1a. $\vec{E} = -\nabla V$

$= -2xy\,\hat{x} - (x^2+1)\,\hat{y}$

b. $\int \vec{E}\cdot d\vec{l} = \int -2xy\,dx - (x^2+1)\,dy$

but $x=y$, $dx=dy$ on path

$\int \vec{E}\cdot d\vec{l} = \int_0^2 \left(-2x^2 - (x^2+1)\right) dx$

$= -3x^3/3 - x \Big|_0^2$

$= \boxed{-10}$

c. $V(0,0,0) = 0$

$V(2,2,2) = 10$

$\Delta V = 10 = -\int \vec{E}\cdot d\vec{l}$

as expected

2. $\rho(\vec{r}) = q\,\delta^3(\vec{r}-\vec{r}_1) - q\,\delta^3(\vec{r}-\vec{r}_2)$

3a. $\int \vec{E}\cdot d\vec{a} = E\cdot 2\pi s\cdot L$

$Q_{enc} = \pi s^2 L K \qquad s<R$

$\pi R^2 L K \qquad s>R$

$$\boxed{\vec{E} = \begin{cases} Ks/2\varepsilon_0\;\hat{s} & s<R \\ KR^2/2\varepsilon_0 s\;\hat{s} & s>R \end{cases}}$$

3b. $\Delta V = -\int_0^R \vec{E} \cdot d\vec{l}$

$= -\int_0^R ks/2\varepsilon_0 \, ds$

$= -\left. \frac{ks^2}{4\varepsilon_0} \right|_0^R$

$= \boxed{-kR^2/4\varepsilon_0}$

4a. $\rho = \varepsilon_0 \nabla \cdot \vec{E}$

$= \varepsilon_0 \cdot \frac{1}{r^2} \partial/\partial r \left(r^2 \cdot r \sin\theta \right)$

$= \varepsilon_0 \cdot \frac{1}{r^2} \cdot 3r^2 \sin\theta$

$= 3\varepsilon_0 \sin\theta$

b. $Q = \int \rho(\vec{r}) \, d\tau$

$= \int 3\varepsilon_0 \sin\theta \cdot r^2 \sin\theta \, d\theta \, d\phi \, dr$

$= 3\varepsilon_0 \int_0^{2\pi} d\phi \int_0^R r^2 \, dr \int_0^\pi \sin^2\theta$

$= 6\pi\varepsilon_0 \cdot \frac{R^3}{3} \cdot \pi/2$

$= \boxed{\pi^2 \varepsilon_0 R^3}$

$Q_a = -Q$
$Q_b = +Q$