

**EXAM:**

Course title: "Atomic Spectroscopy and Collisional Excitations in Plasmas"  
 with Workshop on: SUPERSTRUCTURE, R-Matrix codes  
 Cairo University, Giza, March 28 - April 16, 2015  
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Total points = 45

Note: Number of points for each question is given within parentheses

Good luck!

1. i) What are the most abundant elements in the universe? (1)
- ii) Which elements give the most information of an object? (1)
- ii) How are elements heavier than iron formed (1)?
2. i) How do we describe a black body? (1)
- ii) Why do we see the yellow sun? (1)
- iii) What is opacity? (1)
- iv) What are the main atomic processes that cause opacity? (1)
3. i) Which part of an atom is studied under Atomic Physics? (1)
- ii) How do we identify an element from an astrophysical spectra? (1)
- iii) How do we detect a black hole? (1)
4. i) Write down the Rydberg formula for hydrogen? (1)
- ii) What is the  $K_\alpha$  line? (1)
- iii) Give its wavelength of Lyman $\alpha$ . (1)
5. i) What is quantum defect? (1)
- ii) Write down the Rydberg formula with the quantum defect. (1)
- iii) When is this formula used? (1)
6. i) What is the configuration for an atomic system? (1)
- ii) Write down the ground configuration of oxygen atom. (1)
- iii) How do we write the symmetry of an electronic state with quantum numbers including fine structure. (1)
7. i) What are equivalent and non-equivalent states? (1)
- ii) Which of them have less number of LS states and why? (1)
- iii) Write down all the LS states of  $2p3d$  and list them in energy according to Hund's rule. (2)
- iv) Write down all the LS states of  $2p^2$  and list them in energy order following Hund's rule. (2)
8. i) Why do we get exact wavefunction for hydrogen, but not for multi-electron systems? (1) ii) What equations do we need to solve for multi-electron systems? (1)

9. i) What approximations can we use to include relativistic effects for higher accuracy? (1)  
ii) What interaction splits the LS term energy in to fine structure levels? (1)
10. i) What is a radiative transition and what is the name of the rules that define the transitions? (2)  
ii) Name the 5 types of radiative transitions, with specifications of allowed or forbidden, that SS calculates. (2)  
iii) How can the lifetime of an atomic state be calculated? (1)
11. Write down the most dominant atomic processes that form plasma spectra. (2)
12. i) What is the difference in features between hydrogenic and multi-electron photoionization? (1)  
ii) Which approximation can calculate the resonances naturally? (1)
13. i) What is an autoionizing state? (1)  
ii) What does it lead to? (1)
14. i) What is the relation between photoionization and electron-ion recombination? (1)  
ii) How many ways does electronic recombination take place? (1)  
iii) Which is the method that incorporates them together? (1)
15. We had demonstration of SUPERSTRUCTURE (SS) and R-Matrix codes. i) What does SS calculate? (1)  
ii) What do R-matrix codes calculate? (1)