Electricity Review Sheet Solutions

1. answers: I – B, II – B, III - B, IV – A or C

I. Friction charging causes electrons to move from the animal fur to Object A, which becomes negative.
II. Conduction charging causes excess electrons in the negatively charged object to be shared with Object A, so object A becomes negatively charged.
III. Induction charging causes Object A to be oppositely charge, so using a positive object induces a negative charge on Object A.
IV. Object A can be attracted to a negatively charged object if it oppositely charged positive, but also may be attracted by polarization if it is neutral.

2. answer: A

Ordinarily only electrons can be moved from one body to another (movement of protons requires high-energy collisions in accelerators!). So a glass rod acquires a positive charge, when rubbed with silk, by losing electrons.

3. answer: D

The positively charged rod near the electroscope will attract some electrons into the knob (top) of the electroscope, leaving the electroscope polarized, but still neutral. The correct representation has negative signs in the knob, and positive signs in the leaves (bottom).

4. answer: B

Electric field lines point towards negative charges and away from positive charges (a test charge is always assumed to be positive). Sphere A must be negative and sphere B must be positive. Sphere B is twice the charge of A since it was twice as many electric field lines.

5. answer: C

$$F_e = \frac{kq_1q_2}{r^2} = \frac{9\times10^9(1.6\times10^{-19})^2}{(1.00\times10^{-8})^2}$$

$$F_e = 2.30\times10^{-12}\text{ N}$$

6. answer: A

$$\text{number of electrons} = \frac{\text{charge}}{\text{fundamental charge}}$$

$$n = \frac{q}{e} = \frac{-8\times10^{-6}}{-1.6\times10^{-19}} = 5\times10^{13}$$

7. answer: B

Electrical resistance depends *directly* on temperature, length, and resistivity. It depends inversely on cross-sectional area. That is, the wider the diameter of resistor the less the resistance (much like a drinking straw has less resistance than a narrow stirring straw.)

8. answer: D

Using the definition of resistance as the ratio of voltage divided by current:

$$R = \frac{\Delta V}{I} \quad \Rightarrow \quad I = \frac{\Delta V}{R} = \frac{0.40\text{ volt}}{100\ \Omega} = 0.004\text{ A}$$

Converting amps to milliamps:

$$0.004\text{ A}\times\frac{1\text{ mA}}{10^{-3}\text{ A}} = 4.0\text{ mA}$$

9. answer: C

$$\Delta V = \frac{PE}{q} = \frac{work}{q} \quad 10 = \frac{work}{2\times10^{-4}} \quad work = 2\times10^{-3}\text{ J}$$

10. answer: C

$$E = \frac{kq}{r^2} \quad 3600 = \frac{(9\times10^9)(q)}{0.1^2} \quad q = 4\times10^{-9}\text{ C} = 4\text{ nC}$$

11. answer: D

The electric field inside this parallel plate capacitor is constant (except at the left and right ends). The field points down because a positive test charge is used to define the direction of an electric field, and the positive test charge would be repelled by the positive charges above, and attracted by the negative charges below it.

12. answer: C

$$\Delta V = I(R_1 + R_2) \quad 12 = 2(3 + R_2) \quad R_2 = 3\ \Omega$$

13. answer: D

$$PE = P(t) = I\Delta V(t) = 10(120)(30) = 3.6\times10^4\text{ J}$$

14. answer: B

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{20} + \frac{1}{30} \quad R_{eq} = 12\ \Omega$$

15. answer: B

$$I = \frac{\Delta V}{R} = \frac{12}{20} = 0.60\text{ A}$$

16. answer: A

$$P = \frac{\Delta V^2}{R} = \frac{12^2}{30} = 4.8\text{ W}$$

17. answer: C

The ammeter must be placed in series with resistor #1 within the branch, so at position 3. The voltmeter must be placed in parallel across resistor #2, so at position 1.

18. answer: D

circuit A: $R_{eq} = 2 + 2 = 4\ \Omega$

circuit B: $R_{eq} = (2^{-1} + 2^{-1})^{-1} = 1\ \Omega$

circuit C: $R_{eq} = 1 + 1 = 2\ \Omega$

circuit D: $R_{eq} = (1^{-1} + 1^{-1})^{-1} = \frac{1}{2}\ \Omega$

smallest resistance is circuit D

19a.

$$F_e = \frac{kq_1q_2}{r^2} = \frac{(9\times10^9)(8\times1.6\times10^{-19})^2}{(5.9\times10^{-15})^2} = \boxed{424\text{ N}}$$

19b.

$$F_e = \frac{kq_1q_2}{r^2} = \frac{(9\times10^9)(-1.6\times10^{-19})(8\times1.6\times10^{-19})}{(2.4\times10^{-14})^2}$$

$F_e = -3.2$ N (to the right)

$$F_e = \frac{kq_1q_3}{r^2} = \frac{(9\times10^9)(-1.6\times10^{-19})(8\times1.6\times10^{-19})}{(2.4\times10^{-14} + 5.9\times10^{-15})^2}$$

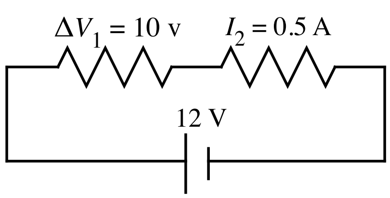
$F_e = -2.06$ N (to the right)

$\Sigma F = 3.2 + 2.06 = \boxed{5.26\text{ N (to the right)}}$

19c.

$$E = \frac{F_e}{q_0} = \frac{5.26}{(1.6\times10^{-19})} = \boxed{3.29\times10^{19}\text{ N/C, to the left}}$$

20a.



20b.

$\Delta V = \Delta V_1 + \Delta V_2 \qquad 12 = 10 + \Delta V_2 \qquad \Delta V_2 = \boxed{2\text{ v}}$

20c.

$I = I_1 = I_2 = 0.5\text{ A}$

$\Delta V_1 = I_1R_1 \qquad 10 = 0.5R_1 \qquad R_1 = \boxed{20\ \Omega}$

20d.

$\Delta V = IR_{eq} \qquad 12 = 0.5R_{eq} \qquad R_{eq} = \boxed{24\ \Omega}$

20e.

$P_2 = I_2\Delta V_2 = 0.5(10) = 5\text{ W}$

table method:

	R	I	V	P
R_1	4	0.5	2	1
R_2	20	**0.5**	**10**	5
R_{eq}	24	0.5	**12**	6

21a.

$\Delta V_1 = I_1R_1 \qquad 120 = 0.60R_1 \qquad R_1 = \boxed{200\ \Omega}$

21b.

$\Delta V_2 = I_2R_2 \qquad 120 = I_2(240) \qquad I_2 = \boxed{0.5\text{ A}}$

21c.

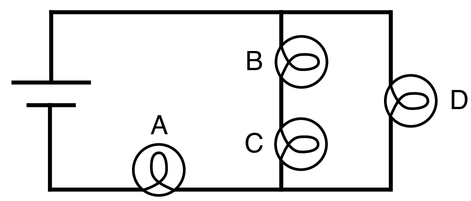
$P_3 = I_3\Delta V_3 \qquad 80 = I_3(120) \qquad I_3 = \boxed{0.67\text{ A}}$

21d.

$P = I_1\Delta V_1 = 0.6(120) = \boxed{72\text{ W}}$

	R	I	V	P
R_1	200	**0.6**	120	72
R_2	**240**	0.5	120	60
R_3	180	0.67	120	**80**
R_{eq}	67.9	1.767	**120**	212

22a.



22b.

$R_{BC} = R_B + R_C = 12 + 12 = 24\ \Omega$

$R_{BCD} = (R_{BC}{}^{-1} + R_D{}^{-1})^{-1} = (24^{-1} + 12^{-1})^{-1} = 8\ \Omega$

$R_{eq} = R_A + R_{BCD} = 8 + 12 = 20\ \Omega$

22c,d,e.

Series:

	R	I	V	P
R_B	**12**	0.1	1.2	0.12
R_C	**12**	0.1	1.2	0.12
R_{BC}	24	0.1	2.4	0.24

Parallel:

	R	I	V	P
R_{BC}	24	0.1	2.4	0.24
R_D	**12**	0.2	2.4	0.48
R_{BCD}	8	0.3	2.4	0.72

Series:

	R	I	V	P
R_{BCD}	8	0.3	2.4	0.72
R_A	**12**	0.3	3.6	1.08
R_{eq}	20	0.3	**6**	1.80

23a.

$$R_{12} = R_1 + R_2 = 6 + 4 = 10\ \Omega$$

$$R_{123} = (R_{12}^{-1} + R_3^{-1})^{-1} = (10^{-1} + 15^{-1})^{-1} = 6\ \Omega$$

$$R_{eq} = R_{123} + R_4 + R_5 = 6 + 4 + 2 = \boxed{12\ \Omega}$$

$$I = \frac{\Delta V}{R_{eq}} = \frac{36}{12} = \boxed{3\text{ A}}$$

$$P = \frac{\Delta V^2}{R_{eq}} = \frac{36^2}{12} = \boxed{108\text{ W}}$$

23b.

$$I = I_4 = I_5 = \boxed{3\text{ A}}$$

$$\Delta V_5 = I_5 R_5 = 3(2) = \boxed{6\text{ v}}$$

$$P_5 = I_5 \Delta V_5 = 3(6) = \boxed{18\text{ W}}$$

$$\Delta V_4 = I_4 R_4 = 3(4) = \boxed{12\text{ v}}$$

$$P_4 = I_4 \Delta V_4 = 3(12) = \boxed{36\text{ W}}$$

$$\Delta V_3 = \Delta V_{123} = \Delta V - \Delta V_{45} = 36 - 18 = \boxed{18\text{ v}}$$

$$\Delta V_3 = I_3 R_3 \qquad 18 = I_3(15) \qquad I_3 = \boxed{1.2\text{ A}}$$

$$P_3 = I_3 \Delta V_3 = 1.2(18) = \boxed{21.6\text{ W}}$$

$$I_1 = I_2 = I - I_3 = 3 - 1.2 = \boxed{1.8\text{ A}}$$

$$\Delta V_2 = I_2 R_2 = 1.8(4) = \boxed{7.2\text{ v}}$$

$$P_2 = I_2 \Delta V_2 = 1.8(7.2) = \boxed{12.96\text{ W}}$$

$$\Delta V_1 = I_1 R_1 = 1.8(6) = \boxed{10.8\text{ v}}$$

$$P_1 = I_1 \Delta V_1 = 1.8(10.8) = \boxed{19.44\text{ W}}$$

Using the table method, work through each resistor column from the first table, to the second, then to the third.

Then complete the third table for the final series circuit. Only the known values are shown in bold. All others are found by multiplication or division.

Then complete the second table. Notice the bottom row is simply taken from the table below it.

Finally, complete the first table. Again, notice the bottom row is simply taken from the table below it

Series:

	R	I	V	P
R_1	**6**	1.8	10.8	19.44
R_2	**4**	1.8	7.2	12.96
R_{12}	10	1.8	18	32.4

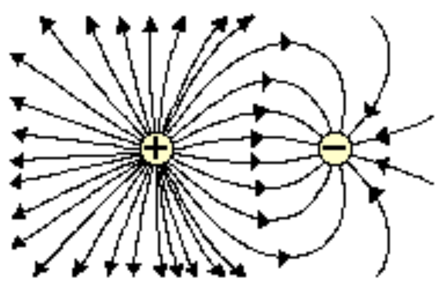
Parallel:

	R	I	V	P
R_{12}	**10**	1.8	18	32.4
R_3	**15**	1.2	18	21.6
R_{123}	6	3	18	54

Series:

	R	I	V	P
R_{123}	6	3	18	54
R_4	**4**	3	12	36
R_5	**2**	3	6	18
R_{eq}	12	3	**36**	108

24a.



24b.

$$q_1 = +3\text{ nC} \times \frac{10^{-9}\text{ C}}{1\text{ nC}} = +3 \times 10^{-9}\text{C}$$

$$q_2 = -1\text{ nC} \times \frac{10^{-9}\text{ C}}{1\text{ nC}} = -1 \times 10^{-9}\text{C}$$

$$E_1 = \frac{kq_1}{r_1^2} = \frac{9.0 \times 10^9 (3 \times 10^{-9})}{(0.5\text{ m})^2} = 108\text{ N/C, right}$$

$$E_2 = \frac{kq_2}{r_1^2} = \frac{9.0 \times 10^9 (1 \times 10^{-9})}{(0.5\text{ m})^2} = 36\text{ N/C, right}$$

$$E_{TOTAL} = E_1 + E_2 = 108\text{ N/C} + 36\text{ N/C} = \boxed{144\text{ N/C, right}}$$

24c.

The forces balance on the 2 nC charge:

$$\frac{k(3\text{ nC})(2\text{ nC})}{(1+r)^2} = \frac{k(1\text{ nC})(2\text{ nC})}{(r)^2}$$

$r = 1.37$ m, right of the -1.0 nC charge