INKPHYSICS FLASHCARDS

Electricity

Year 12 · 24 cards · fronts and backs

Print double-sided, flipping on the long edge, and each answer lands behind its question. Cut along the card borders.

Definitions in mark-scheme wording, the equations that are not on the data sheet, each lesson's check question, and the misconceptions that lose marks. The same cards run on the website with spaced-repetition scheduling, at inkphysics.co.uk/flashcards.

DEFINITION

Define: Electric current.

CURRENT, CHARGE AND THE DIRECTION PROBLEM

DEFINITION

Define: Potential difference.

CURRENT, CHARGE AND THE DIRECTION PROBLEM

DEFINITION

Define: Resistance.

CURRENT, CHARGE AND THE DIRECTION PROBLEM

CHECK YOURSELF

A lamp carries a current of 0.25 A for 2.0 minutes. (a) How much charge passes through it? (b) How many electrons is that?

Hint: Seconds first. Then remember that charge comes in fixed lumps.

CURRENT, CHARGE AND THE DIRECTION PROBLEM

SPOT THE ERROR

Say what is wrong with this claim:

The current arrows show which way the electrons go.

CURRENT, CHARGE AND THE DIRECTION PROBLEM

DEFINITION

Define: Ohm's law.

CURRENT-VOLTAGE CHARACTERISTICS

DEFINITION

Define: Semiconductor diode.

CURRENT-VOLTAGE CHARACTERISTICS

CHECK YOURSELF

From a filament lamp's characteristic: at 2.0 V the current is 0.50 A, and at 12 V it is 1.5 A. Find the resistance at each point, and explain the change.

Hint: Resistance is a ratio of coordinates, taken twice.

CURRENT-VOLTAGE CHARACTERISTICS

DEFINITION

The work done per unit charge moving between two points: $V = W/Q$, in volts.

CURRENT, CHARGE AND THE DIRECTION PROBLEM

DEFINITION

The rate of flow of charge: $I = \Delta Q/\Delta t$.

CURRENT, CHARGE AND THE DIRECTION PROBLEM

CHECK YOURSELF

(a) $\Delta Q = I\Delta t = 0.25 \times 120 = 30$ C.

(b) Each electron carries 1.60×10^{-19} C, so $n = 30 / 1.60 \times 10^{-19} = 1.9 \times 10^{20}$ electrons. A colossal number for a modest lamp; at counts like that, grainy charge behaves as a smooth fluid.

CURRENT, CHARGE AND THE DIRECTION PROBLEM

DEFINITION

The ratio of the potential difference across a component to the current through it: $R = V/I$.

CURRENT, CHARGE AND THE DIRECTION PROBLEM

DEFINITION

The current through an ohmic conductor is proportional to the potential difference across it, provided physical conditions such as temperature stay constant.

CURRENT-VOLTAGE CHARACTERISTICS

SPOT THE ERROR

Conventional current runs from + to - by an agreement that predates the electron. In a metal the moving charges are electrons, drifting the other way — and both descriptions give identical answers to every circuit question.

CURRENT, CHARGE AND THE DIRECTION PROBLEM

CHECK YOURSELF

At 2.0 V: $R = V/I = 2.0 / 0.50 = 4.0\ \Omega$. At 12 V: $R = 12 / 1.5 = 8.0\ \Omega$.

The resistance has doubled because the larger current runs the filament far hotter: its ions vibrate more, the carriers collide with them more often, and the same pd drives proportionally less current.

CURRENT-VOLTAGE CHARACTERISTICS

DEFINITION

A component that conducts with low resistance in the forward direction, above about 0.6 V, and has very high resistance in reverse.

CURRENT-VOLTAGE CHARACTERISTICS

SPOT THE ERROR

Say what is wrong with this claim:

Ohm's law applies to everything.

CURRENT-VOLTAGE CHARACTERISTICS

DEFINITION

Define: Resistivity.

RESISTIVITY AND SUPERCONDUCTIVITY

DEFINITION

Define: Superconductor.

RESISTIVITY AND SUPERCONDUCTIVITY

DEFINITION

Define: Thermistor.

RESISTIVITY AND SUPERCONDUCTIVITY

CHECK YOURSELF

A wire of length 2.5 m and diameter 0.40 mm has a resistance of 1.2 Ω. Find the resistivity of its material.

Hint: Area from the diameter first, in metres, then rearrange the resistivity equation.

RESISTIVITY AND SUPERCONDUCTIVITY

SPOT THE ERROR

Say what is wrong with this claim:

A material has a resistance.

RESISTIVITY AND SUPERCONDUCTIVITY

EQUATION — NOT ON THE DATA SHEET

Electrical energy transferred in time t:

E = ?

CIRCUITS AND KIRCHHOFF'S LAWS

CHECK YOURSELF

A 6.0 Ω and a 3.0 Ω resistor are connected in parallel, and the pair is in series with a 4.0 Ω resistor across a 12 V supply. Find the current drawn from the supply and the pd across the parallel pair.

Hint: Collapse the parallel pair first, then treat the circuit as a simple series loop.

CIRCUITS AND KIRCHHOFF'S LAWS

DEFINITION

The property of a material given by $\rho = RA/L$: the resistance of a piece of the material of unit length and unit cross-sectional area.

RESISTIVITY AND SUPERCONDUCTIVITY

SPOT THE ERROR

Ohm's law is not a universal law but a special case: current proportional to pd, at constant temperature. Filament lamps and diodes disobey it. $R = V/I$ still defines resistance at any point, but only for ohmic conductors is it constant.

CURRENT-VOLTAGE CHARACTERISTICS

DEFINITION

A semiconductor component whose resistance falls steeply as temperature rises.

RESISTIVITY AND SUPERCONDUCTIVITY

DEFINITION

A material whose resistivity falls to exactly zero when cooled below its critical temperature.

RESISTIVITY AND SUPERCONDUCTIVITY

SPOT THE ERROR

Resistance belongs to a specific object — double the wire's length and you double its R. Resistivity is the material's own property, the same for a centimetre of copper as for a kilometre of it.

RESISTIVITY AND SUPERCONDUCTIVITY

CHECK YOURSELF

Area: $A = \pi d^2/4 = \pi \times (0.40 \times 10^{-3})^2 / 4 = 1.26 \times 10^{-7}$ m^2.

$\rho = RA/L = 1.2 \times 1.26 \times 10^{-7} / 2.5 = 6.0 \times 10^{-8}\ \Omega$ m, a value typical of a pure metal.

RESISTIVITY AND SUPERCONDUCTIVITY

CHECK YOURSELF

Parallel pair: $1/R = 1/6.0 + 1/3.0$ gives $R = 2.0\ \Omega$, smaller than either branch, as it must be.

Total resistance: $2.0 + 4.0 = 6.0\ \Omega$, so the supply current is $I = 12 / 6.0 = 2.0$ A.

The pd across the pair: $V = IR = 2.0 \times 2.0 = 4.0$ V, leaving 8.0 V across the 4.0 Ω resistor. The loop's 12 V is fully accounted for.

CIRCUITS AND KIRCHHOFF'S LAWS

EQUATION — NOT ON THE DATA SHEET

$E = IVt$

CIRCUITS AND KIRCHHOFF'S LAWS

SPOT THE ERROR

Say what is wrong with this claim:

Current gets used up on the way round.

CIRCUITS AND KIRCHHOFF'S LAWS

EQUATION — NOT ON THE DATA SHEET

Potential divider output:

V_{out} = ?

POTENTIAL DIVIDERS

CHECK YOURSELF

A divider is built from a 4.0 kΩ resistor above an 8.0 kΩ resistor across a 12 V supply, output across the 8.0 kΩ. (a) Find the output. (b) The 4.0 kΩ resistor is replaced by a thermistor, which then warms up. What happens to the output, and why?

Hint: Part (b) needs no numbers: follow the ratio.

POTENTIAL DIVIDERS

SPOT THE ERROR

Say what is wrong with this claim:

The battery decides the voltage across each component.

POTENTIAL DIVIDERS

DEFINITION

Define: Electromotive force.

EMF AND INTERNAL RESISTANCE

DEFINITION

Define: Internal resistance.

EMF AND INTERNAL RESISTANCE

CHECK YOURSELF

A battery of emf 9.0 V and internal resistance 0.60 Ω drives a 4.4 Ω resistor. Find the current, the terminal pd, and the lost volts.

Hint: The emf pays for both resistances; the terminals only show the external share.

EMF AND INTERNAL RESISTANCE

SPOT THE ERROR

Say what is wrong with this claim:

A 1.5 V battery gives you 1.5 volts.

EMF AND INTERNAL RESISTANCE

EQUATION — NOT ON THE DATA SHEET

$V_{out} = V_{in} \times (R_2)/(R_1 + R_2)$

POTENTIAL DIVIDERS

SPOT THE ERROR

Current is charge in motion, and charge is conserved: the current returning to the battery equals the current that left it. What gets spent around the circuit is energy per coulomb — potential difference — not current.

CIRCUITS AND KIRCHHOFF'S LAWS

SPOT THE ERROR

The battery fixes only the total across the chain. How that total divides is set by the resistances: the same current flows through both, so each takes a share proportional to its resistance.

POTENTIAL DIVIDERS

CHECK YOURSELF

(a) V_{out} = 12 × 8.0/4.0 + 8.0 = 8.0 V.

(b) Warming an ntc thermistor lowers its resistance, so its share of the 12 V falls, and the share across the fixed 8.0 kΩ resistor, the output, rises towards 12 V. The supply never changed; the ratio did.

POTENTIAL DIVIDERS

DEFINITION

The resistance inside a source that makes the terminal pd fall below the emf when current flows: V = ε - Ir.

EMF AND INTERNAL RESISTANCE

DEFINITION

The energy transferred to each coulomb of charge by a source: ε = E/Q, equal to the terminal pd when no current flows.

EMF AND INTERNAL RESISTANCE

SPOT THE ERROR

The emf is the energy per coulomb the cell converts; some of it is spent inside the cell on its own internal resistance. The terminals deliver V = ε - Ir, so the harder you draw current, the less of the 1.5 V you see.

EMF AND INTERNAL RESISTANCE

CHECK YOURSELF

Current: I = ε/R + r = 9.0 / (4.4 + 0.60) = 1.8 A.

Terminal pd: V = IR = 1.8 × 4.4 = 7.9 V (equivalently ε - Ir).

Lost volts: Ir = 1.8 × 0.60 = 1.1 V. The 9.0 V splits as 7.9 outside plus 1.1 inside, and the books balance.

EMF AND INTERNAL RESISTANCE