Date	Protagonists	Basis of Generalization or Theory	Weaknesses or/& Advantages
1774	Antoine **Lavoisier** (1743 – 1794)	Acids are substances containing oxygen	Davy found that 'oxymuriatic acid' was in fact hydrochloric acid, $HC\ell$, containing no oxygen
1810	Sir Humphry **Davy** (1778 – 1829)	Acids contain hydrogen as the important element	Many H-containing substances are not acids
1838	Justus von **Liebig** (1803 – 1873)	Substances which can react with metals to produce hydrogen gas	Oxidizing acids like nitric acid (HNO_3) do not generally give $H_{2(g)}$ with metals
1884	Svante **Arrhenius** (1859 – 1927) First comprehensive theory of acids and bases that attempted to explain acidity at the atomic level	**Acid solutions** in water are *electrolytes* and their solutions **contain hydrogen ions**, $\mathbf{H^+}$, while **bases produce hydroxide ions**, $\mathbf{OH^-}$ **Strong acids** are **completely ionized** in H_2O: $HC\ell_{(aq)} \rightarrow H^{1+}_{(aq)} + C\ell^{1-}_{(aq)}$. **Weak acids** are only **partially ionized**: $HOAc_{(aq)} = H^{1+}_{(aq)} + AcO^{1-}_{(aq)}$ [Ac = CH_3CO = acetyl]	Ideas could only be applied to aqueous solutions - but acid-base reactions were known that took place in non-aqueous solvents or without any solvent, *e.g.,* $NH_{3(g)} + HC\ell_{(g)} \rightarrow NH_4C\ell_{(s)}$ $MgO_{(s)} + SO_{3(g)} \rightarrow MgSO_{4(s)}$
1923	Johannes **Brønsted** (1879 – 1947) & Thomas **Lowry** (1874 – 1936) Independently proposed this more general definition	An **acid** is a **proton ($\mathbf{H^+}$ ion) donor** A **base** is a **proton ($\mathbf{H^+}$ ion) acceptor** $HC\ell_{(aq)} + H_2O_{(\ell)} = H_3O^{1+}_{(aq)} + C\ell^{1-}_{(aq)}$ acid **1** base **2** *conjugate* acid **2** *conjugate* base **1** $H_2SO_{4(\ell)} + HNO_{3(\ell)} = H_2NO_3^{1+}{}_{(\ell)} + HSO_4^{1-}{}_{(\ell)}$ acid **1** base **2** *conjugate* acid **2** *conjugate* base **1**	Became known as Brønsted-Lowry theory of acids & bases and represented a great step forward in this field. Definition applies to all *protic* solvents, not only H_2O. Acids & bases not considered in isolation and readily interprets the different properties of pure acids *and* acids in solution. Acids are not confined to neutral species or positive ions. $HSO_4^{1-}{}_{(aq)} + H_2O_{(\ell)} = H_3O^{1+}_{(aq)} + SO_4^{2-}{}_{(aq)}$
(1923) 1938	G N **Lewis** (1875 – 1946) Theory of wider applicability than that of Brønsted-Lowry	An **acid** is an **electron-pair acceptor** A **base** is an **electron-pair donor** $F_3B + :NH_3 = F_3B{\leftarrow}:NH_3$ Lewis acid Lewis base	The proton (H^+ ion) is an acid under this definition and so are a great number of other species. Theory greatly increases the number of reactions considered as acid-base, crucially those *not* occurring in protic solvents. Limitation of theory - it can be too general, *e.g.,* Pb(II) → Pb(IV) is acid-base <u>and</u> redox using the Lewis system.