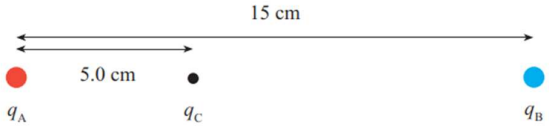
Questions

2007 Q6

6. Charges q_A and q_B are in a vacuum and have a distance of 15 cm between their centres. Charge q_C is placed on the line joining q_A and q_B, at a point where it experiences zero net force. This point is 5.0 cm from charge q_A, as shown in the diagram below:



[*This diagram is not drawn to scale.*]

Using proportionality, calculate the ratio of charge q_B to charge q_A.

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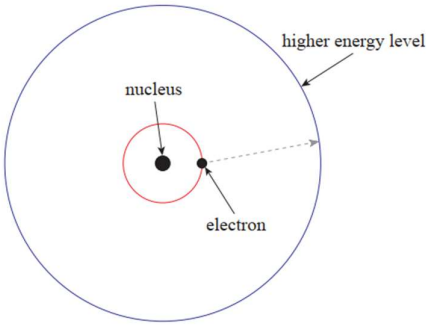
_____ (4 marks)

2010 Q6

6. The electron in a hydrogen atom is orbiting in its ground state at a radius of 5.3×10^{-11} m. The atom is excited, causing the electron to move to a higher energy level, which is at a radius of 2.12×10^{-10} m.



[*This diagram is not drawn to scale.*]

Using proportionality, determine the factor by which the electric force on the electron due to the nucleus has changed.

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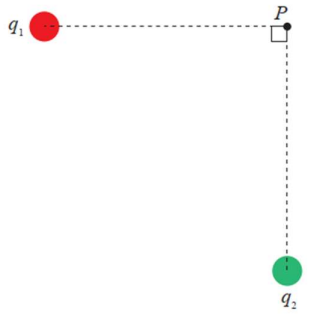
_____ (3 marks)

2011 Q6a

6. The diagram below shows two point charges in a vacuum. Charge q_1 has a positive charge of magnitude $2.0\,\mu C$ and charge q_2 has a negative charge of magnitude $5.0\,\mu C$. Point P is equidistant from the two charges, and forms a right angle with the two charges.



The magnitude of the electric field at point P due to q_1 is $1.02\times10^7\,NC^{-1}$.

(a) Using proportionality, show that the magnitude of the electric field at point P due to q_2 is $2.55\times10^7\,NC^{-1}$.

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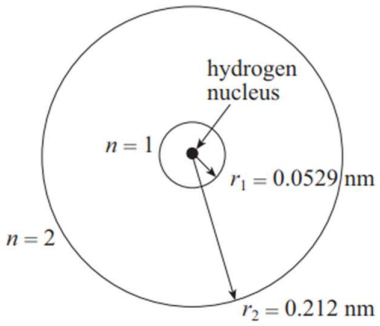
_____ (2 marks)

2006 Q24

24. Electrons can orbit the nucleus of an atom at various radii in discrete energy levels. There is an electrostatic force of attraction between the positive nucleus and the negative electron. The lowest two energy levels of hydrogen, $n = 1$ and $n = 2$, have radii $r_1 = 0.0529$ nm and $r_2 = 0.212$ nm respectively, as shown in the diagram below:



[*This diagram is not drawn to scale.*]

Using proportionality:

- discuss the factors that affect the magnitude of the electrostatic force of attraction;
- compare the magnitude of the electrostatic forces acting on the electron in the $n = 1$ and the $n = 2$ energy levels. (12 marks)

ANSWERS

2007 Q6

6. $\vec{F}_{CA} = -\vec{F}_{CB}$

$F \propto \frac{q}{r^2}$

$\therefore \frac{q_A}{r_{CA}^2} = \frac{q_B}{r_{CB}^2} \Rightarrow \frac{q_B}{q_A} = \frac{r_{CB}^2}{r_{CA}^2}$

$= \frac{(2r_{CA})^2}{r_{CA}^2} = 4$

2010 Q6

6 $F = \frac{1}{4\pi\varepsilon_0}\frac{qQ}{r^2}$

$F \propto \frac{1}{r^2}$

$4 \times 2.12 \times 10^{-10}\ m = 5.3 \times 10^{-10}\ m$

Distance increased by factor of 4

$F \propto \frac{1}{4^2}$

F = 1/16 original force

2011 Q6a

6. (a) $\boldsymbol{E} = \boldsymbol{F}q \ \therefore \boldsymbol{E} \propto q$

As q_2 is 2.5 q_1 $\therefore \boldsymbol{E_2} = 2.5\ \boldsymbol{E_1}$

$\boldsymbol{E_2} = 2.5 \times 1.01 \times 10^7 = 2.55 \times 10^7\ N\ C^{-1}$

2006 Q24

24. Coulomb's law states that the magnitude of an electrostatic force is directly proportional to the product of the charges and inversely proportional to the distance between the charges squared, ie $F \propto \frac{q_1 q_2}{r^2}$.

The charges of the nucleus and electron are fixed in a hydrogen atom with the charge on the nucleus being equal to that of a single proton. So for the hydrogen nucleus the magnitude of the electrostatic force is inversely proportional to the distance between the charges squared only. That is $F \propto \frac{1}{r^2}$.

The ratio of the radii of the two states is approximately four as shown by the calculation $\frac{r_2}{r_1} = \frac{0.212}{0.0529} \approx 4$. This means that the radius of the electron orbit in the $n = 2$ state is approximately four times as large as the radius of the electron orbit in the $n = 1$ state.

Because the electrostatic force is inversely proportional to the radius squared, this means that the force on the electron in the $n = 1$ state, F_1, is approximately sixteen times larger than the force on the electron in the $n = 2$ state, F_2, as shown by the calculation

$\frac{F_1}{F_2} = \frac{r_2^2}{r_1^2} \approx \frac{(4r_1)^2}{r_1^2} \approx 4^2 \approx 16$.