PHAS1228/2010 PROBLEM SHEET 2

Problem Sheet 2, handed out Friday 5th Feb., due in Friday 12th Feb. 16:00

1. A monatomic ideal gas is compressed adiabatically and reversibly until its volume has been reduced to one eighth of the original volume. It is then allowed to expand isothermally and reversibly until its volume is back to the original volume. Calculate the ratio of the final to the initial pressure [3].

2. For a monatomic ideal gas, the equation of state $PV = nRT$ and the fact the C_V is a constant led to the three well-known equations: (i) $W = -nRT\ln(V_f/V_i)$, (ii) $C_P = C_V + nR$ and (iii) $PV^\gamma =$ constant. Identify the meaning of each equation and derive analogous equations for the case in which the gas equation of state is $PV^2 = n^2cT$ and constant C_V (here c is a constant). Hint: in part (iii) do not introduce γ until after integration. [Marks: 3×3].

3. Find the three equations (i), (ii), (iii) as in the previous question, but this time using the equation of state $P(V - nb) = nRT$ where b is a constant. Hint: look for a very quick and easy proof. [4]

4. State the equation that defines the isothermal compressibility and state the Van der Waals equation of state. Calculate the isothermal compressibility of the Van der Waals fluid. [2]

5. Write down the first law in infinitesimal form for an ideal gas, assuming a reversible process and introducing C_V. Show that the differential $dS = đQ/T$ can be integrated. Hence show that S is a state function. (Later in the course we will see that S is, in fact, the entropy). [2]