Energy changes in reactions

1. It takes 243 kJ to break 1 mol of Cl—Cl bonds.

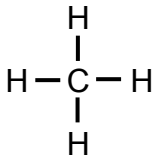
   a) How much energy is needed to break 2 mol of these bonds?

   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_4. A molecule of methane can be drawn like this:

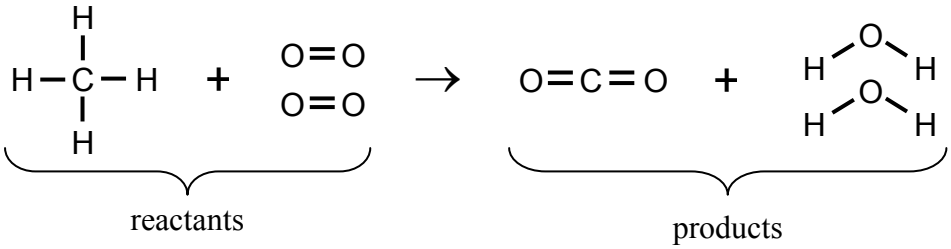


   a) How much energy is needed to break 1 mol of C—H bonds?

   b) How many C—H bonds are there in a molecule of CH_4?

   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: $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
   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.

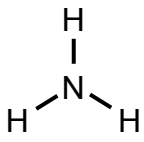
   c) The energy change in the reaction, ΔH, is energy in – energy out.
   Work out ΔH for this reaction using your answers to parts a) and b).

   d) Is this reaction exothermic or endothermic? Explain how you know.

4. Ammonia, NH_3, 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: $N_2 + 3H_2 \rightleftharpoons 2NH_3$.

   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 $N_2 + 3H_2 \rightleftharpoons 2NH_3$.

   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.

