Physics 152
September 22, 2006

Roster No.:_____

Score:_____

Midterm Exam #1, Part A

Exam time limit: 50 minutes. You may use a calculator and both sides of ONE sheet of notes, *handwritten only*. Closed book; no collaboration. Ignore gravity and relativistic effects in all problems, unless told otherwise.

Part A: For each question, fill in the letter of the one best answer on your bubble answer sheet.

Physical constants:

$k_e = 8.988 \times 10^9\ \mathrm{N \cdot m^2/C^2}$ $\quad e = 1.602 \times 10^{-19}\ \mathrm{C}$ $\quad m_e = 9.109 \times 10^{-31}\ \mathrm{kg}$

$\varepsilon_0 = 1/4\pi k_e = 8.854 \times 10^{-12}\ \mathrm{C^2/(N \cdot m^2)}$ $\quad m_p = 1.673 \times 10^{-27}\ \mathrm{kg}$

(2 pts. each) **Convert** the following quantities into the given units:

1. 240 MeV = _____ keV

A. 2.4 keV
B. 24 keV
C. 2400 keV
D. 24,000 keV
E. 240,000 keV

2. 85 mW = _____ MW

A. 8.5×10^{-8} MW
B. 8.5×10^{-5} MW
C. 85 MW
D. 8.5×10^{7} MW
E. 8.5×10^{10} MW

3. 2.0 $\mathrm{km^2}$ = _____ $\mathrm{m^2}$

A. $2.0 \times 10^{-4}\ \mathrm{m^2}$
B. $2.0 \times 10^{-3}\ \mathrm{m^2}$
C. $2.0 \times 10^{3}\ \mathrm{m^2}$
D. $2.0 \times 10^{4}\ \mathrm{m^2}$
E. $2.0 \times 10^{6}\ \mathrm{m^2}$

Suppose you have two metal plates fixed with a uniform separation of 2.0 cm, and each plate is a large square measuring 20. cm on a side.

4. (3 pts.) What is the **capacitance** of the parallel plates?

A. 18 pF
B. 88 pF
C. 560 pF
D. 8.4 nF
E. 40 nF

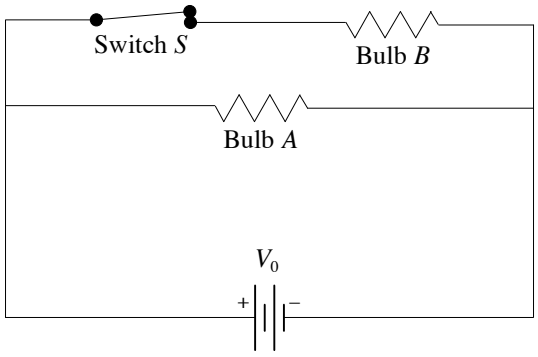
5. (2 pts.) A spark will jump between the two plates if the electric field between the plates exceeds 3.0×10^6 V/m. What minimum **potential difference** must you apply to the two plates to make a spark jump between them?

A. 120 V
B. 3.3 kV
C. 60. kV
D. 170 kV
E. 3.0 MV

6. (3 pts.) You have a second identical pair of parallel plates, except that pair *B* is filled with a slab of non-conducting plastic ($\kappa = 2.2$) between the plates, while pair *A* is filled only by air. You connect both pairs of plates to identical batteries, and you wait for both pairs of plates to finish charging up. Then, all of the following statements are true **EXCEPT** which one?

A. Pair *B* has a greater capacitance than pair *A*.
B. Pair *B* has the same potential difference between its plates as pair *A*.
C. Pair *B* has less charge on its plates than pair *A*.
D. Pair *B* has more energy stored than pair *A*.
E. Pair *B* has a greater dielectric constant than pair *A*.

Two light bulbs, *A* and *B*, are connected to a 120.-V DC voltage source and a switch *S* as shown below. The bulbs have resistances of $R_A = 288\ \Omega$ and $R_B = 192\ \Omega$.



7. (2 pts.) While the switch is OPEN, the **power** dissipated by bulb *A* is:

A. 12.0 W
B. 17.0 W
C. 50.0 W
D. 75.0 W
E. 120. W

8. (2 pts.) While the switch is CLOSED, the **power** dissipated by *ONLY* bulb *A* is:

A. 17.0 W
B. 38.0 W
C. 50.0 W
D. 75.0 W
E. 96.0 W

9. (1 pt.) More **current** flows through the **battery** while the switch is CLOSED than when it is OPEN.

A. **True**
B. **False**

10. (1 pt.) More **current** flows through **bulb *A*** while the switch is CLOSED than when it is OPEN.

A. **True**
B. **False**

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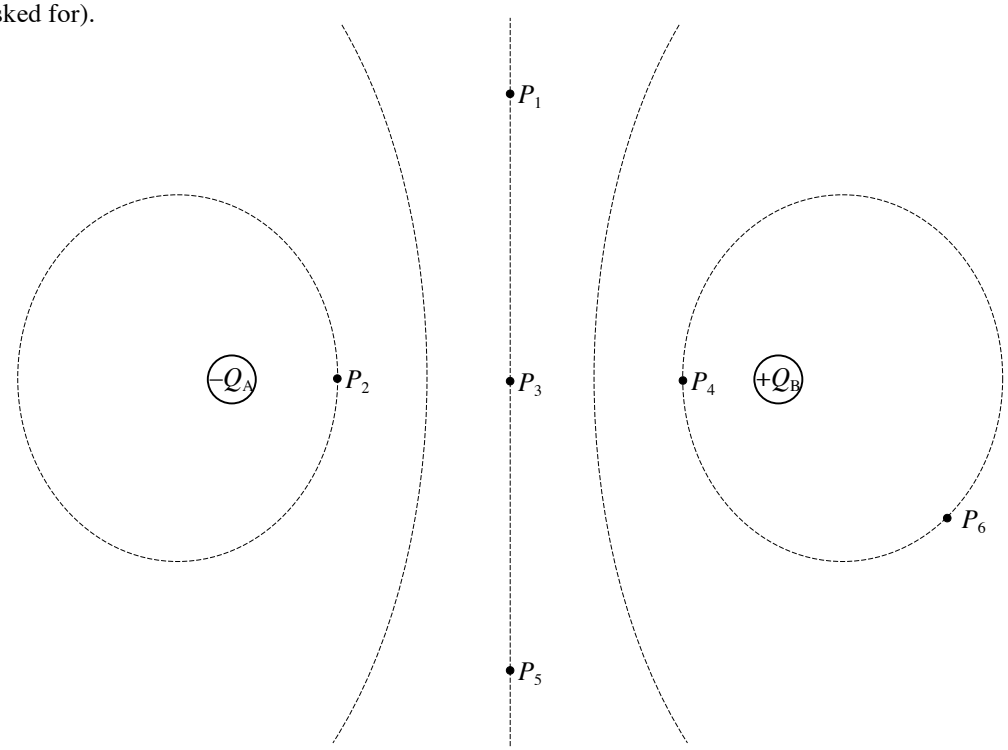
Midterm Exam #1, Part B

Part B: **Show your work** on all free-response questions. Be sure to use **proper units** and **significant figures** in your final answers. For any multiple-choice questions, circle the letter of the one best answer (unless more than one answer is asked for).



1. Two point charges, $Q_A = -2.5$ nC and $Q_B = +2.5$ nC, are fixed in space as shown above, forming an equal dipole. Five equipotential surfaces (dashed curves above) are drawn for you in the diagram. (Assume that $V = 0$ at $r = \infty$ away from the charges.)

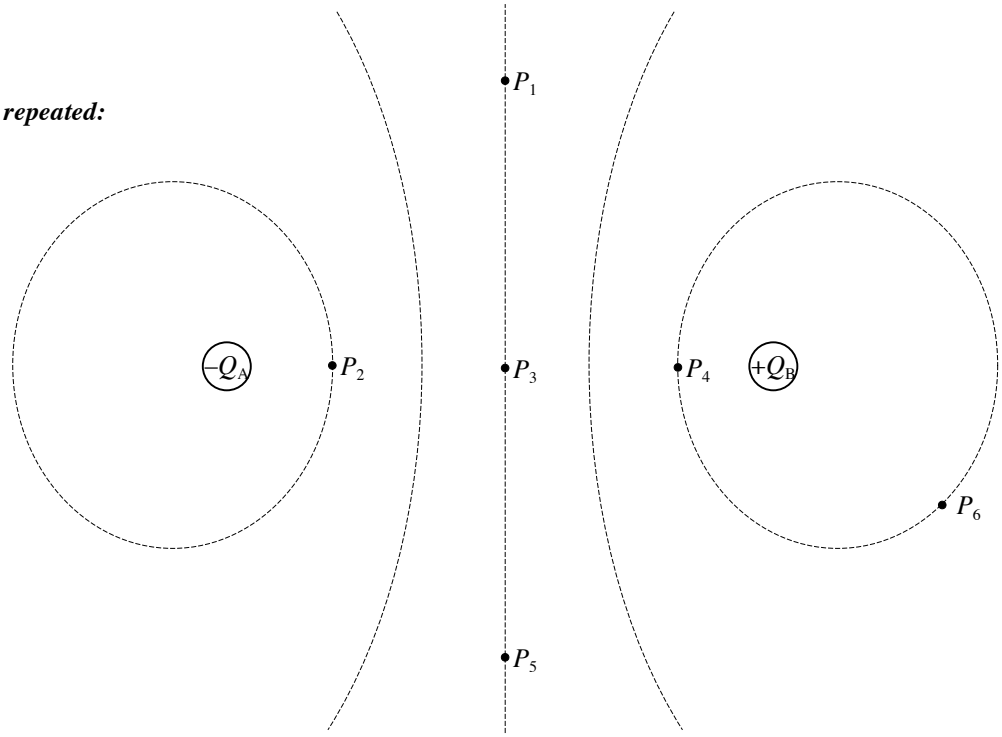
a. (2 pts.) Suppose that the five equipotential lines shown above correspond to **potentials** of –200. V, –100. V, 0 V, +100. V, and +200. V. **Clearly label** the corresponding equipotentials with these five values.

b. (2 pts.) **Draw** between 8 and 12 **electric field lines** on the diagram above. Include **directional arrowheads** on ALL of your field lines.

c. (4 pts.) Suppose that a *proton* is moved from a point located on the –200.-volt equipotential line to a point on the +200-volt equipotential line. (The proton starts and ends at rest.) How much **energy** does this require? Show your work. Express your final answer in **electron-volts**:

1. ***continued:***

Same diagram repeated:



d. (2 pts.) Suppose that a proton is moved from point P_1 to point P_5. (The proton starts and ends at rest.) How much **energy** does this require? Explain and/or show your work:

e. (1 pt.) Moving a proton from point P_2 to point P_6 requires _____ **energy** than moving a proton from point P_2 to point P_4. (The proton starts and ends at rest in either case.)

A. more B. the same C. less D. cannot determine from information given

f. (1 pt.) Suppose that an *electron* is released from rest at point P_3. Immediately afterward, the electron experiences a net electric **force** in which **direction**?

A. toward P_1 C. toward P_4 E. out of the plane of the page
B. toward P_2 D. toward P_5 F. zero net force

g. (8 pts.) Recall that $Q_A = -2.5$ nC and $Q_B = +2.5$ nC. Q_A and Q_B are separated by a distance of 60. cm, and the point P_3 is located exactly halfway between them. Find the **magnitude and direction** of the total **electric field** at point P_3:

2. Suppose you have three identical capacitors: $C_1 = C_2 = C_3 = 50.0$ nF. You also have a 10.0-V battery. (Be sure to make your capacitor symbols look *different from* your battery symbol in the diagrams you draw below.)

a. (2 pts.) **Draw a schematic diagram** of all three capacitors connected in SERIES with the battery:

b. (2 pts.) **Draw a schematic diagram** of all three capacitors connected in PARALLEL with the battery:

c. (6 pts.) Devise a new configuration using the *same three capacitors* that has an equivalent capacitance of 75.0 nF. **Draw a schematic diagram** of your new configuration below. Include a calculation of the **equivalent capacitance**, showing that it indeed equals 75.0 nF.