Unit 14 · Electricity and Magnetism

HARDER PRACTICE QUESTIONS

Full marks 46

Write your answers on separate paper. Show your working. A silicon diode takes about 0.7 V when forward biased.

1 Spot the error [3]

Jenisha wants to make a 50 Ω, 10 mA galvanometer read up to 50 mA. She wrote:
"$S = I_g G \div I = (0.01 \times 50) \div 0.05 = 10\ \Omega$. So I connect 10 Ω in series with the galvanometer."
Find her two mistakes and give the correct design.

2 A meter changes what it measures [5]

i. Two 1,000 Ω resistors are in series across a 10 V supply. What is the p.d. across one of them?
ii. A voltmeter of resistance 1,000 Ω is connected across that resistor. What does it read now?
iii. What does a digital voltmeter of 10 million ohms read?
iv. A 3 V cell drives a current through 10 Ω. Find the current with no ammeter, with an ammeter of 0.5 Ω and with one of 5 Ω.
v. What do these say about a good meter?

3 Read the hydrometer [4]

A mechanic reads a lead-acid cell's acid as it gives a steady 5 A.

Time (h)	0	2	4	6	8	10
Density (g/cm^3)	1.28	1.25	1.22	1.19	1.16	1.13

i. Why does the density fall?
ii. The cell should be charged below about 1.15 g/cm^3. After about how long is that?
iii. How much charge has it given by then, in ampere-hours?
iv. What will the hydrometer show during charging?

4 Show that [4]

A galvanometer's range is to be made n times larger.

i. Starting from $I_g G = (I - I_g)S$, show that for an ammeter with $I = nI_g$, $S = \dfrac{G}{n-1}$.
ii. Check this with the unit's 50 Ω, 10 mA galvanometer made to read 1 A.
iii. Show that a voltmeter whose range is n times $I_g G$ needs a multiplier $R = (n-1)G$.

5 Two ranges, one meter [4]

A galvanometer has $G = 40\ \Omega$ and $I_g = 5$ mA. One switch position puts R_1 in series, for a 0–3 V range; the other adds R_2 as well, for a 0–15 V range.

i. Find R_1 and R_2.
ii. On the 15 V range, the pointer stands at 40% of the scale. What is the voltage, and how much current flows in the coil?

6 In a power cut [4]

A family's inverter has one 12 V, 150 Ah lead-acid battery, of which only half the charge should be used. It runs five 9 W lights, a 60 W fan and a 15 W router.

i. For how long can it run them, ignoring losses?
ii. For how long, if the inverter loses a tenth of the energy?
iii. They add a second, identical battery in parallel. What changes, the voltage or the time?

7 Setting the night light [4]

A night light has a 6 V supply, a fixed resistor R between +6 V and the base of a transistor, and an LDR between the base and 0 V. The transistor switches on at 0.7 V, and its collector current is 100 times the base current.

i. With R = 10 kΩ, at what LDR resistance does it switch on?

ii. Prashant wants it to switch on only when the LDR reaches 5 kΩ. What R does he need?

iii. Once on, the base stays at 0.7 V. With this R, about how much collector current can flow? Will it run a lamp that takes 50 mA?

8 Read the equations [3]

Add the two half-equations of a discharging lead-acid cell, $Pb + SO_4^{2-} \rightarrow PbSO_4 + 2e^-$ and $PbO_2 + 4H^+ + SO_4^{2-} + 2e^- \rightarrow PbSO_4 + 2H_2O$, and show that they give the unit's overall equation. For each lead atom used up at the negative plate, how many H_2SO_4 are used up and how many H_2O made?

9 Three LEDs [3]

Three LEDs, each working at 2 V and 20 mA, run from a 12 V battery.

i. All three are in series with one resistor. Find its resistance.

ii. Instead, each is in its own branch with its own resistor. Find each resistance, and the total current.

iii. Which way takes less current from the battery?

10 Fair test [3]

Kopila thinks a rechargeable AA cell keeps a torch lit longer than a new dry cell. Plan a fair test.

i. What will she change, and what will she measure?

ii. Name two things she must keep the same.

iii. How will she make the result more reliable?

11 Predict, then explain [4]

i. An iron nail hangs from a thread, pulled sideways by a magnet. A flame heats it until red-hot, above 770 °C. What happens? What happens as it cools?

ii. A 0.5 V supply is joined to a silicon diode, forward biased, with a lamp. Does the lamp light? And with a germanium diode?

iii. A piece of gadolinium is held near a magnet, first just out of a fridge, then on a warm day in Kathmandu. What differs?

12 Correct the misconceptions [3]

The paragraph has three mistakes. Write each one and correct it.

Alina wrote: "A bigger lead-acid cell gives a higher voltage. While the cell runs down, its acid gets stronger. A voltmeter should be connected in series, so that all the current passes through it."

13 Make your own [2]

Invent a galvanometer (G and I_g) and a shunt so that the ammeter's range comes out as a round number. Show that it works.