

van der Waals equation

- an attempt to modify $PV = nRT$ to account for several facts.
 - gas molecules actually have SIZE (they take up space)
 - attractive and repulsive forces

$$PV = nRT \quad] \text{ Ideal gas equation}$$

$$\left(P + \frac{n^2 a}{V^2} \right) (V - nb) = nRT \quad] \text{ van der Waals equation}$$

attempts to account for attractive / repulsive forces

attempts to account for molecular size

* "a" and "b" are experimentally determined parameters that are different for each gas. p 208

He: $a = 0,0346$, $b = 0,0238$ tiny, no special attractive forces

H₂O: $a = 5,537$, $b = 0,03049$ small, but strong attractions between molecules

CH₃CH₂OH: $a = 12,56$ $b = 0,08710$ larger, and strong attractions between molecules

2500 L of chlorine gas at 25.0 C and 1.00 atm are used to make hydrochloric acid. How many grams of hydrochloric acid could be produced if all the chlorine reacts?



1 - Convert 2500 L chlorine gas to moles. Use IDEAL GAS LAW, $PV=nRT$

2 - Convert moles chlorine gas to moles HCl. Use CHEMICAL EQUATION

3 - Convert moles HCl to mass HCl. Use FORMULA WEIGHT.

$$\textcircled{1} PV = nRT \quad \left| \quad P = 1.00 \text{ atm} \quad R = 0.08206 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}} \right.$$

$$n = \frac{PV}{RT} \quad \left| \quad V = 2500 \text{ L} \quad T = 25.0^\circ\text{C} = 298.2 \text{ K} \right.$$

$$n_{\text{Cl}_2} = \frac{(1.00 \text{ atm})(2500 \text{ L})}{(0.08206 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}})(298.2 \text{ K})} = 102.1646983 \text{ mol Cl}_2$$

$$\textcircled{2} \text{ mol Cl}_2 = 2 \text{ mol HCl} \quad \textcircled{3} \text{ HCl} - \text{H}^{\circ} 1 \times 1.008$$

$$\text{Cl}^{\circ} 1 \times 35.45$$

$$\underline{36.458 \text{ g HCl}} = \text{mol HCl}$$

$$102.1646983 \text{ mol Cl}_2 \times \frac{2 \text{ mol HCl}}{\text{mol Cl}_2} \times \frac{36.458 \text{ g HCl}}{\text{mol HCl}} = \boxed{7450 \text{ g HCl}}$$

- thermodynamics: the study of energy transfer

Conservation of energy: Energy may change form, but the overall amount of energy remains constant. "first law of thermodynamics"

- ... but what IS energy?

- energy is the ability to do "work"

↑
motion of matter

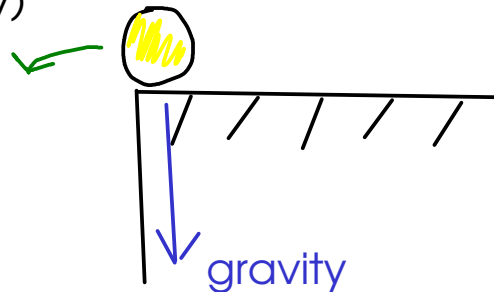
Kinds of energy?

- Kinetic energy: energy of matter in motion $E_K = \frac{1}{2} m v^2$

mass

velocity

- Potential energy: energy of matter that is being acted on by a field of force (like gravity)



When the ball falls, its potential energy is converted to kinetic!

- What sort of energy concerns chemists? Energy that is absorbed or released during chemical reactions.

- Energy can be stored in chemicals ... molecules and atoms.

INTERNAL ENERGY: "U"



related to the kinetic and potential energy of atoms, molecules, and their component parts.

- We measure energy transfer ... which is called HEAT. (HEAT is the flow of energy from an area of higher temperature to an area of lower temperature)

Q: heat

SYSTEM: the object or material under study

SURROUNDINGS: everything else

Type of process	Energy is ...	Sign of Q	Temp of SURROUNDINGS ...
ENDOTHERMIC	transferred from SURROUNDINGS to SYSTEM	+	decreases
EXOTHERMIC	transferred from SYSTEM to SURROUNDINGS	-	increases