off at a tangent. This is achieved by applying a magnetic field. The magnitude of the force (F) is given by the following formula:

$$F = Bzv \qquad (3.2)$$

These forces are equal and in opposite directions in order to ensure that the ions continue to follow the same path. Thus, we can write:

$$mv^2/r = Bzv \qquad (3.3)$$

Π Can you remember two ways in which we can express the formula for the kinetic energy of ions which have passed through a potential difference of V? (Hint: consider equations (2.2) and (2.3) in the previous chapter.)

The gain in kinetic energy is proportional to the potential difference through which the ions have passed. Therefore:

$$\tfrac{1}{2}mv^2 = zV \qquad (3.4)$$

Π Now, can you remember which ratio mass spectrometers measure?

The answer is m/z.

Therefore, it would be a good idea if we could rearrange these two equations in some way so as to get a formula in which m/z was the subject. This will involve a little bit of algebra.

The 'trick' in this case is to remember that the velocity of the ion as it traverses the magnetic field is governed solely by the kinetic energy it acquires during acceleration, so let's try and eliminate v from both formulae. (Apart from m, which we will need as part of our final subject, m/z it is the only term that occurs in both equations.)

Rearranging, by making v^2 the subject of equation (3.4), gives the following:

$$v^2 = 2zV/m \qquad (3.5)$$

Let us now make v the subject of equations (3.3). This gives:

$$v^2 = Bzvr/m \qquad (3.6)$$

Cancelling the v on both sides of the equation gives:

$$v = Bzr/m \qquad (3.7)$$

By squaring both sides of the equation we obtain:

$$v^2 = B^2z^2r^2/m^2 \qquad (3.8)$$

Now, 'equate' equations (3.5) and (3.8) in v^2; this gives:

$$2zV/m = B^2z^2r^2/m^2 \qquad (3.9)$$

Next we can rearrange, and cancel the z and m terms to give:

$$2Vm^2/m = B^2z^2r^2/z$$

from which

$$2Vm = B^2zr^2 \qquad (3.10)$$

Remember that we need to make m/z the subject, so:

$$m/z = B^2r^2/2V \qquad (3.11)$$

Finished—that was somewhat laborious!

Π So far so good then, but what does this mean in terms of our ion beam?

It means that for any particular fixed value of the magnetic field strength, B, and accelerating voltage, V, only ions of one particular mass/charge ration (m/z) will follow the required circular path of radius r to reach the detector. All other ions with different m/z values will be trying to follow circles of different radii and will not therefore reach the detector (see Figure 3.1c).