

## 1 Bottle in a Bottle 2

Consider the bottle in a bottle problem in a previous problem set, summarized here. A small bottle of helium is placed inside a large bottle, which otherwise contains vacuum. The inner bottle contains a slow leak, so that the helium leaks into the outer bottle. The inner bottle contains one tenth the volume of the outer bottle, which is insulated.

The volume of the small bottle is  $0.001 \text{ m}^3$  and the volume of the big bottle is  $0.01 \text{ m}^3$ . The initial state of the gas in the small bottle was  $p = 106 \text{ Pa}$  and its temperature  $T = 300 \text{ K}$ . Approximate the helium gas as an ideal gas of equations of state  $pV = Nk_B T$  and  $U = \frac{3}{2} Nk_B T$ .



- (a) How many molecules of gas does the large bottle contain? What is the final temperature of the gas?
- (b) Compute the integral  $\int \frac{dQ}{T}$  and the change of entropy  $\Delta S$  between the initial state (gas in the small bottle) and the final state (gas leaked in the big bottle).
- (c) Discuss your results.