AP® PHYSICS B (Form B)
2007 SCORING GUIDELINES

General Notes About 2007 AP Physics Scoring Guidelines

1. The solutions contain the most common method of solving the free-response questions and the allocation of points for this solution. Some also contain a common alternate solution. Other methods of solution also receive appropriate credit for correct work.

2. Generally, double penalty for errors is avoided. For example, if an incorrect answer to part (a) is correctly substituted into an otherwise correct solution to part (b), full credit will usually be awarded. One exception to this may be cases when the numerical answer to a later part should be easily recognized as wrong, e.g., a speed faster than the speed of light in vacuum.

3. Implicit statements of concepts normally receive credit. For example, if use of the equation expressing a particular concept is worth one point, and a student's solution contains the application of that equation to the problem but the student does not write the basic equation, the point is still awarded. However, when students are asked to derive and expression it is normally expected that they will begin by writing one or more fundamental equations, such as those given on the AP Physics exam equation sheet. For a description of the use of such terms as "derive" and "calculate" on the exams, and what is expected for each, see "The Free-Response Sections—Student Presentation" in the *AP Physics Course Description* .

4. The scoring guidelines typically show numerical results using the value $g = 9.8 \text{ m/s}^2$, but use of 10 m/s^2 is of course also acceptable. Solutions usually show numerical answers using both values when they are significantly different.

5. Strict rules regarding significant digits are usually not applied to numerical answers. However, in some cases answers containing too many digits may be penalized. In general, two to four significant digits are acceptable. Numerical answers that differ from the published answer due to differences in rounding throughout the question typically receive full credit. Exceptions to these guidelines usually occur when rounding makes a difference in obtaining a reasonable answer. For example, suppose a solution requires subtracting two numbers that should have five significant figures and that differ starting with the fourth digit (e.g., 20.295 and 20.278). Rounding to three digits will lose the accuracy required to determine the difference in the numbers, and some credit may be lost.

Question 3

15 points total **Distribution of points**

(a) 3 points

For a statement of Ohm's law, recognizing that $I_C = 0$ — 1 point

$V = IR$

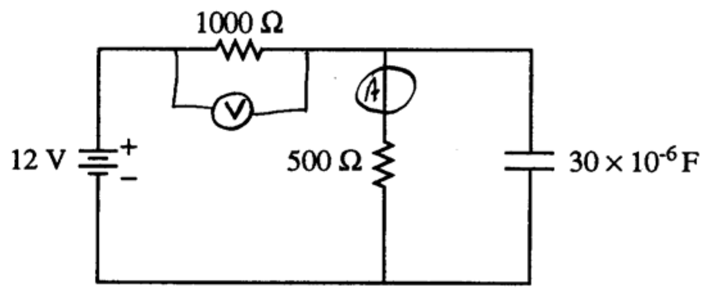
For the calculation of the total resistance — 1 point

$R_{\text{total}} = 1000\ \Omega + 500\ \Omega = 1500\ \Omega$

For the correct answer, including units — 1 point

$I = \dfrac{12\text{ V}}{1500\ \Omega} = 8.0 \times 10^{-3}\text{ A}$

(b)



(i) 2 points

For the ammeter in series anywhere in the circuit except the capacitor branch — 2 points

(ii) 2 points

For the voltmeter in parallel across the $1000\ \Omega$ resistor — 2 points

(c) 3 points

For a correct equation relating the charge, voltage, and capacitance — 1 point

$Q = CV_C$ or $C = \dfrac{Q}{V_C}$

For recognizing that the voltage drop across the capacitor is the same as the voltage drop across the $500\ \Omega$ resistor — 1 point

$V_C = IR_{500} = \left(8.0 \times 10^{-3}\text{ A}\right)(500\ \Omega) = 4.0\text{ V}$

For the correct answer with the correct units — 1 point

$Q = \left(30 \times 10^{-6}\text{ F}\right)(4.0\text{ V})$

$Q = 1.2 \times 10^{-4}\text{ C}$

Question 3 (continued)

Distribution of points

(d) 2 points

For a correct equation for the power dissipated — 1 point

$P = I^2R_{1000}$ or $V_{1000}I$ or $\dfrac{V_{1000}^2}{R_{1000}}$

Calculation for the second two relationships

$V_{1000} = IR_{1000} = \left(8.0 \times 10^{-3}\ \text{A}\right)(1000\ \Omega) = 8.0\ \text{V}$

For the correct substitutions — 1 point

$P = \left(8.0 \times 10^{-3}\ \text{A}\right)^2(1000\ \Omega)$ or $(8.0\ \text{V})\left(8.0 \times 10^{-3}\ \text{A}\right)$ or $\dfrac{(8.0\ \text{V})^2}{1000\ \Omega}$

$P = 6.4 \times 10^{-2}\ \text{W}$

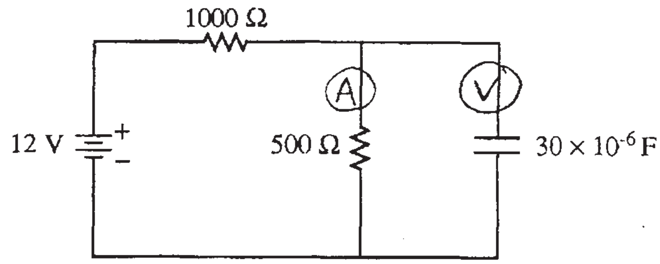
(e) 3 points

For choosing "Larger" — 1 point

For correct justification in words or with numerical example. For example: — 2 points

"Replacing the $500\ \Omega$ resistor with a larger resistor lowers the steady state current, causing the voltage across the $1000\ \Omega$ resistor to decrease and the voltage across the replacement resistor to increase." (1 point)

"The capacitor is in parallel with the replacement resistor, and so its voltage increases and therefore its charge increases since $Q = CV$." (1 point)



3. (15 points)

In the circuit above, a 12.0 V battery is connected to two resistors, one of resistance 1000 Ω and the other of resistance 500 Ω. A capacitor with a capacitance of 30×10^{-6} F is connected in parallel with the 500 Ω resistor. The circuit has been connected for a long time, and all currents have reached their steady states.

(a) Calculate the current in the 500 Ω resistor.

$R_{series} = R_1 + R_2$

$R_T = 1000\Omega + 500\Omega$

$R_T = 1500\Omega$

I_{series} = constant

$V = IR$

$12V = I\ (1500\Omega)$

$I = 0.008A$

(b)

i. Draw an ammeter in the circuit above in a location such that it could measure the current in the 500 Ω resistor. Use the symbol Ⓐ to indicate the ammeter.

ii. Draw a voltmeter in the circuit above in a location such that it could measure the voltage across the 1000 Ω resistor. Use the symbol Ⓥ to indicate the voltmeter.

(c) Calculate the charge stored on the capacitor.

$C = \frac{Q}{V}$ $\quad Q = CV$

$V = IR$

$Voltage_{1000\Omega} = (1000\Omega)(0.008A)$

$V = 8V$

$Voltage_{500\Omega} = 12V - 8V = 4V$

V = constant in parallel circuit

$V_{500\Omega} = 4V = V_{capacitor}$

$Q = CV$

$Q = (30 \times 10^{-6}F)(4V)$

$Q = 1.2 \times 10^{-4}C$

GO ON TO THE NEXT PAGE.

(d) Calculate the power dissipated in the 1000 Ω resistor.

$P = IV = I^2R$ $V = IR$

$I = 0.008A$

$R = 1000\Omega$

$P = (0.008A)^2 (1000\Omega)$

$P = 0.064\ W$

(e) The capacitor is now discharged, and the 500 Ω resistor is removed and replaced by a resistor of greater resistance. The circuit is reconnected, and currents are again allowed to come to their steady-state values. Is the charge now stored on the capacitor larger, smaller, or the same as it was in part (c)?

_✓_ Larger ____ Smaller ____ The same as

Justify your answer.

Changed stored on capacitor is given by:

$Q = CV$

The resistor added will result in a greater total resistance in the circuit since

$R_{series} = R_1 + R_2$

This increase in R_T will decrease I running in the circuit, such that $I < 0.008A$

$V=IR$ $V_{1000\Omega} = (1000\Omega)(I)$, so $V_{1000\Omega}$ will decrease.

Since $V_{500\Omega} = 12V - V_{1000\Omega}$, then

$V_{500\Omega}$ will increase

V in parallel is the same, so $V_{across\ capacitor} = V_{500\Omega}$

If $Q = CV$, and V increases, then Q increases

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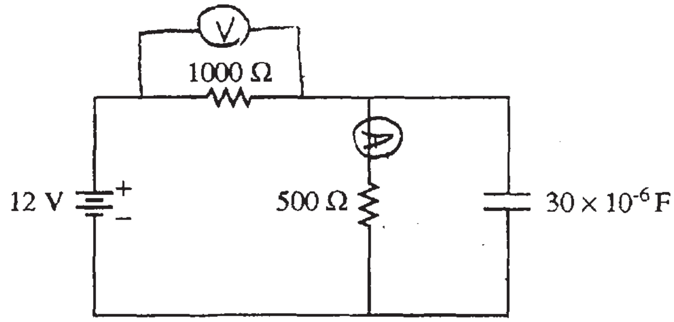

3. (15 points)

In the circuit above, a 12.0 V battery is connected to two resistors, one of resistance 1000 Ω and the other of resistance 500 Ω. A capacitor with a capacitance of 30×10^{-6} F is connected in parallel with the 500 Ω resistor. The circuit has been connected for a long time, and all currents have reached their steady states.

(a) Calculate the current in the 500 Ω resistor.

$$I = \frac{V}{R} = \frac{12\text{ V}}{(1000+500)\ \Omega} = 0.008\text{ A}$$

$$= 8 \times 10^{-3}\text{ A}$$

(b)

i. Draw an ammeter in the circuit above in a location such that it could measure the current in the 500 Ω resistor. Use the symbol Ⓐ to indicate the ammeter.

ii. Draw a voltmeter in the circuit above in a location such that it could measure the voltage across the 1000 Ω resistor. Use the symbol Ⓥ to indicate the voltmeter.

(c) Calculate the charge stored on the capacitor.

$$Q = CV = (30 \times 10^{-6})\text{F} \times 12\text{ V}$$

$$= 0.00036\text{ C}$$

$$= 3.6 \times 10^{-4}\text{ C}$$

GO ON TO THE NEXT PAGE.

(d) Calculate the power dissipated in the 1000 Ω resistor.

$P = VI = I^2R = (8\times10^{-3})^2 \times 1000$

$= 0.064 W$

$= 6.4\times10^{-2} W$

(e) The capacitor is now discharged, and the 500 Ω resistor is removed and replaced by a resistor of greater resistance. The circuit is reconnected, and currents are again allowed to come to their steady-state values. Is the charge now stored on the capacitor larger, smaller, or the same as it was in part (c)?

____ Larger ____ Smaller _✓_ The same as

Justify your answer.

$Q = CV$, however,

in this situation, $C = \epsilon_0 \frac{A}{d}$ stays the same

and V, which is emf of the circuit, remains

12V. As a result, the charge stays the same.

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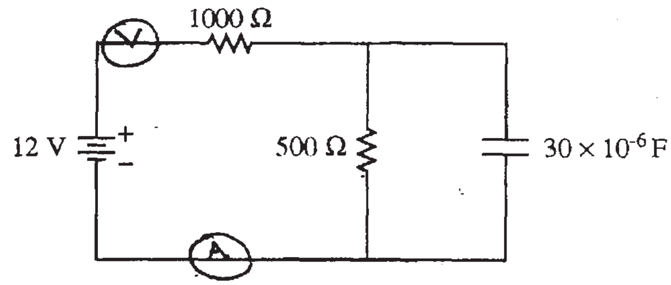

3. (15 points)

In the circuit above, a 12.0 V battery is connected to two resistors, one of resistance 1000 Ω and the other of resistance 500 Ω. A capacitor with a capacitance of 30×10^{-6} F is connected in parallel with the 500 Ω resistor. The circuit has been connected for a long time, and all currents have reached their steady states.

(a) Calculate the current in the 500 Ω resistor.

$I = \frac{V}{R}$ $I = \frac{12V}{500\Omega}$

$I = .024A$

(b)

i. Draw an ammeter in the circuit above in a location such that it could measure the current in the 500 Ω resistor. Use the symbol (A) to indicate the ammeter.

ii. Draw a voltmeter in the circuit above in a location such that it could measure the voltage across the 1000 Ω resistor. Use the symbol (V) to indicate the voltmeter.

(c) Calculate the charge stored on the capacitor.

$Q = CV$ $Q = (30 \times 10^{-6} F) 12v$

$Q = 3.6 \times 10^{-4}$

GO ON TO THE NEXT PAGE.

(d) Calculate the power dissipated in the 1000 Ω resistor.

$P = IV$

$I = \frac{12v}{1000\Omega} = .012A$

$I = \frac{V}{R}$

$P = (.012A)12v$

$= .144w$

(e) The capacitor is now discharged, and the 500 Ω resistor is removed and replaced by a resistor of greater resistance. The circuit is reconnected, and currents are again allowed to come to their steady-state values. Is the charge now stored on the capacitor larger, smaller, or the same as it was in part (c)?

____ Larger ____ Smaller ✓ The same as

Justify your answer.

The voltage did not change, hence the capacitor is not effected by the change in resistor.

GO ON TO THE NEXT PAGE.

Question 3

Sample: B3A
Score: 13

The only deduction in this otherwise well-written response was the loss of 2 points for the incorrect placement of the voltmeter in the circuit. The justification in part (e) is especially detailed and complete.

Sample: B3B
Score: 10

This response received full credit for parts (a) and (b) but only 1 point for the correct equation in part (c). Part (d) received full credit, but part (e) received no credit for an incorrectly checked space and incorrect reasoning.

Sample: B3C
Score: 5

Part (a) received only 1 point for the correct statement of Ohm's law but nothing more because the total resistance is incorrect. Part (b)(i) received 2 points full credit because the ammeter, while not placed in the same branch as the 500 ohm resistor, does correctly measure the current for the steady state condition specified. The voltmeter is incorrectly placed, so part (b)(ii) earned no credit. Parts (c) and (d) only received 1 point each for correct equations; the substitutions are incorrect. Part (e) received no credit.