

Ch. 22 Electrostatics; 11th edition

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2. Why does gravitational force predominate over electrical force for astronomical bodies?

Ans. The stars, planets, moons interstellar dust etc. have an even distribution of protons and electrons and are therefore electrically neutral. Since the net charge is zero, the electrical force is zero.

3. Name the positive and negative charge carriers

Ans. The protons are positively charged and the electrons are negatively charged. They each have the same amount of charge, but have opposite types.

4. How does the charge of one electron compare the charge of another?

Ans. If you see one electron, you see them all. They all have exactly the same mass and charge.

6. What is a positive ion? A negative ion?

Ans. A positive ion is an atom that is positively charged because it lost an electron. A negative ion is an atom that is negatively charged because it has gained an electron.

11. How is Coulomb's law similar to Newton's law of gravitation? How is it different?

Ans. Coulomb's law
$$F = \frac{kq_1q_2}{d^2}$$

Law of gravity
$$F = \frac{\gamma m_1 m_2}{d^2}$$

Similarities: a) they both are force laws
b) Force is inversely proportional to distance squared.
c) They both have constants

Differences: a) Charges come in two types while mass only comes in one type.
b) Gravity only attracts while the electric force can attract or repel objects.
c) The electric force is much, much larger than the force of gravity.

Extra: When a Van de Graaff generator charges a person, the hair on their head stands up. Why does this happen?

Ans. Like charge objects repel each other. The person's head and strands of hair have the same charge. The person's head repels his or her hair and the strands of hair repel each other. Coulomb's law describes this.

Extra: Which is stronger, the electrical force between an electron and a proton or the gravitational force between these particles? Is the difference large or small?

Ans. The electrical force is much stronger.

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Extra: In terms of attraction and repulsion, how do negative particles affect negative particles? How do negatives affect positives.

Ans. Negative particles repel negative particles and attract positive particles.

Extra: What kind of charge does an atom acquire when electrons are stripped away from it?

Ans. The atom becomes positively charged when it loses electrons.

Extra: What happens to the electrical force between two charged objects when the distance between them is doubled? Tripled?

Ans. The force is inversely proportional to the separation distance squared. Therefore if the distance is doubled, the new force is $1/2$ squared = $1/4$ of its original value. If the distance is tripled, the new force is $1/3$ squared = $1/9$ of the original value. There are two steps here. Invert and square.

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4. Why do clothes often cling together when tumbling in the clothes dryer?

Ans. The electrons from one area of the clothing are transferred to another. The parts of the clothing that lost electrons are left positively charged while the parts that gained electrons are negatively charged. Unlike charged areas of the clothing attract each other.

8. When combing your hair, electrons are transferred from your hair to the comb? What is the charge of your hair? Charge of the comb?

Ans. Since your hair lost electrons, it is positively charged. The comb gained electrons and is therefore negatively charged.

14. Strictly speaking, when an object acquires a positive charge by the transfer of charge, what happens to the mass? What happens to its mass when it acquires a negative charge?

Ans. An object becomes positively charged when it loses electrons. Therefore its mass must decrease a tiny, tiny bit. When it becomes negatively charged, it has gained electrons and therefore its mass must increase a tiny, tiny bit.

23. How does the magnitude of electric force compare between a pair of charged particles when they are brought to half their original distance of separation?

Ans. 4 times greater. Do the other parts yourself and ask in class if you are unsure.

24. How does the magnitude of electrical force between a pair of charged objects change when the objects are moved twice as far apart?

Ans. The new force will be $1/4$ of the old force.

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28. The proportionality constant k in Coulomb's law is very large while the proportionality constant γ in Newton's law of gravity is almost zero. What does this mean for the relative strengths of these two forces?

Ans. The electric force is fundamentally much larger than the force of gravity.

Extra: Compare the force and acceleration of an electron and a proton placed separately in an electric field.

Ans. The magnitude of the force on each will be the same but the direction of the force applied to them will be opposite. Since the proton is about 1840 times more massive than the electron, its acceleration will only be $1/1840^{\text{th}}$ that of the electron.

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1. Two point charges are separated by 6 cm. The attractive force between them is 20 N. Find the force between them when they are separated by 12 cm.

Ans. Since the separation distance is doubled, the force will be $1/2^2 = 1/4^{\text{th}}$ the original value. $1/4 (20\text{N}) = 5$ newtons. Remember, there is an inverse-square relationship between the distance and the force.

7. The potential difference between a storm cloud and the ground is 100 million volts. If a charge of 2 Coulombs flashes in a bolt from the cloud to Earth, what is the change of potential energy?

Ans. From the definition of voltage, $V = \frac{E}{q}$ if we solve for energy we get:

$$E = Vq = 100\text{million volts}(2\text{Coulombs}) = 200\text{million joules}$$