25. (a) We solve for B from $m = B^2qx^2/8V$ (see Sample Problem 29-3):

$$B = \sqrt{\frac{8Vm}{qx^2}} \ .$$

We evaluate this expression using $x = 2.00\,\text{m}$:

$$B = \sqrt{\frac{8(100 \times 10^3\,\text{V})(3.92 \times 10^{-25}\,\text{kg})}{(3.20 \times 10^{-19}\,\text{C})(2.00\,\text{m})^2}} = 0.495\ \text{T} \ .$$

(b) Let N be the number of ions that are separated by the machine per unit time. The current is $i = qN$ and the mass that is separated per unit time is $M = mN$, where m is the mass of a single ion. M has the value

$$M = \frac{100 \times 10^{-6}\,\text{kg}}{3600\,\text{s}} = 2.78 \times 10^{-8}\,\text{kg/s} \ .$$

Since $N = M/m$ we have

$$i = \frac{qM}{m} = \frac{(3.20 \times 10^{-19}\,\text{C})(2.78 \times 10^{-8}\ \text{kg/s})}{3.92 \times 10^{-25}\,\text{kg}} = 2.27 \times 10^{-2}\ \text{A} \ .$$

(c) Each ion deposits energy qV in the cup, so the energy deposited in time Δt is given by

$$E = NqV\,\Delta t = \frac{iqV}{q}\,\Delta t = iV\,\Delta t \ .$$

For $\Delta t = 1.0\text{h}$,

$$E = (2.27 \times 10^{-2}\,\text{A})(100 \times 10^3\,\text{V})(3600\,\text{s}) = 8.17 \times 10^6\ \text{J} \ .$$

To obtain the second expression, i/q is substituted for N.