Answers to exam-style questions

Topic 5

Where appropriate, 1 ✓ = 1 mark

1 B

2 C

3 B

4 C

5 A

6 D

7 C

8 C

9 C

10 C

11 B

12 **a** It does not because the graph is not a straight line (through the origin). ✓

b The current is 2.35 mA. ✓

And so $R = \frac{V}{I} = \frac{4.0}{2.35 \times 10^{-3}} = 1.70 \times 10^{3} \approx 1.7 \times 10^{3}\ \Omega$. ✓

c $R = \rho \frac{L}{A} = \rho \frac{L}{\pi r^2} \Rightarrow L = \frac{\pi r^2 R}{\rho}$ ✓

$L = \frac{\pi \times (0.25 \times 10^{-3})^2 \times 1.70 \times 10^{3}}{3.0 \times 10^{-7}} = 1.1\ \text{km}$ ✓

d **i** Both lamps take the same current, 1.0 mA and so the potential difference across each is 1.0 V and hence the emf of the battery is 1.0 V. ✓

ii The power in each lamp is $P = VI = 1.0 \times 1.0 \times 10^{-3} = 1.0 \times 10^{-3}$ W. ✓

e The electric field established inside the wires and lamps forces electrons to accelerate. ✓

The accelerated electrons collide with atoms of the lamp filament transferring energy to them and increasing their random kinetic energy. ✓

The increased kinetic energy of the atoms shows up macroscopically as increased temperature (since the average random kinetic energy is proportional to temperature). ✓

13 **a** From $P = \frac{V^2}{R} \Rightarrow R = \frac{V^2}{P}$. ✓

$R = \frac{230^2}{1500} = 35.3 \approx 35\ \Omega$. ✓

b **i** The top right device is short circuited and no current passes through the lower device. Hence $P = 1500$ W. ✓

ii The top right device is short circuited and the top left and lower devices are connected n parallel so $P = 3000$ W. ✓

iii The lower device takes no current and the upper two are now in series. The voltage across each is 115 V and so the power in each is 1500/4 for a total of 750 W. ✓

iv The lower device dissipates 1500 W and the upper two 750 W for a total of 2250 W. ✓

c i We use $V = E - Ir$ to find $11.5 = E - 9.80 \times 0.0500$. ✓
Hence $E = 11.99 \approx 12$ V. ✓

ii We must decide if the current changes when the switch closes. If the source had no internal resistance there would be no change. But here it does so the current will change.

With the switch open the lamp takes current 9.80 A. Its resistance is $R = \frac{11.5}{9.80} \approx 1.17\ \Omega$. ✓

With the switch closed the total resistance of the circuit is $R = \frac{1.17 \times 25}{25 + 1.17} + 0.050 = 1.17\ \Omega$. ✓

iii The current in the circuit is then 10.3 A. The current in the lamp is then $I = \frac{25}{25 + 1.17} \times 10.3 = 9.83$ A and is larger than before, so the lamp is brighter. ✓

$I = 10.3 - 9.83 = 0.46$ A ✓

14 a i To the left. ✓

ii Upwards. ✓

b In 1 second the electrons that will cross a cross sectional area of the conductor are at most a distance v from the cross section. ✓
The number of electrons in this volume is vAn. ✓
The current is the charge that will cross the cross sectional area in 1 s and so this is $qvAn$. ✓

c The magnetic force on the electrons pushes electrons towards the top of the conductor. ✓
The bottom side of the conductor has a net positive charge and so a potential difference is established between B and T. ✓

d i Electrons will stop moving upwards when $qE = qvB$. ✓
Hence $\frac{V}{d} = vB$. ✓

ii From $I = qvAn$ we find $v = \frac{I}{qAn}$ and so $v = \frac{0.50}{1.6 \times 10^{-19} \times 4.2 \times 10^{-6} \times 3.2 \times 10^{28}} = 2.3 \times 10^{-5}\ \text{m s}^{-1}$. ✓

Assuming a square cross section $d = \sqrt{4.2 \times 10^{-6}} = 2.1 \times 10^{-3}$ m. ✓
Hence $V = 2.3 \times 10^{-5} \times 0.20 \times 2.1 \times 10^{-3} = 9.7 \times 10^{-9}$ V. ✓

e With negative charge carriers. ✓
The polarity of the Hall voltage is such that the top side of the conductor will be negative. ✓

15 a The work done by the magnetic force on the charge is zero because the force is at right angles to the velocity. ✓
Since the work done by the net force is the change in kinetic energy, and hence in speed, is zero. ✓

b The magnetic force on the proton is always at right angles to the velocity. ✓
Which is the condition for circular motion. ✓

c i From Newton's second law $qvB = \frac{mv^2}{R}$ ✓

Cancelling one power of the speed gives the answer. ✓

ii $R = \frac{mv}{qB} = \frac{1.673 \times 10^{-27} \times 3.6 \times 10^{6}}{1.60 \times 10^{-19} \times 0.25}$ ✓

$R = 1.505 \times 10^{-1}$ m ✓ (you must show the answer to at least one more significant figure than what the answer requires)

iii The time for one full revolution is $T = \frac{2\pi R}{v} = 2.63 \times 10^{-5}$ s. ✓

And we need a quarter of this, so 6.6×10^{-6} s. ✓

d i From $R = \frac{mv}{qB}$ we find $\frac{R_1}{R_2} = \frac{m_1}{m_2}$. ✓

And so $\frac{38.0}{41.8} = \frac{3.32 \times 10^{-26}}{m_2}$ leading to $m_2 = \frac{41.8 \times 3.32 \times 10^{-26}}{38.0} = 3.65 \times 10^{-26}$ kg. ✓

ii The extra mass is due to some of the atoms having extra neutrons in the nucleus. ✓
This confirms the existence of isotopes. ✓

16 a A and B take the same current and so are equally bright. ✓

C takes half the current of A and B so is 4 times less bright. ✓

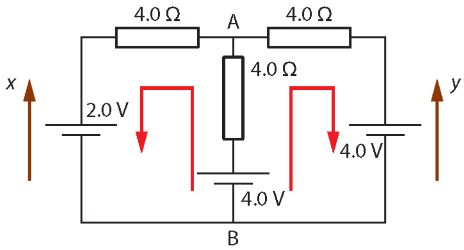
b The potential difference across A and B before C burns out is $\frac{\varepsilon}{2}$ where ε is the emf of the source. ✓

After C burns out the potential difference is still ε so there is no change. ✓

c With B burnt out A will not light. ✓

C still has potential difference ε across it so its brightness will be unaffected. ✓

17 a We denote the currents as shown in the diagram. The current in the middle cell is then $x + y$ directed downwards. ✓



Kirchhoff's loop law states that:

$4.0 - 2.0 = -4(x + y) - 4x$ or $4x + 2y = -1$ ✓

$4.0 - 4.0 = -4(x + y) - 4y$ or $x + 2y = 0$ ✓

Solving gives $x = -0.34$ A, $y = 0.17$ A ✓

(This means that the current through the left cell is down (0.34 A) in the middle cell is up (0.14 A) and in the right cell up (0.17 A).)

b $V = 4.0 - 4.0 \times 0.17$ ✓

$V = 3.4$ V ✓

c In the cell to the right and the middle, the power is $P = VI = 4.0 \times 0.17 = 0.68$ W. ✓

In the left cell, the power is $P = VI = 2.0 \times (-0.34) = -0.68$ W. ✓

The negative sign indicates that this cell is being charged. ✓