Chemistry 11

Mole III

Name:
Date:
Block:

1. **Relative Atomic Mass**
2. **The Mole**
3. **Molar Mass**

Relative Atomic Mass

Mass: The amount of matter in an object.

Atomic Mass:

- The mass of a particular atom.
- The atomic mass is found by comparing the mass of an element to the mass of an atom of carbon-12. Carbon-12 is assigned an atomic mass of exactly 12.00 u. u = unified atomic mass unit
- The mass of one individual atom is extremely small. A large number of atoms is needed to provide enough mass to measure.
- A mole is…

The Mole

THE MOLE

Avogadro's Number
1 mole = 6.02214179 x 10^{23} items
**items = atoms/molecules/particles etc

The abbreviation for the unit mole is _____.

Think about the term "dozen".

We can say …
… a **dozen** eggs = 12 eggs
… a **dozen** books = 12 books

Similarly, a **mole** of particles = 6.02 x 10^{23} particles
… a mole of eggs = 6.02 x 10^{23} eggs

HOW BIG IS THE MOLE?

If you were able to count atoms at the rate of 10 million per second, it would take about 2 billion years to count the atoms in one mole.

One mole of paper would make a stack that would reach to the moon more than 80 billion times.

If you had Avogadro's number of unpopped popcorn kernels, and spread them across the US, the country would be covered in popcorn to a depth of 9 miles.

One mole of seconds is about 19 quadrillion years, or 4 240 666 times the age of the Earth, or 954 150 times the age of the universe.

One mole of donuts divided equally among Earth's people, each person would have 90 trillion donuts.

Practice Problems:

1. How many lithium atoms are in 3.2 mol of lithium?

$$3.2\,\text{mol} \times \frac{6.022\times10^{23}\,\text{atoms}}{1\,\text{mol}} = 1.9\times10^{24}\,\text{Li atoms}$$

2. Find the number of chromium ions in 3.5 mol of chromium ions.

$$3.5\,\text{mol} \times \frac{6.022\times10^{23}\,\text{ions}}{1\,\text{mol}} = 2.1\times10^{24}\,\text{Cr ions}$$

3. How many **atoms** are in 0.23 mol of NaCl?

$$0.23\,\text{mol} \times \frac{6.022\times10^{23}\,\text{molecule}_{NaCl}}{1\,\text{mol}} \times \frac{2\,\text{atoms}}{1\,\text{molecule}} = 2.8\times10^{23}\,\text{atoms of NaCl}$$

4. 7.3 x 10^{24} carbon monoxide molecules represent how many moles of carbon monoxide?

$$7.3\times10^{24}\,\text{molecules}_{CO} \times \frac{1\,\text{mol}}{6.022\times10^{23}\,\text{molecules}} = 12\,\text{mol}_{CO}$$

5. How many moles of argon do 1.81 x 10^{22} atoms of argon represent?

$$1.81\times10^{22}\,\text{atoms}_{Ar} \times \frac{1\,\text{mol}}{6.022\times10^{23}\,\text{atoms}} = 0.0301\,\text{mol Ar} = 3.01\times10^{-2}\,\text{mol}_{Ar}$$

6. How many hydrogen atoms are there in 1.0 mole of water? How many oxygen atoms are there in 1.0 mole of water? What is the ratio of hydrogen atoms to oxygen atoms?

Ratio: 2H to 1O (H_2O)

$$1.0\,\text{mol}_{H_2O} \times \frac{6.022\times10^{23}\,\text{molecule}}{1\,\text{mol}} \times \frac{2\,\text{H atoms}}{1\,\text{molecule}} = 1.2\times10^{24}\,\text{atoms}_H$$

$$1.0\,\text{mol}_{H_2O} \times \frac{6.022\times10^{23}\,\text{molecule}_{H_2O}}{1\,\text{mol}_{H_2O}} \times \frac{1\,\text{O atom}}{1\,\text{H}_2\text{O molecule}} = 6.022\times10^{23}\,\text{atoms} = 6.0\times10^{23}\,\text{atoms}_O$$

Movie: How Big Is a Mole (https://www.youtube.com/watch?v=TEl4jeETVmg)

Molar Mass

Each element has a unique atomic mass.
Each compound has a unique molecular mass.

WHAT IS MOLECULAR MASS?

- The sum of the atomic mass of each element that makes up the compound
- Unit = unified mass units (μ)
- Example:
  - H_2O $(2\times H) + (1\times O)$
    $(2\times 1.01) + (1\times 16.00) = 18.02\,\mu$

*** WHAT IS MOLAR MASS? ***

- The molecular mass expressed in grams per mole
- It is a Conversion factor.
- Unit: grams per mole (g/mol)

Example:

What is the molar mass of $MgCl_2$?

- # of Mg atoms = 1
- Atomic mass of Mg = 24.31 u
- # of Cl atoms = 2
- Atomic mass of Cl = 35.45 u

- Molar mass =

$(1 \times 24.31) + (2 \times 35.45)$

$= 95.21\ g/mol\ MgCl_2$

What is the molar mass of $Al_2(SO_4)_3$?

- # of Al atoms = 2
- Atomic mass of Al = 26.98 u
- # of S atoms = 3
- Atomic mass of S = 32.07 u
- # of O atoms = 12
- Atomic mass of O = 16.00 u

- Molar mass =

$(2 \times 26.98) + (3 \times 32.07) + (12 \times 16.00)$

$= 342.17\ g/mol\ Al_2(SO_4)_3$

Practice Problem I: (Find the Molar Mass)

7. What is the molar mass of $Na_2Cr_2O_7$?

$(2 \times 22.99) + (2 \times 52.00) + (7 \times 16.00)$

$= 261.98\ g/mol\ Na_2Cr_2O_7$

8. What is the molar mass of iron (III) sulphide? Fe_2S_3

$(2 \times 55.85) + (3 \times 32.07)$

$= 207.91\ g/mol\ Fe_2S_3$

9. What is the molar mass of ammonium nitrate? NH_4NO_3

$(2 \times 14.01) + (4 \times 1.01) + (3 \times 16.00)$

$= 80.06\ g/mol\ NH_4NO_3$

10. What is the molar mass of propane, C_3H_8?

$(3 \times 12.01) + (8 \times 1.01)$

$= 44.11\ g/mol\ C_3H_8$

* Molar Mass = 2 decimal places!

Compound	Formula	Molar Mass (g/mol)
a) Na_2O	---	61.98 g/mol
b) $Cu(NO_3)_2$	---	187.57 g/mol
c) Calcium chloride Ca^{2+} Cl^-	$CaCl_2$	110.98 g/mol
d) Iron (II) oxide	FeO	71.85 g/mol
e) Iron (III) oxide	Fe_2O_3	159.70 g/mol
f) Copper (I) nitride	Cu_3N	204.66 g/mol
g) Potassium permanganate	$KMnO_4$	158.04 g/mol
h) KBr	---	119.00 g/mol
i) Nitrogen gas	N_2	28.02 g/mol
j) Argon gas	Ar	39.95 g/mol
k) H_2SO_4	---	98.09 g/mol

a) 61.98 g/mol b) 187.57 g/mol c) 110.98 g/mol d) 71.85 g/mol e) 159.70 g/mol f) 204.66 g/mol
g) 158.04 g/mol h) 119.00 g/mol i) 28.02 g/mol j) 39.95 g/mol k) 98.09 g/mol

Practice Problem II: (Conversions + Molar Mass)

11. Find the mass of 4.60 moles of $Ca(OH)_2$.

Molar Mass: $(1 \times 40.08) + (2 \times 16.00) + (2 \times 1.01) = 74.10\ g/mol\ Ca(OH)_2$

$$4.60\ mol\ Ca(OH)_2 \times \frac{74.10\ g}{1\ mol} = 340.86 = \boxed{341\ g\ Ca(OH)_2}$$

3 sf

12. Calculate the number of moles present in a 358.0 gram sample of sodium carbonate.

$Na_2CO_3 = 105.99\ g/mol$

$$358.0\ g\ Na_2CO_3 \times \frac{1\ mol}{105.99\ g} = \boxed{3.378\ mol\ Na_2CO_3}$$

4 sf

13. How much would a sample of 7.4 mol of MgO weigh in kilograms?

$MgO = 40.31\ g/mol$

$$7.4\ mol\ MgO \times \frac{40.31\ g}{1\ mol} \times \frac{1\ kg}{1000\ g} = \boxed{0.30\ kg\ MgO}$$

2 sf

14. A sample of $CoCl_2$ weighs 4524 grams. How many mol of $CoCl_2$ are in this sample?

Molar Mass: $(1 \times 58.93) + (2 \times 35.45) = 129.83\ g/mol$

$$4524\ g\ CoCl_2 \times \frac{1\ mol}{129.83\ g} = \boxed{34.85\ mol\ CoCl_2}$$

4 sf

15. How many moles of water are in 1.8 g of water?

$H_2O = 18.02\ g/mol$

$$1.8\ g\ H_2O \times \frac{1\ mol}{18.02\ g} = 0.0998 = \boxed{0.10\ mol\ H_2O}$$

2 sf

16. Very large quantities of chemicals are produced in the chemical industry. Worldwide production of sulphuric acid (H_2SO_4) is estimated at two trillion (2.0×10^{12}) moles annually. How many tonnes of H_2SO_4 is this? (1 tonne = 1000 kg)

$H_2SO_4 = 98.09\ g/mol$

$$2.0 \times 10^{12}\ mol\ H_2SO_4 \times \frac{98.09\ g}{1\ mol} \times \frac{1\ kg}{1000\ g} \times \frac{1\ tonne}{1000\ kg} = \boxed{2.0 \times 10^{8}\ tonnes\ H_2SO_4}$$

17. A mass of a 0.0150 mol sample of a gas that is known to have sulfur and oxygen has a mass of 0.9615g.

a) Find the molar mass of this gas.

$$\text{Molar mass} = \frac{g}{mol} = \frac{0.9615\,g}{0.0150\,mol} = 64.1\,g/mol$$

b) Determine the molecular formula for this gas.
Write the formulae for several possible compounds of sulfur and oxygen, starting with the simplest.
Calculate the molar mass for each one and find which one matches with the calculated molar mass in (a).

Possible Formula for S & O	Molar Mass	Correct?
SO	48.07 g/mol	No
SO_2	64.07 g/mol	Yes!
S_2O	80.14 g/mol	No
SO_3	80.07 g/mol	No

The molecular formula for the compound is SO_2.

18. How many molecules are in 200.0g of NaCl? NaCl = 58.44 g/mol

$$200.0\,g_{NaCl} \times \frac{1\,mol}{58.44\,g} \times \frac{6.022\times10^{23}\,\text{molecules}}{1\,mol} = 2.061\times10^{24}\,\text{molecules}_{NaCl}$$

4 sf

19. How many atoms are in 2 molecules of $Hg(IO_3)_2$?

1+2+6 = 9

$$2\,\text{molecules}_{Hg(IO_3)_2} \times \frac{9\,\text{atoms}}{1\,\text{molecule}} = 18\,\text{atoms}\ Hg(IO_3)_2$$

20. How many molecules are in 64.0g of FeS? FeS = 87.92 g/mol

$$64.0\,g_{FeS} \times \frac{1\,mol}{87.92\,g} \times \frac{6.022\times10^{23}\,\text{molecules}}{1\,mol} = 4.38\times10^{23}\,\text{molecules}_{FeS}$$

3 sf

21. How many moles are in 2.75×10^{23} atoms of Fe?

$$2.75\times10^{23}\,\text{atoms}_{Fe} \times \frac{1\,mol}{6.022\times10^{23}\,\text{atoms}} = 0.457\,mol\ Fe$$

3 sf

22. What is the mass of 3.00 x 10^{22} atoms of Pt?

$$3.00\times10^{22}\ \text{atoms Pt}\times\frac{1\ \text{mol}}{6.022\times10^{23}\ \text{atoms}}\times\frac{195.08\ \text{g}}{1\ \text{mol}}=9.72\ \text{g Pt}$$

3sf

23. What is the density of acetic acid, CH_3COOH, if 0.250 mol has a volume of 14.3 mL?

Density = g/mL

CH_3COOH = 60.02 g/mol

$$\frac{0.250\ \text{mol CH}_3\text{COOH}}{14.3\ \text{mL}}\times\frac{60.02\ \text{g}}{1\ \text{mol}}=1.05\ \text{g/mL CH}_3\text{COOH}$$

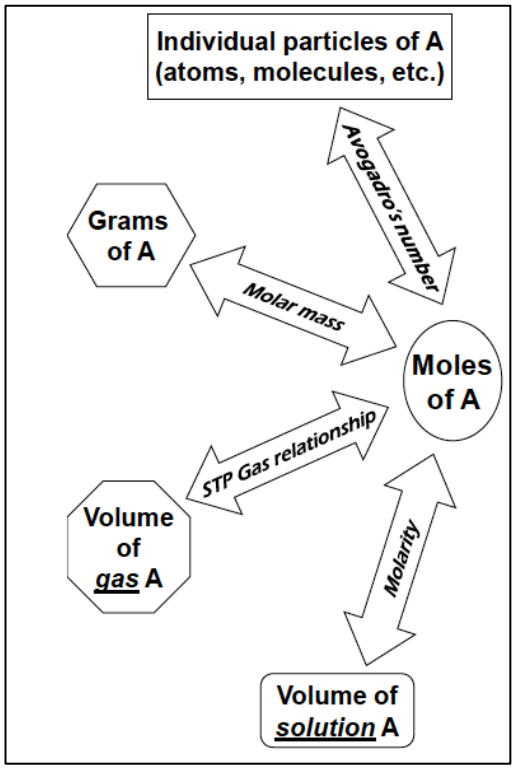
3sf

24. How many moles are in 85.0 mg of CuSCN?

CuSCN = 121.64 g/mol

$$85.0\ \text{mg CuSCN}\times\frac{1\ \text{g}}{1000\ \text{mg}}\times\frac{1\ \text{mol}}{121.64\ \text{g}}=6.99\times10^{-4}\ \text{mol CuSCN}$$

3sf



1) 1.9x10^{24} atoms 2) 2.1x10^{24} ions 3) 2.8x10^{23} atoms
4) 12 mol 5) 0.0301 mol 6) 1.2x10^{24} atoms, 6.0x10^{23} atoms, ratio is 2:1 7) 261.98 g/mol 8) 207.91 g/mol
9) 80.06 g/mol 10) 44.11g/mol 11) 341g
12) 3.378 mol 13) 0.30 kg 14) 34.85 mol 15) 0.10 mol
16) 2.0x10^{8} tonnes 17) 64.1 g/mol, SO_2
18) 2.061x10^{24} molecules 19) 18 atoms
20) 4.38x10^{23} molecules 21) 0.457 moles 22) 9.72g
23) 1.05g/mL 24) 6.99x10^{-4} mol