Ch. 11 Prob. 64

$m_\alpha = 6.64 \times 10^{-27}\ kg$

$q = 3.2 \times 10^{-19}\ C$

$\vec{v} = (2.0\hat{i} - 4.0\hat{k}) \times 10^6\ m/s$

$\vec{E} = (5.0\hat{i} - 2.0\hat{j}) \times 10^4\ \frac{V}{m}$

$\vec{B} = (1.0\hat{i} + 4.0\hat{k}) \times 10^{-2}\ T$

What is the initial force on the alpha particle?

$$\vec{F} = q\vec{E} + q\vec{v} \times \vec{B}$$

$q\vec{E}$: electric force; $q\vec{v} \times \vec{B}$: magnetic force

$$\vec{F}_e = q\vec{E} = (3.2 \times 10^{-19}\ C)(5.0\hat{i} - 2.0\hat{j}) \times 10^4\ \frac{V}{m}$$

$$= (16\hat{i} - 6.4\hat{j}) \times 10^{-15}\ N$$

$$\vec{F}_m = q\vec{v} \times \vec{B} = (3.2 \times 10^{-19}\ C)\left[(2.0\hat{i} - 4.0\hat{k}) \times 10^6\ m/s\right] \times \left[(1.0\hat{i} + 4.0\hat{k}) \times 10^{-2}\ T\right]$$

$$= 3.2 \times 10^{-15}\left[(2.0\hat{i} - 4.0\hat{k}) \times (1.0\hat{i} + 4.0\hat{k})\right] N$$

$$= 3.2 \times 10^{-15}\left[2.0(\hat{i} \times \hat{i}) + 8.0(\hat{i} \times \hat{k}) - 4.0(\hat{k} \times \hat{i}) - 16.0(\hat{k} \times \hat{k})\right]$$

$$= 3.2 \times 10^{-15}\left[0 + 8.0(-\hat{j}) - 4.0(\hat{j}) - 0\right]$$

$$= 3.2 \times 10^{-15}(-12.0\hat{j}) = -38.4 \times 10^{-15}\hat{j}\ N$$

$$\vec{F}_{total} = \vec{F}_e + \vec{F}_m = (16\hat{i} - 6.4\hat{j}) \times 10^{-15}\ N + -38.4 \times 10^{-15}\hat{j}\ N$$

$$= (16\hat{i} - 6.4\hat{j} - 38.4\hat{j}) \times 10^{-15}\ N$$

$$\boxed{\vec{F}_{tot} = (16\hat{i} - 44.8\hat{j}) \times 10^{-15}\ N}$$