Classical ramification theory deals with extensions of complete discrete valuation rings with perfect residue fields. We would like to study arbitrary valuation rings with possibly imperfect residue fields and possibly non-discrete valuations of rank \( \geq 1 \), since several fascinating complications arise for such rings. In particular, defect may occur (i.e. we can have a non-trivial extension, such that there is no extension of the residue field or the value group) when the residue characteristic is positive. In "Ramification Theory I", we presented a generalization of Kato’s Swan conductor for degree \( p \) extensions of arbitrary valuation fields in residue characteristic \( p > 0 \). Now we discuss a generalization and further refinement of the refined Swan conductor in this case. Our hope is that these results will have many interesting applications in algebraic geometry and number theory.