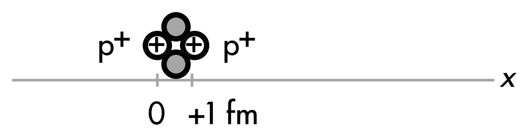
A proton ($+1.602\times10^{-19}$ C) and an electron (-1.602×10^{-19} C) lie along the x-axis. The proton is at the origin, and the electron is at x = +0.0529 nm, approximating the ground state of a hydrogen atom.

1. The electric potential energy of these two charges is:
(A) negative.
(B) zero.
(C) positive.
(D) (Unsure/guessing/lost/help!)

2. If the separation distance between these two charges increases, the electric potential energy:
(A) decreases (becomes a smaller positive number).
(B) decreases (becomes a larger negative number).
(C) remains constant.
(D) increases (becomes a larger positive number).
(E) increases (becomes a smaller negative number).
(F) (Unsure/guessing/lost/help!)

Two protons ($+1.602\times10^{-19}$ C) along the x-axis, one at the origin, and the other at x = +1 fm, approximate the nucleus of a helium atom (with two neutrons, which can be ignored).

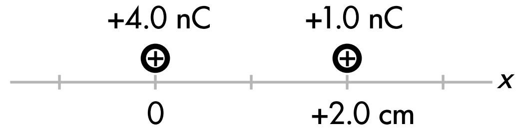


3. The electric potential energy of these two charges is:
(A) negative.
(B) zero.
(C) positive.
(D) (Unsure/guessing/lost/help!)

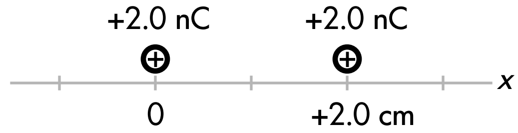
4. If the separation distance between the two protons increases, the electric potential energy:
(A) decreases (becomes a smaller positive number).
(B) decreases (becomes a larger negative number).
(C) remains constant.
(D) increases (becomes a larger positive number).
(E) increases (becomes a smaller negative number).
(F) (Unsure/guessing/lost/help!)

Consider two sets of two point charges that lie along the *x*-axis:

+4.0 nC charge at the origin, and a +1.0 nC charge at *x* = +2.0 cm.



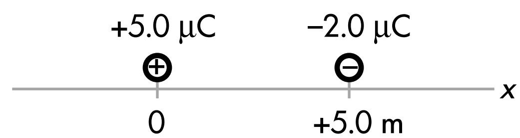
Two +2.0 nC charges,at the origin and at *x* = +2.0 cm.



5. The __________ have the greater amount of electric potential energy.
(A) +4.0 nC charge and +1.0 nC charge.
(B) two +2.0 nC charges.
(C) (There is a tie.)
(D) (Unsure/guessing/lost/help!)

6. Moving the __________ 1.0 cm closer would require more work by an external agent.
(A) +4.0 nC charge and +1.0 nC charge.
(B) two +2.0 nC charges.
(C) (There is a tie.)
(D) (Unsure/guessing/lost/help!)

Two point charges lie along the *x*-axis. A +5.0 μC charge is at the origin, and a –2.0 μC charge is at x = +5.0 m.

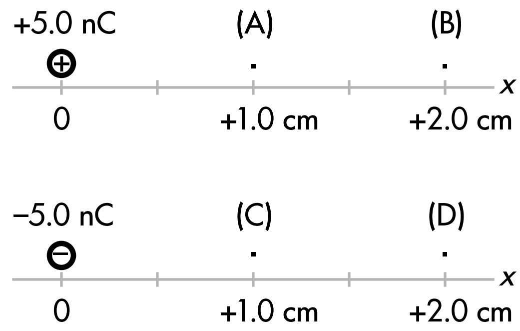


7. Which process would require more work by an external agent?
(A) Holding the +5.0 μC charge fixed, while moving the –2.0 μC charge very far away.
(B) Holding the –2.0 μC charge fixed, while moving the +5.0 μC charge very far away.
(C) (There is a tie.)
(D) (Unsure/guessing/lost/help!)

8. In general, if the distance between any two charges with $\begin{bmatrix}\text{the same}\\ \text{opposite}\end{bmatrix}$ signs $\begin{vmatrix}\text{increases}\\ \text{decreases}\end{vmatrix}$,

the electric potential energy:
(A) decreases (becomes a smaller positive number).
(B) decreases (becomes a larger negative number).
(C) remains constant.
(D) increases (becomes a larger positive number).
(E) increases (becomes a smaller negative number).
(F) (Unsure/guessing/lost/help!)

Consider two sets of point charges fixed at the origin, and the locations (A)-(D) along the *x*-axis.



9. Rank the locations from lowest electric potential (greatest negative value) to highest electric potential (greatest positive value). Indicate ties, if any.

________ ________ ________ ________

(lowest *V*) (highest *V*)

Now consider the following processes:

Moving from location (A)→(B).
Moving from location (B)→(A).
Moving from location (C)→(D).
Moving from location (D)→(C).

10. Identify the process(es) (if any) where the value of the electric potential would *decrease*.

Process(es):

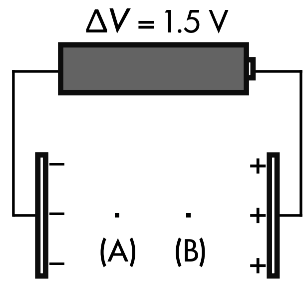
11. Identify the process(es) (if any) where a *positive* test charge would experience a *decrease* in electric potential energy.

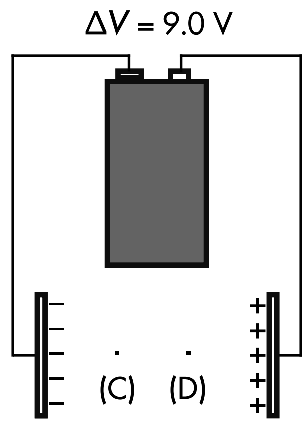
Positive test charge process(es):

12. Identify the process(es) (if any) where a *negative* test charge would experience a *decrease* in electric potential energy.

Negative test charge process(es):

Two different batteries are each connected to a capacitor (two parallel metal plates) that is initially uncharged. As a result, these plates of these capacitors become charged. Locations (A)-(D) are located between the charged capacitor plates.





Consider the following processes:

Moving from location (A)→(B).
Moving from location (B)→(A).
Moving from location (C)→(D).
Moving from location (D)→(C).

13. Identify the process(es) (if any) where the value of the electric potential would *decrease*.

Process(es):

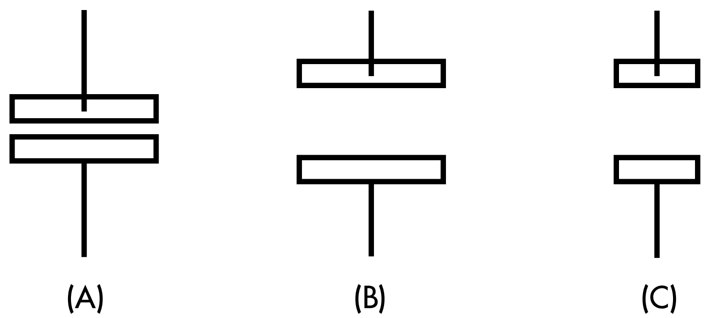
14. Identify the process(es) (if any) where a *positive* test charge would experience a *decrease* in electric potential energy.

Positive test charge process(es):

15. Identify the process(es) (if any) where a *negative* test charge would experience a *decrease* in electric potential energy.

Negative test charge process(es):

Three different parallel plate capacitors are each connected to identical 9.0 V batteries. Capacitors (A) and (B) have the same area; capacitors (B) and (C) have the same separation distance.



16. Rank the capacitors from lowest to highest capacitance value. Indicate ties, if any.

________ ________ ________
(lowest C) (highest C)

17. Rank the capacitors from least to greatest amount of charge stored. Indicate ties, if any.

________ ________ ________
(least Q) (most Q)

18. Rank the capacitors from least to greatest amount of electric potential energy stored. Indicate ties, if any.

________ ________ ________
(least *EPE*) (most *EPE*)

19. $\begin{bmatrix}\text{Increasing}\\\text{Decreasing}\end{bmatrix}$ the $\begin{bmatrix}\text{separation gap}\\\text{area}\end{bmatrix}$ of a parallel plate capacitor would __________ its capacitance.

(A) increase.
(B) decrease.
(C) remain constant.
(D) (Not enough information is given.)
(E) (Unsure/guessing/lost/help!)

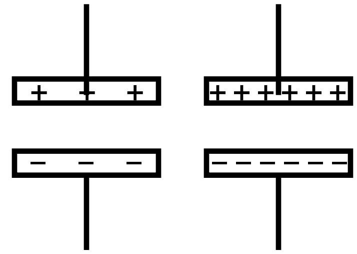
20. $\begin{bmatrix}\text{Increasing}\\\text{Decreasing}\end{bmatrix}$ the charge on a capacitor is would __________ its $\begin{bmatrix}\text{potential difference}\\\text{capacitance}\\\text{energy stored}\end{bmatrix}$.

(A) increase.
(B) decrease.
(C) remain constant.
(D) (Not enough information is given.)
(E) (Unsure/guessing/lost/help!)

21. $\begin{bmatrix}\text{Increasing}\\\text{Decreasing}\end{bmatrix}$ the potential difference of a capacitor would __________ its $\begin{bmatrix}\text{charge}\\\text{capacitance}\\\text{energy stored}\end{bmatrix}$.

(A) increase.
(B) decrease.
(C) remain constant.
(D) (Not enough information is given.)
(E) (Unsure/guessing/lost/help!)

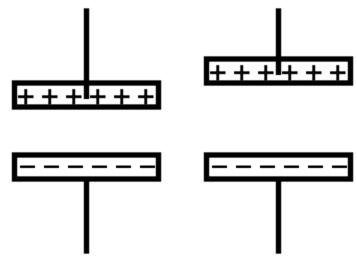
Two parallel plate capacitors have the same area, and same separation gaps, but different amounts of charge.



22. The parallel plate capacitor with ___________ charge has [a greater potential difference / more energy stored].

(A) more.
(B) less.
(C) (There is a tie.)
(D) (Not enough information is given.)
(E) (Unsure/guessing/lost/help!)

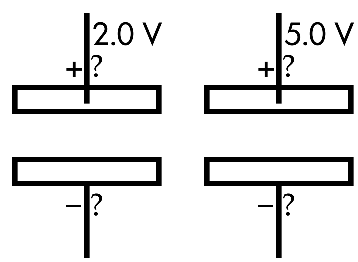
Two parallel plate capacitors have the same area, and same charge, but different separation gaps.



23. The parallel plate capacitor with the ___________ separation gap has [a greater potential difference / more energy stored].

(A) narrower.
(B) wider.
(C) (There is a tie.)
(D) (Not enough information is given.)
(E) (Unsure/guessing/lost/help!)

Two parallel plate capacitors have the same area, and same separation gaps, but different potential differences, and each has an unknown amount of charge.



24. The parallel plate capacitor with the ___________ potential difference has more [charge / energy stored].

(A) greater.
(B) lesser.
(C) (There is a tie.)
(D) (Not enough information is given.)
(E) (Unsure/guessing/lost/help!)

25. A parallel plate capacitor is charged to a set potential difference by a battery, which is then disconnected. Afterwards, the parallel plates are separated a little more.

While the parallel plates are separating, the [capacitance / charge / potential difference / energy stored] will:

(A) increase.
(B) decrease.
(C) remain constant.
(D) (Not enough information is given.)
(E) (Unsure/guessing/lost/help!)

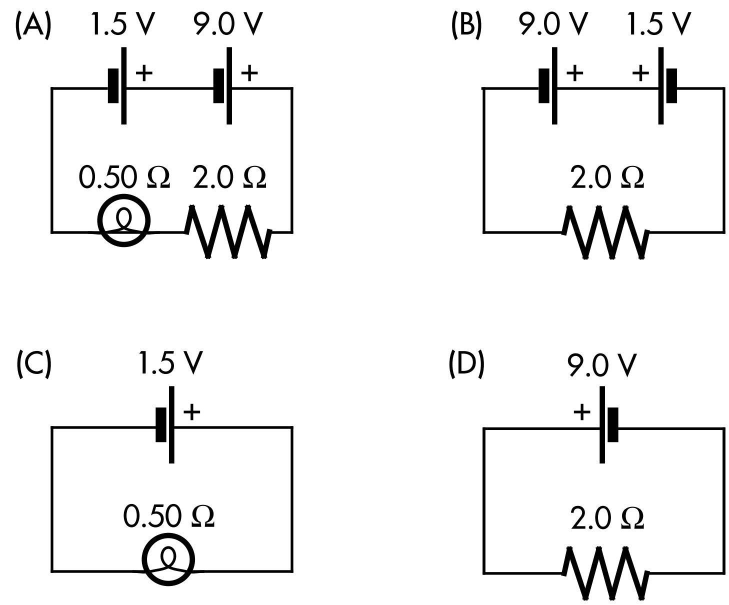
---

26. A parallel plate capacitor is connected to a battery that supplies a constant potential difference. While the battery is still attached, the parallel plates are separated a little more.

While the parallel plates are separating, the [capacitance / charge / potential difference / energy stored] will:

(A) increase.
(B) decrease.
(C) remain constant.
(D) (Not enough information is given.)
(E) (Unsure/guessing/lost/help!)

In these series circuits below, 9.0 V batteries and/or 1.5 V batteries, are wired to 0.50 Ω light bulbs and/or 2.0 Ω resistors. All circuit elements and wires are ideal.



27. Rank the circuits from lowest to highest equivalent emf. Indicate ties, if any.

________ (lowest $\mathscr{E}$) ________ ________ ________ (highest $\mathscr{E}$)

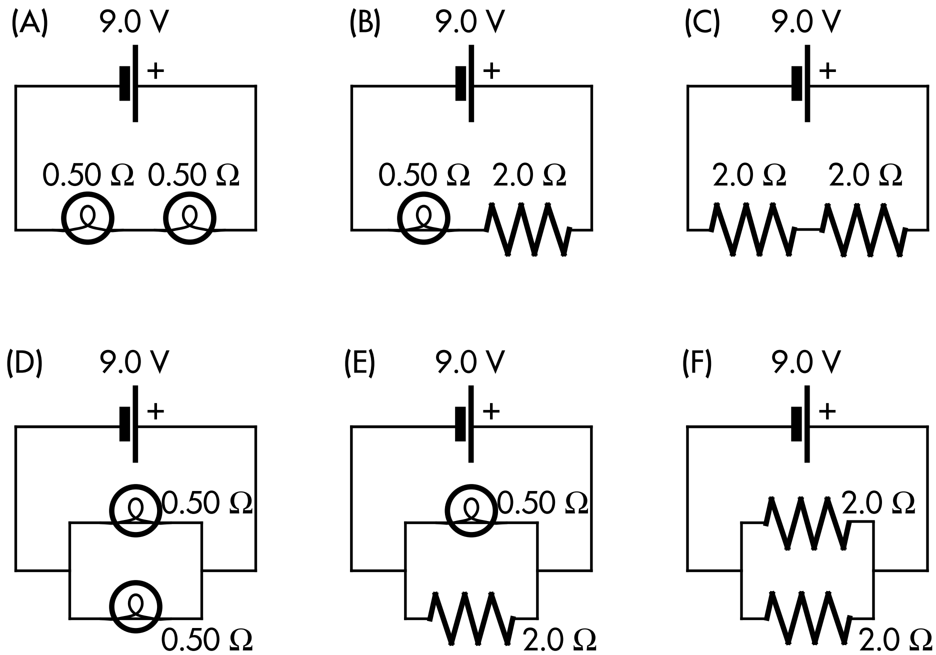
28. Rank the circuits from lowest to highest equivalent resistance. Indicate ties, if any.

________ (lowest R_{eq}) ________ ________ ________ (highest R_{eq})

29. Rank the circuits from least to greatest amount of current flowing through it. Indicate ties, if any.

________ (least I) ________ ________ ________ (greatest I)

In these series and parallel circuits below, 9.0 V batteries are wired to 0.50 Ω light bulbs and/or 2.0 Ω resistors. All circuit elements and wires are ideal.



30. Rank the circuits from lowest to highest equivalent resistance. Indicate ties, if any.

________ ________ ________ ________ ________ ________

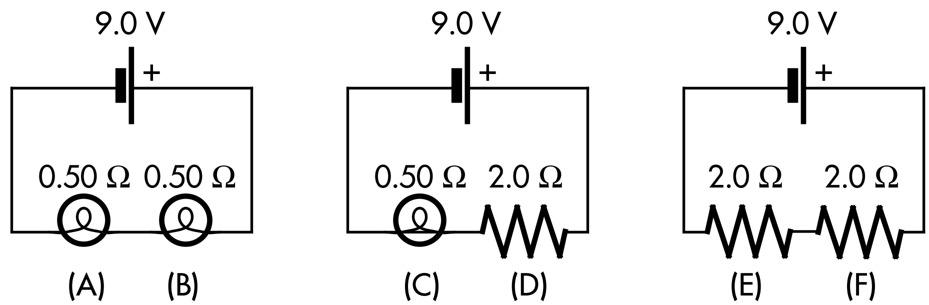
(lowest R_{eq}) (highest R_{eq})

31. Rank the circuits from least to greatest amount of current flowing through the *battery*. Indicate ties, if any.

________ ________ ________ ________ ________ ________

(least I) (greatest I)

In these series circuits below, 9.0 V batteries are wired to 0.50 Ω light bulbs and/or 2.0 Ω resistors. All circuit elements and wires are ideal.



32. Rank the circuit elements from least to greatest amount of current flowing through them. Indicate ties, if any.

________ ________ ________ ________ ________ ________

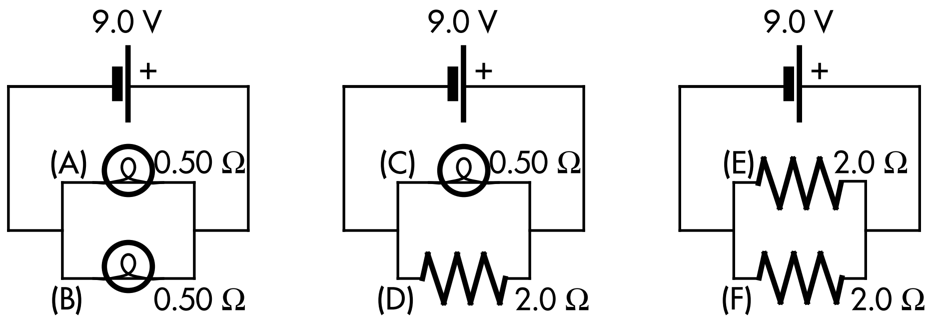
(least I) (greatest I)

33. Rank the circuit elements from lowest to highest potential drop. Indicate ties, if any.

________ ________ ________ ________ ________ ________

(lowest ΔV) (highest ΔV)

In these parallel circuits below, 9.0 V batteries are wired to 0.50 Ω light bulbs and/or 2.0 Ω resistors. All circuit elements and wires are ideal.



34. Rank the circuit elements from lowest to highest potential drop. Indicate ties, if any.

________ ________ ________ ________ ________ ________

(lowest ΔV) (highest ΔV)

35. Rank the circuit elements from least to greatest amount of current flowing through them. Indicate ties, if any.

________ ________ ________ ________ ________ ________

(least I) (greatest I)

36. $\begin{bmatrix} \text{electric field} \\ \text{electric potential} \\ \text{electric potential energy} \\ \text{power} \\ \text{charge} \\ \text{current} \\ \text{resistance} \\ \text{capacitance} \end{bmatrix}$ is measured in units of:

(A) A (amperes).
(B) C (coulombs).
(C) F (farads).
(D) J (joules).
(E) N/C (newtons per coulomb).
(F) Ω (ohms).
(G) V (volts).
(H) W (watts).

37. The unit of $\begin{bmatrix} \text{A (amperes)} \\ \text{C (coulombs)} \\ \text{F (farads)} \\ \text{J (joules)} \\ \text{N/C (newtons per coulomb)} \\ \Omega\text{ (ohms)} \\ \text{V (volts)} \\ \text{W (watts)} \end{bmatrix}$ is a measure of:

(A) electric field.
(B) electric potential.
(C) electric potential energy.
(D) power.
(E) charge.
(F) current.
(G) resistance.
(H) capacitance.

Equations and constants:

$|e| = 1.602\times10^{-19}\text{ C}$; $k = 8.99\times10^{9}\ \dfrac{\text{N}\cdot\text{m}^2}{\text{C}^2}$; $EPE = k\dfrac{q_1q_2}{r}$; $\Delta EPE = q(\Delta V)$; $V = k\dfrac{Q}{r}$.

$C = \dfrac{Q}{\Delta V}$; $C = \dfrac{A}{4\pi kd}$; $\Delta V = -Ed$; $EPE = \dfrac{1}{2}Q(\Delta V)$.

$I = \dfrac{\Delta q}{\Delta t}$; $I = \dfrac{\Delta V}{R}$; $P = I(\Delta V)$; $\sum I_{in} = \sum I_{out}$; $\sum_{loop}\Delta V_{rises} = \sum_{loop}\Delta V_{drops}$; $R_{eq} = \sum R_i$; $\dfrac{1}{R_{eq}} = \sum\dfrac{1}{R_i}$.