($\Longrightarrow$)
Suppose a language L is decidable.
Let M be a decider TM such that $\mathcal{L}(M) = L$
Let $S = x_1,\ x_2,\ \ldots$ be the sequence of words of L in shortlex order.

Here's an enumerator that prints L in shortlex order
$E =$ "Ignore the input
1. for $i = 1$ to ∞
2. run M on x_i
3. if M accepts x_i
4. print x_i"

($\Longleftarrow$)
Suppose enumerator E enumerates L.

Here's a TM that is a decider for L.
$M =$ "On input w
1. run E
2. if E prints w
3. accept
4. if the output of $E > |w|$"
5. reject"

To prove M is a decider, we will look at 2 cases:
Case 1: L is unbounded
M never loops since $|x_i|$ is increasing as i increases.
Since Σ is finite, x_i will eventually increase as you can't
have an infinite list of words with equal length.
Line 4 will eventually be true which leads to M rejecting.

Case 2: L is bounded
If the length of words in L is bounded by some $n \in \mathbb{N}$, then S is finite.
So even if $|w| > n$, E will eventually stop printing which leads to
M rejecting.