KATHMANDU UNIVERSITY
End Semester Examination
September 2024

Marks Scored:

Level : B.Sc./B.Tech.
Year : I

Course : PHYS 105
Semester : II

Exam Roll No. :

Time: 30 mins.

F. M. : 20

Registration No.:

01 SEP 2024

Date :

SECTION "A"
[20Q. × 1 = 20 marks]

Choose and encircle the most appropriate answer.

1. The process of diffusion of solvent through a semi-permeable membrane from less concentrated solution into a more concentrated solution is called
   a. diffusion b. osmosis c. solubilization d. dissolution

2. If a small spherical particle of radius 'a' is moving in a fluid of viscosity η at temperature T, then the coefficient of diffusion or diffusivity is given by
   a. $\frac{K_B T}{3\pi\eta a}$ b. $\frac{K_B T}{6\pi\eta a}$ c. $\frac{3K_B T}{\pi\eta a}$ d. $\frac{6K_B T}{\pi\eta a}$

3. Which membrane pump is responsible for keeping the potassium ion concentration higher inside than outside a cell?
   a. Sodium-potassium ion pump b. Hydrogen-potassium ion pump
   c. Calcium-hydrogen ion pump d. ATP-ADP ion pump

4. A typical neuron has a resting membrane potential of about:
   a. $-70\,mV$ b. $-70V$ c. $+70\,mV$ d. $+70V$

5. You smell something delicious baking. Which sensory receptors receive that information?
   a. Telereceptors b. Olfactory receptors
   c. Somatic receptors d. Visceral receptors

6. What is the significance of the wave function in quantum mechanics?
   a. It describes the position of particles with certainty.
   b. It determines the exact momentum of particles.
   c. It provides information about the probability of finding particles at different positions.
   d. It directly calculates the total energy of particles.

7. Which subshell has a complex shape and consists of 5 orbitals?
   a. s-subshell b. p-subshell c. d-subshell d. f-subshell

8. Which type of molecular spectra is typically observed in the ultraviolet and visible regions of the electromagnetic spectrum?
   a. Vibrational Spectra b. Rotational Spectra
   c. Electronic Spectra d. Infrared Spectra

9. Which of the following hybridizations is associated with a linear molecule?
   a. sp^2 b. sp c. sp^3 d. sp^3d

10. In NMR, what happens when a spin $\frac{1}{2}$ nucleus transitions from a lower energy level to a higher energy level?

a. It emits X-rays
b. It releases gamma rays
c. It absorbs radiofrequency pulses
d. It produces visible light

Fill in the blanks. The symbols, unless mentioned otherwise, have their usual meanings.

11. An average cell is about $25\mu m$. A glucose molecule has a radius $0.7nm$. Given that coefficient of viscosity inside body is $0.00178NS/m^2$ and temperature of the body is $310K$ and Boltzmann constant $k_B = 1.38\times10^{-23}J/K$. The time to diffuse $25\mu m$ for glucose molecule is _____

12. Flux of water ϕ_w is related to the hydrostatic pressure P and osmotic pressure π as _____

13. For the outstanding achievement of voltage clamp technique in neuro biophysics, the 1963 Nobel prize in physiology and medicine was awarded to _____

14. The brain activity during near death is not caused by any sensory excitation input by the failure of enzyme _____ due to lack of blood supply.

15. When an axon potential arrives at the terminal of presynaptic fiber, it triggers the release of chemical substance, called _____

16. Before we open the box and observe the cat, it exists in a superposition of states. This means that the cat is simultaneously in the _____ states, represented by two different components of the wave function.

17. For an electron in the third energy level $(n=3)$, the possible values of the orbital angular momentum quantum number (l) are _____

18. The interaction energy due to the induced dipole-induced dipole is given by the London dispersion equation _____

19. In pure rotational spectrum, by measuring (change in frequency) $\Delta\upsilon$, we can calculate the moment of inertia I of the molecule, which in turn allows us to determine the distance r between the nuclei, providing information about the _____

20. AFM tips and cantilevers are usually micro-fabricated from materials such as Si (silicon) or _____

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SECTION "B"
[5Q × 4 = 20 marks]

Attempt ALL questions.

1. Discuss the diffusion equation and obtain the differential form of Fick's law.

OR

A sheet of steel $2.5\,mm$ thick has nitrogen atmospheres on both sides at 900^0C and is permitted to achieve a steady-state diffusion condition. The diffusion coefficient for nitrogen in steel at this temperature is $1.2\times10^{-10}\,m^2/s$ and diffusion flux is found to be $1.0\times10^{-7}\,kg/m^2s$. Also, it is known that the concentration of nitrogen in the steel at the high-pressure surface is $2\,kg/m^3$. How far into the sheet from this high pressure side will the concentration be $0.5\,kg/m^3$. Assume a linear concentration profile.

2. Write short note about near death experience (NDE).

3. Explain any four quantum numbers associated with vector model of atom in detail.

OR

What is the electromagnetic spectrum? Differentiate between continuous and line spectra. Also explain the intensity rule determined by different transition in L and J transitions. [0.5+1+2.5]

4. Explain interaction energy of a diatomic molecule along with necessary graphs/diagram.

5. Write the molecular orbital configuration of Oxygen molecule. Explain the bond order, stability, and magnetic nature of Hydrogen molecule and its two ions.

OR

Explain the theory of vibrational and rotational spectra of molecules.

SECTION "C"
[5Q × 7 = 35 marks]

Attempt ALL questions.

6. Discuss neuronal cable theory and show that the voltage signal falls away exponentially.

P.T.O.

7. What do you mean by diffusion? Discuss Langevin's theory of random movements and obtain a result analogy with Einstein's result. Compare the two results; determine the expression for coefficient of diffusion or diffusivity.

OR

What do you mean by water flux? Derive an expression for the relation of hydrostatic pressure and osmotic pressure. And hence find the magnitude of Osmotic pressure.

8. Describe with the neat diagram the internal structure of human ear.

OR

Write in detail about diffusion potential. At what condition diffusion potential becomes Nernst potential

9. Derive a relation for the Bohr radius and energy of the n^{th} permissible orbit and calculate the radius and energy of first Bohr orbit of the hydrogen atom. An electron with a gyromagnetic ratio (γ) of approximately $1.7609 \times 10^{11}\ rad/_{Ts}$ is placed in a magnetic field with strength (B) of $0.5T$. Calculate the Larmor frequency (ωL) for this electron's precession in the magnetic field.

10. Explain the working principle of NMR with all necessary diagrams. Explain T_1 and T_2 relaxation mechanisms and four applications of NMR.

OR

Explain all types of molecular interaction with equation of interaction energy, necessary diagrams, and examples.