

Advanced Atomic and Molecular Physics

Final Exam

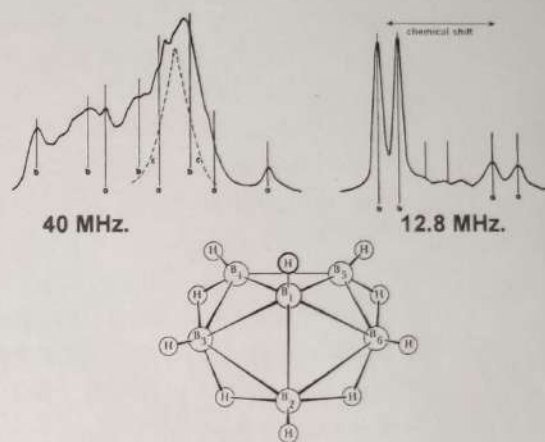
Dear Students, please aim for short and economic answers. In many cases, a single sentence will be sufficient to answer the extra questions. When discussing experimental setups, please also provide labelled sketches.

All the best,

Andreas Hauser

1) Nuclear magnetic resonance

- (3p) Describe the principle of nuclear magnetic resonance measurements (NMR) in stationary and in pulsed setups. Why is it necessary to generate extremely strong magnetic fields?
- (2p) The picture to the right shows NMR measurements on hexaborane, one on H atoms, one on B atoms. Which belongs to which? How do you know, given the molecular structure shown in the lower graphics?
- (3p) Which types on spin relaxation can be distinguished in pulsed measurements?
- (2p) What can be derived from the relaxation times, and how is this information used e.g. in medical applications of NMR?



2) Atomic beam magnetic resonance

- (3p) Briefly describe the principle and the setup of the atomic beam magnetic resonance experiment of Rabi. Provide a labelled sketch of the apparatus.
- (1p) Why is it necessary to apply an inhomogeneous magnetic field in the first and the third section?
- (1p) Why is a homogeneous magnetic field applied in the middle section?
- (1p) Look at the figure to the right. What are the quantum numbers I , J and F denoting?
- (1p) How do we call the regime in which F is still a good quantum number?
- (1p) Which of the upper m_F levels is particularly well suited for this experiment and why?
- (2p) How large should the field gradient of a 20 cm long magnetic field be to achieve a deflection of sodium atoms ($m = 23$ u) in their $^2S_{1/2}$ state by 3° in a Rabi-type apparatus if the atoms fly with $v = 600$ m/s through the field? ($\mu_B = 9.27 \cdot 10^{-24}$ J/T)

