329.

Problem 29.31 (RHK)

A proton orbits with speed $v = 294 \text{ km s}^{-1}$ *just outside a charged sphere of radius* $r = 1.13 \text{ cm}$. *We have to find the charge on the sphere.*

Solution:

Let Q be the charge on the sphere. As the proton is orbiting the sphere in a circular orbit of radius $r = 1.13 \text{ cm}$. The centripetal force for circular motion will be provided by the Coulomb attraction of the proton by the charge on the sphere. We therefore have the equation

$$\frac{|Q|e}{4\pi\varepsilon_0 r^2} = \frac{m_p v^2}{r},$$

where mass of the proton, $m_p = 1.67 \times 10^{-27}$ kg, and charge of the proton, $e = 1.6 \times 10^{-19}$ C.

It is given that

$v = 294 \text{ km s}^{-1}$,

and

$r = 1.13$ cm.

Therefore,

$$|Q| = \frac{4\pi\varepsilon_0 m_p r v^2}{e} = \frac{1.67\times10^{-27}\times1.13\times10^{-2}\times\left(294\times10^{3}\right)^2}{8.99\times10^{9}\times1.6\times10^{-19}}\ \text{C}$$

$$= 1.13\times10^{-9}\ \text{C}.$$

As the proton is attracted by the charge on the sphere, the sign of the charge is negative.

Therefore,

$Q = -1.13$ nC.