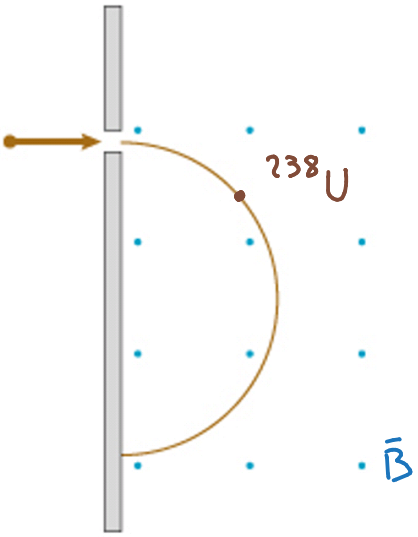
In a mass spectrometer, charged particles are injected into a region of uniform magnetic field (all with the same speed), where they travel along circular trajectories and, in this example, are collected after completing one-half of a complete circular orbit. If different mass isotopes are injected, they will trace different paths and be collected at different locations.

A beam of singly ionized uranium atoms (U 235 and U 238) is injected into the mass spectrometer shown in the figure.

The ions all have the same velocities and charges. The U 238 ions follow the trajectory illustrated.



Will the U 235 ions strike the collecting plate above, below, or at the same location as the U 238 ions ?

SOLUTION

Once inside the spectrometer, the particles are acted on by a magnetic force and they trace circular paths. Applying Newton's second law to their motion results in the equation

$$m\bar{a} = q\bar{v} \times \bar{B}$$

In our scenario, the velocity and field vectors are perpendicular. Also, since the particle moves along a circular path, the acceleration must equal the expression for centripetal acceleration:

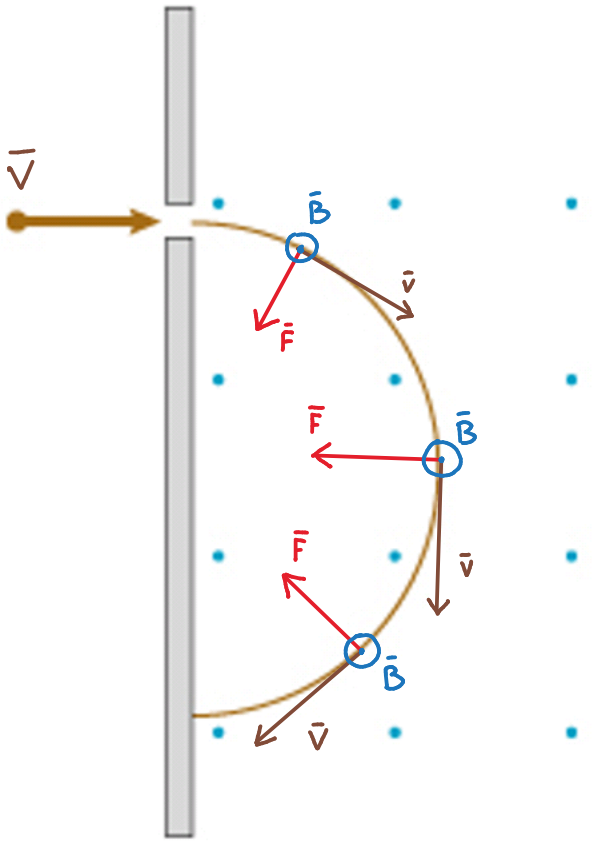
$$F_c = m\frac{v^2}{r}\hat{r}$$

$$\Big|$$

$$F_L = q\bar{v} \times \bar{B}$$

$$qvB = \frac{mv^2}{r}$$

$$r = \frac{mv^2}{qvB}$$



NB: The higher the mass of the ions, the longer the radius of the trajectory

Lighter isotopes have a semi-circular trajectory with smaller radius of curvature, so the isotope U 235 will impinge on the detector above the position where U 238 does

U 235 has an atomic weight of 235 atomic mass units. U 238 instead have an atomic weight of 238 atomic mass units.
one atomic mass unit is 1.660 × 10^−27 kg.

calculate the radius of the trajectory of both U 235 isotopes and U 238 isotopes.