25$\bar{0}$0 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 2500 L chlorine gas to moles. Use IDEAL GAS EQUATION.
2 - Convert moles chlorine gas to moles HCl. Use CHEMICAL EQUATION.
3 - Convert moles HCl to mass. Use FORMULA WEIGHT (and a unit conversion)

(1) $PV = nRT$ | $P = 1.00\ \text{atm}$ | $R = 0.08206\ \frac{L \cdot atm}{mol \cdot K}$

$n = \frac{PV}{RT}$ | $V = 25\bar{0}0\ L$ | $T = 25.0°C = 298.2\ K$

$$n_{Cl_2} = \frac{(1.00\ atm)(25\bar{0}0\ L)}{(0.08206\ \frac{L \cdot atm}{mol \cdot K})(298.2\ K)} = 102.164983\ mol\ Cl_2$$

(2) $mol\ Cl_2 = 2\ mol\ HCl$

(3) $36.458\ g\ HCl = mol\ HCl$

HCl: H - 1 x 1.008
1 x 35.45
36.458

$$102.164983\ mol\ Cl_2 \times \frac{2\ mol\ HCl}{mol\ Cl_2} \times \frac{36.458\ g\ HCl}{mol\ HCl} = 7450\ g\ HCl$$

Convert answer to kg ... $kg = 10^3\ g$

$$7450\ g\ HCl \times \frac{kg}{10^3\ g} = 7.45\ kg\ HCl$$

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

If 48.90 mL of 0.250 M HCl solution reacts with sodium carbonate to produce 50.0 mL of carbon dioxide gas at 290.2 K, what is the pressure of the carbon dioxide gas?

---

1 - Convert 48.90 mL of HCL solution to moles using MOLARITY.
2 - Convert moles HCl to moles carbon dioxide gas using CHEMICAL EQUATION
3 - Convert moles carbon dioxide to pressure. Use IDEAL GAS EQUATION.

---

① $0.250\ mol\ HCl = L$ $\quad mL = 10^{-3}\,L$ $\quad$ ② $2\ mol\ HCl = mol\ CO_2$

$$48.90\ mL \times \frac{10^{-3}\,L}{mL} \times \underset{①}{\frac{0.250\ mol\ HCl}{L}} \times \underset{②}{\frac{mol\ CO_2}{2\ mol\ HCl}} = 0.0061125\ mol\ CO_2$$

---

③ $PV = nRT$ $\qquad n = 0.0061125\ mol\ CO_2 \qquad T = 290.2\,K$

$P = \dfrac{nRT}{V}$ $\qquad R = 0.08206\ \dfrac{L\cdot atm}{mol\cdot K} \qquad V = 50.0\ mL = 0.0500\,L$

$$P = \frac{(0.0061125\ mol\ CO_2)\left(0.08206\ \frac{L\cdot atm}{mol\cdot K}\right)(290.2\,K)}{(0.0500\,L)} = \boxed{2.91\ atm}$$

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"

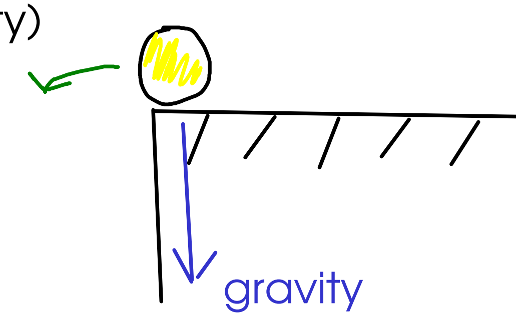
    ↑ motion of matter

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.

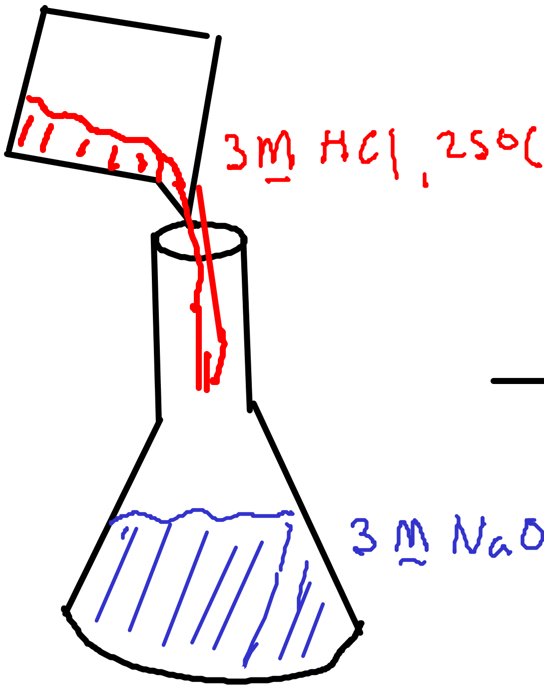
- We measure energy transfer ... which is called HEAT. (HEAT is the flow of energy from an area of higher temperature to an area of lower temperature)

Q : heat

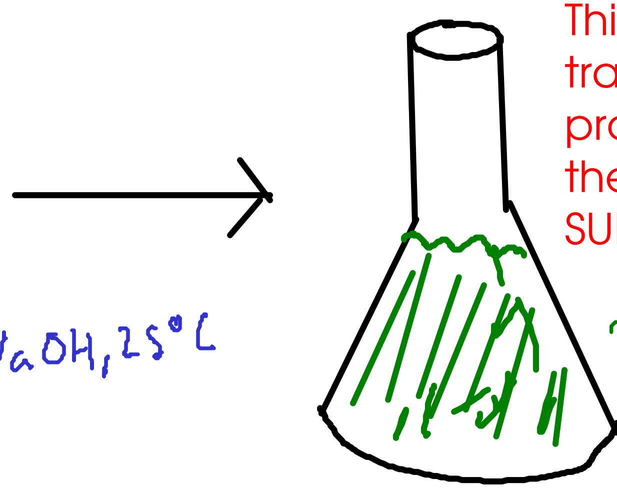
SYSTEM: the object or material under study

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 SURROUNDINGS	—	increases



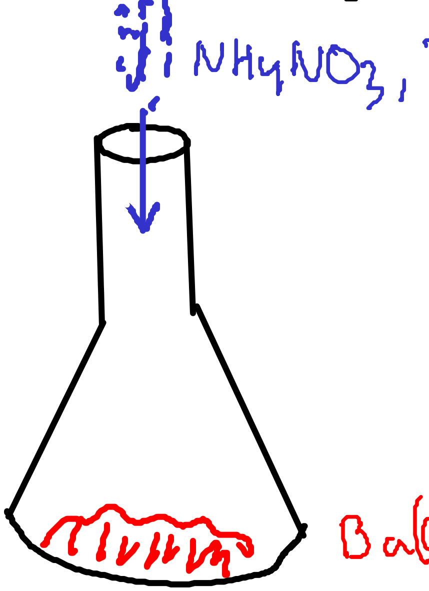
$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(\ell)$$

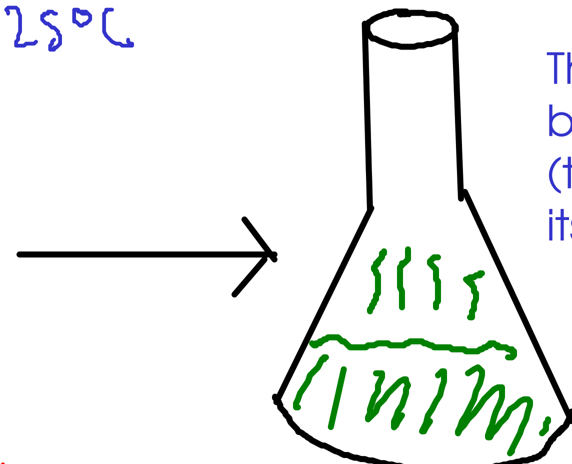


This reaction is EXOTHERMIC. Energy is transferred from the reactants and products (the SYSTEM) to the water in the flask, the flask, etc. (the SURROUNDINGS)

3 M NaCl + H_2O, ~40°C

$$Ba(OH)_2\cdot 8H_2O(s) + 2NH_4NO_3(s) \rightarrow 2NH_3(aq) + 10H_2O(\ell) + Ba(NO_3)_2(aq)$$





This reaction is ENDOTHERMIC. Energy is being transferred from the room/flask/etc. (the SURROUNDINGS) to the reaction itself (the SYSTEM).

NH_3, H_2O, $Ba(NO_3)_2(aq)$, <0°C