After Class 1

(A follow-up to today’s lecture—nothing here is for credit, but it’s strongly recommended)

Here are some follow-ups to items in Monday’s pre-class slides (and along with the suggested reading, be sure to work through the complete slide set—it’s lengthy but it’s a very good introduction to electric charge):

Slide 9

Example: You rub a plastic rod against a wool rug. Then you touch each object to a different but identical metal sphere. Which sphere then has more mass?

The plastic was negatively charged; it had excess electrons, which it took from the wool. The wool was positively charged; it was missing electrons, which it lost to the plastic. When the plastic is touched to a sphere, some of the excess electrons transfer to the sphere; that sphere gains a little mass. When the wool is touched to sphere, some electrons transfer from the sphere to the wool; that sphere loses a little mass. So the first sphere has more mass.

How about if you then touch the spheres together?
We can’t say for sure that the first sphere gained exactly as many electrons as the second sphere lost. This is because the other objects (the rod and the wool) weren’t identical in size and shape, so the configuration of the electrons (or missing electrons)—which always maximize the spaces between one another, weren’t necessarily the same as a result of the two transfers. However, no matter which sphere has more net charge, when they’re touched together, since those two objects are identical in size and shape, they’ll each take on identical charge distributions.

How could you then induce a charge difference between them once again?
Allow another charged object to approach one sphere (without touching it). This will polarize that sphere. Then touch the two spheres together, which—because of the influence of the other object on one of the sphere—will result in more of net charge moving onto the sphere farthest from the other object. Now just separate the two spheres once again.

Slide 10

Example: Two objects, formerly identical and electrically neutral, now have equal and opposite net charges of ±3.0 µC. What’s the difference in their masses now? [\(m_e = 9.11 \times 10^{-31} \text{ kg}; e = 1.60 \times 10^{-19} \text{ C}\)]

First, find out how many extra electrons the net charge magnitude represents:

\[
\frac{3.0 \, \mu\text{C}}{1.60 \times 10^{-19} \, \text{C/electron}} = 1.875 \times 10^{13} \, \text{electrons.}
\]

This is how many extra electrons reside on the negatively charged object—and how many electrons are missing from the positively charged object. How much mass is this?

\[
(1.875 \times 10^{13} \, \text{electrons})(9.11 \times 10^{-31} \, \text{kg/electron}) = 1.71 \times 10^{-17} \, \text{kg}
\]

So if the objects originally had a mass \(m\), now one of them has a mass of \(m + 1.71 \times 10^{-17}\); and the other has a mass of \(m - 1.71 \times 10^{-17}\). So the difference is \(2(1.71 \times 10^{-17}) = 3.42 \times 10^{-17} \, \text{kg}\).

A. 1.07 \times 10^{-13} \text{ kg}
B. 1.71 \times 10^{-17} \text{ kg}
C. 3.42 \times 10^{-17} \text{ kg}
D. 3.29 \times 10^{-24} \text{ kg}
E. None of the above.
Example: Three metal spheres, A, B and C, are identical in all respects, except that A carries a net charge of +10q; B carries a net charge of −2q; and C carries no net charge.

(a) What is the total net charge of all three spheres? +8q

(b) A and B are touched together, then separated. Next, A and C are touched together, then separated. Finally, B and C are touched together, then separated. What net charge does C now carry? +3q

(c) What is the total net charge of all three spheres now? +8q

An electroscope is positively charged by touching it with a positive glass rod. The electroscope leaves spread apart and the glass rod is removed. Then a negatively charged plastic rod is brought close to the top of the electroscope, but it doesn’t touch. What happens to the leaves?

1. The leaves get closer together
2. The leaves spread further apart
3. The leaves don’t move
4. One leaf moves higher, the other lower

The negatively charged rod pushes negative charge away from the top of the spectroscope toward the bottom (i.e. toward the leaves). This effectively neutralizes at least some of the net positive charge that was distributed over the outside of those leaves, so they don’t repel each other so much.

If a negative charged rod is held near a neutral metal ball, the ball is attracted to the rod. This happens because…

1. There are magnetic effects.
2. The rod polarizes the metal.
3. The rod and the ball have opposite net charges.

Three balls are suspended from thin threads. Balls 1 and 2 repel each other and balls 2 and 3 attract each other. From this we can conclude that

1. 1 and 3 carry charges of opposite sign.
2. 1 and 3 carry charges of equal sign.
3. All three carry the charges of the same sign.
4. One of the balls carries no charge.
5. We need to do more experiments to determine the sign of the charges.

The only sure sign that two objects have same net charge types is if they repel one another, so here we know only that balls 1 and 2 carry the same net charge type. But ball 2 attracting ball 3 could mean either that ball 3 has a net charge of type opposite to 2 (and 1); or, that ball 3 is neutral but has been polarized by its proximity to ball 2, thus being attracted to 2 for that reason.