AP Physics 2 – Circuits and Capacitors Selected Answers

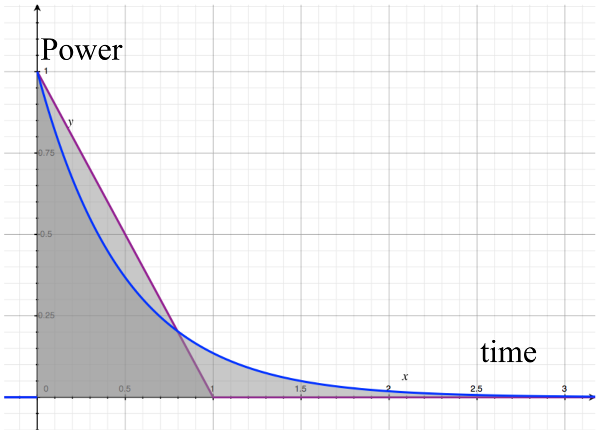
1. a. 4300 C
   b. $2\underline{0}$ mA
   c. 43 h
2. a. 1400 C
   b. 9.0 A by conservation of charge
   c. 36 ns
3. a. 0.177 A
   b. 29.5 mA
   c. 0.354 A
4. a. 18 mA
   b. 0.11 W
   c. 390 J
5. 0.17 A, 2.4 V
6. 44 Ω at most so that current is at least 5.5 A – numbers determined by assuming *all* of the heat generated by the stove eye goes into *only* the water (not true)
7. a. 16 Ω
   b. 7.0 Ω
   c. 4.1×10^{-4} Ωm
8. a. 64 mΩ
   b. 9.2 W
   c. The heat released would be 1/4 as much because the resistance would be $1/2^2$ the original value. (new value = 2.3 W)
9. a. 5.06 Ω
   b. 8.88 V
   c. 0.0576 V
   d. The less the current and/or the better the quality of the wires (less resistance) the closer to reality the assumption that voltage drops across wires can be ignored in circuit analysis. Even in this problem (with large current and lousy wires) the assumption would cause only about 1% error in various results.
10. $R = \rho DL^2/m$
11. a. 59.2 mA
    b. 5.92 V
    c. 4.6 mW
    d. 5.99 mA, 5.99 V, 0.047 mW
    e. 1.56 kΩ
12. a. 7.7 mΩ
    b. 2.1 kW
    c. 21 minutes
13. a. 1.50 V
    b. 0.7 Ω
    c. 2.2 A will be current if connected to a conductor with zero resistance.
14. a. When there is greater current the rate at which energy is wasted in the form of heat dissipated by internal resistance increases. In other words the efficiency is greater when the current is less.

b. $E = U\dfrac{R}{R+r}$ This shows that for greater value of external resistance *R* a greater proportion of energy is extracted given a fixed internal resistance *r*.

15. a. 1.21 V, 36.6 mA
    b. 3.70 V, 112 mA
16. a. 1.20 V, 36.2 mA series
    3.53 V, 107 mA parallel
    b. As shown by the numerical results the internal resistance has very little effect on the outcome for the resistors in series and so it could be neglected with little error (about 1%). However, because the current through the battery is much greater with resistors in parallel it causes a much more significant drop in terminal voltage, which would cause error around 5% if internal resistance is neglected.
17. a. $\frac{I_{parallel}}{I_{series}} = \frac{3r+R}{r+3R}$
    b. 3, 1/3
    c. The effective emf and internal resistance: 3$\mathcal{E}$ and 3*r* when connected in series, $\mathcal{E}$ and *r*/3 when connected in parallel. Therefore internal resistance increases when in series and decreases when in parallel.
18. a. $V_1 : V_2 : V_3 = 3 : 2 : 1$
    b. $P_1 : P_2 : P_3 = 9 : 4 : 1$
    c. $R_1 = 4R/9$; $R_2 = 4R$
19. a. 0.56 W
    b. 1.0 A
    c. 44 Ω
20. a. 83 Ω
    b. 1.6 W
21. a. 0.90 mC
    b. 2.7 mJ
    c. 8.5 V (or greater)
22. a. 0.17 F
    b. 3.0 J
23. a. $24\underline{0}0$ V
    b. 69.4 μF
    c. 4.17 ms (actually about 5 times this!)
    d. 49.0 A

24. a. $P = \dfrac{2U}{RC}$

b. $t = RC$

c. 

25. a. 2.00 A

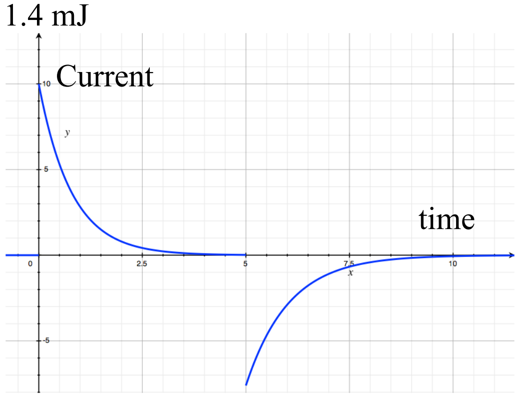
b. 0.68 mC

c. 1.20 mJ lost, 0.602 mJ gained, 0.602 mJ dissipated

26. a. 15 mW, 0

b. 1.1 V, 0.36 V

c. 1.4 mJ

d. 

27. a. 9.09 μF

b. 11$\underline{0}$ μF

c. series: $Q_1 = Q_2 = 81.8$ μC; $U_1 = 33.4$ μJ, $U_2 = 334$ μJ

parallel: $Q_1 = 90\underline{0}$ μC, $Q_2 = 90.0$ μC; $U_1 = 4.05$ mJ, $U_2 = 0.405$ mJ

28. a. initial: 0 V, 0.27 A; eventual: 2.76 V, 0 A

b. 1.3 mC, 0.91 mV, 2.2 mC

29. a. 34 mA

b. 4$\underline{0}$ mA

c. 1.1 mJ, 3.5 mJ

d. 7.7 mJ by flipping switch back and forth many times

30. a. 4.43×10^{-11} F

b. 565 V, 565 kN/C

31. a.

b. As plates are farther apart the field between is “less intense” and starts to spread out – eventually resembling the field between two point charges and having properties governed by

Coulomb's Law and the dependence on inverse square of the distance.
c.

32. 3.1 m
33. a. 2.3 nC
    b. 4.6 nJ
    c. 9.2 μN
    d. Point charges separated like this would attract 21 mN decreasing to 12 mN while pulled apart. Because the charge on the plates is spread out instead of concentrated into a "point", the field and resulting force is much less than Coulomb's Law would indicate.
34. a. -2.5×10^{-10} C
    b. Because the capacitor loses charge it must flow "backward" through the battery and will increase its energy by a small amount. The energy must come from whatever or whoever removed the dielectric slab – this requires work because the slab is attracted to the charged plates due to the phenomenon of induction.
35. $C = \dfrac{2\varepsilon_0 A}{d}$