Do not forget to put units on your final answers. Leave your answers in terms of $K$ treated as a number without units or $\varepsilon_0$ also treated as a number without units.

1. We are interested on the force on the 5 C charge.

   (1) Draw and identify all the $\vec{r}$ vectors for the force on the 5 C charge.

   (2) Find the $x$- and $y$-components of the net electrostatic force on the 5 C charge.

\[
\vec{F}_{eq} = k \frac{(5)(-9)}{3^2} \hat{r}_{eq} = -5k \hat{r} = -5k (-2) = 5k \hat{x}
\]

\[
\vec{F}_{25} = k \frac{(5)(25)}{5^2} \hat{r}_{25} = 5k \left[ -\frac{3}{5} \hat{x} - \frac{4}{5} \hat{y} \right]
\]

\[
\vec{F}_{total} = \vec{F}_{eq} + \vec{F}_{25} = k \left[ 3\hat{x} - 4\hat{y} \right] N
\]
2. Identify X in the following nuclear reactions:

a) $^1\text{H} + ^9\text{Be} \rightarrow X + ^1\text{H}$

\[ \text{X has a charge } 0 + 5 = 5 \]
\[ \# \text{oxygen nucleons} = 10 - 1 = 9 \]
\[ \Rightarrow \text{ } \text{ } 9 \text{O} \]

b) $^{13}\text{C} + ^1\text{H} \rightarrow X$

\[ \Rightarrow \text{ } \text{ } 13 \text{N} \]

c) $^{15}\text{N} + ^1\text{H} \rightarrow X + ^4\text{He}$

\[ \Rightarrow \text{ } \text{ } 12 \text{C} \]

3. A charged particle of charge 2 C and mass 3 kg is moving in the +x direction with a velocity of 20 m/s. If this particle enters an electric field of $E = -6 \frac{N}{C} \hat{i}$, how fast will it be going in 3 s?

\[ \vec{F} = m \vec{a} = q \vec{E} \]
\[ \vec{a} = \frac{q \vec{E}}{m} = \frac{(2)(-6)}{3} \hat{i} = -4 \frac{C}{s} \]

\[ V_f = V_i + a t \]
\[ = 20 + (-4)(3) \]
\[ = 8 \text{ m/s} \]
4. A cube with faces parallel to the x-, y- and z-axes has edge length 2 m. There is an electric field parallel to the z-axis. On the top face of the cube the field is \( E = 40 \hat{k} \text{ N/C} \) and on the bottom face the field is \( E = 30 \hat{k} \text{ N/C} \). What is the net charge inside the cube?

\[
\begin{align*}
\Phi_{\text{top}} &= \int 40 \hat{k} \cdot d\mathbf{A} = 40A \\
\Phi_{\text{bottom}} &= \int 30 \cos 180^\circ \hat{k} \cdot d\mathbf{A} = -30A \\
\Phi_{\text{rider}} &= 0 \\
\Phi_{\text{total}} &= 10A = 10 (2\times2) = 40 = \frac{Q_{\text{enclosed}}}{\varepsilon_0} \\
Q_{\text{enclosed}} &= 40 \varepsilon_0 \text{ C}
\end{align*}
\]

5. A conductor containing a cavity carries a net charge of 10 C. If the charge \( q \) inside the cavity is -6 C, how much charge is on the inner surface of the conductor and how much charge is on the outer surface of the conductor?

**Conductor**

\[
Q_{\text{enclosed}} = 0
\]

\[
Q_{\text{enclosed}} = -6 + Q(\text{on inner surface}) = 0
\]

\[
\Rightarrow Q(\text{on inner surface}) = +6 \text{ C}
\]

\[
Q_{\text{inner}} + Q_{\text{outer}} = 10
\]

\[
Q_{\text{outer}} = 10 - Q_{\text{inner}} = 4 \text{ C}
\]
6a) How much work is required to move a charge of 6 C from the bottom left corner of the rectangle to the top right corner for a path along the diagonal?

b) How much work required to move the same charge starting from the bottom left corner of the rectangle (1) move along the +x-axis to the lower right hand corner of the rectangle and then (2) move up along the +y-axis to top right corner of the rectangle?

\[
\text{Work} = \Delta \text{ Potential energy} = \text{PE (stop)} - \text{PE (start)}
\]

\[
\text{PE (stop)} = \frac{k(-4)(6)}{4} + \frac{k(6)(6)}{3} = -6k + 12k = 6k
\]

\[
\text{PE (start)} = \frac{k(-4)(6)}{3} + \frac{k(6)(6)}{4} = -8k + 9k = k
\]

\[
\text{Work} = 6k - k = 5k \text{ J}
\]

b) Work only depends on stopping point & starting point & is independent of path.

\[
\text{Work (any path)} = 5k \text{ J}
\]