Stoichiometry

Chapter 12

the relationship between the relative quantities of substances taking part in a reaction or forming a compound, typically a ratio of whole integers.

Origin

From Greek:

- “stoicheion” (= element)
- “metron” (= measure)

Warmup – Mole Conversions

1. What is the molar mass of sulfur dioxide (SO_2)?
2. How many moles of SO_2 are in 256 g of SO_2?
3. How many grams SO_2 are in 2.50 mol SO_2?
4. How many SO_2 molecules are in 2.50 mol SO_2?
5. How many moles SO_2 are in 1.82×10^{22} SO_2 molecules?

Stoichiometry Conversion Factors

1. **mass**
   Molar mass of an element or compound, in grams

2. **# particles**

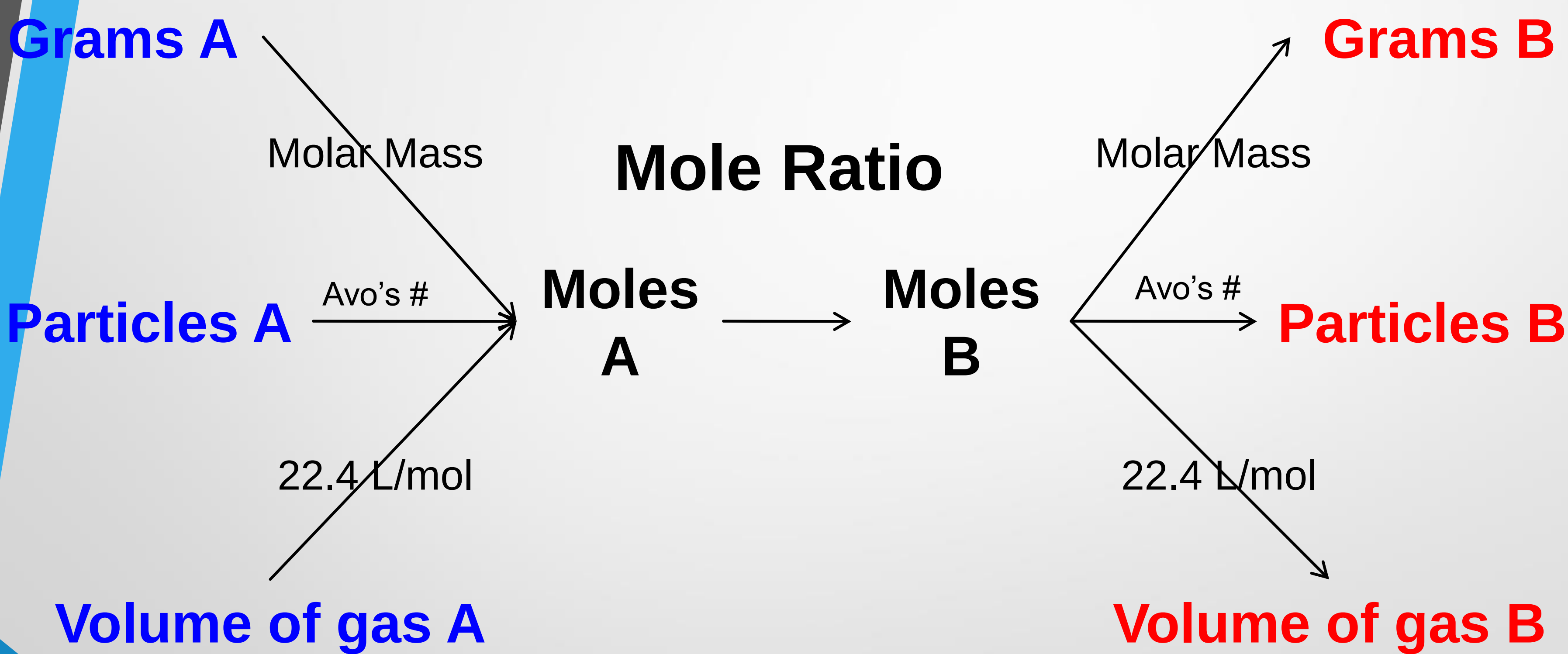
   1 mol of any type of particle (element, molecule, etc.) = 6.02×10^{23} particles

3. **Volume**
   1 mol of a gas at STP (standard temperature and pressure) = 22.4 L

4. **ΔH**

   1 mol = (+/-) .... kJ

Pathways From Known to Unknown



Stoichiometry Conversion Factors

- mass → volume (mass → mol → mol → L)
- volume → volume (L → mol → mol → L) (gases @ STP)
- # particle → mass (particle → mol → mol → mass)

Stoichiometry

Moles meet chemical equations

Another variation on conversion factors

1. Add the use of **mole ratios** as conversion factors

2. Instead of converting single compounds/elements

   from moles → mass → # particles,

   use information about one compound/element

   in a chemical reaction to determine the

   mass/moles/#particles/volume of another compound/element involved in that chemical reaction.

Stoichiometry Steps

1. Write balanced chemical equation.

Then, get to moles ASAP.

2. Determine **moles** of known.
3. Use **mole ratio** to switch from moles of known to moles of unknown.
4. Convert from **moles** of unknown to desired units of unknown.

Mole Ratio

= ratio of coefficients in chemical equation

can be used with any two compounds present in the equation – two reactants, two products, or a reactant and a product

Identify the mole ratios in the following equations:

$N_{2(g)} + 3\ H_{2(g)} \rightarrow 2\ NH_{3(g)}$

$4\ Zn_{(s)} + 10\ HNO_{3(aq)} \rightarrow 4\ Zn(NO_3)_{2(aq)} + N_2O_{(g)} + 5\ H_2O_{(l)}$

Stoichiometry

$2\ H_2S\ (g)\ +\ 3\ O_2\ (g) \rightarrow 2\ SO_2\ (g)\ +\ 2\ H_2O\ (g)$

particles:

2 3 2 2

moles:

2 3 2 2

Volume (if gas)

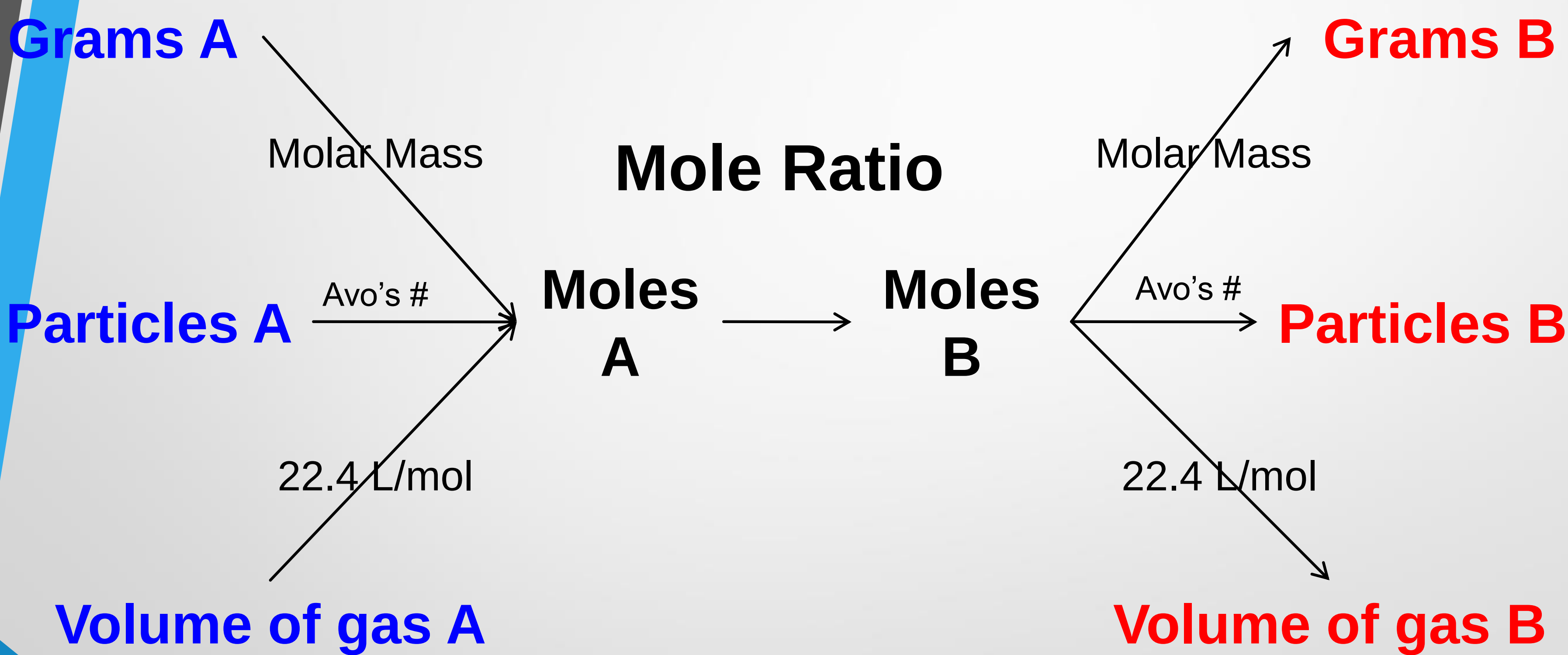
44.8 L 67.2 L 44.8 L 44.8 L

Mass is conserved:

2 mol x 34.08 g/mol + 3 mol x 32.00 g/mol → 2 mol x 64.06 g/mol + 2 mol x 18.01 g/mol

68.16 g + 96.00 g = 128.12 g + 36.02 g

Pathways From Known to Unknown



$2\ H_2S\ (g) + 3\ O_2\ (g) \rightarrow 2\ SO_2\ (g) + 2\ H_2O\ (g)$

1. How many moles of SO_2 will be produced if we started with 15.0 mol O_2?

2. How many liters of SO_2 will be produced if we start with 15.0 mol O_2? (at STP)

3. How many grams of SO_2 will be produced if we started with 15.0 mol O_2?

4. How many moles of SO_2 will be produced if we start with 16.5 L O_2? (at STP)

$2\ H_2S\ (g)\ +\ 3\ O_2\ (g) \rightarrow 2\ SO_2\ (g)\ +\ 2\ H_2O\ (g)$

5. How many mol SO_2 will be produced if we start with 16.5 g O_2?

6. How many L SO_2 will be produced if we start with 16.5 L O_2? (at STP)

7. How many grams of SO_2 will be produced if we start with 16.5 g O_2?

Thermochemical Stoichiometry

- The amount of energy (in kJ) can be incorporated into mole ratios.
- $C_6H_{12}O_{6(aq)} + 6\ O_{2(g)} \rightarrow 6\ CO_{2(g)} + 6\ H_2O_{(l)} +$ **2870 kJ**
- $\Delta H = -2870$ kJ/mol glucose
- Mole Ratios Examples

$$\frac{1\text{ mol } C_6H_{12}O_6}{2870\text{ kJ}} \qquad \frac{6\text{ mol } CO_2}{6\text{ mol } O_2} \qquad 6\text{ mol } H_2O = 1\text{ mol } C_6H_{12}O_6 \qquad \frac{2870\text{ kJ}}{6\text{ mol } H_2O}$$

Thermochemical Stoichiometry Problems

$C_6H_{12}O_{6(aq)} + 6\,O_{2(g)} \rightarrow 6\,CO_{2(g)} + 6\,H_2O_{(l)} +$ **2870 kJ**

1. How much energy (in kJ) will be released when 675 g of glucose is burned?

A: 10,800 kJ

Thermochemical Stoichiometry Problems

$C_6H_{12}O_{6(aq)} + 6\,O_{2(g)} \rightarrow 6\,CO_{2(g)} + 6\,H_2O_{(l)} +$ **2870 kJ**

2. If 398 kJ is released when a certain amount of glucose is burned, how many grams of oxygen are consumed?

A: 26.6 g

Thermochemical Stoichiometry Problems

$C_6H_{12}O_{6(aq)} + 6\ O_{2(g)} \rightarrow 6\ CO_{2(g)} + 6\ H_2O_{(l)} + $ **2870 kJ**

3. If 5782 kJ is released when a certain amount of glucose is burned, how many liters of carbon dioxide are released, assuming the reaction takes place at STP?

A: 271 L

Warmup – acids and bases

- What is the pH of a solution of nitric acid (strong acid) that has a concentration of 10^{-4} M?

  4
- What is its pOH?

  10
- Concentration of OH^-?

  10^{-10} M

- Compare strong acids with weak acids. Use concentration, extent of ionization, and pH in your answer.
- Strong acids ionize completely in water, so the concentration of H^+ is the same as the compound itself. A weak acid of equal concentration (molarity) will have a lower concentration of H^+, and thus a higher pH.