**Chapter 22 Summary of terms**

**Electricity**

* General term for electrical phenomenon, much like gravity has to do with gravitational phenomenon
* Electricity at rest, static electricity or electrostatics

**Electrical Forces**

* Universe consists of two kinds of particles – positives and negatives.
* Electric charge: Fundamental electrical property to which the mutual attractions or repulsions between electrons and protons is attributed
* Positives repel positives but attracts negatives
* Negatives repel negatives but attracts positives
* Like kinds repel and unlike kinds attract
* There are equal numbers of each
* Force that one charge exerts on another
  + When the charges are the same sign, they repel
  + When the charges are opposite, they attract

**Atomic Structure**

* Inside every matter are atoms
* Inside every atom are positive and negative charges
* These charges are held together by the enormous attraction of electric forces
* By forming compact and evenly mixed clusters of positives and negatives, the huge electric forces have balanced themselves out almost perfectly.

**Molecule**

* When two or more atoms join to form a molecule
* The molecule also contains balanced positives and negatives

**Matter**

* When trillions of molecules combine to form a speck of matter
* The electrical forces balance again

**Between two pieces of ordinary matter**

* There is scarcely any electrical attraction or repulsion at all
* Because each piece contains equal number of positives and negatives
* Between Earth & Moon, there is no electrical forces; only gravitational force

**Electric Charges in atom**

* Fundamental electrical property
  + to which the mutual attractions and repulsions

* + between electrons and protons is attributed.
* The terms positive and negative refer to electric charge,
  + The fundamental quantity that underlies all electrical phenomenon
* The positively charged particles in ordinary matter are protons
* The negatively charged particles are electrons
* The neutral particles are called neutrons
* The protons, electrons and neutrons make up the atom

**Electric charges in a molecule**

* When two atoms get close together,
* The balance of attractive and repelling forces is not perfect
* Because electrons whiz around within the volume of each atom
* The atoms may then attract each other and form a molecule
* All the chemical bonding forces that hold atoms together to form molecules are electrical in nature

**Important facts about atoms**

1. Every atom is composed of a positively charged nucleus surrounded by negatively charged electrons
2. The electrons of all atoms are identical. Each has the same quantity of negative charge and the same mass
3. Protons and neutrons compose the nucleus
4. Except Hydrogen atom which has no neutron
5. Protons are about 1800 times more massive than electrons
6. Neutrons have slightly more mass than the protons and have no net charge
7. Atoms usually have as many electrons as protons, so the atom has zero net charge

**Question**– Why don’t protons pull the oppositely charged electrons into the nucleus?

**Answer**-

According to classical physics, in about a hundred –millionth of a second,

the electron would spiral into the nucleus, emitting EMR (electro magnetic

radiation) as it did so.

According quantum mechanics, an electron behaves like a wave and requires

a certain amount of space related to its wavelength (Chapter 32)

**Question**- Why don’t protons in the nucleus mutually repel and fly apart?

Or

What holds the nucleus together?

**Answer-** In addition to the electrical forces in the nucleus, even stronger

non-electrical nuclear forces hold the protons together and overcome the

electrical repulsion. (Chapter 33)

**Check Point page 385**

1. What is the fundamental rule of electrical phenomenon?
2. How does the charge of an electron differ from the charge of a proton?

**Exercises page 401**

1. At the atomic level, what is meant by something is electrically charged?
2. Why are objects with vast numbers of electrons, normally not electrically charged?

**Conservation of Charge**

* Whenever something is charged, no electrons are created or destroyed
* Electrons are simply transferred from one material to another
* Charge is conserved

**Neutral atom**

* In a neutral atom, there are as many electrons or protons, so there is no net charge
* The positive balances the negative exactly

**An ion**

* If an electron is removed from an atom, then it is no longer neutral
* The atom then has one more positive charge (proton) than negative charge (electron) and is said to be positively charged
* A charged atom is called an ion
* A positive ion has a net positive charge
* A negative ion, an atom with one or more extra electrons, is negatively charged
* So, an object having unequal numbers of electrons and protons is electrically charged
* If it has more electrons than protons, it is negatively charged
* If it has fewer electrons than protons, it is positively charged

**Charge is quantized**

* An electrically charged object has an excess or deficiency of some whole number of electrons
* Charge of the object is a whole number multiple of the charge of an electron
* Electrons cannot be divided into fractions of electrons
* Charge is made of elementary units called quanta
* We say that charge is quantized, with the smallest quantum of charge being that of the electron (or proton)
* In all matter, no smaller units of charge have ever been observed
* All charged objects to date have a charge that is a whole-number multiple of the charge of a single electron or proton

**Check Point page 386**

If you scuff electrons onto your feet while walking across a rug, are you negatively or positively charged?

**Exercises page 401**

5 Why will dust be attracted to a DVD wiped with a dry cloth?

**Coulomb’s Law**

* It states that
* For 2 charged objects
* that are much smaller than the distance between them,
* Force between the 2 objects
* Varies directly as the product of their charges
* And inversely as the square of separation distance
* The force acts along a straight line from one charged object to the other

F = k q1q2 **/** d2

Where,

d is the distance between the charged particles

q1 represents the quantity of charge of one particle

q2 represents the quantity of charge of the other particle

and k is the proportionality constant = 9 x 109 N. m2/C2

* Unit of Charge = coulomb or C

**Gravitational Force versus Electrical Forces**

* Gravitational force is inversely proportional to the square of separation distance
* Electrical force is inversely proportional to the square of separation distance
* Gravitational forces are only attractive
* Electrical force may be either attractive or repulsive
* Gravitational constant is a very small number ~ 10 -11 N.m2**/**kg2
* Electrical constant is a very large number ~ 10 9 N.m2**/**C2
* Gravitational force is very weak
* Electrical force is very strong

**Check Point page 387**

1. The proton that is the nucleus of the hydrogen atom attracts the electron that orbits it. Relative to this force, does the electron attract the proton with less force, with more force, or with the same amount of force?
2. If a proton at a particular distance from a charged particle is repelled with a given force, by how much will the force decrease when the proton is 3 times farther away from the particle? When it is 5 times farther away?
3. What is the sign of the charge of the particle in this case?

**Exercises page 401**

1. At some automobile toll booths, a thin metal wire protrudes from the road, making contact with cars before they reach the toll collector. What is the purpose of this wire?
2. Strictly speaking will a penny be slightly more massive if it has a negative charge or a positive charge?

**Conductors and Insulators**

* Conductors: Any material having free charged particles that easily flow through it when an electric force acts on them
* Metals are good conductors of electric current and heat
* Electric current : Flow of electric charge that transports energy from one place to another
* It is easy to establish an electric current in metals
* because one or more of the electrons in the outer shell of its atoms are not anchored
* to the nuclei of particular atoms but are free to wander in the material
* The expensive metals such as silver, gold and platinum are best conductors
* They don’t corrode
* Are commonly used in small quantities for high value products
* Copper and aluminum are commonly used in wiring electrical systems
* Because of their good performances and lower cost
* Insulators: A material without free charged particles and through which charge does not easily flow
* Electrons are tightly bound and belong to particular atoms
* Electrons are not free to wander about among other atoms in the material
* Consequently, it isn’t easy to make them flow.
* These materials are poor conductors of electric current and heat
* Glass is an extremely good insulator and is used to keep electrical wires away from the metal towers that carry them
* Many plastics are also good insulators, which is why wiring in our home is covered with a layer of plastic

**Charging**

* We charge things by transferring electrons from one place to another

1. Physical contact

* As occurs when substances are
* rubbed together
* or simply touched

1. Induction

* We can redistribute the charge on an object
  + - By putting a charged object near it

1. **Charging by Friction and contact**
2. Electrical effects produced by friction when electrons are transferred by friction when one material rubs against the other
   * + Stroke a cat’s fur
     + Comb our clean, dry hair in front of a mirror in a dark room
     + Scuff our shoes across a rug and touch a door knob
     + Sliding across a plastic seat while parked in an automobile
     + Clothes in a clothes dryer
3. Charging by contact when electrons transfer from one material to another by simply touching

* When a negatively charged rod is placed in contact with a neutral object, some electrons will move to the neutral object
* If the object is a good conductor, electrons will spread to all parts its surface because the transferred electrons repel one another
* If the object is a poor conductor, it may be necessary to touch the rod at several places on the object in order to get a more –or-less uniform distribution of charge

1. **Charging by Induction**
2. Charging by induction occurs during thunderstorms. The negatively charged bottoms of cloud induce a positive charge on the surface of the ground below
3. If you bring a charged object near a conducting surface, electrons are made to move in the surface material, even without physical contact

The charged rod has never touched them, and the rod retains the same charge it had initially

Fig. 22.7 page 390

**Check Point page 391**

1. Would the charges induced on the spheres A and B of Fig. 22.7 necessarily be exactly equal and opposite?

**Exercises page 401 and 402**

19. When one material is rubbed against another, electrons jump readily from one to the other but protons do not. Why is this? (Think in atomic terms)

21. What does inverse-square law tell you about the relationship between force and distance?

23. How does the magnitude of electrical force between a pair of charged particles are moved half as apart? One-third as far apart?

25. When you double the distance between a pair of charged particles, what effect does this have on the force between them? Does it depend on the sign of the charges? What law defends your answer?

27. When you double the charge on both particles in a pair, what effect does this have on the force between them? Does it depend on the sign of the charge?

**Charge Polarization**

Electrically Polarized: Term applied to an atom or molecule in which the charges are aligned so that one side has a slight excess of positive charge and the other side a slight excess of negative charge

* Charging by induction is not restricted to conductors
* When a charged rod is brought near an insulator
  + There are no free electrons that can migrate throughout the insulating medium
  + Instead there is a rearrangement of charges within the atoms**/**molecules themselves
  + Although atoms don’t move from the relatively fixed positions
  + But their “centers of charge” are moved
  + One side of the atom**/**molecule is induced into becoming more negative ( or positive) than the opposite side
  + The atom**/**molecule is said to be electrically polarized
* If the charged rod is negative,
  + then positive part of the atom**/**molecule is tugged in a direction toward the rod
  + and the negative side of the atom**/**molecule is pushed in a direction away from the rod
  + The positive and negative parts of the atom and molecules become aligned
  + They are electrically polarized
  + Example: bits of paper are attracted to comb passed through your hair
    - When the charged comb is brought near bits of paper

* + - the molecules in the paper are polarized
    - the sign of the charge closest to comb is opposite to the comb’s charge
    - the charges of the same sign are slightly more distant
    - Closeness wins, and the bits of paper experience a net attraction
    - Sometimes paper bits will cling to the comb & suddenly fly off
    - This repulsion occurs because the paper bits acquire the same sign of charge as the charged comb, when they come in contact

**Check Point page 392**

1. A negatively charged rod is brought close to some small pieces of neutral paper. The positive sides of molecules in the paper are attracted to the rod and the negative sides of the molecules are repelled. Why don’t these attractive and repulsive forces cancel out?

**Electric Field**

* Defined as electric force per unit charge,
* Electric field = F**/**q
* It can be considered to be an “aura” surrounding charged objects
* It is a storehouse of electric energy.
* About a charged point
* the field decreases with distance according to the inverse square law.
* It has both magnitude and direction
* The direction of force and field at that point are the same
* If the ball were positively charged, the vectors would point away from its center
* If the ball were negatively charged, the vectors would point towards its center
* For an isolated charge, the lines extend to infinity
* For 2 or more opposite charges, we represent lines as emanating from a positive charge and terminating on a negative charge

**Exercises page 402**

31. Suppose that the strength of the electric field about an isolated point charge has a certain value at a distance of 1 m. How will the electric field strength compare at a distance of 2 m from the point charge? What law guides your answer?

33. Measurements show that there is an electric field surrounding Earth. Its magnitude is about 100 N**/**C at Earth’s surface, and it points inward towards Earth’s center. From this information can state whether Earth is negatively or positively charged?

**Electric Potential**

* A charged object has potential energy by virtue of its location in an electric field
* Work is required to push a charged particle against the electric field of a charged body
  + This work changes the electric potential energy of the charged particle
  + Consider the particle with a small positive charge located at some distance from a positively charged sphere in Fig. 22.23 (b)
  + If you push the particle closer to the sphere, you will expend energy to overcome electrical repulsion
  + That is, you will do work in pushing the charged particle against the electric field of the sphere
  + This work done in moving the particle to its new location increases its energy
  + We call the energy of the particle possesses by virtue of its location electric potential energy
  + If the particle is released, it accelerates in a direction away from the sphere, and its electric potential energy changes to kinetic energy. If we instead push a particle with twice the charge
* We do twice as much work pushing it
* So doubly charged particle in the same location
  + has twice as much electric potential energy as before as before
  + If we instead push a particle with 3 times the charge
  + has thrice as much electric potential energy as before as before
* It is convenient to work with charged particles in an electric field
* Electric Potential Energy per unit charge
* Electric Potential = electric potential energy **/** charge
* 1 volt = 1 joule **/** 1 coulomb
* An object with 10 C of charge at a specific location
* has 10 times as much electric potential energy ( E = F/q)
* as an object with 1 C of charge.
* But 10 times as much electric potential energy
* for 10 times as much charge gives the
* same value as electric potential energy per 1 C of charge
* 1.5 volt battery gives 1.5 joules of energy to every coulomb of charge passing through the battery
* Electric potential and voltage are same, so either may be used

**Check point page 397**

If twice as many coulombs were in the test charge near the charged sphere in Fig. 22.23 b, how would the electric potential energy of the test charge relative to the sphere be affected? How would its electric potential be affected?

**Exercises page 402**

52. What is the voltage at the location of 0.0001 C charge that has an electric potential energy of 0.5 joules? (both measured relative to the same reference point)