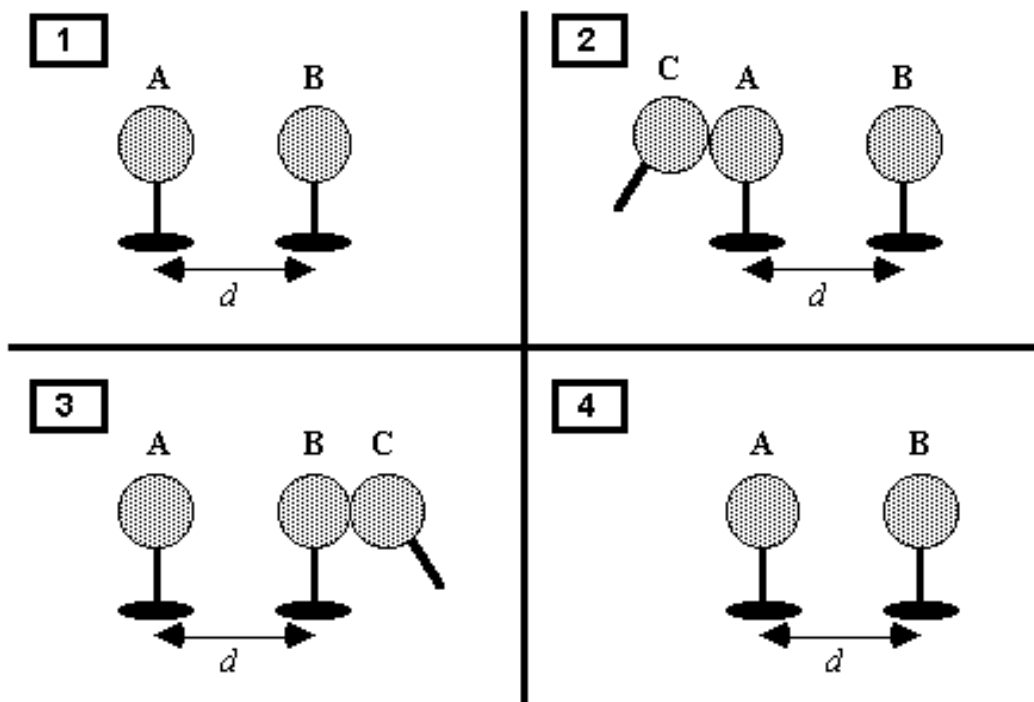


1. One mole of a substance contains 6.02×10^{23} protons and an equal number of electrons. If the protons could somehow be separated from the electrons and placed in separate containers separated by 1.00×10^3 m, what would be the magnitude of the electrostatic force exerted by one box on the other?

- A. 8.7×10^8 N
- B. 9.5×10^9 N
- C. 2.2×10^{10} N
- D. 8.3×10^{13} N
- E. 1.6×10^{19} N

2. In Frame 1, two identical conducting spheres, **A** and **B**, carry equal amounts of excess charge that have the same sign. The spheres are separated by a distance d ; and sphere **A** exerts an electrostatic force on sphere **B** which has a magnitude F . A third sphere, **C**, which is handled only by an insulating rod, is introduced in Frame 2. Sphere **C** is identical to **A** and **B** except that it is *initially uncharged*. Sphere **C** is touched first to sphere **A**, in Frame 2, and then to sphere **B**, in Frame 3, and is finally removed in Frame 4.

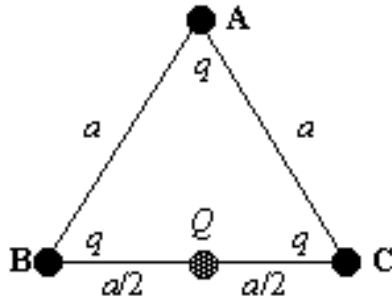


Determine the magnitude of the electrostatic force that sphere **A** exerts on sphere **B** in Frame 4.

- A. $F/2$
- B. $F/3$
- C. $3F/4$
- D. $3F/8$
- E. zero

3. A conducting sphere has a net charge of -4.8×10^{-17} C. What is the approximate number of excess electrons on the sphere?
- A. 100
- B. 200
- C. 300
- D. 400
- E. 500

The figure shows an equilateral triangle **ABC**. A positive point charge $+q$ is located at each of the three vertices **A**, **B**, and **C**. Each side of the triangle is of length a .



A point charge Q (that may be positive or negative) is placed at the mid-point between **B** and **C**.

4. Is it possible to choose the value of Q (*that is non-zero*) such that the force on Q is zero? Explain why or why not.
- A. Yes, because the forces on Q are vectors and three vectors can add to zero.
- B. No, because the forces on Q are vectors and three vectors can never add to zero.
- C. Yes, because the electric force at the mid-point between **B** and **C** is zero whether a charge is placed there or not.
- D. No, because the forces on Q due to the charges at **B** and **C** point in the same direction.
- E. No, because a fourth charge would be needed to cancel the force on Q due to the charge at **A**.

5. Determine an expression for the magnitude and sign of Q so that the net force on the charge at **A** is zero.

___ A.

$$Q = +q \left(\frac{3\sqrt{3}}{4} \right)$$

___ B.

$$Q = -q \left(\frac{3\sqrt{3}}{4} \right)$$

___ C.

$$Q = -q \left(\frac{4\sqrt{3}}{3} \right)$$

___ D.

$$Q = +q \left(\frac{3}{4\sqrt{3}} \right)$$

___ E.

$$Q = +q \left(\frac{4\sqrt{3}}{3} \right)$$

6. Determine the ratio of the electrostatic force to the gravitational force between a proton and an electron, F_E/F_G . **Note:** $k = 8.99 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2$; $G = 6.672 \times 10^{-11} \text{ N}\cdot\text{m}^2/\text{kg}^2$; $m_e = 9.109 \times 10^{-31} \text{ kg}$; and $m_p = 1.672 \times 10^{-27} \text{ kg}$.

___ A. 1.24×10^{23}

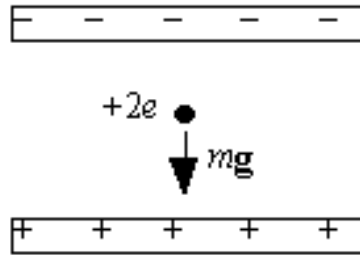
___ B. 2.52×10^{29}

___ C. 1.15×10^{31}

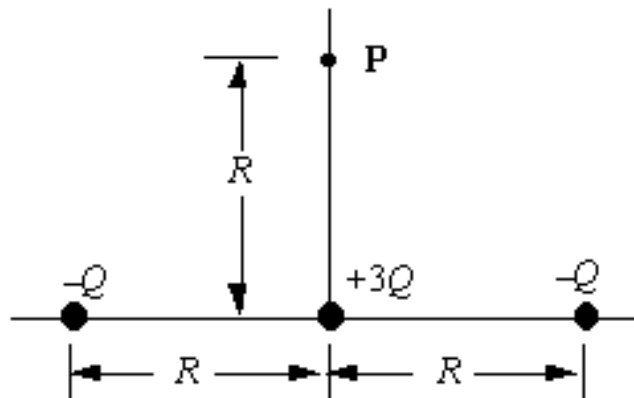
___ D. 2.27×10^{39}

___ E. 1.42×10^{58}

7. A helium nucleus is located between the plates of a parallel-plate capacitor as shown. The nucleus has a charge of $+2e$ and a mass of 6.6×10^{-27} kg. What is the magnitude of the electric field such that the electric force exactly balances the weight of the helium nucleus so that it remains stationary?



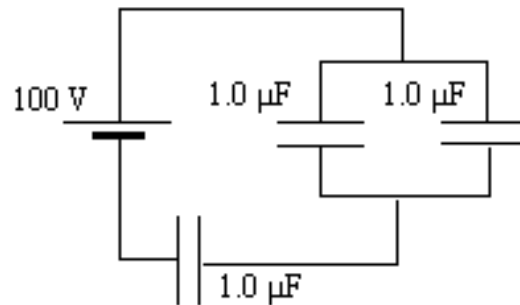
- A. 4.0×10^{-7} N/C
 B. 6.6×10^{-26} N/C
 C. 2.0×10^{-7} N/C
 D. 5.0×10^{-3} N/C
 E. 1.4×10^8 N/C
8. Three point charges $-Q$, $-Q$, and $+3Q$ are arranged along a line as shown in the sketch.



What is the electric potential at the point P?

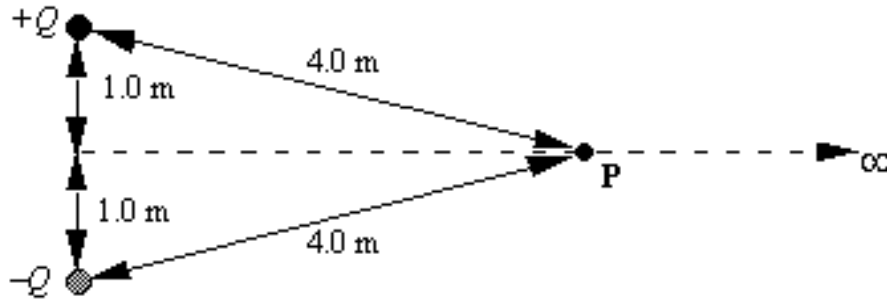
- A. $+kQ/R$
 B. $-2kQ/R$
 C. $-1.6kQ/R$
 D. $+1.6kQ/R$
 E. $+4.4kQ/R$

9. A capacitor has a very large capacitance of 10 F. The capacitor is charged by placing a potential difference of 2 V between its plates. How much energy is stored in the capacitor?
- ___ A. 2000 J
 ___ B. 500 J
 ___ C. 100 J
 ___ D. 40 J
 ___ E. 20 J
10. What is the equivalent capacitance of the combination of capacitors shown in the circuit?



- ___ A. 0.37 μF
 ___ B. 3.3 μF
 ___ C. 4.6 μF
 ___ D. 0.67 μF
 ___ E. 2.1 μF
11. Two wires, **A** and **B**, and a variable resistor, **R**, are connected in series to a battery. Which one of the following results will occur if the resistance of **R** is increased?
- ___ A. The current through **A** and **B** will increase.
 ___ B. The voltage across **A** and **B** will increase.
 ___ C. The voltage across the entire circuit will increase.
 ___ D. The power used by the entire circuit will increase.
 ___ E. The current through the entire circuit will decrease.

Two charges of opposite sign and equal magnitude $Q = 2.0 \text{ C}$ are held 2.0 m apart as shown in the figure.



12. Determine the electric potential at the point **P**.

- A. $1.1 \times 10^9 \text{ V}$
- B. $2.2 \times 10^9 \text{ V}$
- C. $4.5 \times 10^9 \text{ V}$
- D. $9.0 \times 10^9 \text{ V}$
- E. zero

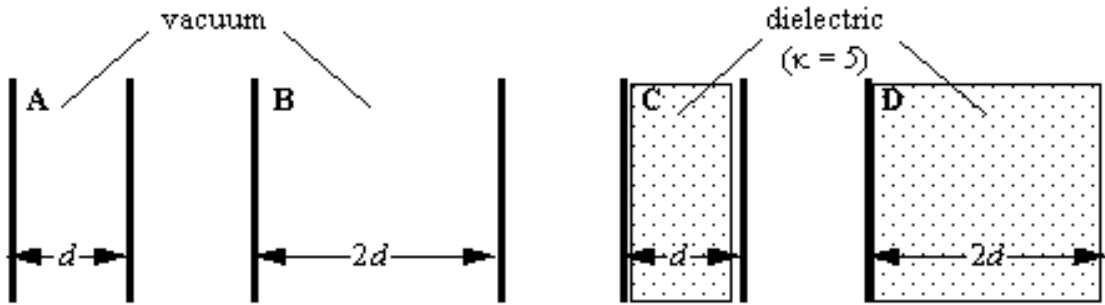
13. Determine the magnitude of the electric field at the point **P**.

- A. $2.2 \times 10^9 \text{ V/m}$
- B. $5.6 \times 10^8 \text{ V/m}$
- C. $4.4 \times 10^8 \text{ V/m}$
- D. $2.8 \times 10^8 \text{ V/m}$
- E. zero

14. How many electrons flow through a battery that delivers a current of 3.0 A for 12 s ?

- A. 4
- B. 36
- C. 4.8×10^{15}
- D. 6.4×10^{18}
- E. 2.2×10^{20}

The figure below shows four parallel plate capacitors: **A**, **B**, **C**, and **D**. Each capacitor carries the same charge q and has the same plate area A . As suggested by the figure, the plates of capacitors **A** and **C** are separated by a distance d while those of **B** and **D** are separated by a distance $2d$. Capacitors **A** and **B** are maintained in vacuum while capacitors **C** and **D** contain dielectrics with constant $\kappa = 5$.



15. Which list below places the capacitors in order of *increasing* capacitance?

- A. **A, B, C, D**
- B. **B, A, C, D**
- C. **A, B, D, C**
- D. **B, A, D, C**
- E. **D, C, B, A**

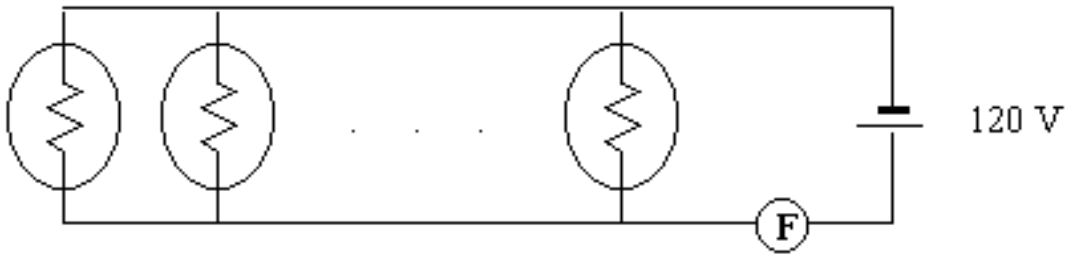
16. Which capacitor has the largest potential difference between its plates?

- A. **A**
- B. **B**
- C. **C**
- D. **D**
- E. **A and D are the same and larger than B or C.**

17. A resistor dissipates 1.5 W when it is connected to a battery with a potential difference of 12 V. What is the resistance of the resistor?

- A. 0.13 Ω
- B. 220 Ω
- C. 18 Ω
- D. 8.0 Ω
- E. 96 Ω

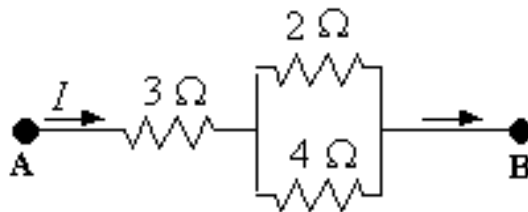
18. Some light bulbs are connected in parallel to a 120 V source as shown in the figure. Each bulb dissipates an average power of 60 W.



The circuit has a fuse **F** that burns out when the current in the circuit exceeds 9 A. Determine the largest number of bulbs, that can be used in this circuit without burning out the fuse.

- A. 9
- B. 17
- C. 25
- D. 34
- E. 36

Three resistors are connected as shown in the figure. The potential difference between points **A** and **B** is 26 V.



19. What is the equivalent resistance between the points **A** and **B**?

- A. 3.8 Ω
- B. 4.3 Ω
- C. 5.1 Ω
- D. 6.8 Ω
- E. 9.0 Ω

20. How much current flows through the 3-Ω resistor?

- A. 2.0 A
- B. 4.0 A
- C. 6.0 A
- D. 8.7 A
- E. 10.0 A

Answer Key

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