1. (b).
2. (d).
3. (b).
4. (b).
5. (c).
6. The chemical membrane is **to prevent the two ions from each electrode from mixing**. If the ions mix, one ion can be attracted to the other electrode along with that electrode's ion. The result is that it could "coat" the other electrode, and then essentially the two electrodes are identical.

9. (a) $V = V_1 + V_2 + V_3 = 1.5\text{ V} + 1.5\text{ V} + 1.5\text{ V} = \boxed{4.5\text{ V}}$. (b) $V = V_1 = V_2 = V_3 = \boxed{1.5\text{ V}}$.

12. Using just one battery at a time gives three voltages: 1.0 V, 3.0 V, and 12 V.
Using just two batteries at a time gives six voltages:
two in series at a time, 4.0 V, 13 V, and 15 V;
two in parallel at a time, 1.0 V, 3.0 V, 1.0 V;
so three more different voltages of 4.0 V, 13 V, and 15 V.
Using three batteries at a time gives eight voltages:
two in parallel, then in series with the third, 13 V, 4.0 V, and 4.0 V;
all three in series, 16 V; all three in parallel, 1.0 V;
two in series, then parallel to the third, 4.0 V, 3.0 V, 1.0 V;
so there is one new different voltage of 16 V.
Therefore there are **7 different voltages**, and they are
1.0 V, 3.0 V, 4.0 V, 12 V, 13 V, 15 V, and 16 V.

14. (d), because $q = It$.

15. (a), because $I = \frac{q}{t}$.

16. (b), because electrons have negative charges.

17. (a) The electron flow in the resistor is **upward**.
(b) The current in the resistor is **downward**.
(c) The current in the battery is **upward**.

18. This is because the **electric field travels close to the speed of light**. Although the electron moves slowly, there are immediate movements of electrons as soon as a voltage is applied, because there are free electrons everywhere in the circuit.

19. $I = \frac{q}{t} = \frac{30\text{ C}}{120\text{ s}} = \boxed{0.25\text{ A}}$.

27. (a).

28. (c). Twice the current means half the resistance, when the voltage is kept constant.

29. (a). Three times the current means three times the voltage, when the resistance is kept constant.

30. (c). $I = V/R$. If V doubles and R becomes 1/3 as large, I goes up by six times.

31. From $V = (R)I$ ($y = mx$ is the equation for a straight line where m is the slope) we conclude that $\boxed{\text{the one with the shallower slope}}$ is less resistive.

$\boxed{32}$. This is because the $\boxed{\text{resistance is low and the current is high at turn-on}}$. Once the lamp is hot, its resistance increases and current decreases, so there is less chance of burning out.

33. (a) $R = \frac{\rho L}{A}$, ☞ $\frac{R_2}{R_1} = \frac{L_2}{L_1}\frac{A_1}{A_2} = (2)(\frac{1}{2}) = 1$. Also $I = \frac{V}{R}$. So the current is the $\boxed{\text{same}}$.

(b) Since $A = \frac{\pi d^2}{4}$, half the diameter means 1/4 the area, so $\frac{A_2}{A_1} = 1/4$.

39. $V = IR = (0.50\text{ A})(2.0\ \Omega) = \boxed{1.0\text{ V}}$.

40. $R = \frac{V}{I} = \frac{100 \times 10^{-3}\text{ V}}{12.5 \times 10^{-3}\text{ A}} = \boxed{8.00\ \Omega}$.

41. $R = \frac{\rho L}{A} = \frac{\rho L}{\pi r^2} = \frac{(1.70 \times 10^{-8}\ \Omega\cdot\text{m})(0.60\text{ m})}{\pi(0.05 \times 10^{-2}\text{ m})^2} = \boxed{1.3 \times 10^{-2}\ \Omega}$.

Therefore $\frac{R_2}{R_1} = (1)(4) = 4$. Thus $\frac{I_2}{I_1} = \frac{R_1}{R_2} = 1/4$, i.e., $\boxed{\text{one-quarter the current}}$.

47. (a) $\Delta R = R_o\, \alpha \Delta T = (25\text{ m}\Omega)(6.80 \times 10^{-3}\text{ C}^{\circ -1})(27\text{ C}^\circ) = \boxed{4.6\text{ m}\Omega}$.

(b) $I_o = \frac{V}{R_o}$ and $I = \frac{V}{R}$. $\frac{I}{I_o} = \frac{R_o}{R} = \frac{25\text{ m}\Omega}{(25 + 4.6)\text{ m}\Omega} = 0.845$. $I = (0.845)I_o = (0.845)(10.0\text{ mA}) = \boxed{8.5\text{ mA}}$.

48. $R_1 = \frac{V_1}{I_1} = \frac{12\text{ V}}{0.185\text{ A}} = 65\ \Omega$, $R_2 = \frac{90\text{ V}}{1.25\text{ A}} = 72\ \Omega$. So it is $\boxed{\text{not ohmic}}$ since $R \neq$ constant.

55. (d).

56. (b), since $P = \frac{V^2}{R}$.

57. (d), because $P = I^2 R$.

58. $P = \frac{V^2}{R}$. So its $\boxed{\text{power output would quadruple, and it would overheat and burn out}}$.

59. Since $P = \frac{V^2}{R}$, the bulb of higher power has smaller resistance or thicker wire.

So $\boxed{\text{the wire in the 60-W bulb would be thicker}}$.

60. The $\boxed{5.0\ \Omega}$ consumes more power, because it has the smaller resistance.

With the $\boxed{\text{same voltage, more curent}}$ is through the 5.0 Ω, so the power is more.

61. $P = \dfrac{V^2}{R}$, ☞ $R = \dfrac{V^2}{P} = \dfrac{(120\text{ V})^2}{100\text{ W}} = \boxed{144\ \Omega}$.

$\boxed{62}$. $P = \dfrac{V^2}{R} = \dfrac{(110\text{ V})^2}{10\ \Omega} = \boxed{1.2 \times 10^3\text{ W}}$.

68. (a) $I = \dfrac{V}{R} = \dfrac{1.50\text{ V}}{2.50\ \Omega} = \boxed{0.600\text{ A}}$.

(b) $q = It = (0.600\text{ A})(6.00\text{ h})(3600\text{ s/h}) = \boxed{1.30 \times 10^4\text{ C}}$.

(c) $E = qV = (1.30 \times 10^4\text{ C})(1.50\text{ V}) = \boxed{1.94 \times 10^4\text{ J}}$.

Alternate method: $E = pt = I^2Rt = (0.600\text{ A})^2(2.50\ \Omega)(6.00\text{ h})(3600\text{ s/h}) = 1.94 \times 10^4\text{ J}$.

77. (a) $E = Pt = \dfrac{V^2}{R}\ t = \dfrac{[4(1.5\text{ V})]^2(60\text{ s})}{20\ \Omega} = \boxed{1.1 \times 10^2\text{ J}}$.

$\boxed{83}$. $E = \Sigma(Pt) = (5.0\text{ kW})(0.30)(24\text{ h/d})(30\text{ d}) + (0.8\text{ kW})(0.50\text{ h}) + (1.2\text{ kW})(8.0\text{ h}) + (0.900\text{ kW})(1/4\text{ h/d})(30$

$\text{d})$

$+ (0.5\text{ kW})(0.15)(24\text{ h/d})(30\text{ d}) + (10.5\text{ kW})(10\text{ h}) + (0.1\text{ kW})(120\text{ h}) = 1268\text{ kWh}$.

So it costs (1268 kWh)($0.12 /kWh) = $\boxed{\$152}$.

(b) $E = \dfrac{(1.5\text{ V})^2(60\text{ s})}{20\ \Omega} = \boxed{6.8\text{ J}}$.