Physics 112

Exp.#1: Linear and Nonlinear Elements

Preliminary Laboratory Questions

1) Find the value of the electric resistance of a carbon resistor from the four colors ordered on it as: yellow, black, red and silver.

Answer : $40\times 10^{2} \pm 400$

2) How an ammeter is connected in an electric circuit and why?

Answer : An ammeter is connected in series with the circuit because the purpose of the ammeter is to measure the current through the circuit. Since the ammeter is a low impedance device, connecting it in parallel with the circuit would cause a short circuit, damaging the ammeter and/or the circuit.

* It should be connected in series, so that maximum current can pass through it, for accurate measurement of current.

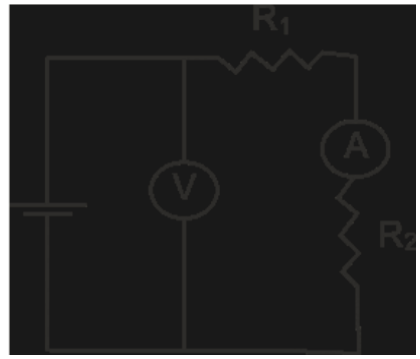
3) How an voltmeter is connected in an electric circuit and why?

Answer : An voltmeter is connected in parallel with the circuit because the purpose of the voltmeter is to measure the potential difference BETWEEN two points so it should be connected to these two points and the only way for circuit and voltmeter to be both connected to the same 2 points is in parallel

The fact that voltmeters have high resistance while **ammeter** have **low resistance** is the side effect of the way how they are connected to reduce the error introduced by devices into measured value.

4) Consider the circuit shown: Find the value of R2

If R1=100 Ω , the reading of the voltmeter 10 V and the reading of the ammeter 20 mA.



Answer :

Rs= R1+R2

$$R_s = \frac{V_S}{I_S} = \frac{10}{20\times10^{-3}} = 500\Omega$$

R2=Rs-R1= 500-100=400Ω

5) If the resistance of the tungsten wire in the light bulb is 2 Ω at 20 ˚C what would be its resistance at a temperature of 1320 ˚C, if the thermal coefficient of o resistance of tungsten is **4.5 x 10^{-3}** ˚C-1 .

Answer:

$$R = R_0\left[1+\alpha(T-T_0)\right]$$

$$= 2\left[1+4.5X10^{-3}(1320-20)\right]$$

$$= 13.7\Omega$$

6) Explain how you can measure the temperature of glow of the tungsten filament in the light bulb.

It would be pretty difficult to directly measure the temperature of the filament so we have to use something other than a thermometer for the measurement.

* It should be possible to estimate the temperature of the filament from the light spectrum. Basically, treat the light bulb like a perfect black body radiator and use Plank's Law .All tungsten filament lamps have a color temperature of around 2700°-3200°k,The color usually helps us to estimate how much is the temperature.

Another way, which is a bit easier, is to use basic electronic theory to calculate the temperature of the filament that is required to produce the manufacturer's specifications for the bulb. For example, consider a typical 100 watt, 120 VAC light bulb with a tungsten filament. The bulb consumes (and radiates) 100 watts of power. A light bulb is a purely resistive load so Power=(Voltage)*(Current). Plugging in 100 watts as the power, 120 as the voltage (actually, that's the RMS voltage), and solving for current we get an RMS current of 0.83 amps.

Since the bulb is just a resistor it obeys Ohm's Law; Voltage=(Current)*(Resistance). Our voltage is 120 and we determined the current to be 0.83 amps, so the resistance of the bulb when it is operating is 120/0.83= 144 ohms.

If you take a 100W incandescent light bulb and measure its resistance at room temperature you get a value of about 15 Ohms. The difference between the room temperature resistance and the resistance when the bulb is operating is due to the affect of temperature on the filament's resistance. Metals (and conductors in general) increase their resistance as they are heated. The resistance at a particular temperature can be calculated with;

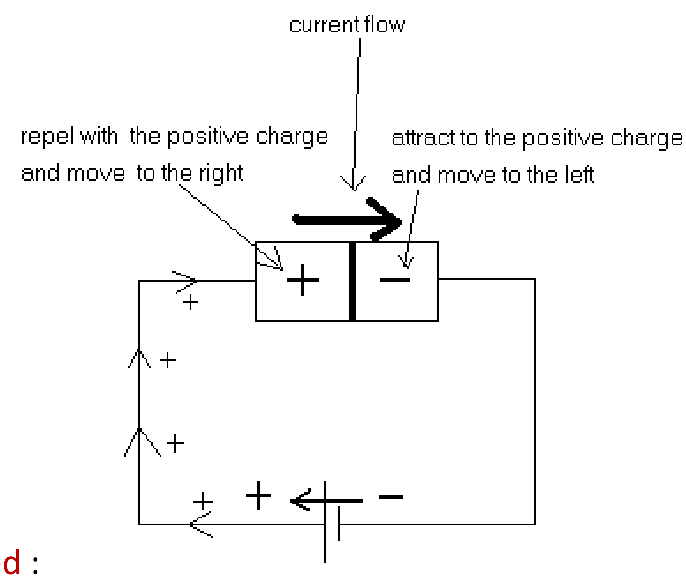
R=Rref*(1 + alpha(T-Tref)] Where, R is the resistance at temperature T degrees Celsius. Rref is the resistance at a standard temperature Tref (often 0C or 20C). Alpha is the "temperature coefficient of resistance" for the material.

For tungsten alpha=0.0044/C with a Tref of 20C (68F).

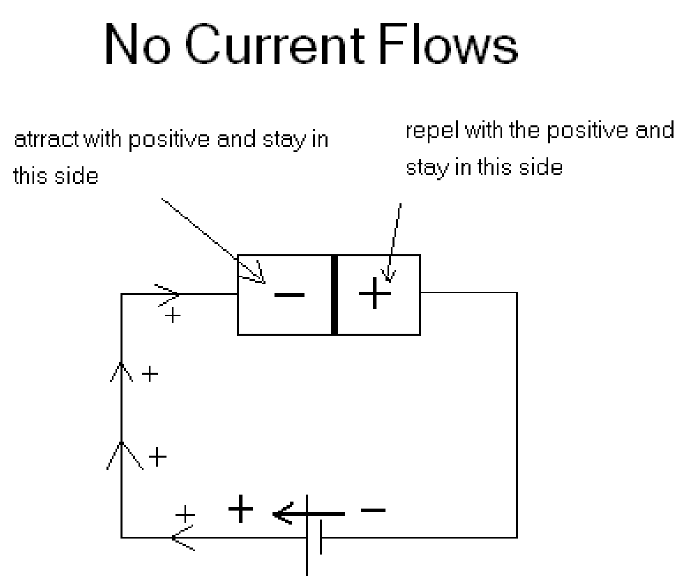
If we assume that the 15 Ohm resistance at room temperature is close enough to the value at 20C (68F) then we can use Rref=15 ohms and R is the 144 ohms we calculated from the wattage and voltage of the bulb. Plugging these numbers into the equation; 144=15*(1 + 0.0044*(T - 20)) Solving for T (the temperature required to get the filament's resistance to 144 ohms) we get T=1975C (about 3600F). That's pretty hot!

7)Explain how a current flows in a semiconducting diode in the two states of biasing.

In forward biased:



In reverse biased :



9)Find the current in a silicon diode with a reverse saturation current of IS= 12 pA

when it is biased;

a-Forward at 0.26 V, and 0.52 V

b-Reverse at 0.26 V, and 0.52 V

$$I = I_s(e^{v/Vt} - 1)$$

a-Forward

at 0.26 V

$$I = 12 \times 10^{-12}(e^{0.26/0.026} - 1)Amper = 2.6 \times 10^{-7}\ Amper$$

at 0.52 V

$$I = 12 \times 10^{-12}(e^{0.52/0.026} - 1)Amper = 5.8 \times 10^{-3}\ Amper$$

b-Reverse

at 0.26 V

$$I = 12 \times 10^{-12} Amper$$

at 0.52 V

$$I = 12 \times 10^{-12} Amper$$

9) Find the voltage on the diode at very high current (take I=1A).

$$V = Vt \ln\left(\frac{I}{Is}\right) = 0.026\ \times \ln\left(\frac{1}{12 \times 10^{-12}}\right) = 0.65\ volt$$