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

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?

$M_{HCl} = \dfrac{\text{mol HCl}}{\text{L solution}}$ ← $48.90\text{ mL} = 0.04890\text{ L}$

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1 - Convert 125.0 mL carbon dioxide gas to moles carbon dioxide using ideal gas equation
2 - Convert moles carbon dioxide to moles hydrochloric acid using chemical equation
3 - Calculate molarity of hydrochloric acid from moles and volume

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① $PV = nRT$ | $P = 0.950\text{ atm}$ | $R = 0.08206\ \frac{L \cdot atm}{mol \cdot K}$

$n = \dfrac{PV}{RT}$ | $V = 125.0\text{ mL} = 0.1250\text{ L}$ | $T = 290.2\text{ K}$

$$n_{CO_2} = \frac{(0.950\text{ atm})(0.1250\text{ L})}{\left(0.08206\ \frac{L \cdot atm}{mol \cdot K}\right)(290.2\text{ K})} = 0.004986619\text{ mol } CO_2$$

$2\text{ mol HCl} = \text{mol } CO_2$

② $0.004986619\text{ mol } CO_2 \times \dfrac{2\text{ mol HCl}}{\text{mol } CO_2} = 0.009973238\text{ mol HCl}$

③ $M_{HCl} = \dfrac{\text{mol HCl}}{\text{L solution}} = \dfrac{0.009973238\text{ mol HCl}}{0.04890\text{ L}} = \boxed{0.204\ \underline{M}\ HCl}$

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

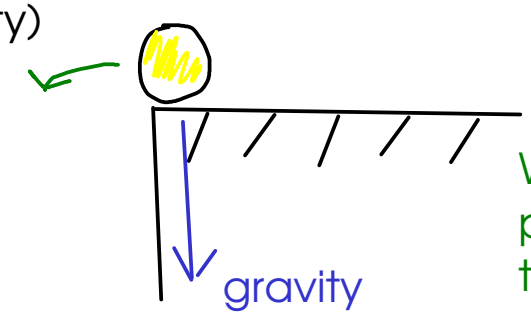
Kinds of energy?

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

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

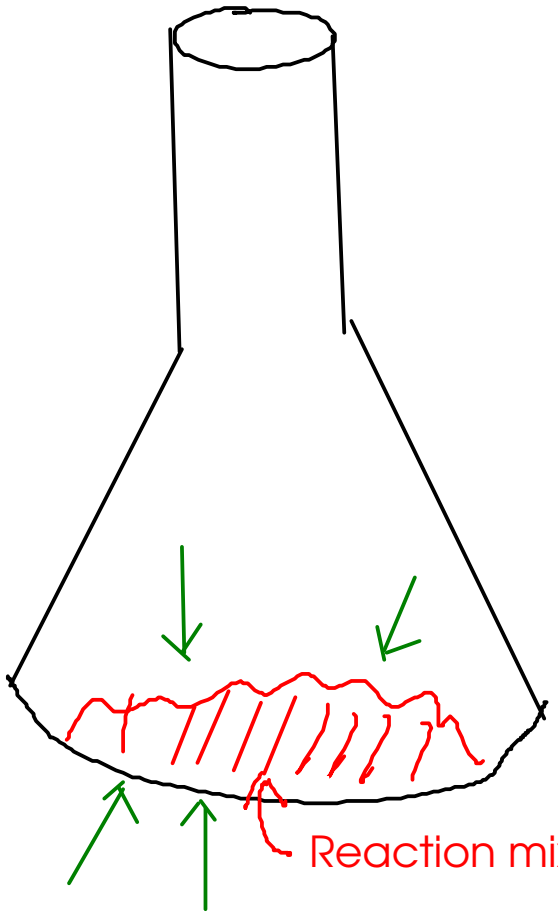
SYSTEM: the object or material under study

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 SUROUNDINGS	−	increases

Reaction demonstration:

$$Ba(OH)_2 \cdot 8H_2O(s) + 2NH_4NO_3(s) \longrightarrow 10\,H_2O(l) + 2NH_3(aq) + Ba(NO_3)_2(aq)$$



Observations:
* Formation of liquid
* Reaction vessel is COLD
* Distinct odor (ammonia)

ENERGY flows from the SURROUNDINGS to the SYSTEM.
This is an ENDOTHERMIC process:

$$Q > 0$$