Electrical Circuits

DC Circuit Analysis Quiz – Answer Key

1. **(C) 2Ω.** For parallel resistors: $1/R_{eq} = 1/6 + 1/6 + 1/6 = 3/6 = 1/2$, so $R_{eq} = 2\Omega$.

2. **(B) The sum of currents entering a node equals the sum leaving.** KCL is based on conservation of charge—no charge accumulates at a node: $\sum I_{in} = \sum I_{out}$.

3. **(B) 36W.** Current $I = V/R = 12/4 = 3$A. Power $P = I^2R = 9 \times 4 = 36$W. Or $P = V^2/R = 144/4 = 36$W.

4. **(B) Current.** In series, components share the same current path. Voltage divides across components; total resistance is the sum of individual resistances.

5. **(B) $R \times C$.** Time constant $\tau = RC$ (in seconds when R in ohms, C in farads). After one time constant, capacitor charges to 63.2% of final value.

6. **True.** An ideal voltage source has zero internal resistance and maintains constant terminal voltage regardless of load current (infinite current capability in theory).

7. **False.** Thevenin's theorem states a linear circuit can be replaced by a voltage source in series with a resistor (V_{Th} in series with R_{Th}). Norton's theorem uses a current source in parallel with a resistor.

8. **True.** Maximum power transfer theorem: P_{max} occurs when $R_{load} = R_{source}$. At this point, efficiency is 50% (half the power dissipated in source resistance).

9. **Kirchhoff's Voltage Law (KVL):**

   - Statement: The algebraic sum of voltages around any closed loop equals zero
   - Based on conservation of energy
   - Sign convention: Voltage rises positive, drops negative (or vice versa, consistently)
   - Equation: $\sum V = 0$ around any closed path

   Kirchhoff's Current Law (KCL):

   - Statement: Sum of currents entering a node equals sum leaving
   - Based on conservation of charge
   - Equation: $\sum I_{in} = \sum I_{out}$ or $\sum I = 0$ (with sign convention)

   Analysis procedure:

   (a) Identify nodes and assign node voltages or loop currents

   (b) Apply KCL at each node (for nodal analysis)

   (c) Apply KVL around each independent loop (for mesh analysis)

   (d) Solve simultaneous equations

Example (two-loop circuit): Loop 1: $V_s - I_1R_1 - (I_1 - I_2)R_2 = 0$ Loop 2: $(I_2 - I_1)R_2 - I_2R_3 = 0$

10. **Thevenin's Theorem:**

    - Any linear two-terminal circuit can be replaced by a voltage source V_{Th} in series with a resistance R_{Th}
    - V_{Th} = open-circuit voltage across terminals
    - R_{Th} = equivalent resistance seen from terminals with sources deactivated (voltage sources shorted, current sources opened)

    Norton's Theorem:

    - Any linear two-terminal circuit can be replaced by a current source I_N in parallel with a resistance R_N
    - I_N = short-circuit current between terminals
    - R_N = equivalent resistance (same as R_{Th})

    Finding Thevenin equivalent:

    (a) Remove the load from the circuit

    (b) Calculate V_{Th}: voltage across open terminals

    (c) Calculate R_{Th}: deactivate sources, find equivalent resistance

    (d) Reconnect load to Thevenin equivalent

    Relationship between Thevenin and Norton:

    $$\begin{aligned} V_{Th} &= I_N \times R_N \\ R_{Th} &= R_N \\ I_N &= V_{Th}/R_{Th} \end{aligned}$$

    Thevenin and Norton are source transformations—either can represent the same circuit behavior at the terminals.