } \mathbf{H_2O}\ \textbf{mlcls} = 2.56\ \text{mL } H_2O \times \frac{1.00\ \text{g}}{1.00\ \text{mL}} \times \frac{1\ \text{mol } H_2O}{18.02\ \text{g } H_2O} \times \frac{6.022\times10^{23}\ \text{mlcls } H_2O}{1\ \text{mol } H_2O} = \boxed{\mathbf{8.56\times10^{22}\ mlcls}}$$