Effects of Electric Current — Joule's Law & Power

TEACHER ANSWER KEY & DERIVATIONS

Q1. What is the SI unit of heat energy produced in an electrical conductor? [1 Mark]

(A) Watt (W)

(B) Joule (J) ✓ Correct

(C) Ampere (A)

(D) Volt (V)

STEP-BY-STEP DERIVATION & EXPLANATION:
Heat energy H is measured in Joules (J) according to SI standards. Power is measured in Watts (W).

Q2. According to Joule's Law, which equation represents heat energy H produced by current I through resistance R in time t? [1 Mark]

(A) $H = V \times I$

(B) $H = I^2 R t$ ✓ Correct

(C) $H = V / R t$

(D) $H = P t^2$

STEP-BY-STEP DERIVATION & EXPLANATION:
Joule's Law of heating states $H = I^2 R t$, where heat is directly proportional to square of current, resistance, and time.

Q3. If the electric current flowing through a fixed resistor is doubled, how does the heat energy generated change? [1 Mark]

(A) Increases by 2 times

(B) Increases by 4 times ✓ Correct

(C) Decreases to half

(D) Remains unchanged

STEP-BY-STEP DERIVATION & EXPLANATION:
Since $H \propto I^2$, doubling current ($2^2 = 4$) increases heat generation by 4 times.

Q4. Which of the following is the correct formula for electric power P in terms of voltage V and resistance R? [1 Mark]

(A) $P = V \times R$

(B) $P = V^2 / R$ ✓ Correct

(C) $P = I^2 V$

(D) $P = V R t$

STEP-BY-STEP DERIVATION & EXPLANATION:
Electric power $P = V I$. Substituting $I = V / R$ gives $P = V^2 / R$.

Q5. Why is a safety fuse wire constructed using a tin-lead alloy? [1 Mark]

(A) High melting point & zero resistance

(B) Low melting point & appropriate resistance ✓ Correct

(C) High boiling point & high conductivity

(D) Low ductility

STEP-BY-STEP DERIVATION & EXPLANATION:
Fuse wire has a low melting point so that when excess current flows (I^2R heat builds up), it melts quickly to break the circuit.

Q6. What is the commercial unit of electrical energy consumed in households? [1 Mark]

(A) Watt-second

(B) Kilowatt-hour (kWh) ✓ Correct

(C) Volt-Ampere

(D) Ohm-metre

STEP-BY-STEP DERIVATION & EXPLANATION:
1 Kilowatt-hour (kWh) $= 3.6 \times 10^6$ Joules $= 1$ Unit of electricity.

Q7. An electrical appliance rated $230\ V$ consumes $920\ W$ power. What is the current drawn by the appliance? [1 Mark]

(A) $2\ A$

(B) $4\ A$ ✓ Correct

(C) $6\ A$

(D) $10\ A$

STEP-BY-STEP DERIVATION & EXPLANATION:
Using $P = V \times I \Rightarrow I = P / V = 920 / 230 = 4$ Amperes (A).

Q8. How are high-power electrical appliances connected in domestic distribution wiring? [1 Mark]

(A) Series connection

(B) Parallel connection ✓ Correct

(C) Single line loop

(D) Open circuit

STEP-BY-STEP DERIVATION & EXPLANATION:
Appliances are connected in parallel so each appliance receives full supply voltage ($230\ V$) independently.

Q9. What is the primary function of earthing in household electrical wiring? [1 Mark]

(A) Increase electrical voltage

(B) Prevent electric shock during insulation leakage ✓ Correct

(C) Reduce electricity bill

(D) Boost current frequency

STEP-BY-STEP DERIVATION & EXPLANATION:
Earthing connects the metal body of appliances to the ground, providing a safe low-resistance path for leakage currents.

Q10. An electric heater of $100\ \Omega$ resistance operates on a $200\ V$ line for $10\ s$. Calculate heat H generated. [1 Mark]

(A) 2,000 J

(B) 4,000 J ✓ Correct

(C) 20,000 J

(D) 40,000 J

STEP-BY-STEP DERIVATION & EXPLANATION:

Using $H = V^2 / R t = 200^2 / 100 \times 10 = 40,000 / 100 \times 10 = 400 \times 10 = 4,000$ Joules (J).