Physics 3374/6351 Professor Scalise
Practice Midterm Fall 2016

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1. A gas satisfies the relation $U = \dfrac{aS^4}{NV^2}$ where a is a constant, N is the number of particles which is held fixed, V is the volume, and S is the entropy.

   (a) Derive an expression for the temperature T.

   (b) Derive an expression for the pressure P.

   (c) What is the equation of state (an equation relating P, V, T, and N) for this gas?

2. Given 100 distinguishable coins which can show either heads or tails, (express numerical all answers in scientific notation, not formulae)

   (a) How many possible states N_s are there?

   (b) How many states have no heads showing?

   (c) How many states have exactly one head showing?

   (d) How many states have exactly two heads showing?

   (e) If the coins are randomized, what is the most likely number of heads showi ng?

   (f) How many states have this most likely number of heads showing?

   (g) What fraction of the total number of states is this?

   (h) If another 100 coins are added to the original 100, what is the new number of possible states in terms of the original number N_s?

   (i) Is the number of possible states extrinsic? If yes, explain why; if no, suggest an extrinsic quantity.

3. A peculiar gas is observed to be governed by two relations:

$$U(V,T) = Vf(T) \qquad \text{and} \qquad \mathrm{P(T)} = \frac{1}{3}\mathrm{f(T)}$$

   where U is the energy, P is the pressure, and $f(T)$ is a function of the absolute temperature T. Hints: find dU, use the first law to find dS, look at the mixed partial derivatives noting that dS is an exact differential, obtain a differential equation for $f(T)$.

   (a) How does the energy U depend on T?

   (b) How does the pressure P depend on T?

   (c) How does the entropy S depend on V and T?