Skills Worksheet

# Sample Problem Set

## Teacher Notes and Answers

### MOLE CONCEPT

1. a. $3.7 \times 10^{-4}$ mol Pd
   b. 150 mol Fe
   c. 0.040 mol Ta
   d. $5.38 \times 10^{-5}$ mol Sb
   e. 41.1 mol Ba
   f. $3.51 \times 10^{-8}$ mol Mo
2. a. 52.10 g Cr
   b. $1.5 \times 10^{4}$ g or 15 kg Al
   c. $8.23 \times 10^{-7}$ g Ne
   d. $3 \times 10^{2}$ g or 0.3 kg Ti
   e. 1.1 g Xe
   f. $2.28 \times 10^{5}$ g or 228 kg Li
3. a. $1.02 \times 10^{25}$ atoms Ge
   b. $3.700 \times 10^{23}$ atoms Cu
   c. $1.82 \times 10^{24}$ atoms Sn
   d. $1.2 \times 10^{30}$ atoms C
   e. $1.1 \times 10^{21}$ atoms Zr
   f. $1.943 \times 10^{14}$ atoms K
4. a. 10.00 mol Co
   b. 0.176 mol W
   c. $4.995 \times 10^{-5}$ mol Ag
   d. $1.6 \times 10^{-15}$ mol Pu
   e. $7.66 \times 10^{-7}$ mol Rn
   f. $1 \times 10^{-11}$ mol Ce
5. a. $2.5 \times 10^{19}$ atoms Au
   b. $5.10 \times 10^{24}$ atoms Mo
   c. $4.96 \times 10^{20}$ atoms Am
   d. $3.011 \times 10^{26}$ atoms Ne
   e. $2.03 \times 10^{18}$ atoms Bi
   f. $9.4 \times 10^{16}$ atoms U
6. a. 117 g Rb
   b. 223 g Mn
   c. $2.11 \times 10^{5}$ g Te
   d. $2.6 \times 10^{-3}$ g Rh
   e. $3.31 \times 10^{-8}$ g Ra
   f. $8.71 \times 10^{-5}$ g Hf
7. a. 0.749 mol $CH_3COOH$
   b. 0.0213 mol $Pb(NO_3)_2$
   c. $3 \times 10^{4}$ mol $Fe_2O_3$
   d. $2.66 \times 10^{-4}$ mol $C_2H_5NH_2$
   e. $1.13 \times 10^{-5}$ mol $C_{17}H_{35}COOH$
   f. 378 mol $(NH_4)_2SO_4$
8. a. 764 g $SeOBr_2$
   b. $4.88 \times 10^{4}$ g $CaCO_3$
   c. 2.7 g $C_{20}H_{28}O_2$
   d. $9.74 \times 10^{-6}$ g $C_{10}H_{14}N_2$
   e. 529 g $Sr(NO_3)_2$
   f. $1.23 \times 10^{-3}$ g $UF_6$
9. a. $2.57 \times 10^{24}$ formula units $WO_3$
   b. $1.81 \times 10^{21}$ formula units $Sr(NO_3)_2$
   c. $4.37 \times 10^{25}$ molecules $C_6H_5CH_3$
   d. $3.08 \times 10^{17}$ molecules $C_{29}H_{50}O_2$
   e. $9.0 \times 10^{26}$ molecules $N_2H_4$
   f. $5.96 \times 10^{23}$ molecules $C_6H_5NO_2$
10. a. $1.14 \times 10^{24}$ formula units $FePO_4$
    b. $6.4 \times 10^{19}$ molecules $C_5H_5N$
    c. $6.9 \times 10^{20}$ molecules $(CH_3)_2CHCH_2OH$
    d. $8.7 \times 10^{17}$ formula units $Hg(C_2H_3O_2)_2$
    e. $5.5 \times 10^{19}$ formula units $Li_2CO_3$
11. a. 52.9 g $F_2$
    b. $1.19 \times 10^{3}$ g or 1.19 kg $BeSO_4$
    c. $1.388 \times 10^{5}$ g or 138.8 kg $CHCl_3$
    d. $9.6 \times 10^{-12}$ g $Cr(CHO_2)_3$
    e. $6.6 \times 10^{-4}$ g $HNO_3$
    f. $2.38 \times 10^{4}$ g or 23.8 kg $C_2Cl_2F_4$
12. 0.158 mol Au
    0.159 mol Pt
    0.288 mol Ag
13. 0.234 mol $C_6H_5OH$
14. 3.8 g $I_2$
15. $1.00 \times 10^{22}$ atoms C
16. a. 0.0721 mol $CaCl_2$
       55.49 mol $H_2O$
    b. 0.0721 mol $Ca^{2+}$
       0.144 mol $Cl^-$
17. a. 1.325 mol $C_{12}H_{22}O_{11}$
    b. 7.762 mol NaCl
18. 0.400 mol ions
19. 4.75 mol atoms
20. a. 249 g $H_2O$
    b. 13.8 mol $H_2O$
    c. 36.1 mL $H_2O$
    d. 36.0 g $H_2O$
21. The mass of a sugar molecule is much greater than the mass of a water molecule. Therefore, the mass of 1 mol of sugar

molecules is much greater than the mass of 1
mol of water molecules.

22. 1.52 g Al

23. 0.14 mol $O_2$

24. a.  0.500 mol Ag

    0.250 mol S

  b.  0.157 mol $Ag_2S$

    0.313 mol Ag

    0.157 mol S

  c.  33.8 g Ag

    5.03 g S

Skills Worksheet

# Sample Problem Set

## Mole Concept

Suppose you want to carry out a reaction that requires combining one atom of iron with one atom of sulfur. How much iron should you use? How much sulfur? When you look around the lab, there is no device that can count numbers of atoms. Besides, the merest speck (0.001 g) of iron contains over a billion billion atoms. The same is true of sulfur.

Fortunately, you do have a way to relate mass and numbers of atoms. One iron atom has a mass of 55.847 amu, and 55.847 g of iron contains $6.022\ 137 \times 10^{23}$ atoms of iron. Likewise, 32.066 g of sulfur contains $6.022\ 137 \times 10^{23}$ atoms of sulfur. Knowing this, you can measure out 55.847 g of iron and 32.066 g of sulfur and be pretty certain that you have the same number of atoms of each.

The number $6.022\ 137 \times 10^{23}$ is called Avogadro's number. For most purposes it is rounded off to $6.022 \times 10^{23}$. Because this is an awkward number to write over and over again, chemists refer to it as a *mole* (abbreviated mol). $6.022 \times 10^{23}$ objects is called a mole, just as you call 12 objects a dozen.

Look again at how these quantities are related.

$$55.847 \text{ g of iron} = 6.022 \times 10^{23} \text{ iron atoms} = 1 \text{ mol of iron}$$
$$32.066 \text{ g of sulfur} = 6.022 \times 10^{23} \text{ sulfur atoms} = 1 \text{ mol of sulfur}$$

**General Plan for Converting Mass, Amount,
and Number of Particles**
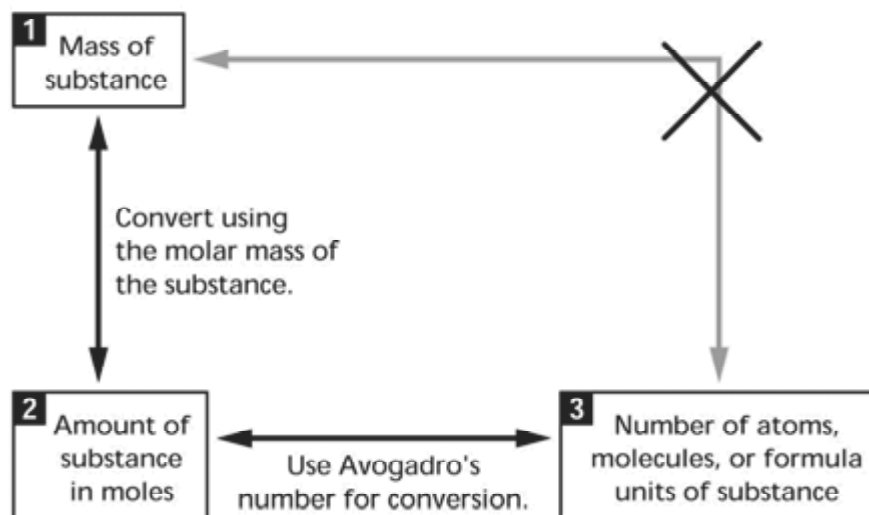
# Problems Involving Atoms and Elements

## SAMPLE PROBLEM 1

**A chemist has a jar containing 388.2 g of iron filings. How many moles of iron does the jar contain?**

# Solution

## ANALYZE

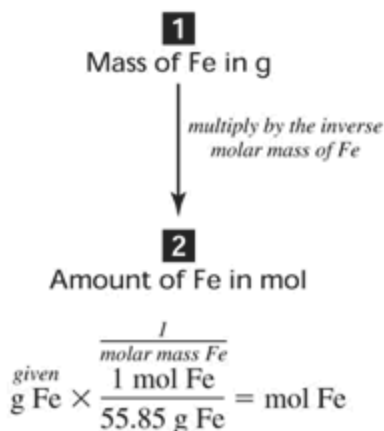What is given in the problem?    **mass of iron in grams**

What are you asked to find?    **amount of iron in moles**

| Items | Data |
|---|---|
| Mass of iron | 388.2 g |
| Molar mass of iron* | 55.85 g/mol |
| Amount of iron | ? mol |

*determined from the periodic table

## PLAN

What step is needed to convert from grams of Fe to number of moles of Fe?
**The molar mass of iron can be used to convert mass of iron to amount of iron in moles.**

<div align="center">

**1**
Mass of Fe in g

*multiply by the inverse molar mass of Fe*

↓

**2**
Amount of Fe in mol

</div>

$$\overset{given}{g\ Fe} \times \overset{\frac{1}{molar\ mass\ Fe}}{\frac{1\ mol\ Fe}{55.85\ g\ Fe}} = mol\ Fe$$

## COMPUTE

$$388.2\,g\,Fe \times \frac{1\ mol\ Fe}{55.85\,g\,Fe} = 6.951\ mol\ Fe$$

## EVALUATE

Are the units correct?
**Yes; the answer has the correct units of moles of Fe.**

Is the number of significant figures correct?
**Yes; the number of significant figures is correct because there are four significant figures in the given value of 388.2 g Fe.**

Is the answer reasonable?
**Yes; 388.2 g Fe is about seven times the molar mass. Therefore, the sample contains about 7 mol.**

## Practice

1. Calculate the number of moles in each of the following masses:

   a. 64.1 g of aluminum **ans: 2.38 mol Al**

   b. 28.1 g of silicon **ans: 1.00 mol Si**

   c. 0.255 g of sulfur **ans: $7.95 \times 10^{-3}$ mol S**

   d. 850.5 g of zinc **ans: 13.01 mol Zn**

## Sample Problem 2

**A student needs 0.366 mol of zinc for a reaction. What mass of zinc in grams should the student obtain?**

## Solution

**ANALYZE**

What is given in the problem?    **amount of zinc needed in moles**

What are you asked to find?    **mass of zinc in grams**

| Items | Data |
|-------|------|
| Amount of zinc | 0.366 mol |
| Molar mass of zinc | 65.39 g/mol |
| Mass of zinc | ? g |

**PLAN**

What step is needed to convert from moles of Zn to grams of Zn?
**The molar mass of zinc can be used to convert amount of zinc to mass of zinc.**

$$\overset{2}{\text{Amount of Zn in mol}} \xrightarrow[\substack{\textit{multiply by the} \\ \textit{molar mass of Zn}}]{} \overset{1}{\text{Mass of Zn in mol}}$$

$$\overset{\textit{given}}{\text{mol Zn}} \times \frac{\overset{\textit{molar mass Zn}}{65.39 \, \text{g Zn}}}{1 \, \text{mol Zn}} = \text{g Zn}$$

**COMPUTE**

$$0.366 \text{ mol Zn} \times \frac{65.39 \text{ g Zn}}{1 \text{ mol Zn}} = 23.9 \text{ g Zn}$$

**EVALUATE**

Are the units correct?
**Yes; the answer has the correct units of grams of Zn.**

Is the number of significant figures correct?
**Yes; the number of significant figures is correct because there are three significant figures in the given value of 0.366 mol Zn.**

Is the answer reasonable?
**Yes; 0.366 mol is about 1/3 mol. 23.9 g is about 1/3 the molar mass of Zn.**

| Sample Problem Set *continued*

## Practice

1. Calculate the mass of each of the following amounts:

a. 1.22 mol sodium **ans: 28.0 g Na**

b. 14.5 mol copper **ans: 921 g Cu**

c. 0.275 mol mercury **ans: 55.2 g Hg**

d. $9.37 \times 10^{-23}$ mol magnesium **ans: 0.228 Mg**

## Sample Problem 3

**How many moles of lithium are there in $1.204 \times 10^{24}$ lithium atoms?**

## Solution

### ANALYZE

What is given in the problem?　　**number of lithium atoms**

What are you asked to find?　　**amount of lithium in moles**

| Items | Data |
|---|---|
| Number of lithium atoms | $1.204 \times 10^{24}$ atoms |
| Avogadro's number—the number of atoms per mole | $6.022 \times 10^{23}$ atoms/mol |
| Amount of lithium | ? mol |

### PLAN

What step is needed to convert from number of atoms of Li to moles of Li?
**Avogadro's number is the number of atoms per mole of lithium and can be used to calculate the number of moles from the number of atoms.**

$$\text{Number of Li atoms} \xrightarrow[\substack{multiply \ \ by \ the \ inverse \ of \\ Avogadro's \ number}]{} \text{Amount of Li in mol}$$

$$\underset{\substack{given}}{\text{atoms Li}} \times \frac{1 \text{ mol Li}}{6.022 \times 10^{23} \text{ atoms Li}} = \text{mol Li}$$

### COMPUTE

$$1.204 \times 10^{24} \text{ atoms Li} \times \frac{1 \text{ mol Li}}{6.022 \times 10^{23} \text{ atoms Li}} = 1.999 , \text{mol Li}$$

### EVALUATE

Are the units correct?
**Yes; the answer has the correct units of moles of Li.**

Is the number of significant figures correct?
**Yes; four significant figures is correct.**

Is the answer reasonable?
**Yes; $1.204 \times 10^{24}$ is approximately twice Avogadro's number. Therefore, it is reasonable that this number of atoms would equal about 2 mol.**

Sample Problem Set *continued*

## Practice

1. Calculate the amount in moles in each of the following quantities:

 a. $3.01 \times 10^{23}$ atoms of rubidium **ans: 0.500 mol Rb**

 b. $8.08 \times 10^{22}$ atoms of krypton **ans: 0.134 mol Kr**

 c. 5 700 000 000 atoms of lead **ans: $9.5 \times 10^{-15}$ mol Pb**

 d. $2.997 \times 10^{25}$ atoms of vanadium **ans: 49.77 mol V**

| Sample Problem Set *continued*

**CONVERTING THE AMOUNT OF AN ELEMENT IN MOLES TO THE NUMBER OF ATOMS**

In Sample Problem 3, you were asked to determine the number of moles in $1.204 \times 10^{24}$ atoms of lithium. Had you been given the amount in moles and asked to calculate the number of atoms, you would have simply multiplied by Avogadro's number. Steps 2 and 3 of the plan for solving Sample Problem 3 would have been reversed.

## Practice

1. Calculate the number of atoms in each of the following amounts:

   a. 1.004 mol bismuth **ans: $6.046 \times 10^{23}$ atoms Bi**

   b. 2.5 mol manganese **ans: $1.5 \times 10^{24}$ atoms Mg**

   c. 0.000 000 2 mol helium **ans: $1 \times 10^{17}$ atoms He**

   d. 32.6 mol strontium **ans: $1.96 \times 10^{25}$ atoms Sr**

| Sample Problem Set *continued*

# Sample Problem 4

**How many boron atoms are there in 2.00 g of boron?**

# Solution

## ANALYZE

What is given in the problem?  **mass of boron in grams**

What are you asked to find?  **number of boron atoms**

| Items | Data |
|---|---|
| Mass of boron | 2.00 g |
| Molar mass of boron | 10.81 g/mol |
| Avogadro's number—the number of boron atoms per mole of boron | $6.022 \times 10^{23}$ atoms/mol |
| Number of boron atoms | ? atoms |

## PLAN

What steps are needed to convert from grams of B to number of atoms of B?
**First, you must convert the mass of boron to moles of boron by using the molar mass of boron. Then you can use Avogadro's number to convert amount in moles to number of atoms of boron.**
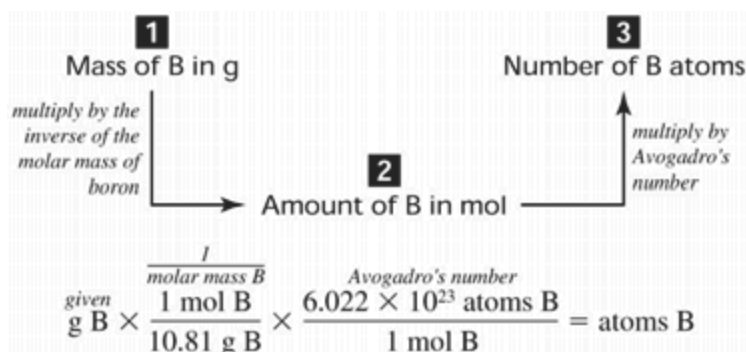


## COMPUTE

$$2.00 \text{ g B} \times \frac{1 \text{ mol B}}{10.81 \text{ g B}} \times \frac{6.022 \times 10^{23} \text{ atoms B}}{1 \text{ mol B}} = 1.11 \times 10^{23} \text{ atoms B}$$

## EVALUATE

Are the units correct?
**Yes; the answer has the correct units of atoms of boron.**

Is the number of significant figures correct?
**Yes; the mass of boron was given to three significant figures.**

| Sample Problem Set *continued* |

Is the answer reasonable?

**Yes; 2 g of boron is about 1/5 of the molar mass of boron. Therefore, 2.00 g boron will contain about 1/5 of an Avogadro's constant of atoms.**

## Practice

1. Calculate the number of atoms in each of the following masses:

   a. 54.0 g of aluminum **ans: $1.21 \times 10^{24}$ atoms Al**

   b. 69.45 g of lanthanum **ans: $3.011 \times 10^{23}$ atoms La**

   c. 0.697 g of gallium **ans: $6.02 \times 10^{21}$ atoms Ga**

   d. 0.000 000 020 g beryllium **ans: $1.3 \times 10^{15}$ atoms Be**

Sample Problem Set *continued*

**CONVERTING NUMBER OF ATOMS OF AN ELEMENT TO MASS**

Sample Problem 4 uses the progression of steps $1 \rightarrow 2 \rightarrow 3$ to convert from the mass of an element to the number of atoms. In order to calculate the mass from a given number of atoms, these steps will be reversed. The number of moles in the sample will be calculated. Then this value will be converted to the mass in grams.

# Practice

1. Calculate the mass of the following numbers of atoms:

    a. $6.022 \times 10^{24}$ atoms of tantalum **ans: 1810. g Ta**

    b. $3.01 \times 10^{21}$ atoms of cobalt **ans: 0.295 g Co**

    c. $1.506 \times 10^{24}$ atoms of argon **ans: 99.91 g Ar**

    d. $1.20 \times 10^{25}$ atoms of helium **ans: 79.7 g He**

| Sample Problem Set *continued*

## Problems Involving Molecules, Formula Units, and Ions

How many water molecules are there in 200.0 g of water? What is the mass of 15.7 mol of nitrogen gas? Both of these substances consist of molecules, not single atoms. Look back at the diagram of the General Plan for Converting Mass, Amount, and Numbers of Particles. You can see that the same conversion methods can be used with molecular compounds and elements, such as $CO_2$, $H_2O$, $H_2SO_4$, and $O_2$.

For example, 1 mol of water contains $6.022 \times 10^{23}$ $H_2O$ *molecules*. The mass of a molecule of water is the sum of the masses of two hydrogen atoms and one oxygen atom, and is equal to 18.02 amu. Therefore, 1 mol of water has a mass of 18.02 g. In the same way, you can relate amount, mass, and number of formula units for ionic compounds, such as $NaCl$, $CaBr_2$, and $Al_2(SO_4)_3$.

## Sample Problem 5

**How many moles of carbon dioxide are in 66.0 g of dry ice, which is solid $CO_2$?**

## Solution

### ANALYZE

What is given in the problem?  **mass of carbon dioxide**

What are you asked to find?  **amount of carbon dioxide**

| Items | Data |
|---|---|
| Mass of $CO_2$ | 66.0 g |
| Molar mass of $CO_2$ | 44.0 g/mol |
| Amount of $CO_2$ | ? mol |

### PLAN

What step is needed to convert from grams of $CO_2$ to moles of $CO_2$?
**The molar mass of $CO_2$ can be used to convert mass of $CO_2$ to moles of $CO_2$.**

$$\underset{\text{multiply by the inverse of the}\\ \text{molar mass of } CO_2}{\overset{1}{\text{Mass of } CO_2 \text{ in g}} \longrightarrow} \overset{2}{\text{Amount of } CO_2 \text{ in mol}}$$

$$\overset{given}{\underset{}{g\,CO_2}} \times \overset{\frac{1}{molar\ mass\ CO_2}}{\frac{1\,\text{mol}\,CO_2}{44.01\,\text{g}\,CO_2}} = \text{mol}\,CO_2$$

### COMPUTE

$$66.0\,\text{g}\,CO_2 \times \frac{1\,\text{mol}\,CO_2}{44.01\,\text{g}\,CO_2} = 1.50\ \text{mol}\,CO_2$$

| Sample Problem Set *continued*

## EVALUATE

Are the units correct?
**Yes; the answer has the correct units of moles $CO_2$.**

Is the number of significant figures correct?
**Yes; the number of significant figures is correct because the mass of $CO_2$ was given to three significant figures.**

Is the answer reasonable?
**Yes; 66 g is about 3/2 the value of the molar mass of $CO_2$. It is reasonable that the sample contains 3/2 (1.5) mol.**

## Practice

1. Calculate the number of moles in each of the following masses:

   a. 3.00 g of boron tribromide, $BBr_3$ **ans: 0.0120 mol $BBr_3$**

   b. 0.472 g of sodium fluoride, NaF **ans: 0.0112 mol NaF**

   c. $7.50 \times 10^2$ g of methanol, $CH_3OH$ **ans: 23.4 mol $CH_3OH$**

   d. 50.0 g of calcium chlorate, $Ca(ClO_3)_2$ **ans: 0.242 mol $Ca(ClO_3)_2$**

| Sample Problem Set *continued*

**CONVERTING MOLES OF A COMPOUND TO MASS**

Perhaps you have noticed that Sample Problems 1 and 5 are very much alike. In each case, you multiplied the mass by the inverse of the molar mass to calculate the number of moles. The only difference in the two problems is that iron is an element and $CO_2$ is a compound containing a carbon atom and two oxygen atoms.

In Sample Problem 2, you determined the mass of 1.366 mol of zinc. Suppose that you are now asked to determine the mass of 1.366 mol of the molecular compound ammonia, $NH_3$. You can follow the same plan as you did in Sample Problem 2, but this time use the molar mass of ammonia.

## Practice

1. Determine the mass of each of the following amounts:

    a. 1.366 mol of $NH_3$ **ans: 23.28 g $NH_3$**

    b. 0.120 mol of glucose, $C_6H_{12}O_6$ **ans: 21.6 g $C_6H_{12}O_6$**

    c. 6.94 mol barium chloride, $BaCl_2$ **ans: $1.45 \times 10^3$ g or 1.45 kg $BaCl_2$**

    d. 0.005 mol of propane, $C_3H_8$ **ans: 0.2 g $C_3H_8$**

Sample Problem Set *continued*

# Sample Problem 6

**Determine the number of molecules in 0.0500 mol of hexane, $C_6H_{14}$.**

# Solution

### ANALYZE

What is given in the problem?    **amount of hexane in moles**

What are you asked to find?    **number of molecules of hexane**

| Items | Data |
|---|---|
| Amount of hexane | 0.0500 mol |
| Avogadro's number—the number of molecules per mole of hexane | $6.022 \times 10^{23}$ molecules/mol |
| Molecules of hexane | ? molecules |

### PLAN

What step is needed to convert from moles of $C_6H_{14}$ to number of molecules of $C_6H_{14}$?
**Avogadro's number is the number of molecules per mole of hexane and can be used to calculate the number of molecules from number of moles.**

$$\text{Amount of } \overset{2}{C}_6H_{14} \text{ in mol} \xrightarrow[\substack{\textit{multiply by} \\ \textit{Avogadro's number}}]{} \text{Number of } \overset{3}{C}_6H_{14} \text{ molecules}$$

$$\overset{\textit{given}}{\text{mol } C_6H_{14}} \times \frac{\overset{\textit{Avogadro's number}}{6.022 \times 10^{23} \text{ molecules } C_6H_{14}}}{1 \text{ mol } C_6H_{14}} = \text{molecules } C_6H_{14}$$

### COMPUTE

$$0.0500 \text{ mol } C_6H_{14} \times \frac{6.022 \times 10^{23} \text{ molecules } C_6H_{14}}{1 \text{ mol } C_6H_{14}} = 3.01 \times 10^{22} \text{ molecules } C_6H_{14}$$

### EVALUATE

Are the units correct?
**Yes; the answer has the correct units of molecules of $C_6H_{14}$.**

Is the number of significant figures correct?
**Yes; three significant figures is correct.**

Is the answer reasonable?
**Yes; multiplying Avogadro's number by 0.05 would yield a product that is a factor of 10 less with a value of $3 \times 10^{22}$.**

| Sample Problem Set *continued* |

# Practice

1. Calculate the number of molecules in each of the following amounts:

   a. 4.99 mol of methane, $CH_4$ **ans: $3.00 \times 10^{24}$ molecules $CH_4$**

   b. 0.005 20 mol of nitrogen gas, $N_2$ **ans: $3.13 \times 10^{21}$ molecules $N_2$**

   c. 1.05 mol of phosphorus trichloride, $PCl_3$ **ans: $6.32 \times 10^{23}$ molecules $PCl_3$**

   d. $3.5 \times 10^{-5}$ mol of vitamin C, ascorbic acid, $C_6H_8O_6$
      **ans: $2.1 \times 10^{19}$ molecules $C_6H_8O_6$**

| Sample Problem Set *continued*

## USING FORMULA UNITS OF IONIC COMPOUNDS

Ionic compounds do not exist as molecules. A crystal of sodium chloride, for example, consists of $Na^+$ ions and $Cl^-$ ions in a 1:1 ratio. Chemists refer to a combination of one $Na^+$ ion and one $Cl^-$ ion as one formula unit of NaCl. A mole of an ionic compound consists of $6.022 \times 10^{23}$ formula units. The mass of one formula unit is called the formula mass. This mass is used in the same way atomic mass or molecular mass is used in calculations.

## Practice

1. Calculate the number of formula units in the following amounts:

   a. 1.25 mol of potassium bromide, KBr **ans: $7.53 \times 10^{23}$ formula units KBr**

   b. 5.00 mol of magnesium chloride, $MgCl_2$ **ans: $3.01 \times 10^{24}$ formula units $MgCl_2$**

   c. 0.025 mol of sodium carbonate, $Na_2CO_3$ **ans: $1.5 \times 10^{22}$ formula units $Na_2CO_3$**

   d. $6.82 \times 10^{-6}$ mol of lead(II) nitrate, $Pb(NO_3)_2$ **ans: $4.11 \times 10^{18}$ formula units $Pb(NO_3)_2$**

**CONVERTING NUMBER OF MOLECULES OR FORMULA UNITS TO AMOUNT IN MOLES**

In Sample Problem 3, you determined the amount in moles of the element lithium. Suppose that you are asked to determine the amount in moles of copper(II) hydroxide in $3.34 \times 10^{34}$ formula units of $Cu(OH)_2$. You can follow the same plan as you did in Sample Problem 3.

# Practice

1. Calculate the amount in moles of the following numbers of molecules or formula units:

   a. $3.34 \times 10^{34}$ formula units of $Cu(OH)_2$ **ans: $5.55 \times 10^{10}$ mol $Cu(OH)_2$**

   b. $1.17 \times 10^{16}$ molecules of $H_2S$ **ans: $1.94 \times 10^{-8}$ mol $H_2S$**

   c. $5.47 \times 10^{21}$ formula units of nickel(II) sulfate, NiSO4 **ans: $9.08 \times 10^{-3}$ mol $NiSO_4$**

   d. $7.66 \times 10^{19}$ molecules of hydrogen peroxide, $H_2O_2$ *ans:* **$1.27 \times 10^{-4}$ mol $H_2O_2$**

## Sample Problem 7

**What is the mass of a sample consisting of $1.00 \times 10^{22}$ formula units of $MgSO_4$?**

## Solution

### ANALYZE

What is given in the problem?    **number of magnesium sulfate formula units**

What are you asked to find?    **mass of magnesium sulfate in grams**

| Items | Data |
|---|---|
| Number of formula units of magnesium sulfate | $1.00 \times 10^{22}$ formula units |
| Avogadro's number—the number of formula units of magnesium sulfate per mole | $6.022 \times 10^{23}$ formula units/mol |
| Molar mass of magnesium sulfate | 120.37 g/mol |
| Mass of magnesium sulfate | ? g |

### PLAN

What steps are needed to convert from formula units of $MgSO_4$ to grams of $MgSO_4$?

**First, you must convert the number of formula units of $MgSO_4$ to amount of $MgSO_4$ by using Avogadro's number. Then you can use the molar mass of $MgSO_4$ to convert amount in moles to mass of $MgSO_4$.**
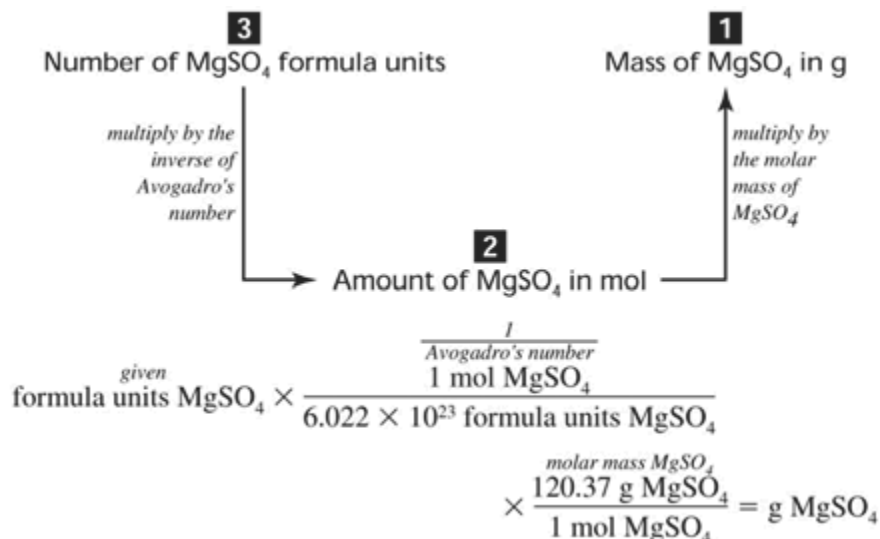
## COMPUTE

$$1.00 \times 10^{22} \text{ formula units MgSO}_4 \times \frac{1 \text{ mol MgSO}_4}{6.022 \times 10^{23} \text{ formula units MgSO}_4}$$

$$\times \frac{120.37 \text{ g MgSO}_4}{1 \text{ mol MgSO}_4} = 2.00 \text{ g MgSO}_4$$

## EVALUATE

Are the units correct?
**Yes; the answer has the correct units of grams of MgSO₄.**

Is the number of significant figures correct?
**Yes; the number of significant figures is correct because data were given to three significant figures.**

Is the answer reasonable?
**Yes; 2 g of MgSO4 is about 1/60 of the molar mass of MgSO₄. Therefore, 2.00 g MgSO₄ will contain about 1/60 of an Avogadro's number of formula units.**

# Practice

1. Calculate the mass of each of the following quantities:

   a. $2.41 \times 10^{24}$ molecules of hydrogen, $H_2$ **ans: 8.08 g H₂**

   b. $5.00 \times 10^{21}$ formula units of aluminum hydroxide, $Al(OH)_3$ **ans: 0.648 g Al(OH)₃**

   c. $8.25 \times 10^{22}$ molecules of bromine pentafluoride, $BrF_5$ **ans: 24.0 g BrF₅**

   d. $1.20 \times 10^{23}$ formula units of sodium oxalate, $Na_2C_2O_4$ **ans: 26.7 g Na₂C₂O₄**

Sample Problem Set *continued*

**CONVERTING MOLECULES OR FORMULA UNITS OF A COMPOUND TO MASS**

In Sample Problem 4, you converted a given mass of boron to the number of boron atoms present in the sample. You can now apply the same method to convert mass of an ionic or molecular compound to numbers of molecules or formula units.

# Practice

1. Calculate the number of molecules or formula units in each of the following masses:

   a. 22.9 g of sodium sulfide, $Na_2S$ **ans: $1.77 \times 10^{23}$ formula units $Na_2S$**

   b. 0.272 g of nickel(II) nitrate, $Ni(NO_3)_2$ **ans: $8.96 \times 10^{20}$ formula units $Ni(NO_3)_2$**

   c. 260 mg of acrylonitrile, $CH_2CHCN$ **ans: $3.0 \times 10^{21}$ molecules $CH_2CHCN$**

| Sample Problem Set *continued*

## Additional Problems

1. Calculate the number of moles in each of the following masses:
   a. 0.039 g of palladium
   b. 8200 g of iron
   c. 0.0073 kg of tantalum
   d. 0.006 55 g of antimony
   e. 5.64 kg of barium
   f. $3.37 \times 10^{-6}$ g of molybdenum

2. Calculate the mass in grams of each of the following amounts:
   a. 1.002 mol of chromium
   b. 550 mol of aluminum
   c. $4.08 \times 10^{-8}$ mol of neon
   d. 7 mol of titanium
   e. 0.0086 mol of xenon
   f. $3.29 \times 10^{4}$ mol of lithium

3. Calculate the number of atoms in each of the following amounts:
   a. 17.0 mol of germanium
   b. 0.6144 mol of copper
   c. 3.02 mol of tin
   d. $2.0 \times 10^{6}$ mol of carbon
   e. 0.0019 mol of zirconium
   f. $3.227 \times 10^{-10}$ mol of potassium

4. Calculate the number of moles in each of the following quantities:
   a. $6.022 \times 10^{24}$ atoms of cobalt
   b. $1.06 \times 10^{23}$ atoms of tungsten
   c. $3.008 \times 10^{19}$ atoms of silver
   d. 950 000 000 atoms of plutonium
   e. $4.61 \times 10^{17}$ atoms of radon
   f. 8 trillion atoms of cerium

5. Calculate the number of atoms in each of the following masses:
   a. 0.0082 g of gold
   b. 812 g of molybdenum
   c. $2.00 \times 10^{2}$ mg of americium
   d. 10.09 kg of neon
   e. 0.705 mg of bismuth
   f. 37 µg of uranium

**Sample Problem Set** *continued*

6. Calculate the mass of each of the following:

   a. $8.22 \times 10^{23}$ atoms of rubidium

   b. 4.05 Avogadro's numbers of manganese atoms

   c. $9.96 \times 10^{26}$ atoms of tellurium

   d. 0.000 025 Avogadro's numbers of rhodium atoms

   e. 88 300 000 000 000 atoms of radium

   f. $2.94 \times 10^{17}$ atoms of hafnium

7. Calculate the number of moles in each of the following masses:

   a. 45.0 g of acetic acid, $CH_3COOH$

   b. 7.04 g of lead(II) nitrate, $Pb(NO_3)_2$

   c. 5000 kg of iron(III) oxide, $Fe_2O_3$

   d. 12.0 mg of ethylamine, $C_2H_5NH_2$

   e. 0.003 22 g of stearic acid, $C_{17}H_{35}COOH$

   f. 50.0 kg of ammonium sulfate, $(NH_4)_2SO_4$

8. Calculate the mass of each of the following amounts:

   a. 3.00 mol of selenium oxybromide, $SeOBr_2$

   b. 488 mol of calcium carbonate, $CaCO_3$

   c. 0.0091 mol of retinoic acid, $C_{20}H_{28}O_2$

   d. $6.00 \times 10^{-8}$ mol of nicotine, $C_{10}H_{14}N_2$

   e. 2.50 mol of strontium nitrate, $Sr(NO_3)_2$

   f. $3.50 \times 10^{-6}$ mol of uranium hexafluoride, $UF_6$

9. Calculate the number of molecules or formula units in each of the following amounts:

   a. 4.27 mol of tungsten(VI) oxide, $WO_3$

   b. 0.003 00 mol of strontium nitrate, $Sr(NO_3)_2$

   c. 72.5 mol of toluene, $C_6H_5CH_3$

   d. $5.11 \times 10^{-7}$ mol of $\alpha$-tocopherol (vitamin E), $C_{29}H_{50}O_2$

   e. 1500 mol of hydrazine, $N_2H_4$

   f. 0.989 mol of nitrobenzene $C_6H_5NO_2$

10. Calculate the number of molecules or formula units in each of the following masses:

   a. 285 g of iron(III) phosphate, $FePO_4$

   b. 0.0084 g of $C_5H_5N$

   c. 85 mg of 2-methyl-1-propanol, $(CH_3)_2CHCH_2OH$

   d. $4.6 \times 10^{-4}$ g of mercury(II) acetate, $Hg(C_2H_3O_2)_2$

   e. 0.0067 g of lithium carbonate, $Li_2CO_3$

Sample Problem Set *continued*

11. Calculate the mass of each of the following quantities:

   a. $8.39 \times 10^{23}$ molecules of fluorine, $F_2$

   b. $6.82 \times 10^{24}$ formula units of beryllium sulfate, $BeSO_4$

   c. $7.004 \times 10^{26}$ molecules of chloroform, $CHCl_3$

   d. 31 billion formula units of chromium(III) formate, $Cr(CHO_2)_3$

   e. $6.3 \times 10^{18}$ molecules of nitric acid, $HNO_3$

   f. $8.37 \times 10^{25}$ molecules of freon 114, $C_2Cl_2F_4$

12. Precious metals are commonly measured in troy ounces. A troy ounce is equivalent to 31.1 g. How many moles are in a troy ounce of gold? How many moles are in a troy ounce of platinum? of silver?

13. A chemist needs 22.0 g of phenol, $C_6H_5OH$, for an experiment. How many moles of phenol is this?

14. A student needs 0.015 mol of iodine crystals, $I_2$, for an experiment. What mass of iodine crystals should the student obtain?

15. The weight of a diamond is given in carats. One carat is equivalent to 200. mg. A pure diamond is made up entirely of carbon atoms. How many carbon atoms make up a 1.00 carat diamond?

16. 8.00 g of calcium chloride, $CaCl_2$, is dissolved in 1.000 kg of water.

   a. How many moles of $CaCl_2$ are in solution? How many moles of water are present?

   b. Assume that the ionic compound, $CaCl_2$, separates completely into $Ca^{2+}$ and $Cl^-$ ions when it dissolves in water. How many moles of each ion are present in the solution?

17. How many moles are in each of the following masses?

   a. 453.6 g (1.000 pound) of sucrose (table sugar), $C_{12}H_{22}O_{11}$

   b. 1.000 pound of table salt, NaCl

18. When the ionic compound $NH_4Cl$ dissolves in water, it breaks into one ammonium ion, $NH_4^+$, and one chloride ion, $Cl^-$ If you dissolved 10.7 g of $NH_4Cl$ in water, how many moles of ions would be in solution?

19. What is the total amount in moles of atoms in a jar that contains $2.41 \times 10^{24}$ atoms of chromium, $1.51 \times 10^{23}$ atoms of nickel, and $3.01 \times 10^{23}$ atoms of copper?

20. The density of liquid water is 0.997 g/mL at 25°C.

   a. Calculate the mass of 250.0 mL (about a cupful) of water.

   b. How many moles of water are in 250.0 mL of water? Hint: Use the result of (a).

   c. Calculate the volume that would be occupied by 2.000 mol of water at 25°C.

   d. What mass of water is 2.000 mol of water?

**Sample Problem Set** *continued*

21. An Avogadro's number (1 mol) of sugar molecules has a mass of 342 g, but an Avogadro's number (1 mol) of water molecules has a mass of only 18 g. Explain why there is such a difference between the mass of 1 mol of sugar and the mass of 1 mol of water.

22. Calculate the mass of aluminum that would have the same number of atoms as 6.35 g of cadmium.

23. A chemist weighs a steel cylinder of compressed oxygen, $O_2$, and finds that it has a mass of 1027.8 g. After some of the oxygen is used in an experiment, the cylinder has a mass of 1023.2 g. How many moles of oxygen gas are used in the experiment?

24. Suppose that you could decompose 0.250 mol of $Ag_2S$ into its elements.

   a. How many moles of silver would you have? How many moles of sulfur would you have?

   b. How many moles of $Ag_2S$ are there in 38.8 g of $Ag_2S$? How many moles of silver and sulfur would be produced from this amount of $Ag_2S$?

   c. Calculate the masses of silver and sulfur produced in (b).