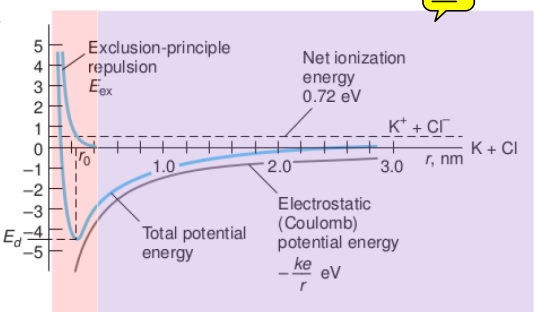
JOINT INSTITUTE
交大密西根学院

MODERN PHYSICS (Summer 2020)

Review Questions
(week of 13 July 2020)

1. What is spin–orbit coupling? (Idea only.)
2. Including the spin quantum number, but ignoring the spin–orbit coupling, the degeneracy of energy levels in the hydrogen atom is ..... [Answer: $2n^2$]
3. *True or false?* Identical quantum particles are indistinguishable.
4. *Indicate the right answer*: The wave function of a system of identical *fermions* is symmetric/antisymmetric with respect to exchange of two particles.
5. *Indicate the right answer*: The wave function of a system of identical *bosons* is symmetric/antisymmetric with respect to exchange of two particles.
6. *Mark the correct answer.* Particles with half-integer spin number s are bosons/fermions.
7. *Mark the correct answer.* Particles with integer spin number s are bosons/fermions.
8. *True or false?* Electron is a boson.
9. What is the Pauli exclusion principle? What particles does it apply to?
10. *True or false?* Electrons are subject to the Pauli exclusion principle.
11. Name the bonding mechanisms you know.
12. Briefly (qualitatively) describe how a molecule with an ionic bond is formed.
13. A molecule with an ionic bond forms as a result of competition between the attractive long-range ..... interaction between the ions and the repulsive short-range interaction due to .....
14. *True or false? In a molecule with an ionic bond an electron is transferred from one atom to another.*
    In a molecule with an ionic bond an electron is shared by both atoms.
15. What electrons in an atom are called valence electrons?
16. What is the electron affinity of an atom?
17. What is the dissociation energy of a molecule?
18. Sketch the graph of the potential energy of a molecule with an ionic bond as a function of the atom separation. On the graph mark the equilibrium separation and the dissociation energy. Explain how can we find the energy due to Pauli–exclusion repulsion at the equilibrium separation.
19. What interaction dominates in an ionic–bond molecule, if the separation distance is much less than the equilibrium separation? Much greater?
20. The energy of repulsion due to the Pauli exclusion principle is usually repulsive interaction is short/long–range [choose the correct word].
21. Why the bonding mechanism in a H_2 molecule cannot be ionic?
22. What is the bonding mechanism in a H_2 molecule?



23. What is the bonding/antibonding orbital in a molecule with a covalent bond? Which has lower energy?

24. Why don't the two electrons in a H_2 molecule occupy the antibonding orbital?

25. Explain the relation between the symmetry of the spin and the spatial part of a two-electron wave function in a H_2 molecule.

26. What is the exchange symmetry of the spin part of the wave function for the spin-singlet configuration of two $s = 1/2$ particles? Same question for the spin-triplet.

27. The bonding orbital in a H_2 is described by a two-electron wave function that is spin–. . . . . and space–. . . . . with respect to interchange of two electrons. [Answer: spin-antisymmetric (or spin-singlet) and space-symmetric]

28. The bonding orbital in a H_2 molecule corresponds to the spin–-. . . . . configuration of two electrons.

29. *True or false?*

    - In a molecule with a covalent bond electrons are transferred from one atom to another.
    - In a molecule with a covalent bond electrons are shared by atoms.
    - The bonding mechanism in homo-atomic molecules is . . . . . .

30. Usually, the bonding mechanism in a molecule is neither purely ionic nor purely covalent. How do we define to what extent is the bond ionic?

31. The magnitude of the electric dipole of a diatomic molecule with separation distance between atoms $1.1 \cdot 10^{-10}$ m has been measured at $0.77 \times 1.6 \cdot 10^{-19} \times 1.1 \cdot 10^{-10}$ C·m.

    To what extent is the bond ionic (give your answer in %)?