



## EXPERIMENT PROCEDURE

- Record the characteristic for a thermionic diode at three different cathode heater voltages.
- Identify the space charge and saturation regions.
- Confirm the Schottky-Langmuir law.

## OBJECTIVE

Record the characteristic for a thermionic diode.

## SUMMARY

In a thermionic diode, free electrons carry a flow of current between the heated cathode and the anode when a positive voltage is applied between the cathode and anode. The current increases along with the voltage until a saturation point is reached. However, if the voltage is negative, the current is zero.

## REQUIRED APPARATUS

Quantity	Description	Number
1	Diode S	1000613
1	Tube Holder S	1014525
1	DC Power Supply 0 – 500 V (230 V, 50/60 Hz)	1003308 or
	DC Power Supply 0 – 500 V (115 V, 50/60 Hz)	1003307
1	Analogue Multimeter AM50	1003073
1	Set of 15 Safety Experiment Leads, 75 cm	1002843

# 1

## BASIC PRINCIPLES

A thermionic diode is an evacuated glass tube that contains two electrodes, a heated cathode that emits electrons due to the thermoelectric effect and an anode (see Fig. 1). A positive voltage between cathode and anode causes a current flow due to the transport of these emitted electrons from the cathode to the anode. If the voltage is low, the anode current is prevented from flowing since the charge of the emitted electrodes around the cathode, the space charge, shields the field of the cathode itself. As the anode voltage rises, the field lines penetrate more deeply into the space around the cathode and the anode current increases. It continues to rise until the space around the cathode is fully discharged so that the anode current reaches saturation level. When the voltage is sufficiently negative, however, electrons cannot get to the anode at all so that the anode current is zero in this case.

The way the anode current  $I_A$  depends on the anode voltage  $U_A$  is called the characteristic of the diode (see Fig. 2). There are three distinct areas, the reverse-bias region (a), the space charge region (b) and the saturation region (c).

In the reverse bias region the anode is at a negative voltage with respect to the cathode. Electrons are then unable to move against the electric field. In the space charge region the anode current depends on the anode voltage in accordance with the Schottky-Langmuir law:

$$(1) \quad I_A \sim U_A^{\frac{3}{2}}$$

In the saturation region the anode current depends on the temperature of the cathode. By increasing the heater voltage  $U_F$  the anode current can be made to increase.

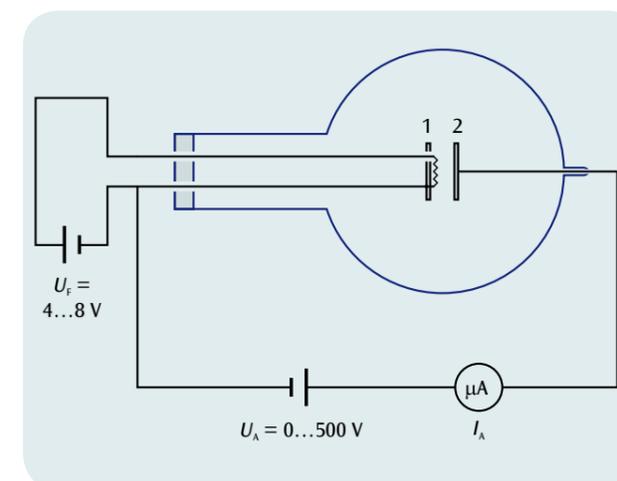


Fig. 1: Circuit for recording the characteristic of a thermionic diode.  
1: Cathode, 2: Anode

## EVALUATION

### Reverse bias region:

Since electrons are emitted from the cathode with a kinetic energy  $E_{kin} > 0$  a current flows in the anode only until the voltage of the anode is sufficiently negative that even the fastest of the emitted electrons is unable to overcome the field to reach the anode.

### Space charge region:

For weak field strengths, not all the electrons emitted from the cathode are transported to the anode. They occupy the space around the cathode in a cloud creating a negative space charge. When the voltage is low, field lines for the anode thus reach only as far as the electrons in the cloud and not the cathode itself. The latter is thus shielded from the anode field. Only as the voltage increases do the field lines penetrate further into the cathode causing the anode current to rise. The increase continues until the space charge around the cathode is dissipated, at which point the anode current is saturated.

### Saturated region:

In the saturation region the anode current does not depend on the anode voltage at all. It can nevertheless be increased by increasing the number of electrons emitted from the cathode in unit time. This can be achieved by raising the temperature of the cathode. The saturation current therefore depends on the heater voltage.

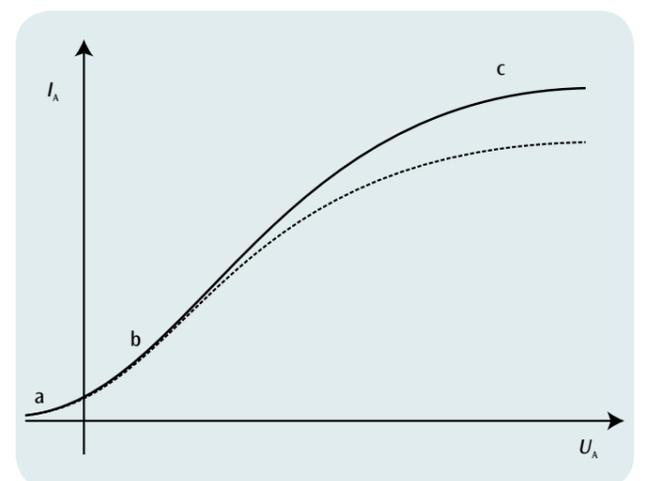


Fig. 2: Characteristic of a thermionic diode.  
a: Reverse bias region, b: Space charge region, c: Saturation region