1. Experimental Objectives

1) Understand the concept of thermionic electron emission and verify Schottky effect
2) Understand the concept of work function of a metal
3) Learn how to measure metal work function based on Richardson straight-line method
4) Understand magnetron principle and determine charge-mass ratio (e/m) by magnetron

2. Experimental Procedures

A. Preparation

1) Plug the ideal diode into the socket onto the ideal diode mount. Connect wires between the main unit and the ideal diode mount by matching number pairs (L+/L- for coil).
2) Double check the correctness of wire connections before turning on power.

B. Determination of work function

1) Set the button "Work F. / e/m" to "Work F.". Set a certain filament current (0.650 A). Preheat for 10 minutes.
2) At the fixed filament current (e.g. 0.650 A), from low to high, slowly change accelerating voltage U_a, while recording the corresponding emission current I_e' (i.e. I_a on the panel) into a table (please refer to Sec. 7: data recording and processing).
3) Increase filament current with an interval of 0.025 A, repeat step 2, till 0.800 A.
4) Draw $\lg I_e' \sim \sqrt{U_a}$ line and do linear curve-fitting to the data. Find $\lg I_e$ at each filament current, i.e. different temperatures (using Table 1).
5) Draw $\lg \frac{I_e}{T^2} \sim \frac{1}{T}$ line. Find escape potential value φ from the slope of the fitted straight line, and compare it with the theoretical value.

C. Measurement of e/m by magnetron method

1) Install and connect the magnetization coil. Let the ideal diode locate in the center of the coil. Set the button "Work F. / e/m" to "e/m".
2) Adjust the filament current to a certain value within 0.730 A ~ 0.750 A such as 0.745 A. Preheat for 10 minutes. Please note that filament temperature will change over time, filament current may change as well. During experiment, if necessary, re-adjust the filament current to maintain a constant filament current value.
3) Set anode voltage to 5.0 V. From small to large, gradually change magnetization current I_s while recording I_s with corresponding anode current I_a into a table (please refer to Sec. 7: data recording and processing) until I_a is close to zero. **Note**: during experiment, filament current I_f and anode voltage U_a must remain unchanged.
4) Set anode voltage to 10.0 V, 15.0 V, 20.0 V, 25.0 V and 30.0 V, respectively; repeat step 3) at each voltage.
5) Plot $I_a \sim I_s$ curve, and find I_c values under different anode voltages.
6) Plot $U_a \sim I_c^2$ graph to determine the relationship between U_a and I_c^2. Use related formula to derive charge-mass ratio, and compare it with the theoretical value.

3. Examples of Data Recording and Processing

Note: the following data are for reference purposes only, not the criteria for apparatus performance.

A. Determination of work function

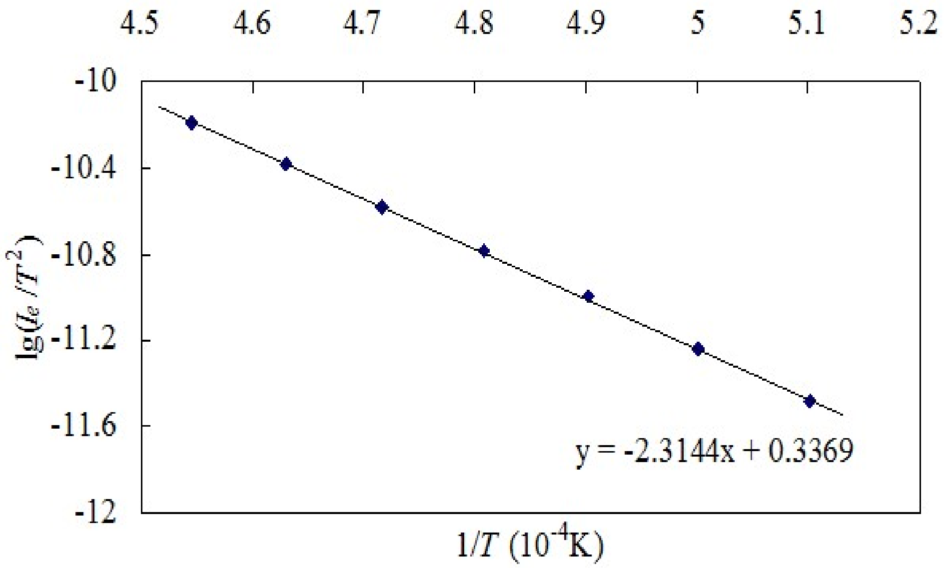
Adjust filament current I_f from 0.650 A to 0.800 A with a step of 0.025 A while measuring accelerating voltage U_a and emission current I_e', as recorded in the table below.

$\sqrt{U_a}$ (V) / Ie' (uA) / I_f (A)	4.0	5.0	6.0	7.0	8.0	9.0	10.0
0.650	14	14	15	15	16	16	16
0.675	26	26	28	28	29	30	30
0.700	46	47	48	49	50	51	52
0.725	76	78	82	83	84	85	86
0.750	126	129	131	134	137	139	141
0.775	210	214	219	223	227	231	235
0.800	336	341	352	359	365	371	377

Plot $\lg I_e' \sim \sqrt{U_a}$ lines at each filament current, find $\lg I_e$ values under different filament currents, as follows:

Filament T (10^3 K)	1.96	2.00	2.04	2.08	2.12	2.16	2.20
$\lg I_e$	-4.90	-4.63	-4.37	-4.15	-3.93	-3.71	-3.50
$\frac{1}{T}$ (10^{-4}K)	5.10	5.00	4.90	4.81	4.72	4.63	4.54
$\lg \frac{I_e}{T^2}$	-11.48	-11.24	-10.99	-10.78	-10.58	-10.38	-10.19

Based on lg*Ie* and *T* values, plot $\lg \frac{I_e}{T^2} \sim \frac{1}{T}$ line, as follows:



The slope of the fitted line is -23144, calculate the escape potential as 4.59 V using formula (2), and compared with the theoretical value of 4.54 V, leading to a relative error of ~1.1%.

B. Measurement of e/m by magnetron method

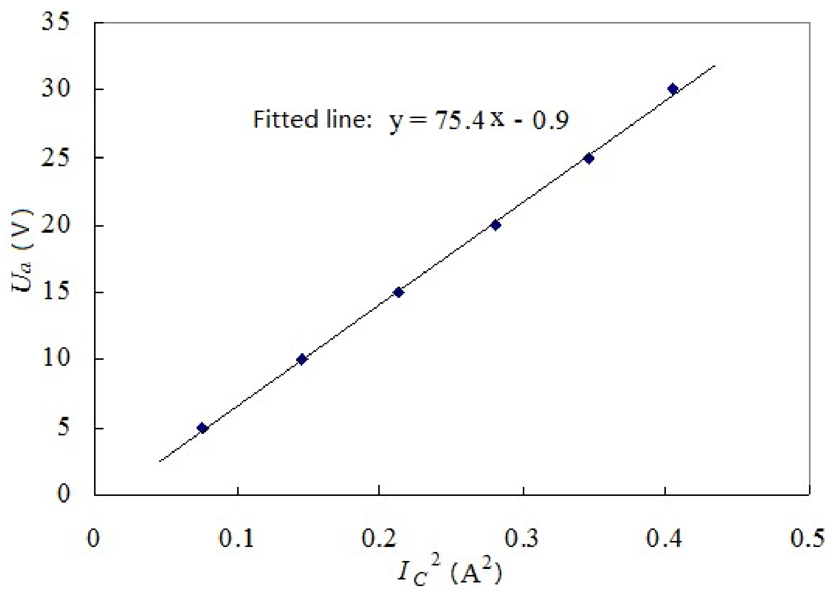
Set filament current to 0.745 A, and sequentially set anode voltage to 5.0 V, 10.0 V, 15.0 V, 20.0 V, 25.0 V, and 30.0 V, respectively. Determine the relationship between magnetization current I_s and anode current I_a, until anode current I_a is close to zero. Anode current I_a (μA) under different accelerating voltage U_a and magnetization current I_s are recorded in the table below.

U_a (V) / I_a(μA) / I_s(A)	5.0	10.0	15.0	20.0	25.0	30.0
0.100	108	112	115	116	119	120
0.200	108	112	115	116	119	120
0.250	72	112	115	116	119	120
0.260	49	112	115	116	119	120
0.270	32	112	115	116	119	120
0.280	21	112	115	116	119	120
0.290	14	112	115	116	119	120
0.300	8	112	115	116	119	120
0.350	0	86	115	116	119	120
0.360	0	62	115	116	119	120
0.370	0	42	115	116	119	120
0.380	0	28	115	116	119	120
0.390	0	20	115	116	119	120
0.400	0	13	115	116	119	120
0.410	0	6	115	116	119	120
0.420	0	2	110	116	119	120
0.430	0	0	88	116	119	120
0.440	0	0	62	116	119	120
0.450	0	0	41	116	119	120
0.460	0	0	29	116	119	120
0.470	0	0	21	116	119	120
0.480	0	0	15	116	119	120
0.490	0	0	10	104	119	120
0.500	0	0	5	85	119	120
0.510	0	0	0	58	119	120
0.520	0	0	0	39	119	120
0.530	0	0	0	29	119	120
0.540	0	0	0	22	119	120
0.550	0	0	0	16	108	120
0.560	0	0	0	11	83	120
0.570	0	0	0	6	54	120
0.580	0	0	0	2	39	120
0.590	0	0	0	0	29	120
0.600	0	0	0	0	22	114
0.610	0	0	0	0	14	92
0.620	0	0	0	0	8	64
0.630	0	0	0	0	3	43
0.640	0	0	0	0	0	34
0.650	0	0	0	0	0	27
0.660	0	0	0	0	0	21
0.670	0	0	0	0	0	15
0.680	0	0	0	0	0	6
0.690	0	0	0	0	0	0
0.700	0	0	0	0	0	0

Based on above data, plot $I_a \sim I_S$ graphs at all U_a values. On each $I_a \sim I_S$ curve, take the point of one-fourth of the maximum anode current I_{a0} as the critical point (Q). Find I_c values of different anode voltages, as follows:

U_a (V)	5.0	10.0	15.0	20.0	25.0	30.0
I_C (A)	0.274	0.380	0.461	0.530	0.588	0.636
I_C^2 (A^2)	0.075	0.144	0.212	0.281	0.346	0.404

Plot $U_a \sim I_C^2$ graph as follows:



As U_a and I_C^2 are in a linear relationship, by doing linear curve-fitting to the data, the fitted slope is 75.4. Using formula (11), the charge-mass ratio of electron is calculated as 1.805×10^{11} C/Kg. Compared with the theoretical value of 1.759×10^{11} C/Kg, the relative error is 2.6%.