General and Structural Chemistry
Mid Sem Exam: Spring 2020
IIIT-Hyderabad

Full Marks: 50 **Time: 1:30 Hours**

Use of non-programmable scientific calculator is allowed.

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Q.1. (a) Why do elements in a group often exhibit similarities in physicochemical properties? **(1)**

(b) The electron affinity of carbon is greater than that of nitrogen; indeed, the latter is negative. Suggest reasons for this observation. **(2)**

(c) Tin forms tin(IV) oxide when heated in air but lead forms lead(II) oxide. Why? **(2)**

(d) Which properties of Li are useful in the Lithium-Ion Batteries? Justify your answer with the help of a schematic diagram of a typical Lithium-Ion Battery. **(3)**

(e) What is the main thermodynamic driving force for the thermite reaction, as given below? $2\ Al\ (s) + Fe_2O_3\ (s) \rightarrow 2\ Fe\ (s) + Al_2O_3\ (s)$ **(2)**

Q.2. (a) Au has a melting point of 1064°C whereas Hg is a liquid at room temperature and has a melting point of −39°C, though Au and Hg are neighbors on the periodic table. How can one explain such unusual differences between Au and Hg? **(5)**

(b) Draw the Lewis dot structure of O_2 molecule. Based on this structure, what conclusion can one draw about the magnetic property of this molecule? How can you explain the magnetic behavior of the O_2 molecule? Mention one of the uses of the magnetic property of the O_2 molecule. **(1,1,2,1)**

Q.3. (a) What is the Born-Oppenheimer (BO) Approximation? What is its usefulness in the molecular orbital theory? **(3)**

(b) What is the overlap integral? Draw a schematic plot showing the variation of the overlap integral with the internuclear distance for a H_2 molecule. Explain the nature of the plot. **(1,2)**

(c) When sodium metal, Na(s), is brought into contact with chlorine gas, $Cl_2(g)$, a violent reaction ensues and the product of this very exothermic reaction (ΔH_f° =

−410.9 kJ/mol) is sodium chloride, NaCl(s). However, the formation of gaseous sodium ion from solid sodium costs energy (604 kJ/mol) higher than the formation of one mol gaseous chlorine anion from the Cl_2 (g) molecule (−227 kJ/mol). The overall process appears to be an endothermic process, then how does stable NaCl(s) form? **(3)**

(b) By using the photoelectron spectroscopy, what kind of information can we get regarding the molecular orbitals? **(1)**

Q.4. (a) Draw schematic energy diagram showing the relationship between the atomic and molecular orbital energy levels for the valence electrons in HF. Based on the MO diagram, calculate the bond order of the molecule and comment on the polarity of the molecule. Why is the estimated dipole moment smaller in the excited state than in the ground state? **(2,1,1,1)**

(b) CO (carbon monoxide) forms an extensive series of carbonyl complexes with *d*-elements via the carbon end. Explain this behavior by using the molecular orbital theory. **(5)**

Q.5. (a) Which experimental techniques provide information regarding the bond strengths, bond lengths, and bond angles of molecules? **(1.5)**

(b) For each of the following coordination complex ions, sketch the crystal field (CF) *splitting diagram*, *label* the *d*-orbitals, *label* each energy level with its *group theoretical symbol*, *fill* in the electrons, and *predict* the magnetism: $[FeF_6]^{3-}$ and $[Fe(CN)_6]^{3-}$ ions. *Conclude* about whether each complex is high spin or low spin. **(2, 0.5, 1.5, 2, 1.5, 1)**

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