HONORS CHEMISTRY – Timeline of Particle Discoveries

1895 - **X-rays** produced by Wilhelm Röntgen (later identified as photons)
1897 - **Electron** discovered by J. J. Thomson
1899 - **Alpha particle** discovered by Ernest Rutherford in uranium radiation
1900 - **Gamma ray** (high-energy photon) discovered by Paul Villard in uranium decay
1911 - **Atomic nucleus** identified by Ernest Rutherford, based on scattering observed by Hans Geiger and Ernest Marsden.
1919 - **Proton** discovered by Ernest Rutherford
1932 - **Neutron** discovered by James Chadwick (predicted by Rutherford in 1920
1932 - **Positron**, the first antiparticle, discovered by Carl D. Anderson (proposed by Paul Dirac in 1927)
1937 - **Muon** discovered by Seth Neddermeyer, Carl Anderson, J.C. Street, and E.C. Stevenson, using cloud chamber measurements of cosmic rays. (It was mistaken for the **pion** until 1947.
1947 - **Pion** discovered by Cecil Powell (predicted by Hideki Yukawa in 1935
1947 - **Kaon**, the first strange particle, discovered by G.D. Rochester and C.C. Butler
1955 - **Antiproton** discovered by Owen Chamberlain , Emilio Segrè, Clyde Wiegand, and Thomas Ypsilantis
1956 - **Neutrino** detected by Frederick Reines and Clyde Cowan (proposed by Wolfgang Pauli in 1931 to explain the apparent violation of energy conservation in beta decay)
1962 - **Muon neutrino** shown to be distinct from **electron neutrino** by group headed by Leon Lederman
1969 - **Partons** (internal constituents of hadrons) observed in deep inelastic scattering experiments between protons and electrons at SLAC; this was eventually associated with the quark model (predicted by Murray Gell-Mann and George Zweig in 1963) and thus constitutes the discovery of the up quark, down quark, and strange quark.
1974 - **J/_ particle** discovered by groups headed by Burton Richter and Samuel Ting, demonstrating the existence of the charm quark (proposed by Sheldon Glashow, John Iliopoulos, and Luciano Maiani in 1970)
1975 - **Tau lepton** discovered by group headed by Martin Perl
1977 - **Upsilon particle** discovered at Fermilab, demonstrating the existence of the bottom quark (proposed by Kobayashi and Maskawa in 1973)
1979 - **Gluon** observed indirectly in three jet events at DESY
1983 - **W and Z bosons** discovered by Carlo Rubbia, Simon van der Meer, and the CERN UA-1 collaboration (predicted in detail by Sheldon Glashow, Abdus Salam, and Steven Weinberg in the 1960s)
1995 - **Top quark** discovered at Fermilab
2000 - **Tau neutrino** shown to be distinct from other neutrinos at Fermilab