Current Electricity – Topic Test

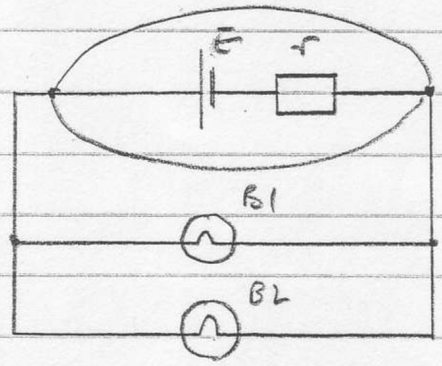
A level Physics
Current
Electricity

Answer all questions
State the Physics + explain
all your working.
Underline all answers.

- electron charge
  $e = -1.6 \times 10^{-19}$ C
- free electron density
  in Cu; $n_{Cu} = 10^{29}/m^3$
- resistivity...
  $\rho_{Cu} = 1.7 \times 10^{-8}$ Ωm
  $\rho_{tungsten} = 6 \times 10^{-8}$ Ωm

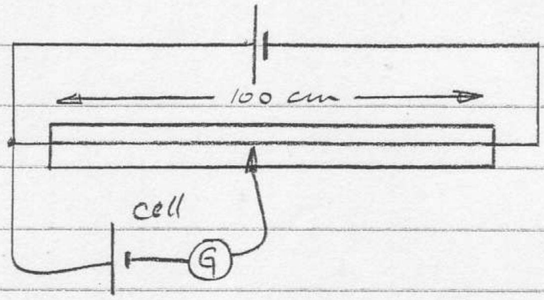
1. Define ...
(a) the Ampere
(b) the Volt
(c) the Watt
(d) electrical resistivity (4×2=8)

2. The real cell shown
has an emf of 2.0V and
internal resistance of 1 Ω.
Bulb B1 has resistance 8 Ω
Bulb B2 has resistance 12 Ω



(a) Explain what an emf of 2.0V
means (2)
(b) Calculate the total resistance of the bulbs (2)
(c) Calculate the total current delivered by the cell (2)
(d) Calculate the external cell p.d. (2)

3.(a) Briefly explain how the
potentiometer shown can be
used to measure an unknown
cell emf, with a standard
cell, of known emf, being available (4)



(b) The standard cell, emf = 1.02 V, has a balance length
of 45.2 cm. A Nicad cell gives a balance length
of 55.4 cm.
Calculate the emf of the Nicad cell (2)

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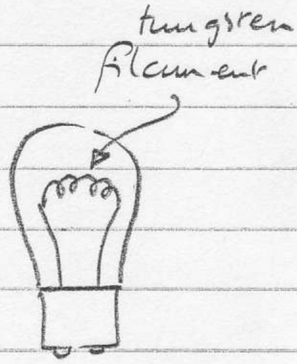
3(c) Why is the potentiometer the only device that can measure directly the emf of a cell? (2)

(d) The Nicad cell is connected across 40 Ω resistor, and the new balance length is found to be 54.5 cm. Calculate the current through the 40 Ω resistor, and then the Nicad cell's internal resistance. (4)

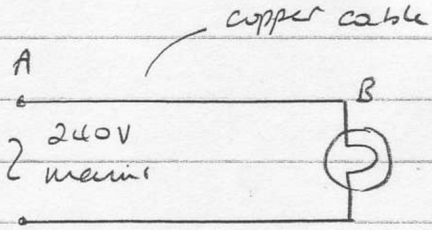


4. The diagram shows a 60 W, 240 V mains bulb.

(a) Calculate the resistance of the filament when the bulb is working. (2)

(b) How much electrical energy is transformed to heat and light in 6 hours? (2)

(c) The copper cable to the bulb is 5 m long. It is made of 22 strands of copper each 0·1 mm diameter. Calculate the area of the cable (2)



(d) Calculate the speed of electron flow (2)

(e) Calculate the resistance of the 5 m length AB. (2)

(f) The bulb filament is made of 20 cm of tungsten wire, area 2.8×10^{-5} mm^2. Tungsten metal has a resistivity of 6×10^{-8} Ωm when cold. Calculate the resistance of the cold filament, and comment on it in comparison with your answer to (a). (4)

(g) When the bulb is switched on it takes a short time (a fraction of a second) to become fully bright. Sketch and explain a graph of current against time. Put suitable scales on your graph. (4)

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Answers

A Physics
Current Elec.

1(a) 1A = 1C charge / sec $I = Q/t$

1V = 1J / C charge $V = E/Q$

1W = 1J energy change / sec $P = E/t$

(d) – ρ resistivity = Res. between opp. faces of 1 m cube, $\rho = \frac{RA}{l}$. Ωm. [8]

2. (a) 2V = 2J energy / C passing through cell. (2)

(b) $R_T = R_1 \times R_2 / R_1 + R_2 = \underline{4.8\ \Omega}$ (2) (c) $I = \frac{E}{R_T + r} = \frac{2}{4.8 + 1} = \underline{0.345\ A}$ (2)

(d) $E = IR + Ir = V_{ext} + Ir \rightarrow V_{ext} = E - Ir = 2 - (0.345 \times 1) = \underline{1.655\ V}$ (2) [8]

3 (a) Find the balance length (1) (l_{st}) for the standard cell, where no current (1) is drawn from the cell. Find the balance length (1) for the test cell. Find E_{test} using $E_{test}/E_{st} = l_{test}/l_{st}$ (1)

(b) $E_{Nicad} / E_{st} = l_{Nicad} / l_{st} \rightarrow E_{Nicad} = 1.25\ V$. (2)

(c) Emf can only be measured when no current is taken from the cell – only the potentiometer can do this [5.5 "look! no 'n'!]

(d) I through resistor = V_{cell}/R $V_{cell} = 54.5/45.2 \times 1.02 = \underline{1.23\ V}$ (1) (< 1.25V!

so $I = 1.23/40 = \underline{0.03075\ A}$ (1) [12]

$E_{cell} = V_{ext} + Ir$ (1) $\rightarrow r = E - V/I = \frac{1.25 - 1.23}{0.03075} = \underline{0.65\ \Omega}$ (1) (4)

4. (a) $P = IV = V^2/R \rightarrow R_{hot} = V^2/P = 960\ \Omega$ Hot (2)

(b) Energy $E = Q \times V = ItV = P \times t$ (1) $= 60 \times (6 \times 60 \times 60) = 1,296,000 = 1.3$ MJ — sec, J

(c) $A = \pi r^2 \times 22 = \pi \times (0.05 \times 10^{-3})^2 \times 22 = \underline{1.73 \times 10^{-7}\ m^2}$ (2) d = 0.1 mm

(d) $I = nAve \rightarrow v = I/nAe$

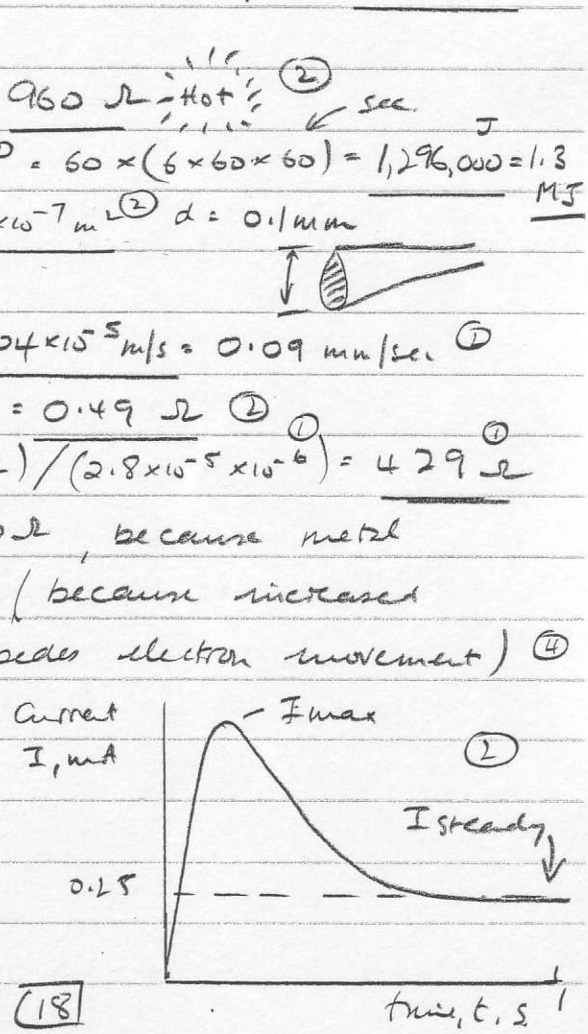
I to bulb $= P/V = 0.25A$ so $v_{electrons} = \underline{9.04 \times 10^{-5}\ m/s} = 0.09\ mm/sec$ (1)

(e) $R = \rho l / A = 1.7 \times 10^{-8} \times 5 / 1.73 \times 10^{-7} = \underline{0.49\ \Omega}$ (2)

(f) $R_{filament} = \rho l / A = (6 \times 10^{-8} \times 0.2)$ (1) $/ (2.8 \times 10^{-5} \times 10^{-6}) = \underline{429\ \Omega}$ (1)

This is much less than $R_{hot} = 960\ \Omega$, because metal resistance increases with temperature (because increased amplitude of atomic vibration impedes electron movement) (4)

(g) The cold, low resistance filament takes a large current initially. As it heats up, resistance increases, and current falls to the steady value of 0.25 A (1) [18]



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