Unit 14 · Electricity and Magnetism

HARDER PRACTICE QUESTIONS · ANSWER KEY

Full marks 46

Give the marks for the points in the marking scheme; an answer in other words that says the same is right.

1 Spot the error

ANSWER U · 3

1. The shunt carries only the current that doesn't go through the coil, so she must divide by $I - I_g$: S = 0.5 ÷ (0.05 − 0.01) = **12.5 Ω**.
2. It goes **in parallel**, not in series. In series all the current would still pass through the coil. Check: 0.01 A × 50 Ω = 0.5 V, and 0.04 A × 12.5 Ω = 0.5 V.

MARKING SCHEME

- ✓ Divide by $I - I_g$, not I.
- ✓ S = 12.5 Ω.
- ✓ In parallel, not series.

2 A meter changes what it measures

ANSWER A · 5

i. **5 V**, half the supply.

ii. The two 1,000 Ω in parallel make 500 Ω. Total 1,500 Ω, and I = 10 ÷ 1,500 = 6.67 mA, so the reading is 6.67 mA × 500 Ω = **3.33 V**.

iii. In parallel with 1,000 Ω it makes 999.9 Ω, so the reading is 10 × 999.9 ÷ 1,999.9 = **5.00 V**, to three figures.

iv. 3 ÷ 10 = **0.30 A**; 3 ÷ 10.5 = **0.29 A**; 3 ÷ 15 = **0.20 A**.

v. A voltmeter must have a very high resistance, and an ammeter a very low one, or they change what they measure.

MARKING SCHEME

- ✓ 5 V.
- ✓ 3.33 V, from the 500 Ω in parallel.
- ✓ 5.00 V.
- ✓ 0.30 A, 0.29 A, 0.20 A.
- ✓ Voltmeter very high, ammeter very low, so as not to change the circuit.

3 Read the hydrometer

ANSWER A · 4

(The readings are made up, within the unit's 1.28 to about 1.12 g/cm^3.)

i. Discharging uses up sulphuric acid and makes water, so the acid gets more dilute.

ii. It falls 0.03 every 2 hours, or 0.015 per hour. 1.28 − 1.15 = 0.13, and 0.13 ÷ 0.015 = **about 8.7 hours**.

iii. 5 A × 8.7 h = **about 43 Ah**.

iv. The density rises back towards 1.28 g/cm^3, as the acid is made again.

MARKING SCHEME

- ✓ Acid used up and water made.
- ✓ About 8.7 hours.
- ✓ About 43 Ah.
- ✓ The density rises towards 1.28 g/cm^3.

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4 Show that

ANSWER HA · 4

i. $I_gG = (nI_g - I_g)S = (n-1)I_gS$. Dividing by I_g: G = (n − 1)S, so $S = \frac{G}{n-1}$.

ii. n = 1 ÷ 0.01 = 100, so S = 50 ÷ 99 = **0.505** Ω, the unit's answer.

iii. V = nI_gG = I_g(G + R), so nG = G + R, and R = (n − 1)G.

MARKING SCHEME

✓ $I_gG = (n-1)I_gS$.

✓ $S = \frac{G}{n-1}$.

✓ n = 100 gives S = 0.505 Ω.

✓ nG = G + R, so R = (n − 1)G.

5 Two ranges, one meter

ANSWER A · 4

i. 3 ÷ 0.005 = 600 Ω in all, so R_1 = 600 − 40 = **560** Ω. 15 ÷ 0.005 = 3,000 Ω in all, so R_2 = 3,000 − 600 = **2,400** Ω.

ii. The deflection is proportional to the coil's current: 0.4 × 15 = **6 V**, and 0.4 × 5 mA = **2 mA**.

MARKING SCHEME

✓ R_1 = 560 Ω.

✓ R_2 = 2,400 Ω.

✓ 6 V.

✓ 2 mA.

6 In a power cut

ANSWER A · 4

i. Power: 5 × 9 + 60 + 15 = 120 W. Usable energy: 12 V × 75 Ah = 900 Wh. Time: 900 ÷ 120 = **7.5 hours**.

ii. 900 × 0.9 = 810 Wh, and 810 ÷ 120 = **about 6.75 hours**.

iii. The voltage stays 12 V; **the time doubles**, since the two hold twice the charge.

MARKING SCHEME

✓ 120 W and 900 Wh.

✓ 7.5 hours.

✓ About 6.75 hours.

✓ The voltage stays; the time doubles.

7 Setting the night light

ANSWER HA · 4

i. $6 \times \frac{L}{10+L} = 0.7$, so 6L = 7 + 0.7L, and L = 7 ÷ 5.3 = **about 1.3 kΩ**.

ii. $6 \times \frac{5}{R+5} = 0.7$, so R + 5 = 30 ÷ 0.7 = 42.9, and R = **about 38 kΩ**.

iii. Base current: (6 − 0.7) ÷ 38,000 = 0.14 mA, so collector current about **14 mA**. **Not enough**: a 50 mA lamp needs a base current of 0.5 mA.

MARKING SCHEME

✓ About 1.3 kΩ.

✓ About 38 kΩ.

✓ Base current 0.14 mA, so about 14 mA.

✓ Not enough for 50 mA.

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8 Read the equations

ANSWER U · 3

Adding, the $2e^-$ cancel: $Pb + PbO_2 + 4H^+ + 2SO_4^{2-} \rightarrow 2PbSO_4 + 2H_2O$. Now $4H^+ + 2SO_4^{2-}$ is $2H_2SO_4$, so $Pb + PbO_2 + 2H_2SO_4 \rightarrow 2PbSO_4 + 2H_2O$.
For each lead atom: **2 H_2SO_4 used up and 2 H_2O made**. Both make the acid more dilute.

MARKING SCHEME

- ✓ The electrons cancel when the equations are added.
- ✓ $4H^+ + 2SO_4^{2-}$ written as $2H_2SO_4$, giving the overall equation.
- ✓ 2 H_2SO_4 used up and 2 H_2O made.

9 Three LEDs

ANSWER A · 3

i. $12 - 3 \times 2 = 6$ V across the resistor at 0.02 A: $R = 6 \div 0.02 =$ **300** Ω.
ii. $12 - 2 = 10$ V: $R = 10 \div 0.02 =$ **500** Ω each, and the total is $3 \times 20 =$ **60 mA**.
iii. **In series**: only 20 mA.

MARKING SCHEME

- ✓ 300 Ω.
- ✓ 500 Ω each and 60 mA in all.
- ✓ In series, 20 mA.

10 Fair test

MARKING SCHEME A · 3

- ✓ Changes the cell; measures the time.
- ✓ Any two things kept the same.
- ✓ Repeats with several cells and averages.

11 Predict, then explain

ANSWER U · 4

i. Above iron's Curie temperature (770 °C) the domains fall apart and it becomes paramagnetic, so **the nail swings away**. As it cools, the domains return and **it is pulled back**.
ii. **No**: silicon needs about 0.7 V to start conducting. **With germanium, yes**, in principle: it needs only about 0.3 V, though little is left to drive the lamp.
iii. Its Curie temperature is only about 19 °C. Out of the fridge it is ferromagnetic and **strongly pulled**; on a warm day it is paramagnetic and only **weakly pulled**.

MARKING SCHEME

- ✓ The nail swings away above 770 °C, as the domains fall apart.
- ✓ It is pulled back as it cools.
- ✓ Silicon: no current below 0.7 V; germanium conducts, needing about 0.3 V.
- ✓ Gadolinium strongly pulled when cold, weakly when warm (Curie temperature about 19 °C).

12 Correct the misconceptions

ANSWER U · 3

1. Each cell gives about 2 V however big it is: its size decides how much charge it can store.
2. Its acid gets more dilute, and its density falls: sulphuric acid is used up and water is made.
3. A voltmeter is connected in parallel, and has a very high resistance. In series, it would let almost no current through.

MARKING SCHEME

- ✓ About 2 V whatever the size.
- ✓ The acid gets more dilute.
- ✓ A voltmeter goes in parallel.

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13 Make your own

ANSWER HA · 2

Any set that fits $I = I_g + \frac{I_g G}{S}$. For example G = 99 Ω, I_g = 1 mA, S = 1 Ω: $I_g G$ = 0.099 V, the shunt carries 0.099 A, and I = 0.099 + 0.001 = 0.1 A.

MARKING SCHEME

- ✓ A galvanometer and a shunt with a round range.
- ✓ The p.d. and the two currents worked out.

See it at Science Playground

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- **Magnetic Lines of Force** (exhibit): The screws are made of a ferromagnetic material: near the magnet their domains line up, so each screw becomes a magnet itself and is pulled strongly.
- **Solar House Model** (exhibit): The solar panels charge the battery by day, and it gives the energy back when sunlight is weak: a rechargeable battery, a secondary cell.

Marks by level	Knowledge	Understanding	Application	Higher ability	Total
Marks	0	13	23	10	**46**

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