

2014 AP[®] PHYSICS C: ELECTRICITY AND MAGNETISM FREE-RESPONSE QUESTIONS

E&M.3.

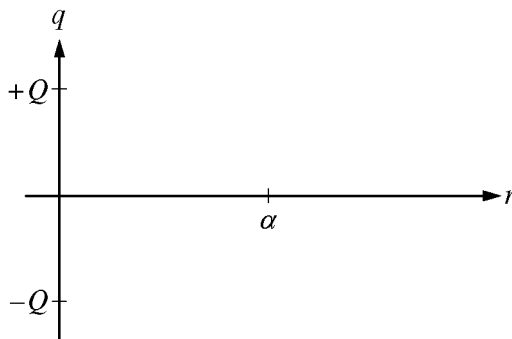
A scientist describes an electrically neutral atom with a model that consists of a nucleus that is a point particle with positive charge $+Q$ at the center of the atom and an electron volume charge density of the form

$$\rho(r) = \begin{cases} -\frac{\beta}{r^2} e^{-r/\alpha} & r < \alpha \\ 0 & r > \alpha \end{cases}$$

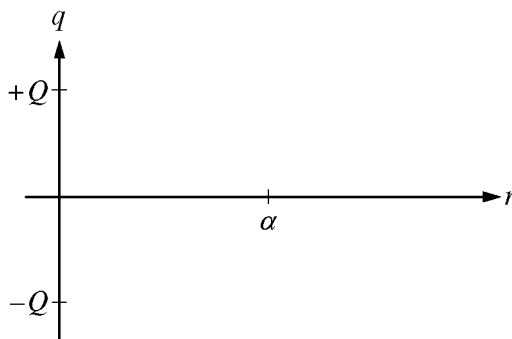
where α and β are positive constants and r is the distance from the center of the atom.

- (a) On the axes below, let r stand for the radius of a Gaussian sphere. Sketch the graph for each of the following charges enclosed by the Gaussian sphere as a function of r . Explicitly label any intercepts, asymptotes, maxima, or minima with numerical values or algebraic expressions, as appropriate.

- i. The nuclear charge only



- ii. The electron charge only



**AP[®] PHYSICS C - ELECTRICITY AND MAGNETISM
2014 SCORING GUIDELINES**

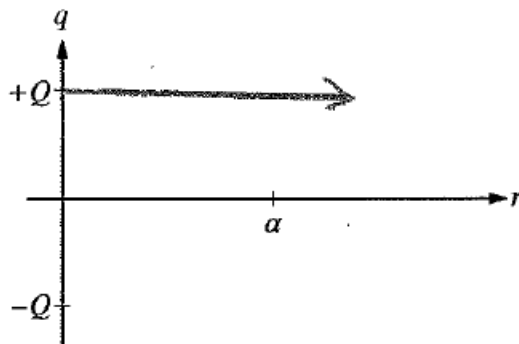
Question 3

15 points total

**Distribution
of points**

(a)

i. 2 points



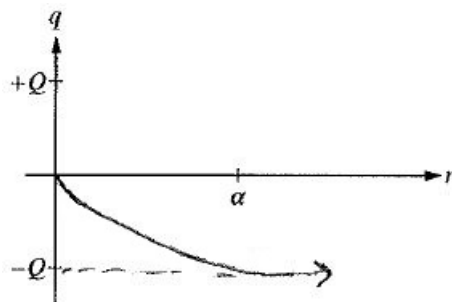
For a graph that starts at $q = +Q$

1 point

For a horizontal line (at $q = +Q$)

1 point

ii. 3 points



For a graph that starts at $q = 0$ for $r = 0$

1 point

For a concave upward curve in the 4th quadrant between $r = 0$ and $r = \alpha$

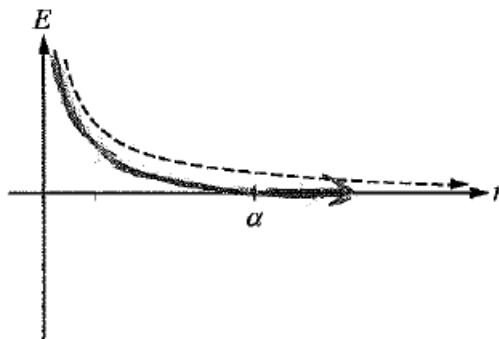
1 point

For a graph that approaches $-Q$ at $r = \alpha$ and equals $-Q$ beyond that point

1 point

(b)

2 points



For a graph that is decreasing and between the dashed curve and the x-axis

1 point

For a graph that goes to zero at $r = \alpha$ and is zero beyond that point

1 point