Simple Step-by-Step Guides to Solving Chemistry Problems

Mass, Moles & Number of Particles

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Mass, Moles & Number of Particles

The **mole** links the mass of a substance to the number of **formula units** (particles – atoms, molecules) it contains. The mass of one mole of an element or compound is referred to as its **molar mass**, which is its **relative atomic mass** (A_r) or **relative formula mass** (M_r) in grams.

Molar Mass (M_r) = Relative Formula Mass (RFM) in grams

If you have m grams of a substance which has a molar mass of M_r, then the amount of a substance in moles, n, is given by:

Molar Mass (M_r) = Mass (m)/ Number of Moles (n)

Number of Moles (n) = Mass (m) / Molar Mass (M_r)

Number of Particles = Number of Moles (n) x 6.02 x 10^{23}

If you know the values of any two of n, m or M_r, then you can calculate the third using one of the equations above.

Chemistry Calculating Frame for Moles, Mass and Number of Particles of Atoms & Molecules

The following simple calculating frame can be used to determine mass, number of moles, the number of particles and volume for elements and chemical compounds.

	Symbols	Equations	Given information	Calculated information
Chemical Formula	$X_aY_bZ_c$			
Relative Formula Mass	M_r			
Mass	m	n x M_r		
Number of Particles		n x 6.02 x 10^{23}		
Number of Moles	n	m/M_r		

Step 1: Construct a table based on the one above.

Step 2: Insert all given/known information in column 3.
Note: M_r can be determined using A_r values from the Periodic Table.

Step 3: Identify which parameter(s) that need to be calculated in column 3 using a question mark.

Step 4: Using the equations in column 2 and the information in column 3, calculate the unknown values and insert in column 4.

Example 1: How many moles of sodium hydrogen carbonatite ($NaHCO_3$) are present in 12 g of $NaHCO_3$?

Data from periodic table: A_r[Na] = 23; A_r[H] = 1; A_r[O] = 16

	Symbols	Equations	Given data	Calculated values
Formula	$NaHCO_3$			
Relative Formula Mass	M_r			100
Mass (g)	m	n x M_r	12	
Number of Particles		n x 6.02 x 10^{23}		
Number of Moles	n	m/M_r	**?**	12/100 = **0.12**
Volume (litre)	V	n x V_m		

Answer: 0.12 moles

Example 2: What is the mass of 0.25 moles of nitrogen dioxide (NO_2)?

Answer:
Data from periodic table: A_r[N] = 14; A_r[O] = 16

Relative Formula Mass (M_r) of NO_2 = 14 + (16 x 2) = 46

	Symbols	Equations	Given information	Calculated information
Formula	NO_2			
Relative Formula Mass	M_r			46
Mass	m	n x M_r	**?**	0.25 x 46 = **11.5**
Number of Particles		n x 6.02 x 10^{23}		
Number of Moles	n	m/M_r	0.25	

Answer: 11.5 g

Example 3: How many formula units are present in 1.25 x 10^{-3} moles of aluminium sulfate, $Al_2(SO_4)_3$?

Data from periodic table: A_r[Al] = 27; A_r[S] = 32; A_r[O] = 16

Relative Formula Mass (M_r) of $Al_2(SO_4)_3$ = (27 x 2) + (32 x 3) + (16 x 12) = 342

	Symbols	Equations	Given information	Calculated information
Formula	$Al_2(SO_4)_3$			
Relative Formula Mass	M_r			
Mass	M	n x M_r		
Number of Particles (formula units)		n x 6.02 x 10^{23}	**?**	1.25 x 10^{-3} x 6.02 x 10^{23} = **7.525 x 10^{20}**
Number of Moles	N	m/M_r	1.25 10^{-3}	

Example 4: How many formula units of calcium chloride ($CaCl_2$) are present in 11 g of $CaCl_2$?

	Symbols	Equations	Given information	Calculated information
Formula	$CaCl_2$			
Relative Formula Mass	M_r			111
Mass	M	n x M_r	11	
Number of Particles (formula units)		n x 6.02 x 10^{23}	**?**	0.1 x 6.02 x 10^{23} = **6.02 x 10^{22}**
Number of Moles	N	m/M_r	1.25 x 10^{-3}	11/111 =0.1

Relative Formula Mass (M_r) of calcium chloride ($CaCl_2$) = 40 + (35.5 x 2) = 111

Number of moles (n) = mass / RFM = 11/111 = 0.1

Number of Formula Units = Number of Moles (n) x 6.02 x 10^{23}
= 0.1 x 6.02 x 10^{23}
= 6.02 x 10^{22}

Relative Formula Mass (M_r) of calcium chloride ($CaCl_2$) = 40 + (35.5 x 2) = 111

Number of moles (n) = mass / RFM
= 11/111 = 0.1

Number of Formula Units = Number of Moles (n) x 6.02 x 10^{23}
= 0.1 x 6.02 x 10^{23} = 6.02 x 10^{22}

Practice Problems

1. How many moles of substance are present in the following?
   a. 5.30 g of sodium carbonate, Na_2CO_3

b. 0.35 g of zinc nitrate, $Zn(NO_3)_2$
c. 0.008 g of sodium hydroxide, NaOH
d. 1.25 g of calcium carbonate, $CaCO_3$
e. 3.5 g of benzene, C_6H_6
f. 12 g of glucose, $C_6H_{12}O_6$
g. 1g of uranium dioxide, UO_2
h. 0.3 g aluminium sulphate, $Al_2(SO_4)_3$
i. 1.2 g iron (III) oxide, Fe_2O_3
j. 3.4 g sulphur trioxide, SO_3

2. How many formula units are present in the following?

a. 0.25 moles of Cl_2
b. 5 moles of CO_2
c. 10g of $CaCO_3$
d. 2.45×10^{-3} moles of NH_3
e. 0.34 kg of Fe_3O_4
f. 2.56 moles of C_6H_6
g. 1×10^{-6} g of Au
h. 0.12 moles of $CuSO_4$
i. 1 tonne of N_2
j. 4.45×10^{-6} moles of $(NH_4)_2CO_3$

3. Determine the mass of the following:

a. 2 moles of carbon dioxide, CO_2
b. 0.01 moles of nitrogen dioxide, NO_2
c. 1 x 10-5 moles of benzene, C_6H_6
d. 2.03 x 10-3 moles of uranium dioxide, UO_2
e. 1.12 moles of sulphuric acid, H_2SO_4
f. 3×10^{-4} moles of calcium carbonate, $CaCO_3$
g. 1.2 moles of ethane, C_2H_4
h. 0.5 moles ethanoic acid, CH_3COOH
i. 1.25 x 10-3 moles sodium hydroxide, NaOH
j. 0.025 moles potassium dichromate, $K_2Cr_2O_7$

Answers are given on the next page.

Practice Problem Answers

1. How many moles of substance are present in the following?

Number of Moles = Mass/M_r

a. 5.30 g of sodium carbonate, Na_2CO_3

Answer

M_r [$Na(CO_3)_2$] = 106 g mol^{-1}

Number of moles in 5.3 g of sodium carbonate = mass/M_r = 5.3/106 = **0.05**

b. 0.35 g of zinc nitrate, $Zn(NO_3)_2$

Answer

M_r [$Zn(NO_3)_2$] = 189 g mol^{-1}

Number of moles in 0.35 g of zinc nitrate = mass/M_r = 0.35/189 = **1.85 x 10^{-3}**

c. 0.008 g of sodium hydroxide, NaOH

Answer

M_r [NaOH] = 40 g mol^{-1}

Number of moles in 0.008g of sodium hydroxide = mass/M_r = 0.008/40 = **2 x 10^{-4}**

d. 1.25 g of calcium carbonate, $CaCO_3$

Answer

M_r [$CaCO_3$] = 100 g mol^{-1}

Number of moles in 1.25g of calcium carbonate = mass/M_r = 1.25/100 = **0.0125**

e. 3.5 g of benzene, C_6H_6

Answer

M_r [C_6H_6] = 78 g mol^{-1}

Number of moles of benzene in 3.5g = mass/M_r = 3.5/78 = **0.045**

f. 12 g of glucose, $C_6H_{12}O_6$

Answer

M_r [$C_6H_{12}O_6$] = 180 g mol^{-1}

Number of moles in 12g of glucose = mass/M_r = 12/180 = **0.067**

g. 1g of uranium dioxide, UO_2

Answer

M_r [UO_2] = 270 g mol^{-1}

Number of moles in 1g of uranium dioxide = mass/M_r = 1/270 = **3.7 x 10^{-3}**

h. 0.3 g aluminium sulphate, $Al_2(SO_4)_3$

Answer

M_r [$Al_2(SO_4)_3$] = 342 g mol^{-1}

Number of moles in 0.3g aluminium sulphate = mass/M_r = 0.3/342 = **8.77 x 10^{-4}**

i. 1.2 g iron (III) oxide, Fe_2O_3

Answer

M_r [Fe_2O_3] = 160 g mol^{-1}

Number of moles in 1.2 g iron (III) oxide = mass/M_r = 1.2/160 = **7.5 x 10^{-3}**

j. 3.4 g sulphur trioxide, SO_3

Answer

M_r [SO_3] = 80 g mol^{-1}

Number of moles in 3.4 g sulphur trioxide, SO_3 = mass/M_r =3.4 /80 = **0.0425**

2. How many formula units are present in the following?

Number of formula units = Number of moles x 6.02 x 10^{23}

a. 0.25 moles of Cl_2

Answer

Number of molecules of Cl_2 in 0.25 moles = 0.25 x 6.02 x 10^{23} = **1.51 x 10^{23}**

b. 5 moles of CO_2

Answer

Number of molecules of CO_2 in 5 moles = 5 x 6.02 x 10^{23} = **3.01 x 10^{24}**

c. 10g of $CaCO_3$

Answer

M_r [$CaCO_3$] = 100

Number of moles in10g of $CaCO_3$ = mass/Mr = 10/100 = 0.1

Number of formula units in 10 g of $CaCO_3$ = 0.1 x 6.02 x 10^{23} = **6.02 x 10^{22}**

d. 2.45 x 10^{-3} moles of NH_3

Answer

Number of formula units (molecules) of NH_3 in 2.45 x 10^{-3} moles = 2.45 x 10^{-3} x 6.02 x 10^{23} = **1.48 x 10^{21}**

e. 0.34 kg of Fe_3O_4

Answer

Mr [Fe_3O_4] = 232

Number of moles of Fe_3O_4 in 340 g (0.34 kg) = mass/M_r = 340/232 = 1.47

Number of formula units in 0.24 kg of Fe_3O_4 = 1.47 x 6.02 x 10^{23} = **8.85 x 10^{23}**

f. 2.56 moles of C_6H_6

Answer

Number of particles (molecules) in 2.56 moles of C_6H_6 = 2.56 x 6.02 x 10^{23} = **1.54 x 10^{24}**

g. 1 x 10^{-6} g of Au

Answer

Number of moles of Au in 1 x 10^{-6} g = 1 x 10^{-6}/197 = 5.08 x 10^{-9}

Number of atoms of Au in 1 x 10^{-6} g = 5.08 x 10^{-9} x 6.02 x 10^{23} = **3.06 x 10^{15}**

h. 0.12 moles of $CuSO_4$

Answer

Number of formula units of $CuSO_4$ in 0.12 moles = 0.12 x 6.02 x 10^{23} = **7.22 x 10^{22}**

i. 1 tonne of N_2

Answer

M_r [N_2] = 28

Number of moles of N_2 in 1000 g (1 tonne) = 1000/28 = 35.7
Number of formula units in 1 tonne N_2 = 35.7 x 6.02 x 10^{23} = 2.15 x 10^{25}

j. 4.45 x 10^{-6} moles of $(NH_4)_2CO_3$
Answer
Number of formula units in 4.45 x 10^{-6} moles of $(NH_4)_2CO_3$ =4.45 x 10^{-6} x 6.02 x 10^{23} = **2.68 x 10^{18}**

3. Determine the mass of the following:

Mass = Number of Moles x M_r

a. 2 moles of carbon dioxide, CO_2
Answer
M_r [CO_2] = 44 g mol^{-1}
Mass of 2 moles of carbon dioxide = number of moles x M_r = 2 x 44 = **88 g**

b. 0.01 moles of nitrogen dioxide, NO_2
Answer
M_r [NO_2] = 48 g mol^{-1}
Mass of 0.01 moles of nitrogen dioxide = number of moles x M_r = 0.01 x 46 = **0.46 g**

c. 1 x 10^{-5} moles of benzene, C_6H_6
Answer
M_r [C_6H_6 = 78 g mol^{-1}
Mass of 1 x 10^{-5} moles of benzene = number of moles x M_r = 1 x 10^{-5} x 78 = **7.8 x 10^{-4} g**

d. 2.03 x 10^{-3} moles of uranium dioxide, UO_2
Answer
M_r [UO_2] = 270 g mol^{-1}
Mass of 2.03 x 10^{-3} moles of uranium dioxide = number of moles x M_r = 2.03 x 10^{-3} x 270 = **0.55 g**

e. 1.12 moles of sulphuric acid, H_2SO_4
Answer
M_r [H_2SO_4] = 98 g mol^{-1}
Mass of 1.12 moles of sulfuric acid = number of moles x M_r = 1.12 x 98 = 109.76 g

f. 3 x 10^{-4} moles of calcium carbonate, $CaCO_3$
Answer
M_r [$CaCO_3$] = 100 g mol^{-1}
Mass of 3 x 10^{-4} moles of calcium carbonate= number of moles x M_r = 3 x 10^{-4} x 100 **= 0.03 g**

g. 1.2 moles of ethane, C_2H_4
Answer
M_r [C_2H_4 = 28 g mol^{-1}
Mass of 1.2 moles of ethane = number of moles x M_r = 1.2 x 28 = **33.6 g**

h. 0.5 moles ethanoic acid, CH_3COOH
Answer
Mr [CH_3COOH] = 60 g mol^{-1}

Mass of 0.5 moles ethanoic acid = number of moles x M_r =0.5 x 60 = **30 g**

i. 1.25×10^{-3} moles sodium hydroxide, NaOH

Answer

M_r [NaOH] = 40 g mol^{-1}

Mass of 1.25×10^{-3} moles of sodium hydroxide = number of moles x M_r = 1.2×10^{-3} x 40 = **0.48 g**

j. 0.025 moles potassium dichromate, $K_2Cr_2O_7$

Answer

M_r [$K_2Cr_2O_7$] = 294 g mol^{-1}

Mass of 0.025 moles of potassium dichromate = number of moles x M_r = 0.025 x 294 = **7.35 g**