JH ASTRONOMY AND ASTROPHYSICS: AS 3015

Nebulae: Sample exam questions

1. Distinguish between the terms *natural*, *thermal* and *collisional* broadening of spectral lines. Write down formulae that represent the profiles of spectral lines broadened by these processes, defining all terms that are used, and sketch the form of the spectral lines. Explain clearly how the pressure affects the relative importance of the different processes.

   (15 marks)

   Write down the equation of radiative transfer, and its formal solution, for radiation passing through a medium. If the source function is constant along a path through the medium, derive an expression for the emergent specific intensity.

   (15 marks)

   Use this result to explain why some sources display absorption line spectra, and others emission line spectra. Give one example of each.

   (10 marks)

2. Define the three Einstein coefficients A_{21}, B_{12} and B_{21}.

   (6 marks)

   Explain what is meant by the *principle of detailed balance* and the *Boltzmann law*. Hence, derive an expression for the mean intensity of radiation in thermal equilibrium in terms of the Einstein coefficients.

   (12 marks)

   By requiring that the expression derived above equal the Planck function at all frequencies, derive the *Einstein relations* between the coefficients.

   (10 marks)

   Two energy levels have statistical weights g_1 (for the lower level) and g_2, and populations n_1 and n_2. The frequency of a photon emitted or absorbed during a transition between them is ν. At temperature T what ratio between n_1 and n_2 do you expect (i) when local thermodynamic equilibrium applies, (ii) out of LTE, and (iii) in a maser source?

   (12 marks)