Exam II: Chapters 15—17

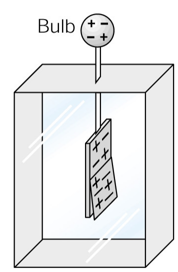
1. Explain the concept of charge quantization.
   A) Charges must always exist in pairs of one positive and one negative charge.
   B) Charges can be created or destroyed, but cannot be transferred among objects.
   C) Charges can be moved around, but only inside the actual atom where they exist.
   D) Charges can only exist as whole numbers of particles: you cannot have half an electron.
   E) Charges can be moved or transferred from one object to another, but not created or destroyed.

2. Explain the concept of charge conservation.
   A) Charges must always exist in pairs of one positive and one negative charge.
   B) Charges can be created or destroyed, but cannot be transferred among objects.
   C) Charges can be moved around, but only inside the actual atom where they exist.
   D) Charges can only exist as whole numbers of particles: you cannot have half an electron.
   E) Charges can be moved or transferred from one object to another, but not created or destroyed.

3. By scuffling across the carpet, you accumulate an excess charge of -2.4×10^{-19}C.
   A) This is pretty substantial. Don't touch the kitty's nose, that's just mean.
   B) This is a tiny amount of charge. You would not get any shock if you touched the light switch.
   C) This is a pretty small amount of charge, but you would feel it as a shock if you touch a metal object.
   D) This is a trick question. You cannot accumulate an excess negative charge.
   E) This is a trick question. You can accumulate a negative charge, just not this particular quantity of negative charge.

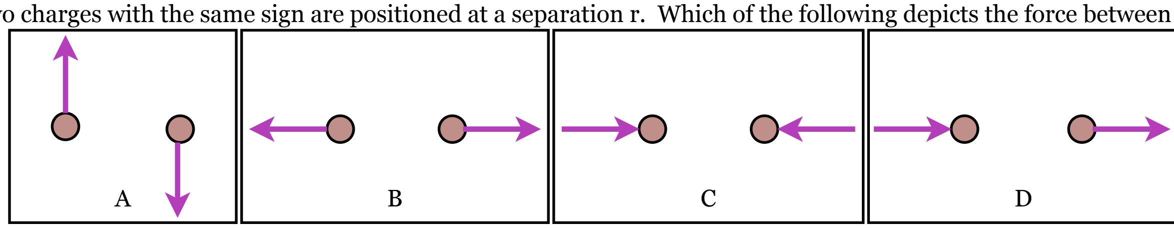
4. If you charge a plastic rod or comb by rubbing it with a wool cloth, you are
   A) conducting negative charges from the rod to the cloth.
   B) using induction to move positive charges from the cloth to the rod.
   C) using friction to move negative charges from the cloth to the rod.
   D) using pair production to create new proton-antiproton pairs. The protons stay on the cloth (positive) and the anti-protons move to the rod, making it negative.
   E) experiencing a hallucination. Charges cannot be moved; that is the fundamental principle of charge conservation!!

5. You move the charged rod close to (but not touching) a stream of water from the faucet.
   A) Why? Nothing happens because water is not a metallic conductor.
   B) I would not do that if I were you. This is incredibly dangerous, and you could get electrocuted.
   C) This is an example of electrostatic induction. The charged rod causes the polar molecules to move, deflecting the stream, but no charges are added to or subtracted from the water.
   D) This is an example of electrical conduction, as the negative rod pulls positive charges out of the water molecules. Positive charges will move to the rod until the rod becomes electrically neutral.
   E) Sometimes this works, sometimes not. It's a parlor trick that has nothing to do with electric charges. Whether or not the stream deflects is a function of the strength of the magnetic field of the rod (so your rod needs an iron core to be magnetic).



6. Touch a negatively charged rod to the bulb of the electroscope shown on the right.
   A) Nothing happens. Nothing can happen unless the rod is positively charged.
   B) I would not do that if I were you. This is incredibly dangerous, and you could get electrocuted.
   C) The foil leaves separate, because one leaf is positive and the other will be negative. One leaf becomes negative when the rod attracts positive charges to the bulb.
   D) It's hard to see, but the leaves will actually draw closer together. The negative rod pulls protons to the bulb, causing the negative foil leaves to be pulled together as well.
   E) The foil leaves of the electroscope will separate. Negative charges from the rod will be conducted to the bulb, and move to the foil, where the leaves repel each other.

7. Two charges with the same sign are positioned at a separation r. Which of the following depicts the force between them?

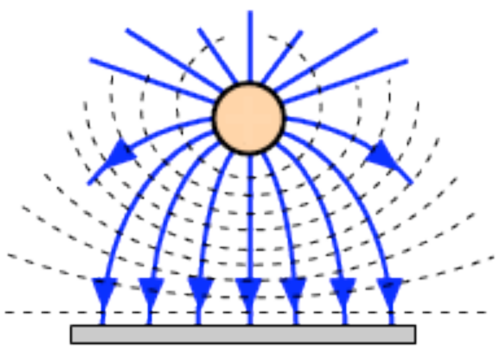


8. If you move one charge to a new position x half as far from the other ($x = \frac{1}{2}r$), the force between the charges
   A) decreases to ½ its previous magnitude.
   B) decreases to ¼ its previous magnitude.
   C) doubles.
   D) quadruples.
   E) does not change.

9. Assume that the two charges are equal in magnitude. Without changing the separation, you replace one charge q with a new charge Q that is four times as big (Q = 4q). The force between the charges
   A) decreases to ½ its previous magnitude.
   B) decreases to ¼ its previous magnitude.
   C) doubles.
   D) quadruples.

10. Using the original two charges (same sign, same magnitude q), how much work must be done by an external force to bring the charges together from ∞ to a separation r?
   A) $U = +(kq^2)/r$
   B) $U = -(kq^2)/r$
   C) $U = +(kq)/r^2$
   D) $U = -(kq)/r^2$
   E) U = 0

11. What is most responsible for making insulators poor conductors of charge?
   A) A full valence shell makes it difficult to move electrons from atom to atom.
   B) The high density of most insulators effectively prevents the movement of any charges.
   C) They have a crystal structure; the long–range order makes it difficult to move electrons.
   D) They typically have heavy nuclei: the more protons in the nucleus, the more difficult it becomes to pull protons out of the nucleus and pass them from atom to atom.



A point charge is placed above a uniformly charged plate as shown to the left. Answer the following questions 12 through 16 using responses:
A = TRUE **B = FALSE** **C = UNKNOWN**

12. The point is negative and the plate is positively charged.

13. Both point and plate are negatively charged.

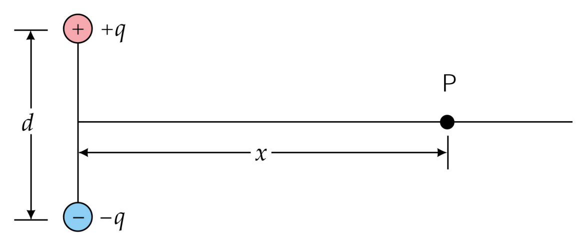
14. The field strength increases with distance, and reaches its maximum value when you get to an infinite distance away from the point charge.

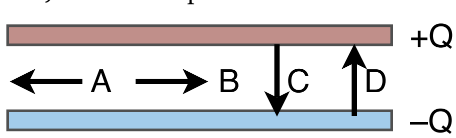
15. A positive charge released somewhere between the point and the plate will follow a solid-line path, moving toward the plate.

16. A negative charge, placed exactly half way between point and plate will be in equilibrium: it will not move in any direction.

17. A positive charge (+q) is positioned at the origin, and negative charge (−3q) is fixed at (0.10m, 0). Where would you place a positive test charge in order that it feels zero force (it is in equilibrium)? Assume +x = → and +y = ↑.
   A) Nowhere; there is no equilibrium position for a positive test charge.
   B) On the x-axis, exactly in between the charges: (0.05m, 0).
   C) Somewhere on the x-axis, between 0 and 0.10m. Closer to (+q) than (−3q).
   D) On the x-axis, to the right of (−3q): x > 0.10m.
   E) On the x-axis, to the left of (+q): x < 0.

18. The positive and negative charges shown have the same magnitude. What is the direction of the electric field vector **E** at point P? Assume +x = → and +y = ↑.
   A) **E** points in the +x direction.
   B) **E** points in the −x direction.
   C) **E** points in the +y direction.
   D) E points in the −y direction.
   E) **E** has components in both the +x and +y directions.





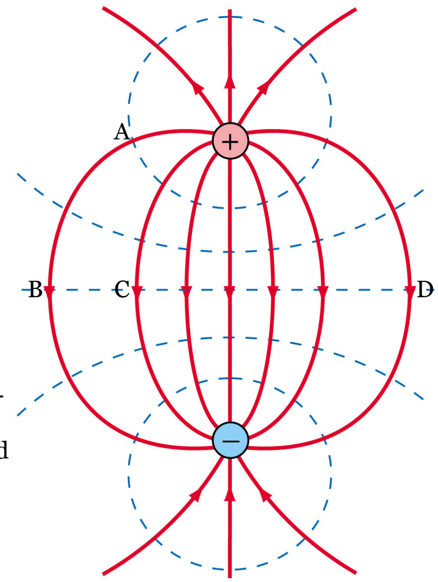
Two conducting plates are arranged parallel to each other as shown. The plates are charged as labeled. **Q=8.0μC** and the plates have area **A = 0.1m²**.

19. The electric field vector is shown by which arrow? **C**

20. Calculate the electric field strength. Express your answer in megaN/C (10^6N/C), and use two sig figs. **$9.048 \times 10^6 = 9.0 \times 10^6$N/C**

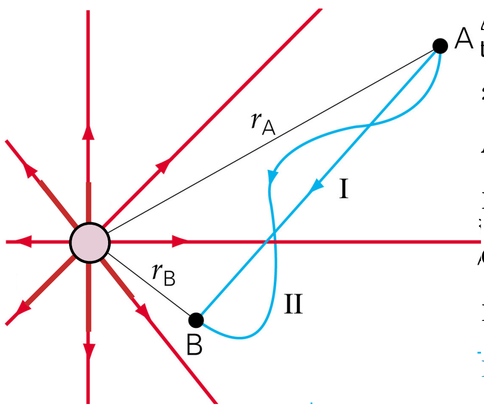
21. Increasing the area of each plate will
   A) have no effect on the magnitude of the field.
   B) change the direction of the field from A to B.
   C) change the direction of the field from D to C
   D) increase the magnitude of the electric field.
   E) decrease the magnitude of the electric field.

22. To double the electric field between the two plates, you should
   A) double the quantity of charge stored, from Q to 2Q.
   B) halve the quantity of charge stored, from Q to ½Q.
   C) double the plate separation from d to 2d.
   D) halve the plate separation from d to ½d.
   E) do none of these. The *only* way to double the field is to double the area of each plate, from A to 2A.



23. On the figure to the right, two opposite point charges are separated by a fixed distance d. The equipotentials
   A) are represented by the solid lines.
   B) are represented by the dotted lines.
   C) are single points located exactly where the point charges are located.
   D) are represented by the empty spaces between both sets of lines.
   E) are non-existent. There are no equipotentials possible for the configuration of charge shown.

24. A positive test charge is released from point A.
   A) It will move from higher to lower potential, along the solid line shown, to B.
   B) It will move along the solid line, but from a lower to a higher potential at B.
   C) It will not follow any of the lines shown, and will end up at point C.
   D) It will follow the dotted line, and end up circling the top charge in the clockwise direction.
   E) It will circle, but from A to B then to the bottom charge, up around to D, and then end up back where it started, at point A.



A point charge +Q is fixed as shown on the left.

25. A test charge will be moved from point A to point B.
   A) Follow path I. The shorter path is more efficient because less work will be done.
   B) Follow path II. The longer path is the better choice because more energy will be used.
   C) Follow neither path: choose the path that makes a straight line from A to +Q, then from +Q to B. This is the only path over which no work will be done.
   D) Follow either path, it does not matter. No work will be done no matter what path you choose.
   E) Follow either path. The same amount of work must be done in either case, and it will not be equal to zero.

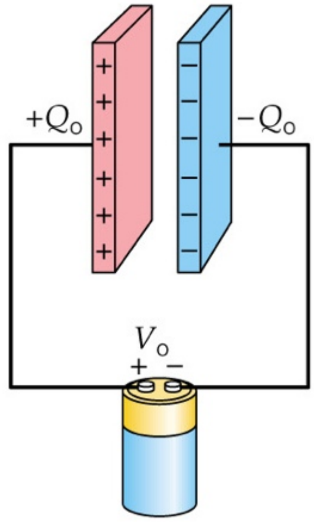
26. From point A to point B, the potential difference ΔV is
   A) positive. B) negative. C) zero. D) indeterminate.

27. The positive charge shown above has a magnitude of **+2.0μC**. Determine the radius of the 1kV (**1000V**) equipotential. Express your answer in meters (two sig figs). **r = 18m**

28. If the fixed charge +Q is replaced by an equal but opposite charge –Q, a test charge at position A will have
   A) a lower potential than the same test charge positioned at point B.
   B) the same potential as an identical test charge positioned at point B.
   C) a higher potential than an identical test charge placed at position B.
   D) zero potential whether positioned at point A or point B, or anywhere at all.

29. What does it mean to say "electrons fall up?"
   A) Electrons are not subject to gravitational forces.
   B) An electron will fall away from a positive charge, from higher potential to lower potential.
   C) An electron will fall toward another negative charge, from a higher potential to a lower potential.
   D) An electron will fall away from another negative charge, from lower potential to higher potential.
   E) Nothing, really. It's a cliché, like saying "It's raining cats and dogs!" Nobody really thinks that several species of small furry animals are falling out of the sky.

30. The parallel plate capacitor shown in the circuit on the right has an area **0.20m²**, a plate separation of **0.2mm**, and is attached to a **6V** battery. How much **work** is done to move a **+3.0μC** charge from the positive to the negative plate? Express your answer in μJ, with two sig figs. **W = 18μJ**



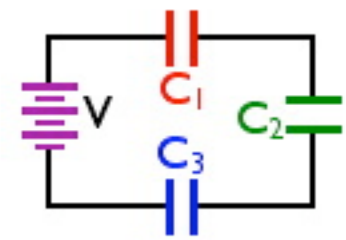
31. What is the capacitance? Answer in nanoFarads (10^{-9}F) with two sig figs.
C = 8.85nF = 8.9nF

32. If the 6V battery is replaced by a 12V battery, the amount of stored charge
   A) remains constant, and the capacitance increases.
   B) decreases while the capacitance remains constant.
   C) decreases while the capacitance increases.
   D) increases while the capacitance remains constant.
   E) increases while the capacitance increases as well.

33. How does the replacing the battery change the amount of energy stored?
   A) It doesn't; $U = \frac{1}{2}Q^2/C$, so the energy remains constant.
   B) Since $U = \frac{1}{2}QV$, doubling the voltage doubles the stored energy.
   C) Because $U = \frac{1}{2}CV^2$, doubling the voltage quadruples the stored energy.
   D) These answers are all crazy talk. $E = \frac{1}{2}mv^2$, but the charges are stationary on the plates. No motion, no energy. The battery is not relevant.

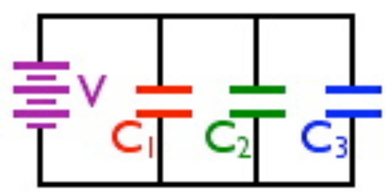
34. Leaving the battery alone now, what is the effect of increasing the plate separation to **0.4mm**?
   A) The capacitance doubles: $C = 2C_0$. This also doubles the amount of charge that can be stored.
   B) The capacitance halves: $C = \frac{1}{2}C_0$. The stored charge must also decrease by half: $Q = \frac{1}{2}Q_0$.
   C) Capacitance increases as the square of the separation: $C = 4C_0$. Stored charge decreases to $\frac{1}{4}Q_0$.
   D) Capacitance decreases as the inverse square of the separation: $C = \frac{1}{4}C_0$. Charge is unchanged.
   E) The capacitance does not change. You have to change the voltage to get a change in the capacitance.

35. A capacitor has **C_0 = 0.2μF** and is connected to a **12V** battery. It is allowed to charge fully, then the battery is disconnected and a polystyrene dielectric is inserted between the plates. Polystyrene (styrofoam) has a dielectric constant **κ = 2.6**. What happens to the capacitance when the polystyrene slab is inserted? What about the energy?
   A) Capacitance and energy will both be increased by the dielectric.
   B) Neither the capacitance nor the energy will change as a result of the dielectric.
   C) The capacitance decreases, but the energy stored by the capacitor increases.
   D) Both capacitance and energy are decreased when the dielectric material is inserted.
   E) The dielectric will increase the capacitance, but disconnecting the battery means the energy decreases.



The circuit on the left has a **12V** battery connected to three capacitors in series. The capacitances are **C_1 = 2μF**, **C_2 = 3μF**, and **C_3 = 5μF**.

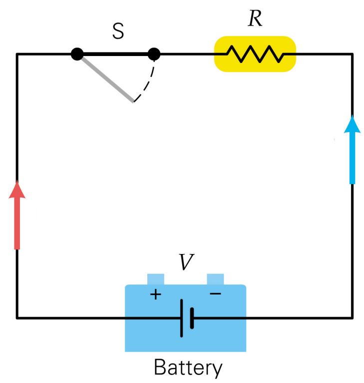
36. What is the voltage drop across capacitor C_2?
   A) The voltage across each of the capacitors is 12V: the battery voltage.
   B) The voltage across each of the capacitors is the same: (12V)/(2+3+5) = 1.2V
   C) The voltage across C_2 is V_2 = (12V)(3/10) = 3.6V. Similarly, V1 = 2.4V and V_3 = 6V. The sum of the voltages must equal 12V.
   D) The voltage across C2 is V_2 = 3V. Similarly, V_1 = 2V and V_3 = 5V. There is no reason why the voltages have to add up to any specific value.



37. The same three capacitors are rewired so that they are now in parallel with the original **12V** battery. Compare the amount of charge stored by each capacitor.
   A) Capacitor C_1 stores 6μC, capacitor C_2 stores 4μC, and C_3 stores 2.4μC.
   B) All three capacitors store the same amount of charge: Q = (12V)(10μF) = 120μC.
   C) Capacitor C_1 stores the least amount of charge, 24μC. Capacitor C_2 stores 36μC, while C_3 stores a whopping 60μC.
   D) The total amount of stored charge is 120μC, distributed evenly between all three capacitors: 40μC on each.

38. Compare the amount of energy stored by C_1 in the parallel circuit to C_1 in the series configuration.
   A) Same capacitor, same battery--same amount of stored energy.
   B) Same capacitor, but C_1 stores more charge in series, so it stores more energy.
   C) The voltage across the parallel C_1 will be higher than across the series C_1. Parallel stores more energy.

39. Does the (+) terminal of a battery actually have a (+) charge?
   A) Sure. What's your point? The (+) terminal has extra protons, and the (–) terminal has extra electrons.
   B) Well, actually, it doesn't. The (+) terminal is actually negative. It's just less negative than the (–) terminal.



40. When the switch is closed on the circuit shown on the right, what is the direction of the current?
    A) Electrons will move clockwise, so the current will be counterclockwise.
    B) Electrons will move clockwise, so the direction of the current is clockwise.
    C) Electrons move counterclockwise, so that is the direction of the current.
    D) Electrons move counterclockwise, so the direction of current is clockwise.
    E) There will be no current unless the switch is left open!

41. When the switch is closed on the circuit, the ammeter (device *R*) reads 0.5A.
    A) Electrons are pushed away from the negative terminal of the power supply, and travel all the way around the circuit until they reach the positive terminal of the power supply.
    B) Electrons are sort of moving. If the current is 1A, this would mean 1 electron was moving around the circuit; 0.5A is impossible because it would mean only half an electron moved!
    C) Electrons are not moving at all. The definition of current says that (+) charges are moving. If the ammeter reads 0.5A, it's because *protons* are moving around the circuit from (+) to (–).
    D) Electrons are moving, but not all the way around the circuit. They move locally, and if the electrons are moving to the left, the convention says that current flows to the right.
    E) Electrons and protons are both moving, and in opposite directions. There will be 0.25A of electrons moving (+) to (–) around the circuit, and 0.25A of protons moving in the opposite direction, (–) to (+).

42. Two wires are made of the same copper. Different lengths, different thicknesses.
    A) The longer wire will have more resistance then the shorter wire.
    B) The thicker wire will have more resistance than the thinner wire.
    C) The wires will have the same resistance, because they are made of the same material.
    D) The wire with the thicker coating of insulation will have greater resistance regardless of the material or geometry of the wire.

43. Two wires have the same length and the same diameter. One is copper ($\rho_{Cu} = 1.70\text{x}10^{-8}\Omega\cdot\text{m}$), the other is NiChrome ($\rho_{NiCr} = 100\text{x}10^{-8}\Omega\cdot\text{m}$). At room temperature (20°C), the copper wire
    A) will have greater resistance than the NiChrome.
    B) will have a smaller resistance than the NiChrome wire.
    C) will have exactly the same resistance as the NiChrome wire.
    D) cannot be compared to the NiChrome; there is no way to determine which wire will have greater resistance.

44. What is the *resistance* of an electric blow dryer that draws a current of **15A** when connected to a **120-V** household circuit?
    A) 12Ω B) 10Ω **C) 8Ω** D) 6Ω E) 4Ω

45. How much *power* does this blow dryer use?
    A) 8W B) 15W C) 120W D) 1000W **E) 1800W**