CH 16-2 – Coulomb's Law

Important Ideas

- For a conductor, charge distributes itself across the surface in response to external forces. In equilibrium, the net force on charge is zero.
- For an insulator, atoms become polarized in response to external forces.
- The electrostatic (or Coulomb) force on a particle of charge q_1 by another particle of charge q_2 has a magnitude

$$F = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2} \tag{1}$$

where $\frac{1}{4\pi\epsilon_0} = 9 \times 10^9$ Nm^2/C^2 is the called the electrostatic constant and r is the distance between the charged particles. This is called *Coulomb's Law.*

- For a force in two dimensions, the component F_x is along the x-axis and the component F_y is along the y-axis. The magnitude of the force is the hypotenuse of a right triangle. Thus,

$$F = \sqrt{F_x^2 + F_y^2} \tag{2}$$

- The net force on a particle of charge q is the sum of all of the forces on the particle.

$$\vec{F}_{net} = \vec{F}_1 + \vec{F}_2 \tag{3}$$

Because you are adding vectors, you must find the x and y components of each force. Add the x and y components of the forces separately.

$$F_{net_x} = F_{1x} + F_{2x} \tag{4}$$
$$F_{net_y} = F_{1y} + F_{2y} \tag{5}$$

The magnitude and direction of the net force are:

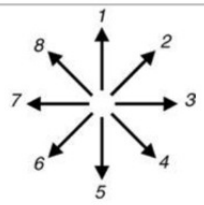
$$|\vec{F}_{net}| = \sqrt{F_{net,x}^2 + F_{net,y}^2} \tag{6}$$
$$\theta = \tan^{-1}\left(\frac{F_{net,y}}{F_{net,x}}\right) \tag{7}$$

where θ is with respect to the $+x$ axis.

Examples

1. Will a charged particle and neutral atom attract, repel, or not interact?
   (a) attract
   (b) repel
   (c) not interact
2. A negatively charged ion is located to the left of a neutral molecule. Sketch a diagram showing the polarization of the molecule.

3.

A negative point charge causes a neutral molecule to polarize, as shown below. What is the direction of the *electric force on the point charge,* due to the induced dipole? 	 *9* zero magnitude

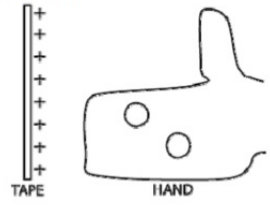
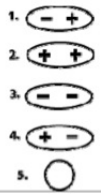
4.

A point charge is brought near a neutral molecule. (There is nothing else nearby). Is it possible for the point charge and the neutral molecule to repel each other?	1. Yes. The molecule can polarize so that it repels the point charge. 2. No. The molecule can only polarize in a way that will attract the point charge.

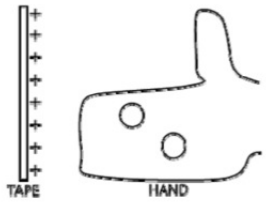
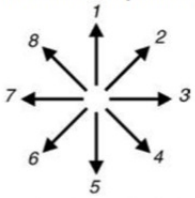
5.

You observe that a tape is attracted to a negatively charged plastic pen. What can you conclude?	1. The tape is positively charged. 2. The tape is negatively charged. 3. The tape is neutral. 4. The tape could be positive or neutral. 5. The tape could be positive, negative, or neutral.

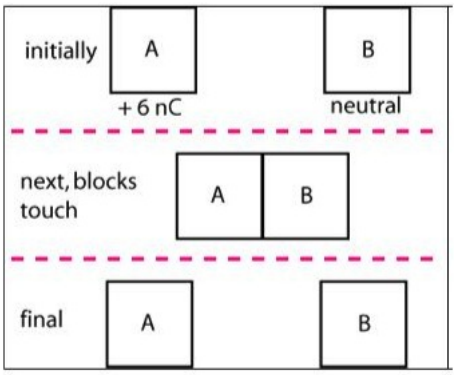
6.

A positively charged tape is held near your hand. 	Which diagram best shows the polarization of a molecule in your hand? 

7.

	What is the direction of the force on the tape, due to the polarized molecules in your hand?  *9* zero magnitude

8. A & B are identical metal blocks.



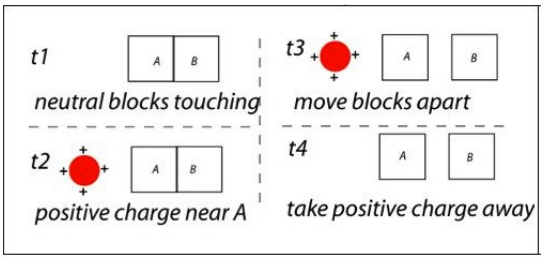
What is the final charge of block B?

(a) +6 nC
(b) +3 nC
(c) 0
(d) -3 nC
(e) -6 nC

9. In the previous question, what charge is transferred?

(a) Protons move from A to B.
(b) Electrons move from B to A.
(c) Both protons and electrons move.
(d) No charges move.

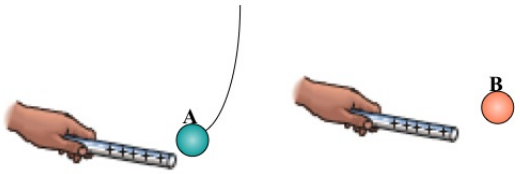
10. Two aluminum blocks, A and B, are initially neutral. They have insulating handles, which are not shown.



At a time after t4, what is the net charge of A?

(a) positive
(b) negative
(c) neutral

11. A positively charged rod is brought toward two small conducting spheres suspended by insulating cords. Sphere A is attracted to the rod; sphere B is repelled by it.



(a) This shows that A initially _____.

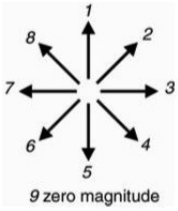
(a) must have been positively charged.
(b) must have been neutral.
(c) must have been negatively charged.
(d) could have been positively charged or neutral .
(e) could have been negatively charged or neutral.

(b) This shows that B initially _____.

(a) must have been positively charged.
(b) must have been neutral.
(c) must have been negatively charged.
(d) could have been positively charged or neutral .
(e) could have been negatively charged or neutral.

12. Two positively charged spheres exert a force of 0.1 N on each other as shown below.

What is the direction of the electrostatic force on Sphere A by Sphere B?



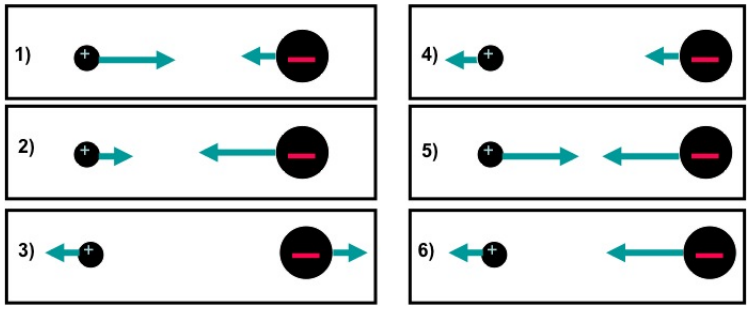
13. Sphere A has a charge 1 μC. Sphere B has 10 times as much charge as Sphere A. On which sphere is the electrostatic force the largest (in magnitude)?

(a) Sphere A

(b) Sphere B

(c) Neither, because the force on each sphere is the same (in magnitude)

14. Given a small positive charge and a large negative charge, which figure best represents the forces that the charges place on each other?



15. Two metal spheres with opposite charge are connected by a rod. The assembly is placed near another negative charge.

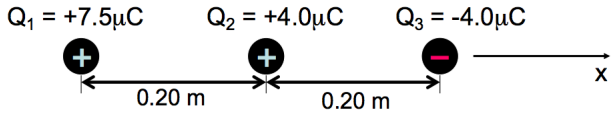
What is the direction of the net force on the assembly?

(a) The net force is directed toward the right.

(b) The net force is directed toward the left.

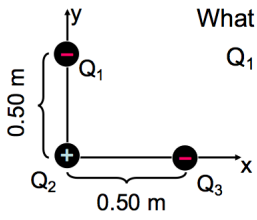
(c) The net force is zero.

16.



What is the net force on Q_1 due to Q_2 and Q_3?

17.



What is the net force on Q_1 due to Q_2 and Q_3?

Q_1 = -4.5μC Q_2 = +5.0μC Q_3 = -8.2μC