

Ph.D. Programme in Chemistry

Model Question Paper

RESEARCH APTITUDE ASSESSMENT TEST

Time : 2 Hours

Max. Marks : 75

I. Part A: Multiple Choice Questions 30 x 1 mark = 30 marks

Choose the correct Response viz., A, B, C, D or E for the Questions from 1 - 30 which carry ONE mark each. Please NOTE that an **incorrect response** will attract **negative marking**. (For Multiple Choice question with 5 options,  $\frac{1}{4}$ th mark shall be deducted for an incorrect answer.)

1. The first half-life of a zeroth order reaction is 200s. The duration of the next half- life is ( )  
A) 200s B) 100s C) 400s D) 50s E) cannot be predicted

2. Consider the following parallel reactions: ( )  
A  $\rightarrow$  B, rate constant  $k_1$ , activation energy 45.3kJmol<sup>-1</sup>  
B  $\rightarrow$  C, rate constant  $k_2$ , activation energy 69.8kJmol<sup>-1</sup>  
If the rate constants are equal at 320 K, the temperature at which  $k_1/k_2 = 2$ , is  
A) 298 K B) 250 K C) 273 K D) 310 K E) 225 K

3. Oxygen for metabolism is taken up by Haemoglobin(Hb) to form oxyhaemoglobin(HbO<sub>2</sub>) according to the simplified equation ( )  
Hb(aq) + O<sub>2</sub>(aq)  $\rightarrow$  HbO<sub>2</sub>(aq)

Where the second order rate constant is  $2.1 \times 10^{-6} \text{ M}^{-1}\text{s}^{-1}$  at 37°C. For an average adult, the concentrations of Hb and O<sub>2</sub> in the blood and in the lungs are  $8 \times 10^{-6} \text{ M}$  and  $1.5 \times 10^{-6} \text{ M}$  respectively. The rate of formation of HbO<sub>2</sub> is

- A)  $5 \times 10^{-5} \text{ M s}^{-1}$  B)  $5 \times 10^{-4} \text{ M s}^{-1}$  C)  $2.5 \times 10^{-5} \text{ M s}^{-1}$   
D)  $1 \times 10^{-4} \text{ M s}^{-1}$  E)  $2.5 \times 10^{-4} \text{ M s}^{-1}$
4. The NMR signal of a compound is found to be 240Hz downfield from the TMS peak using a spectrometer operating at 60MHz. The chemical shift  $\delta$  in ppm relative to TMS is ( )  
A) 2 ppm B) 3 ppm C) 5 ppm  
D) 4 ppm E) 6 ppm

5. Which one of the following compounds is coloured? ( )  
 A) benzene      B) naphthalene      C) anthracene  
 D) cyclohexane      E) tetracene

6. Which one of the following compounds/ ions has point group  $D_3$ ? ( )  
 A)  $[\text{CoF}_6]^{3-}$       B)  $[\text{CoCl}_6]^{3-}$       C)  $[\text{Co}(\text{en})_3]^{3+}$   
 D)  $[\text{Co}(\text{gly})_3]$       E)  $[\text{CoBr}_6]^{3-}$

7. Crystallisation of sodium acetate from a super saturated solution occurs spontaneously. Which one of the following is true from this observation? ( )  
 A)  $\Delta G = -ve, \Delta S = -ve, \Delta H = -ve$       B)  $\Delta G = -ve, \Delta S = -ve, \Delta H = +ve$   
 C)  $\Delta G = -ve, \Delta S = +ve, \Delta H = -ve$       D)  $\Delta G = +ve, \Delta S = -ve, \Delta H = -ve$   
 E)  $\Delta G = -ve, \Delta S = +ve, \Delta H = +ve$

8. Consider the following system at equilibrium ( )  

$$\text{CaCO}_3(\text{s}) \rightleftharpoons \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$$

The number of phases (P), components(C ) and degrees of freedom are

A)  $P= 3, C=1, F= 0$       B)       $P= 3, C=2, F= 1$       C)       $P= 3, C=3, F= 2$   
 D)  $P= 2, C=1, F= 1$       E)       $P= 2, C=2, F= 2$

9. Among the following molecules identify the one whose symmetry number is 12. ( )  
 A)  $\text{BF}_3$       B)       $\text{SO}_2$       C)       $\text{CHCl}_3$       D)       $\text{CH}_4$       E)       $\text{NH}_3$

10. Using the following standard reduction potentials, ( )  

$$\text{Cu}^{2+} + 2e \rightarrow \text{Cu}, E_{10} = 0.342 \text{ V}$$

$$\text{Cu}^{2+} + e \rightarrow \text{Cu}^+, E_{20} = 0.153 \text{ V}$$
 the standard reduction potential for  $\text{Cu}^+ | \text{Cu}$ , calculated is  
 A) 0.495 V      B) 0.189 V      C) -0.189V  
 D) 0.531V      E) 0.248 V

11. Which one of the following species/molecules can be detected by ESR spectroscopy? ( )  
 A) Nitric oxide      B) Methane      C) Ethane      D) Ethylene      E) Methyl carbocation

12.  $[M+2]^+$  peak of 33% abundance is observed in the mass spectrum of ( )  
 A) Iodobenzene      B) Fluorobenzene      C) Phenol  
 D) Bromobenzene      E) Chlorobenzene

13. In the  $^{13}\text{C}$  NMR spectrum a peak at  $\sim\delta 175$  is observed. The compound is ( )  
 A) Paracetamol    B) p-Aminophenol    C) Phenol  
 D) Catechol    E) Resorcinol
14. Which one of the following techniques is the most suitable to study the composition of lemon grass oil? ( )  
 A) HPLC    B) GC-MS    C) TGA    D) IR    E) NMR
15. Among the following identify the most stable dimethylcyclohexane. ( )  
 A) cis-1,2    B) trans-1,2    C) cis-1,3  
 D) trans-1,4    E) cis-1,4
16. to 30. ....

## Part - B

**II. Answer any 9 of the following in about 150 words each in the sheets provided with the question paper:**

(9 x 5 = 45 marks)

1. The pre-exponential factor and activation energy for the hydrolysis of t-butyl chloride are  $2.1 \times 10^{16} \text{ s}^{-1}$  and  $102 \text{ kJmol}^{-1}$ , respectively. Calculate the values of  $\Delta S^\ddagger$  and  $\Delta H^\ddagger$  at 286 K for the reaction.
2. The hydrolysis of urea,  
 $(\text{NH}_2)_2\text{CO} + \text{H}_2\text{O} \rightarrow 2\text{NH}_3 + \text{CO}_2$   
 has been studied by many researchers. At  $100^\circ\text{C}$ , the pseudo first order rate constant is  $4.2 \times 10^{-5} \text{ s}^{-1}$ . The reaction is catalyzed by the enzyme urease, which at  $21^\circ\text{C}$  has a rate constant of  $3 \times 10^{-4} \text{ s}^{-1}$ . If the enthalpies of activation for the uncatalyzed and catalyzed reactions are  $134 \text{ kJmol}^{-1}$  and  $43.9 \text{ kJmol}^{-1}$ , respectively, calculate the temperature at which the nonenzymatic hydrolysis of urea would proceed at the same rate as the enzymatic hydrolysis at  $21^\circ\text{C}$ .
3. a) What is the probability of locating a particle in a one dimensional box between  $a/4$  and  $3a/4$ , where 'a' is the length of the box. Assume the particle to be in the lowest level.  
 b) Explain in terms of their electron configurations, why  $\text{Fe}^{2+}$  is more easily oxidized to  $\text{Fe}^{3+}$  than  $\text{Mn}^{2+}$  to  $\text{Mn}^{3+}$ .

(3+2=5marks)

4. Construct the character table for water molecule of  $C_{2v}$  point group.
5. Sketch the COSY( $^1H$ - $^1H$ ) NMR spectrum of nicotinic acid(pyridine-3-carboxylic acid).
6. to 12. ....

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