

ASTROCHEMISTRY – A MOLECULAR APPROACH

CHEM657/ASTR657

Spring 2021

Prof. Ralf I. Kaiser
Office Hours M, 1:00-2:00
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The class will meet each Friday through Skype from 1:30 pm to 4:30 pm. The first class will be on January 15, 2021. Please do add me to your skype account a few days prior to this class.

The ultimate goal of this class is to understand and to predict the fundamental chemical and physical processes leading to the formation of molecules ranging from diatomics (H_2) to complex, astrobiologically important species (amino acids, sugars) in the interstellar medium and in our Solar System – both in the gas phase (molecular clouds, star forming regions, atmospheres of planets and their moons) and in the solid state (interstellar grains, icy planets and moons, comets). A detailed understanding of these processes is imperative to correctly interpret data from astronomical observations and from actual space missions and to develop realistic models how distinct interstellar and Solar System environments are processed chemically. Current misconceptions in astrochemistry are also highlighted and refuted.

OVERVIEW

1. overview of matter and physical conditions in the interstellar medium
2. molecular geometry, chemical bond strengths, electronic states
3. molecular composition of the interstellar medium (neutrals, cations, anions)
4. overview of interstellar environments (gas phase, ices, temperature, pressures, molecules)

GAS PHASE PROCESSES

5. characteristics & energetics of a chemical reaction
6. direct versus indirect reactions; barriers versus barrier-less
7. collision theory gas phase
8. reaction classes in interstellar chemistry: understanding why molecules are formed in the ISM
9. retro-synthesis gas phase chemistry: prediction where molecules are formed in the ISM

SOLID STATE REACTIONS

10. thermal reactions on interstellar grains
11. suprathermal versus thermal rate constants
12. collision theory solid state (CASINO and TRIM)
13. retro-synthesis solid state chemistry
14. experimental studies of interaction of ionizing radiation with matter

LABORATORY ASTROPHYSICS

15. kinetics of low temperature reactions
16. soft photo ionization of complex organic molecules
17. spectroscopy (infrared, Raman, UVVIS)

GRADING

The grading for this three-credit course is based on one midterm (30 %), one presentation (30 %), and the final (40 %). The exams will not be curved. No makeup exams will be given.