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Electricity: Ohm's Law and Capacitors

Study Guide — Electricity

Pre-med style questions on current, voltage, resistance, power, series/parallel circuits, meters, internal resistance, and capacitors (Q=CV, series/parallel, energy, dielectrics, and RC charging/discharging). Focused on conceptual traps and exam-style reasoning.

75 items — Study Guide with Answers

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1 **Electric current is best defined as:**

- A The total charge contained in a wire
- B The energy carried by electrons each second
- C The force pushing charges through a conductor
- D **The rate of flow of electric charge** ✓
- E The resistance of a circuit to charge flow

▶ **Explanation:** Current is defined as charge per unit time ($I = \Delta Q/\Delta t$). Voltage relates to energy per charge, and resistance relates to how strongly the circuit opposes current.

2 **In a metal wire connected to a battery, the direction of conventional current is:**

- A The same direction as electron drift
- B **Opposite to electron drift** ✓
- C Always from the negative terminal to the positive terminal in the external circuit
- D Random because electrons move randomly
- E Only within the battery, not in the wire

▶ **Explanation:** Conventional current is defined as the direction positive charge would move (from $+$ to $-$ in the external circuit). In metals, electrons drift from $-$ to $+$, so electron drift is opposite to conventional current.

3 **Potential difference (voltage) between two points is best interpreted as:**

- A Charge per unit time

- B **Energy transferred per unit charge** ✓
- C Force per unit charge
- D Energy transferred per unit time
- E Resistance per unit length

▶ **Explanation:** Voltage is energy per charge: $V = W/Q$. Force per charge is electric field (N/C). Energy per time is power.

4 **A battery has emf E and internal resistance r. When it delivers current to an external circuit, the terminal potential difference is typically:**

- A Greater than E because current "boosts" the voltage
- B Equal to E for any current
- C **Less than E because some energy per charge is lost inside the battery** ✓
- D Zero because voltage is used up in the battery
- E Negative because internal resistance reverses polarity

▶ **Explanation:** Terminal voltage drops below emf when current flows because a voltage drop occurs across the internal resistance (often written $V_{terminal} = E - Ir$).

5 **Ohm's law states that for an ohmic conductor:**

- A Current is proportional to resistance
- B Voltage is proportional to resistance
- C **Voltage is proportional to current, provided temperature (and other physical conditions) are constant** ✓
- D Power is proportional to current

E Resistance is proportional to voltage for all materials

▶ **Explanation:** Ohm's law is V I at constant physical conditions (especially temperature). Non-ohmic devices (like filament lamps/diodes) do not show a constant V/I ratio.

6 Which component is most likely to be approximately ohmic over a wide range of currents at constant temperature?

- A A filament lamp
- B **A fixed metal resistor** ✓
- C A diode
- D An LED
- E A thermistor

▶ **Explanation:** A fixed metal resistor (kept at constant temperature) typically shows a linear V–I relationship. Filament lamps and diodes/LEDs are strongly non-linear; thermistors change resistance with temperature.

7 A graph of voltage V (vertical axis) against current I (horizontal axis) for an ohmic resistor is a straight line through the origin. The slope of this line equals:

- A 1/R
- B **R** ✓
- C Power
- D Charge
- E Capacitance

▶ **Explanation:** From $V = IR$, the slope $\Delta V/\Delta I$ equals R. A common trap is mixing it up with an I–V graph, where the slope would be $1/R$.

8 **A graph of current I (vertical axis) against voltage V (horizontal axis) for an ohmic resistor is a straight line through the origin. The slope of this line equals:**

- A R
- B **1/R** ✓
- C IR
- D V/R^2
- E Capacitance

▶ **Explanation:** Rearrange $V = IR$ to $I = (1/R)V$. So slope $\Delta I/\Delta V$ is $1/R$ (conductance).

9 **A resistor stays at constant temperature. If the potential difference across it doubles, the current through it will:**

- A Halve
- B **Double** ✓
- C Quadruple
- D Stay the same
- E Become zero

▶ **Explanation:** For an ohmic resistor at constant temperature, $V = IR$, so I is directly proportional to V. Doubling V doubles I.

10 **A uniform wire has resistance R. If its length is doubled (same material and cross-sectional area), its resistance becomes:**

- A R/2
- B R
- C **2R** ✓
- D 4R
- E R^2

▶ **Explanation:** Resistance of a uniform wire follows $R = \ L/A$. Doubling L doubles R (if and A stay the same).

11 **A uniform wire has resistance R. If its cross-sectional area is doubled (same material and length), its resistance becomes:**

- A 2R
- B R
- C **R/2** ✓
- D 4R
- E R^2

▶ **Explanation:** From $R = \ L/A$, increasing A reduces R. Doubling A halves R.

12 **Which statement about resistivity is correct?**

- A depends on the length of the conductor
- B depends on the cross-sectional area of the conductor

C **is a property of the material (and temperature), not the object's shape ✓**

D is the same as resistance R

E is measured in ohms (Ω)

▶ **Explanation:** Resistivity is a material property (affected by temperature). Geometry changes resistance via L and A, but not . Units of are Ω · m, not Ω.

13 **As the temperature of a typical metal wire increases, its resistance usually:**

A Decreases because electrons move faster

B **Increases because lattice vibrations cause more collisions ✓**

C Stays constant because resistance depends only on length

D Becomes zero

E Becomes negative

▶ **Explanation:** In metals, higher temperature increases lattice vibrations, increasing electron scattering and thus resistance.

14 **A filament lamp is connected to a battery. As the current increases, the filament heats up. Which best describes the lamp's I–V behavior?**

A Linear: V is always proportional to I

B **Nonlinear: resistance increases with current/temperature, so the slope V/I increases ✓**

C Nonlinear: resistance decreases with current/temperature, so the slope V/I decreases

D The current becomes independent of voltage

E The lamp becomes a perfect conductor at higher current

▶ **Explanation:** A filament's resistance rises as it heats, so current does not increase proportionally with voltage. The I–V curve bends because the effective resistance increases.

15 **An NTC thermistor is a component whose resistance decreases when temperature increases. Which best explains why it is non-ohmic in typical use?**

- A Because Ohm's law never applies to semiconductors
- B **Because the resistance changes as current heats it, so V is not proportional to I under changing temperature** ✓
- C Because it has zero resistance at all temperatures
- D Because it only works in parallel circuits
- E Because current is not defined in thermistors

▶ **Explanation:** Ohm's law requires constant physical conditions. In an NTC thermistor, current can heat the device, changing its resistance, so the V–I relationship becomes nonlinear.

16 **Two resistors are connected in series to a battery. Which statement is always true (ideal components)?**

- A The voltage across each resistor is the same
- B **The current through each resistor is the same** ✓
- C The power dissipated by each resistor is the same
- D The resistance of the combination is less than each resistor
- E The total current equals the sum of currents through each resistor

▶ **Explanation:** In series, there is only one path, so the same current flows through each component. Voltages generally divide, and equivalent resistance is the sum (larger than each).

17 **Two resistors R1 and R2 are connected in series. If R2 > R1, then the voltage drop across R2 is:**

- A Smaller than across R1 because current chooses the easier path
- B Equal to across R1 because series circuits share voltage equally
- C **Greater than across R1 because the same current flows and V = IR** ✓
- D Zero because the larger resistor blocks the circuit
- E Unpredictable without knowing the battery's internal resistance

▶ **Explanation:** In series, current is the same through both. Since V = IR, the larger resistance has the larger voltage drop.

18 **Two resistors are connected in parallel to a battery. Which statement is always true (ideal components)?**

- A The current through each resistor is the same
- B **The voltage across each resistor is the same** ✓
- C The equivalent resistance is the sum of the resistances
- D The voltage across the combination is zero
- E The power dissipated by each resistor is equal

▶ **Explanation:** In parallel, each branch connects across the same two nodes, so each branch has the same potential difference. Currents can differ depending on resistance.

19 **Which statement about equivalent resistance is correct?**

- A Two resistors in series have an equivalent resistance smaller than either one
- B Two resistors in parallel have an equivalent resistance larger than either one

C **For two resistors in parallel, the equivalent resistance is less than the smaller resistor** ✓

D Series and parallel give the same equivalent resistance

E Equivalent resistance is always the average of the resistances

▶ **Explanation:** Parallel provides more paths for current, so overall opposition decreases: R_{eq} in parallel is always less than the smallest individual resistor.

20 **A circuit has a fixed battery voltage and a single resistor. If a second resistor is added in series, the total current drawn from the battery will:**

A Increase

B **Decrease** ✓

C Stay the same

D Become zero for any added resistor

E Reverse direction

▶ **Explanation:** Adding a series resistor increases total resistance, so with fixed voltage the current $I = V/R_{total}$ decreases.

21 **A circuit has a fixed battery voltage and a single resistor. If a second resistor is added in parallel, the total current drawn from the battery will:**

A Decrease because current splits

B **Increase because total equivalent resistance decreases** ✓

C Stay the same because voltage stays the same

D Become zero because parallel cancels resistance

E Become unpredictable

▶ **Explanation:** Parallel reduces equivalent resistance. With a fixed supply voltage, $I_{total} = V/R_{eq}$ increases even though current splits between branches.

22 **A single identical bulb is connected to an ideal battery. Then two identical bulbs are connected in series to the same battery. Compared with the single-bulb case, each bulb in series will be:**

- A Brighter
- B **Dimmer** ✓
- C Same brightness
- D Off (no current flows)
- E Brightness cannot be compared without the bulb's color

▶ **Explanation:** Two identical bulbs in series have higher total resistance, reducing current. Each bulb gets less power, so each is dimmer than a single bulb alone.

23 **A single identical bulb is connected to an ideal battery. Then two identical bulbs are connected in parallel to the same battery. Compared with the single-bulb case, each bulb in parallel will be:**

- A Brighter
- B Dimmer
- C **Same brightness** ✓
- D Off because current splits
- E Alternating between bright and dim

▶ **Explanation:** In parallel, each bulb gets the full battery voltage, so each dissipates the same power as a single bulb alone (assuming an ideal battery with no internal resistance). Total current increases, but brightness per bulb stays the same.

24 **Two resistors R1 and R2 are in series with a battery. Which resistor dissipates more power?**

- A The smaller resistance always dissipates more power
- **B The larger resistance always dissipates more power ✓**
- C They dissipate equal power in series
- D Power depends only on the battery voltage, so it's equal
- E Impossible to know without numerical values

▶ **Explanation:** In series the current is the same through both. Power in a resistor can be written $P = I^2R$, so the larger R dissipates more power.

25 **Two resistors R1 and R2 are connected in parallel across the same ideal battery. Which resistor dissipates more power?**

- A The larger resistance always dissipates more power
- **B The smaller resistance always dissipates more power ✓**
- C They dissipate equal power in parallel
- D Power depends only on current, so it's equal
- E Impossible to know without numerical values

▶ **Explanation:** In parallel, each resistor has the same voltage V. Power is $P = V^2/R$, so the smaller resistance dissipates more power (since dividing by smaller R gives larger P).

26 **Which expression for electrical power is always valid for any circuit element?**

- A **$P = IV$** ✓
- B $P = I/R$
- C $P = V/R$
- D $P = IR$
- E $P = V^2I$

▶ **Explanation:** Power transferred electrically is $P = IV$ (rate of energy transfer = charge flow rate × energy per charge). Other forms like $P = I^2R$ or V^2/R follow only when Ohm's law applies for a resistor.

27 For a resistor that obeys Ohm's law, which expression for power dissipated in the resistor is correct?

- A $P = V + I$
- B **$P = I^2R$** ✓
- C $P = R/I^2$
- D $P = V/R^2$
- E $P = R^2/I$

▶ **Explanation:** Starting from $P = IV$ and using $V = IR$ for a resistor gives $P = I(IR) = I^2R$.

28 For a resistor that obeys Ohm's law, which alternative expression for power is correct?

- A **$P = V^2/R$** ✓
- B $P = V/R^2$
- C $P = R/V^2$
- D $P = V^2R$

E $P = (V/R)^2R^2$

▶ **Explanation:** From $P = IV$ and $I = V/R$ for an ohmic resistor, $P = V(V/R) = V^2/R$.

29 **A heater uses power P for a time t. The electrical energy transferred is:**

A $E = P/t$

B **$E = Pt$** ✓

C $E = P^2t$

D $E = It$

E $E = V/t$

▶ **Explanation:** Power is energy per unit time. Rearranging gives energy $E = Pt$.

30 **A fuse in a household circuit is designed to:**

A Increase current when needed

B Measure voltage in parallel

C **Melt and break the circuit if current exceeds a safe value** ✓

D Provide extra resistance to save energy

E Store charge to smooth out voltage

▶ **Explanation:** A fuse is a safety device placed in series that melts when excessive current flows, interrupting the circuit to prevent overheating/fire.

31 **Compared with a fuse, a circuit breaker has the advantage that it:**

- A Works only for low voltages
- B **Can be reset after tripping** ✓
- C Always allows more current before breaking
- D Stores electrical energy
- E Reduces the resistance of the circuit

▶ **Explanation:** A breaker trips when current is too high but can be reset, unlike a fuse which must be replaced after it melts.

32 **A voltmeter should be connected:**

- A In series with the component, with very low resistance
- B **In parallel with the component, with very high resistance** ✓
- C In parallel with the component, with very low resistance
- D In series with the component, with very high resistance
- E Across the battery only, never across components

▶ **Explanation:** A voltmeter measures potential difference across a component, so it must be in parallel. High resistance ensures it draws negligible current and doesn't significantly disturb the circuit.

33 **An ammeter should be connected:**

- A **In series with the component, with very low resistance** ✓
- B In parallel with the component, with very low resistance

C In series with the component, with very high resistance

D In parallel with the component, with very high resistance

E Only across the battery terminals

▶ **Explanation:** An ammeter measures the current through a component, so it must be in series. Low resistance prevents it from significantly reducing current.

34 **If a voltmeter mistakenly had a LOW resistance and was connected in parallel across a resistor, what would be the main consequence?**

A It would measure the voltage more accurately

B **It would draw significant current and change the circuit's behavior (measurement error)** ✓

C It would stop current in the whole circuit

D The resistor would become ohmic

E Voltage would become negative

▶ **Explanation:** A low-resistance voltmeter in parallel becomes an extra low-resistance branch, drawing significant current and altering the total current and voltage distribution—so the measurement is disturbed.

35 **If an ammeter mistakenly had a HIGH resistance and was placed in series, what would be the main consequence?**

A It would increase current because resistance adds power

B **It would greatly reduce the circuit current, making the measurement unrepresentative** ✓

C It would not affect current because series current is fixed

D It would reverse the current direction

E It would make the circuit parallel

▶ **Explanation:** A high-resistance ammeter in series increases total resistance, reducing current and changing the circuit conditions. A proper ammeter must have very low resistance.

36 A 'short circuit' is dangerous primarily because it:

A Increases resistance so much that devices stop working

B **Creates a very large current that can cause overheating and fire ✓**

C Makes voltage negative

D Eliminates the need for fuses

E Stops all charge movement

▶ **Explanation:** A short circuit provides a very low resistance path, so current becomes very large (limited mainly by internal resistance), causing large power dissipation and heating.

37 An 'open circuit' means:

A The resistance is very small

B The current is maximum

C **There is a break so no complete path for current (current is zero) ✓**

D The battery voltage becomes infinite

E The circuit becomes parallel

▶ **Explanation:** If the circuit is open (broken), there is no closed loop, so current cannot flow ($I = 0$).

38 **Kirchhoff's junction rule states that at a junction (node):**

- A Voltage is the same in all branches
- B **Sum of currents entering equals sum of currents leaving** ✓
- C Sum of resistances equals zero
- D Current is the same in all branches
- E Power is conserved in each component

▶ **Explanation:** Kirchhoff's current law is conservation of charge: no net charge builds up at a junction, so currents in and out must balance.

39 **Kirchhoff's loop rule states that around any closed loop in a circuit:**

- A The sum of currents is zero
- B The sum of resistances is zero
- C **The sum of potential differences (rises and drops) is zero** ✓
- D The sum of powers is zero
- E Voltage is always the same across all elements

▶ **Explanation:** Kirchhoff's voltage law reflects conservation of energy: the net change in electric potential around a loop is zero (voltage rises equal voltage drops).

40 **Two resistors form a potential divider (series) connected to a battery. The output voltage is measured across the LOWER resistor R2. If R2 is increased (battery voltage fixed), the output voltage across R2 will:**

- A **Increase** ✓

B Decrease

C Stay the same

D Become zero

E Become equal to the current

▶ **Explanation:** For a divider, $V_{out} = V_{supply} \times R2/(R1+R2)$. Increasing R2 increases the fraction of total resistance across which you measure, so V_{out} rises (approaching V_{supply} as R2 dominates).

41 A potential divider has R1 on top and R2 on bottom. The output is taken across R2. If R1 is increased while R2 and the supply stay fixed, the output voltage across R2 will:

A Increase

B **Decrease** ✓

C Stay the same

D Become equal to the supply voltage

E Become negative

▶ **Explanation:** $V_{out} = V_{supply} \times R2/(R1+R2)$. Increasing R1 increases the denominator, reducing V_{out}. The trap is forgetting the output is across R2, not across the whole divider.

42 A battery has emf E and internal resistance r. Which statement is correct when the battery supplies a larger current to a load?

A Terminal voltage increases because more electrons leave the battery

B **Terminal voltage decreases because the internal voltage drop Ir increases** ✓

C Terminal voltage stays equal to E always

D Emf decreases to conserve energy

E Internal resistance becomes zero

▶ **Explanation:** As current increases, the internal drop Ir grows, so $V_{terminal} = E - Ir$ decreases. Emf is a property of the source (approximately constant), while terminal voltage depends on load current.

43 A battery is not connected to anything (open circuit). Ideally, the terminal potential difference measured across its terminals equals:

A 0

B **Its emf** ✓

C Half its emf

D Negative emf

E Ir

▶ **Explanation:** With no current ($I = 0$), there is no internal drop Ir, so terminal voltage equals the emf.

44 Capacitance C is defined as:

A $C = V/Q$

B $\mathbf{C = Q/V}$ ✓

C $C = IV$

D $C = IR$

E $C = V/I$

▶ **Explanation:** Capacitance measures how much charge is stored per unit potential difference: $C = Q/V$.

45 **The SI unit of capacitance is the farad (F). One farad is equivalent to:**

- A $C \cdot V$
- B V/C
- C **C/V** ✓
- D J/C
- E $N \cdot m$

▶ **Explanation:** From $C = Q/V$, the unit is coulomb per volt (C/V). J/C is a volt, not a farad.

46 **For a capacitor with fixed capacitance C, if the charge on it doubles, the potential difference across it will:**

- A Halve
- B **Double** ✓
- C Quadruple
- D Stay the same
- E Become zero

▶ **Explanation:** $Q = CV$, so $V = Q/C$. If Q doubles while C is constant, V doubles.

47 **For a capacitor connected to a fixed battery voltage V, if the capacitance doubles, the charge stored on the capacitor will:**

- A Halve

B **Double** ✓

C Quadruple

D Stay the same

E Become zero

▶ **Explanation:** With V fixed, Q = CV. Doubling C doubles Q.

48 **A charged capacitor primarily stores energy in:**

A The motion of electrons through the capacitor

B **The electric field between its plates** ✓

C The magnetic field inside the plates (only)

D Heat in the dielectric (always)

E The capacitor's resistance

▶ **Explanation:** A capacitor stores energy in the electric field created by separated charges. During charging/discharging, energy can also be dissipated in circuit resistance, but that's not where it is stored.

49 **Which expression gives the energy stored in a capacitor of capacitance C at potential difference V?**

A $U = CV$

B **$U = (1/2)CV^2$** ✓

C $U = IV$

D $U = V^2/C$

E $U = (1/2)C/V^2$

▶ **Explanation:** Energy stored is $U = (1/2)CV^2$ (also equal to $Q^2/(2C)$ or $(1/2)QV$). Forms like CV have units of charge, not energy.

50 **A capacitor remains at fixed capacitance C. If the voltage across it doubles, the stored energy becomes:**

- A Twice as large
- B **Four times as large** ✓
- C Half as large
- D One quarter as large
- E Unchanged

▶ **Explanation:** $U = (1/2)CV^2$, so energy scales with V^2. Doubling V makes U four times larger.

51 **A capacitor stays connected to a battery so V is constant. If capacitance C doubles, the stored energy becomes:**

- A Half as large
- B **Twice as large** ✓
- C Four times as large
- D Unchanged
- E Zero

▶ **Explanation:** With V fixed, $U = (1/2)CV^2$ is directly proportional to C. Doubling C doubles U.

52 **Two capacitors are connected in parallel to a battery. Which statement is correct?**

- A The charge on each capacitor is the same
- B **The voltage across each capacitor is the same ✓**
- C The equivalent capacitance is smaller than either capacitor
- D The current through each capacitor is constant forever
- E Parallel capacitors always reduce total stored energy

▶ **Explanation:** In parallel, capacitors share the same two nodes, so they have the same voltage. Their charges generally differ ($Q = CV$). Equivalent capacitance increases in parallel.

53 **Two capacitors are connected in series. Which statement is correct (ideal capacitors)?**

- A Each capacitor has the same voltage
- B **Each capacitor stores the same charge magnitude ✓**
- C The equivalent capacitance is the sum of the capacitances
- D The equivalent capacitance is greater than each individual capacitance
- E No charge can exist on capacitors in series

▶ **Explanation:** In series, the same charge must pass onto each capacitor, so charge magnitudes are equal. Voltages generally divide (not necessarily equal). Equivalent capacitance is less than the smallest capacitor.

54 **Which statement about equivalent capacitance is correct?**

- A Capacitors in series add directly: $C_{eq} = C1 + C2$

B **Capacitors in parallel add directly: $C_{eq} = C1 + C2$ ✓**

C Capacitors in parallel always reduce total capacitance

D Capacitors in series always give C_{eq} larger than each capacitor

E C_{eq} for series is always the average of C1 and C2

▶ **Explanation:** Parallel capacitors add: $C_{eq} = C1 + C2$. Series capacitors combine via reciprocals: $1/C_{eq} = 1/C1 + 1/C2$, giving a smaller capacitance than either.

55 Two identical capacitors each of capacitance C are connected in series. Their equivalent capacitance is:

A 2C

B C

C **C/2 ✓**

D C^2

E 0

▶ **Explanation:** For two in series: $1/C_{eq} = 1/C + 1/C = 2/C$, so $C_{eq} = C/2$. Series reduces capacitance.

56 Two identical capacitors each of capacitance C are connected in parallel. Their equivalent capacitance is:

A C/2

B C

C **2C ✓**

D C^2

E 0

▶ **Explanation:** Parallel capacitances add: $C_{eq} = C + C = 2C$.

57 **For a parallel-plate capacitor, capacitance increases if you:**

- A Decrease the plate area
- B Increase the plate separation
- C **Increase the plate area** ✓
- D Remove charge from the plates
- E Decrease the battery voltage

▶ **Explanation:** For parallel plates, C A/d (and depends on dielectric). Larger plate area means more capacitance. Voltage and charge change Q and V, not the capacitance itself (geometry/material property).

58 **For a parallel-plate capacitor, capacitance decreases if you:**

- A Decrease the plate separation
- B **Increase the plate separation** ✓
- C Insert a dielectric
- D Increase the plate area
- E Increase the charge on the plates

▶ **Explanation:** C 1/d, so increasing separation reduces capacitance. A dielectric increases capacitance, and changing charge does not change capacitance for fixed geometry/material.

59 **Inserting a dielectric between capacitor plates (without changing geometry) generally causes the capacitance to:**

- A Decrease
- B **Increase** ✓
- C Stay the same
- D Become zero
- E Become negative

▶ **Explanation:** A dielectric increases capacitance by reducing the effective electric field for a given charge, allowing more charge to be stored for the same voltage.

60 **An uncharged capacitor is connected to a DC battery through a resistor. Immediately after connection ($t = 0+$), the capacitor behaves most like:**

- A An open circuit (no current)
- B **A short circuit (very low voltage across it initially)** ✓
- C A constant current source
- D A diode
- E A fuse

▶ **Explanation:** At $t = 0$, the capacitor has no charge, so $Vc = Q/C = 0$. It initially allows maximum current limited by the resistor, like a short (not a sustained short forever).

61 **In the same RC charging circuit, after a long time (steady state with DC), the capacitor behaves most like:**

- A A short circuit

- **B** A resistor of value R
- **C** **An open circuit (no current through it)** ✓
- **D** A current source
- **E** A transformer

▶ **Explanation:** With DC, once fully charged, the capacitor's voltage equals the battery voltage and no further charge flows, so current becomes zero: it behaves like an open circuit.

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62 **The time constant of an RC circuit is:**

- **A** $= R/C$
- **B** **$= RC$** ✓
- **C** $= C/R$
- **D** $= R + C$
- **E** $= 1/(RC)$

▶ **Explanation:** The RC time constant is $= RC$ and sets the timescale of exponential charging/discharging.

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63 **The SI unit of the RC time constant $= RC$ is:**

- **A** Ohm (Ω)
- **B** Farad (F)
- **C** **Second (s)** ✓
- **D** Volt (V)
- **E** Watt (W)

▶ **Explanation:** $\Omega \cdot F = (V/A) \cdot (C/V) = C/A = s$, since 1 A = 1 C/s.

64 **In an RC charging circuit, after one time constant = RC, the capacitor voltage Vc is approximately:**

- A 0% of the final battery voltage
- B 37% of the final battery voltage
- C 50% of the final battery voltage
- D **63% of the final battery voltage** ✓
- E 100% of the final battery voltage

▶ **Explanation:** Charging follows Vc(t) = V(1 − e^(−t/RC)). At t = RC, Vc V(1 − 1/e) 0.63V.

65 **In an RC charging circuit, after one time constant , the current has fallen to approximately:**

- A 0% of its initial value
- B **37% of its initial value** ✓
- C 50% of its initial value
- D 63% of its initial value
- E 100% of its initial value

▶ **Explanation:** Charging current decays as I(t) = I0 e^(−t/RC). At t = RC, I I0/e 0.37 I0.

66 **If resistance R in an RC circuit is doubled while capacitance C stays the same, the time constant becomes:**

- A Half as large
- B **Twice as large ✓**
- C Four times as large
- D Unchanged
- E Zero

▶ **Explanation:** Since = RC, doubling R doubles . The process becomes slower (takes longer to reach the same fraction of final voltage).

67 **If capacitance C in an RC circuit is doubled while resistance R stays the same, the time constant becomes:**

- A Half as large
- B **Twice as large ✓**
- C Four times as large
- D Unchanged
- E Zero

▶ **Explanation:** = RC, so doubling C doubles , slowing charging/discharging.

68 **An uncharged capacitor is charged from an ideal battery through a resistor R. Which statement about the INITIAL charging current ($t = 0+$) is correct?**

- A It depends on the capacitance C: larger C gives larger initial current
- B It depends on the capacitance C: larger C gives smaller initial current

C **It is approximately V/R and does not depend on C** ✓

D It is zero because capacitors block DC

E It is infinite because the capacitor is a short circuit forever

▶ **Explanation:** At t = 0+, the capacitor voltage is 0, so the full battery voltage appears across the resistor, giving I0 = V/R. Capacitance affects how quickly current decays, not the initial value.

69 A capacitor initially charged to voltage V0 discharges through a resistor R. After one time constant = RC, the capacitor voltage is approximately:

A 0% of V0

B **37% of V0** ✓

C 50% of V0

D 63% of V0

E 100% of V0

▶ **Explanation:** Discharging follows V(t) = V0 e^(−t/RC). At t = RC, V V0/e 0.37 V0.

70 When a charged capacitor discharges through a resistor, the energy originally stored in the capacitor is mainly converted into:

A Gravitational potential energy

B Kinetic energy of the capacitor plates

C **Heat in the resistor (thermal energy)** ✓

D Extra electric charge created from nothing

E Mass of the electrons

▶ **Explanation:** During discharge, current flows through the resistor and electrical energy is dissipated as thermal energy (Joule heating). The capacitor's electric field energy decreases accordingly.

71 A capacitor is charged from an ideal battery of voltage V through a resistor until fully charged. (Ideal components.) Compared to the total energy supplied by the battery, the energy finally stored in the capacitor is:

- A All of it (100%)
- B **About half of it; the other half is dissipated as heat in the resistor** ✓
- C About a quarter of it
- D Zero; no energy is stored in a capacitor
- E More than the battery supplied (energy gain)

▶ **Explanation:** Charging a capacitor through a resistor from a fixed-voltage source results in energy stored $U = (1/2)CV^2$. The battery supplies CV^2 in total; the other half is dissipated in the resistor as heat (a classic conceptual result).

72 A capacitor remains connected to a battery (constant V). A dielectric is inserted fully between the plates. What happens?

- A Capacitance decreases, charge decreases, stored energy decreases
- B Capacitance increases, voltage increases, charge stays the same
- C **Capacitance increases, voltage stays the same, charge increases** ✓
- D Capacitance increases, charge stays the same, voltage increases
- E Nothing changes because the battery fixes everything

▶ **Explanation:** With the battery connected, V is fixed. Inserting a dielectric increases C, so $Q = CV$ increases. Additional charge flows from the battery onto the plates; energy stored also increases (battery does work).

73 **A charged capacitor is isolated (disconnected from any battery) so its charge Q is fixed. A dielectric is inserted fully between the plates. What happens?**

- A **Capacitance increases, voltage decreases, stored energy decreases ✓**
- B Capacitance increases, voltage increases, stored energy increases
- C Capacitance decreases, voltage decreases, stored energy decreases
- D Capacitance stays the same because it is isolated
- E Charge becomes zero instantly

▶ **Explanation:** With Q fixed and C increased, $V = Q/C$ decreases. Energy $U = Q^2/(2C)$ decreases as C increases. The "missing" energy is transferred to mechanical work/heat as the dielectric is pulled in.

74 **A capacitor C is charged to voltage V and then disconnected from the battery. It is then connected in parallel to an identical uncharged capacitor. Which statement is correct (ideal wires, no battery)?**

- A Final voltage remains V and total stored energy stays the same
- B **Final voltage becomes V/2 and some energy is dissipated (e.g., as heat/radiation) during charge redistribution ✓**
- C Final voltage becomes 2V because charge doubles
- D Final voltage becomes zero because charge cancels
- E Charge is not conserved in capacitors, so nothing can be predicted

▶ **Explanation:** Total charge is conserved. Two identical capacitors in parallel share the charge equally, so the voltage halves. Energy decreases because redistribution involves current flow through resistance of wires, dissipating energy (even if tiny).

75 Why can a capacitor help smooth the output of a rectifier (reducing ripple in a DC supply)?

- A Because it permanently increases the battery voltage
- B Because it converts AC directly into DC without losses
- C **Because it stores charge when voltage is high and releases charge when voltage drops, reducing fluctuations** ✓
- D Because it blocks all current so the output becomes constant
- E Because capacitance decreases when voltage changes

▶ **Explanation:** A smoothing capacitor charges up near the peaks of the rectified voltage and discharges between peaks into the load, keeping the output voltage from dropping as much (less ripple).