study notes, physics 7D, UCI summer 2003

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Constants to know

1. permitivity in vacume $\varepsilon_0 = 8.8542 \times 10^{-12}$ Nm^2/C^2. related is columb constant, k, which is 8.987×10^9 Nm^2/C^2
2. gravitional constant $G = 6.7 \times 10^{-11}$ Nm^2/kg^2
3. electron charge $q_e = -1.6 \times 10^{-19}$ C
4. electron mass 9.11×10^{-31} kg
5. proton mass 1.67×10^{-27} kg
6. resistivity ρ. copper=1.7×10^{-8} ohm meter. see page 847.
7. $1eV = 1.6 \times 10^{-19} Jouls$
8. one mole contains avegadro number of atoms=6.02×10^{23}. need to be given the weight of a mole of a substance. If given density, then we can find number of electrons per one meter cubic. use it in the equation $v = \frac{I}{nqA}$

1 Things to know

$x = y \tan\varphi \Longrightarrow dx = y \sec^2\varphi \, d\varphi$
$\cos' x = -\sin x$
$\sec^2 x = \frac{1}{\cos^2 x}$
$(1 + \tan^2 x) = \sec^2 x$

2 Notes

To move a point charge from one point A to another point B, the field E must do some amount of work. Since there is no free luch in life, there is an energy exchange. (conservation of energy). The energy needed to move the charge comes from the loss of the charge potional energy.

Hence this is why the potional energy of the charge is reduced by the amount of work it has done. This is why we put a minus sign in this express $\Delta U = -q_o \int_A^B E \cdot dl$

We can only talk about potential energy differences and electric potential differences. The difference between U and V is that V is the energy difference PER UNIT charge.

3 Definitions

1. Electric field **E** is force per unit charge. Has units of Newton per Columb. To get a feel for E, a lamp will produce an E of about 10 N/C, and a baloon rubbed on hair will produce an E of 1,000 N/C. Since there are about 6×10^{18} electrons to make one columb of charge, then a lamp will cause a force of 10 N on those electrons, or a force of about 10^{-17} Newton on each electron. Now, since E near an electron in a hydrogen atom is about 5×10^{11} N/C, then the force on an electron in a hydrogen atom is about 10^{-7} N, or it is about 10^{10} as large as the force produce outside a lamp. This shows that at atomic scale, the columb forces are much greater, this is due to the much smaller distance, and the $1/r^2$ term in coulmb law.

2. When we decrease distance between capcitor plates, charge on each plate increaes, hence capacitance increases. But voltage across the plates is always the same as the battery voltage.

3. $V = W/Q$, i.e. Volt is work per unit charge. i.e. $Work = V * Q$

4. $V_A - V_B = -\int_B^A \mathbf{E} \cdot \mathbf{ds}$

5. For a point charges
$F = k\frac{Q_1 Q_2}{r^2}$
$E = k\frac{Q}{r^2}$
$V = k\frac{Q}{r}$

6. $E_r = -\frac{dV}{dr}$ so if we know E we can find V by integration

7. Capacitance formulas
$Q = CV$
$C = \frac{\epsilon_0\ A}{d}$
$E = \frac{\sigma}{\varepsilon_0}$ where σ is the charge density on the capictor plate $= \frac{Q}{A}$
$V = Ed$
potential energy stored in capacitor $U = \frac{1}{2}C\left(\Delta V\right)^2$
capacitance of a sphere with radius r and charge Q is $C = 4\pi\epsilon_0 r$
Energy stored in a capacitor $= \frac{1}{2}CV^2$.
Energy per unit volume inside a capacitor is $\frac{1}{2}\epsilon_0 E^2$

8. Area of sphere= $4\pi R^2$

9. Circumferance of circle $= 2\pi R$

10. area of circle $= \pi R^2$

11. $n\ q\ A\ v = I$, note that here n is the number of electrons per square meter! , so to find this value, one needs to know the density, and the molar mass and avegadro number. Once n is found, then speed v is easily found since I is given.

12. Current density J, is current per unit area. Hence $J = \frac{I}{A} = nqv$

13. $\mathbf{J} = \sigma\mathbf{E}$, this is OHM's law. $V = RI$, where $R \equiv \rho\frac{L}{A}$, where ρ is the resistivity, which is ohms per meter.

14. ρ is defined as $\frac{m_e}{nq^2\tau}$ where τ is the average time between collisions. n is the number of electrons per meter cubic.

15. power supplied to a resistor by a battery is $P = IV$ or $P = I^2R$

16. Remember, if given the battary internal resistance, then add it to the external resistance to get the total resistance.

4 Typical values of things

1. the Earth magnetic field is typically around 500 mG.

2. 6.24×10^{18} electrons make up one Columb of negative charge.

3. One cubic cm of copper contains about 10^{23} electrons. So one cubic cm of copper contains about $100,000$ of negative columb charge.

4. In typical rubbbing of glass by silk, only about a total $10^{-6}C$ of charge is transfered, this is about 10^{12} electrons being transfered, or about the number of electrons inside a micro cubic cm.

5 What is a spectrometer

(spectrograph, quantometer, spark emission, optical emission, spec, OES, ICP, plasma, spectro analyzer)?

A spectrometer system is a device that vaporizes material in a plasma discharge, either by electrical sparking for metallic samples, or by a sustained plasma(ICP) for fluids to generate light which emits spectral information on the elemental concentration of the sample. The spectrometer measures the light energy of several wavelengths and converts the light energy to electrical current, where it is measured or digitized by electronics and applied to calibration curves stored in the operating software. Analysis times are less than 1 minute. The printout display shows sample I.D.'s, alloy names, and elemental concentration for each element in % concentration or PPM. Accuracy is outstanding and detection limits are PPB.

6 On spark in air and voltage

from the net

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The electric field required to cause sparks through air is roughly 30
KV per centimeter.
 In any situations where the electric field is not evenly distributed
between the electrodes, the air can break down in a part of the gap
between the electrodes. The ionized air is conductive enough to
facilitate breakdown, or ionization, of the remaining portion. Between
sharp points, the voltage required to cause a spark is about 11 KV per
centimeter at most voltages from 5 to 40 KV. At higher voltages, lower
voltages per centimeter can cause sparking.
 The voltage required to generate a spark varies roughly inversely with
the density of the air. Therefore, this voltage varies roughly directly
with barometric pressure and roughly inversely with absolute temperature.
 However, as to humidity....
 Even on a bad summer day in southern, eastern, or midwestern parts of
the USA....
 "Tropically" humid air is generally 3 to 4 percent water vapor, and 96
to 97 percent of the gases normally found in air. I believe this usually
does not make much difference.
 Just beware that some normally insulating substances will absorb water
from air if the relative humidity is high. This can affect the behavior
of the insulators at higher voltages. This sometimes affects the nature
of sparks, coronas, and other discharges from points at or near where
conductors meet humidity-sensitive insulators. Also, dust that settles
on insulators may contain salt or other humidity-sensitive substances.
This may cause humidity-dependent performance of insulators.
 This effect varies widely with amount and nature of any dust, type and
grade of the insulator, etc. etc. Such info will probably not be found
in general tables.
 For more specific information about spark-gap voltages and how they
vary with pressure and temperature, see the spark-gap voltage table in
the Handbook of Chemistry and Physics, published by the Chemical Rubber
Publishing Co. Sorry, this table does not quantitavely mention the
effects of humidity.
 - Don Klipstein (Jr) (don@misty.com or klipstei@netaxs.com)
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7 Paschen's Law

from the net

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In 1889, F. Pashchen published a paper ( Wied. Ann., 37, 69)
which set out what has become known as Paschen's Law. The
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law essentially states that the breakdown characteristics of a gap are a function (generally not linear) of the product of the gas pressure and the gap length, usually written as V= f(pd), where p is the pressure and d is the gap distance. In actuality, the pressure should be replaced by the gas density. For air, and gaps on the order of a millimeter, the breakdown is roughly a linear function of the gap length: V = 30pd + 1.35 kV, where d is in centimeters, and p is in atmospheres.

8 references

The internet, wiki