In-course Examination

Physics, CSE-1104

March 08,2018

Answer ALL questions | Time: 1 hour 30 minutes | [Marks 25]

1. Consider an ideal gas undergoing a reversible adiabatic compression or expansion.

   (a) Starting from the first law of thermodynamics, show that

   i. $nC_V dT = nRT(dP/P) - nRdT$ [2]

   ii. $nC_V dT = -nRT(dV/V)$ [2]

   (b) Derive equations: (a) relating T and P **using i. above** and (b) relating T and V **using ii. above**, for the reversible adiabatic process (compression or expansion) of an ideal gas with constant heat capacities. Hence find the relation between (c) P and V for the adiabatic process. [1+1+1]

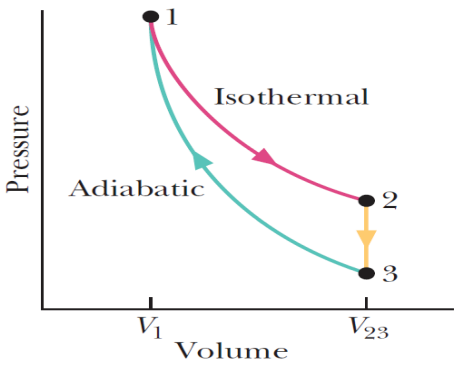
2. n moles of a diatomic ideal gas are taken through the cycle with the molecules rotating but not oscillating, where $V_{23} = 3.00V_1$.

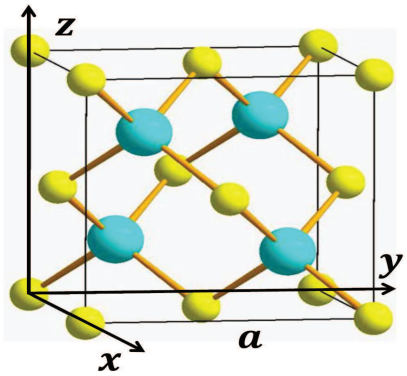
   (a) What are the values of p_2/p_1, p_3/p_1 and T_3/T_1 ? $[\frac{1}{2} \times 3 = 1.5]$

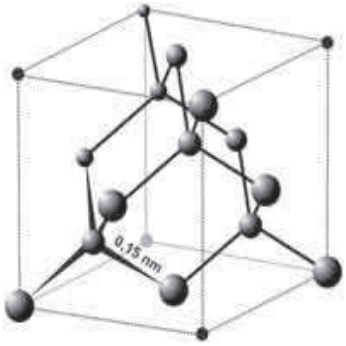
   (b) For path $1 \to 2$, what are (i) W/nRT_1, (ii) Q/nRT_1, (iii) $\Delta E_{int}/nRT_1$ and (iv) $\Delta S/nR$? $[\frac{1}{2} \times 4 = 2]$

   (c) For path $3 \to 1$, what are (i) W/nRT_1, (ii) Q/nRT_1, (iii) $\Delta E_{int}/nRT_1$ and (iv) $\Delta S/nR$? $[\frac{1}{2} \times 4 = 2]$

   (d) Find the average speed, rms speed and the most probable speed of the gas at state 1 in terms of p_1 and V_1. $[\frac{1}{2} \times 3 = 1.5]$







3. Consider the crystal structure of Sphalerite or Zinc Blend (ZnS) as shown in the second figure above. The larger spheres represent S atoms and the smaller ones represent Zn atoms.

   (a) Identify the type of the Bravais lattice. [1]

   (b) Draw the three primitive lattice vectors $\vec{a}_1, \vec{a}_2, \vec{a}_3$ and write them in terms of the Cartesian unit vectors $\hat{x}$, $\hat{y}$ and $\hat{z}$. Taking the length of the side of the cube as a, find the volume of the primitive unit cell. $[1 + 1 = 2]$

   (c) Mark the basis of the crystal and find the position vectors of the atoms in the basis. $[1 + 0.5 + 0.5 = 2]$

   (d) Find the coordination number of the Zn and S atoms. $[0.5 + 0.5 = 1]$

   (e) If Zn and S atoms are replaced by carbon atoms, the above becomes the structure of diamond (c.f. third figure above). Assuming C atoms as hard spheres, find the packing fraction of the diamond structure. [3]

   (f) Find the Miller indices of a plane passing through three C atoms in the middle of the xy-, zx- and zy- planes (as shown in the figure). [2]