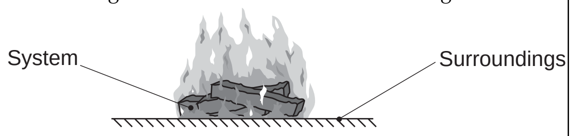
Chemical change: energy

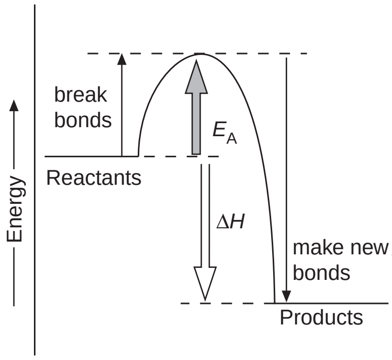
EXOTHERMIC CHANGES

The system (the reacting substances) *loses energy to the surroundings*.

e.g. the burning of carbon is an exothermic change.



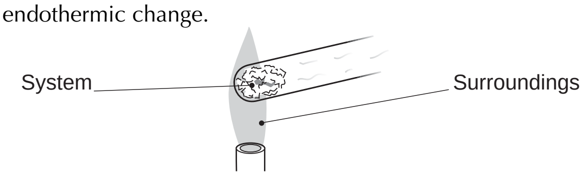
The system loses energy to the surroundings because *less* energy is needed to *break* the bonds in the reactants than to *make* the new bonds in the products.



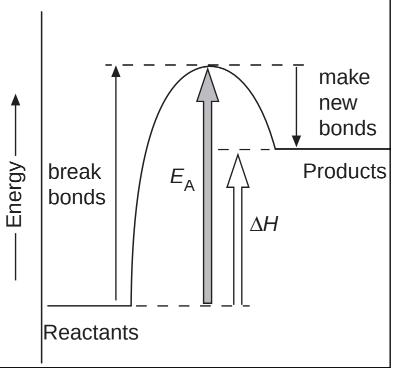
ENDOTHERMIC CHANGES

The system *gains energy from the surroundings*.

e.g. the decomposition of copper carbonate is an endothermic change.



The system gains energy from the surroundings because *more* energy is needed to *break* the bonds in the reactants than to *make* the new bonds in the products.



The energy content of the reactants and products is given the name **enthalpy**. It has the symbol *H*. The difference in enthalpy (the **enthalpy change**) is written mathematically as Ø*H* and is measured in kilojoules, kJ.

The energy needed to break the bond in the reactant is called the **activation energy**. It has the symbol $\boldsymbol{E_A}$.

FUELS

Fuels are substances which react exothermically with air making safe products. They combust (burn) easily, so storing them can be a problem.

Hydrogen reacts exothermically and the product (water) is totally safe. But hydrogen is difficult and dangerous to store.

$$2H_2(g) + O_2(g) \longrightarrow 2H_2O(g)$$

Bonds broken	Bonds made	Total energy change
2 H–H = 2 × 436	4 H–O = 4 × 463	
1 O=O = 496		
1368 kJ	1852 kJ	1852 – 1368 = 484 kJ

Methane (natural or North Sea gas) reacts exothermically. The products are carbon dioxide and water. These are safe, although carbon dioxide contributes to global warming.

$$CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(g)$$

Bonds broken	Bonds made	Total energy change
4 C–H = 4 × 412	2 C=O = 2 × 743	
2 O=O = 2 × 496	4 H–O = 4 × 463	
2640	3338	3338 – 2640 = 698 kJ

Comparing fuels

The most efficient fuel is one that gives out most energy per gram.

4 g of hydrogen produce 484 kJ, so 1 g → 121 kJ
16 g of methane produce 698 kJ, so 1 g → 43.6 kJ

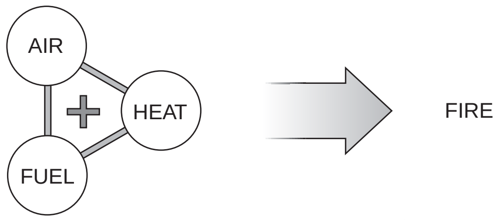
Hydrogen in the more efficient fuel.

FIRE

Fire triangle

For a fire to burn, fuel, air, and heat are needed. The heat provides the **activation energy**, $\boldsymbol{E_A}$, to break existing bonds.

These three requirements are shown in the fire triangle.



REACTANTS + ACTIVATION ENERGY ⟹ REACTION

Preventing or putting out fires

A fire can be prevented by removing any one of the components of the fire triangle:

- remove the air (fire blankets, foam)
- remove the fuel (turn off fuel, use fire breaks in forests)
- remove heat (spray with water)

INCOMPLETE COMBUSTION

In the open air, a fuel reacts with oxygen until it is used up. The fuel is **completely combusted**.

If the supply of air is limited, the oxygen in the air may be used up before the fuel. The fuel is incompletely combusted.

If a hydrocarbon is **incompletely combusted**, the carbon in it may be:

- only partially oxidized, forming carbon monoxide
- unburnt, forming soot (as in a yellow Bunsen flame)

In car engines, turbos pump more air into the engine. This improves efficiency because it helps the fuel to combust completely.