DPP - Daily Practice Problems

Chapter-wise Sheets

Date : ______ **Start Time :** ______ **End Time :** ______

PHYSICS

CP26

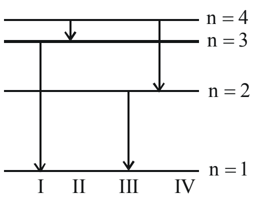
SYLLABUS : Atoms

Max. Marks : 180 **Marking Scheme :** (+4) for correct & (–1) for incorrect answer **Time : 60 min.**

INSTRUCTIONS : This Daily Practice Problem Sheet contains 45 MCQs. For each question only one option is correct. Darken the correct circle/ bubble in the Response Grid provided on each page.

1. The potential energy associated with an electron in the orbit
(a) increases with the increases in radii of the orbit
(b) decreases with the increase in the radii of the orbit
(c) remains the same with the change in the radii of the orbit
(d) None of these

2. The diagram shows the energy levels for an electron in a certain atom. Which transition shown represents the emission of a photon with the most energy?



(a) IV (b) III (c) II (d) I

3. Electrons in a certain energy level $n = n_1$, can emit 3 spectral lines. When they are in another energy level, $n = n_2$. They can emit 6 spectral lines. The orbital speed of the electrons in the two orbits are in the ratio of

(a) 4 : 3 (b) 3 : 4 (c) 2 : 1 (d) 1 : 2

4. In Rutherford scattering experiment, the number of α-particles scattered at 60° is 5×10^6. The number of α-particles scattered at 120° will be

(a) 15×10^6 (b) $\frac{3}{5} \times 10^6$

(c) $\frac{5}{9} \times 10^6$ (d) None of these

5. In the Bohr model an electron moves in a circular orbit around the proton. Considering the orbiting electron to be a circular current loop, the magnetic moment of the hydrogen atom, when the electron is in n^{th} excited state, is :

(a) $\left(\frac{e}{2m}\frac{n^2h}{2\pi}\right)$ (b) $\left(\frac{e}{m}\right)\frac{nh}{2\pi}$

(c) $\left(\frac{e}{2m}\right)\frac{nh}{2\pi}$ (d) $\left(\frac{e}{m}\right)\frac{n^2h}{2\pi}$

RESPONSE GRID	1. ⓐⓑⓒⓓ	2. ⓐⓑⓒⓓ	3. ⓐⓑⓒⓓ	4. ⓐⓑⓒⓓ	5. ⓐⓑⓒⓓ

Space for Rough Work

6. A 12.5 eV electron beam is used to bombard gaseous hydrogen at room temperature. It will emit :
(a) 2 lines in the Lyman series and 1 line in the Balmar series
(b) 3 lines in the Lyman series
(c) 1 line in the Lyman series and 2 lines in the Balmar series
(d) 3 lines in the Balmer series

7. A Hydrogen atom and a Li^{++} ion are both in the second excited state. If ℓ_H and ℓ_{Li} are their respective electronic angular momenta, and E_H and E_{Li} their respective energies, then
(a) $\ell_H > \ell_{Li}$ and $|E_H| > |E_{Li}|$ (b) $\ell_H = \ell_{Li}$ and $|E_H| < |E_{Li}|$
(c) $\ell_H = \ell_{Li}$ and $|E_H| > |E_{Li}|$ (d) $\ell_H < \ell_{Li}$ and $|E_H| < |E_{Li}|$

8. The radius of hydrogen atom in its ground state is 5.3×10^{-11} m. After collision with an electron it is found to have a radius of 21.2×10^{-11} m. What is the principal quantum number n of the final state of the atom
(a) $n = 4$ (b) $n = 2$ (c) $n = 16$ (d) $n = 3$

9. When hydrogen atom is in its first excited level, its radius is
(a) four times its ground state radius
(b) twice
(c) same
(d) half

10. Consider 3rd orbit of He^+ (Helium), using non-relativistic approach, the speed of electron in this orbit will be [given K $= 9 \times 10^9$ constant, Z = 2 and h (Plank's Constant) $= 6.6 \times 10^{-34}$ J s]
(a) 1.46×10^6 m/s (b) 0.73×10^6 m/s
(c) 3.0×10^8 m/s (d) 2.92×10^6 m/s

11. An electron in the hydrogen atom jumps from excited state n to the ground state. The wavelength so emitted illuminates a photosensitive material having work function 2.75 eV. If the stopping potential of the photoelectron is 10 V, the value of n is
(a) 3 (b) 4 (c) 5 (d) 2

12. The electron in a hydrogen atom makes a transition from an excited state to the ground state. Which of the following statements is true?
(a) Its kinetic energy increases and its potential energy decreases.
(b) Its kinetic energy decreases, potential energy increases.
(c) Its kinetic and its potential energy increases.
(d) Its kinetic, potential energy decrease.

13. An energy of 24.6 eV is required to remove one of the electrons from a neutral helium atom. The energy in (eV) required to remove both the electrons from a neutral helium atom is
(a) 38.2 (b) 49.2 (c) 51.8 (d) 79.0

14. One of the lines in the emission spectrum of Li^{2+} has the same wavelength as that of the 2nd line of Balmer series in hydrogen spectrum. The electronic transition corresponding to this line is $n = 12 \rightarrow n = x$. Find the value of x.
(a) 8 (b) 6 (c) 7 (c) 5

15. If the atom ${}_{100}Fm^{257}$ follows the Bohr model and the radius of ${}_{100}Fm^{257}$ is n times the Bohr radius, then find n.
(a) 100 (b) 200 (c) 4 (d) 1/4

16. The energy of He^+ in the ground state is – 54.4 eV, then the energy of Li^{++} in the first excited state will be
(a) –30.6 eV (b) 27.2 eV
(c) –13.6 eV (d) –27.2 eV

17. If the angular momentum of an electron in an orbit is J then the K.E. of the electron in that orbit is
(a) $\frac{J^2}{2mr^2}$ (b) $\frac{Jv}{r}$ (c) $\frac{J^2}{2m}$ (d) $\frac{J^2}{2\pi}$

18. Suppose an electron is attracted towards the origin by a force $\frac{k}{r}$ where 'k' is a constant and 'r' is the distance of the electron from the origin. By applying Bohr model to this system, the radius of the n^{th} orbital of the electron is found to be 'r_n' and the kinetic energy of the electron to be 'T_n'. Then which of the following is true?
(a) $T_n \propto \frac{1}{n^2}, r_n \propto n^2$ (b) T_n independent of n, $r_n \propto n$
(c) $T_n \propto \frac{1}{n}, r_n \propto n$ (d) $T_n \propto \frac{1}{n}, r_n \propto n^2$

19. In Hydrogen spectrum, the wavelength of H_α line is 656 nm, whereas in the spectrum of a distant galaxy, H_α line wavelength is 706 nm. Estimated speed of the galaxy with respect to earth is
(a) 2×10^8 m/s (b) 2×10^7 m/s
(c) 2×10^6 m/s (d) 2×10^5 m/s

20. In the hydrogen atom, an electron makes a transition from n = 2 to n = 1. The magnetic field produced by the circulating electron at the nucleus
(a) decreases 16 times (b) increases 4 times
(c) decreases 4 times (d) increases 32 times

21. What is the radius of iodine atom (At. no. 53, mass no. 126)
(a) 2.5×10^{-11} m (b) 2.5×10^{-9} m
(c) 7×10^{-9} m (d) 7×10^{-6} m

22. When an α-particle of mass 'm' moving with velocity 'v' bombards on a heavy nucleus of charge 'Ze', its distance of closest approach from the nucleus depends on m as :
(a) $\frac{1}{m}$ (b) $\frac{1}{\sqrt{m}}$ (c) $\frac{1}{m^2}$ (d) m

RESPONSE GRID					
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	11. ⓐⓑⓒⓓ	12. ⓐⓑⓒⓓ	13. ⓐⓑⓒⓓ	14. ⓐⓑⓒⓓ	15. ⓐⓑⓒⓓ
	16. ⓐⓑⓒⓓ	17. ⓐⓑⓒⓓ	18. ⓐⓑⓒⓓ	19. ⓐⓑⓒⓓ	20. ⓐⓑⓒⓓ
	21. ⓐⓑⓒⓓ	22. ⓐⓑⓒⓓ			

Space for Rough Work

23. The ionization energy of the electron in the hydrogen atom in its ground state is 13.6 eV. The atoms are excited to higher energy levels to emit radiations of 6 wavelengths. Maximum wavelength of emitted radiation corresponds to the transition between

(a) n = 3 to n = 1 states (b) n = 2 to n = 1 states
(c) n = 4 to n = 3 states (d) n = 3 to n = 2 states

24. The wavelengths involved in the spectrum of deuterium $\left({}_1^2D\right)$ are slightly different from that of hydrogen spectrum, because

(a) the size of the two nuclei are different
(b) the nuclear forces are different in the two cases
(c) the masses of the two nuclei are different
(d) the attraction between the electron and the nucleus is differernt in the two cases

25. An electron in hydrogen atom makes a transition $n_1 \rightarrow n_2$ where n_1 and n_2 are principal quantum numbers of the two states. Assuming Bohr's model to be valid the time period of the electron in the initial state is eight times that in the final state. The possible values of n_1 and n_2 are

(a) $n_1 = 4$ and $n_2 = 2$ (b) $n_1 = 6$ and $n_2 = 2$
(c) $n_1 = 8$ and $n_2 = 1$ (d) $n_1 = 8$ and $n_2 = 2$

26. Ina hydrogen like atom electronmake transition from an energy level with quantum number n to another with quantum number (n – 1). If n>>1, the frequency of radiation emitted is proportional to :

(a) $\frac{1}{n}$ (b) $\frac{1}{n^2}$ (c) $\frac{1}{n^{3/2}}$ (d) $\frac{1}{n^3}$

27. The spectrum obtained from a sodium vapour lamp is an example of

(a) band spectrum
(b) continuous spectrum
(c) emission spectrum
(d) absorption spectrum

28. Ionization potential of hydrogen atom is 13.6eV. Hydrogen atoms in the ground state are excited by monochromatic radiation of photon energy 12.1 eV. According to Bohr's theory, the spectral lines emitted by hydrogen will be

(a) three (b) four (c) one (d) two

29. The Bohr model of atoms

(a) predicts the same emission spectra for all types of atoms
(b) assumes that the angular momentum of electrons is quantised
(c) uses Einstein's photoelectric equation
(d) predicts continuous emission spectra for atoms

30. The largest wavelength in the ultraviolet region of the hydrogen spectrum is 122 nm. The smallest wavelength in the infrared region of the hydrogen spectrum (to the nearest integer) is

(a) 802 nm (b) 823 nm (c) 1882 nm (d) 1648 nm

31. A doubly ionised Li atom is excited from its ground state (n = 1) to n = 3 state. The wavelengths of the spectral lines are given by λ_{32}, λ_{31} and λ_{21}. The ratio $\lambda_{32}/\lambda_{31}$ and $\lambda_{21}/\lambda_{31}$ are, respectively

(a) 8.1, 0.67 (b) 8.1, 1.2
(c) 6.4, 1.2 (d) 6.4, 0.67

32. In Rutherford scattering experiment, what will be the correct angle for α-scattering for an impact parameter, $b = 0$?

(a) 90° (b) 270° (c) 0° (d) 180°

33. Consider 3rd orbit of He^+ (Helium), using non-relativistic approach, the speed of electron in this orbit will be [given K = 9 × 10^9 constant, Z = 2 and h (Plank's Constant) = 6.6 × 10^{-34} J s]

(a) 1.46 × 10^6 m/s (b) 0.73 × 10^6 m/s
(c) 3.0 × 10^8 m/s (d) 2.92 × 10^6 m/s

34. The ionization energy of hydrogen atom is 13.6 eV. Following Bohr's theory, the energy corresponding to a transition between 3rd and 4th orbit is

(a) 3.40 eV (b) 1.51 eV (c) 0.85 eV (d) 0.66 eV

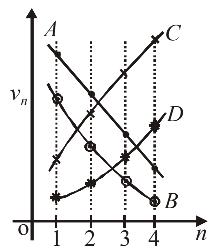
35. The transition from the state $n = 3$ to $n = 1$ in a hydrogen like atom results in ultraviolet radiation. Infrared radiation will be obtained in the transition from :

(a) 2 → 1 (b) 3 → 2 (c) 4 → 2 (d) 4 → 3

36. Given the value of Rydberg constant is $10^7 m^{-1}$, the wave number of the last line of the Balmer series in hydrogen spectrum will be :

(a) 0.025 × 10^4 m^{-1} (b) 0.5 × 10^7 m^{-1}
(c) 0.25 × 10^7 m^{-1} (d) 2.5 × 10^7 m^{-1}

37. Which of the plots shown in the figure represents speed (v_n) of the electron in a hydrogen atom as a function of the principal quantum number (n)?



(a) *B* (b) *D* (c) *C* (d) *A*

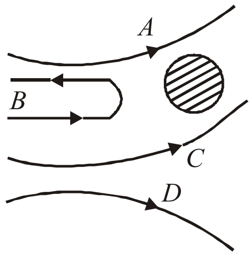
RESPONSE GRID					
	23. ⓐⓑⓒⓓ	24. ⓐⓑⓒⓓ	25. ⓐⓑⓒⓓ	26. ⓐⓑⓒⓓ	27. ⓐⓑⓒⓓ
	28. ⓐⓑⓒⓓ	29. ⓐⓑⓒⓓ	30. ⓐⓑⓒⓓ	31. ⓐⓑⓒⓓ	32. ⓐⓑⓒⓓ
	33. ⓐⓑⓒⓓ	34. ⓐⓑⓒⓓ	35. ⓐⓑⓒⓓ	36. ⓐⓑⓒⓓ	37. ⓐⓑⓒⓓ

Space for Rough Work

38. The ionisation potential of H-atom is 13.6 V. When it is excited from ground state by monochromatic radiations of 970.6 Å, the number of emission lines will be (according to Bohr's theory)
(a) 10 (b) 8 (c) 6 (d) 4

39. The energy of hydrogen atom in nth orbit is E_n, then the energy in nth orbit of single ionised helium atom will be
(a) $4E_n$ (b) $E_n/4$ (c) $2E_n$ (d) $E_n/2$

40. In the Rutherford experiment, α-particles are scattered from a nucleus as shown. Out of the four paths, which path is not possible?



(a) D (b) B (c) C (d) A

41. An electron changes its position from orbit $n = 2$ to the orbit $n = 4$ of an atom. The wavelength of the emitted radiations is (R = Rydberg's constant)
(a) $\frac{16}{R}$ (b) $\frac{16}{3R}$ (c) $\frac{16}{5R}$ (d) $\frac{16}{7R}$

42. In a Rutherford scattering experiment when a projectile of charge Z_1 and mass M_1 approaches a target nucleus of charge Z_2 and mass M_2, the distance of closest approach is r_0. The energy of the projectile is
(a) directly proportional to $Z_1 Z_2$
(b) inversely proportional to Z_1
(c) directly proportional to mass M_1
(d) directly proportional to $M_1 \times M_2$

43. The wavelength of the first spectral line in the Balmer series of hydrogen atom is 6561 A°. The wavelength of the second spectral line in the Balmer series of singly-ionized helium atom is
(a) 1215 Å (b) 1640 Å (c) 2430 Å (d) 4687 Å

44. If υ_1 is the frequency of the series limit of Lyman series, υ_2 is the frequency of the first line of Lyman series and υ_3 is the frequency of the series limit of the Balmer series then
(a) $\upsilon_1 - \upsilon_2 = \upsilon_3$ (b) $\upsilon_1 = \upsilon_2 - \upsilon_3$
(c) $\frac{1}{\upsilon_2} = \frac{1}{\upsilon_1} + \frac{1}{\upsilon_3}$ (d) $\frac{1}{\upsilon_1} = \frac{1}{\upsilon_2} + \frac{1}{\upsilon_3}$

45. In a hypothetical Bohr hydrogen atom, the mass of the electron is doubled. The energy E'_0 and radius r'_0 of the first orbit will be (r_0 is the Bohr radius)
(a) –11.2 eV (b) –6.8 eV (c) –13.6 eV (d) –27.2 eV

RESPONSE GRID	
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	43.ⓐⓑⓒⓓ 44.ⓐⓑⓒⓓ 45.ⓐⓑⓒⓓ

DAILY PRACTICE PROBLEM DPP CHAPTERWISE CP26 - PHYSICS			
Total Questions	45	Total Marks	180
Attempted		Correct	
Incorrect		Net Score	
Cut-off Score	50	Qualifying Score	70
Success Gap = Net Score – Qualifying Score			
Net Score = (Correct × 4) – (Incorrect × 1)			

Space for Rough Work

DAILY PRACTICE PROBLEMS

PHYSICS SOLUTIONS

DPP/CP26

1. (b) P.E. $= \frac{-Ze^2}{4\pi\varepsilon_0 r}$. Negative sign indicates that revolving electron is bound to the positive nucleus.
So, it decreases with increase in radii of orbit.

2. (b) $E = Rhc\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

E will be maximum for the transition for which $\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$ is maximum. Here n_2 is the higher energy level.

Clearly, $\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$ is maximum for the third transition, i.e. 2 → 1. I transition represents the absorption of energy.

3. (a) Number of emission spectral lines

$$N = \frac{n(n-1)}{2}$$

$\therefore 3 = \frac{n_1(n_1-1)}{2}$, in first case.

Or $n_1^2 - n_1 - 6 = 0$ or $(n_1 - 3)(n_1 + 2) = 0$
Take positive root.
$\therefore n_1 = 3$

Again, $6 = \frac{n_2(n_2-1)}{2}$, in second case.

Or $n_2^2 - n_2 - 12 = 0$ or $(n_2 - 4)(n_2 + 3) = 0$.
Take positive root, or $n_2 = 4$

Now velocity of electron $\upsilon = \frac{2\pi KZe^2}{nh}$

$\therefore \frac{\upsilon_1}{\upsilon_2} = \frac{n_2}{n_1} = \frac{4}{3}$.

4. (c) $N \propto \frac{1}{\sin^4\theta/2}$; $\frac{N_2}{N_1} = \frac{\sin^4(\theta_1/2)}{\sin^4(\theta_2/2)}$

or $\frac{N_2}{5\times10^6} = \frac{\sin^4(60°/2)}{\sin^4(120°/2)}$

or $\frac{N_2}{5\times10^6} = \frac{\sin^4 30°}{\sin^4 60°}$

or $N_2 = 5\times10^6 \times \left(\frac{1}{2}\right)^4\left(\frac{2}{\sqrt{3}}\right)^4 = \frac{5}{9}\times10^6$

5. (c) Magnetic moment of the hydrogen atom, when the electron is in n^{th} excited state, i.e., $n' = (n+1)$
As magnetic moment $M_n = I_nA = i_n(\pi r_n^2)$

$$i_n = eV_n = \frac{mz^2e^5}{4\varepsilon_0^2 n^3h^3}$$

$$r_n = \frac{n^2h^2}{4\pi^2 kzme^2}\left(k = \frac{1}{4\pi\epsilon_0}\right)$$

Solving we get magnetic moment of the hydrogen atom for n^{th} excited state

$$M_{n'} = \left(\frac{e}{2m}\right)\frac{nh}{2\pi}$$

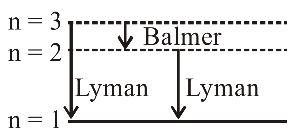
6. (a) $E = \frac{hc}{\lambda} \Rightarrow \lambda = \frac{hc}{E} = \frac{6.62\times10^{-34}\times3\times10^8}{12.5\times1.6\times10^{-19}}$
$= 993\,A°$

$$\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

(where Rydberg constant, $R = 1.097\times10^7$)

or, $\frac{1}{993\times10^{-10}} = 1.097\times10^7\left(\frac{1}{1^2} - \frac{1}{n_2^2}\right)$

Solving we get $n_2 = 3$
Spectral lines
Total number of spectral lines = 3
Two lines in Lyman series for $n_1 = 1, n_2 = 2$ and $n_1 = 1, n_2 = 3$ and one in Balmer series for $n_1 = 2$, $n_2 = 3$



7. (b) $l = \frac{nh}{2\pi}, |E| \propto Z^2/n^2; n = 3$

$\Rightarrow l_H = l_{Li}$ and $|E_H| < |E_{Li}|$

8. (b) $r \propto n^2$

$\therefore \frac{\text{radius of final state}}{\text{radius of initial state}} = n^2$

$\frac{21.2\times10^{-11}}{5.3\times10^{-11}} = n^2$

$\therefore$ $n^2 = 4$ or $n = 2$

9. (a) $R = \frac{R_0 n^2}{Z}$

Radius in ground state $= \frac{R_0}{Z}$

Radius in first excited state $= \frac{R_0\times4}{Z}$ $(\because n = 2)$

Hence, radius of first excited state is four times the radius in ground state.

10. (a) Speed of electron in nth orbit

$$V_n = \frac{2\pi KZe^2}{nh}$$

$$V = (2.19 \times 10^6 \text{ m/s}) \frac{Z}{n}$$

$$V = (2.19 \times 10^6) \frac{2}{3} \quad (Z = 2 \;\&\; n = 3)$$

$$V = 1.46 \times 10^6 \text{ m/s}$$

11. (b) $KE_{max} = 10eV$

$\phi = 2.75$ eV

Total incident energy

$E = \phi + KE_{max} = 12.75$ eV

$\therefore$ Energy is released when electron jumps from the excited state n to the ground state.

$\because E_4 - E_1 = \{-0.85 - (-13.6)\text{ ev}\}$
$= 12.75$eV

$\therefore$ value of n = 4

12. (a) As the electron comes nearer to the nucleus the potential energy decreases

$$\left(\because \frac{-k.Ze^2}{r} = \text{P.E. and } r \text{ decreases}\right)$$

The K.E. will increase $\left[\because \text{K.E.} = \frac{1}{2}|\text{P.E.}| = \frac{1}{2}\frac{kZe^2}{r}\right]$

The total energy decreases $\left[\text{T.E.} = -\frac{1}{2}\frac{kZe^2}{r}\right]$

13. (d) When one e^- is removed from neutral helium atom, it becomes a one e^- species.
For one e^- species we know

$$E_n = \frac{-13.6Z^2}{n^2} \text{ eV/atom}$$

For helium ion, $Z = 2$ and for first orbit $n = 1$.

$$\therefore \quad E_1 = \frac{-13.6}{(1)^2} \times 2^2 = -54.4 \text{ eV}$$

$\therefore$ Energy required to remove this $e^- = +54.4$ eV

$\therefore$ Total energy required = 54.4 + 24.6 = 79 eV

14. (b) For 2nd line of Balmer series in hydrogen spectrum

$$\frac{1}{\lambda} = R(1)\left(\frac{1}{2^2} - \frac{1}{4^2}\right) = \frac{3}{16}R$$

For Li^{2+} $\left[\frac{1}{\lambda} = R \times 9\left(\frac{1}{x^2} - \frac{1}{12^2}\right) = \frac{3R}{16}\right]$

which is satisfied by n = 12 → n = 6.

15. (d) For an atom following Bohr's model, the radius is given by

$r_m = \frac{r_0 m^2}{Z}$ where r_0 = Bohr's radius and m = orbit number.

For Fm, $m = 5$ (Fifth orbit in which the outermost electron is present)

$$\therefore \; r_m = \frac{r_0 5^2}{100} = nr_0 \text{ (given)} \Rightarrow n = \frac{1}{4}$$

16. (a) Energy of electron in n^{th} orbit is

$$E_n = -(Rch)\frac{Z^2}{n^2} = -54.4 \text{ eV}$$

For He^+ is ground state

$$E_1 = -(Rch)\frac{(2)^2}{(1)^2} = -54.4 \Rightarrow Rch = 13.6$$

$\therefore$ For Li^{++} in first excited state (n = 2)

$$E' = -13.6 \times \frac{(3)^2}{(2)^2} = -30.6 \text{ eV}$$

17. (a) Angular momentum = mrv = J

$$\therefore \quad v = \frac{J}{mr}$$

$$\text{K. E. of electron} = \frac{1}{2}mv^2 = \frac{1}{2}m\left(\frac{J}{mr}\right)^2$$

$$= \frac{J^2}{2mr^2}$$

18. (b) When $F = \frac{k}{r}$ = centripetal force, then $\frac{k}{r} = \frac{mv^2}{r}$

$\Rightarrow mv^2 = $ constant $\quad \Rightarrow$ kinetic energy is constant

$\Rightarrow T$ is independent of n.

19. (b) $\frac{1}{\lambda'} = \frac{1}{\lambda}\sqrt{\frac{c-v}{c+v}}$

Here, $\lambda' = 706$ nm, $\lambda = 656$ nm

$$\therefore \quad \frac{c-v}{c+v} = \left(\frac{\lambda}{\lambda'}\right)^2 = \left(\frac{656}{706}\right)^2 = 0.86$$

$$\Rightarrow \quad \frac{v}{c} = \frac{0.14}{1.86}$$

$$\Rightarrow \quad v = 0.075 \times 3 \times 10^8 = 2.25 \times 10^7 \text{m/s}$$

20. (d) $\because \; B = \frac{\mu_0 I}{2r}$ and $I = \frac{e}{T}$

$$B = \frac{\mu_0 e}{2rT} \quad [r \propto n^2, T \propto n^5]; \quad B \propto \frac{1}{n^5}$$

21. (a) 53 electrons in iodine atom are distributed as 2, 8, 18, 18, 7

$\therefore n = 5$

$$r_n = (0.53 \times 10^{-10})\frac{n^2}{Z}$$

$$= \frac{0.53 \times 10^{-10} \times 5^2}{53} = 2.5 \times 10^{-11} \text{m}$$

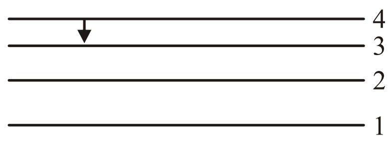
22. (a) At closest distance of approach, the kinetic energy of the particle will convert completely into electrostatic potential energy.

Kinetic energy K.E. $= \frac{1}{2}mv^2$

Potential energy P.E. $= \frac{KQq}{r}$

$\frac{1}{2}mv^2 = \frac{KQq}{r} \Rightarrow r \propto \frac{1}{m}$

23. (c) $\frac{n(n-1)}{2} = 6$



$n^2 - n - 12 = 0$

$(n-4)(n+3) = 0$ or $n = 4$

24. (c) The wavelength of spectrum is given by

$\frac{1}{\lambda} = Rz^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$ where $R = \frac{1.097 \times 10^7}{1 + \frac{m}{M}}$

where m = mass of electron

M = mass of nucleus.

For different M, R is different and therefore λ is different.

25. (a) $\because T \propto n^3$

$Tn_1 = 8\,Tn_2$ (given)

Hence, $n_1 = 2n_2$

26. (d) $\Delta E = h\nu$

$\nu = \frac{\Delta E}{h} = k\left[\frac{1}{(n-1)^2} - \frac{1}{n^2}\right] = \frac{k(2n-1)}{n^2(n-1)^2}$

$\approx \frac{2k}{n^3}$ or $\nu \propto \frac{1}{n^3}$

27. (c) A spectrum is observed, when light coming directly from a source is examined with a spectroscope. Therefore spectrum obtained from a sodium vapour lamp is emission spectrum.

28. (a) Energy of ground state 13.6 eV

Energy of first excited state

$= -\frac{13.6}{4} = -3.4$ eV

Energy of second excited state

$= -\frac{13.6}{9} = -1.5$ eV

Difference between ground state and 2nd excited state $= 13.6 - 1.5 = 12.1$ eV

So, electron can be excited upto 3rd orbit

No. of possible transition

$1 \to 2, 1 \to 3, 2 \to 3$

So, three lines are possible.

29. (b) In Bohr's model, angular momentum is quantised i.e

$\ell = n\left(\frac{h}{2\pi}\right)$

30. (b) The smallest frequency and largest wavelength in ultraviolet region will be for transition of electron from orbit 2 to orbit 1.

$\therefore \frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

$\Rightarrow \frac{1}{122 \times 10^{-9} m} = R\left[\frac{1}{1^2} - \frac{1}{2^2}\right] = R\left[1 - \frac{1}{4}\right] = \frac{3R}{4}$

$\Rightarrow R = \frac{4}{3 \times 122 \times 10^{-9}} m^{-1}$

The highest frequency and smallest wavelength for infrared region will be for transition of electron from ∞ to 3rd orbit.

$\therefore \frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) \Rightarrow \frac{1}{\lambda} = \frac{4}{3 \times 122 \times 10^{-9}}\left(\frac{1}{3^2} - \frac{1}{\infty}\right)$

$\therefore \lambda = \frac{3 \times 122 \times 9 \times 10^{-9}}{4} = 823.5\text{nm}$

31. (c) $\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$ where R = Rydberg constant

$\frac{1}{\lambda_{32}} = \left(\frac{1}{4} - \frac{1}{9}\right) = \frac{5}{36}$

$\Rightarrow \lambda_{32} = \frac{36}{5}$

Similarly solving for λ_{31} and λ_{21}

$\lambda_{31} = \frac{9}{8}$ and $\lambda_{21} = \frac{4}{3}$

$\therefore \frac{\lambda_{32}}{\lambda_{31}} = 6.4$ and $\frac{\lambda_{21}}{\lambda_{31}} \simeq 1.2$

32. (d) $b = \frac{Ze^2 \cot\left(\frac{\theta}{2}\right)}{4\pi \in_0 k_i} = 0 \Rightarrow \cot\left(\frac{\theta}{2}\right) = 0$

$\Rightarrow \frac{\theta}{2} = 90°$ or $\theta = 180°$

33. (a) Speed of electron in nth orbit

$V_n = \frac{2\pi KZe^2}{nh}$

$V = (2.19 \times 10^6 \text{ m/s}) \frac{Z}{n}$

$V = (2.19 \times 10^6) \frac{2}{3}$ $(Z = 2 \,\&\, n = 3)$

$V = 1.46 \times 10^6$ m/s

34. (d) $E = E_4 - E_3$

$= -\frac{13.6}{4^2} - \left(-\frac{13.6}{3^2}\right) = -0.85 + 1.51$

$= 0.66$ eV

35. (d) $\because$ The frequency of the transition $\nu \propto \frac{1}{n^2}$, when $n = 1, 2, 3.$

36. (c) According to Bohr's theory, the wave number of the last line of the Balmer series in hydrogen spectrum,

For hydrogen atom z = 1

$$\frac{1}{\lambda} = RZ^2\left(\frac{1}{n_2^2} - \frac{1}{n_1^2}\right)$$

$$= 10^7 \times 1^2\left(\frac{1}{2^2} - \frac{1}{\infty^2}\right)$$

$\Rightarrow$ wave number $\frac{1}{\lambda} = 0.25 \times 10^7\ m^{-1}$

37. (a) Velocity of electron in n^{th} orbit of hydrogen atom is given by :

$$V_n = \frac{2\pi KZe^2}{nh}$$

Substituting the values we get,

$$V_n = \frac{2.2\times10^6}{n} m/s \quad \text{or} \quad V_n \propto \frac{1}{n}$$

As principal quantum number increases, velocity decreases.

38. (c) $\frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

$$\Rightarrow \frac{1}{970.6\times10^{-10}} = 1.097\times10^7\left[\frac{1}{1^2} - \frac{1}{n_2^2}\right] \Rightarrow n_2 = 4$$

$\therefore$ Number of emission line $N = \frac{n(n-1)}{2} = \frac{4\times3}{2} = 6$

39. (a) We have $E_n = \frac{-2\pi^2 mK^2Z^2e^4}{n^2h^2}$. For helium $Z = 2$. Hence requisite answer is $4E_n$

40. (c) As α-particles are doubly ionised helium He^{++} i.e. Positively charged and nucleus is also positively charged and we know that like charges repel each other.

41. (b) $\bar{v} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$, where $n_1 = 2, n_2 = 4$

$$\bar{v} = R\left(\frac{1}{4} - \frac{1}{16}\right)$$

$$\frac{1}{\lambda} = R\left(\frac{12}{4\times16}\right) \Rightarrow \lambda = \frac{16}{3R}$$

42. (a) The kinetic energy of the projectile is given by

$$\frac{1}{2}mv^2 = \frac{Ze(2e)}{4\pi\varepsilon_0 r_0} = \frac{Z_1 Z_2}{4\pi\varepsilon_0 r_0}$$

Thus energy of the projectile is directly proportional to Z_1, Z_2

43. (a) We know that $\frac{1}{\lambda} = RZ^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

The wave length of first spectral line in the Balmer series of hydrogen atom is 6561Å . Here $n_2 = 3$ and $n_1 = 2$

$$\therefore \frac{1}{6561} = R(1)^2\left(\frac{1}{4} - \frac{1}{9}\right) = \frac{5R}{36} \quad \text{...(i)}$$

For the second spectral line in the Balmer series of singly ionised helium ion $n_2 = 4$ and $n_1 = 2$; $Z = 2$

$$\therefore \frac{1}{\lambda} = R(2)^2\left[\frac{1}{4} - \frac{1}{16}\right] = \frac{3R}{4} \quad \text{...(ii)}$$

Dividing equation (i) and equation (ii) we get

$$\frac{\lambda}{6561} = \frac{5R}{36}\times\frac{4}{3R} = \frac{5}{27}$$

$\therefore \quad \lambda = 1215$ Å

44. (a) For Lyman series

$$\upsilon = R_C\left[\frac{1}{1^2} - \frac{1}{n^2}\right]$$

where n = 2, 3, 4, ...

For the series limit of Lyman series, $n = \infty$

$$\therefore \quad \upsilon_1 = R_C\left[\frac{1}{1^2} - \frac{1}{\infty^2}\right] = R_C \quad \text{...(i)}$$

For the first line of Lyman series, $n = 2$

$$\therefore \quad \upsilon_2 = R_C\left[\frac{1}{1^2} - \frac{1}{2^2}\right] = \frac{3}{4}R_C \quad \text{...(ii)}$$

For Balmer series

$$\upsilon = R_C\left[\frac{1}{2^2} - \frac{1}{n^2}\right]$$

where n = 3, 4, 5 .....

For the series limit of Balmer series, $n = \infty$

$$\therefore \quad \upsilon_3 = R_C\left[\frac{1}{2^2} - \frac{1}{\infty^2}\right] = \frac{R_C}{4} \quad \text{...(iii)}$$

From equation (i), (ii) and (iii), we get

$\upsilon_1 = \upsilon_2 + \upsilon_3$ or $\upsilon_1 - \upsilon_2 = \upsilon_3$

45. (d) As $r \propto \frac{1}{m}$ $\quad \therefore r_0' = \frac{1}{2}r_0$

As $E \propto m$ $\quad \therefore E_0' = 2(-13.6) = -27.2\ eV$