Name _____   Date _____

PH 102 Exam I

1. A "free" electron and a "free" proton are placed in an identical electric field. Which of the following statements are true? *Check all that apply.*

○ Each particle is acted on by the same electric force and has the same acceleration.
○ The electric force on the proton is greater in magnitude than the force on the electron, but in the opposite direction.
○ The electric force on the proton is equal in magnitude to the force on the electron, but in the opposite direction.
○ The magnitude of the acceleration of the electron is greater than that of the proton.
○ Both particles have the same acceleration.
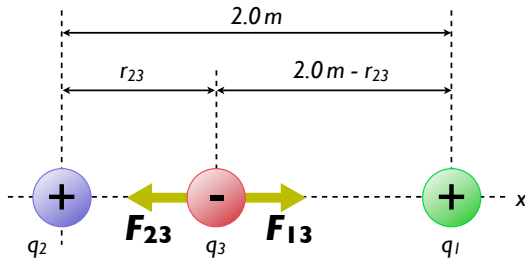
2. Three point charges lie along the x axis, as shown at left. A positive charge $q_1 = 15\,\mu$C is at $x = 2$ m, and a positive charge of $q_2 = 6\,\mu$C is at the origin. Where must a *negative* charge q_3 be placed on the x-axis such that the resulting electric force on it is zero?

○ $x = +0.77$ m
○ $x = -3.44$ m
○ $x = +1.34$ m
○ $x = -1.44$ m

3. What is the electric flux through the surface at right?

○ $+5\,\text{C}/\epsilon_0$
○ $-3\,\text{C}/\epsilon_0$
○ 0
○ $+6\,\text{C}/\epsilon_0$
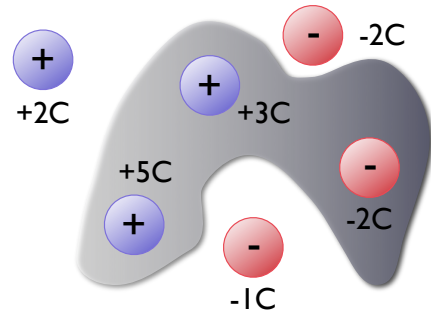
4. A point charge q is located at the center of a (non-conducting) spherical shell of radius a that has a charge $-q$ uniformly distributed on its surface. What is the electric field *for all points outside the spherical shell?*

○ none of these
○ $E = 0$
○ $E = q/4\pi r^2$
○ $E = kq/r^2$
○ $E = kq^2/r^2$

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5. What is the electric field inside the same shell a distance r from the center?

○ $E = kq/r^2$
○ $E = kq^2/r^2$
○ none of these
○ $E = 0$
○ $E = q/4\pi r^2$

6. A spherical conducting object A with a charge of $+Q$ is lowered through a hole into a metal (conducting) container B that is initially uncharged (and is not grounded). When A is at the center of B, but not touching it, the charge on the inner surface of B is:

○ $+Q$
○ $-Q$
○ 0
○ $+Q/2$
○ $-Q/2$

7. Consider a collection of charges in a given region, and suppose all other charges are distant and have negligible effect. The electric potential is taken to be zero at infinity. If the electric potential at a given point in the region is zero, which of the following statements must be true?

○ The electric field is zero at that point.
○ The electric potential energy is a minimum at that point.
○ There is no net charge in the region.
○ Some charges in the region are positive and some are negative.
○ The charges have the same sign and are symmetrically arranged around the given point.

8. Electrons in a TV tube are accelerated from rest through a potential difference of 2.00×10^4 V from an electrode towards the screen 25.0 cm away. What is the magnitude of the electric field, if it assumed to be constant over the whole distance?

○ 800 V/m
○ 5.00×10^5 V/m
○ 8.00×10^4 V/m
○ 5.00×10^3 V/m

9. A proton moves 1.5 cm parallel to a uniform electric field of $E = 240$ N/C. How much work is done by the field on the proton?

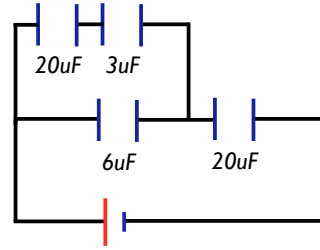○ 3.84×10^{-17} J
○ 5.76×10^{-19} J
○ 5.76×10^{-17} J
○ 1.60×10^4 J

10. To recharge a 12 V battery, a charger must move 3.3×10^5 C of charge from the negative to the positive terminal. How much work is done by the charger, in Joules?

○ 7.92×10^6 J
○ 3.31×10^5 J
○ 2.75×10^4 J
○ 3.96×10^6 J

11. What is the effective capacitance of the four capacitors shown at right?

- ○ $4.84\,\mu$F
- ○ $6.02\,\mu$F
- ○ $24.8\,\mu$F
- ○ $49.0\,\mu$F

20uF   3uF

6uF   20uF

12. Calculate the speed of a proton that is accelerated from rest through a potential difference of 104 V.

- ○ 6.04×10^6 m/s
- ○ 2.01×10^5 m/s
- ○ 3.96×10^4 m/s
- ○ 1.41×10^5 m/s

+ x

I_a I_b I_c I_d
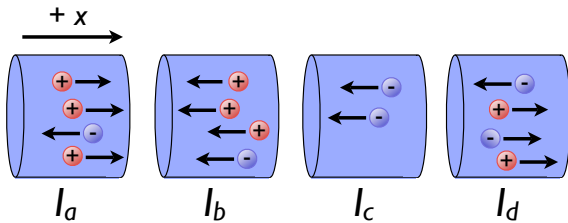
13. Consider the positive and negative charges moving horizontally through the four regions at left. Rank the magnitudes of the currents in these four regions *from highest to lowest*. Positive current is defined as positive charges moving in the $+x$ direction.

- ○ $I_a > I_c = I_d > I_b$
- ○ $I_a > I_d > I_c > I_b$
- ○ $I_d > I_a > I_b > I_c$
- ○ $I_a > I_d = I_b > I_c$

14. In a time interval of 1.37 sec, the amount of charge that passes through a light bulb is 1.73 C. How many electrons pass through the bulb in **5.00 sec**?
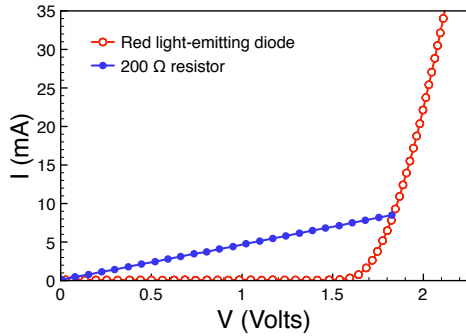
- ○ 8.47×10^{19}
- ○ 4.58×10^{17}
- ○ 3.95×10^{19}
- ○ 7.90×10^{18}

15. A toaster is rated at 550 W when connected to a 130 V source. What current does the toaster carry?

- ○ 5.04 A
- ○ 1.83 A
- ○ 2.12 A
- ○ 4.23 A

17. A potential difference of 11 V is found to produce a current of 0.45 A in a 3.8 m length of wire with a uniform radius of 0.38 cm. What is the resistivity of the wire?

- ○ $204\,\Omega \cdot$ m
- ○ $2.04 \times 10^6\,\Omega \cdot$ m
- ○ $2.94\,\Omega \cdot$ m
- ○ $2.94 \times 10^{-4}\,\Omega \cdot$ m

16. The figure at right shows the current-voltage relationship for a light-emitting diode (LED) and a resistor. When the voltage is 1.0 V, which has the higher resistance? *Hint: what does the slope of this plot mean?*

○ The resistor.
○ The LED.
○ Cannot be determined.
○ They have the same resistance.

18. Suppose a (cylindrical) electrical wire is replaced with one of the same material, but having every linear dimension doubled - the length and radius are twice their original values. Does the new wire have:

○ the same resistance
○ twice the resistance
○ half the resistance
○ four times the resistance
○ one quarter the resistance

19. Suppose a current-carrying wire has a cross-sectional area that gradually becomes smaller along the wire, so that the wire has the shape of a very long cone. How does the drift speed vary along the wire?

○ It slows down as the cross section becomes smaller
○ It speeds up as the cross section becomes smaller
○ It doesn't change
○ More information is needed

20. What is the equivalent resistance of the five resistors at right?

○ $28\,\Omega$
○ $74\,\Omega$
○ $22\,\Omega$
○ $54\,\Omega$
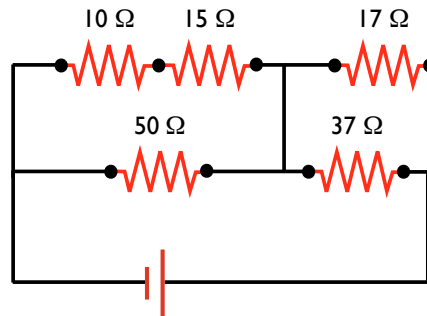
21. Kirchhoff's rules result from two basic physical laws. What are they?

○ Conservation of Energy and Charge quantization
○ Conservation of Energy and Conservation of Momentum
○ Conservation of Charge and Conservation of Energy
○ Coulomb's law and Conservation of Charge
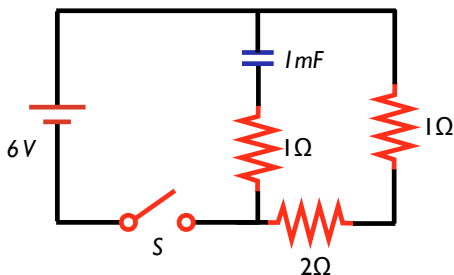
22. The switch S is suddenly closed in the figure at left. After a long time compared to the time constant of the capacitor, what will the current be in the $2\,\Omega$ resistor? *Hint: what is the capacitor doing after a long time?*
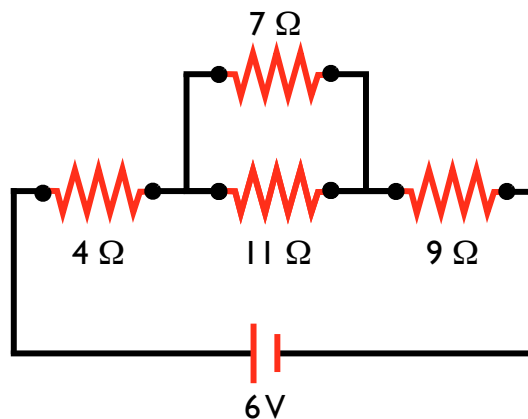
- ○ 2 A
- ○ 4 A
- ○ 3 A
- ○ 1 A

23. Two 1.60 V batteries - with their positive terminals in the same direction - are inserted in series into the barrel of a flashlight. One battery has an internal resistance of $0.270\,\Omega$, the other has an internal resistance of $0.151\,\Omega$. When the switch is closed, a current of 0.600 A passes through the lamp. What is the lamp's resistance?

- ○ $2.25\,\Omega$
- ○ $3.73\,\Omega$
- ○ $4.91\,\Omega$
- ○ $6.80\,\Omega$

24. What is the current through the $9\,\Omega$ resistor in the figure at right?

- ○ 347 mA
- ○ 581 mA
- ○ 716 mA
- ○ 1.32 A

Useful Things

Constants:

$$k_e \approx 9 \times 10^9\,\text{N} \cdot \text{m}^2/\text{C}^2$$
$$e = 1.602 \times 10^{-19}\,\text{C}$$
$$\epsilon_0 = 8.85 \times 10^{12}\,\text{C}^2/\text{N} \cdot \text{m}^2$$
$$m_{e^-} = 9.11 \times 10^{-31}\,\text{kg} \quad \text{Electron mass}$$
$$m_{p^+} = 1.67 \times 10^{-27}\,\text{kg} \quad \text{Proton mass}$$

Quadratic formula:

$$ax^2 + bx^2 + c = 0$$
$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Basic Equations:

$$\vec{\mathbf{F}}_{\text{net}} = m\vec{\mathbf{a}} \quad \text{Newton's Second Law}$$
$$\text{KE} = \frac{1}{2}mv^2 \quad \text{Kinetic energy}$$
$$\text{KE}_{\text{initial}} + \text{PE}_{\text{initial}} = \text{KE}_{\text{final}} + \text{PE}_{\text{final}}$$