**Table 2: NAND Gate Data**

| $V_A$ (V) | $V_B$ (V) | $V_{DA}$ (V) | $V_{DB}$ (V) | $V_P$ (V) | $I_{R1}$ (mA) | $I_{R2}$ (mA) | $V_B$ (mV) | $V_Y$ (V) |
|---|---|---|---|---|---|---|---|---|
| 4.95 | 4.95 | -3.11 | -3.11 | 1.81 | 1.12 | 2.28 | 1.71 | 0.02 |
| 4.95 | 0 | -4.93 | 0.5 | 0.5 | 2.01 | 0.03 | 0.01 | 4.93 |
| 0 | 0 | 0.49 | 0.49 | 0.5 | 2.01 | 0.032 | 0.01 | 4.93 |
| 0 | 4.95 | 0.60 | -4.33 | 0.6 | 1.96 | 0.027 | 0.03 | 4.94 |

**Table 3: Inverter Data**

| Input A (V) | Input B (V) | $V_P$ (V) | $V_B$ (V) | Output Y (V) |
|---|---|---|---|---|
| 4.95 | 0 | 0.5 | 0.01 | 4.93 |
| 4.95 | 4.95 | 1.81 | 0.71 | 0.02 |

*Signature*

## Report

Please answer the following questions briefly in the given space.

1. Using experimental data, find the operating mode of **Q1** when input A is **HIGH** and input B is **LOW**. Additionally, find whether diodes **DA** and **DB** are ON or OFF (by using the voltage across them).

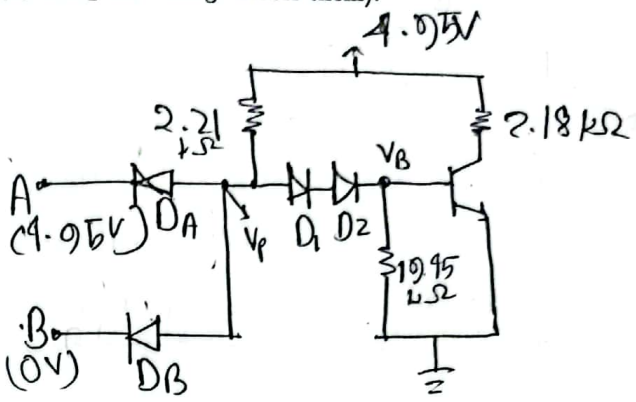
**Ans.**

Here, $I_E = 0mA$

$$I_B = \frac{V_B - 0}{19.95} = 0.01 \approx 0mA$$

$$I_e = I_{R_2} = 0.03 \approx 0mA$$

$\therefore$ Q1 is in cutoff mode




for Diode DA;

Voltage in cathode > voltage in anode

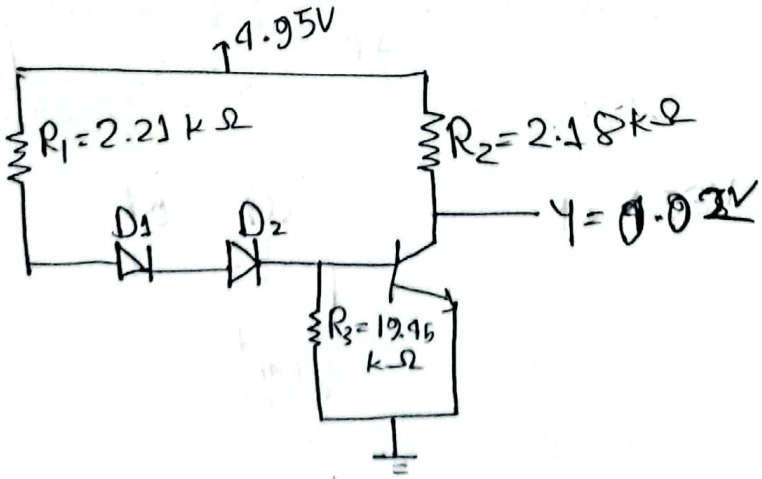
which means DA is off

for DB, voltage in cathode < Votage in anode, meaning DB is ON.

2. Assume that the **output** of the circuit shown in Fig: 1 is **LOW**. Draw the partial circuit consisting of only those components which remain active.

**Ans.**

In order to get Low output from this circuit, diodes DA and DB has to be off. Therefore the active part of the circuit is drawn below.



3. What should be the relation between the currents $I_{R1}$, $I_B$ and $I_{RB}$ when all inputs are **HIGH**? Did you obtain a similar result in your experiment? Explain briefly. (use a Multi-meter as Ammeter to measure $I_B$).

**Ans.** When all inputs are HIGH, diodes DA and DB are OFF while $D_1$ and $D_2$ are ON. $I_{R1}$ can travel through $D_1$ and $D_2$ and be divided into $I_B$ and $I_{RB}$

theoretically $I_{RB} = \frac{V_B - 0}{20k\Omega} = \frac{0.7 - 0}{20k\Omega} = 0.035\,mA$

$\therefore I_B = I_{R1} - I_{RB} = 1.42 - 0.035 = 1.385\,mA$

from the experiment, we get $I_{RB}^* = \frac{0.71 - 0}{19.45}\,mA$

$= 0.037\,mA$

$\therefore$ Experimentally $I_B = I_{R1} - I_{RB}^* = 1.383\,mA$

$\therefore$ Theoretical $I_B$ is very close to experimental $I_B$

Because the $I_{R1} = I_{RB} + I_B$ relation is True.

4. Use the relation between the currents $I_{R1}$, $I_B$ and $I_{RB}$ when all inputs are **HIGH** to verify the operating mode of Q1. [Assume beta ($\beta_F$) $\geq$ 100]

**Ans.**

The experimental value of y when both of the inputs are high is 0.02 V. This suggests $Q_1$ is in saturation mo

Here, $I_C = I_{R2} = 2.28\,mA$

$I_B = 1.383\,mA$ $\quad \frac{I_C}{I_B} = \frac{2.28}{1.383} = 1.64 < \beta_F$

which verifies that $Q_1$ is in saturation

5. Will the circuit still work properly as NAND gate if the diodes $D_1$ **and** $D_2$ are removed? Measure the output voltage for the four different cases and verify.

**Ans.**

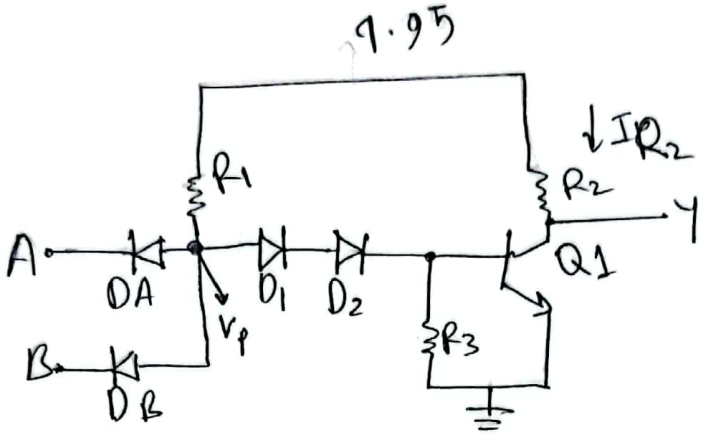
| $V_A$ | $V_B$ | $V_y$ |
|---|---|---|
| 0 | 0 | 4.94 |
| 0 | 4.95 | 4.95 |
| 4.95 | 0 | 4.94 |
| 4.95 | 4.91 | 0.03 |

6. Vary the **input A** from **0V to 5V** while keeping **input B** fixed at 5V. What is the **maximum** value of **input A** for which the **output** remains **HIGH**? [consider any voltage above 1V as **HIGH**]

**Ans.**

1.08 V is the maximum value of input A for which the output remains HIGH

7. Verify the result of **table 2** using theoretical calculation and comment on the result (Use extra pa necessary).




I

theoretically, when A and B are both high (9.95V), DA and DB should be OFF and Vp will be High, resulting in the transistor to be in saturation mode. Therefore, output should be LOW, VB should be near 0.7 and Ie>0. All of these assumptions are proven true in the first row of Data Table 2.

When either of the inputs are low, Vp remains low resulting in the transistor to be in cutoff mode and the output to be High. Ie, IE and IB should be near zero. These assumptions are also proven right in the 2nd and 4th row of Data Table 2.

finally if both of the inputs are low, that would result in DA, DB ON, VP = LOW, Q1 is in saturation, output is High. Also proven right in row 3 of the table.