

Write your name on the test booklet. Do NOT simply write an answer. Give a calculation and/or reasoning that supports your answer. Do all work and write all answers in the test booklet. Circle or clearly delineate all relevant work so that I do not take points off for errors in your scratch work.

- 1) A volume V at temperature T contains N spin-0 bosons of mass m .
(a) Compute N and the energy U as functions of the chemical potential μ . Use this result to determine the critical temperature T_c at which a Bose condensate emerges. (b) Find N and U below T_c and approximate $U(N, V, T)$ in the low temperature limit.

- 2) The partition function and equation of state for the van der Waals gas model are given in the notes. (a) Determine the constants a and b appearing in the equation of state in terms of T_c , P_c and V_c . (b) Find the energy U and the heat capacity $C_V = \left(\frac{\partial U}{\partial T}\right)_V$, also in terms of T_c , P_c and V_c .

- 3) (a) Find the mass density for a white dwarf in terms of fundamental constants (e.g., particle masses, \hbar) and the total mass of the star, M . Use this result to find a relation between the total mass and the radius. (b) Find the mass density for a neutron star in terms of fundamental constants (e.g., particle masses, \hbar) and the total mass of the star, M . Use this result to find a relation between the total mass and the radius. (c) Estimate the maximum mass of a white dwarf and the maximum mass of a neutron star.