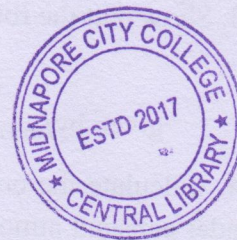


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PG (NEW) CBCS
M.Sc. Semester-I Examination, 2018
CHEMISTRY
PAPER: CEM-101
(PHYSICAL CHEMISTRY-I)

**Full Marks: 40****Time: 2 Hours****Group- A****Answer any four questions:****2×4**

1. A quantum Harmonic Oscillator can't be in rest even in its ground vibrational level. Explain
2. Show that rotational spectral lines of a rigid diatomic molecule are equispaced.
3. What are the factors that govern the width of the spectral lines?
4. Which one of the following functions is quantum mechanically acceptable? Give reasons.
 - (i) $\psi(x) = e^{-|x|}$ ($-\infty \leq x \leq \infty$)
 - (ii) $\psi(x) = e^{-x}$ ($-\infty \leq x \leq \infty$)
5. Explain the "surface to volume" property of nanoparticle.
6. As a first approximation, the compressibility factor of Van-der-Wall gas is given by

$$Z = 1 + \left(b - \frac{a}{RT}\right) \frac{P}{RT}$$

Using this expression for the compressibility factor, derive the expression for the fugacity of the Van-der-Wall gas.

7. Calculate the ratio of population of molecules in two energy levels separated by 10 kJmol^{-1} at 27°C .
8. Write the appropriate functional dependence of "S" and complete the following.

$$\left(\frac{\partial S}{\partial T}\right)_{u,n} = \left(\frac{\partial S}{\partial T}\right)_{u,v} + ?$$

Group-B**Answer any four questions:****4×4**

9. Derive the expression for the molar translational partition function in term of the thermal de-Broglie wave length.
10. (a) Ψ is an eigen function of a linear operator \hat{A} with the eigen value ∞ . Then show that Ψ is also an eigen function of $e^{\hat{A}}$. What is the eigen value?
 (b) Does the probability density depend on time?
11. Discuss the 'top-down' and 'bottom-up' nanoparticle synthesis.
12. Expand $\tan^{-1} x$ in power of $\left(x - \frac{\pi}{4}\right)$ upto three terms.

(Turn Over)

13. Show that the rotational quantum number for which intensity of spectral line is maximum is

$$\text{given by } J_{max} = \sqrt{\frac{kT}{2Bhc}} - \frac{1}{2}$$

14. Calculate the entropy change when 1 kg water at 27 °C is superheated steam at 200 °C under constant atmospheric pressure (sp. Heat of liquid water = 4180 Jkg⁻¹, sp. heat of steam = (1670 + 0.49T) Jkg⁻¹ at T K and latent heat of vaporization = 23 × 10⁵ Jkg⁻¹).

15. Calculate the characteristics rotational temperature for H₂ gas at any temperature T.

Given: The moment of inertia of H₂ gas molecule at T is 4.60 × 10⁻⁴¹ kg m², h = 6.626 × 10⁻³⁴

Js, K = 1.38 × 10⁻⁴¹ JK⁻¹.

16. What do you mean by fundamental overtones and hot bands in vibrational spectra?

Group-C

Answer any two questions:

8×2

17. (a) Show that $\frac{d}{dx}$ is an antihermitian operator. Comment on the nature of its eigen values.

(b) Show that two operators \hat{A} and \hat{B} must have simultaneous eigen function if they commute with each other.

(c) If 0.01 m is the uncertainty in position along x direction then comment on the minimum uncertainty in momentum along x and y directions. (3+3+2)

18. (a) Wave function for particle in a box of length 'a' at n = 1 state is given by

$$\psi(x) = \sqrt{\frac{2}{a}} \sin\left(\frac{\pi x}{a}\right)$$

(b) What do you mean by 'mean ionic activity coefficient'?

Calculate the mean ionic activity coefficient of 0.02 M Zn₃(PO₄)₂ at 25 °C assuming complete dissociation of the electrolyte and using Debye-Huckel limiting equation.

(Given: A = 0.51 M^{-1/2} for water solvent). (4+4)

19. (a) Derive the expression for wavenumber for vibrational rotational lines in the spectrum of a diatomic molecule.

(b) Classify the following molecules as symmetric, asymmetric and spherical top.

Give reasons. CCl₄, SF₆, CH₃Cl, C₆H₆.

(4+4)

20. (a) How will you synthesize silver nanoparticles? Pⁿ

(b) Show that $[\hat{x}, \hat{P}^n] = n\hbar^{-1}P^{n-1}$, where n is natural number, and \hat{x} , and \hat{P} are position momentum operators, respectively. (4+4)

