Answer THREE questions from Section A and THREE questions from Section B.

You are advised to spend no more than 10 minutes on each Section A answer, and about 30 minutes on each Section B answer.

The numbers in square brackets indicate the provisional allocation of maximum marks for sub–sections of the question.

SECTION A

1. Briefly contrast the differences in temperature, density and hydrogen ionization state for the four main phases of the interstellar medium. [4]

   Quote the percentage (by number) of hydrogen atoms, helium atoms, and heavier elements (metals) in the generic ISM. [3]

2. State what types of atomic transitions are observed as interstellar absorption lines. [1]

   List the two types of bright objects that can be used as background sources to probe interstellar atomic gas in the line-of-sight in the near and distant Universe. [2]

   Explain how the Equivalent Width of an absorption line is calculated. You may want to draw a diagram to illustrate your answer. [4]

3. Describe the only way in which dark nebulae can be identified in the optical regime. In which part of the electromagnetic spectrum would you expect to see emission lines from dark nebulae, and from what type of particle do they arise? [3]

   Briefly describe the four mechanisms that compress the ISM and trigger star formation. [4]

SECTION B

4. Describe the dominant heating and cooling mechanisms in a pure hydrogen H II region, with reference to photoionization, thermalisation, and recombination? What energy does a photon need to have to photoionise hydrogen? Describe (with the aid of a diagram) how these mechanisms operate in a hydrogen atom. Include in your diagram a description of what the Lyman, Balmer and Paschen series are. [8]

   What are the dominant sources of heating and cooling in a diffuse cloud (where hydrogen is mostly neutral)? [3]

   Discuss briefly how forbidden lines form and why forbidden lines cannot be observed on Earth? Why are forbidden lines very efficient at cooling gas?[9]

5. Describe what is meant by Hydrostatic Equilibrium for a gaseous body, and Jeans' Mass of an interstellar cloud. What interstellar temperatures are most conducive to star formation and why? [5]

   Briefly describe the mechanism through which a protostar gains mass, with reference to the accretion disk. Where does the surplus energy of the accreting matter go? [4]

   How do protostars lose mass as they are forming? Describe in simple terms the physical mechanism that channels the outflow. At approximately what speeds is the mass ejected, and how long do these ejection episodes last? What is the name of a protostar that is losing mass in this way? What is the main observation evidence that stars lose mass? [7]

   Sketch a simple cartoon of an idealised protostar and its surroundings, labelling the components discussed above. [4]

6. Outline the basic approach used to determine gas element abundances from measurements of interstellar absorption lines. [7]

What would be the difference between observing an interstellar cloud with strong forbidden lines and weak forbidden lines? How would this affect the nebular cooling rate? [3]

What is found when the abundances of metals in the ISM is compared to those in the Sun? How does this help in determining the chemical composition of interstellar dust? [2]

At what wavelength does neutral *atomic* hydrogen (H I) emit light. In simple terms, explain how this emission process occurs? You may use a diagram to illustrate your answer. [6]

Hydrogen in its *molecular* form (H_2) is hard to detect. Emission from what molecule is commonly used to trace its existence? On average, in what proportions are H_2 and this molecule found? [2]

PHAS2521/2007 **END OF PAPER**