Solutions to the Extra Practice Problems for Chapter 14

1. The PE is -0.303 J. We can use Equation (14.1) once we convert the charge to 0.0121 C.

$$\mathrm{PE} = \mathrm{q} \cdot \mathrm{V}$$

$$\mathrm{PE} = (0.0121\ \mathrm{C}) \cdot (-25.0\ \mathrm{volts}) = (0.0121\ \cancel{\mathrm{C}}) \cdot \left(-25.0\ \frac{\mathrm{J}}{\cancel{\mathrm{C}}}\right) = -0.303\ \mathrm{J}$$

It has to be listed as negative.

2. The charge is -1.8×10^{-7} C. We can use Equation (14.2) for this once we convert the distance to 0.22 m.

$$\mathrm{V} = \frac{\mathrm{k} \cdot \mathrm{Q}}{\mathrm{r}}$$

$$-7{,}500\ \mathrm{volts} = \frac{\left(8.99\times10^{9}\ \frac{\mathrm{N} \cdot \mathrm{m}^2}{\mathrm{C}^2}\right) \cdot (\mathrm{Q})}{0.22\ \mathrm{m}}$$

$$\mathrm{Q} = \frac{(-7{,}500\ \mathrm{volts}) \cdot (0.22\ \mathrm{m})}{8.99\times10^{9}\ \frac{\mathrm{N} \cdot \mathrm{m}^2}{\mathrm{C}^2}} = \frac{(-7{,}500\ \frac{\cancel{\mathrm{N}} \cdot \cancel{\mathrm{m}}}{\cancel{\mathrm{C}}}) \cdot (0.22\ \cancel{\mathrm{m}})}{8.99\times10^{9}\ \frac{\cancel{\mathrm{N}} \cdot \cancel{\mathrm{m}}^2}{\cancel{\mathrm{C}^2}}} = -1.8 \times 10^{-7}\ \mathrm{C}$$

3. The potential difference is 116,000 J/C. We just need to use Equation (14.2) to get the potential at each position, and then calculate ΔV. However, we need to make sure we understand the second distance. It travels 15.0 cm, but in which direction? Since it is released from rest, it will travel *towards* the stationary charge, since it is attracted to it. Thus, the second position is 15.0 cm closer to the stationary charge, or 40.0 cm. Of course, the distances must be converted to 0.550 m and 0.400 m. Also, the value for the charge on the particle isn't used, since we are only being asked to get ΔV. However, the value of the stationary charge is used, and it must be converted to 1.90×10^{-5} C.

$$\mathrm{V} = \frac{\mathrm{k} \cdot \mathrm{Q}}{\mathrm{r}}$$

$$\mathrm{V_{initial}} = \frac{\left(8.99\times10^{9}\ \frac{\mathrm{N} \cdot \mathrm{m}^{\cancel{2}}}{\mathrm{C}^{\cancel{2}}}\right) \cdot (1.90 \times 10^{-5}\ \cancel{\mathrm{C}})}{0.550\ \cancel{\mathrm{m}}} = 311{,}000\ \frac{\mathrm{J}}{\mathrm{C}}$$

$$\mathrm{V_{final}} = \frac{\left(8.99\times10^{9}\ \frac{\mathrm{N} \cdot \mathrm{m}^{\cancel{2}}}{\mathrm{C}^{\cancel{2}}}\right) \cdot (1.90 \times 10^{-5}\ \cancel{\mathrm{C}})}{0.400\ \cancel{\mathrm{m}}} = 427{,}000\ \frac{\mathrm{J}}{\mathrm{C}}$$

$$\Delta\mathrm{V} = \mathrm{V_{final}} - \mathrm{V_{initial}} = 427{,}000\ \frac{\mathrm{J}}{\mathrm{C}} - 311{,}000\ \frac{\mathrm{J}}{\mathrm{C}} = 116{,}000\ \frac{\mathrm{J}}{\mathrm{C}}$$

4. The speed is 7,770 m/s. The change in potential energy will tell us the change in kinetic energy, which will get us the speed. However, we need to get the change in potential to get the change in potential energy. The stationary charge needs to be converted to 0.0250 C, and the distances to 0.330 m and 0.500 m.

$$\mathrm{V_{initial}} = \frac{\left(8.99\times10^{9}\ \frac{\mathrm{N} \cdot \mathrm{m}^{\cancel{2}}}{\mathrm{C}^{\cancel{2}}}\right) \cdot (0.0250\ \cancel{\mathrm{C}})}{0.330\ \cancel{\mathrm{m}}} = 681{,}000{,}000\ \frac{\mathrm{J}}{\mathrm{C}}$$

$$V_{final} = \frac{\left(8.99\times10^9 \frac{N\cdot m^{\cancel{2}}}{C^{\cancel{2}}}\right)\cdot(0.0250\,\cancel{C})}{0.500\,\cancel{m}} = 4.50\times10^8\ \frac{J}{C}$$

$$\Delta V = V_{final} - V_{initial} = 4.50\times10^8\frac{J}{C} - 681{,}000{,}000\ \frac{J}{C} = -231{,}000{,}000\ \frac{J}{C}$$

We can figure out the change in potential energy once we convert the charge of the particle to 0.0150 C.

$$\Delta PE = q\cdot\Delta V = (0.0150\,\cancel{C})\cdot\left(-231{,}000{,}000\frac{J}{\cancel{C}}\right) = -3{,}470{,}000\ J$$

That means PE *decreased* by 3,470,000 J, so KE must have *increased* by 3,470,000 J. It started at rest, so KE was zero. Thus, the increase means KE is now 3,470,000 J. Now we can get v when we convert mass to 0.115 kg:

$$KE = \frac{1}{2}m\cdot v^2$$

$$3{,}470{,}000\ J = \frac{1}{2}(0.1150\ kg)\cdot v^2$$

$$v = \sqrt{\frac{2\cdot 3{,}470{,}000\ J}{0.1150\ kg}} = \sqrt{\frac{2\cdot 3{,}470{,}000\ \frac{\cancel{kg}\cdot m^2}{s^2}}{0.1150\,\cancel{kg}}} = 7{,}770\frac{m}{s}$$

5. <u>The speed is 20 m/s</u>. The kinetic energy gets us the speed, but we have to determine how it changes by getting the change in potential energy. That depends on the potential difference. Converting the stationary charge to -1.5×10^{-5} C and the distances to 0.54 m and 0.41 m, we get:

$$V_{initial} = \frac{\left(8.99\times10^9 \frac{N\cdot m^{\cancel{2}}}{C^{\cancel{2}}}\right)\cdot(-1.5\times10^{-5}\,\cancel{C})}{0.54\,\cancel{m}} = -250{,}000\ \frac{J}{C}$$

$$V_{final} = \frac{\left(8.99\times10^9 \frac{N\cdot m^{\cancel{2}}}{C^{\cancel{2}}}\right)\cdot(-1.5\times10^{-5}\,\cancel{C})}{0.41\,\cancel{m}} = -330{,}000\ \frac{J}{C}$$

$$\Delta V = V_{final} - V_{initial} = -330{,}000\frac{J}{C} - -250{,}000\ \frac{J}{C} = -80{,}000\ \frac{J}{C}$$

We can figure out the change in potential energy once we convert the charge of the particle to -3.5×10^{-5} C.

$$\Delta PE = q\cdot\Delta V = (-3.5\times10^{-5}\,\cancel{C})\cdot\left(-80{,}000\frac{J}{\cancel{C}}\right) = 3\ J$$

We are limited to one significant figure because of the -80,000 J/C. Since ΔPE is positive, that means PE *increased*. This tells us KE *decreased* by 3 J. We can determine how much KE it originally had once we convert mass to 0.025 kg:

$$KE = \frac{1}{2}m\cdot v^2 = \frac{1}{2}(0.025\ kg)\cdot\left(22\frac{m}{s}\right)^2 = 6.1\ J$$

That means the new KE is 6.1 J – 3 J = 3 J. We are limited to the ones place because of 3 J. That will give us the new speed:

$$KE = \frac{1}{2}m\cdot v^2$$

$$3\ \text{J} = \frac{1}{2}(0.025\ \text{kg}) \cdot \text{v}^2$$

$$\text{v} = \sqrt{\frac{2 \cdot 3\ \text{J}}{0.025\ \text{kg}}} = \sqrt{\frac{2 \cdot 3 \frac{\cancel{\text{kg}} \cdot \text{m}^2}{\text{s}^2}}{0.025\ \cancel{\text{kg}}}} = 20 \frac{\text{m}}{\text{s}}$$

6. <u>The electric permittivity is 6.81×10^{-6} F/m</u>. We need to calculate the area of the plates, but the dimensions must be in meters. Thus, the area is (0.015 m)·(0.022 m)= 0.00033 m^2. The thickness must also be changed to 0.000155 m, and the capacitance to 1.45×10^{-5} F.

$$\text{C} = \frac{\varepsilon \cdot \text{A}}{\text{d}}$$

$$1.45 \times 10^{-5}\ \text{F} = \frac{\varepsilon \cdot (0.00033\ \text{m}^2)}{0.000155\ \text{m}}$$

$$\varepsilon = \frac{(1.45 \times 10^{-5}\ \text{F})(0.000155\ \cancel{\text{m}})}{0.00033\ \cancel{\text{m}^2}} = 6.81\times10^{-6} \frac{\text{F}}{\text{m}}$$

7. <u>The potential difference is 1,470 volts</u>. The capacitance must be converted to 1.50×10^{-5} F and the charge to 0.0220 coulombs.

$$\text{Q} = \text{C} \cdot \Delta\text{V}$$

$$0.0220\ \text{coulombs} = (1.50\times10^{-5}\ \text{F}) \cdot \Delta\text{V}$$

$$\Delta\text{V} = \frac{0.0220\ \text{coulombs}}{1.50\times10^{-5}\ \text{F}} = \frac{0.0220\ \cancel{\text{coulombs}}}{1.50\times10^{-5} \frac{\cancel{\text{coulombs}}}{\text{volt}}} = 1{,}470\ \text{volts}$$

8. <u>You could use a dielectric with a larger permittivity, increase the area of the plates, or use a thinner dielectric</u>. Look at the equation for capacitance. Since ε and A are on top of the fraction, increasing either will increase the capacitance. Since d is in the denominator, making it smaller will increase the capacitance.

9. <u>The potential difference is 26,000 volts</u>. We first need the capacitance. Converting the thickness to 0.0010 m:

$$\text{C} = \frac{\varepsilon \cdot \text{A}}{\text{d}} = \frac{(1.5\times10^{-8} \frac{\text{F}}{\cancel{\text{m}}}) \cdot (0.25\ \cancel{\text{m}^2})}{0.0010\ \cancel{\text{m}}} = 3.8\times10^{-6}\ \text{F}$$

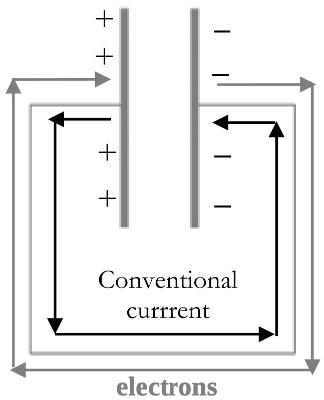
Now we can get the potential difference after converting the charge to 0.099 coulombs:

$$\text{Q} = \text{C} \cdot \Delta\text{V}$$

$$0.099\ \text{coulombs} = (3.8\times10^{-6}\ \text{F}) \cdot \Delta\text{V}$$

$$\Delta\text{V} = \frac{0.099\ \text{coulombs}}{3.8\times10^{-6}\ \text{F}} = \frac{0.099\ \cancel{\text{coulombs}}}{3.8\times10^{-6} \frac{\cancel{\text{coulombs}}}{\text{volt}}} = 26{,}000\ \text{volts}$$

10.



Electrons flow from negative to positive, while conventional current flows from positive to negative.