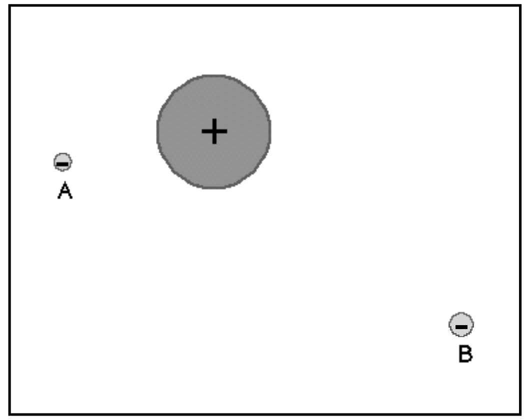
# Electrostatics Problem Set

1. Two negative point charges, **A** and **B**, exist in the space around a uniform sphere (radius *r*) of positive charge density. Charge **A** has magnitude $-Q_0$ and is located at a distance $2r$ from the edge of the sphere. Charge **B** has magnitude $-2Q_0$ and is located at a distance $5r$ from the edge of the sphere. What is the ratio of the magnitude of the electrostatic force exerted by the sphere upon **A** to the magnitude of the force exerted upon **B**?




   a. 25:8
   b. 1:1
   c. 5:4
   d. 2:1

2. A negatively charged rubber rod, without touching, is brought in close proximity to an electrically neutral metallic sphere. The sphere has a copper wire running from its base into a large copper plate buried in moist soil. The wire is cut and the rubber rod is removed from the proximity of the sphere. Which of following describes the present condition of the sphere?

   I. The surface of the sphere is uniformly and negatively charged.
   II. The surface of the sphere is uniformly and positively charged.
   III. The potential difference between the sphere and the ground is positive.

   a. I
   b. II
   c. II and III
   d. I and III

3. A storm-cloud can be thought of as one plate of a giant capacitor, with the earth being the other plate. With which of the following units would we measure the charge contained in a storm-cloud?

   a. farads
   b. coulombs
   c. amperes
   d. volts

4. Which of the following would serve as a poor conductor?

   a. molten sodium chloride
   b. metallic silver
   c. fused quartz ($SiO_2$)
   d. all are good conductors

5. What is the electric field intensity at a point 30 millimeters from a charge of 1 X $10^{-5}$ C? (remember the Coulomb constant $k$ = 9 X $10^9$ N $m^2$ $C^{-1}$)

a. 1.0 N/C
b. 3.0 X $10^6$ N/C
c. 1.0 X $10^8$ N/C
d. 1.0 X $10^6$ N/C

6. An electron gun, similar to the type found in a cathode ray tube, beams electrons into an external zone of high potential, from which they towards travel towards an area of lower potential. As the electrons move from the high potential to the low potential area:

a. they slow down.
b. their potential energy increases.
c. they move with the electric field lines.
d. all of the above.

7. A mole of electrons contains the magnitude of charge: 96,500 C (1 *faraday*). Approximately how much will the temperature rise in one mole of alpha particles ($He^{++}$) moving in a vacuum through a 1 mV decrease in potential? (remember the molar heat capacity of an ideal gas is 3/2 R)

a. 15 K
b. 8 K
c. -8 K
d. 19 K

8. The capacitance of a parallel plate capacitor:

a. is inversely proportional to the area of its plates and inversely proportional to the plate separation.
b. is directly proportional to the area of its plates and inversely proportional to the plate separation.
c. is directly proportional to the area of its plates and directly proportional to the plate separation.
c. is inversely proportional to the area of its plates and directly proportional to the plate separation.

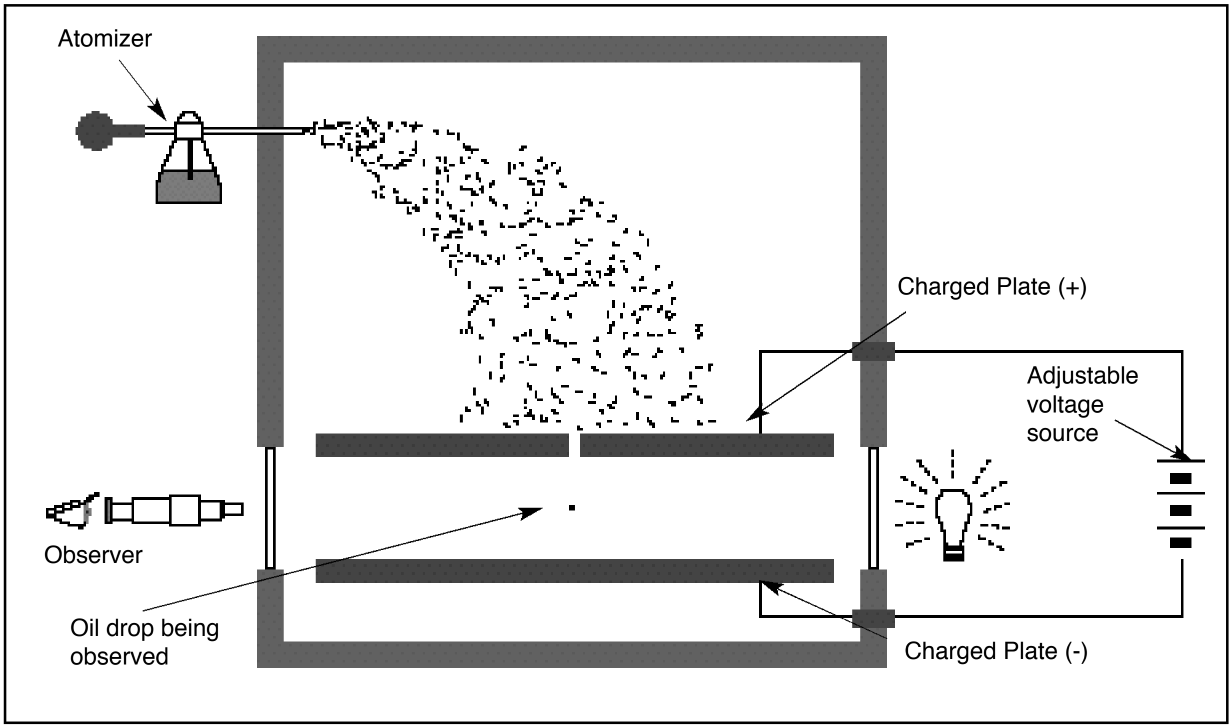
9. A dielectric:

a. weakens the electric field between the plates of a capacitor.
b. decreases the maximum operating voltage of a capacitor.
c. strengthens the electric field between the plates of a capacitor.
d. decreases the capacitance of a capacitor.

10. Moving the plates of a charged capacitor further apart before discharging:

a. decreases the energy released upon discharge
b. increases the energy released upon discharge
c. does not change the amount of energy released upon discharge
d. decreases the electric potential between the plates.

The following passage pertains to questions 11-16




In 1909, the U.S. physicist Robert Millikan (1868-1953) performed a series of experiments, in which, by observing the behavior of electrically charged oil droplets within a uniform electric field, he was able to determine the charge on an electron. The apparatus utilized by Millikan in these experiments is illustrated by the schematic above. A spray bottle produces a fine mist of oil droplets. Some of these pass through an aperture into a viewing chamber, where they may be observed.

To determine the mass of a particular droplet, the experimenter observes the rate at which it falls in the earth's gravitational field. The drop reaches a terminal velocity, which depends on the mass of the droplet, the oil density and the viscosity of the air.

Some of the oil droplets possess an electric charge, acquired when they attach themselves to ions produced by the irradiation of the surrounding air with X-rays. When such a droplet passes into the viewing chamber, the electric field of the two charged plates produces a force on the droplet opposite in direction to that of the earth's gravitational field. If one adjusts the voltage on the plates, the electrical force on the droplet can be made to balance the gravitational force exactly, and the droplet will remain suspended.

In this manner, the experimenter determines the magnitude of the electric field necessary to produce a force on the droplet equal in magnitude to the opposing force of gravity. The charge on the droplet may then be determined. Millikan obtained values such as the following for the magnitude of the charge on certain droplets:

$$e = -1.6 \times 10^{-19}\ \text{C}$$

$$e = -6.4 \times 10^{-19}\ \text{C}$$

$$e = -8.0 \times 10^{-19}\ \text{C}$$

11. If the electrical field strength is of slightly lower magnitude than necessary to oppose the action of the earth's gravitational field, the oil droplet slowly descends. As it does so:

   a. both its electrical potential energy and gravitational potential energy decrease

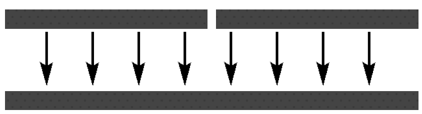
   b. its electrical potential energy decreases while its gravitational potential energy increases

   c. its electrical potential energy increases while its gravitational potential energy decreases

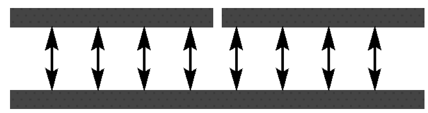
   d. both its electrical potential energy and gravitational potential energy increase

12. Which of the following is the most proper representation of the electric field between the charged plates?

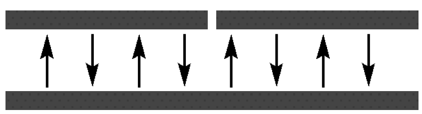
a.



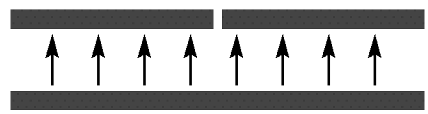
b.



c.



d.



13. If the charged plates, separated by a distance of one decimeter, have a potential difference of 10,000 volts, what is the magnitude of the electric field between them?

   a. 1,000 N/C

   b. 10,000 N/C

   c. 100,000 N/C

   d. none of the above

14. Which of the following statements are true with regard to the frictional force of the air upon the droplet at terminal velocity and the electrical force upon the droplet at the later time it is suspended within the viewing chamber?

   I. The two forces are equal in magnitude.
   II. The two forces are conservative in nature.
   III. The two forces are performing work.

   a. I
   b. I and III
   c. II and III
   d. I, II, and III

15. The charges on the oil droplets possess magnitudes commonly divisible by 1.6 X $10^{-19}$ C. The fact that electric charge cannot be more finely divided is a consequence of:

a. the conservation of electric charge

b. Coulomb's law

c. the quantum nature of electric charge

d. the photoelectric effect

16. Using $q$ as the charge on a certain droplet, $m$ as its mass, $d$ as the distance between the charged plates, and $g$ as the acceleration due to gravity, express the correct voltage to apply across the plates in order to suspend the droplet in the viewing chamber?

a. $\frac{mgd}{q}$

b. $\frac{mgq}{d}$

c. $\frac{mgq}{d^2}$

d. $\frac{mgd^2}{q}$