Electromagnetic Theory

CREDIT HOURS FIRST LEVEL(PHYSICS /PHYSICS AND COMPUTER SCIENCE PROGRAM)

104 PH

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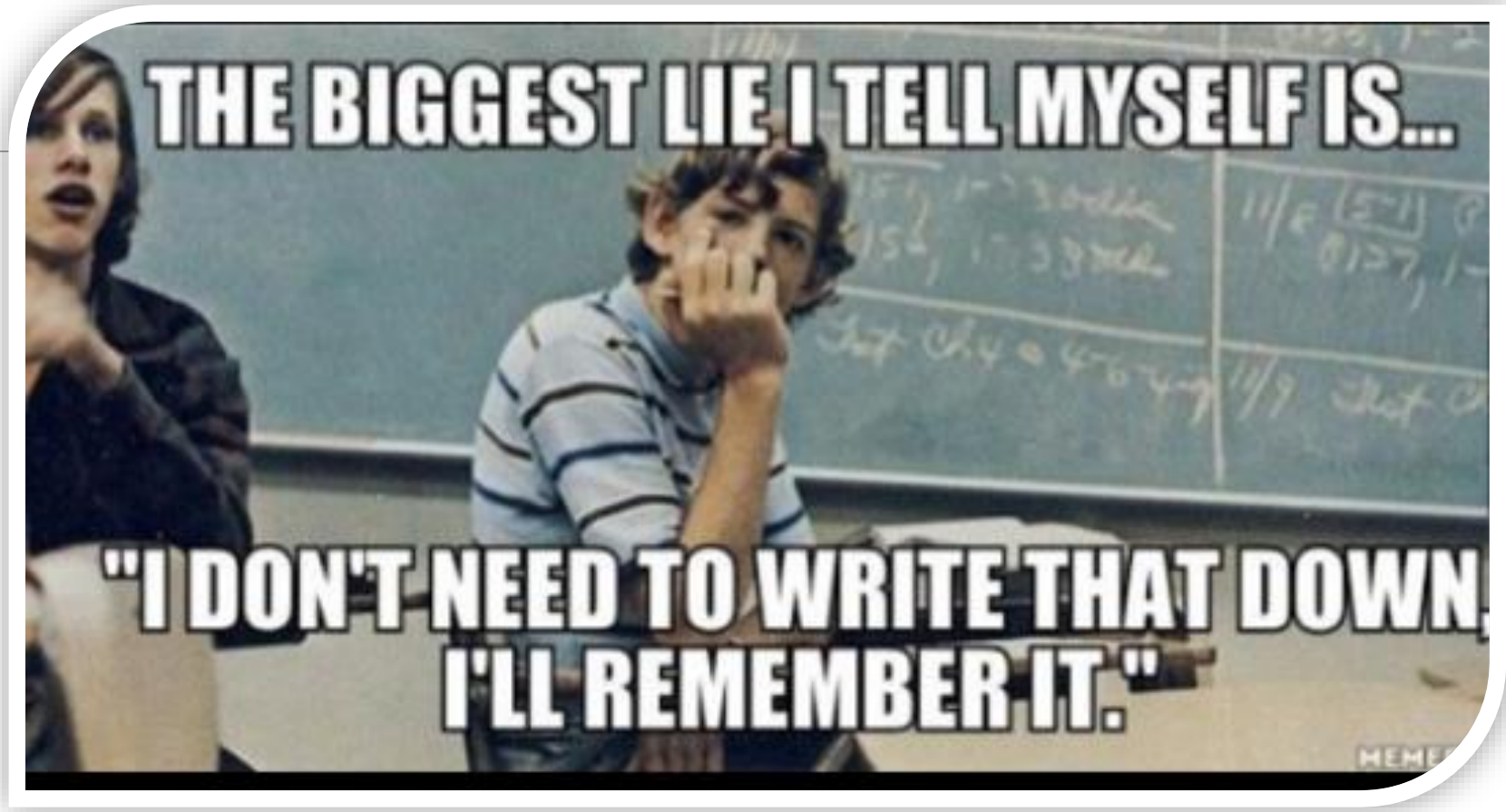

THE BIGGEST LIE I TELL MYSELF IS...
"I DON'T NEED TO WRITE THAT DOWN, I'LL REMEMBER IT."

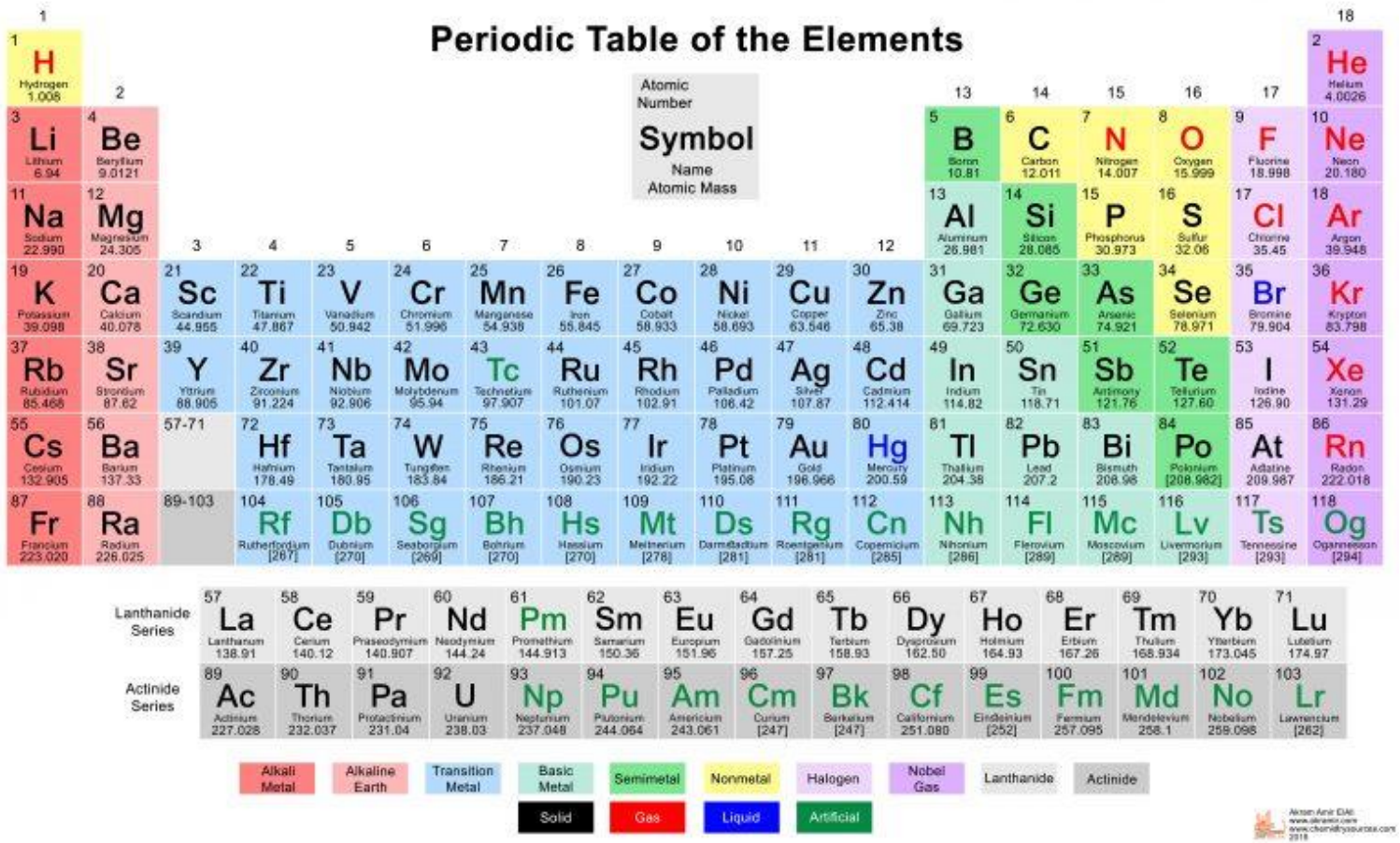
History

600 BC	Greeks first discover attractive properties of amber when rubbed.
1600 AD	Electric bodies repel as well as attract.
1735 AD	du Fay: Two distinct types of electricity
1750 AD	Franklin: Positive and Negative Charge
1770 AD	Coulomb: “Inverse Square Law”
1890 AD	J.J. Thompson: Quantization of electric charge - “Electron”

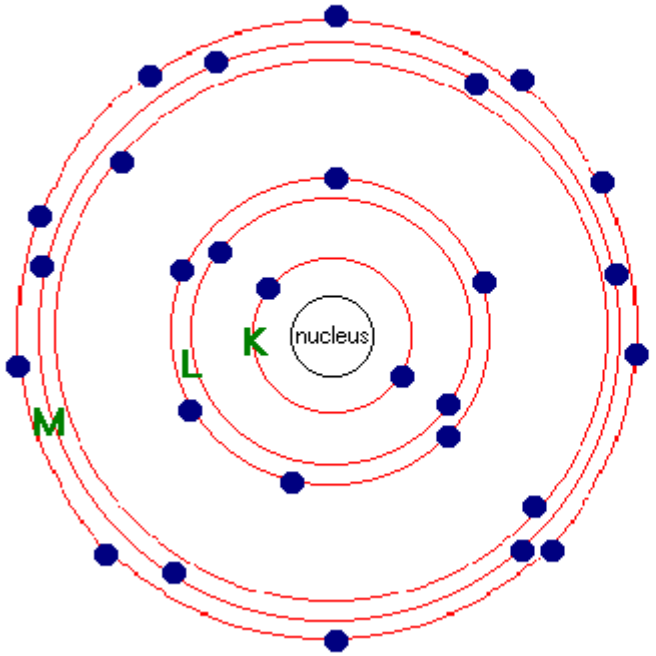
Electrostatics

Summary of things we know:

1. Something called "electric charge" exists on matter. We detect it's presence by attraction or repulsion to other "charge".
2. Two kinds of charge:
    1. Positive - which we attribute to a deficit of electrons.
    2. Negative - which we attribute to an excess of electrons.
    3. In matter, the positive charges are stuck in place in the nuclei. Matter is negatively charged when extra electrons are added, and positively charged when electrons are removed.
3. "Electrons" are carriers of ***negative*** electric charge
4. Like charges repel; unlike charges attract
5. Charge is conserved in a closed system. The number of electrons always remains the same
6. Conductors permit electrons to flow; Insulators inhibit the flow of electrons.
7. Force of attraction or repulsion ~ $1 / r^2$


Periodic Table of the Elements
Atomic Number
Symbol
Name
Atomic Mass
1 H Hydrogen 1.008
2 He Helium 4.0026
3 Li Lithium 6.94
4 Be Beryllium 9.0121
5 B Boron 10.81
6 C Carbon 12.011
7 N Nitrogen 14.007
8 O Oxygen 15.999
9 F Fluorine 18.998
10 Ne Neon 20.180
11 Na Sodium 22.990
12 Mg Magnesium 24.305
13 Al Aluminum 26.981
14 Si Silicon 28.085
15 P Phosphorus 30.973
16 S Sulfur 32.06
17 Cl Chlorine 35.45
18 Ar Argon 39.948
19 K Potassium 39.098
20 Ca Calcium 40.078
21 Sc Scandium 44.955
22 Ti Titanium 47.867
23 V Vanadium 50.942
24 Cr Chromium 51.996
25 Mn Manganese 54.938
26 Fe Iron 55.845
27 Co Cobalt 58.933
28 Ni Nickel 58.693
29 Cu Copper 63.546
30 Zn Zinc 65.38
31 Ga Gallium 69.723
32 Ge Germanium 72.630
33 As Arsenic 74.921
34 Se Selenium 78.971
35 Br Bromine 79.904
36 Kr Krypton 83.798
37 Rb Rubidium 85.468
38 Sr Strontium 87.62
39 Y Yttrium 88.905
40 Zr Zirconium 91.224
41 Nb Niobium 92.906
42 Mo Molybdenum 95.94
43 Tc Technetium 97.907
44 Ru Ruthenium 101.07
45 Rh Rhodium 102.91
46 Pd Palladium 106.42
47 Ag Silver 107.87
48 Cd Cadmium 112.414
49 In Indium 114.82
50 Sn Tin 118.71
51 Sb Antimony 121.76
52 Te Tellurium 127.60
53 I Iodine 126.90
54 Xe Xenon 131.29
55 Cs Cesium 132.905
56 Ba Barium 137.33
57-71
72 Hf Hafnium 178.49
73 Ta Tantalum 180.95
74 W Tungsten 183.84
75 Re Rhenium 186.21
76 Os Osmium 190.23
77 Ir Iridium 192.22
78 Pt Platinum 195.08
79 Au Gold 196.966
80 Hg Mercury 200.59
81 Tl Thallium 204.38
82 Pb Lead 207.2
83 Bi Bismuth 208.98
84 Po Polonium [208.982]
85 At Astatine 209.987
86 Rn Radon 222.018
87 Fr Francium 223.020
88 Ra Radium 226.025
89-103
104 Rf Rutherfordium [267]
105 Db Dubnium [270]
106 Sg Seaborgium [269]
107 Bh Bohrium [270]
108 Hs Hassium [270]
109 Mt Meitnerium [278]
110 Ds Darmstadtium [281]
111 Rg Roentgenium [281]
112 Cn Copernicium [285]
113 Nh Nihonium [286]
114 Fl Flerovium [289]
115 Mc Moscovium [289]
116 Lv Livermorium [293]
117 Ts Tennessine [293]
118 Og Oganneson [294]
Lanthanide Series
57 La Lanthanum 138.91
58 Ce Cerium 140.12
59 Pr Praseodymium 140.907
60 Nd Neodymium 144.24
61 Pm Promethium 144.913
62 Sm Samarium 150.36
63 Eu Europium 151.96
64 Gd Gadolinium 157.25
65 Tb Terbium 158.93
66 Dy Dysprosium 162.50
67 Ho Holmium 164.93
68 Er Erbium 167.26
69 Tm Thulium 168.934
70 Yb Ytterbium 173.045
71 Lu Lutetium 174.97
Actinide Series
89 Ac Actinium 227.028
90 Th Thorium 232.037
91 Pa Protactinium 231.04
92 U Uranium 238.03
93 Np Neptunium 237.048
94 Pu Plutonium 244.064
95 Am Americium 243.061
96 Cm Curium [247]
97 Bk Berkelium [247]
98 Cf Californium 251.080
99 Es Einsteinium [252]
100 Fm Fermium 257.095
101 Md Mendelevium 258.1
102 No Nobelium 259.098
103 Lr Lawrencium [262]
Alkali Metal
Alkaline Earth
Transition Metal
Basic Metal
Semimetal
Nonmetal
Halogen
Nobel Gas
Lanthanide
Actinide
Solid
Gas
Liquid
Artificial

What makes a good conductor?



Nickel Atom (Z=28)

electron

nucleus **Protons + Neutrons**

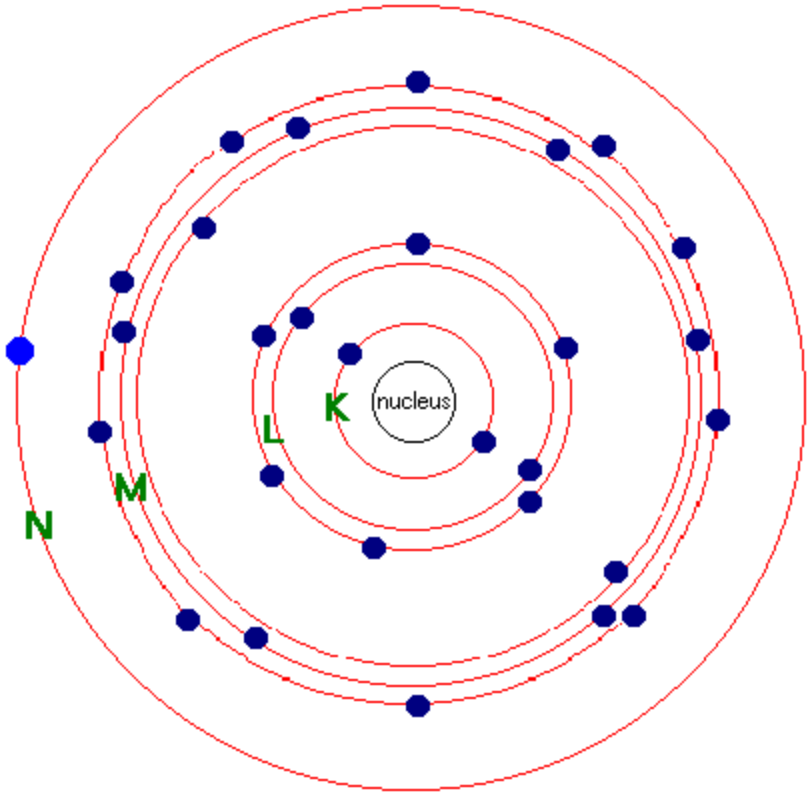
SHELL	Sub shell	Max # of electrons
K	s	2
L	s	2
	p	6
M	s	2
	p	6
	d	10

Copper atom

29 Protons

29 Electrons

29 Neutrons



Let's introduce some definitions before we continue:

to quantify "electric charge" we label the amount of charge on a body as: q

q = quantity of electric charge

We can have -q (negative charge)
or +q (positive charge)

We further define a basic unit of charge (just as we defined the basic unit of mass as a kilogram) as: the "Coulomb"

One Coulomb = 1.0 C = 6.242×10^{18} electrons

This means that a SINGLE electron carries a very small charge. Can you figure out how much charge (in "Coulombs") are on a single electron?

$-$_____ C on 1 e^-

This number is a constant and a very important value. It also represents the charge on the PROTON (but +)

Charge is Quantized

Q = MULTIPLE OF AN ELEMENTARY CHARGE E,

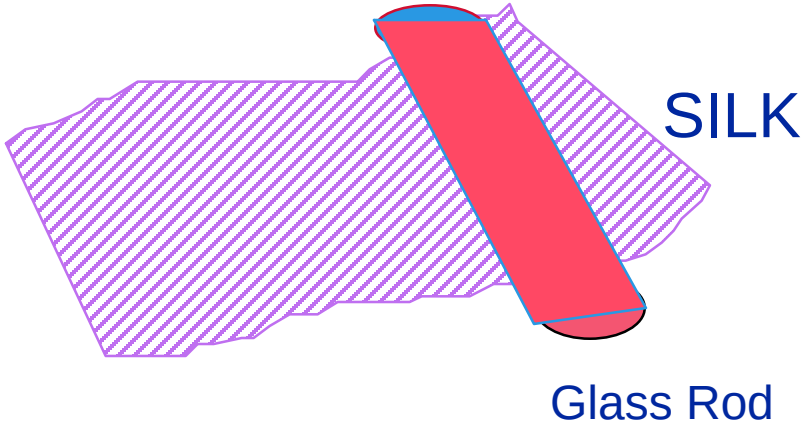
E = 1.6 X 10^{-19} COULOMBS

	Charge	Mass	Diameter
electron	- e	1	0
proton	+e	1836	~10^{-15}m
neutron	0	1839	~10^{-15}m
positron	+e	1	0

(Protons and neutrons are made up of quarks, whose charge is quantized in multiples of e/3. Quarks can't be isolated.)

Electric Charge

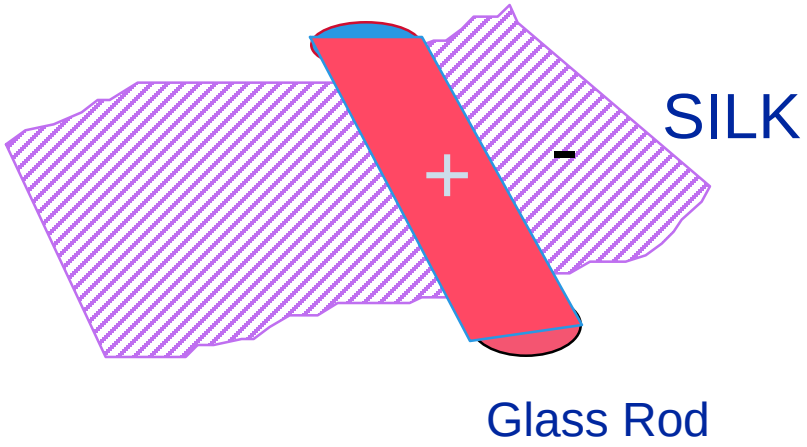
The Transfer of Charge



Some materials attract electrons more than others.

Electric Charge

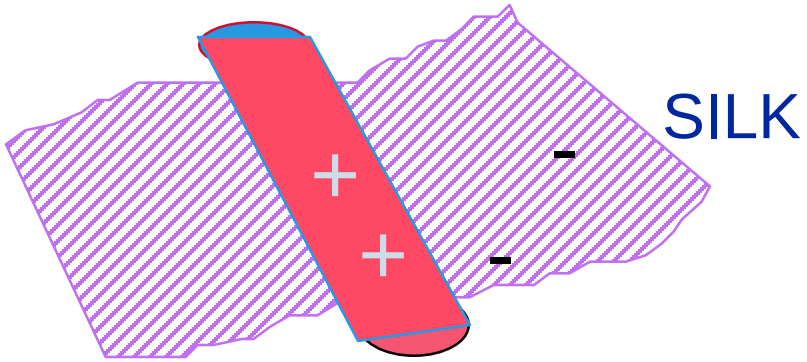
The Transfer of Charge



As the glass rod is rubbed against silk,
electrons are pulled off the glass onto the silk.

Electric Charge

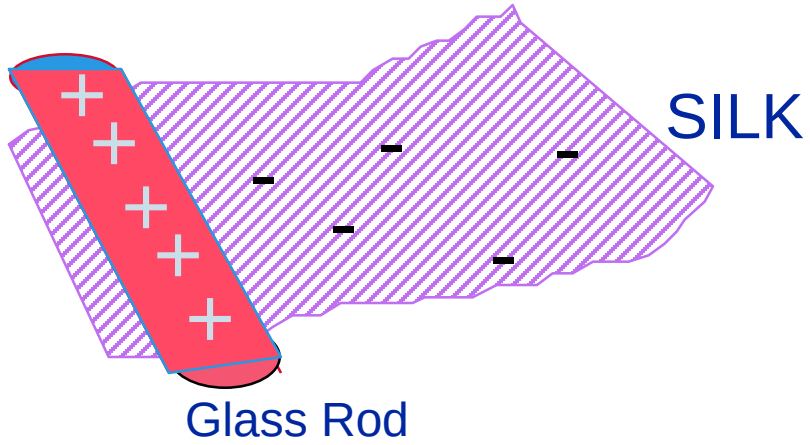
The Transfer of Charge



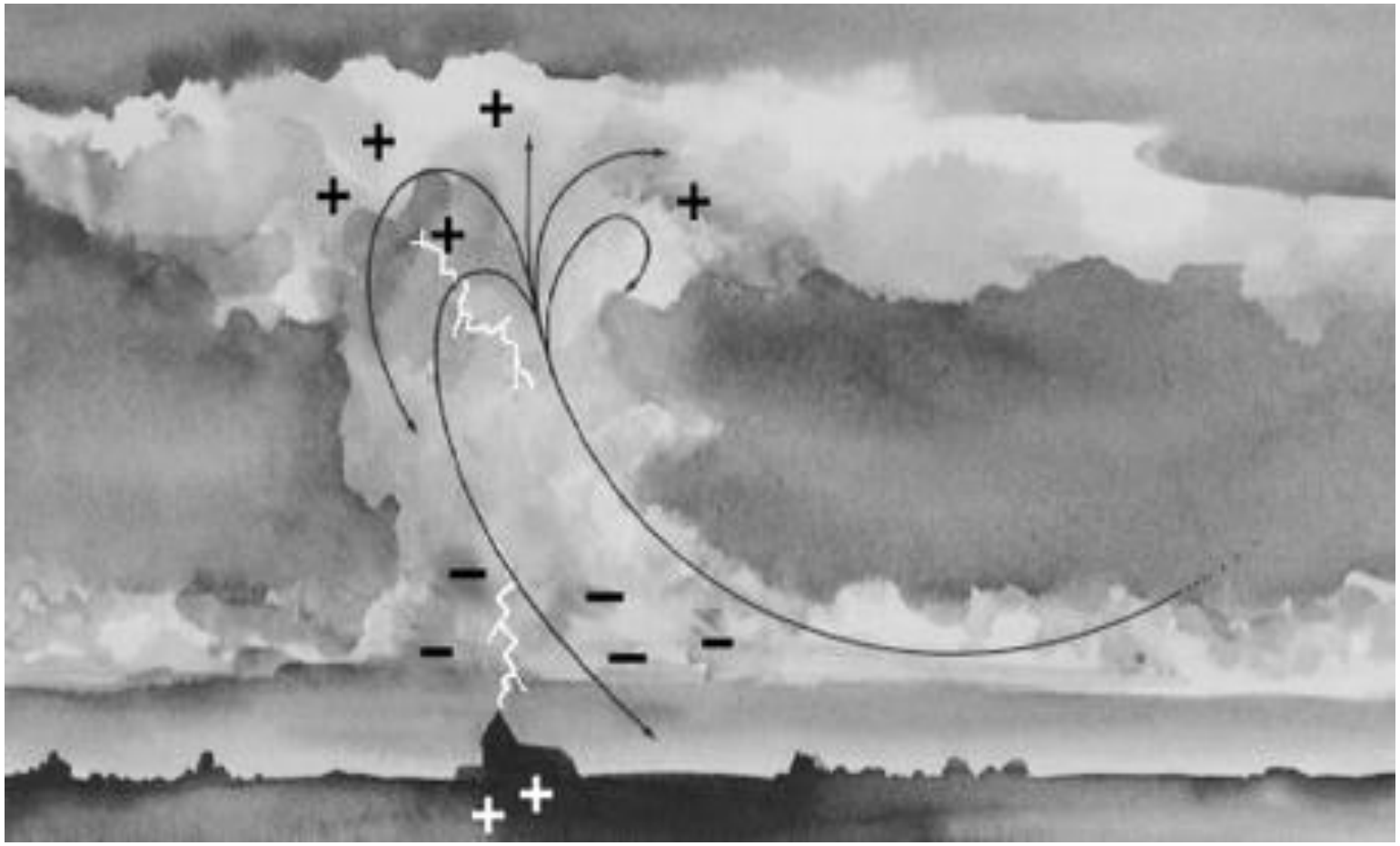
Usually matter is charge neutral, because the number of electrons and protons are equal. But here the silk has an excess of electrons and the rod a deficit.

Electric Charge

The Transfer of Charge



Glass and silk are insulators:
charges stuck on them stay put.



Typical current in a lightning bolt is 40,000 Amperes (that's about 40,000 Coulombs per second) with a voltage of up to 100,000,000 volts.