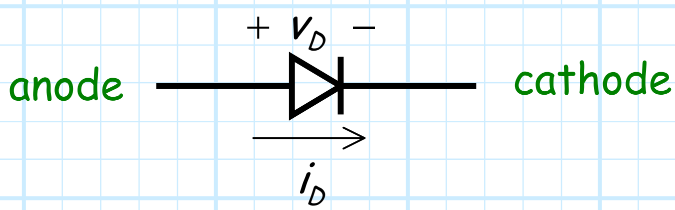
3.2 Terminal Characteristics of Junction Diodes (pp.147-153)

A Junction Diode – A semi-conductor implementation, usually in Silicon.

I.E., A "real" diode!

Similar to an **ideal** diode, its circuit symbol is:



HO: The Junction Diode Curve

HO: The Junction Diode Equation

A. The Forward Bias Region

Consider when $v_D \gg nV_T$ (i.e, when $v_D \gg \approx 25mV$).

→ The junction diode is said to be "forward biased" (f.b.)!

Note then (when $v_D \gg \approx 25mV$) that $e^{v_D / nV_T} \gg 1$, so that a **forward biased** junction diode **approximation** is:

$$
\begin{aligned}
i_D &= I_s \left(e^{v_D / nV_T} - 1 \right) \\
&\approx I_s \, e^{v_D / nV_T} \qquad \text{for} \quad v_D \gg nV_T
\end{aligned}
$$

An **exponential** curve !

→ i_D increases rapidly with v_D in the f.b. region!

Example: $I_s = 10^{-12}$, n=1

v_D (V)	i_D
0.4	9 μA
0.5	0.5 mA
0.6	26 mA
0.7	1.4 A
0.8	79 A
0.9	4311A → I'm melting!

∴ A junction diode in forward bias with **significant** but **plausible** current always has a voltage v_D between approximately 0.5V and 0.8 V!

I.E., $0.5 < v_D < 0.8$ (aprox.) when in f.b.

Therfore, we often **APPROXIMATE** the **forward biased** junction diode voltage as simply:

$$v_D \simeq 0.7 \text{ V}$$

Note that this approximation:

a) is typically accurate to within a few hundred mVs.

b) is completely subjective (e.g., some texts use 0.6 or 0.65 V).

HO: The Junction Diode Forward Bias Equation

HO: Example: A Junction Diode Circuit

B. The Reverse Bias Region

Now consider when $v_D \ll -nV_T$ (i.e, when $v_D \ll \approx -25mV$).

→ The junction diode is said to be "reverse biased" (r.b.)!

Note then that now $e^{v_D/nV_T} \ll 1$, so that a **reverse biased** junction diode **approximation** is:

$$\begin{aligned} i_D &= I_s\left(e^{v_D/nV_T} - 1\right) \\ &\approx -I_s \qquad\qquad for \quad v_D \ll -nV_T \end{aligned}$$

Therefore, a reverse biased junction diode has a **tiny, negative** current.

→ Scale current I_s if very sensitive to temperature (e.g. doubles for each 10° C rise).

HO: Forward and Reverse Bias Approximations

C. The Breakdown Region

If v_D becomes too **negative**, then diode will **breakdown** (b.d.)!

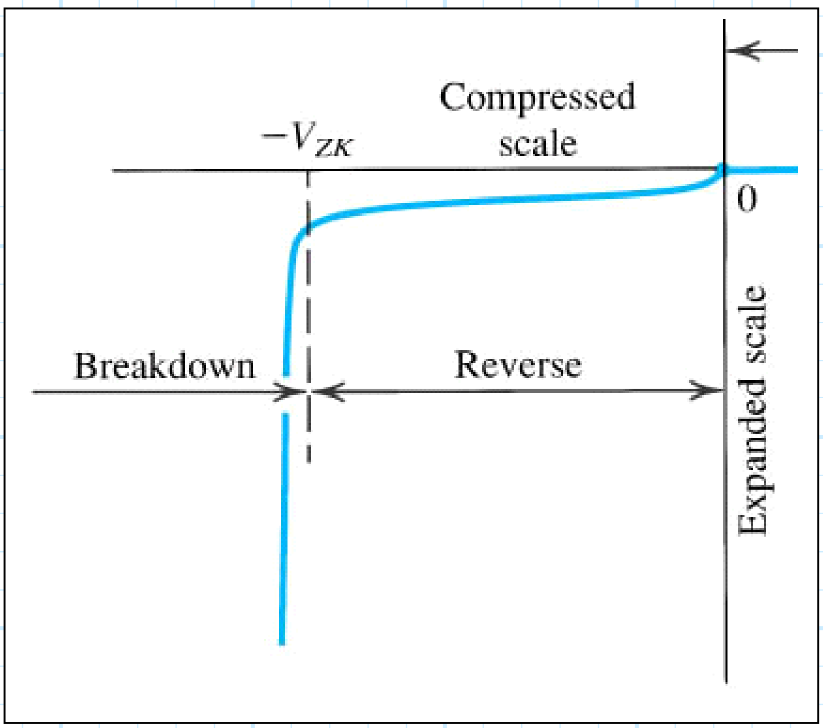
* I.E., **significant** current **will** flow from cathode to anode ($i_D < 0$!).

* v_D will remain at approximately $-V_{ZK}$, **regardless** of i_D.

Therefore, **breakdown** is describe mathematically as:

$$i_D < 0, \quad v_D \simeq -V_{ZK} \quad (\textit{for bd})$$

Note that V_{ZK} is a "knee" voltage (i.e., value is **subjective**).



V_{ZK} is typically greater than 25 V.

D. Power Dissipation in Junction Diodes

Consider the **power** dissipated by a junction diode (i.e., $P = V\,I$)

f.b. → $P \simeq 0.7\, i_D$ (moderate)

r.b → $P \simeq -I_s\, v_D$ (tiny)

b.d → $P \simeq -V_{ZK}\, i_D$ (big, potentially destructive)

Thus, we typically try to **avoid** breakdown. In other words, we desire V_{ZK} to be as **big** as possible!