Selected Homework Solutions – Chapter 1

1-2.1. See Fig.1.1 and the accompanying discussion of the amber effect.

1-4.3. Conductors: your body, a penny. Insulators: your clothing, plastic (unless it has been given a metallic film, as with some platic bags that hold computer chips), your comb (unless it is metallic), a styrofoam cup.

1-5.1. "A Penny Saved Is a Penny Earned" implies money conservation in a situation where there is flow of resources, both in and out. If the rates of outflow and inflow are 209 pennies per day, then decreasing the outflow to 208 pennies per day, without changing the inflow, has the same effect on savings as 209 pennies daily outflow and 210 pennies daily inflow.

1-6.9. When the negatively charged rod is brought near the grounded sphere, driven by electrostatic induction negative charge flows away from the sphere, leaving the sphere positively charged. When the ground connection is removed, the sphere can no longer change its charge state through that connection. Hence, when the negative rod is removed, the sphere remains positively charged.

1-8.1. People come in integer values; you are either alive or you are dead. There is no such thing as people conservation, as established by the phenomena of birth and death.

1-8.5. With $Q = N(-e)$, the number N of excess electrons is $N = Q/(-e) = -5 \times 10^{-10}/(-1.6 \times 10^{-19} = 3.125 \times 10^9$.

1-9.1. Use $q = \int (dq/ds)ds = \int \lambda ds$. Since $\lambda = Ax^2$ has units of C/m, A has units of C/m^3. Then

$$q_{a,2a} = \int_a^{2a} Ax^2 dx = (A/3)x^3|_a^{2a} = (A/3)(8a^3 - a^3) = (7Aa^3/3),$$

$$q_{2a,3a} = \int_{2a}^{3a} Ax^2 dx = (A/3)x^3|_{2a}^{3a} = (A/3)(27a^3 - 8a^3) = (19Aa^3/3).$$

Hence $q_{a,3a} = (26Aa^3/3)$, and the average charge per unit length is $\overline{\lambda} = q_{a,3a}/2a = (13Aa^2/3)$.

1-9.2. The arc length is $l = \int_0^\alpha R d\theta = R\alpha$. Hence the average charge per unit length is $\overline{\lambda} = Q/\alpha R$.

1-9.3. (a) The charge per unit length for rods 1 and 2 are q_1/l_1 and q_2/l_2, respectively. (b) The total charge is $q_1 + q_2$. The total length is $l_1 + l_2$. The average charge per unit length is $\overline{\lambda} = (q_1 + q_2)/(l_1 + l_2)$. (c) If $l_1 \to 0$, then $\overline{\lambda} \to (q_1 + q_2)/l_2$, as if all the charge is concentrated over a total length of l_2. (d) If $l_1 = l_2$, then $\overline{\lambda} \to (q_1 + q_2)/2l_2$.

1-9.4. Since $\sigma = Br^2$ has units of C/m^2, B has units of C/m^4.

$$dQ = (dQ/dA)dA = \sigma dA = Br^2(2\pi r dr) = (2\pi B)r^3 dr.$$

Then

$$Q = \int dQ = \int_0^a (2\pi B) r^3 dr = (2\pi B)(1/4)a^4 = (\pi B a^4/2).$$

Hence $\overline{\sigma} = Q/A = (\pi B a^4/2)/(\pi a^2) = Ba^2/2$.

1-9.5. (a) Since $\rho = C + Br$ has units of C/m^3, C has units of C/m^3 and B has units of C/m^4. (b) $dq = (dq/dV)dV = \rho dV = (C + Br)(4\pi r^2 dr)$. (c)

$$Q = \int dq = \int_0^a (C+Br)(4\pi r^2 dr) = (4\pi C)\int_0^a r^2 dr + (4\pi B)\int_0^a r^3 dr = (4\pi C)(a^3/3) + (4\pi B)(a^4/4).$$

(d) Hence

$$\overline{\rho} = Q/V = [(4\pi C)(a^3/3) + (4\pi B)(a^4/4)]/(4\pi a^3/3) = C + (3/4)Ba.$$

1-11.18. Franklin held onto the silk because, as an insulator, it would not conduct electricity from a lightning bolt to his hand. He stayed inside the door frame to prevent the silk thread from becoming wet, for then it would become a good conductor. The twine was conducting, and would thus conduct electricity down from the clouds (or serve as a means whereby electrostatic induction could occur.)

1-G.3. Use insulating gloves for this sequence of operations. First, line up in a row two of the conducting spheres and the Q-sphere. Bring the two conducting spheres in contact with one another; by electrostatic induction they will develop charges q and $-q$, with $-q$ near Q. On removing the q sphere, it will retain its charge. Now take the q sphere and touch it to the third identical conducting sphere. They will share charge equally, giving two spheres with charge $q/2$.

1-G.11. Because B and C are repelled by a negatively charged rod, they are both charged negatively. One way for A to attract B and C is for A to be charged positively; another way is for A to be neutral (attraction by the amber effect); yet a third way is for A to have a very small negative charge, whose repulsive effect on B and C is not enough to overcome the attraction of the amber effect that will take place.

1-G.16. I had intended the energies to be computed per interaction pair, and assuming that **all** atoms in the molecule interact. Some of you considered the atoms to be in a line.

$E(AB) = -2S$; $E(ABC) = -3(2S) = -6S$; $E(AAB) = -2(2S) + S = -3S$; $E(AABB) = -4(2S)+2(S) = -6S, E(AAAB) = -3(2S)+3(S) = -3S$; $E(AAAAB) = -4(2S) + 6(S) = -2S$; $E(AAAAAB) = -5(2S) + 10(S) = 0$; $E(AAAAAAB) = -6(2S) + 15(S) = 3S$. Thus the last (ultimate) and next-to-last (penultimate) molecules are unbound.