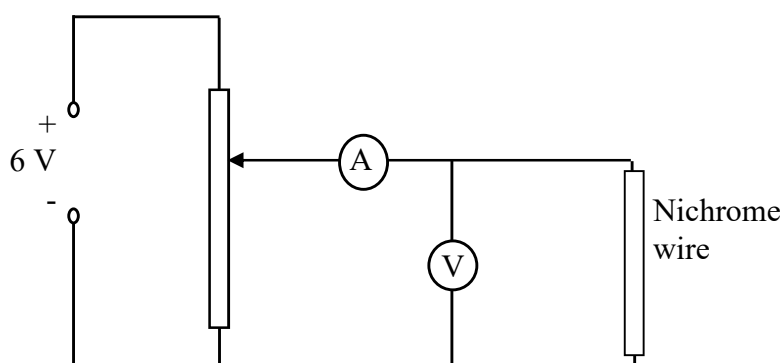## TO INVESTIGATE THE VARIATION OF CURRENT (*I*) WITH P.D. (*V*) FOR (a) A METALLIC CONDUCTOR

Apparatus

Low voltage power supply, rheostat, voltmeter, ammeter, length of nichrome wire.

Procedure

1. Set up the circuit as shown and set the voltage supply at 6 V d.c.
2. Adjust the potential divider to obtain different values for the voltage *V* and hence for the current *I*.
3. Obtain at least six values for *V* and *I* using the voltmeter and the ammeter.
4. Plot a graph of *I* against *V*.

Results

V/V	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5
I/A									

Conclusion

A straight line through the origin $\Rightarrow I \propto V$.

Notes

A varying voltage can be obtained from a fixed supply voltage by using a potential divider. It consists of a variable resistor or fixed resistors in series. Move the slider to change the output voltage. This results in the output voltage from the potential divider being a fraction of the input voltage.

The value of *R* may be determined from the reciprocal of the slope of the graph.

1 m of 26 s.w.g. nichrome wire, wound on a plastic comb, may be used in this experiment. This has a resistance of approximately 7.0 Ω.

TO INVESTIGATE THE VARIATION OF CURRENT (*I*) WITH P.D. (*V*) FOR (b) A FILAMENT BULB

Apparatus

Replace the length of nichrome wire in the circuit with a 6 V, 0.06 A filament bulb and replace the ammeter with a milliammeter.

Procedure

1. Adjust the potential divider to obtain different values for the voltage *V* and hence for the current *I*.
2. Obtain at least ten values for *V* and *I* using the voltmeter and the milliammeter.
3. Plot a graph of *I* against *V* and join the points in a smooth, continuous curve.

Results

V/V	0.2	0.5	0.8	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5
I/mA											

Notes

The resistance of the filament increases with temperature.

The shape of the curve shows that Ohm's law is not obeyed as the temperature of the filament changed with changing current.

If a multimeter is used as the ammeter, change the lead from the 10 A socket to the mA socket and select the appropriate current scale.

TO INVESTIGATE THE VARIATION OF CURRENT (*I*) WITH P.D. (*V*) FOR (c) COPPER SULFATE SOLUTION WITH COPPER ELECTRODES

Apparatus

Replace the filament bulb in the circuit with copper electrodes in copper sulfate solution.

Procedure

1. Adjust the potential divider to obtain different values for the voltage V and hence for the current I.
2. Obtain at least six values for V and I using the voltmeter and the milliammeter.
3. Plot a graph of I against V.

Results

V/V	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5
I/mA										

Conclusion

A straight line through the origin $\Rightarrow I \propto V$.

Notes

The copper sulfate solution may be made by adding 15 g of copper sulfate to 100 cm^3 of warm water. Adding 2 cm^3 of concentrated sulphuric acid ensures that the solution stays clear and this will enable it to be reused a number of times.

TO INVESTIGATE THE VARIATION OF CURRENT (*I*) WITH P.D. (*V*) FOR (d) SEMICONDUCTOR DIODE

Apparatus

Low voltage power supply, rheostat, voltmeter, milliammeter, 330 Ω resistor, silicon diode, e.g. 1N4001.
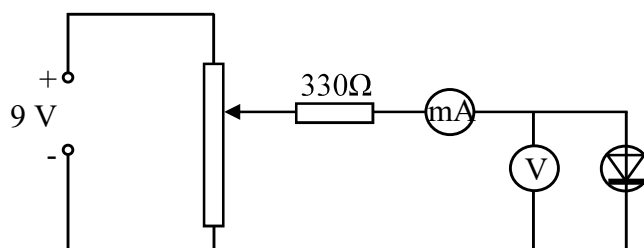
Procedure- Forward Bias

1. Set up the circuit with the semiconductor diode in forward bias as shown and set the voltage supply to 9 V.
2. Adjust the potential divider to obtain different values for the voltage *V* and hence for the current *I*.
3. Obtain at least ten values for *V* and for *I* using the voltmeter and the milliammeter.
4. Plot a graph of *I* against *V* and join the points in a smooth, continuous curve.

Results – Forward Bias

V/V	0.1	0.2	0.4	0.45	0.5	0.55	0.6	0.62	0.64	0.66	0.68	0.70
I/mA												

Notes

A protective resistor, e.g. 330 Ω, should always be used in series with a diode in forward bias.

Almost no current flows until the applied voltage exceeds 0.6 V for a silicon diode but then the current rises rapidly.

A germanium diode, e.g. OA91, gives very little current between 0 and 0.2 V but the current then increases above this voltage.

A light emitting diode gives very little current up to 1.6 V but then the current rises rapidly accompanied by the emission of light.

Apparatus

Low voltage power supply, rheostat, voltmeter, microammeter, silicon diode, e.g. 1N4001.
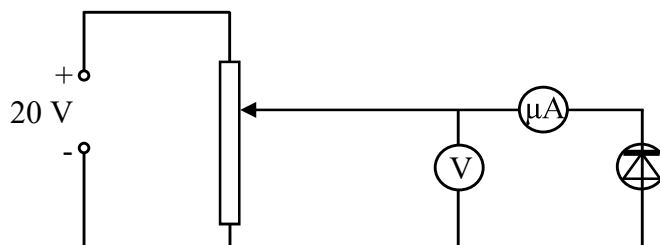
Procedure – Reverse Bias

1. Set up the circuit as above and set the voltage supply at 20 V.
2. The microammeter is used in this part of the experiment, as current values will be very low when a diode is in reverse bias.
3. Adjust the potential divider to obtain different values for the voltage V and hence for the current I.
4. Obtain at least six values for V (0-20 V) and for I using the voltmeter and the microammeter. Higher voltage values are required for conduction in reverse bias.
5. Plot a graph of I against V and join the points in a smooth, continuous curve.

Results – Reverse Bias

V/V	0	2	4	6	8	10	12	14	16
I/μA									

Notes

The position of the voltmeter has changed since a reverse biased diode has a very large resistance that is greater than the resistance of most voltmeters. It is essential that the microammeter reads only the current flowing through the reverse biased diode as the sum of the currents flowing through the voltmeter and reverse biased diode may be much larger.
Since the resistance of the microammeter is negligible compared with the resistance of the reverse biased diode the potential difference across the microammeter and diode is almost the same as the potential difference across the diode alone.

When using a silicon diode it is very difficult to detect the current in reverse bias as the current is so small and changes very little with temperature variations.

For a germanium diode some reverse current can be detected (a few μA) at 4 V reverse bias. This conduction increases rapidly when the diode is heated (by hand).

For information on connecting diodes see the 'Teacher's Handbook': Current Electricity p.45.