$2\bar{5}00$ L of chlorine gas at 25.0 C and 1.00 atm are used to make hydrochloric acid. How many kilograms of hydrochloric acid could be produced if all the chlorine reacts?

$$H_2 + Cl_2 \rightarrow 2\,HCl$$

1 - Convert volume chlorine gas to moles (Use the ideal gas law)
2 - Convert moles chlorine to moles HCl using chemical equation
3 - Convert moles HCl to kg HCl using formula weight (and definition of "kilo-")

$PV = \underline{\underline{n}}RT$

$\frac{PV}{RT} = n$

$P = 1.00\text{ atm}$

$T = 25.0^\circ C = 298.2\text{ K}$

$V = 25\bar{0}0\text{ L}$

$R = 0.08206\ \frac{L \cdot atm}{mol \cdot K}$

$n = ???$

① $$n_{Cl_2} = \frac{(1.00\text{ atm})(25\bar{0}0\text{ L})}{\left(0.08206\ \frac{L \cdot atm}{mol \cdot K}\right)(298.2\text{ K})} = 102.1647\text{ mol } Cl_2$$

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mol Cl_2 = 2 mol HCl | 36.458 g HCl = mol HCl | kg = 10^3 g

$$102.1647\text{ mol } Cl_2 \times \underbrace{\frac{2\text{ mol HCl}}{\text{mol } Cl_2}}_{②} \times \underbrace{\frac{36.458\text{ g HCl}}{\text{mol HCl}} \times \frac{\text{kg}}{10^3\text{ g}}}_{③} = \boxed{7.45\text{ kg HCl}}$$

Calculate the mass of 22650 L of oxygen gas at 25.0 C and 1.18 atm pressure.

$\uparrow O_2$

* Volume of a 10'x10'x8' room

1 - Convert the volume of gas to moles using the ideal gas law
2 - Convert the moles gas to mass using the formula weight (of oxygen gas)

$PV = nRT$

$\frac{PV}{RT} = n$

$P = 1.18\ atm$

$V = 22650\ L$

$T = 25.0°C = 298.2\ K$

$R = 0.08206 \frac{L \cdot atm}{mol \cdot K}$

$n = ???$

① $n = \frac{(1.18\ atm)(22650\ L)}{\left(0.08206 \frac{L \cdot atm}{mol \cdot K}\right)(298.2\ K)} = 1092.222\ mol\ O_2$

$32.00\ g\ O_2 = mol\ O_2$

$= 1092.222\ mol\ O_2 \times \frac{32.00\ g\ O_2}{mol\ O_2} = 35\bar{0}00\ g\ O_2$

$35.0\ kg$

$\downarrow$

$77\ lb$

$$2\,HCl + Na_2CO_3 \rightarrow CO_2 + H_2O + 2\,NaCl$$

If 48.90 mL of hydrochloric acid solution react with sodium carbonate to produce 125.0 mL of carbon dioxide gas at 0.950 atm and 290.2 K. What is the molar concentration of the acid?

We need to find: $\underline{M}$ of HCl $= \dfrac{\text{moles HCl}}{\text{L solution}}$ ← 0,04890 L

We know volume of the acid, so we need to find moles HCl!

1 - Convert volume of carbon dioxide gas to moles using ideal gas law

2 - Convert moles carbon dioxide to moles HCl using chemical equation   2 mol HCl = mol CO_2

$$n = \frac{PV}{RT}$$

$P = 0.950$ atm

$V = 125.0\text{ mL} = 0.1250\text{ L}$

$T = 290.2\text{ K}$

$R = 0,08206\ \dfrac{L\cdot atm}{mol\cdot K}$

$n = ???$

① $$n_{CO_2} = \frac{(0.950\text{ atm})(0.1250\text{ L})}{\left(0,08206\ \frac{L\cdot atm}{mol\cdot K}\right)(290.2\text{ K})} = 0,0049866\text{ mol } CO_2$$

② $$0,0049866\text{ mol } CO_2 \times \frac{2\text{ mol HCl}}{\text{mol } CO_2} = 0.0099732\text{ mol HCl}$$

$$\underline{M} = \frac{\text{moles HCl}}{\text{L solution}} = \frac{0.0099732\text{ mol HCl}}{0,04890\text{ L}} = \boxed{0,204\ \underline{M}\text{ HCl}}$$

ENERGY

- 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?

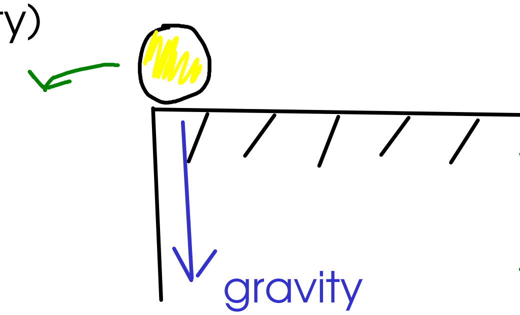
    - energy is the ability to do "work"

      ↑ motion of matter

Kinds of energy?

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

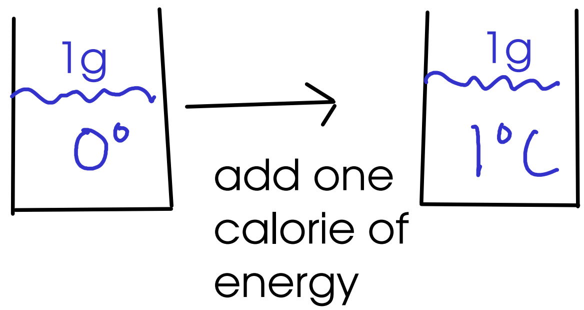
SYSTEM: the object or material under study

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 SUROUNDINGS	—	increases

ENERGY UNITS

- calorie (cal): the amount of energy required to change the temperature of one gram of water by one degree Celsius (or Kelvin)



1g ≈ 1mL for water

- Calories in food? The "Calorie" that is given on American food labels is actually the kilocalorie (kcal)

- Joule (J): SI unit for energy. It's defined based on the equation for kinetic energy.

$$1\ J = 1\ \frac{kg\ m^2}{s^2}, \text{ from}$$

$$E_K = \frac{1}{2} m v^2$$

kinetic energy (E_K), mass (m), velocity (v)

4.184 J = 1 cal

- the Joule is a small unit. For most reactions at lab scale, we'll use kilojoules (kJ).