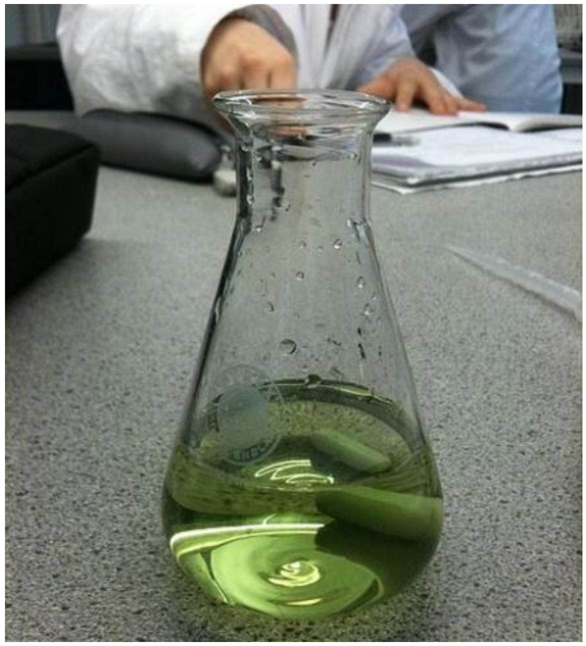
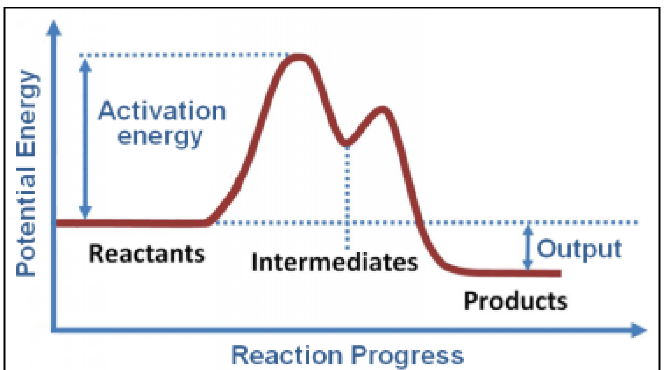
Chemical reaction



Nutralization reaction of sodium hydroxide and hydrochloric acid. Creative Commons



Source: John Brews

A typical reaction path in which energy is released [1]

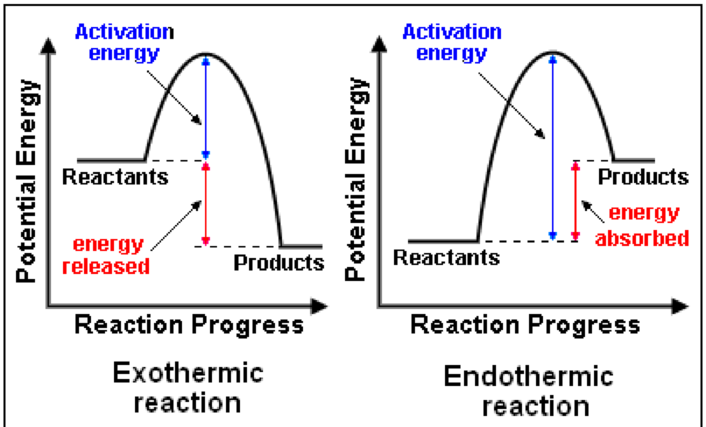
A **chemical reaction** is a process that transforms one set of chemical substances to another. The substances that take part in chemical reactions are known as ***reactants*** and the substances produced by the reaction are known as ***products***. The study of chemical reactions is part of the field of science called chemistry.[2]

Chemical reactions can result in molecules attaching to each other to form larger molecules, molecules breaking apart to form two or more smaller molecules, or rearrangement of atoms within or across molecules. Chemical reactions usually involve the making or breaking of chemical bonds, and in some types of reaction may involve production of electrically charged end products. Reactions can occur in various environments: solids, liquids, gases, or combinations of same.

As exemplified in the adjacent figure, the participating ***reactants*** typically must surmount a thresholdenergy or ***activation energy*** to initiate the reaction, and ***intermediate*** products may exist briefly before the final output ***products*** are formed. In the figure, the ***activation energy*** on the left is the amount of energy change needed to surmount the activation threshold and the energy ***output*** on the right indicates the overall change in energy when the reaction is complete. In the figure's exemplified reaction, the final energy level is below the level of the initial reactants and therefore the reaction requires the input and absorption of energy in some form such as heat, light, or electricity.[3]

Chemical reactions can be either spontaneous[4] and require no input of energy, or non-spontaneous[4]which require the input of some form of energy. Classically, chemical reactions are transformations that involve the movement of electrons during the forming and breaking of chemical bonds. A more general concept of chemical reactions would include nuclear reactions and elementary particle reactions.

Energy changes in reactions



Source: Milton Beychok

Energy level diagrams of exothermic and endothermic reactions.[4][5][6]

In terms of the energy changes that take place during chemical reactions, a reaction may be either ***exothermic*** or ***endothermic***, terms which were first coined by the French chemist Marcellin Berthelot (1827 − 1907).

The meaning of those terms and the difference between them are discussed below and illustrated in the adjacent diagram of the energy profiles for exothermic and endothermic reactions.

Exothermic reactions

Exothermic chemical reactions release energy. The released energy may be in the form of heat, light, electricity, sound or shock waves ... either singly or in combinations.

A few examples of exothermic reactions are:

- Mixing of acids and alkalis (releases heat)
- Combustion of fuels (releases heat and light)

Endothermic reactions

Endothermic chemical reactions absorb energy. The energy absorbed may be in various forms just as is the case with exothermic reactions.

A few examples of endothermic reactions are:

- Dissolving ammonium nitrate (NH_4NO_3) in water (absorbs heat and cools the surroundings)
- Electrolysis of water to form hydrogen and oxygen gases (absorbs electricity)
- Photosynthesis of chlorophyll plus water plus sunlight to form carbohydrates and oxygen (absorbs light)

Reaction types

The common kinds of classical chemical reactions include:[7][8][9]

• **Isomerization**, in which a chemical compound undergoes a structural rearrangement without any change in its net atomic composition.

• **Direct combination or synthesis**, in which two or more chemical elements or compounds unite to form a more complex product:

$N_2 + 3 H_2 \Rightarrow 2 NH_3$

• **Chemical decomposition**, in which a compound is decomposed into elements or smaller compounds:

$2 H2O \Rightarrow 2 H_2 + O_2$

• **Single displacement or substitution**, characterized by an element being displaced out of a compound by a more reactive element:

$2 Na(s) + 2 HCl(aq) \Rightarrow 2 NaCl(aq) + H_2(g)$

• **Metathesis or double displacement**, in which two compounds exchange ions or bonds to form different compounds:

$NaCl(aq) + AgNO_3(aq) \Rightarrow NaNO_3(aq) + AgCl(s)$

• **Acid-base reactions**, broadly characterized as reactions between an acid and a base, can have different definitions depending on the acid-base concept employed. Some of the most common are:

- **Arrhenius** definition: Acids dissociate in water releasing H_3O^+ ions; bases dissociate in water releasing OH^- ions.
- **Brønsted-Lowry** definition: Acids are proton (H^+) donors; bases are proton acceptors. Includes the Arrhenius definition.
- **Lewis** definition: Acids are electron-pair acceptors; bases are electron-pair donors. Includes the Brønsted-Lowry definition.

• **Redox reactions**, in which changes in the oxidation numbers of atoms in the involved species occur. Those reactions can often be interpreted as transfers of electrons between different molecular sites or species. An example of a redox reaction is:

$2 S_2O_3^{2-}(aq) + I_2(aq) \Rightarrow S_4O_6^{2-}(aq) + 2 I^-(aq)$

In which iodine (I_2) is reduced to the iodine anion (I^-) and the thiosulfate anion ($S_2O_3^{2-}$) is oxidized to the tetrathionate anion ($S_4O_6^{2-}$).

• **Combustion**, a kind of redox reaction in which any combustible substance combines with an oxidizing element, usually oxygen, to generate heat and form oxidized products as exemplified in the combustion of methane:

$CH_4 + 2 O_2 \Rightarrow CO_2 + 2 H_2O$

• **Disproportionation** with one reactant forming two distinct products varying in oxidation state as per this example:

$2 Sn^{2+} \Rightarrow Sn + Sn^{4+}$

• **Organic reactions** encompass a very wide assortment of reactions involving organic compounds which are chemical compounds having carbon as the main element in their molecular structure. The reactions in which an organic compound may take part are largely defined by its functional groups.

References

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3. For some qualitative discussions see, for example: (a) John W. Moore, Conrad L. Stanitski and Peter C. Jurs (2009), *Principles of Chemistry: The Molecular Science*, Cengage Learning, ISBN 0-495-39079-8 and (b) Eric V. Anslyn and Dennis A. Dougherty (2006), *Modern Physical Organic Chemistry* , University Science Books, ISBN 1-891389-31-9.
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5. Frederick A. Bettelheim, William H. Brown, Mary K. Campbell and Shawn O. Farrell (2009),*Introduction to General, Organic and Biochemistry.* Brooks/Cole, Cengage Learning, pages 215-216, ISBN 0-495-39112-3.
6. Paul Collison, David Kirkby and Averil Macdonald (2003), *Nelson Modular Science, Volume 2*, Nelson Thornes Ltd., page 151, ISBN 0-7487-6247-7.
7. Note: In the following chemical equations, (aq) indicates an aqueous solution, (g) indicates a gas and (s) indicates a solid. Superscripts with a positive sign (+) indicate a cation and superscripts with a negative sign (−) indicate an anion.
8. H. Stephen Stoker (2011), *General, Organic and Biological Chemistry*, 6th Edition, Brooks/Cole, Cengage Learning, ISBN 1-133-10394-4. (See Chapter 9, "Chemical Reactions")
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Source:
http://www.eoearth.org/view/article/51cbf2507896bb431f6a8b8f/?topic=51cbfc98f702fc2ba812eaa6