

B.Tech 2nd Semester Exam., 2019

(New Course)

CHEMISTRY

Time : 3 hours

Full Marks : 70

Instructions :

- (i) The marks are indicated in the right-hand margin.
- (ii) There are **NINE** questions in this paper.
- (iii) Attempt **FIVE** questions in all.
- (iv) Question No. 1 is compulsory.

1. Answer any seven questions in brief : $2 \times 7 = 14$

- (a) State de Broglie's principle.
- (b) What is an orbital?
- (c) What are the shapes of BF_3 and ClF_3 molecules?
- (d) Which one of NH_3 , PH_3 , AsH_3 and SbH_3 possesses the largest bond angle? Give reason.

(e) Out of Cr^{2+} and Cr^{3+} , which one is stable in aqueous solution?

(f) Cu^+ is colourless, but Cu^{2+} is coloured. Why?

(g) What is selection rule?

(h) A gas expands against vacuum. What is the work done on it?

(i) What is the condition for a reaction to be in equilibrium?

(j) The presence of CO_2 in boiler-fed water should be avoided. Why?

2. (a) Write short notes on the following : 5

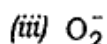
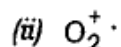
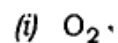
(i) Wave-particle duality

(ii) Heisenberg's uncertainty principle

(b) Discuss photoelectric effect (with mathematical equation) for explaining the particle nature of light. 5

(c) How many photons of light having a wavelength of 4000 \AA are necessary to provide 1 J of energy? ($h = 6.626 \times 10^{-34} \text{ Js}$) 4

3 (a) Which of the following two molecules has a higher bond length?



Explain using molecular-orbital theory. 6

(b) Draw the MO energy-level diagram for NO molecule. Using this diagram, calculate and explain bond orders and magnetic behaviours of (i) NO, (ii) NO^+ and (iii) NO^- . 8

4 (a) The internuclear distance of NaCl is 2.36×10^{-10} m. Calculate the reduced mass and moment of inertia of NaCl (atomic mass of Cl = 35×10^{-3} kg mol⁻¹ and Na = 23×10^{-3} kg mol⁻¹). 4

(b) Calculate the force constant for CO, if it absorbs at 2.143×10^5 m⁻¹ (atomic mass of C = 12×10^{-3} kg mol⁻¹ and O = 16×10^{-3} kg mol⁻¹).

(c) Define chromophore and auxochrome with examples. 4

(d) Which type of electronic transition(s) is/are observed in UV-visible spectrum of propanone in the range 200 nm to 900 nm? Justify your answer. 2

5. (a) How many types of ¹H NMR signals are expected for (i) CH_3CH_2OH and (ii) CH_3OCH_3 ? Mention relative intensity ratio for the signal(s) observed for (i) and (ii). 4

(b) At what frequency shift from TMS, would a group of nuclei with $\delta = 1.5$ resonate in NMR spectrometers operating at 60 MHz and 400 MHz? 4

(c) 2 mol of NH_3 at 300 K occupy a volume of 5×10^{-3} m³. Calculate the pressure using van der Waals equation.

$$(a = 0.417 \text{ Nm}^4 \text{ mol}^{-2})$$

$$\text{and } b = 0.037 \times 10^{-3} \text{ m}^3 \text{ mol}^{-1}$$

Compare the above result with the pressure calculated using ideal gas equation. 6

6 (a) 7 mol of a monatomic ideal gas are compressed reversibly and adiabatically. The initial volume is 15 dm^3 and the final volume is 9 dm^3 . The initial temperature is 27°C .

(i) What would be the final temperature in this process? ✓

(ii) Calculate w , q and ΔU for the process. <http://www.akubihar.com>

Given $C_v = 20.91 \text{ JK}^{-1} \text{ mol}^{-1}$, $\gamma = 1.4$.

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(b) Write a cell (in proper cell representation) whose cell reaction is $\text{AgCl} \rightarrow \text{Ag}^+ + \text{Cl}^-$ using the following standard electrode potentials at 298 K .

$$E^\circ_{\text{AgCl}/\text{Ag}|\text{Cl}^-} = 0.22 \text{ V}, E^\circ_{\text{Ag}^+/\text{Ag}} = 0.80 \text{ V}.$$

Calculate E° of the cell. Calculate solubility product (or solubility constant) of AgCl and its solubility at 298 K .

7

7. (a) A water sample had the following constituents per litre :

$\text{CaCO}_3 = 81 \text{ mg}$, $\text{Mg}(\text{HCO}_3)_2 = 75 \text{ mg}$
 $\text{CaSO}_4 = 136 \text{ mg}$, $\text{MgSO}_4 = 120 \text{ mg}$,
 $\text{NaCl} = 4.7 \text{ mg}$. Calculate the quantities of temporary and permanent hardness in the water sample

Calculate the quantity of lime (78% purity) and soda (92% purity) required for softening of 1.5 million litre of above water sample.

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(b) In an experiment to determine the hardness of a sample of water, 25 mL of $N/50 \text{ Na}_2\text{CO}_3$ solution was added to 100 mL of water sample. After complete precipitation of insoluble carbonate, the unreacted Na_2CO_3 was titrated against $N/50 \text{ H}_2\text{SO}_4$ solution, when 10 mL of acid was required. Calculate the hardness and comment on the nature of hardness so determined.

3

(c) Discuss the advantages and limitations for the removal of hardness by zeolite method.

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8. (a) Write notes on the following :

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(i) Optical isomerism of lactic acid

(ii) Optical isomerism of tartaric acid

(b) Differentiate between the following :

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(i) Enantiomers and diastereomers

(ii) Racemic mixture and meso-compounds

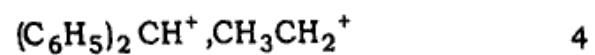
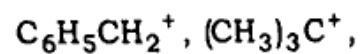
9. (a) Explain the following :

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(i) Trichloroacetic acid is stronger acid than acetic acid.

(ii) The amino group in aniline is *o*- and *p*-directing but amide group is *meta*-directing.

(b) Arrange the following carbocations in order of increasing stability with suitable reasons :



(c) Write short notes on the following : 4

(i) Markownikoff's rule

(ii) Kharasch's rule
