

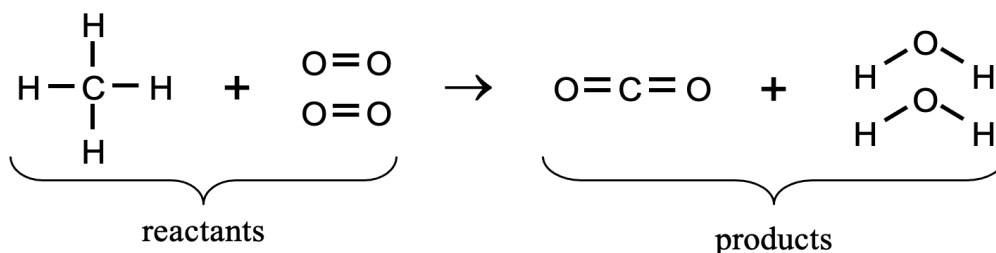
## Energy changes in reactions

1. It takes 243 kJ to break 1 mol of Cl–Cl bonds.
  - a) How much energy is needed to break 2 mol of these bonds?
  - b) How much energy is given out when 1 mol of these bonds are made?

The table shows some mean bond energies. Use them to answer the following questions.

chemical bond	C–H	C=O	O=O	O–H	H–H	N–H	N≡N
mean bond energy (kJ/mol)	435	805	498	464	436	391	945

2. Methane is CH<sub>4</sub>. A molecule of methane can be drawn like this:
  - a) How much energy is needed to break 1 mol of C–H bonds?
  - b) How many C–H bonds are there in a molecule of CH<sub>4</sub>?
  - c) How much energy is needed to break all the bonds in 1 mol of methane?  
Hint: It's not the same as the answer to part a)!
3. Methane reacts with oxygen to form carbon dioxide and water: CH<sub>4</sub> + 2O<sub>2</sub> → CO<sub>2</sub> + 2H<sub>2</sub>O  
These are all the bonds involved in this reaction:



- a) Work out the energy needed to break all the bonds in the reactants.  
Hint: add together the bond energies for **all** the bonds in the reactants.
  - b) Work out the energy given out when all the bonds in the products form.
  - c) The energy change in the reaction, ΔH, is energy in – energy out.  
Work out ΔH for this reaction using your answers to parts a) and b).
  - d) Is this reaction exothermic or endothermic? Explain how you know.
4. Ammonia, NH<sub>3</sub>, is an important chemical. It is used to make fertilisers, explosives, dyes and nylon. Ammonia is made by the Haber process, where nitrogen and hydrogen react together: N<sub>2</sub> + 3H<sub>2</sub> ⇌ 2NH<sub>3</sub>

The ⇌ sign means that it is a reversible reaction

    - a) The bonds in nitrogen are N≡N, in hydrogen they are H–H and in ammonia they are:  
Draw a diagram like the one in question 3 for the reaction N<sub>2</sub> + 3H<sub>2</sub> ⇌ 2NH<sub>3</sub>.
    - b) Work out the energy change for the reaction (show all your working out).
    - c) Explain whether it is an exothermic reaction or an endothermic reaction.

