

## Chemistry Timeline

### Ancient Alchemy 3000 B.C. to 800 A.D.

- c. 3000 B.C. – Egyptians formulate the theory of the Ogdoad, or the “primordial forces”, from which all was formed. These were the elements of chaos that existed before the creation of the sun
- c. 1900 B.C. – Hermes Trismegistus, semi-mythical Egyptian king, who is supposed to have founded of the art of alchemy
- c. 450 B.C. – Empedocles asserts that all things are composed of four primal elements – earth, air, fire, and water, whereby two active and opposing forces, love and hate, or affinity and antipathy, act upon these elements, combining and separating them into infinitely varied forms
- c. 440 B.C. – Democritus propose the idea of the atom, an indivisible particle that all matter is made of
- c. 360 B.C. – Plato coins term ‘elements’ and postulates that the minute particle of each element had a special geometric shape – tetrahedron for fire; octahedron for air; icosahedron for water; and cube for earth)
- c. 350 B.C. – Aristotle articulates his theory of the Five Elements, fire, water, earth, air, and ether
- **0 A.D. – Common Era after the Birth of Christ Begins**
- c. 300 – Zosimos of Panopolis writes some of the oldest known books on alchemy

### Classical Alchemy 800 A.D. to 1661

- c. 815 – Abu Musa Jabir ibn Hayyan isolates numerous acids, including hydrochloric acid, nitric acid, citric acid, acetic acid, tartaric acid, and aqua regia
- c. 900 – Abū Bakr Muhammad ibn Zakarīya al-Rāzi publishes several treatises on chemistry, including some of the earliest descriptions of controlled distillation and extraction methods
- c. 1220 – Robert Grosseteste publishes several Aristotelian commentaries where he lays out an early framework for the scientific method
- c. 1267 – Roger Bacon publishes *Opus Maius*, proposing the scientific method and results of his experiments with gunpowder
- c. 1530 – Paracelsus develops the study of iatrochemistry, a subdiscipline of alchemy dedicated to extending the life
- 1597 – Andreas Libavius publishes *Alchemia*, a prototype chemistry textbook
- 1605 – Sir Francis Bacon publishes *The Proficiency and Advancement of Learning*, containing an outline of the scientific method
- 1605 – Michał Sędziwój publishes the alchemical treatise *A New Light of Alchemy*, proposing the existence of the "food of life" within air
- 1615 – Jean Beguin publishes the early chemistry textbook, *Tyrocinium Chymicum*, with the first-ever chemical equation

- 1637 – René Descartes publishes *Discours de la Méthode*, containing an outline of the scientific method
- 1648 – Publication of the Johann Baptista van Helmont's book *Ortus Medicinae* a major transitional work between alchemy and chemistry, and which also influences Robert Boyle. The book shows the results of experiments and establishes an early version of the Law of Conservation of Mass

## The Modern Chemistry Era 1661 to Present

- 1661 – Robert Boyle publishes *The Sceptical Chymist*, a treatise on the distinction between chemistry and alchemy
- 1662 – Robert Boyle proposes Boyle's Law on the behavior of gases
- 1754 – Joseph Black isolates carbon dioxide
- 1758 – Joseph Black formulates the concept of latent heat to explain the thermochemistry of phase changes
- 1773-1774 – Carl Wilhelm Scheele and Joseph Priestly independently isolate oxygen
- 1778 – Antoine Lavoisier recognizes and names oxygen, and recognizes its importance and role in combustion
- 1787 – Antoine Lavoisier publishes *Méthode de Nomenclature Chimique*, the first modern system of chemical nomenclature
- 1787 – Jacques Charles proposes a corollary to Boyle's Law, which he names Charles's Law, describing the relationship between temperature and volume of a gas
- 1789 – Antoine Lavoisier publishes the first modern chemistry textbook, *Traité Élémentaire de Chimie*
- 1797 – Joseph Proust proposes Law of Definite Proportions, which states that elements always combine in small, whole number ratios to form compounds
- 1800 – Alessandro Volta makes the first chemical battery
- 1803 – John Dalton proposes Dalton's Law, which describes relationship between the components in a mixture of gases and the relative pressure each contributes to that of the overall mixture
- 1805 – Joseph Louis Gay-Lussac discovers that water is composed of two parts hydrogen and one part oxygen
- 1807-1808 – Sir Humphry Davy uses electrolysis to isolate numerous elements, including potassium, sodium, calcium, strontium, barium, chlorine and the first discovery of aluminum
- 1808 – John Dalton publishes *New System of Chemical Philosophy*, which contains first modern scientific description of the atomic theory
- 1808 – Jöns Jakob Berzelius publishes *Lärboki Kemien* in which he proposes modern chemical symbols and notation, and of the concept of relative atomic weight
- 1811 – Amedeo Avogadro proposes Avogadro's law, that equal volumes of gases contain equal numbers of particles
- 1825 – Michael Faraday isolates benzene

- 1828 – Friedrich Wöhler synthesizes urea, thereby establishing that organic compounds could be produced from inorganic starting materials, disproving the theory of “vital life force”
- 1840 – Germain Hess proposes Hess's Law, an early statement of the Law of conservation of energy
- 1847 – Hermann Kolbe obtains acetic acid from completely inorganic sources
- 1848 – Lord Kelvin establishes concept of absolute zero, the temperature at which all molecular motion ceases
- 1849 – Louis Pasteur discovers chirality and in tartaric acid, starting the study of stereochemistry
- 1855 – Benjamin Silliman, Jr. pioneers methods of petroleum cracking, which makes the entire modern petrochemical industry possible
- 1856 – William Henry Perkin synthesizes the first synthetic dye
- 1862 – Alexander Parkes exhibits Parkesine, one of the earliest synthetic polymers
- 1865 – Friedrich August Kekulé von Stradonitz establishes structure of benzene as a six carbon ring
- 1865 – Adolf von Baeyer begins work on indigo dye, a milestone in modern industrial organic chemistry which revolutionizes the dye industry
- 1869 – Dmitri Mendeleev publishes the first modern periodic table
- 1883 – Svante Arrhenius develops ion theory to explain conductivity in electrolytes
- 1884 – Henry Louis Le Chatelier develops Le Chatelier's principle, which explains the response of dynamic chemical equilibria to external stresses
- 1894-1898 – William Ramsay discovers the noble gases
- 1903 – Mikhail Semyonovich Tsvet invents chromatography
- 1905 – Fritz Haber and Carl Bosch develop the Haber process for making ammonia
- 1907 – Leo Hendrik Baekeland invents bakelite, one of the first commercially successful plastics
- 1909 – Ernest Rutherford, Hans Geiger, and Ernest Marsden perform the Gold foil experiment, which proves the nuclear model of the atom, with a small, dense, positive nucleus surrounded by a diffuse electron cloud
- 1909 – Robert Millikan performs the Oil drop experiment, which confirms the existence of electron as the quanta of electric charge, and determines charge/mass ratio of an electron
- 1909 – S. P. L. Sørensen invents the pH concept and develops methods for measuring acidity
- 1912 – William Henry Bragg and William Lawrence Bragg proposes Bragg's law and establishes the field of X-ray crystallography
- 1913 – Niels Bohr introduces concepts of quantum mechanics to atomic structure by proposing what is now known as the Bohr model of the atom
- 1913 – Frederick Soddy proposes the concept of isotopes, that elements with the same chemical properties may have differing atomic weights
- 1916 – Gilbert N. Lewis publishes *The Atom and the Molecule*, the foundation of valence bond theory

- 1921 – Otto Stern and Walther Gerlach establish concept of quantum mechanical spin in subatomic particles
- 1923 – Gilbert N. Lewis and Merle Randall publish *Thermodynamics and the Free Energy of Chemical Substances*, first modern treatise on chemical thermodynamics
- 1923 – Gilbert N. Lewis develops the electron pair theory of acid/base reactions
- 1935 – Wallace Carothers leads a team of chemists at DuPont who invent nylon
- 1932 – Linus Pauling first describes the property of electronegativity as a means of predicting the dipole moment of a chemical bond
- 1937 – Carlo Perrier and Emilio Segrè perform the first confirmed synthesis of technetium-97, the first artificially produced element
- 1937 – Eugene Houdry develops a method of industrial scale catalytic cracking of petroleum, leading to the development of the first modern oil refinery
- 1939 – Linus Pauling publishes *The Nature of the Chemical Bond*, one of the most important modern chemical texts
- 1945-1946 – Felix Bloch and Edward Mills Purcell develop the process of Nuclear Magnetic Resonance, an analytical technique important in elucidating structures of molecules, especially in organic chemistry
- 1952 – Robert Burns Woodward, Geoffrey Wilkinson, and Ernst Otto Fischer discover the structure of ferrocene, one of the founding discoveries of the field of organometallic chemistry
- 1962 – Neil Bartlett synthesizes xenon hexafluoroplatinate, showing for the first time that the noble gases can form chemical compounds
- 1985 – Harold Kroto, Robert Curl and Richard Smalley discover fullerenes, a class of large carbon molecules superficially resembling the geodesic dome designed by architect R. Buckminster Fuller
- 1995 – Eric Cornell and Carl Wieman produce the first Bose–Einstein condensate, a substance that displays quantum mechanical properties on the macroscopic scale