

Thermochemistry

Thermodynamics

All physical and chemical changes are accompanied by changes in energy.

Thermodynamics: the study of energy and its interconversions

Energy

**Energy is the capacity to do work
or produce heat**

Some fundamentals

Mass (m)

Acceleration (a)

$$\mathbf{Force (F) = ma}$$

Units of force: $\text{kg}\cdot\text{m}\cdot\text{s}^{-2}$

(derived term in SI is called a Newton)

Work

- the result of a force acting on a body and producing motion

Some fundamentals (Work)

Force (F)

Distance (l)

Units of force: $\text{kg}\cdot\text{m}\cdot\text{s}^{-2}$

Work = force x distance

Units of work: $\text{kg}\cdot\text{m}^2\cdot\text{s}^{-2}$

(derived term in SI is called a joule)

Some fundamentals (Heat)

symbol: q

**the transfer of energy between two bodies
that are at different temperatures**

has same units (J) as work

Calorie

approximately 1 cal is required to increase the temperature of exactly 1 g of water by 1K or 1°C

$$1 \text{ cal} = 4.184 \text{ J}$$

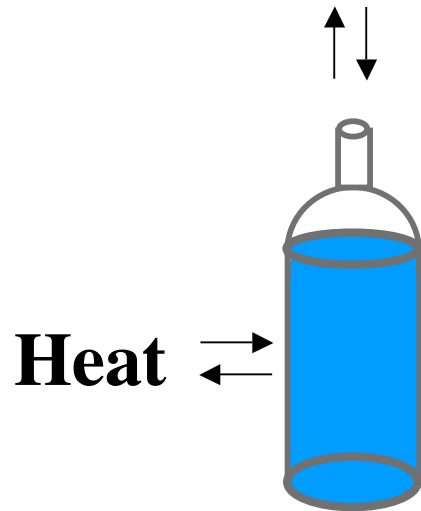
Some terminology

system + surroundings = universe

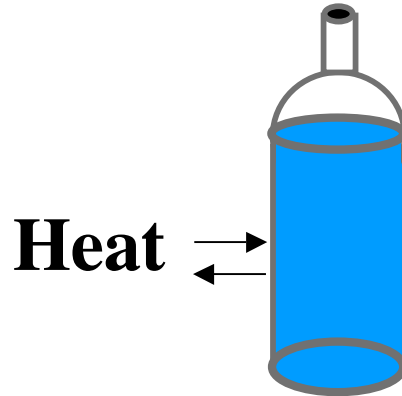

what we study

chemical reactions: reactants and products

Water Vapor



Open system



Closed system



Isolated system

Some terminology

a reaction is exothermic if it gives off heat

energy flows from the
system to the
surroundings

Heat



a reaction is endothermic if it takes in heat

energy flows from the
surroundings to the
system

Heat



The heat released or absorbed during chemical reactions lies in the difference in potential energy between the products and the reactants

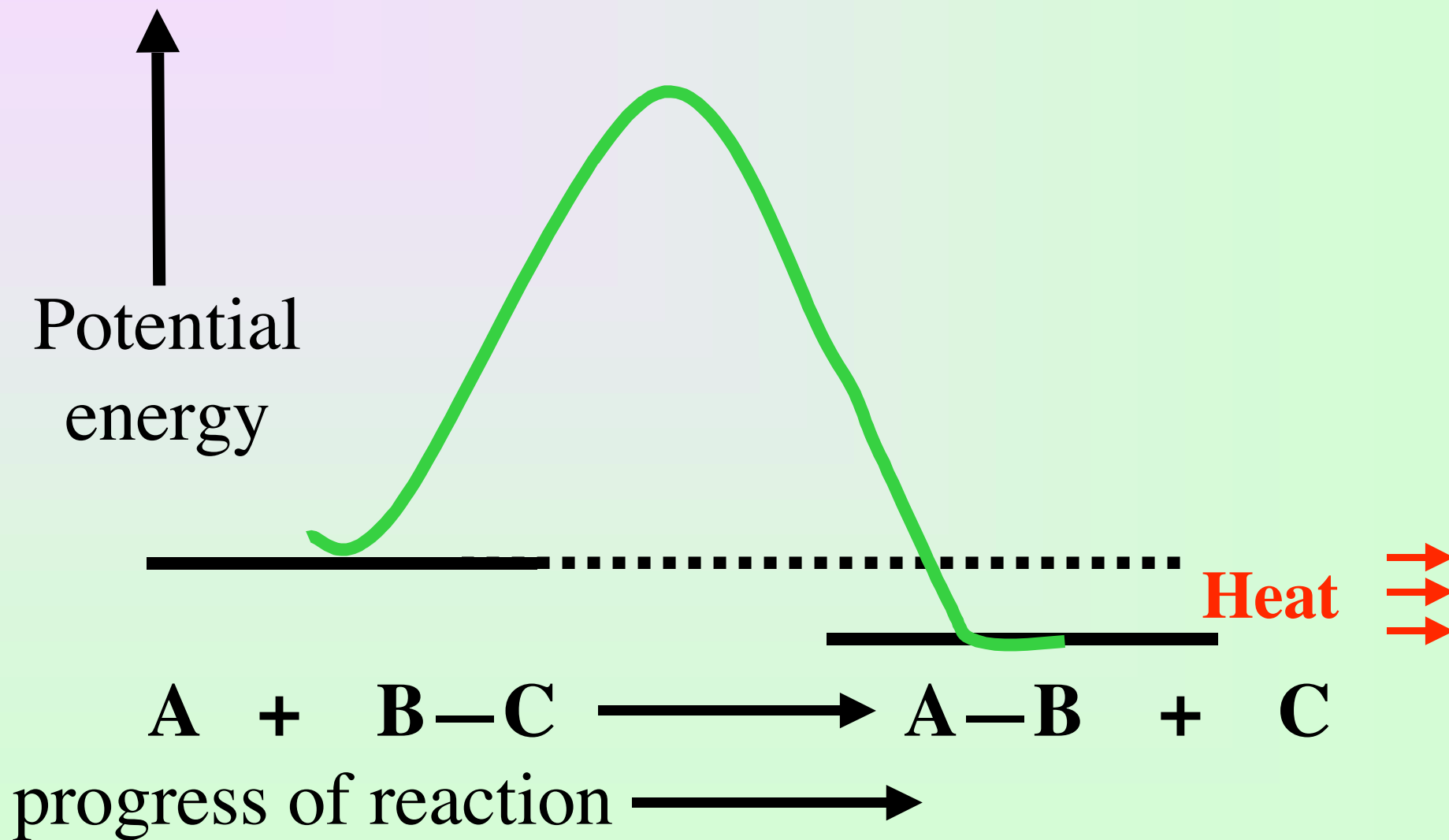
An exothermic reaction



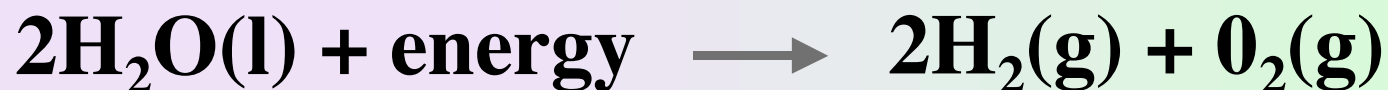
**stronger chemical bonds in products
than in reactants**

less potential energy in products

Consider a hypothetical one-step reaction (exothermic)



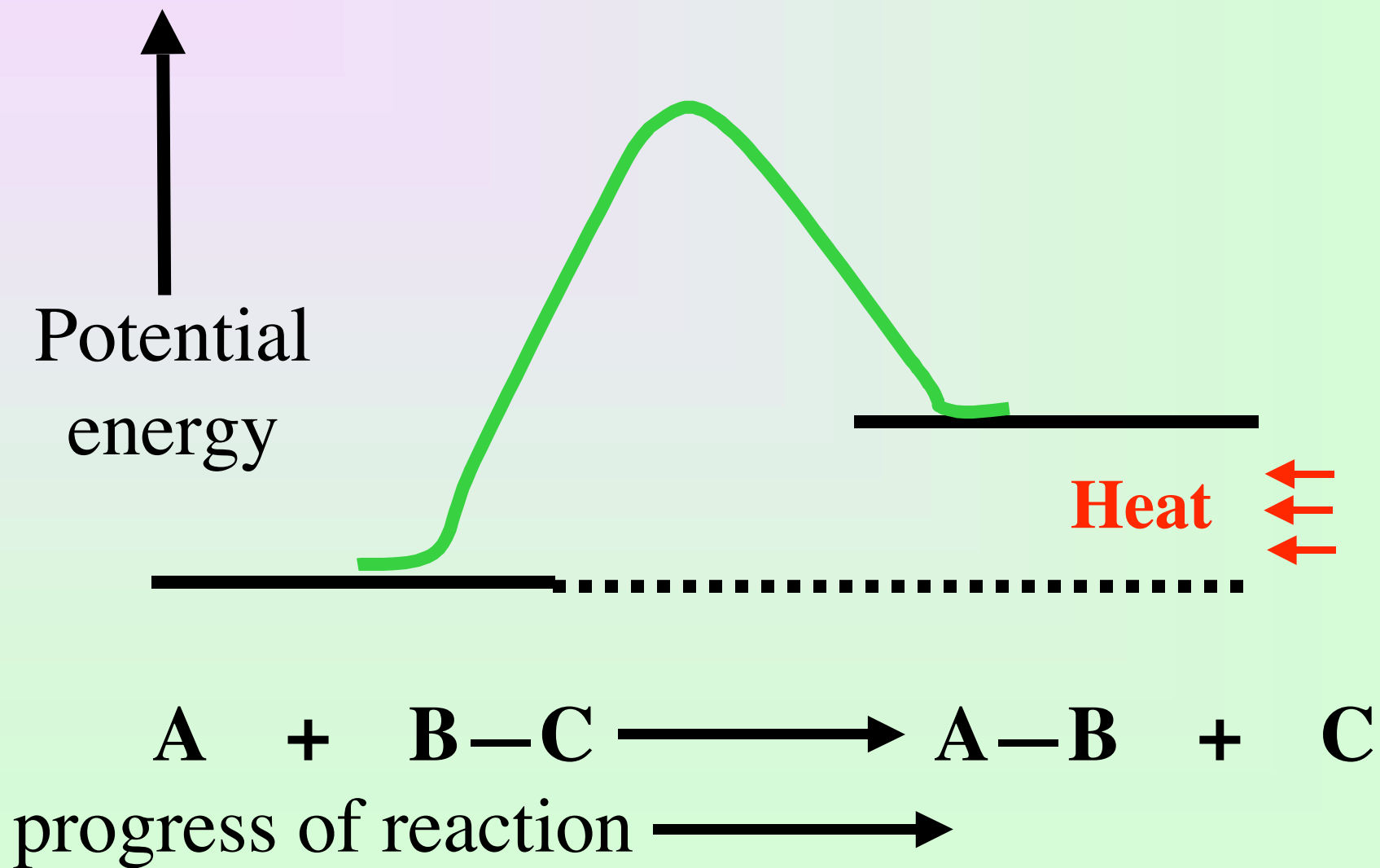
An endothermic reaction



weaker chemical bonds in products
than in reactants

more potential energy in
products

Consider a hypothetical one-step reaction (endothermic)



First Law of Thermodynamics

energy can not be created or destroyed

types of energy

Kinetic (thermal) energy

energy associated with motion

Potential energy

energy available by an object by virtue of its position

Kinetic energy

Energy an object possesses because of its motion

$$\text{kinetic energy} = \frac{1}{2} mu^2$$

Units: kg-m²-s⁻² (joules)

Potential energy

energy an object has because of position

an example is potential energy of an object with the potential to fall

gravitational potential energy = mass X height X gravitational constant

Units: $\text{kg}\cdot\text{m}^2\cdot\text{s}^{-2}$ (joules)

Chemical Potential Energy

**due to the attractive and repulsive forces
between protons and electrons**

Ionic Compounds

Coulomb's Law

the potential energy between two ions in an ionic solid is directly proportional to the product of their charges and inversely proportional to the distance between them

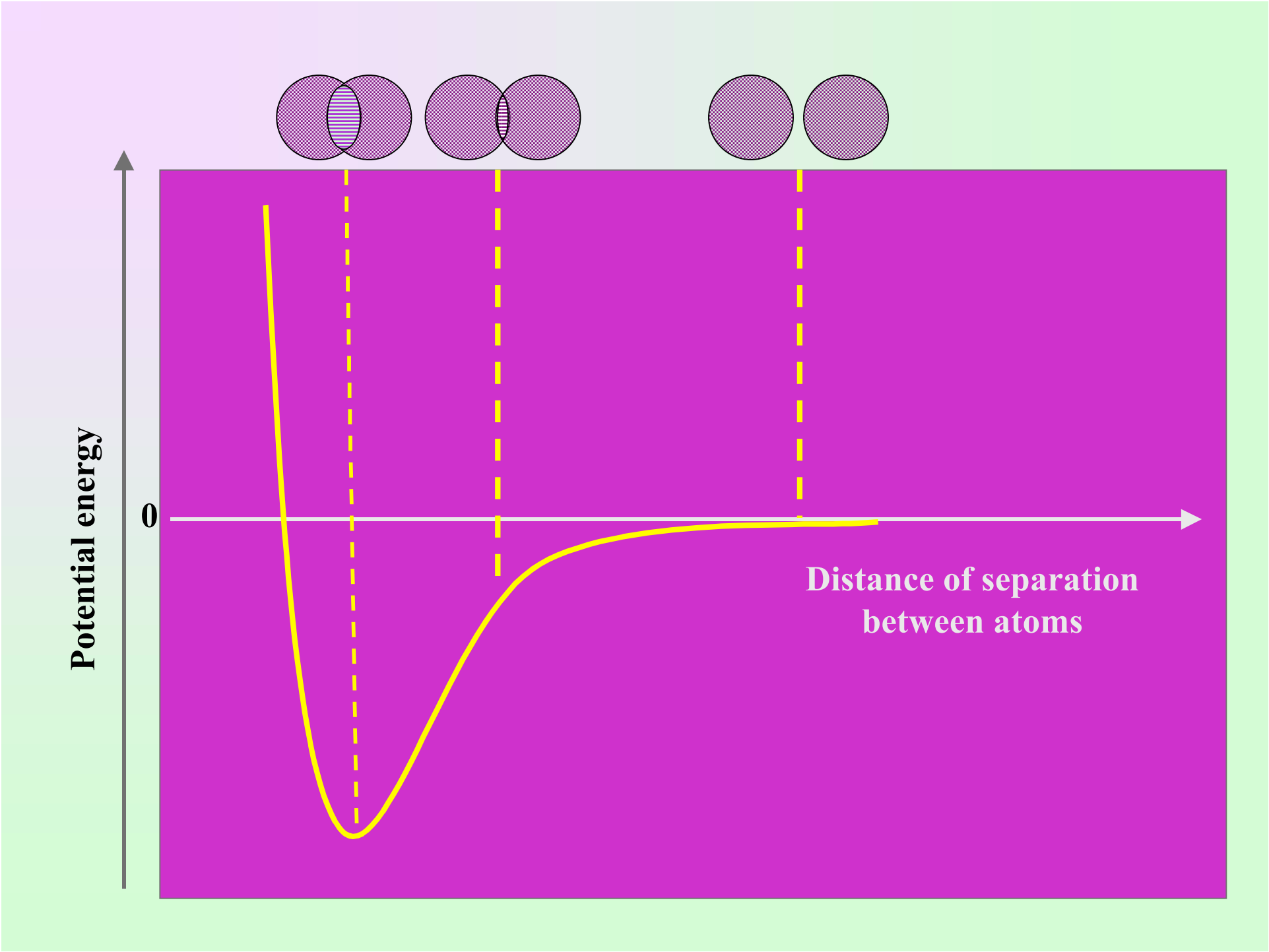
$$E = k \frac{Q_{\text{Li}^+} Q_{\text{F}^-}}{r}$$

Charge on Li⁺ Charge on F⁻

The distance
between the ions

Covalent Compounds

**Compounds containing covalent bonds
(electrons shared by two atoms)**



First Law of Thermodynamics

Energy can be converted from one form to another but can neither be created nor destroyed

Energy = Heat + Work

$$\mathbf{E = q + w}$$

Example : kinetic energy to potential energy