Figure 3.17. (a) Diode circuit, (b) illustration for very negative inputs, (c) equivalent circuit when $D_1$ is off, (d) input/output characteristic.

$$I_{R1} = \frac{0 - V_X}{R_1} = \frac{-(V_{in} + V_{D,on})}{R_1}.$$  \hspace{1cm} (3.21)

Thus, as $V_{in}$ increases from $-\infty$, $I_{R2}$ remains constant but $|I_{R1}|$ decreases; i.e., at some point $I_{R2} = I_{R1}$.

At what point does $D_1$ turn off? Interestingly, in this case it is simpler to seek the condition that results in a zero current through the diode rather than insufficient voltage across it. The observation that at some point, $I_{R2} = I_{R1}$ proves useful here as this condition also implies that $D_1$ carries no current ($KCL$ at node $X$). In other words, $D_1$ turns off if $V_{in}$ is chosen to yield $I_{R2} = I_{R1}$. From (3.20) and (3.22),

$$\frac{V_{D,on}}{R_2} = -\frac{V_{in} + V_{D,on}}{R_1}.$$  \hspace{1cm} (3.23)

and hence

$$V_{in} = -(1 + \frac{R_1}{R_2})V_{D,on}.$$  \hspace{1cm} (3.24)

As $V_{in}$ exceeds this value, the circuit reduces to that shown in Fig. 3.17(c) and

$$V_{out} = \frac{R_1}{R_1 + R_2}V_{in}.$$  \hspace{1cm} (3.25)