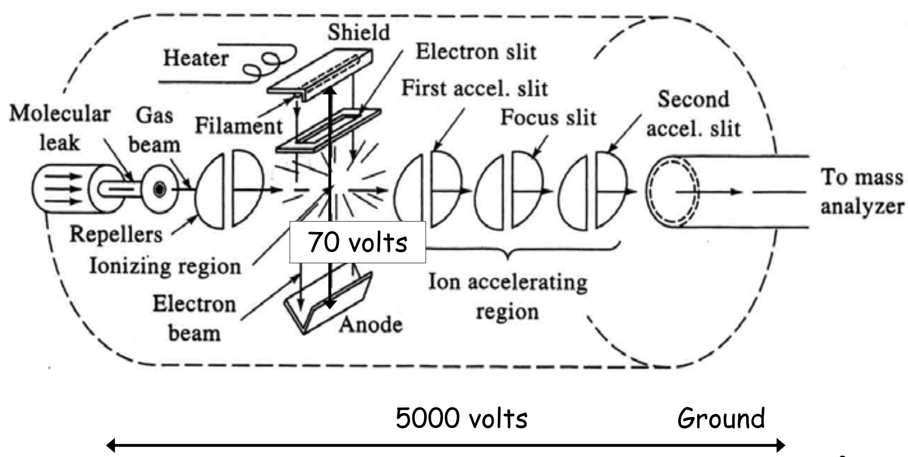
# April 13, 2005

- **Exam #3:** *1 Week from Today!*
- ***Watch for:***
  - ✓Exam #3 Info Page
  - ✓Prob Set #4 Solutions



# Electron Impact Ion Source



# Electron Impact Ionization

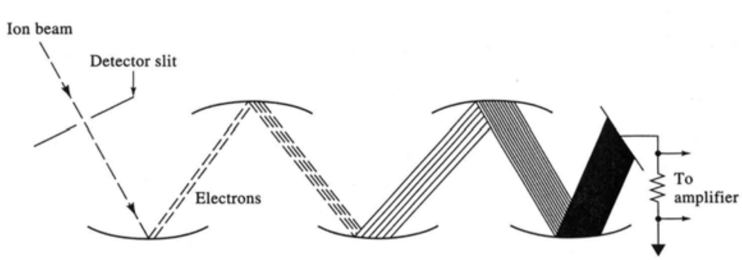
- **Poor Ionization Efficiency**
  -only about $10^{-4}$ % ionized
- **Variable Electron Gun Potential**
  -adjustable from 0 to 70 volts
  -most covalent molecules ionized at 10 eV
  -excess energy results in *fragmentation*

-many other types of ionization sources!



# How are Ions Detected?

- **Electron Multiplier** - fast, sensitive




-like a PMT for ions

**Also:** Faraday Cup, photoplates, etc.

# How are ions separated?

- **Three Types of Mass Analyzers:**
  1. Magnetic Sector
     -physical separation
  2. Time-of-Flight
     -temporal separation
  3. Quadrupole
     -"trajectory stability" separation

*All require low pressure operation.*



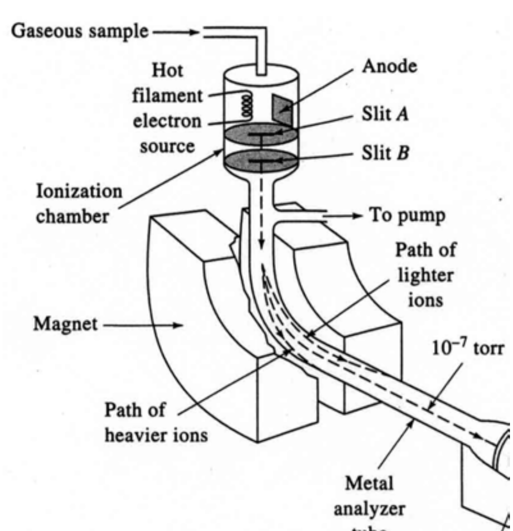
# Magnetic Sector Analyzers

•Ions moving in magnetic field will have a force exerted on them

•Radius of curvature will vary with m/z:

$$\frac{m}{z} = \frac{B^2 r^2}{2V}$$

Where: B = magfield
V = accel. potential
r = radius of sector



# More MagSector Analyzers

- "Scan" by varying *either* **magfield (B)** or **acceleration potential (V)**
  - Only ions having a m/z giving correct **r** will reach exit slit
- <u>NOTE:</u> $\mathbf{r \propto (m/z)^{\frac{1}{2}}}$

  -so, as m/z increases, the *change in r* will <u>decrease</u>

  -**<u>Result:</u>** ion separation gets poorer as m/z increases



# Properties of MagSectors

- <u>Limited Resolution</u>

  -resolution controlled by *spread of K.E.* of ions from the ion source
- <u>Quantifying Resolution</u>

$$\mathbf{R = m/\Delta m}$$

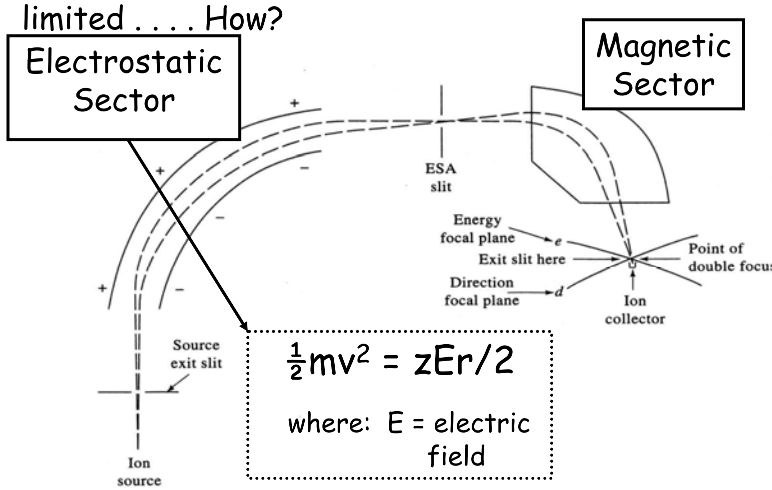
-for magsector: R is typically *~500-1000*

**<u>Example:</u>** $N_2^+$ (28.00616 amu) versus ***CO***$^+$ (27.99491 amu)

R = 28/0.01125 ≈ ***<u>2500</u>*** (magsector not good enough)

# Double-Focusing Analyzers

- Resolution can be improved if the K.E. of the ions is limited . . . . How?




$\frac{1}{2}mv^2 = zEr/2$

where: E = electric field



# Properties of Double-Focusing Analyzers

- **<u>Resolution can be improved *dramatically*</u>**
  - R ≈ 20,000 - 50,000 is common
  - R = 150,000 is possible
  - *Best resolution* of the 3 mass analyzers we are covering

<u>Example:</u>

$C_9H_{10}O_2$ - 150.0681 amu

$C_5H_{10}O_5$ - 150.0528 amu

-need analyzer with R of ~10,000

# Time-of-Flight (TOF) Mass Analyzers

- **Simple concept:**
  - ✓ Accelerate all ions to same K.E.
  - ✓ Velocities of ions will vary with their masses:

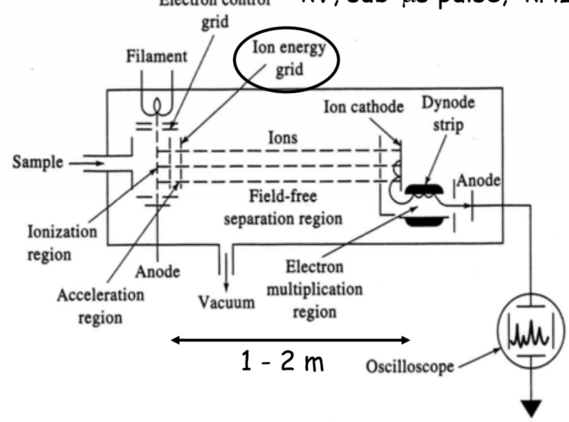
$$v = (2eV/m)^{\frac{1}{2}}$$

v: cm/sec

m: mass/ion (grams)

e: 1.60 x $10^{-12}$ erg/V

kV, sub-μs pulse, kHz






# Properties of TOF Analyzers

- **Resolution:** typically limited to ~500
- ***FAST!***
  - Some typical transit times:

    $H^+$ → 1.58 μs

    $N_2^+$ → 8.37 μs

    $Xe^+$ → 18.17 μs
- Simple, rugged, smaller than magsectors
- *Ideal* with pulsed ion sources