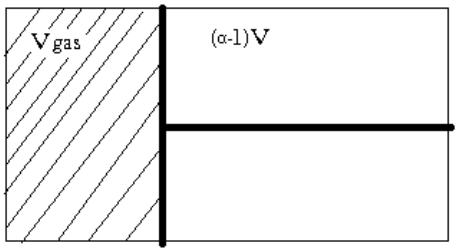
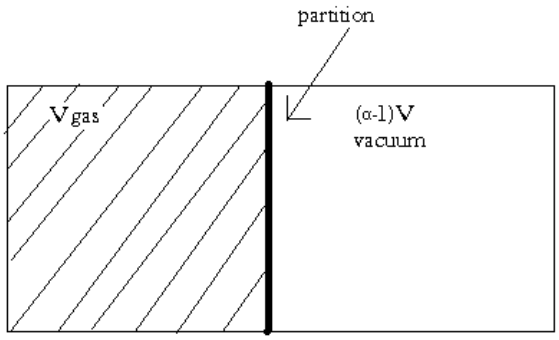
Consider n moles of a gas, initially confined within a volume V and held at temperature T. The gas is expanded to a total volume αV, where α is a constant, by (a) a reversible isothermal expansion and (b) removing a partition and allowing a free expansion into the vacuum. Both cases are illustrated below.

(a)



(b)



Assuming the gas is ideal, derive an expression for the change of entropy of the gas in each case.

Repeat this calculation for case (a), assuming that the gas obeys the van der Waals equation of state

$$\left(p + \frac{n^2 a}{V^2}\right)(V - nb) = nRT$$

Show further that for case (b) the temperature of the van der Waals gas falls by an amount proportional to $(\alpha - 1)/\alpha$