

THE NEW ERA IN PHYSICS
Ch. IX Hist of Science.

1. Begins with discovery of X-rays by Rontgen 1895. 382
2. Grew out of study of electric discharges through gases in partially exhausted tubes. 382.
3. Found accidentally that produced rays ruined photographic plates that were protected from action of ordinary light 382.
4. J.J. Thompson discovered that X-rays passed through gas made it a conductor of electricity. 383.
5. Due to ionizing of the gas by X-rays. 383
6. X-rays led to discovery of radio-activity through arousing question as to whether any matter naturally through off rays such as X-rays. 384
7. Becquerel in 1896 found uranium and its salts affected photographic plate. 384
8. 1897 marked by discovery of ultra atomic corpuscles. 384
9. With these three discoveries the new era in physics had begun. 384
10. Rays given from cathode (neg. electrode) in tube found deflected by magnetic and electric fields, hence not mere vibrations, and could penetrate thin gold-leaf, hence not of atomic size. 384-5.
11. Thompson took view that these rays were composed of small particles which he called corpuscles following Newton. 386
12. Suggested that they were common constituents of all atoms. 387.
13. Velocity found to be on order of 1/10th that of light. 386
14. Indirect measurement of mass of corpuscles by Milikan in 1911 gives figure of 1/1836th part of H atom. 388
15. H atom 1.66×10^{-24} gram hence corpuscle 9×10^{-28} gram. 388
16. Corpuscles carry neg. charge of electricity normally balanced in atom. In case of ionized gas some broken away from atoms producing negative ions while the impoverished atom acts like pos. ion. 388
17. While Thompson explained electricity in terms of matter, Lorentz explained matter in terms of electricity. 389.
18. Approaching from different line Lorentz showed units called electrons to be identical with Thompsons corpuscles. 389
19. Electrons simply component parts of electricity. 389
20. Early assumption that Newtonian mechanics applied ~~thxix~~ to movements of electrons in atoms; hence picture of miniature solar-system built up. 389

21. This idea not feasible in light of present knowledge 1929 389
22. Discovery of anode or positive rays having weight comparable to that of atoms. 390
23. Search of Curie's for various radio-active substances and subsequent discovery of radium, polonium and actinium, about 1900. 391
24. Rutherford (1899) discovered alpha and beta rays and later gamma rays in uranium and other radio-active substances. 392
25. Beta rays shown to possess properties of cathode rays or electrons only having greater velocities. 392
26. Alpha rays deflected by electric and magnetic fields though less easily than in case of beta rays, and in opposite direction. 392
27. Alpha rays subsequently proven to consist of He. 392
28. Gamma rays found not to be deflected by either electric or magnetic fields. 392
29. Like X-rays they are same nature as light waves though of much shorter wave length. 393
30. Discovery of highly radio-active ^{emanation} ~~radiations~~ from radio-active substances. 394
31. Proof of heat thrown off continuously in radio-activity. 395
32. Facts re. radio-activity:
 - a. Radio-activity produces new chemical bodies.
 - b. These bodies result of dissociation of particles, not combinations.
 - c. Activity proportional to mass of radio-active element whether free or combined, hence dissociating particles are atoms not molecules.
 - d. Amt. of energy liberated many thousand times that involved in most violent chemical reaction known. 396.
33. Tracing of descent of Uranium family through 13 steps to Pb. 397.
34. Atoms in form of He atoms first observed directly through radio-activity. 397.
35. By method of counting alpha particles thrown off Rutherford was able to estimate life of radium. 398
36. R mass reduced to $1/2$ in 1590 yrs. 397
37. Radio-activity proves transmutation of elements, but to date no means of control of radio-activity known. 398
38. Radio-active discharge follows laws of probability. 398.
39. Rutherford discovered in 1919 that two H nuclei could be driven out of N by bombardment with alpha particles. 398
40. Matter can be changed to lower atomic weight but process not reversed. 398

41. X-rays found to be deflected by regular arrangement of atoms in chrystals. 399
42. Bragg found length of X-ray from Palladium bombarded by cathode rays to be $.576 \times 10^{-8}$ or $1/10,000$ length of Na. light wave. 399
43. Some 60 octaves of rays now known of which visible light is but one octave. 399.
44. Energy not being evenly distributed in spectra led to Quantum theory of Planck. 402
45. Idea is that radiant energy is given off in stream of minute gushes instead of continuously. 403
46. Size of quanta increase with frequency of radiation. 402
47. These quanta equivalent to Newton's light corpuscles. 403
48. This hard to reconcile with phenomenon of interference which seems to imply continuous waves. 404
49. Broglie has built theory that treats moving light particle as group of waves. 404
50. Development of hist. on structure of atom conceived as minute universe. 404 - 408.
51. Evidence that light atomic nuclei give out energy when formed while heavy atomic nuclei give out energy when broken down. 407
52. Bohr's (1913) development of idea that electrons move only in certain possible orbits discretely separated from each other. 408 et seq.
53. Within given orbit law of inverse squares applies but orbits themselves show other relations. 409
54. Step from one orbit to another seems instantaneous, and corresponds to quantams. 409
55. Light from outermost electrons, X-rays from inner electrons, and radio-activity from nucleus. 410
56. Bohr's theory of atom while sound for H. failed to hold for heavier atoms. 411.
57. 1926. Schrodinger developed theory mathematically that material points are nothing but wave systems, like a storm group of waves on the sea. 413
58. Schrodinger's theory holds with respect to complex atoms where Bohr's broke down. 413.
59. Found that accuracy of determination of focus of wave particle and momentum at same time impossible, hence uncertainty. 413
60. Called principle of indeterminacy by Eddington, but generally principle of uncertainty. 413-14

61. Experiments made in 1927 actually showing electron is accompanied by train of waves. 415.
62. Experimental evidence that electron must have a structure and hence is not ultimate unit of matter or electricity. 415.
63. Electron now has become unknown source of radiation or disembodied wave system. 415.
64. Ultimate conceptions of physics now seem to be reduced to mathematical equations. 415.
65. As Newton saw, the ultimate basis which underlies mechanics cannot be mechanical. 416.
66. Preliminary experiments relative to movement of light relative to ether which led to forming problem of relativity. 416-419
67. 1905 Einstein pointed out absolute space and time had no basis in physical observation or experiment. 419.
68. Only measurement is distance between scratches on bar, and only time that measured by clock set by astronomical events. 420
69. Time and space relative to observer. 420
70. Uniformity of velocity of light becomes fundamental constant. 420
71. Time and space such that light moves with same velocity with respect to any observer. 420
72. Velocity of light constant, but space, time nor mass measured separately show constancy. 420.
73. Object relatively in motion with respect to observer is shortened in direction of flight. 420
74. As moving body decreases in size, mass increases, becoming infinite at velocity of light. 420
75. Calculated and observed change of mass of beta particles show astonishing agreement. 420-1
76. On principle of relativity mass and energy are equivalent on formula $E = mc^2$ 421
77. Relative motion approaching order of light leads to contraction in direction of motion, increase of mass and slowing of time-scale. 421
78. Changes in space and time that take place are such as to compensate each other, hence a combination of the two is the same for all observers. 422
79. Hence time becomes a fourth dimension added onto space. 422
80. One sec. becomes the speed of light. 422

81. Interval in this space-time continuum has the same value, whoever measures it. 422.
82. Other constants are, 1. number, 2. thermodynamic entropy, 3 action, or the product of energy and time which gives us the quantum. 422
83. Owing to finite value of speed of light the stars as seen at any moment do not represent any actual configuration that either is or was at any time in the past, owing to difference in distance from earth. 423.
84. To a man traveling with speed of light relative to us the earth remains in the "now", though time is passing for those who live on the earth. 423
85. There is no single plane separating future from past for all men. 423
86. Time in this system for physics is reversible. 424
87. The second law of thermodynamics is a physical process that can proceed in only one direction. 424