REV-01
BSC/13/07/10

2022/12

SET B

B.Sc. CHEMISTRY
FIFTH SEMESTER
PHYSICAL CHEMISTRY V
BSC – 502

[USE OMR FOR OBJECTIVE PART]

Duration: 3 hrs. **Full Marks: 70**

(Objective)

Time: 30 min. **Marks: 20**

Choose the correct answer from the following: ***1×20=20***

1. The normalization constant for a particle in 1D box in between length 0 to l with wavefunction $\Psi = \sin\left(\frac{n\pi x}{l}\right)$ is

   a. $\sqrt{\frac{2}{l}}$ b. $\sqrt{\frac{2l}{x}}$

   c. $\sqrt{\frac{1}{x}}$ d. $\sqrt{\frac{l}{4}}$

2. Schrodinger equation is a

   a. 1st order differential equation b. 2nd order differential equation

   c. Both a and b d. None of these

3. What is the eigenvalue of $\frac{d}{dx}(e^{ax})$

   a. e^{ax} b. a

   c. 1/a d. Not an eigenvalue equation

4. Hamiltonian is given by the

   a. Difference of kinetic energy and potential energy b. Product of kinetic energy and potential energy

   c. Sum of kinetic energy and potential energy d. Square root of kinetic and potential energy.

5. If $\Phi = Ae^{im\emptyset}$, then the value of A after normalization is

   a. $\frac{1}{\pi}$ b. $\frac{1}{\sqrt{2\pi}}$

   c. $\frac{1}{\sqrt{3\pi}}$ d. $\frac{2}{\sqrt{\pi}}$

6. The value of the commutator of $\hat{x}$ with $\widehat{p_x}$ is

   a. iħ b. -iħ

   c. -h d. ħ

7. The orbital with two radial and two angular nodes is.

   a. 3p b. 3d

   c. 5f d. 5d

8. In fluorescence, which one of the following decay of excited state takes place.
   a. $S_1 \rightarrow S_0$ b. $T_1 \rightarrow S_0$
   c. $T_2 \rightarrow T_1$ d. $T_1 \rightarrow S_0$

9. Which of the following excited state has a long life?
   a. S_1 b. S_2
   c. T_1 d. T_2

10. Which of the following decay with change in multiplicity is known as intersystem crossing (ISC)?
   a. $S_1 \rightarrow S_0$ b. $S_2 \rightarrow S_1$
   c. $T_2 \rightarrow T_1$ d. $S_1 \rightarrow T_1$

11. The frequency range 3×10^{12} Hz–3×10^{14} Hz is in the region of
   a. visible b. microwave
   c. infrared d. radiowave

12. The microwave active molecule is
   a. O_2 b. N_2
   c. Cl_2 d. CO

13. The successive Stokes lines are separated by 8B in the Raman rotational spectrum of
   a. N_2 b. O_2
   c. HCl d. CO

14. The number of multiplet of -OH proton in pure and dry sample of C_2H_5OH in NMR spectra is
   a. three b. one
   c. four d. five

15. Larmor frequency is given by
   a. $\frac{hB_Z}{2\pi I}$ b. $\frac{IB_Z}{2\pi h}$
   c. $\frac{IB_Z}{2\pi\mu}$ d. $\frac{\mu B_Z}{2\pi I}$

16. In a dielectric, phase difference between the field vector $\vec{E}$ and $\vec{H}$ is
   a. 2π b. π
   c. π/2 d. π/4

17. The nucleus which has spin 3/2 among the following is
   a. N^{15} b. Cl^{35}
   c. O^{17} d. F^{19}

18. The velocity of electromagnetic wave in a medium is given by
   a. $\frac{1}{\mu\epsilon}$ b. $\frac{1}{\sqrt{\mu\epsilon}}$
   c. $\sqrt{\frac{\epsilon}{\mu}}$ d. $\sqrt{\frac{\mu}{\epsilon}}$

19. Wave number is expressed by

a. $\frac{c}{\lambda}$ b. $\frac{1}{\lambda}$

c. $\frac{\lambda}{c}$ d. $\frac{c}{\lambda^2}$

20. The selection rule for the transmission among the rotational energy levels of rigid diatomic molecule is

a. $\Delta J = \pm 1$ b. $\Delta J = +1$

c. $\Delta J = -1$ d. $\Delta J = 0, \pm 1$

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Descriptive

Time : 2 hrs. 30 min. Marks : 50

[Answer question no.1 & any four (4) from the rest]

1. **a.** Deduce the expression of stokes and antistokes Raman lines on the basis of quantum theory.Explain the failure of classical theory to explain Raman effect. **4+1=5**

   b.State the Beer-Lambert law. A monochromatic radiation is incident on a solution of 0.05 molar concentration of an absorbing substance. The intensity of the radiation is reduced to one-fourth of the initial value after passing through 10 cm length of the solution. Calculate the molar extinction coefficient. (Given, log 2=0.301) **2+3=5**

2. **a.**Why harmonic oscillator model is not sufficient to explain the IR spectra of diatomic molecule. Write the potential used for anharmonic oscillator. **2+1=3**

   b. Deduce the frequencies of fundamental, first overtone, second overtone, and first hot band. Write the expression of zero-point energy. **6+1=7**

3. **a.** State and explain Frank-Condon principle. Write the mutual exclusion principle and explain it with an example. **2+3=5**

   b. Discuss the mechanism of fluorescence and phosphorescence spectra with a diagram. **5**

4. **a.**State the requirement for a molecule to show pure rotational spectrum. Show that the separation of rotational energy levels increases with the increase of rotational quantum numbers. What change of the rotational spectrum will be obtained if one of the atoms of a diatomic molecule is replaced by a heavy isotope. **1+2+1 =4**

   b.Write the condition of resonance in NMR spectroscopy. Define chemical shift and what are the different scales used in chemical shift and how they are related? Why TMS is used as a reference in NMR spectroscopy. **1+2+3 =6**

5. a. State the condition of resonance in ESR spectroscopy. Why ESR spectra is obtained in derivative mode? At what value of the magnetic field will a free electron resonate in a 9500 MHz ESR spectrometer. **1+1+3 =5**

   b. Find the degeneracy of an excited state in a 3D box with energy three times its ground state. **2**

   c. Find the degeneracy of a 3D simple harmonic oscillator with energy $\frac{91}{2}h\nu$ **3**

6. a. What is quenching? Describe the factors affecting quenching. **2+3=5**

   b. What is a chemical actinometry? Give an example of actinometer. **2**

   c. What is chemiluminescence? Give two examples. **3**

7. a. Give the energy expression of H atom in the nth shell. Derive the average radius of a H-atom. **1+4=5**

   b. What are normalized, orthogonal and orthonormal wavefunctions? What is an expectation value? **3+2=5**

8. a. State the postulates of quantum chemistry. **5**

   b. Derive and solve the Schrodinger equation for a particle in a one-dimensional box. **5**

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