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1. Life and work

Russian physical chemist Academician NN Beketov was born on 1 (13) January 1827 in the village of Alferevka, Penza province, the estate of his father, a former naval officer Nikolai A. Beketov. He was the youngest of three brothers, each of which became a celebrity. Senior Alexei Beketov (1823), a graduate of the Main Engineering School, was a "literary circle", organized by the school Dostoevsky. Middle brother, Andrew Beketov (1825-1902), became the largest Russian botanist, publicist, rector (in 1876-1883) of St. Petersburg University; He was the grandfather of the poet AA Blok on the maternal side. A younger brother, Nicholas, was destined to be the founder of modern physical chemistry.

In 1844, after the end of the 1st Petersburg High School N.N Beketov enrolled in the University of St. Petersburg "to the rank of Natural Sciences II Branch Faculty of Philosophy." There's also trained and brother NN Beketov, Andrei. Then that in November 1846 the brothers Beketovs together with other students staged a small hostel ("Association") by removing together a large apartment on Vasilevsky Island. In this circle were DV Grigorovich, AN Mike, VN Mike, AN Pleshcheyev, AV Khanykov, SD Yanovsky. Among these students was FM Dostoevsky, friendship with whom NN Beketov continued until his death.

In 1849, Beketov graduated from Kazan University and worked with Nikolay Zinin. In 1855, he became a junior scientific assistant in the Department of Chemistry at Kharkov University. In 1859-1887, Beketov was a professor at the same university. In 1865, he defended his PhD thesis on "Research into the phenomenon of displacement of one element by another". In 1886, Beketov moved to Saint Petersburg, where he worked at the academic chemical laboratory and taught at the University for Women. In 1890, Beketov delivered lectures on the "Basics of Thermochemistry" at Moscow State University.

Beketov discovered displacement of metals from solutions of their salts by hydrogen under pressure. He also established that magnesium and zinc displaced other metals from their salts under high temperatures. In 1859-1865, Beketov proved that aluminum restored metals from their oxides under high temperatures. Later on, Beketov's experiments served as a starting point for aluminothermy.

Beketov's biggest merit was his contribution into physical chemistry as an independent science. In 1860, he taught a course on "Relations between physical and chemical phenomena" in Kharkov and a course on "Physical Chemistry" in 1865. In 1864, a Physical Chemistry Department in Kharkov University was established with his active participation, where students would conduct research and do practical work.

In 1886, Beketov was elected a full member of the Petersburg Academy of Sciences.

Beketov's students were Alexander Eltekov, Flavian Flavitsky and others. The poet Alexander Blok was his brother's grandson.

2. Physical chemistry

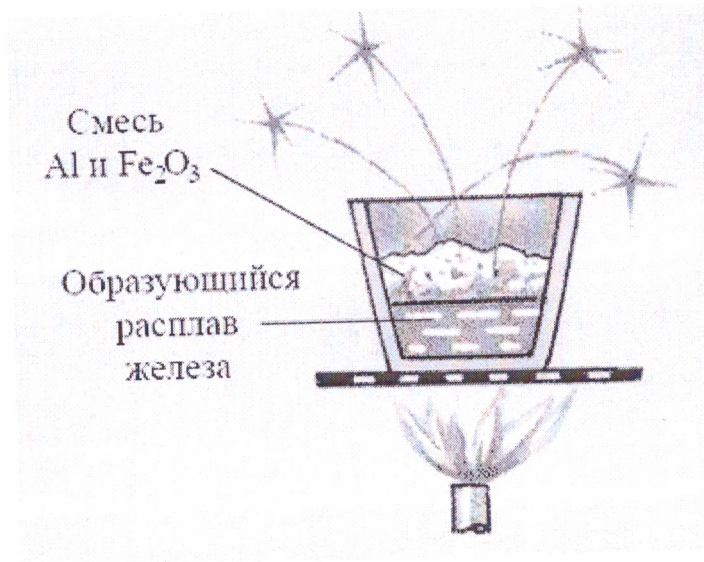
Physical chemistry is the study of macroscopic, atomic, subatomic, and particulate phenomena in chemical systems in terms of laws and concepts of physics. It applies the principles, practices and concepts of physics such as motion, energy, force, time, thermodynamics, quantum chemistry, statistical mechanics and dynamics, equilibrium.

Some of the relationships that physical chemistry strives to resolve include the effects of:

1. Intermolecular forces that act upon the physical properties of materials (plasticity, tensile strength, surface tension in liquids).
2. Reaction kinetics on the rate of a reaction.
3. The identity of ions and the electrical conductivity of materials.
4. Surface chemistry and electrochemistry of membranes.
5. Interaction of one body with another in terms of quantities of heat and work called thermodynamics.
6. Transfer of heat between a chemical system and its surroundings during change of phase or chemical reaction taking place called thermochemistry
7. Study of colligative properties of number of species present in solution.
8. Number of phases, number of components and degree of freedom (or variance) can be correlated with one another with help of phase rule.
9. Reactions of electrochemical cells.

3. Aluminothermic reactions

Aluminothermic reactions are exothermic chemical reactions using aluminium as the reducing agent at high temperature. The process is industrially useful for production of alloys of iron. The most prominent example is the thermite reaction between aluminium and iron oxides:



This reaction is however not relevant to the most important application of aluminothermic reactions, the production of ferroalloys. For the production of iron, a cheaper reducing agent, coke, is used instead via the carbothermic reaction

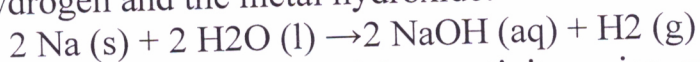
Aluminothermic reactions have been used to welding rail tracks on-site, useful for complex installations or local repairs that cannot be done using continuously welded rail. Another common use is the welding of copper cables (wire) for use in direct burial (grounding/earthing) applications. It is still the only type of electrical connection recognized by the IEEE (IEEE, Std 80-2001) as continuous.

4. Reactivity series

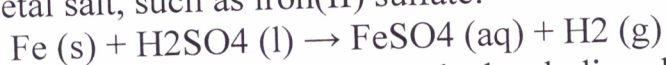
In introductory chemistry, the reactivity series or activity series is an empirical, calculated and a structurally[clarification needed] analytical progression of a series of metals, according to their "reactivity" from highest to lowest. It is used to summarize information about the reactions of metals with acids and water, double displacement reactions and the extraction of metals from their ores.

4.1 Reaction with water and acids

The most reactive metals, such as sodium, will react with cold water to produce hydrogen and the metal hydroxide:



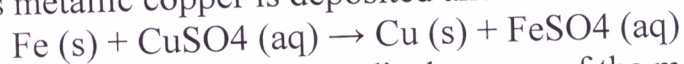
Metals in the middle of the reactivity series, such as iron, will react with acids such as sulfuric acid (but not water at normal temperatures) to give hydrogen and a metal salt, such as iron(II) sulfate:



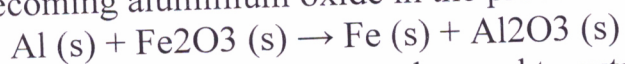
There is some ambiguity at the borderlines between the groups. Magnesium, aluminium and zinc can react with water, but the reaction is usually very slow unless the metal samples are specially prepared to remove the surface layer of oxide which protects the rest of the metal. Copper and silver will react with nitric acid; but because nitric acid is an oxidizing acid, the oxidizing agent is not the H^+ ion as in normal acids, but the NO_3^- ion.

4.2 Single displacement reactions

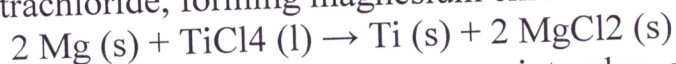
An iron nail placed in a solution of copper sulphate will quickly change colour as metallic copper is deposited and the iron is converted into iron(II) sulfate:



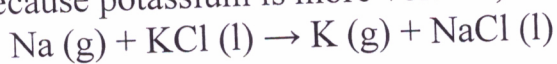
In general, a metal can displace any of the metals which are lower in the reactivity series: the higher metal reduces the ions of the lower metal. This is used in the thermite reaction for preparing small quantities of metallic iron, and in the Kroll process for preparing titanium (Ti comes at about the same level as Al in the reactivity series). For example, aluminium will reduce iron(III) oxide to iron, becoming aluminium oxide in the process:



Similarly, magnesium can be used to extract titanium from titanium tetrachloride, forming magnesium chloride in the process:



However, other factors can come into play, such as in the preparation of metallic potassium by the reduction of potassium chloride with sodium at 850°C . Although sodium is lower than potassium in the reactivity series, the reaction can proceed because potassium is more volatile, and is distilled off from the mixture.



5 Comparison with standard electrode potentials

The reactivity series is sometimes quoted in the strict reverse order of standard electrode potentials, when it is also known as the "electrochemical series":

$\text{Li} > \text{K} > \text{Sr} > \text{Ca} > \text{Na} > \text{Mg} > \text{Al} > \text{Mn} > \text{Zn} > \text{Cr} > \text{Fe} > \text{Cd} > \text{Co} > \text{Ni} > \text{Sn} > \text{Pb} > \text{H} > \text{Cu} > \text{Ag} > \text{Hg} > \text{Pd} > \text{Ir} > \text{Pt} > \text{Au}$

The positions of lithium and sodium are changed on such a series; gold and platinum are also inverted, although this has little practical significance as both metals are highly unreactive.

Standard electrode potentials offer a quantitative measure of the power of a reducing agent, rather than the qualitative considerations of other reactivity series. However, they are only valid for standard conditions: in particular, they only apply to reactions in aqueous solution. Even with this proviso, the electrode potentials of lithium and sodium – and hence their positions in the electrochemical series – appear anomalous. The order of reactivity, as shown by the vigour of the reaction with water or the speed at which the metal surface tarnishes in air, appears to be

potassium > sodium > lithium > alkaline earth metals,
the same as the reverse order of the (gas-phase) ionization energies. This is borne out by the extraction of metallic lithium by the electrolysis of a eutectic mixture of lithium chloride and potassium chloride: lithium metal is formed at the cathode, not potassium.

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