Shivaji University Kolhapur

B.Sc. Part III Physics CSBC Sem VI

Physics Paper- XV:DSE-F3 Atomic and Molecular Physics and Astrophysics

Question Bank

UNIT-1 Chapter :1 Atomic spectra

Select correct alternatives for the following (The correct alternatives in red color)

(i) The transitions from nS levels to the lowest P-level give rise to a spectral series called ....

(a) sharp (b) principal
(c) diffuse (d) fundamental

(ii) The transitions from nD levels to the lowest P level give rise to series of spectral lines called .....

(a) sharp (b) principal
(c) diffuse (d) fundamental

(iii) In (2S ← nP) transitions of principal series with n≥2, corresponds to principal series of------ atom.

(a) Li (b) Na
(c) K (d) Ce

(iv) For a given principal quantum number **n**, the levels with smaller l-value.....

(a) lie higher (b) lie deeper
(c) lie at same level (d) all the above

(v) The transitions which can be excited easily give rise to... series

(a) sharp (b) principal
(c) diffuse (d) fundamental

(vi) Doublet separation increases with----------

(a) atomic number (z) (b) principal quantum number (n)
(c) orbital angular momentum quantum number l (d) all the above

(vii) To explain the observed doublet fine structure of spectral lines, the concept introduced is of.....

(a) orbital motion of electron (b) spin motion of electron
(c) magnetic field at the electron (d) electric field at the electron

(viii) In doublet splitting due to spin-orbit interaction, the relative positions of levels with J=1+1/2 and j=1-1/2 in normal order are----------

(a) j=1-1/2level lies lower (b) j=1+ 1/2level lies lower
(c) both levels lie at same energy (d) all the above

(ix) Larmor frequency of precession of electron in magnetic field B is

(a) ω_L= B/m (b)ω_L=e / m
(c) ω_L= Be /m (d) ω_L=B (m/ e)

(x) Selection rule for j in emission transitions is--------

(a) Δj=0 (b) Δj=+1
(c) Δj=-1 (d) Δj=0,±1

(xi) If the coupling between L^* and S^* is not broken in an external magnetic field, then we observe.....

(a) normal Zeeman effect (b) anomalous Zeeman effect

(c) Paschen back effect (d) none of the above

(xii) When external magnetic field becomes much stronger than internal fields due to spin and orbital motion of electron, then we observe.....

(a) normal Zeeman effect (b) anomalous Zeeman effect

(c) Paschen back effect (d) none of the above

(xiii) The ratio of magnetic moment (μ_l) to the mechanical moment (P_l) of orbital motion of electron is .....

(a)e/2m (b) 2.(e/ 2m)

(c) 2. (e/m) (d)2m/ e

(xiv) The ratio of magnetic moment (μ_s) to the mechanical momer (p_s) of spin motion of electron is .....

(a)e/2m (b) 2. (e/2m)

(c) 2.(e /m) (d) 2. (m/e)

xv) The interaction energy due to orbital motion of electron in extern magnetic field B is given by…..

(a) μ.B (b)m_l(eh /4лm)B

(c) both (a) and (b) (d) neither (a) nor (b)

(xvi) When sodium atom is placed in weak magnetic field, D_1 – line corresponding to transition

($2s_{1/2}$-$2P_{1/2}$) splits into----------.

(a) 2-components (b) 4-components

(c) 6-components (d) 8-components

- **Short answer questions (5 marks)**

1. Give a brief account of spectral notations and optical spectral series due to alkali atoms.
2. In brief, explain the optical spectral series with the help of energy level diagram.
3. What are the observed salient features of the spectra of alkali atoms?
4. Write a note on electron spin-orbit interaction.
5. Write a note on selection rules for optical transitions
6.Estimate the relative intensities of the lines arising from doublet transitions DF and PD.

- **Long answer questions (10 marks)**

1. Derive an expression for the term-value of fine structure level.
2. Discuss both qualitative and quantitative intensity rules used to calculate relative intensity of spectral lives in a doublet. Give simple examples.
3. Calculate the doublet separation for 2P levels in Sodium atom, in terms of a = Ra^1z/n
4. What is normal Zeeman effect? Explain normal Zeeman effect with the help of vector atom model.
5. What is anomalous Zeeman effect? Explain anomalous Zeeman effect.
6. State the selection rules for anomalous Zeeman effect and hence discuss Zeeman splitting of sodium D-lines with necessary energy level diagram.

UNIT-1 Chapter 2: Molecular spectra

Select correct alternatives for the following (The correct alternatives in red color)

(i) A molecular system can be stable if the total energy possessed by the molecular system is .....

(a) zero (b) minimum

(c) maximum (d) infinity

(ii) When a pair of electrons are shared by two atoms in a molecule,then----------is formed.

(a) a covalent bond (b) an ionic bond

(c) a metallic bond (d) no bond

(iii) In H_2-molecule the spins of two electrons are---------

(a) parallel (b) antiparallel

(c) perpendicular (d) inclined

(iv) Rotational kinetic energu of J-level of a diatomic molecule proportional to---------

(a) J (J+1) (b) moment of inertia (1)

(c) both (a) and (b) (d) bond length

(v) Selection rule for pure rotational transition is

(a) $\Delta J = 0$ (b) $\Delta J = \pm 1$

(c) $\Delta J = 0, \pm 1$ (d) $\Delta J = 0,1,2,3,...$

(vi) Zero point energy of a molecule is.....

(a) zero (b) hv_o

(c) $2hv_o$ (d) $1/2hv_o$

(vii) Pure vibrational transitions are governed by selection rule……

(a) $\Delta v = 0$ (b) $\Delta v = +1$

(c) $\Delta v = \pm 1$ (d) $\Delta v = -1$

(viii) Pure rotational spectra occur in----------region.

(a) ultraviolet (uv) (b) infra-red (IR)

(c) microwave (d) visible

(ix) Electronic spectra of diatomic molecules occur in..... region.

(a) visible and uv (b) microwave

(c) IR (d) uv and IR

(x) The relative magnitudes of electronic energy (E_e), vibrational energy (E_v,) and rotational energy (E_j) in a molecule is

(a) $E_e < E_v < E_j$ (b) $E_e > E_v > E_j$

(c) $E_e > E_v = E_j$ (d) $E_e < E_v > E_j$

(xi) Frank-Condon principle helps in estimating the ----------

(a) Moment of inertia of the molecule (b) bond length

(c) Reduced mass of molecule (d) intensity of bands

- **Short answer questions (5 marks)**

1. Explain when a molecular bond can be formed and also types molecular bonds.

2. How H_2^+ molecular ion becomes stable by sharing an electron by two protons?

3. Qualitatively discuss the nature of wave function of H_2^+ molecular ion.

4. What is the nature of wave function of H2-molecule?

5. Write a note on Frank-Condon principle

- **Long answer questions (10 marks)**

1. Obtain an expression for rotational energy of a diatomic molecule
2. With the help of rotational energy level, explain pure rotational spectra of diatomic molecule. In which region the spectra occur
3. Get an expression for vibrational energy levels of a diatomic molecule and hence discuss pure rotational spectra.
4. Discuss vibration-rotation spectra of diatomic molecule. In which spectral region, this spectrum occurs? 10. Write a note on electronic spectra of diatomic molecules.
5. Explain the coarse structure of vibrational bands and the term band system, band sequence and band progression.

Unit II chapter 1 : Raman spectra

Select correct alternatives for the following (The correct alternatives in red color)

(i) With respect to un displaced (incident) line, Raman lines are situated.....

(a) symmetrically on both the sides
(b) only on short wavelength side
(c) asymmetrically on both the sides
(d) on long wavelength side

(ii) If v_i, is incident frequency and v_s is scattered frequency of radiationthen Raman shift (Δv) is given by----------

(a) $\Delta v=v_i+Vs$ (b) $\Delta v= v_i -Vs$
(c) $\Delta v=V_s-Vi$ (d) $\Delta v=2(v_i-v_s)$

(iii) Raman shift in frequency for stokes line is .....

(a) positive (b) negative
(c) zero (d) very small

(iv) Raman shift in frequency for antistokes line is .....

(a) positive (b) negative
(c) zero (d) very large

(v) Raman shift corresponds to .....spectral region.

(a) X-ray (b) ultraviolet
(c) visible (d) infra-red

(vi) Intensity of Raman lines are compared to corresponding Rayleigh line is

(a) very high (b) very low
(c) almost equal (d) just low

(vii) To study Raman effect the optical system be made up of.....

(a) glass (b) CaF_2
(c) calcite (d) quartz

(viii) Raman shift is equal to .....

(a) frequency of vibration of molecule
(b) twice the frequency of rotation of diatomic molecule
(c) both (a) and (b)
(d) none of the above

(ix) To observe Raman effect molecule must be …….

(a) polar (b) non-polar
(c) ionic (d) any of the above

(x) Only intense sources for incident light can produce…….

(a) Raman spectra (b) Infra-red spectra

(c) Microwave spectra (d) Ultraviolet spectra

- **Short answer questions (5 marks)**

1. Give the differences between Raman-spectra and infra-red spectra.
2. Write a note on Raman effect. What are stokes and antistokes lines?
3. List the characteristic properties of Raman lines

- **Long answer questions (10 marks)**

1. Give the classical theory of Raman effect and show that Raman shift is equal to
(i) frequency of vibration of molecule and
(ii) double the frequency of rotation of the molecule.
2. Discuss, quantum theory of Raman effect and explain vibrational Raman spectrum.
3. Discuss quantum theory of Raman effect and explain the rotational Raman spectrum.

Unit II chapter 2 : Structure of universe

Select correct alternatives for the following (The correct alternatives in red color)

(i) The observation of red shift in the spectra of galaxies shows the the galaxies are.....

(a) at rest (b) moving towards us

(c) moving away from us (d) rotating around us

(ii) The astronomer who first observed the red shift in the spectra of distant galaxies was ....

(a) Hubble (b) Slipher

(c) Sandage (d) Kepler

(iii) Galaxies are moving away from…….

(a) each other (b) Earth

(c) Milky-way galaxy (d) Sun

(iv) If V is the velocity of recession of a galaxy at a distance x, then Hubble constant H is given by .....

(a) H=Vx (b) H=V/x

(c) H=x/ v (d) H=V+x

(v) Hubble constant for distant galaxies..... distance of galaxy.

. (a) slightly increases with (b) slightly decreases with

(c) independent of (d) increases rapidly with

(vi) Approximate age of universe is given by…….

(a) Hubble constant H (b)H / v

(c)V/ H (d) I / H

(vii) Big-bang theory was strongly supported by

(a) George Gamow (b) Hubble

(c) fred Hoyle (d) Einstein

(viii) According to following cosmological theory the universe has a beginning and an end....

(a) Big-bang theory (b) oscillating theory

(c) steady-state theory (d) condensation theory

(ix) Distribution of galaxies is an evidence against.

(a) big-bang theory (b) oscillating theory

(c) steady state theory (d) condensation theory

(x) The state of universe when all the matter in the universe concentrated in a small region is called…….

(a) ylem (b) nucleus

(c) big-bang (d) nebula

(xi) From the end-on view Milky-way galaxy is said to have .....shape..

(a) disc (b) spiral

(c) spherical (d) barred spiral

(xii) About 90% matter in the interstellar medium contains…….

(a) dust (b) hydrogen

(c) heliuml (d) ice

(xiii)Birth place of all stars is-------

(a) Milky-way galaxy (b) solar system

(c)Interstellar medium (d) ylem

(xiv) More satisfactory theory which explains the origin of solar system

(a) collision theory (b) nebular theory

(c)condensation theory (d) big-bang theory

- **Short answer questions (5 marks)**

1.Describe the evidence that universe is expanding

2. What is Milky-way galaxy? Describe in details.

3.What are supporting evidences and objections to the condensation theory?

4.Write a note on-

(a) Big-bang theory of universe

(b) Oscillating theory of universe

(c) Steady-state theory of universe

- **Long answer questions (10 marks)**

1.What is Hubble law ? Define Hubble constant. Explain how approximate range and age of universe can be estimated from Hubble law.

2.What is Hubble law? Define Hubble constant. Explain, how changes in Hubble constant can be measured and measurement of rate of change of Hubble constant supports which of the cosmological theory.

3.State and explain any three tests to verify the correctness of cosmological theories and thereby draw conclusion about most acceptable theory

4.Discuss the origin on solar system with special references to condensation theory

Unit II chapter 3 : Stellar evolution

Select correct alternatives for the following (The correct alternatives in red color)

(i) Hertzsprung-Russell diagram is a graph of .....

(a) Luminosity against surface temperature of stars

(b) Surface temperature against Luminosity of stars

(c) Luminosity against surface temperature of stars on log scale

(d) Surface temperature against Luminosity of stars on logarithmic scale

(ii) Red-giants have --------

(a) high luminosity and high surface temperature

(b) low luminosity and low surface temperature

(c) low luminosity and high surface temperature

(d) high luminosity and low surface temperature

(iii) White dwarfs are stars having.....

(a) low luminosity and high surface temperature

(b) high luminosity and low surface temperature

(c) low luminosity and low surface temperature

(d) high luminosity and high surface temperature

(iv) More than 90% of star population belongs to.....

(a) Red-giants (c) Main sequence

(b) White-dwarfs (d) Novae

(v) year old proto star is highly luminous.

(a) 1 (b) 3 (c) 1000 (d) million

(vi) A star in the process of formation is called.

(a) Protostar (b) Red-giant (c) White dwarf (d) Cephied variable

(vii)------- is the mass of star..... is the age of star.

(a) More, more (b) More, smaller (c) Lesser, smaller (d) Lesser, lesser

(viii) Majority of sun-spots occur.

(a) In polar regions (b) Near the equator

(c) Both (a) and (b) (d) None of the above

(ix) Very important characteristic feature of sun-spots is that

(a) they are regions of strong magnetic fields

(b) they are regions of low temperature

(c) they look dark

(d) they have different shapes and sizes

(x) Very important requirement to bring-in nuclear fusion reactions in the inner core of star is------

(a) Presence of light elements

(b) Presence of very high temperature about 107 °K or more

(c) Both (a) and (b)

(d) None of the above

- **Short answer questions (5 marks)**

1.Discuss the basic properties of stars to plot Hertzs prung-Russell diagram.
2. Discuss different classes of star population and their properties with the help of HR-diagram.
3.Explain the formation of proto star and the changes that occur till it forms a normal star.
4.Why sun-spot regions are dark? Explain.
5.What is sun-spot cycle? Discuss its features.
6.Explain, how the strong, local magnetic field regions are created on sun's surface and thereby explain the observed features of sun spots.

- **Long answer questions (10 marks)**

1.What are sun-spots ? Give prominent features of sun-spots.
2.When does star feels aged? Explain the formation of red-giant and
then helium flash.
3. Explain how a small star forms a white dwarf. What is the maximummass limit for the formation of white dwarf.
4. Explain the supernova explosion and formation of neutron star and finally the formation of a block hole.
5."Whether sun can form a black hole?" Explain with reasons
==========