KATHMANDU UNIVERSITY
End Semester Examination
March, 2025

Marks Scored:

Level : B.Sc.
Year : II

Course : PHYS 203
Semester : I

Exam Roll No. :

Time: 30 mins.

F. M. : 20

Registration No.:

Date : 16 March 2025

SECTION "A"
[20Q. × 1 = 20 marks]

Choose and tick the most appropriate answer. The symbols, unless mentioned otherwise, have their usual meanings.

1. Hydrogen atom does not emit X-rays because
   a. its size is very small
   b. energy levels in it are very close to each other
   c. it contains only a single electron
   d. energy levels in it are far apart

2. In the limit of large quantum numbers, quantum theory must agree with classical theory. This principle is known as
   a. Heisenberg Uncertainty Principle
   b. Correspondence Principle
   c. Pauli's Exclusion Principle
   d. Wave-Particle Duality

3. The de-Broglie wavelength associated with a moving particle having momentum p is
   a. p
   b. hp
   c. $\frac{h}{p}$
   d. $\frac{p}{h}$

4. In spectral notation, the state of an atom with $L = 3$ and $S = 0$ is represented as
   a. ${}^3D_1$
   b. ${}^1D_3$
   c. ${}^3F_1$
   d. ${}^1P_3$

5. According to the vector atom model, a transition of an electron between two energy levels is possible only if certain selection rules are satisfied. Which of the following represents the selection rules for $\vec{L}$, $\vec{S}$ and $\vec{J}$ correctly?
   a. $\Delta L = 0$, $\Delta S = \pm 1$ and $\Delta J = 0$ or ± 1
   b. $\Delta L = \pm 1$, $\Delta S = \pm 1$ and $\Delta J = 0$
   c. $\Delta L = \pm 1$, $\Delta S = 0$ and $\Delta J = 0$ or ± 1
   d. $\Delta L = 0$, $\Delta S = 0$ and $\Delta J = \pm 1$

6. In photoelectric effect the number of photo electrons emitted is proportional to
   a. intensity of incident beam
   b. frequency of incident beam
   c. velocity of incident beam
   d. work function of photo cathode

7. Which of the following processes represents the Bremsstrahlung process?
   a. electron → electron + photon
   b. electron + electron → photons
   c. electron + photon → electron
   d. photon + electron → photon

8. The given nuclei ${}_4Be^7$ and ${}_3Li^7$ are represented as
   a. isotopes
   b. isotones
   c. isomers
   d. mirror nuclei

9. In the uranium radioactive series the initial nucleus is ${}_{92}U^{238}$ and end product nucleus is lead ${}_{82}Pb^{206}$. When the uranium nucleus decays to lead, the number of α – particles and the number of β – particles emitted are

a. 6 and 8 b. 8 and 6 c. 16 and 6 d. 32 and 12

10. Which of the following radioactive decay process represents the *K*-electron capture?

a. ${}_0n^1 + {}_1p^1 \rightarrow {}_{-1}e^0 + \bar{\nu}$ b. ${}_1p^1 + {}_1e^0 \rightarrow {}_0n^1 + \bar{\nu}$

c. ${}_0n^1 + {}_1e^0 \rightarrow {}_1p^1 + \nu$ d. ${}_1p^1 + {}_{-1}e^0 \rightarrow {}_0n^1 + \nu$

11. In the following transitions of a hydrogen atom, the one that results in the absorption line with the highest frequency is

a. $n = 1$ and $n = 2$ b. $n = 2$ and $n = 1$

c. $n = 3$ and $n = 6$ d. $n = 6$ and $n = 3$

12. The total binding energy of ${}_1H^2$, ${}_2He^4$, ${}_{26}Fe^{56}$ and ${}_{92}U^{235}$ nuclei are 2.22, 28.3, 492 and 786 MeV respectively. Which of the following is the most stable nucleus?

a. ${}_1H^2$ b. ${}_2He^4$ c. ${}_{26}Fe^{56}$ d. ${}_{92}U^{235}$

13. The primary function of an ionization chamber is to

a. accelerate charged particles b. store radioactive substances

c. detect and measure ionizing radiation d. cool nuclear reactors

14. The possible values of the magnetic quantum number m_l for a hydrogen atom in the *d* state are

a. 0,1,2 b. -1,0,1 c. -2,-1,0,1,2 d. -3,-2,-1,0,1,2,3

15. A betatron is used to accelerate

a. electrons b. protons c. neutrons d. α-particles

Fill in the blanks.

16. In Compton effect, incident X-ray photon has energy 12.4 keV. If the energy of scattered photon is 6.4 keV, then the kinetic energy of recoiled electron is_____.

17. A microscope using photons is used to determine the position of an electron in an atom within a distance of 0.2 Å. The uncertainty in the momentum of electron located in this way is (Given: Planck's constant is 6.62×10^{-34} J s) _____.

18. If the radius of Ho^{165} is 7.731 fm, then the radius of He^4 is_____.

19. The activity of 1 μg of Radon (Rn^{222}) with a half-life of 3.8 days is_____.

20. The spacing between the principle planes of NaCl crystal is 2.82 Å. It is found that first order Bragg's reflection occurs at an angle of 10°. The wavelength of X-rays is_____.

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SECTION "B"
[5Q × 4 = 20 marks]

Attempt *ALL* questions.

1. State and explain Heisenberg's uncertainty principle and illustrate it by using the diffraction of a beam of electron through a slit.

2. A beam of electron enters a uniform magnetic field of 1.2 Tesla. Calculate the energy difference between electrons whose spin are parallel and anti-parallel to the field.

OR

Explain Ritz combination principle. Show that the longest wavelength of the Balmer series and the longest two wavelengths of the Lyman series satisfy to this principle. (Given; Longest wavelength of Balmer series is 656.1 nm and for Lyman series $\lambda_{limit} = 91.13\,nm$)

3. What is Pauli's exclusion principle? On the basis of this principle explain the configuration of electrons in atoms.

4. Some measured X-ray energies in silver ($(Z = 47)$ are $K_\alpha = 21.990$ keV and $K_\beta = 25.145$ keV. The binding energy of K-electron in silver is 25.514 keV. From these data, find (a) the energy of the L_α X-ray and the binding energy of L-electron.

OR

The work function of tungsten metal is 4.52 eV. (a) What is the cutoff wavelength λ_c for tungsten? (b) What is maximum kinetic energy of the electron when radiation of wavelength 198 nm is used? (c) What is the stopping potential in this case?

5. Explain the shell model of the atomic nucleus and the evidence that supports it.

SECTION "C"
[5Q × 7 = 35 marks]

Attempt *ALL* questions.

6. What is the Zeeman effect? Explain the quantum mechanical interpretation of the normal Zeeman effect.

OR

Give the theory of Compton scattering and describe its three possible cases.

P.T.O.

7. Compute the de 'Broglie's wavelength of the following. (a) A 1000 kg automobile travelling at 100 m/s, (b) A 10 gm bullet travelling at 500 m/s and (c) An electron with kinetic energy of 1 eV.

8. Give the construction and working principle of linear accelerator with well-labeled diagram.

OR

Explain the working principle of a betatron including the necessary theoretical background. Derive the condition $\phi = 2\pi r^2 B$ under which a betatron works.

9. Explain the theory of successive disintegration of radioactive substances and describe its two possible cases.

10. Three different rock samples have ratios of numbers of U^{238} (half-life 4.5×10^9 years) atoms to Pb^{206} atoms of 0.5, 1.0 and 2.0. Compute the age of the three rocks.