

1) For a rigid rotor in one dimension (for simplicity) the kinetic energy can be expressed either as  $T = m_1 v_1^2/2 + m_2 v_2^2/2$  or as  $M v_{\text{cm}}^2/2 + \mu v^2/2$ , where  $v_{\text{cm}}$  is the center-of-mass velocity and  $v = v_1 - v_2$ . Prove it! What is  $M$  and  $\mu$  and how do they relate to  $m_1$  and  $m_2$ ?

2) HBr is an almost (but not quite) harmonic oscillator. Its harmonic frequency equals to  $\nu_e = 2650 \text{ cm}^{-1}$ . The anharmonicity is  $x_e \nu_e = 45 \text{ cm}^{-1}$ . What are the frequencies of the fundamental and first overtone transitions? What frequency corresponds to the  $v = 1 \rightarrow v = 2$  transition?