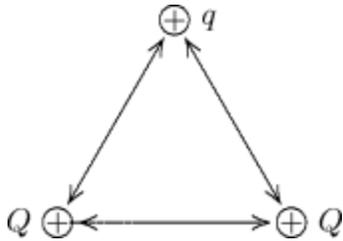


Name: \_\_\_\_\_ Date: \_\_\_\_\_

1. A conductor is distinguished from an insulator with the same number of atoms by the number of:

A) nearly free atoms  
 B) electrons  
 C) nearly free electrons  
 D) protons  
 E) molecules

2. Two particles, each with charge  $Q$ , and a third particle, with charge  $q$ , are placed at the vertices of an equilateral triangle as shown. The net force on the particle with charge  $q$  is:



- A) parallel to the left side of the triangle  
 B) parallel to the right side of the triangle  
 C) parallel to the bottom side of the triangle  
 D) perpendicular to the bottom side of the triangle  
 E) perpendicular to the left side of the triangle
3. To make an uncharged object have a net positive charge:
- A) remove some neutrons  
 B) add some neutrons  
 C) add some electrons  
 D) remove some electrons  
 E) heat it to cause a change of phase

4. An electrical insulator is a material:

- A) containing no electrons
- B) through which electrons do not flow easily
- C) that has more electrons than protons on its surface
- D) cannot be a pure chemical element
- E) must be a crystal

5. Two protons ( $p_1$  and  $p_2$ ) and an electron ( $e$ ) lie on a straight line, as shown. The directions of the force of  $p_1$  on  $e$ , the force of  $p_2$  on  $e$ , and the total force on  $e$ , respectively, are:



- A)  $\rightarrow, \leftarrow, \rightarrow$
- B)  $\leftarrow, \rightarrow, \rightarrow$
- C)  $\rightarrow, \leftarrow, \leftarrow$
- D)  $\leftarrow, \rightarrow, \leftarrow$
- E)  $\leftarrow, \leftarrow, \leftarrow$

6. A negatively charged rubber rod is brought near the knob of a positively charged electroscope. The result is that:

- A) the electroscope leaves will move farther apart
- B) the rod will lose its charge
- C) the electroscope leaves will tend to collapse
- D) the electroscope will become discharged
- E) nothing noticeable will happen

7. Consider the following procedural steps:

1. ground the electroscope
2. remove the ground from the electroscope
3. touch a charged rod to the electroscope
4. bring a charged rod near, but not touching, the electroscope
5. remove the charged rod

To charge an electroscope by induction, use the sequence:

- A) 1, 4, 5, 2
- B) 4, 1, 2, 5
- C) 3, 1, 2, 5
- D) 4, 1, 5, 2
- E) 3, 5

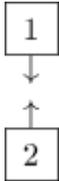
8. A positively charged insulating rod is brought close to an object that is suspended by a string. If the object is attracted toward the rod we can conclude:
- A) the object is positively charged
  - B) the object is negatively charged
  - C) the object is an insulator
  - D) the object is a conductor
  - E) none of the above
9. The leaves of a positively charged electroscope diverge more when an object is brought near the knob of the electroscope. The object must be:
- A) a conductor
  - B) an insulator
  - C) positively charged
  - D) negatively charged
  - E) uncharged
10. Two small charged objects attract each other with a force  $F$  when separated by a distance  $d$ . If the charge on each object is reduced to one-fourth of its original value and the distance between them is reduced to  $d/2$  the force becomes:
- A)  $F/16$
  - B)  $F/8$
  - C)  $F/4$
  - D)  $F/2$
  - E)  $F$
11. In the Rutherford model of the hydrogen atom, a proton (mass  $M$ , charge  $Q$ ) is the nucleus and an electron (mass  $m$ , charge  $q$ ) moves around the proton in a circle of radius  $r$ . Let  $k$  denote the Coulomb force constant ( $1/4\pi\epsilon_0$ ) and  $G$  the universal gravitational constant. The ratio of the electrostatic force to the gravitational force between electron and proton is:
- A)  $kQq/GMmr^2$
  - B)  $GQq/kMm$
  - C)  $kMm/GQq$
  - D)  $GMm/kQq$
  - E)  $kQq/GMm$

12. A particle with a charge of  $5 \times 10^{-6}$  C and a mass of 20 g moves uniformly with a speed of 7 m/s in a circular orbit around a stationary particle with a charge of  $-5 \times 10^{-6}$  C. The radius of the orbit is:
- A) 0
  - B) 0.23 m
  - C) 0.62 m
  - D) 1.6
  - E) 4.4 m
13. A charged insulator can be discharged by passing it just above a flame. This is because the flame:
- A) warms it
  - B) dries it
  - C) contains carbon dioxide
  - D) contains ions
  - E) contains more rapidly moving atoms
14. Charges  $q_1$  and  $q_2$  are on the x axis, with  $q_1$  at  $x = a$  and  $q_2$  at  $x = -2a$ . For the net force on a another charge at the origin to be zero,  $q_1$  and  $q_2$  must be related by  $q_2 =$  :
- A)  $2q_1$
  - B)  $4q_1$
  - C)  $-2q_1$
  - D)  $-4q_1$
  - E)  $-q_1/4$
15. The charge on a glass rod that has been rubbed with silk is called positive:
- A) by arbitrary convention
  - B) so that the proton charge will be positive
  - C) to conform to the conventions adopted for  $G$  and  $m$  in Newton's law of gravitation
  - D) because like charges repel
  - E) because glass is an insulator

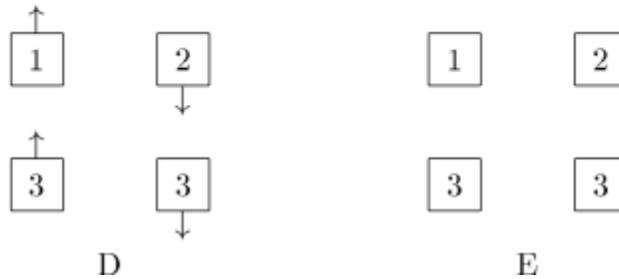
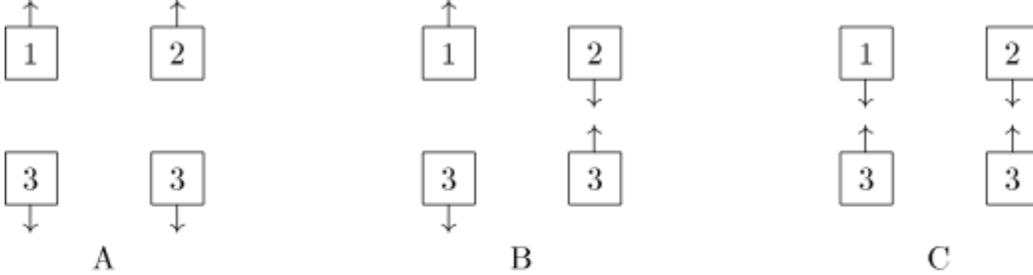
16. A neutral metal ball is suspended by a string. A positively charged insulating rod is placed near the ball, which is observed to be attracted to the rod. This is because:

- A) the ball becomes positively charged by induction
- B) the ball becomes negatively charged by induction
- C) the number of electrons in the ball is more than the number in the rod
- D) the string is not a perfect insulator
- E) there is a rearrangement of the electrons in the ball

17. The diagram shows a pair of heavily charged plastic cubes that attract each other.



Cube 3 is a conductor and is uncharged. Which of the following illustrates the forces between cubes 1 and 3 and between cubes 2 and 3?



- A) A
- B) B
- C) C
- D) D
- E) E

- 18.** Charge is distributed uniformly on the surface of a spherical balloon (an insulator) with a point charge  $q$  inside. The electrical force on  $q$  is greatest when:
- A) it is near the inside surface of the balloon
  - B) it is at the center of the balloon
  - C) it is halfway between the balloon center and the inside surface
  - D) it is anywhere inside (the force is same everywhere and is not zero)
  - E) it is anywhere inside (the force is zero everywhere)
- 19.** Charge  $Q$  is on the  $y$  axis a distance  $a$  from the origin and charge  $q$  is on the  $x$  axis a distance  $d$  from the origin. The value of  $d$  for which the  $x$  component of the force on  $q$  is the greatest is:
- A) 0
  - B)  $a$
  - C)  $\sqrt{2}a$
  - D)  $a/2$
  - E)  $a/\sqrt{2}$
- 20.** Two particles A and B have identical charge  $Q$ . For a net force of zero to be exerted on a third charge it must be placed:
- A) midway between A and B
  - B) on the perpendicular bisector of the line joining A and B but away from the line
  - C) on the line joining A and B, not between the particles
  - D) on the line joining A and B, closer to one of them than the other
  - E) at none of these places (there is no place)
- 21.** Two particles, X and Y, are 4 m apart. X has a charge of  $2Q$  and Y has a charge of  $Q$ . The force of X on Y:
- A) has twice the magnitude of the force of Y on X
  - B) has half the magnitude of the force of Y on X
  - C) has four times the magnitude of the force of Y on X
  - D) has one-fourth the magnitude of the force of Y on X
  - E) has the same magnitude as the force of Y on X

22. A small object has charge  $Q$ . Charge  $q$  is removed from it and placed on a second small object. The two objects are placed 1 m apart. For the force that each object exerts on the other to be a maximum,  $q$  should be:
- A)  $2Q$
  - B)  $Q$
  - C)  $Q/2$
  - D)  $Q/4$
  - E) 0
23. The magnitude of the charge on an electron is approximately:
- A)  $10^{23}$  C
  - B)  $10^{-23}$  C
  - C)  $10^{19}$  C
  - D)  $10^{-19}$  C
  - E)  $10^9$  C
24. A  $2\text{-}\mu\text{C}$  charge is placed at the origin, an identical charge is placed 2 m from the origin on the  $x$  axis, and a third identical charge is placed 2 m from the origin on the  $y$  axis. The magnitude of the force on the charge at the origin is:
- A)  $9.0 \times 10^{-3}$  N
  - B)  $6.4 \times 10^{-3}$  N
  - C)  $1.3 \times 10^{-2}$  N
  - D)  $1.8 \times 10^{-2}$  N
  - E)  $3.6 \times 10^{-2}$  N
25. When a hard rubber rod is given a negative charge by rubbing it with wool:
- A) positive charges are transferred from rod to wool
  - B) negative charges are transferred from rod to wool
  - C) positive charges are transferred from wool to rod
  - D) negative charges are transferred from wool to rod
  - E) negative charges are created and stored on the rod

## Answer Key

1. C
2. D
3. D
4. B
5. D
6. C
7. B
8. E
9. C
10. C
11. E
12. B
13. D
14. B
15. A
16. E
17. C
18. E
19. E
20. A
21. E
22. C
23. D
24. C
25. D