EXPERIMENT 5

Study of the I-V Characteristics of the Common Emitter Configuration of BJT

- **Apparatus :-**

i) 5 V Power Supply
ii) Breadboard
iii) CE mode transistor
iv) Rheostat
v) Resistance (R_B and R_c)
vi) Multimeter 1 (V_{BE}), Multimeter 2 (V_{CE}), Multimeter 3 (I_c), Multimeter 4 (I_B).
vii) Wires.

- **The Junction Transistor and its Action :-**

The bipolar junction transistor (BJT), also called the junction transistor is a three layer device and may be considered as the solid state equivalent of a triode value. If a p-type region is sandwiched between two n-type layers we get an n-p-n type of transistor (Fig).

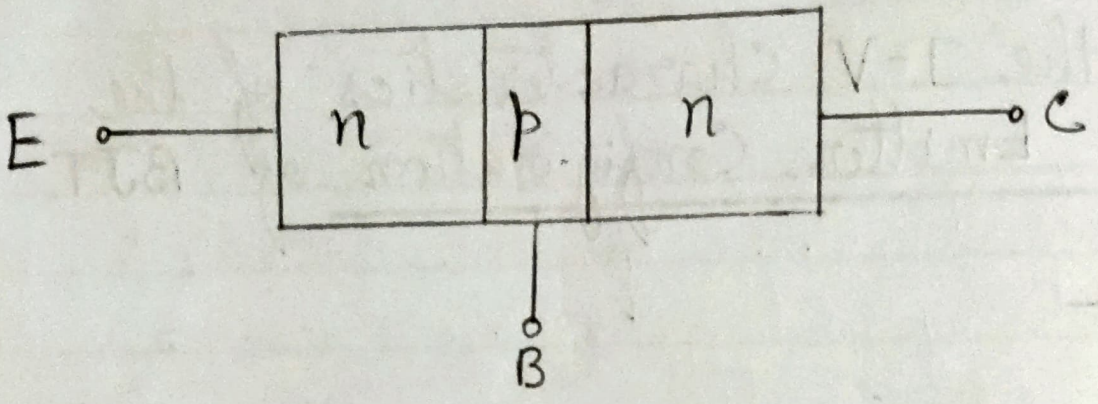


Fig 1: n-p-n transistor

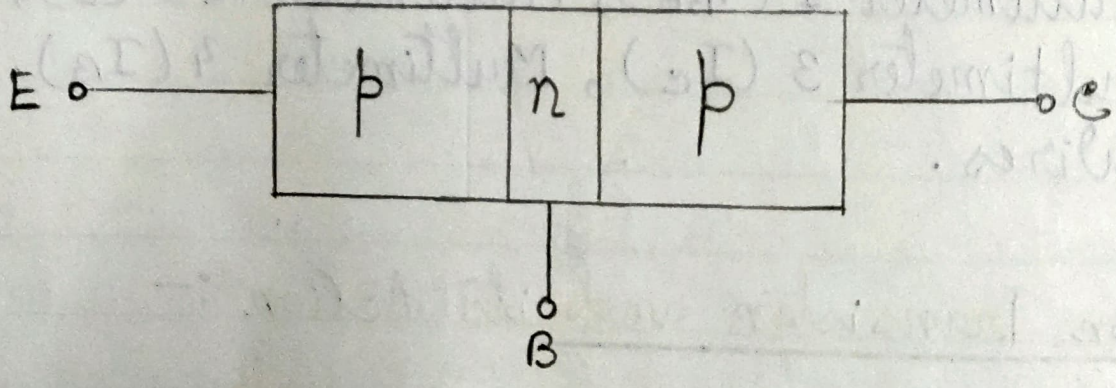


Fig 2: p-n-p transistor

On the other hand, if an n-type region is sandwiched between two p-type layers we get a p-n-p type of transistor (Fig). The central thin layer is called the base (B) whereas the two outer layers are called the emitter (E) and the collector (C). The circuit symbol of such transistors are shown in (Fig and), where the arrow head is in the direction of conventional current flow when emitter-base junctio is forward-biased.

- Different modes of transistor operation :-

The emitter-base (E-B) and the collector-base (C-B) junctions can be forward or reverse biased independently. Thus, we can have four modes of operation. The most common mode is the forward-active where E-B junction is forward-biased and C-B junction is reverse-biased. In this mode the BJT can be used as an amplifier and is the most common mode of operation in analog circuits. When both the junctions are forward-biased the transistor is said to be operating in the saturation mode. In this case the collector current may be appreciable but only a small

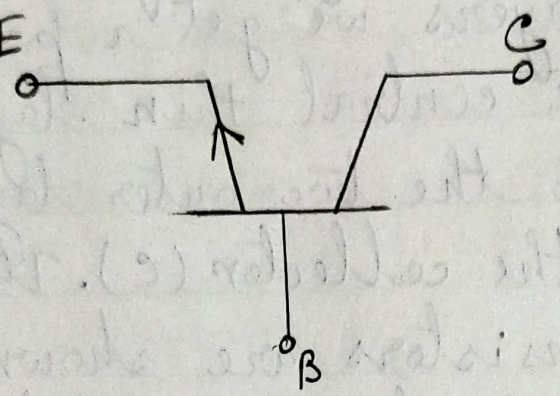


Fig 3: Circuit symbol of n-p-n transistor

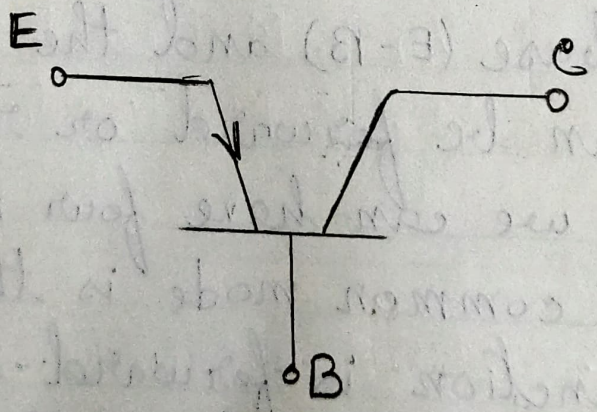


Fig 4: Circuit symbol of p-n-p transistor

voltage exists across the collector junction. This condition is nearly that of a closed switch. If both the junctions are reverse-biased the transistor is said to be operating in the cut-off mode. The transistor then behaves like an open switch with practically zero current and with 'large' reverse junction voltage. Operation of the BJT between cut-off and saturation corresponds to the action of a switch. When E-B junction is reverse-biased and C-B junction is forward-biased the transistor is said to be operating in the reverse-active or inverted mode. This mode is unsuitable for amplification but has some applications in digital circuits.

To draw the static output characteristic curves of a transistor in common-emitter configuration for different base currents and hence to determine the AC current gain (h_{fe}) and the output admittance ~~(h_{oe})~~ (h_{oe}).

- **Theory :-**

For a transistor in common emitter (CE) configuration if the collector current I_c is plotted against the collector

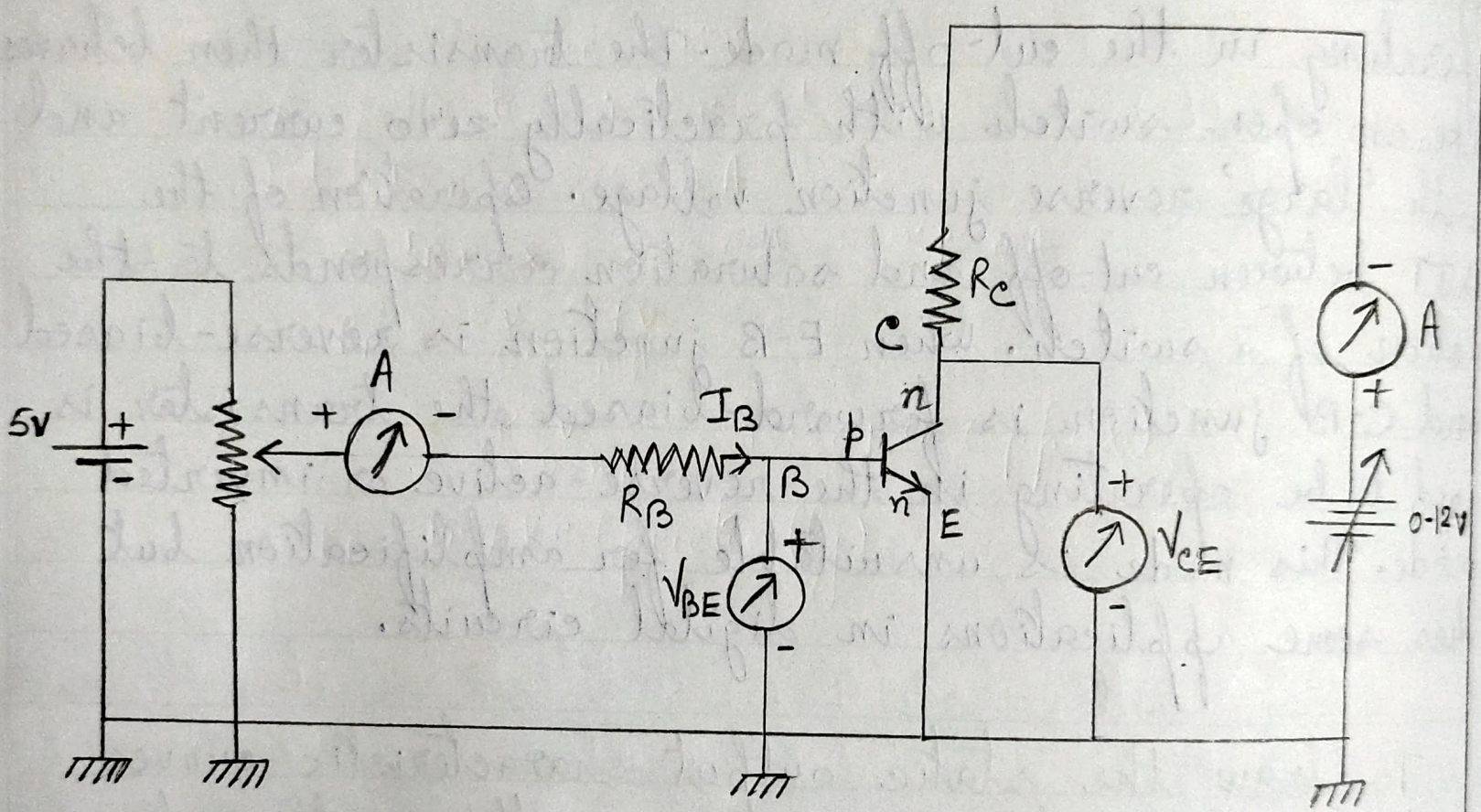


Fig 5: Common Emitter of configuration of a n-p-n transistor

to-emitter voltage V_{CE} keeping the base current I_B at a fixed value, the resulting curve is called the CE mode static output characteristic curve. A family of such curves may be obtained by plotting graphs for various constant values of I_B (Fig). The region of output characteristic curves where the emitter-base junction is forward-biased and the collector-base junction is reverse-biased is the active region of operation.

Now the ac short circuit current gain (h_{fe}) is defined as the ratio of the change in the output collector current to the change in the input base current for a fixed value of collector-to-emitter voltage i.e,

$$h_{fe} = \left.\frac{\delta I_C}{\delta I_B}\right|_{V_{CE} = \text{constant}}$$

The output admittance is defined as the ratio of change in the output collector current to the change in the output collector-to-emitter voltage for a fixed input base current i.e,

$$h_{oe} = \left.\frac{\delta I_C}{\delta V_{CE}}\right|_{I_B = \text{constant}}$$

The values of h_{fe} and h_{oe} at depend on the operating point. To find h_{fe} and h_{oe} corresponding to any operating point Q in a vertical line AB (V_{CE} = constant)

- Calculation of the base resistance and base current :-

Suppose, V_{CE1} =

V_{CE2} =

V_{CE3} =

β of the transistor =

Let, $I_{C\,max}$ =

$\therefore I_{B\,max}$ =

R_B =

= . (approx.)

R_B (practically)

is drawn through the point Q_2 and also a small right-angled triangle PRS is drawn with the hypotenuse, PR as tangent to the curve at the point Q_2, then from

- **Experimental Data :-**

A) Specifications of the transistors and meters used:

Name and type of the transistor =

Maximum ~~allowed~~ collector current =

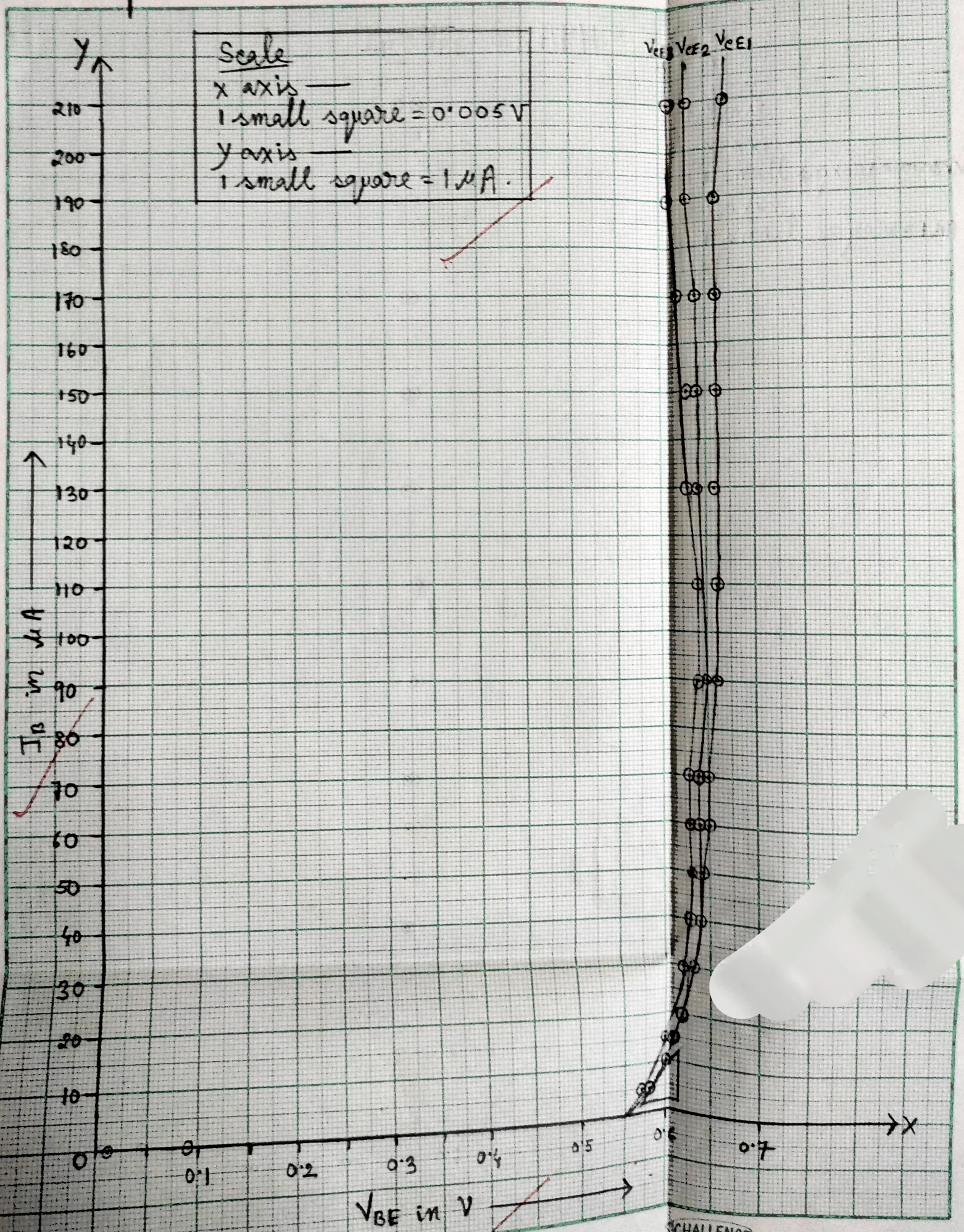
Maximum power dissipation =

B) Data for CE input characteristics :-

TABLE 1

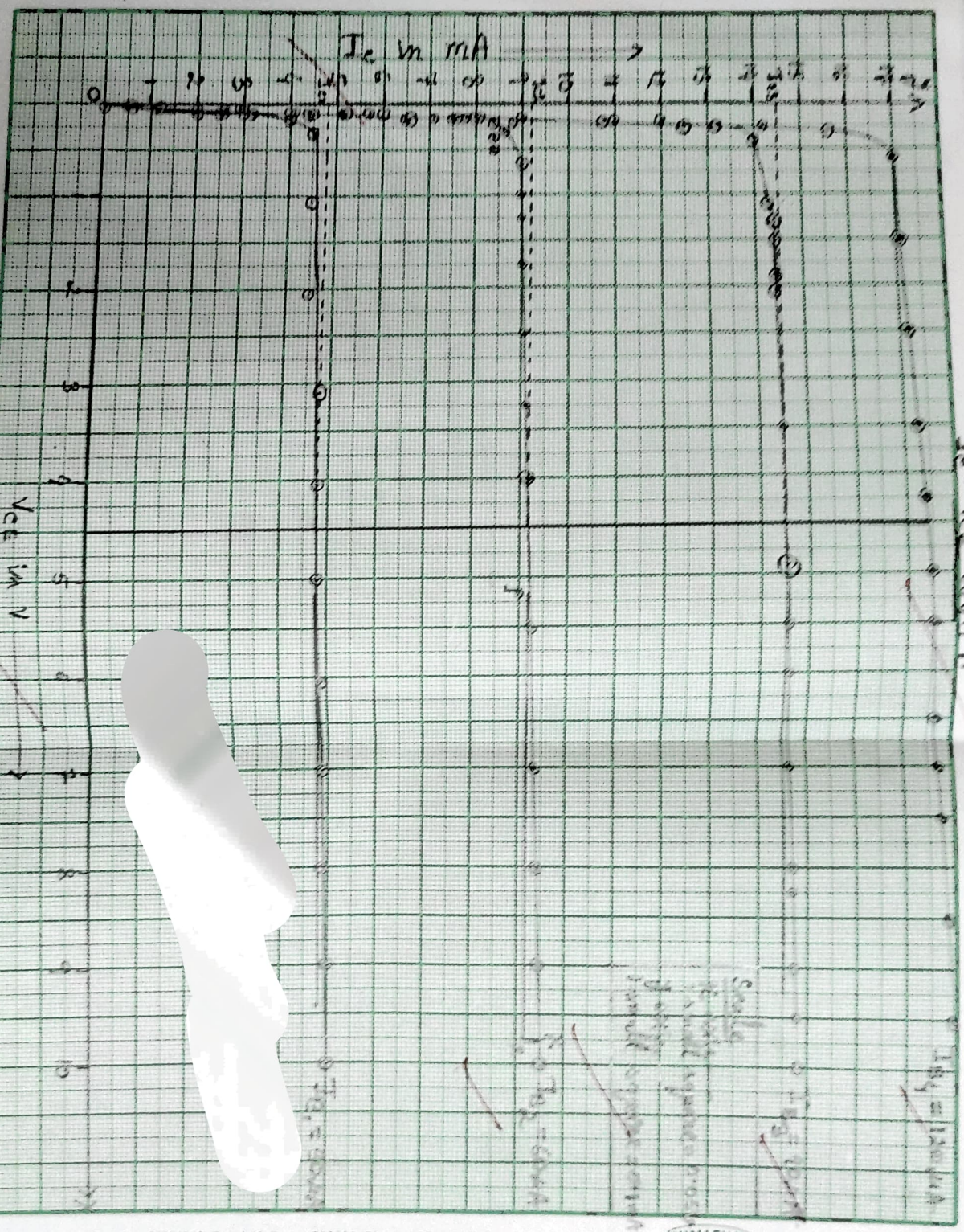
No. of obs.	SET I		SET II		SET III	
	V_{CE_1} = , V		V_{CE_2} = V		V_{CE_3} = , V	
	V_{BE} in V	I_B in μA	V_{BE} in V	I_B in μA	V_{BE} in V	I_B in μA
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						

① CE input characteristics curve :-



I_B-V_{BE} GRAPH

(2) CE output characteristics curve :



c) Data for CE output characteristics :

TABLE 2

No. of Obs.	Set I I_{B1} =		Set II I_{B2} =		Set III I_{B3} =		Set IV I_{B4} =	
	V_{CE} in V	I_C in mA	V_{CE} in V	I_C in mA	V_{CE} in V	I_C in mA	V_{CE} in V	I_C in mA
1								
2					2			
3								
4								
5					3			
6					3			
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								

D) Calculation of h_{fe} and h_{oe} from output characteristics:

TABLE 3

I_{CS} in mA	I_{C1} in mA	I_{B3} in ~~mA~~ μA	I_{B1} in μA	RS in mA	PS in V	$h_{fe} = \frac{I_{C3} - I_{C1}}{I_{B3} - I_{B1}} \times 10^3$	$h_{oe} = \frac{RS}{PS} \times 10^{-3}$ in μ mho

Precautions and Discussions :-

i) If a p-n-p transistor is supplied in the place of n-p-n transistor, the polarities of the power supplies and that of the meters are all to be interchanged.

ii) While the collector-to-emitter voltage is increased the base current may change slightly. So it should be checked and adjusted by the turn pot. P_2 at each step.

iii) Care should be taken that the collector current I_C in no case exceeds the specified maximum safe value.

iv) The properties of a transistor depend on temperature and so if I_C is noted for voltage increasing and for voltage decreasing the readings can differ widely.

v) If there is any initial error in any meter necessary corrections should be made in the readings.

vi) The base circuit should preferably be driven by a current source.

viii) The values of h_{fe} and h_{oe} depend on the operating point. Moreover, the values of h_{fe} and h_{oe} for two transistors having same designation may differ greatly. For this, it is usual to specify these parameters at a particular ! ting point and not by their average values.