

UNIVERSITY OF KANSAS
Department of Physics and Astronomy
Astrophysics I (ASTR 691) — Prof. Crossfield — Fall 2026

In-Class Problems 9

You may use your OoMA Sheet, your handwritten notes, and a scientific or graphing calculator – and you may work in a group. As always, be sure to: show your work, circle or highlight your final answer, list units, use the appropriate number of significant figures, and write your name.

1. Transition Rates [10 pts]

- (a) Define and describe A_{UL} . What are its units? How is it related to j_ν ?
- (b) Define and describe B_{LU} . What are its units? How is it related to α_ν ?
- (c) What is the ratio $\frac{A_{UL}}{B_{LU}}$, in terms of other relevant quantities? How does it relate to the source function, S_ν ?

2. Atomic (i.e., Electronic) Transitions [20 pts]

- (a) Derive the relation that a neutral H atom's energy levels are given by $E_n \approx (-13.6 \text{ eV}) / n^2$. [4 pts]
- (b) For a neutral H atom, draw an energy diagram for transitions between all energy levels $n \leq 6$. [4 pts]
- (c) For these same hydrogen transitions ($n \leq 6$) plot on a graph or number line, and label, the locations of all possible photon wavelengths. Use a logarithmic wavelength axis. [4 pts]
- (d) If any atom loses all but one of its electrons, the spectrum of that ion (e.g. He^+ , Li^{++} , etc.) will resemble that of a Hydrogen atom. How will the ion's energy levels and spectrum be similar to that of hydrogen? how will they be different? [3 pts]
- (e) Consider a spectrum of a star that your colleague recently observed at their telescope. The spectrum shows a spectral absorption line that neither of you are familiar with. Explain how you might go about identifying the physical source of this absorption line. What would be the challenges in this process? How could you obtain a more certain answer or otherwise test your initial conclusion? [5 pts]