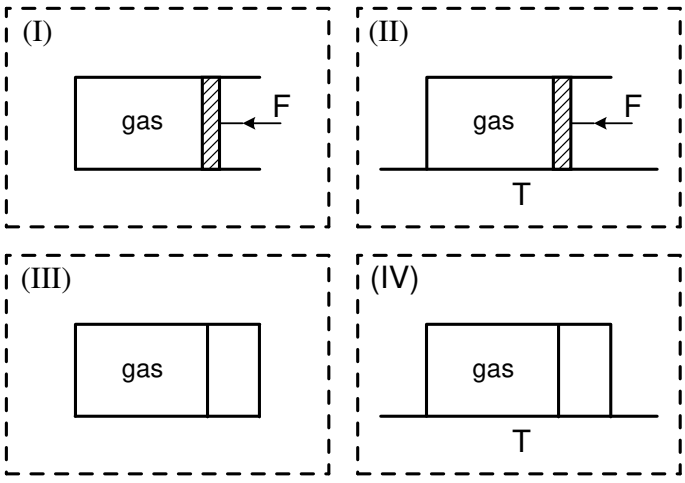
C5.3, Statistical Mechanics

Problem Sheet 2

Mathematical Institute, University of Oxford

January 4, 2021

1. Problem 5.2 in Sethna: *Burning Information & Maxwellian demons.*
2. Problem 5.5 in Sethna: *Pressure-Volume Diagramm.*
3. Problem 5.7 in Sethna: *Does Entropy Increase?*
4. Problem 5.12 in Sethna: *Rubber Band.*
5. Problem 5.13 in Sethna: *How many shuffles?*
6. Problem 5.17 in Sethna: *Deriving entropy.*
7. *The Ideal Gas*: Consider the expansion of a mono-atomic ideal gas of N atoms from volume V_1 to volume V_2 in the four situations depicted in the figure.



In panel (I), the gas is thermally isolated, and the expansion is done slowly with the mechanical force always almost balancing the pressure force. Panel (II) is the

same as (I), but the gas is in thermal contact with a reservoir at temperature T. In panel (III), the gas is thermally isolated, and the expansion occurs by removing the partition to the second region, which initially contains a vacuum. Panel (IV) is the same as (III), but the gas is in contact with a reservoir at temperature T. In panels (I) and (III), the initial state of the gas is also prepared to be at temperature T. The dashed box indicates that the interior (gas or gas plus reservoir) should be considered as an isolated system.

In each case, calculate the following:

a. The final equilibrium temperature and pressure of the gas.

b. The mechanical work extracted from the gas, and the thermal energy transferred from the reservoir in cases (II) and (IV).

c. The change in the entropy of the gas.

d. The change in the entropy of the whole isolated system denoted by the dashed box.

e. State whether the change is reversible or irreversible, and relate your answer to part (d).

8. Problem 6.3 in Sethna: *Negative Temperature.*

9. Problem 6.9 in Sethna: *Gibbs-Duhem.*

10. Problem 6.11 in Sethna: *Barrier Crossing (Chemistry).*
