AQA A-Level Physics: Current Electricity – Calculation Questions

Praneel Physics

1. Calculate the current through a $12\,\Omega$ resistor with $36\,V$ across it. **(P)**

Working and Answer:

$I = \frac{V}{R} = \frac{36}{12} = 3\,A.$

2. Find the resistance when $0.5\,A$ flows with $6\,V$ applied. **(P)**

Working and Answer:

$R = \frac{V}{I} = \frac{6}{0.5} = 12\,\Omega.$

3. Calculate the power dissipated in a $8\,\Omega$ resistor with $4\,A$ flowing. **(P)**

Working and Answer:

$P = I^2R = 4^2 \times 8 = 128\,W.$

4. Determine the charge flowing in $15\,s$ with $2\,A$ current. **(P)**

Working and Answer:

$Q = It = 2 \times 15 = 30\,C.$

5. Calculate the energy transferred by $9\,V$ moving $4\,C$ of charge. **(P)**

Working and Answer:

$E = VQ = 9 \times 4 = 36\,J.$

6. Find the potential difference across $5\,\Omega$ with $0.8\,A$ flowing. **(P)**

Working and Answer:

$V = IR = 0.8 \times 5 = 4\,V.$

7. A $3\,m$ wire of diameter $0.5\,mm$ has resistance $6\,\Omega$. Calculate its resistivity. **(PP)**

Working and Answer:

1. Area $A = \pi(0.25 \times 10^{-3})^2 = 1.96 \times 10^{-7}\,m^2$
2. $\rho = \frac{RA}{L} = \frac{6 \times 1.96 \times 10^{-7}}{3} = 3.93 \times 10^{-7}\,\Omega m.$

8. Calculate total resistance and current for $4\,\Omega$ and $6\,\Omega$ in series with $12\,V$. **(PP)**

Working and Answer:

1. $R_{total} = 4 + 6 = 10\,\Omega$
2. $I = \frac{12}{10} = 1.2\,A.$

9. A $100\,W$ bulb operates at $230\,V$. Find its resistance. **(PP)**

Working and Answer:

1. $P = \frac{V^2}{R}$
2. $R = \frac{230^2}{100} = 529\,\Omega.$

10. Calculate drift velocity for $2\,A$ current in $1\,mm^2$ copper wire ($n = 8.5 \times 10^{28}\,m^{-3}$). **(PP)**

Working and Answer:

1. $v = \frac{I}{nAe} = \frac{2}{8.5\times10^{28}\times10^{-6}\times1.6\times10^{-19}}$
2. $v \approx 0.147\,mm/s$.

11. Find the emf when $3\,A$ flows through $4\,\Omega$ with $0.5\,\Omega$ internal resistance. **(PP)**

Working and Answer:

1. $\epsilon = I(R + r) = 3(4 + 0.5) = 13.5\,V$.

12. Calculate energy stored in $470\,\mu F$ capacitor charged to $12\,V$. **(PP)**

Working and Answer:

1. $E = \frac{1}{2}CV^2 = 0.5 \times 470 \times 10^{-6} \times 144 = 0.0338\,J.$

13. A thermistor's resistance is $8\,k\Omega$ at $20°C$ and $2\,k\Omega$ at $60°C$. Find its resistance at $35°C$ (linear assumption). **(PPP)**

Working and Answer:

1. Rate: $\frac{\Delta R}{\Delta T} = \frac{2000-8000}{60-20} = -150\,\Omega/°C$
2. $R = 8000 + (-150)(35 - 20)$
3. $R = 8000 - 2250 = 5.75\,k\Omega.$

14. A potential divider uses $5\,k\Omega$ and $10\,k\Omega$ resistors with $15\,V$ supply. Find V_{out}. **(PPP)**

Working and Answer:

1. Total resistance: $15\,k\Omega$
2. Current: $I = \frac{15}{15000} = 1\,mA$
3. $V_{out} = I \times 10000 = 10\,V$.

15. A battery ($\epsilon = 6\,V$, $r = 0.4\,\Omega$) powers a $5\,\Omega$ resistor. Find the terminal pd. **(PPP)**

Working and Answer:

1. Current: $I = \frac{6}{5+0.4} \approx 1.11\,A$
2. Terminal pd: $V = 6 - (1.11 \times 0.4) \approx 5.56\,V$.

16. Calculate resistivity of a $4\,m$ wire with $0.8\,mm^2$ area and $3.2\,\Omega$ resistance. **(PPP)**

Working and Answer:

1. $\rho = \frac{RA}{L} = \frac{3.2 \times 0.8 \times 10^{-6}}{4}$
2. $\rho = 6.4 \times 10^{-7}\,\Omega m.$

17. A $60\,W$ bulb operates at $240\,V$. Find its resistance and current. **(PPP)**

Working and Answer:

1. $R = \frac{V^2}{P} = \frac{240^2}{60} = 960\,\Omega$
2. $I = \frac{P}{V} = \frac{60}{240} = 0.25\,A.$

18. A capacitor charges to $9\,V$ with $45\,mC$. Calculate its capacitance. **(PPP)**

Working and Answer:

1. $C = \frac{Q}{V} = \frac{45\times10^{-3}}{9} = 5\,mF$.

19. A battery ($\epsilon = 12\,V$, $r = 0.8\,\Omega$) supplies parallel $3\,\Omega$ and $6\,\Omega$ resistors. Calculate total power dissipated. **(PPPP)**

Working and Answer:

1. Parallel resistance: $R_p = (1/3 + 1/6)^{-1} = 2\,\Omega$
2. Total resistance: $2 + 0.8 = 2.8\,\Omega$
3. Current: $I = \frac{12}{2.8} \approx 4.29\,A$
4. Power: $P = I^2 R_p \approx 4.29^2 \times 2 \approx 36.8\,W$.

20. A copper wire ($\rho = 1.7 \times 10^{-8}\,\Omega m$, diameter $1\,mm$) carries $3\,A$. Calculate electric field strength. **(PPPP)**

Working and Answer:

1. Area: $A = \pi(0.5 \times 10^{-3})^2 = 7.85 \times 10^{-7}\,m^2$
2. Resistance per meter: $\frac{R}{L} = \frac{\rho}{A} \approx 0.0217\,\Omega/m$
3. Potential gradient: $\frac{V}{L} = I\frac{R}{L} = 3 \times 0.0217 \approx 0.065\,V/m$
4. Electric field: $E = 0.065\,V/m$.

21. A capacitor ($100\,\mu F$) discharges through $10\,k\Omega$. Calculate time for charge to halve. **(PPPP)**

Working and Answer:

1. Time constant: $\tau = RC = 10000 \times 100 \times 10^{-6} = 1\,s$
2. $t_{1/2} = \tau \ln 2 \approx 0.693\,s$.

22. A Wheatstone bridge has $R_1 = 120\,\Omega$, $R_2 = 240\,\Omega$, $R_3 = 180\,\Omega$. Find R_4 for balance. **(PPPP)**

Working and Answer:

1. Balance condition: $\frac{R_1}{R_2} = \frac{R_3}{R_4}$
2. $R_4 = R_3 \times \frac{R_2}{R_1} = 180 \times 2 = 360\,\Omega$.

23. A $24\,V$ battery powers series $6\,\Omega$ and parallel $4\,\Omega + 12\,\Omega$ resistors. Find the current. **(PPPP)**

Working and Answer:

1. Parallel resistance: $R_p = (1/4 + 1/12)^{-1} = 3\,\Omega$
2. Total resistance: $6 + 3 = 9\,\Omega$
3. Current: $I = \frac{24}{9} \approx 2.67\,A$.

24. A $0.2\,mm$ diameter gold wire ($\rho = 2.4 \times 10^{-8}\,\Omega m$) carries $0.8\,A$. Find power dissipated per meter. **(PPPP)**

Working and Answer:

1. Area: $A = \pi(0.1 \times 10^{-3})^2 = 3.14 \times 10^{-8}\,m^2$
2. Resistance per meter: $\frac{R}{L} = \frac{\rho}{A} \approx 0.764\,\Omega/m$
3. Power: $P = I^2R \approx 0.8^2 \times 0.764 \approx 0.489\,W/m$.

25. A capacitor ($470\,\mu F$) discharges through $2.2\,k\Omega$. Calculate time for energy to reach 25% of initial. **(PPPPP)**

Working and Answer:

1. Energy $\propto V^2$, so need $V = 0.5V_0$
2. Discharge equation: $0.5 = e^{-t/RC}$
3. $t = -RC \ln 0.5 \approx 0.693 \times 2200 \times 470 \times 10^{-6}$
4. $t \approx 0.717\,s$.

26. A non-ohmic device follows $I = 0.01V^2$. Calculate dynamic resistance at $10\,V$. **(PPPPP)**

Working and Answer:

1. Differentiate: $\frac{dI}{dV} = 0.02V$
2. At $10\,V$: $\frac{dI}{dV} = 0.2\,A/V$
3. Dynamic resistance: $R = 1/(dI/dV) = 5\,\Omega$.

27. A battery ($\epsilon = 15\,V$, $r = 0.6\,\Omega$) supplies parallel $3\,\Omega$ and $6\,\Omega$ in series with $2\,\Omega$. Find terminal pd. **(PPPPP)**

Working and Answer:

1. Parallel resistance: $R_p = (1/3 + 1/6)^{-1} = 2\,\Omega$
2. Total resistance: $2 + 2 + 0.6 = 4.6\,\Omega$
3. Current: $I = \frac{15}{4.6} \approx 3.26\,A$
4. Terminal pd: $V = 15 - (3.26 \times 0.6) \approx 13.04\,V$.

28. A thermistor ($R_{25°C} = 10\,k\Omega$, $R_{75°C} = 2\,k\Omega$) is used in a potential divider with $8\,k\Omega$ resistor and $12\,V$ supply. Find V_{out} at $50°C$ (linear). **(PPPPP)**

Working and Answer:

1. Rate: $\frac{\Delta R}{\Delta T} = \frac{2000-10000}{75-25} = -160\,\Omega/°C$
2. $R_{50°C} = 10000 + (-160)(50-25) = 6\,k\Omega$
3. $V_{out} = 12 \times \frac{8000}{8000+6000} \approx 6.86\,V$.

29. A $0.05\,mm^2$ carbon wire ($\rho = 6 \times 10^{-5}\,\Omega m$) carries $20\,mA$. Calculate power density ($\mathrm{W/m^3}$). **(PPPPP)**

Working and Answer:

1. Resistance per meter: $\frac{R}{L} = \frac{\rho}{A} = \frac{6\times10^{-5}}{5\times10^{-8}} = 1200\,\Omega/m$
2. Power per meter: $P = I^2R = (0.02)^2 \times 1200 = 0.48\,W/m$
3. Volume per meter: $V = 5 \times 10^{-8}\,m^3$
4. Power density: $\frac{0.48}{5\times10^{-8}} = 9.6 \times 10^6\,W/m^3$.

30. A capacitor (C) discharges from $12\,V$ to $3\,V$ in $4\,s$ through $1\,M\Omega$. Find C. **(PPPPP)**

Working and Answer:

1. Discharge equation: $3 = 12e^{-4/RC}$
2. $0.25 = e^{-4/RC}$
3. $\ln 0.25 = -4/RC$
4. $RC = \frac{4}{\ln 4} \approx 2.89\,s$
5. $C = \frac{2.89}{10^6} \approx 2.89\,\mu F.$