

**Indian Institute of Science Education and Research Kolkata**  
**1<sup>st</sup> Year Autumn Semester (2015-2016)**  
**CH1101 – Elements of Chemistry**  
**Mid-Sem Examination**

Time: 1h

Max Marks: 50

**Answers should be to the point.**

1. (a)  $\text{O}(\text{SiH}_3)_2$  is less basic than  $\text{H}_2\text{O}$ . Explain. (6)  
 (b) Arrive at the shapes of (i)  $\text{XeOF}_4$  and (ii)  $\text{PO}_4^{3-}$ . In each case comment on predicted as well as actual geometry. (2 x 3 = 6)
2. Using molecular-orbital energy level diagram arrange (in the increasing order) the N-O bond order in  $\text{NO}$ ,  $\text{NO}^+$ , and  $\text{NO}^-$ . (6)
3. Fill-up the blanks and make comments, as required:

Complexes	Write CFSE in terms of appropriate Dq	Comment on magnetic property	Comment on distorted or perfect structure; if distorted, the nature of distortion – mild or severe	Write electronic distribution in d-orbitals
$[\text{FeCl}_4]^-$				
$[\text{NiCl}_4]^{2-}$				
$[\text{Mn}(\text{H}_2\text{O})_6]^{3+}$				
$[\text{Co}(\text{H}_2\text{O})_6]^{3+}$				
$[\text{Fe}(\text{CN})_6]^{3-}$				

(4 x 4 = 16)

4. Showing orbital interaction diagram (label axes) explain the metal-CO bonding in  $[\text{Cr}(\text{CO})_6]$  and M- $\text{C}_2\text{H}_4$  bonding in  $[\text{PtCl}_3(\text{C}_2\text{H}_4)]^-$ , from the standpoint of metal-ligand interactions. (2 x 4 = 8)
5. Comment on the magnetic property of myoglobin in its deoxy- and oxy-form. (8)

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# End Semester Examination CH1101

Total Marks 100

Q1. Arrive at the shapes of the following compounds. In each case comment on predicted as well as actual geometry. (8)

- i)  $\text{OCIF}_3$       ii)  $\text{PhIO}$       iii)  $\text{NO}_2$       iv)  $(\text{PhO})_2\text{PO}_2^-$

Q2.  $\text{H}_3\text{Si-O-SiH}_3$  is linear in shape whereas  $\text{H}_3\text{C-O-CH}_3$  is bent. Why? (3)

Q3. Predict whether Jahn-Teller distortion occurs or not in the following complexes. If yes, predict what type of distortion (mild or severe) and suggest the modified d-orbital energy level splitting. (4)

- i)  $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$       ii)  $[\text{Mn}(\text{H}_2\text{O})_6]^{2+}$

Q4. Calculate the CFSE for the following complexes: (4)

- i)  $[\text{Co}(\text{H}_2\text{O})_6]^{3+}$ , ii)  $[\text{Co}(\text{CN})_6]^{4-}$ , iii)  $[\text{CoCl}_4]^-$ , iv)  $[\text{Co}(\text{NH}_3)_6]^{3+}$

Q5. Arrange the following in the correct order and fill the data. (8)

		Oxidation State and number of valance electrons or the metal ions (reactant and product)
(A)		$\beta$ -hydride elimination
(B)		Oxidative addition
(C)		Insertion
(D)		Reductive elimination

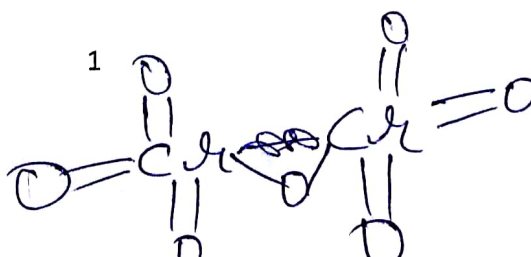
Q6. Arrange the following complexes in the increasing order of C-O stretching frequency. Justify. (3)

- i)  $[\text{Cr}(\text{CO})_6]$       ii)  $[\text{V}(\text{CO})_6]^-$       iii)  $[\text{Mn}(\text{CO})_6]^+$

Q8. Draw the Molecular Orbital diagram of  $\text{N}_2$  and predict the bond order of  $\text{N}_2$ ,  $\text{N}_2^+$  and  $\text{N}_2^-$ . (4)

Q9. What is the need of carbonic anhydrase in our body? Which metal ion is present in carbonic anhydrase and what is the role of metal ion? (4)

Q10. What is the structure of  $[\text{Cr}_2\text{O}_7]^{2-}$ ? Why  $[\text{Cr}_2\text{O}_7]^{2-}$  is intense orange in color? (2)



(6 x 1.5 = 9)

Q.11. Choose the correct answer/statement

- (i) A compound should be called aromatic if
- (a) It is only planar  
(b) ☒ If it is planar and has  $4n+2$   $\pi$ -electron  
(c) If it is planar and has  $4n$   $\pi$ -electron  
(d) None of the above

(ii) The benzylic carbocation will be

- (a) ☒ Aromatic  
(b) Non-aromatic  
(c) Anti-aromatic  
(d) None of the above

(iii) Correct order of increasing reaction rate of  $\text{CH}_3\text{CH}_2\text{Br}$  with the following nucleophiles is

- (a)  $\text{EtOH} > \text{EtSH} > \text{HO}^- > \text{EtO}^- > \text{EtS}^-$   
(b)  $\text{EtOH} > \text{HO}^- > \text{EtSH} > \text{EtO}^- > \text{EtS}^-$   
(c)  $\text{EtS}^- > \text{EtO}^- > \text{HO}^- > \text{EtSH} > \text{EtOH}$   
(d)  $\text{EtS}^- > \text{EtO}^- > \text{EtSH} > \text{HO}^- > \text{EtOH}$

(iv) In the  $\text{S}_{\text{N}}1$  reaction of  $(\text{CH}_3)_3\text{CBr}$  with the following nucleophile predict the increasing order of reaction rate

- (a)  $\text{PhCH}_2\text{S}^- > \text{EtO}^- > \text{HO}^- > \text{H}_2\text{O}$   
(b)  $\text{PhCH}_2\text{S}^- = \text{EtO}^- = \text{HO}^- = \text{H}_2\text{O}$   
(c)  $\text{H}_2\text{O} > \text{PhCH}_2\text{S}^- > \text{EtO}^- > \text{HO}^-$   
(d) None of the above

(v) The modest method for the synthesis of  $\text{PhCH}_2\text{CH}_2\text{CH}_2\text{CH}_3$  from benzene is

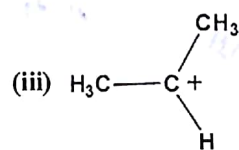
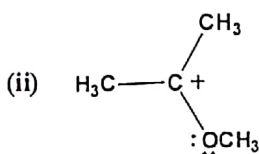
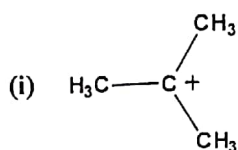
- (a)  $\text{AlCl}_3/\text{dry ether}, \text{CH}_3\text{CH}_2\text{CH}_2\text{CHBr}$   
(b) ☒  $\text{CH}_3\text{CH}_2\text{CH}_2\text{COCl}, \text{AlCl}_3/\text{Water}, \text{Zn(Hg)/HCl}$   
(c)  $\text{TiCl}_3/\text{dry ether}, \text{CH}_3\text{CH}_2\text{CH}_2\text{CHBr}$   
(d) None of the above

(vi) Increasing order of nucleophilicity in polar protic solvent of the following nucleophiles is

- (a)  $\text{F}^- > \text{Cl}^- > \text{Br}^- > \text{I}^-$   
(b)  $\text{I}^- > \text{Cl}^- > \text{Br}^- > \text{F}^-$   
(c) ☒  $\text{I}^- > \text{Br}^- > \text{Cl}^- > \text{F}^-$   
(d)  $\text{Br}^- > \text{F}^- > \text{Cl}^- > \text{I}^-$

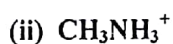
Q12. Compare the stability of these carbocations with reason.

(2)



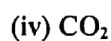
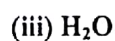
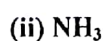
Q13. a) Draw the Lewis structure of the following formula and assign the formal charge.

(3)



b) Predict whether the dipole moment is either zero or non zero

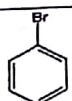

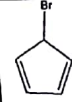

(2)



Q14. Comment on the following:




(8)

(i)

Compound (A)	Predict whether Aromatic/Anti-aromatic/Non-aromatic	$A \xrightarrow{\text{AgBF}_4 / \text{CH}_3\text{CN}} B$ Comment on the reaction feasibility (yes or no) and write the product <b>B</b> if the reaction is feasible	
a) 			
b) 			
c) 			
d) 			

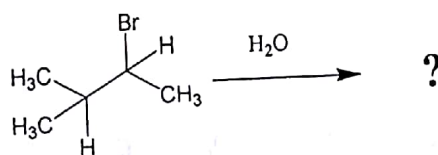
(4)

(ii)

	Compound	Aromatic/Non-aromatic/Anti-aromatic
a)	[10]annulene	
b)		
c)		
d)		

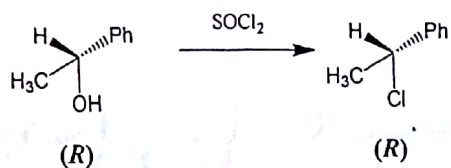
Q15. Write the hydrolysis product of the following reaction with proper justification.

(4)

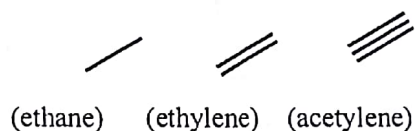




Q16. Assign the reaction type and write the mechanism. (4)

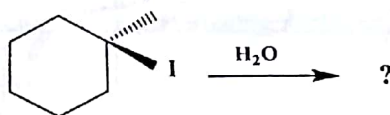


Q17. Arrange the following molecules in increasing order of their acidity and justify your answer. (4)

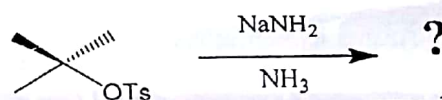


Q18. Write down the products of the following reaction and assign the reaction type. (3 x 2 = 6)

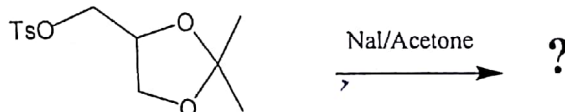
(i)



(ii)

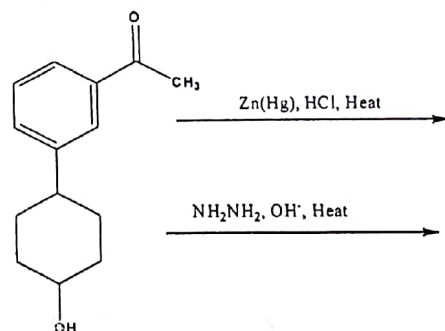


(iii)



Q19. Write down the reaction mechanism of sulfonation and desulfonation reaction of benzene using conc.  $\text{H}_2\text{SO}_4$  as sulfonating agent. (3 + 2 = 5)

Q20. Predict the product (major) of the following reaction? (1.5 x 2 = 3)



Q21. Predict the products in the following reactions. Explain the formation of different products and write their reaction mechanism. (3 + 3)

