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**HD Jain College**
**Ara, Bihar, India**

## SEMESTER 111

### MPHYCC-IO Atomic and Molecular Physics, Lasers (5 Credits)

Course Objectives:

1. Objective of this course is to learn atomic, molecular and spin resonance spectroscopy.
2. To understand mechanism and working of lasers.
3. To be able to understand atomic and molecular transitions and selection rules.
4. To understand the Raman effect and its applications



Course

The End Semester Examination will be of 3 hour duration and will carry 70 marks. The Question paper will be divided into three parts A, B and C. Part A will have ten compulsory questions (multiple choice type) covering the whole syllabus with 2 from each unit (10 X 2 = 20). Part B will have five short answer questions, with one question from each unit. The student is required to answer any four out of them (4 X 5 = 20). Part C will have five long answer questions with one question from each unit. The student is required to answer any three out of them (3 X 10 = 30).

Unit 1: Atomic Physics: Vector Atom Model (LS, JJ Coupling), Fine Structure and Hyperfine Structure, Zeeman Effect, Paschen- Back and Stark Effect.

Intensity, Shape and width of spectral lines, Independent particle model, He atom as an approximation for many electron atomic systems, Slater determinants to write possible multiplets.

Unit 2: Electronic and Molecular Spectra: Molecule as non-rigid rotator, Anharmonic Oscillator (vibration-rotation system), Frank Condon Principle, NMR and ESR. Spectra/Vibration of Polyatomic molecule, Electronic spectra of polyatomic molecules, Chemical analysis by electronic spectroscopy, Spectra of Hydrogen Molecule

Unit 3: Molecular Potential: Concept of Molecular Potential, Separation of electronic and nuclear wave function, Born-Oppenheimer approximation and its breakdown, Analysis by infrared techniques, Molecular orbital theory, LCAO approximation theories.

Unit 4: Raman and Spin Resonance Spectroscopy: Vibrational and pure rotational Raman spectra, Structure determination, Raman and Infrared spectroscopic Technique and instrumentation

Unit 5: Laser: Significance of Einstein's A and B coefficients, pumping schemes, Characteristics of Laser beams, Principles of Fiber Communication, Numerical Aperture.

Laser Operation: Oscillator versus Amplifier, Laser Resonators, Laser rate equations for three and four level Laser systems, Liquid (Dye) Lasers, Gas (C02, Nitrogen and Eximer) lasers, Laser applications in industry, Nuclear science, Spectroscopy. Light detection and Ranging (LIDAR), scanning laser beam devices, Laser communication, (injection photodiode and Avalanche Photodiode), optical computing, and medical applications.

Outcomes:

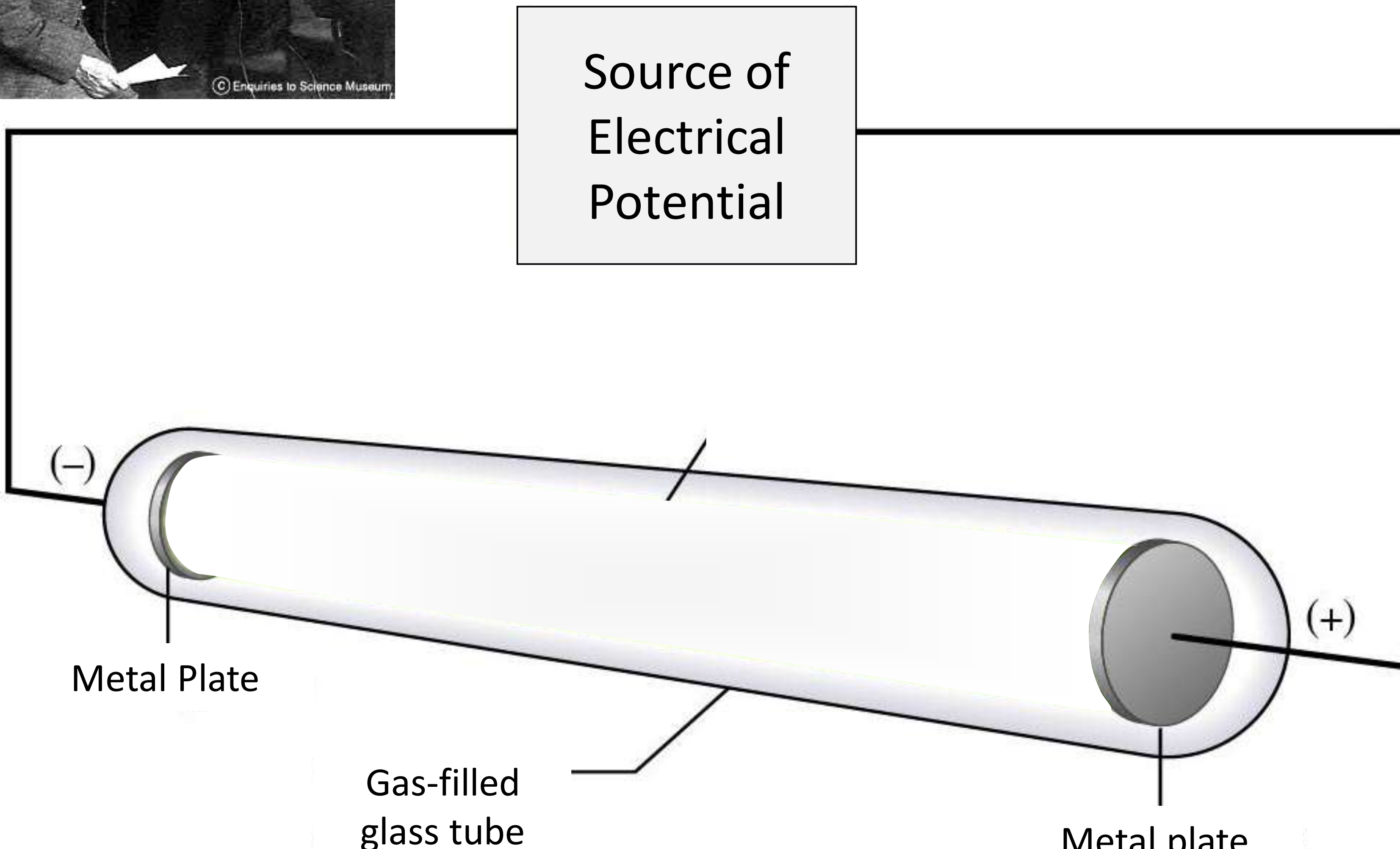
Students will have understanding of:

1. Atomic spectroscopy of one and two valance electron atoms.
2. The change in behavior of atoms in external applied electric and magnetic field.
3. Rotational, vibrational, electronic and Raman spectra of molecules.
4. Electron spin and nuclear magnetic resonance spectroscopy.
5. Principle, working and applications of laser

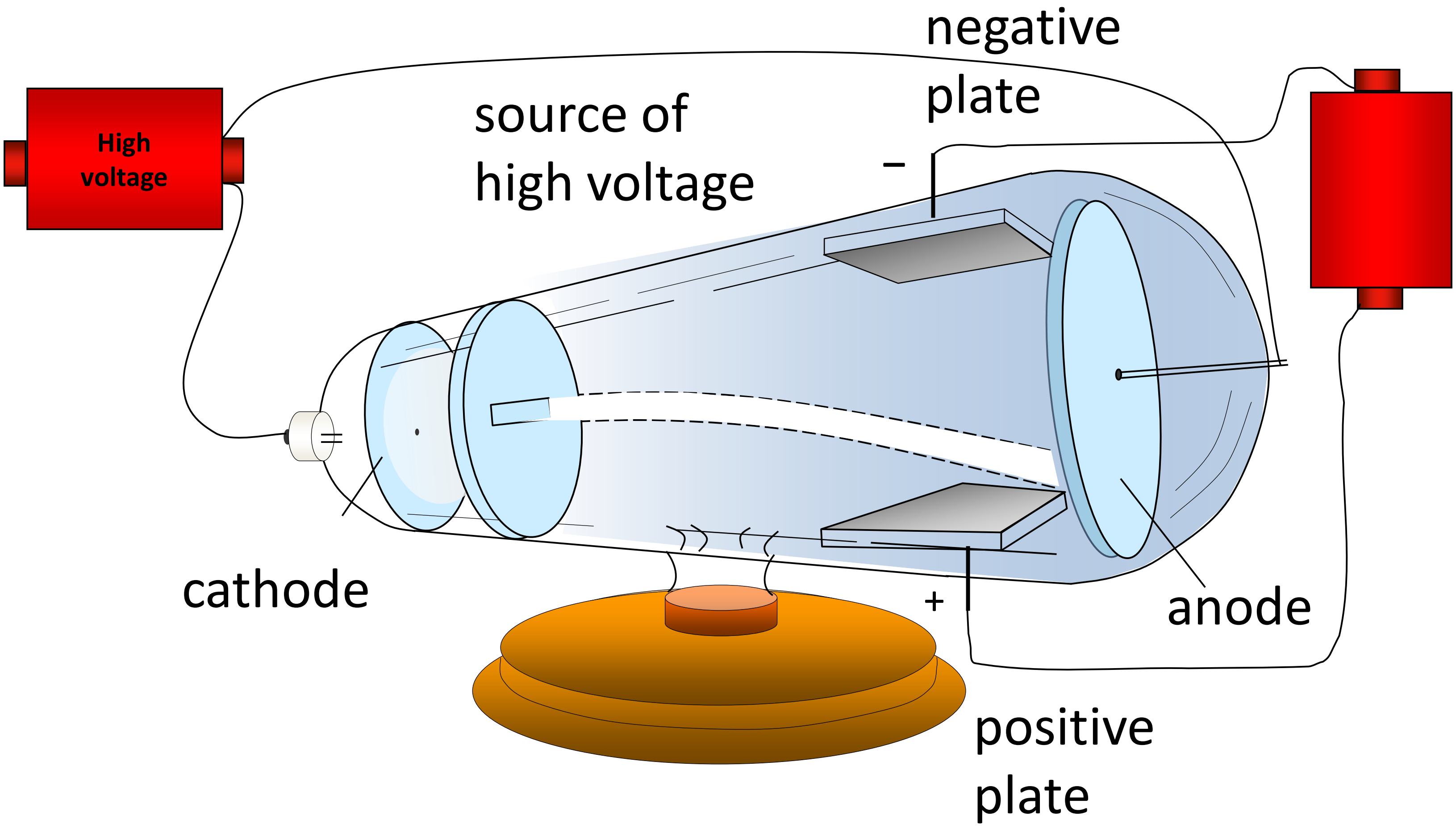
References:


1. H. E. White, Introduction to Atomic Spectra, McGraw Hill, (1934).
2. C. N. Banwell, andE. M. McCash, Fundamentals of molecular spectroscopy, Tata McGraw Hill, (2007).
3. G. Aruldhas, Molecular structure and Spectroscopy, Prentice Hall of India, New Delhi, 2001


# A Cathode Ray Tube



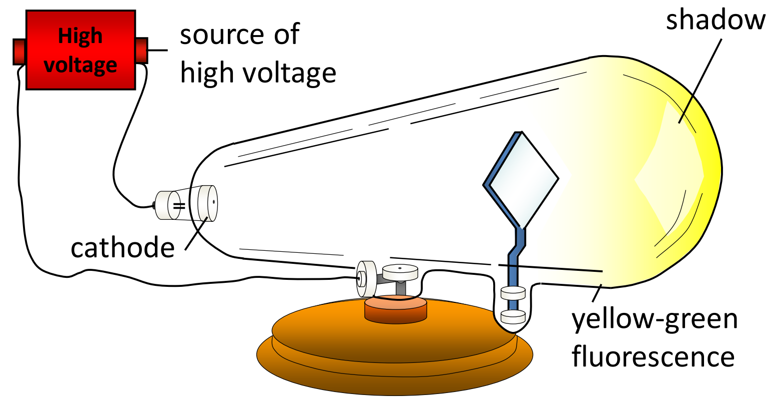
# The Effect of an Electric Field on Cathode Rays



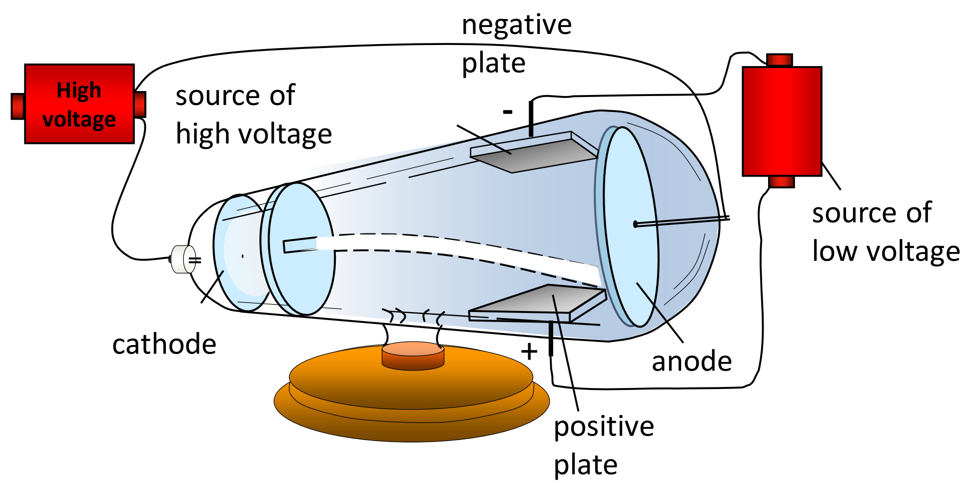
# Cathode Rays

- Cathode ray = electron
- Electrons have a negative charge

(A) The effect of an obstruction on cathode rays




(B) The effect of an electric field on cathode rays

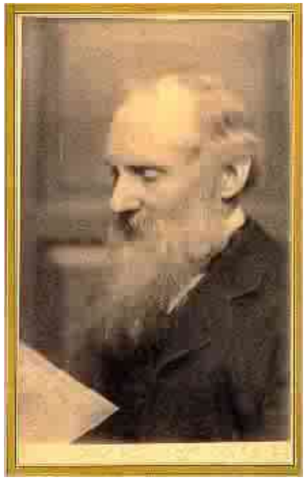


# J.J. Thomson

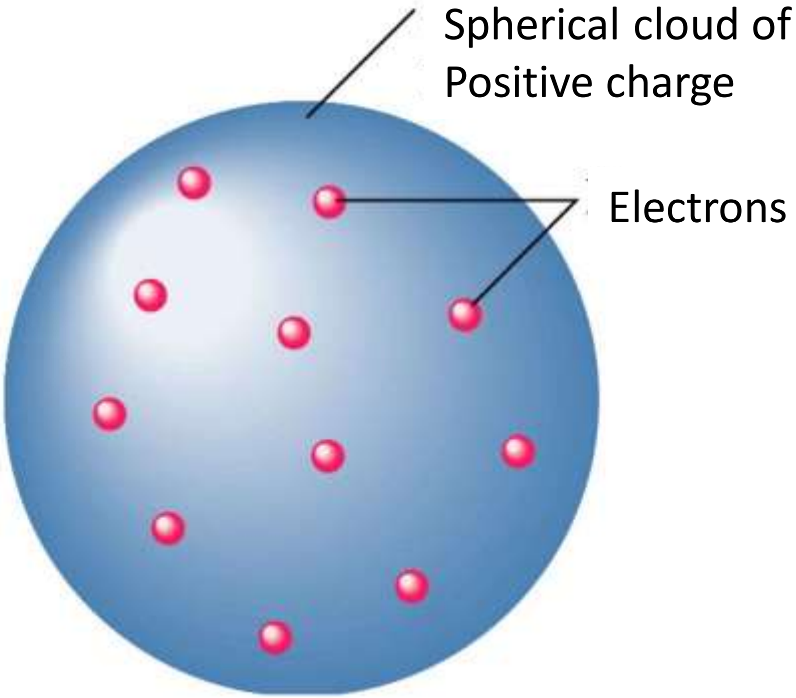
J.J. Thomson

- He proved that atoms of any element can be made to emit tiny negative particles.
- From this he concluded that ALL atoms must contain these negative particles.
- He knew that atoms did not have a net negative charge and so there must be balancing the negative charge.

# William Thomson (Lord Kelvin)

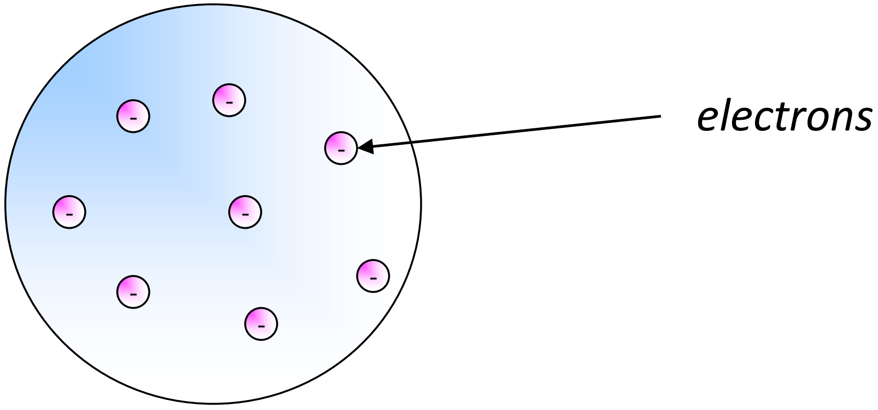


- In 1910 proposed the Plum Pudding model
  - Negative electrons were embedded into a positively charged spherical cloud.



# Thomson Model of the Atom

- J.J. Thomson discovered the electron and knew that electrons could be emitted from matter (1897).
- William Thomson proposed that atoms consist of small, negative electrons embedded in a massive, positive sphere.
- The electrons were like currants in a plum pudding.
- This is called the ‘plum pudding’ model of the atom.

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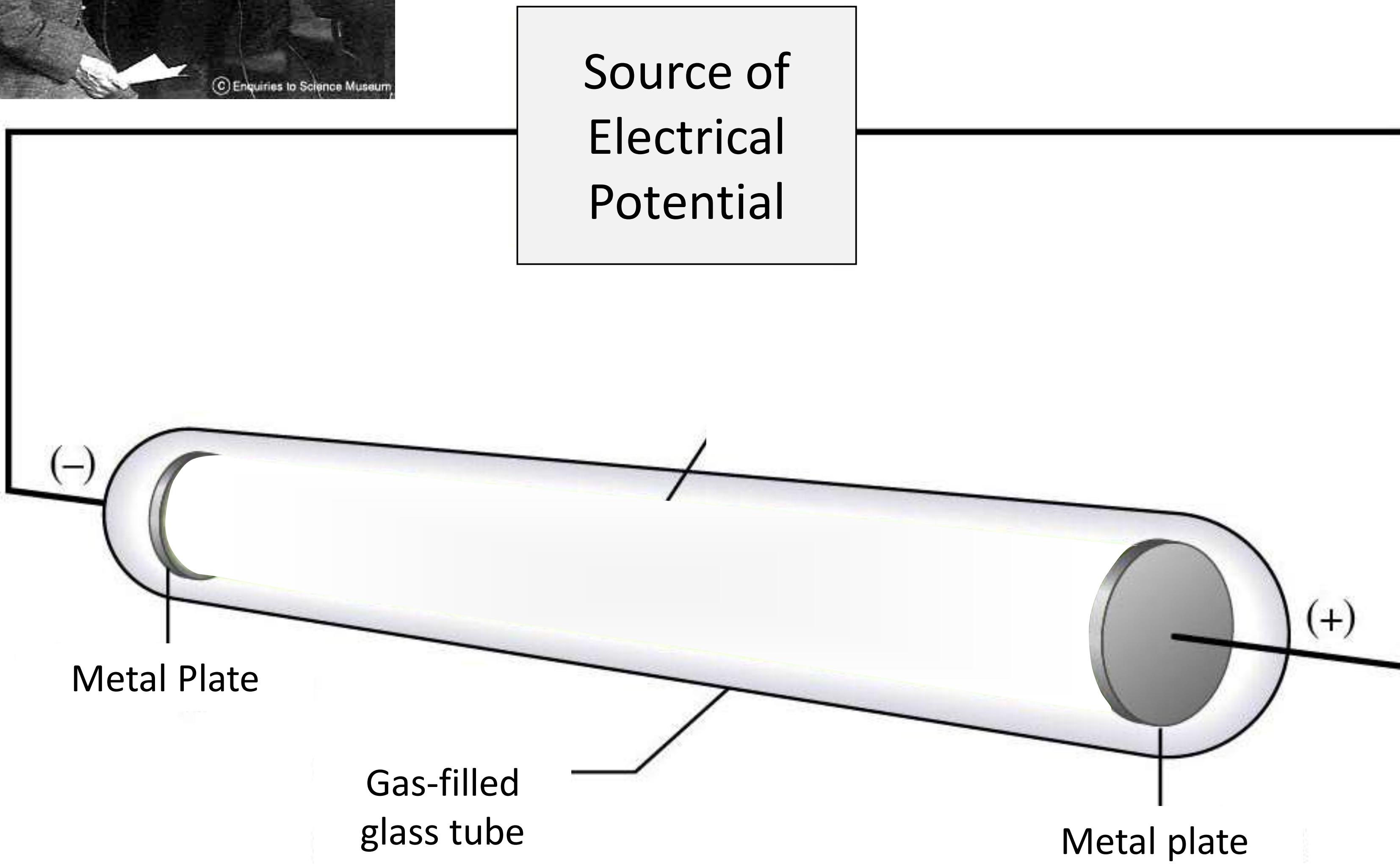
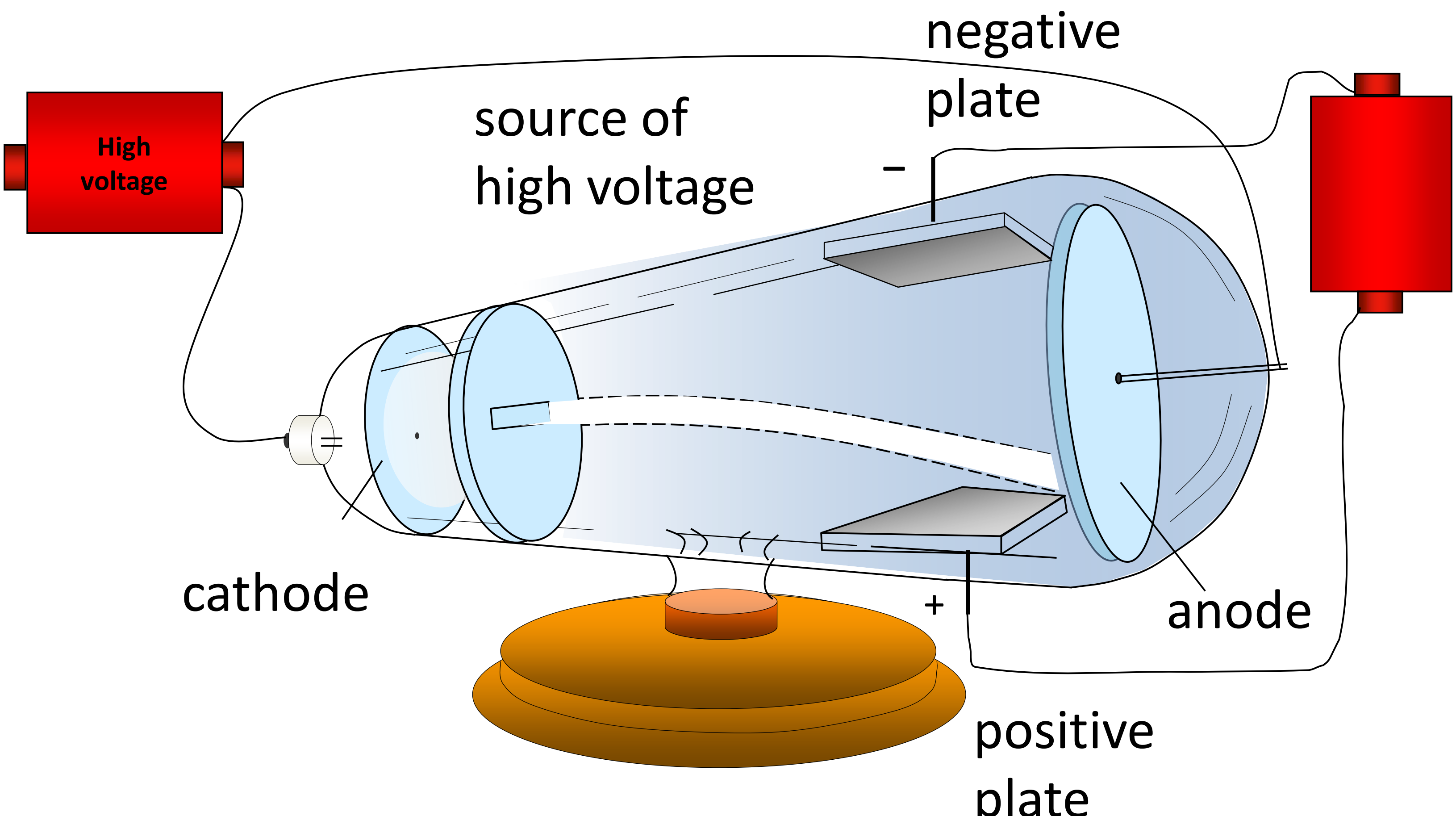



Zumdahl, Zumdahl, DeCoste, World of Chemistry 2002, page 58

# The Effect of an Electric Field on Cathode Rays




Dorin, Demmin, Gabel, Chemistry The Study of Matter , 3rd Edition, 1990, page 117

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