TUTORIAL QUESTIONS: CURRENT OF ELECTRICITY

Question 1

A current of 10 A flows through a lamp for 1 hour. How much charge flows through the lamp in this time? **$Q = It = (60)(60 \times 60) = 36\ 000$ C**

Question 2

What current flows if 180 C of charge passes a point in a circuit in 2 minutes?
$I = Q / t = 180 / (2 \times 60) = 1.5$ A

Question 3

A current of 0.4 A flows around a circuit for 15 s. How much charge flows around the circuit in this time? **$Q = It = (0.4)(15) = 6$ C**

Question 4

What current must flow to supply 150 C of charge in 30 s? **$I = Q/t = 150/30 = 5$A**

Question 5

How much energy is transferred to 1 C of charge:

a. by a 6 V battery, and **$W = VQ = (6)(1) = 6$J**

b. by a 5 kV high-voltage supply? **$W = VQ = (5000)(1) = 5000$J**

Question 6

A 12 V battery drives a current of 2 A round a circuit for 1 minute.

a. How much charge flows around the circuit in this time? **$Q = It = (2)(60) = 120$ C**

b. How much energy transferred to the charge? **$W = VQ = (12)(120) = 1440$ J**

c. How much energy does the charge transfer to the components in the circuit? **1440 J**

Question 7

Find the resistance of a 2.6 m length of eureka wire with cross-sectional area 2.5×10^{-7} m^2.

Eureka resistivity, $\rho = 49.0 \times 10^{-8}$ Ωm

$R = \rho l / A = (49.0 \times 10^{-8})(2.6) / (2.5 \times 10^{-7})$

$R = 5.1\Omega$

Question 8

Calculate the lengths of 0.5 mm diameter manganin wire needed to make resistance coils with resistances of **(manganin resistivity, $\rho = 44.0 \times 10^{-8}\ \Omega m$)**

a. 1 Ω b. 5 Ω c. 10 Ω

a.)Length, $l = RA / \rho = (1.0)(1.96 \times 10^{-7}) / (44 \times 10^{-8})$

$l = 0.45m$

b.)Length, $l = RA / \rho = (5.0)(1.96 \times 10^{-7}) / (44 \times 10^{-8})$

$l = 2.23m$

c.)Length, $l = RA / \rho = (10.0)(1.96 \times 10^{-7}) / (44 \times 10^{-8})$

$l = 4.45m$

Question 9

1 cm^3 of copper is drawn out into the form of a long wire of cross-sectional area $4 \times 10^{-7}\ m^2$. Calculate its resistance. **(copper resistivity, $\rho = 1.69 \times 10^{-8}\ \Omega m$)**

$R = \rho l / A = (1.69 \times 10^{-8})(2.5) / (4 \times 10^{-7})$

$R = 0.11\ \Omega$

Question 10

The voltage supplied by a battery is found to be 3.0 V when measured with a high-resistance voltmeter. When the battery is connected to a 10 Ω resistor, its terminal p.d. drops to 2.8 V. What is its internal resistance?

I = (p.d. drop at 10 ohm resistor) / (10 ohm's resistor)

$I = V/R = (2.8) / (10) = 0.28A$

$E = V_t + Ir$

$3.0 = 2.8 + (0.28)r$; $r = 0.71\ \Omega$

Question 11

A high resistance voltmeter indicates a reading of 1.5 V when connected to a dry cell on open circuit. When the cell is connected to a lamp of resistance R, there is a current of 0.30 A, and the voltmeter reading falls to 1.2 V. What is

(a) the e.m.f. of the cell? **Emf, E = reading of voltmeter across open circuit = 1.5**

(b) The internal resistance of the cell **$E = V_t + Ir$; $1.5 = 1.2 + (0.3)r$; $r = 1\ \Omega$**

(c) The value of R **$R = V/I = (1.2) / (0.3) = 4\ \Omega$**

Question 12

A cell in a deaf aid supplies a current of 2.5 mA through a resistance of 400 Ω. When the wearer turns up the volume, the resistance is changed to 100 Ω and the current rises to 6.0 mA. What are the e.m.f. and the internal resistance of the cell?

$E = V_t + Ir$; $V_t = IR$;

$E = (2.5m)(400) + (2.5m)r$ ----- (1)

$E = (6.0m)(100) + (6.0m)r$ ----- (2)

Solving the simultaneous equations, will give the value of r = 114 Ω and E = 1.29 V

Question 13

At what rate is energy transferred by a 230 V mains supply which provides a current of 8 A to an electric heater? **$P = VI = (230)(8) = 1840$ W**

Question 14

What current flows through a 60 W light bulb when it is connected to a 230 V mains supply.

$I = P/V = (60)(230) = 0.26$ A

Question 15

A large power station supplies electricity to the grid at a voltage of 25 kV. At maximum power, a current of 40 kA flows from the station. What is its maximum power output?

$P = VI = (25 \times 10^3)(40 \times 10^3) = 1 \times 10^9$ W

Question 16

A power station produces 20 MW of power at a voltage of 200 kV. What current does it supply to the grid? **$I = P/V = (20 \times 10^6)/(200 \times 10^3) = 100$ A**

The current from the station flows through power lines 15 km long, with a resistance per unit length of 0.2 Ω km^{-1}. How much power is wasted in these lines?

$P = I^2R = (100)^2(0.2 \times 15) = 30$ kW

Question 17

A calculator is powered by a 3 V battery. The calculator's resistance is 20 kΩ. What power is transferred to the calculator? **$P = V^2/R = (3)^2/(2 \times 10^4) = 4.5 \times 10^{-4}$ W**

Question 18

An iron is marked 240 V, 800 W. If it is used when the supply voltages is only 220 V, what power will be supplied to it?

At 240 V,
$P = IV$; $I = P/V = (800)/(24) = 3.33$ A
$R = V/I = (240)/(3.33) = 72$ Ω (resistance of the iron)

At 220 V supply voltage,
$I = V/R = (220)/(72) = 3.06$ A
$P = VI = (220)(3.06) = 672.2$ W

Question 19

Two domestic light bulbs are labeled 230V, 25 W and 230 V, 150 W respectively. Calculate the resistance of each bulb under its normal operating condition.
For 230V, 25W bulb; $R = V^2/P = (230)^2 / (25) = 2116\ \Omega$
For 230V, 150W bulb; $R = V^2/P = (230)^2 / (150) = 353\ \Omega$

If the 2 bulbs are now connected in series across a 230 V main supply, which bulb will dissipate the greater power? Or is it the same?

$I = V/R = (230) / (2116 + 353) = 0.093$ A

Power dissipated for:
230V, 25W bulb; $P = I^2R = (0.093)^2(2116) = 18.36$ W
230V, 150W bulb; $P = I^2R = (0.093)^2(353) = 3.06$ W

The 25 W bulb will dissipate greater power.

Question 20

The energy required to heat a bathtub full of water to a comfortable temperature is 10 M J. How long will it take an immersion heater to heat the water to the required temperature if it has a resistance of 20Ω and is used with a power supply of 230 V?

$P = V^2/R = (230)^2 / 20 = 2645$ W
Power = Energy / time
Time = Energy / Power = $(10 \times 10^6) / (2645) = 3781$ seconds @ 1 hour 3 minutes

Question 21

Power is supplied from a power station at a potential difference of 120 kV. The power output of the station is 60 MW and is fed through cables of resistance 4.0 Ω to a town. Calculate

a.) Current output from the power station $I = P/V = (60 \times 10^6) / (120 \times 10^3) = 500$ A

b.) power lost heating the cables. $P = I^2R = (500)^2(4) = 1$ M J

c.) power supplied to the town. $P_{town} = P_{station} - P_{cables} = 59$ M J

d.) potential difference supplied to the town. $V = P/I = (59 \times 10^6) / (500) = 118$ kV

e.) resistance of the town $R = V/I = (118\text{ k}) / (500) = 236\ \Omega$

f.) % efficiency of the supply system. $(P_{town} / P_{station}) \times 100\% = (59\text{ M} / 60\text{ M}) \times 100\% = 98.3\ \%$