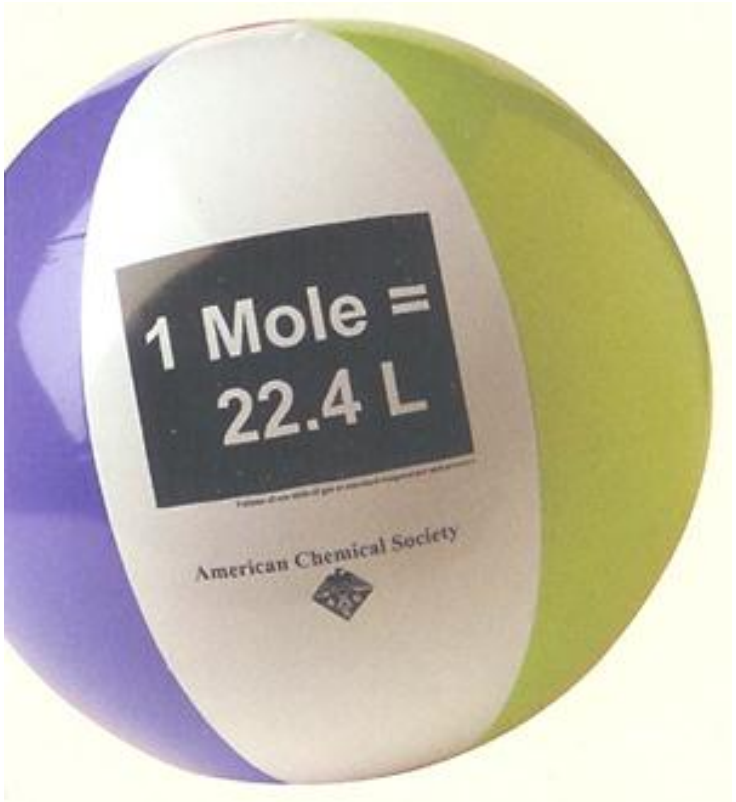
22.4 L
The volume of
1.00 mole of
any gas



Molar Volume

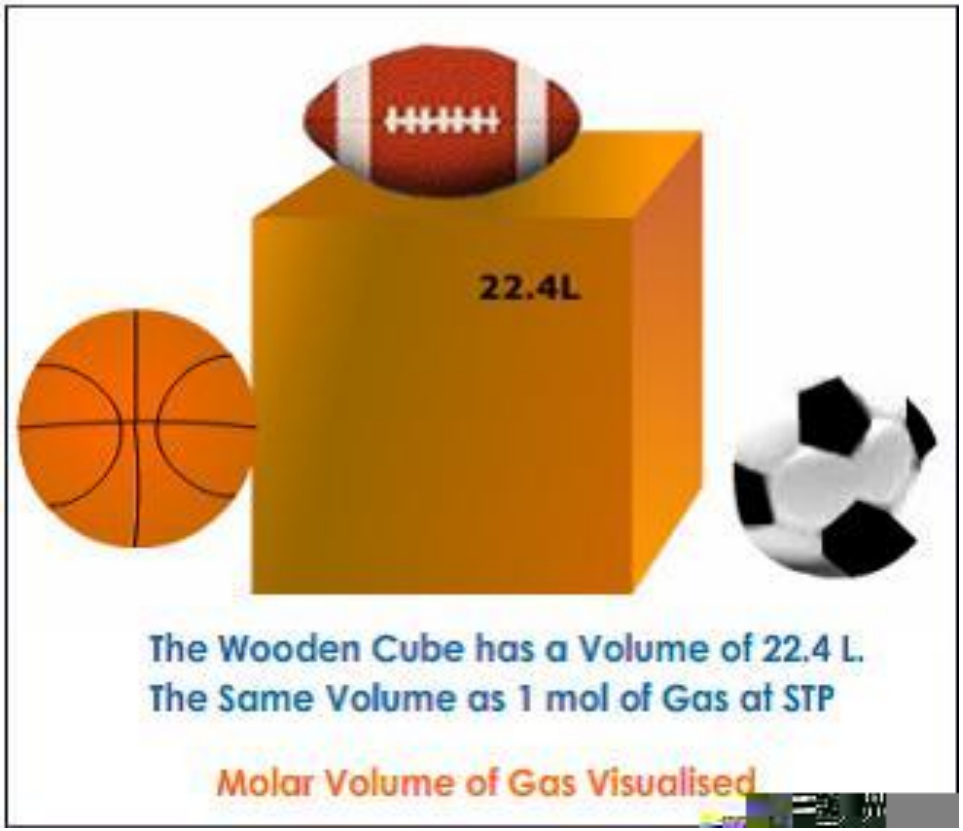
Chapter 3.2

Volume Review

- Volume is the space taken up by particles, atoms or molecules of a substance
- SI unit is Liters (L)
  - Might see cm^3 or mL

Molar Volume

- The space taken up by one mole of particles.
- One mole of any gas at STP will have a volume of **22.4 L**.



What is STP?

- Standard Temperature and Pressure
- 0 degrees Celsius (273 Kelvin) at 1 atmosphere (sea level)
- STP sets a constant standard

Mole Concept and Volume

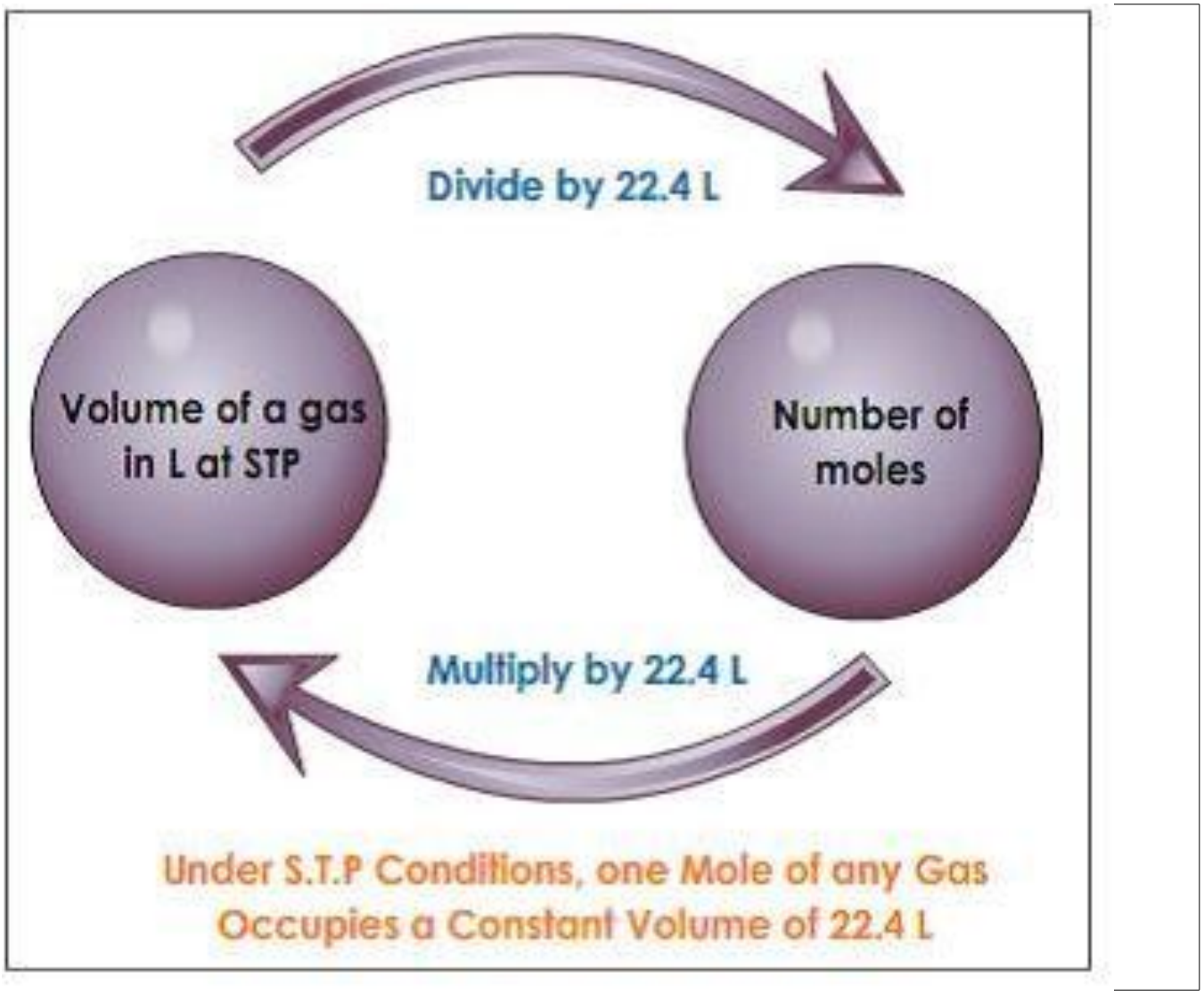
- A mole of a gas is the amount of a substance containing 6.02×10^{23} particles.
- Avogadro discovered that under standard conditions of temperature and pressure, called STP, (1 atm and 273 K) a sample of gas occupies a volume of 22.4 L.

Molar Volume

- The molar volume [22.4 L at STP] plays a vital role in stoichiometric calculations because it is the link between volume and mass in reactions involving gases.
- Conversion factors are

Equivalence Statement	Conversion Factors	
1 mol = 22.4 L @ STP	$\frac{22.4\ \text{L}}{1\ \text{mol}}$ @ STP	$\frac{1\ \text{mol}}{22.4\ \text{L}}$ @ STP

Volume, Mole Conversions



What is the volume of 1.94 moles of CO_2 gas at STP?

- Mol CO_2 to volume CO_2
- 1.94 mol CO_2 x
- 1.94 mol CO_2 x $\frac{22.4L\ CO_2}{1\ molCO_2}$ = 43.5 L of CO_2

Workbook p. 133-134

- Complete
  - Quick check on p. 132
  - Practice problems 1-3 on p. 134
  - This should take you about 3-5 minutes
  - When finished read about multi-step conversions on page 134

Answers p. 134

1. $1.33 \text{ mol } O_2 \times \frac{22.4 \text{ L } O_2}{1 \text{ mol } O_2} = 29.8 \text{ L } O_2$

2. $9.5 \text{ L } SO_2 \times \frac{1 \text{ mol } SO_2}{22.4 \text{ L } SO_2} = 0.42 \text{ mol } SO_2$

3. $0.39 \text{ mol } SiO_2 \times \frac{22.8 \text{ cm}^3 \text{ } SiO_2}{1 \text{ mol } SiO_2} = 8.9 \text{ cm}^3 \text{ } SiO_2$

Multi-Step Conversions

- You can`t convert directly between volume and number of atoms, or mass and volume.
- Once again we will convert through the mole!
- Plan your route and then choose the proper conversions!
- Follow along on page 135

Volume and Items Conversion use

- 22.4L = 1 mole
- 6.02×10^{23} items = 1 mol

Volume to Number of items (atoms) p.135

- The gas in neon signs is at extremely low pressure. How many neon atoms are present in a sign containing 75mL of neon gas at a molar volume that is 100 times greater than the molar volume at STP?
- We have: 75mL of Ne gas – VOLUME
- We want: number of Ne atoms
- The wrinkle – the molar volume is 100 times the molar volume. So 22.4L x100= 2400 L

The gas in neon signs is at extremely low pressure. How many neon atoms are present in a sign containing 75 mL of neon gas at a molar volume that is 100 times greater than the molar volume at STP?

What to Think about

1. Convert: mL → L

2. Convert: L Ne → mol Ne → atoms Ne

3. Setup:

$$0.075 \text{ L Ne} \times \frac{1 \text{ mol Ne}}{? \text{ L Ne}} \times \frac{? \text{ atoms Ne}}{1 \text{ mol Ne}}$$

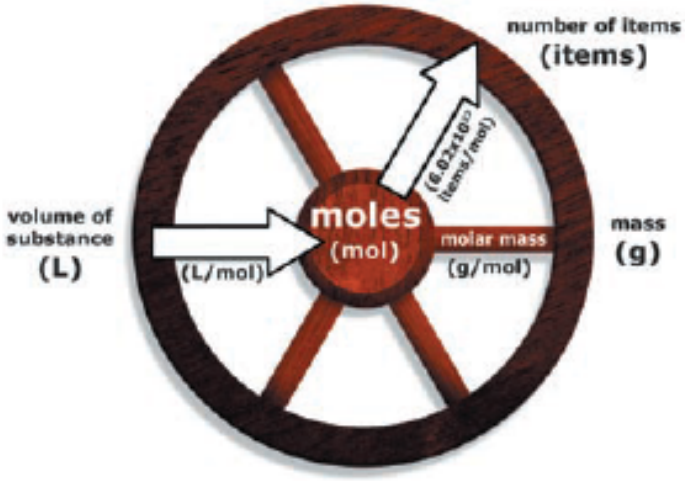
4. Conversion factors:
   2240 L Ne per 1 mol Ne
   6.02×10^{23} atoms Ne per 1 mol Ne

How to Do It

$$75 \text{ ml} \times \frac{1.0 \text{ L}}{1000 \text{ mL}} = 0.075 \text{ L}$$

$$0.075 \text{ L Ne} \times \frac{1 \text{ mol Ne}}{2240 \text{ L Ne}} \times \frac{6.02 \times 10^{23} \text{ atoms Ne}}{1 \text{ mol Ne}}$$

$$= 2.0 \times 10^{19} \text{ atoms Ne}$$



Volume and Mass Conversions

- 22.4L = 1 mole
- Molar mass = 1 mole (from periodic table)

What is the mass of 8.0L of CH_4 at STP?

What to Think about

1. Convert: L CH_4 → mol CH_4 → g CH_4

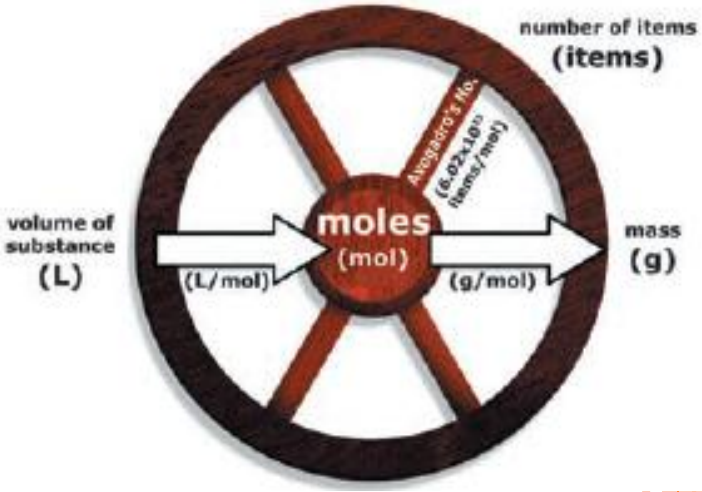
2. Setup:

$$8.0\ \text{L CH}_4 \times \frac{1\ \text{mol CH}_4}{?\ \text{L CH}_4} \times \frac{?\ \text{g CH}_4}{1\ \text{mol CH}_4}$$

3. Conversion factors:
   22.4 L CH_4 per 1 mol CH_4
   16.0 g CH_4 per 1 mol CH_4

How to Do It

$$8.0\ \text{L CH}_4 \times \frac{1\ \text{mol CH}_4}{22.4\ \text{L CH}_4} \times \frac{16.0\ \text{g CH}_4}{1\ \text{mol CH}_4} = 5.7\ \text{g CH}_4$$



Mass of A to Volume of B

- Moles in compounds e.g. CO_2
  - One mole of CO_2 = 1 mole of C
  - One mole of CO_2 = 2 moles of O
- 22.4L = 1 mole

What Volume of CO_2 at STP contains 0.2g of carbon?

What to Think about

1. Convert:
   g C → mol C → mol CO_2 → L CO_2

2. Setup:

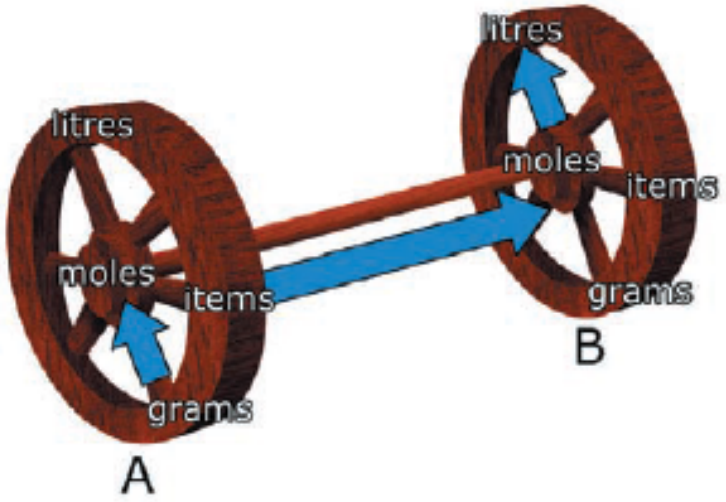
$$0.20\ \text{g C} \times \frac{1\ \text{mol C}}{?\ \text{g C}} \times \frac{1\ \text{mol } CO_2}{?\ \text{mol C}} \times \frac{?\ \text{L } CO_2}{1\ \text{mol } CO_2}$$

3. Conversion factors:
   1 mol C per 12.0 g C
   1 mol CO_2 per 1 mol C
   22.4 L CO_2 per 1 mol CO_2

How to Do It

$$0.20\ \text{g C} \times \frac{1\ \text{mol C}}{12.0\ \text{g C}} \times \frac{1\ \text{mol } CO_2}{1\ \text{mol C}} \times \frac{22.4\ \text{L } CO_2}{1\ \text{mol } CO_2}$$

$$= 0.37\ \text{L } CO_2$$



Converting mass of one substance to volume of another

Workbook

- p. 136 #1-3
  - Try the problems
  - Should take 3-5 minutes
  - If finished early rad about volume and density conversions

Answers

1. $17\ \text{g } H_2S \times \frac{1\ \text{mol } H_2S}{34.1\ \text{g } H_2S} \times \frac{22.4\ \text{L } H_2S}{1\ \text{mol } H_2S} = 11\ \text{L } H_2S$

2. 22.4 L C_3H_8, 3 mol C, 12.0 g C answer 1.6 g C

3. $0.200\ \text{L } C_2H_6O_2 \times \frac{1\ \text{mol } C_2H_6O_2}{0.0559\ \text{L } C_2H_6O_2} \times \frac{6\ \text{mol H}}{1\ \text{mol } C_2H_6O_2} \times \frac{6.02 \times 10^{23}\ \text{atoms H}}{1\ \text{mol H}}$

$= 1.29 \times 10^{25}$ atoms H

Volume and Density Conversions

- Density is the amount of matter in a certain volume
  - Units are usually $\frac{g}{mL}$ or $\frac{g}{L}$
  - Also called mass per volume
- Density IS a conversion factor between mass and volume
  - So when converting from mass to volume you don't need to go through the mole; just multiply or divide by the density!

What is the mass of 2.00L of peroxide (H_2O_2) if it has a density of 1.45g/mL

- Convert to L
  - 1.45g/mL x 1000mL/L = 1450g/L
- We have volume and want mass
  - use $\frac{1450g}{1L}$
- 2.00 L of H_2O_2 x $\frac{1450g}{1L}$ = 2900g
  - Or 2.90 x10^3 g (sig figs!)

Workbook p. 138

- Problems 1-3
- If finished start the review : 3.4 Review Questions
  - 1-6, 8, 9,11-17

Answers

1. $1.33\ \text{g Au} \times \frac{1\ \text{cm}^3\ \text{Au}}{19.42\ \text{g Au}} = 639\ \text{cm}^3\ \text{Au}$

2. $12.7\ \text{mL Hg} \times \frac{13.534\ \text{g Hg}}{1\ \text{mL Hg}} = 172\ \text{g Hg}$

3. $\frac{46.0\ \text{g } C_2H_5OH}{1\ \text{mol } C_2H_5OH} \times \frac{1\ \text{mL } C_2H_5OH}{0.789\ \text{g } C_2H_5OH} = 58.3\ \text{mL/mol } C_2H_5OH$

Workbook /Homework

- 3.4 Review Questions
  - 1-6, 8, 11-17
- CHEM 11 MOLES handout

- Quiz on Monday (for marks)
  - 3.1-3.4
  - Focus will be on conversions with the mole: 3.2 and 3.3