Solution

CET25P12 ATOMS

Class 12 - Physics

1.

(c) assumes that the angular momentum of electrons is quantized

Explanation: Bohr's model of atoms assumes that the angular momentum of electrons is quantized.

2. **(a)** 1026Å

Explanation: Rydberg formula to generate the Lyman series:

$\frac{1}{\lambda} = R(\frac{1}{1^2} - \frac{1}{n^2})$ where n = 2,3,4,... and R = 1.097×10^7 m^{-1}

The wavelengths in Lyman series are all in the UV region i.e. from 121.6 nm to 91.18 nm.

Second line means n = 3, substituting the values of R and n in the above formula, we get the wavelength of the second line as 102.6 nm.

3.

(d) $-k\frac{e^2}{r^3}\vec{r}$

Explanation: The Coulomb force between the nucleus and the electron of a hydrogen atom is $\vec{F} = k\frac{(e)(-e)}{r^2}\hat{r} = -k\frac{e^2}{r^3}\vec{r}$

4.

(d) only on impact parameter

Explanation: only on impact parameter

5.

(c) Thomson's model and Rutherford's model

Explanation: According to Thomson model, an atom consists of a positively charged sphere with electrons filled in it. The positively charged part of the atom in this model is the atom itself and so it has the most mass.

According to Rutherford model, the positive charge and most of the mass of the atom is concentrated in the nucleus of the atom. The nucleus is thus the positively charged part of the atom and it has the most mass.

So both the models say that the positively charged part of the atom possesses most of the mass.

6.

(d) Rutherford's model

Explanation: Rutherford concluded that while most of alpha particles experienced a little force, a few of them experienced a strong repulsive force. This may be possible only if there is extreme dense concentration of positive charge and most of the mass of the atom in the nucleus of the atom. Hence +ve charge of the atom is not be distributed uniformly through out the sphere.

7. **(a)** energy

Explanation: According to the uncertainty principle, $\Delta E \cdot \Delta t \geq \frac{h}{2\pi}$

Thus the time measurement Δt will become uncertain if ΔE is measured with high certainty.

8.

(c) C and N^+

Explanation: Of all, C and N^+ have got the same electronic configuration. There are 2 electrons in first orbit and 4 in the second orbit.

9. **(a)** Thomson's model

Explanation: An atom has a nearly continuous mass distribution in Thomson's model. In the atom, the electrons are embedded in the sphere of positive charge which is distributed uniformly throughout the volume of the atom.

10.

(b) 1.8

Explanation: Longest wavelength in this series = 656.3 nm

Shortest wavelenth = 364.6 nm

Ratio = 656.3 / 364.6 = 1.8

11.

(c) absorb energy

Explanation: An electron in the lower state absorbs energy and moves on to higher energy state. Such electrons are said to be in an excited state.

12.

(d) 2.1×10^{-34} Js

Explanation: The electron revolving in the second orbit (n = 2) has an energy equal to -34 eV. Therefore, its angular momentum is

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

$= \frac{6.6 \times 10^{-34} \text{Js}}{22/7}$

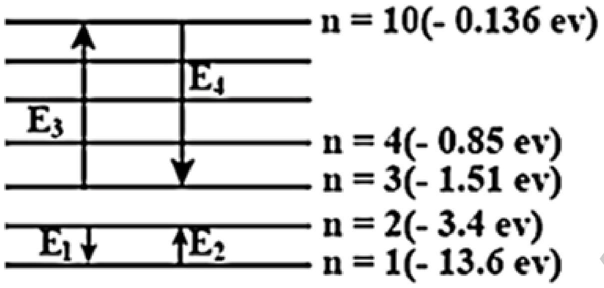
= 2.1×10^{-34} Js

13. **(a)** Crossed and simultaneous

Explanation: Specific charge can be determined when the charge moves in both magnetic field and electric field which are mutually perpendicular to each other so that the net force on it is made zero. In this situation, the direction of motion of charge remains perpendicular to both electric and magnetic field.

14. **(a)** n = 1 to n = 2

Explanation: n = 1 to n = 2



15. **(a)** of the electrons not being subject to a central force

Explanation: The simple Bohr model cannot be directly applied to calculate the energy levels of an atom with many electrons because when we derive the formula for radius or the energy levels etc, we make the assumption that centripetal force is provided only by the electrostatic force of attraction by the nucleus. Hence, this will only work for single-electron atoms. In multi-electron atoms, there will also be repulsion due to other electrons. The simple Bohr model cannot be directly applied to calculate the energy levels of an atom with many electrons.

16.

(d) 10^{-15} to 10^{-14} m

Explanation: Rutherford's experiments suggested the size of the nucleus to be about 10^{-15} to 10^{-14} m. From kinetic theory, the size of an atom was know to be 10^{-10}m.

17.

(c) 54.4 eV

Explanation: $E'_1 = (2)^2 E_1 = 4 \times 13.6 = 54.4$ eV

18.

(d) $r \propto n^2$

Explanation: The radius of nth orbit is given by

$r = 4\pi\varepsilon_0 . \frac{n^2h^2}{4\pi^2 me^2}$

$\therefore r \propto n^2$

19.

(b) 802 nm

Explanation: For the longest wavelength in the ultraviolet region (Lyman series), $n_1 = 1$, $n_2 = 2$

20.

(d) the frame in which the electron is at rest is not inertial.

Explanation: In a hydrogen atom, electrons revolving around a fixed proton nucleus have some centripetal acceleration. So that, its frame of reference is non-inertial. In the frame of reference, where the electron is at rest, the given expression is not true as it forms the non-inertial frame of reference.

As the mass of an electron is negligible as compared to proton, so the centripetal force cannot provide the electrostatic force, $F_p = \frac{m_p v^2}{r}$

So, the given expression is not true, as it forms noninertial frame of reference due to $m_e <<< m_p$ or centripetal force on $F_e <<< F_p$.

21. **(a)** 1.215×10^{-7} m

Explanation: $\frac{1}{\lambda} = R\left[\frac{1}{1^2} - \frac{1}{2^2}\right] = \frac{3R}{4}$

$\lambda = \frac{4}{3R} = \frac{4}{3\times1.097\times10^7} =$ 1.215×10^{-7} m

22.

(b) masses of the two nuclei are different

Explanation: masses of the two nuclei are different

23.

(b) 9R

Explanation: In a hydrogen atom, $v_n \propto \frac{1}{n}$ and $r_n \propto n^2$

Given $v_n = \frac{1}{3}v_1$

$\therefore \frac{v_n}{v_1} = \frac{1}{n} = \frac{1}{3} \Rightarrow n = 3$

Also $\frac{r_3}{r_1} = \frac{3^2}{1^2} = 9$

$\Rightarrow r_3 = 9\ r_1 = 9R$

24.

(c) -3.02 eV

Explanation: -3.02 eV

25.

(d) 6557 $\overset{\circ}{A}$

Explanation: For longest wavelength in Balmer series, $n_1 = 2$ and $n_2 = 3$.

$\frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] = 1098 \times 10^7 \left[\frac{1}{2^2} - \frac{1}{3^2}\right]$

$\lambda = \frac{36\times10^{-7}}{5\times1.098}$ m

= 6577 $\times$ 10^{-10} m

= 6577 $\overset{\circ}{A}$

26.

(c) about the same as predicted by Rutherford’s model

Explanation: The alpha particles which pass close to the nucleus (positively charged) suffer a strong electrostatic force and are scattered through large angles (Rutheford's explanation). Thomson model was unable to explain large angle scattering of alpha particles. However, the average angle of deflection suggested by both is about the same size.

27.

(c) 95 nm

Explanation: 95 nm

28. **(a)** 13.6 eV, –27.2 eV

Explanation: Total energy, $E = -13.6\ eV$

But, $K.E = -E = 13.6\ eV$

and $P.E = -2K.E = -2 \times 13.6 = -27.2\ eV$

29.

(b) $\frac{h}{\pi}$

Explanation: Angular momentum (L) is an integral multiple of $h/2\pi$ where h is the Planck's constant i.e. $L = nh/2\pi$.

For second orbital electron, n=2, so

$L = \frac{2h}{2\pi}$,
$L = \frac{h}{\pi}$

30.

(c) 0.3541 $\overset{\circ}{A}$

Explanation: Wavelength of K_α line is given by K_α

$\frac{1}{\lambda} = R(Z-1)^2\left[\frac{1}{1^2} - \frac{1}{2^2}\right]$

$\therefore \frac{K_\alpha(Zn)}{K_a(Mo)} = \frac{(30-1)^2}{(42-1)^2}$

$\Rightarrow K_\alpha(\text{Zn}) = \frac{29\times29}{41\times41} \times 0.7078\overset{\circ}{A} = 0.3541\ \overset{\circ}{A}$

31.

(d) 10^{-8} cm

Explanation: Radius of first orbit of H-atom = $0.53\overset{\circ}{A} \approx 10^{-8}$ cm.

32. **(a)** Molecular spectrum

Explanation: Band spectrum are produced by molecules radiating their rotational or vibrational energies, or both simultaneously.

Whereas line spectra are also called atomic spectra because the lines represent wavelengths radiated from atoms when electrons change from one energy level to another.

33.

(c) 1 : -1

Explanation: Kinetic energy = - Total energy

$\therefore$ Kinetic energy : Total energy = 1 : - 1

34.

(b) assumes that the angular momentum of electrons is quantised

Explanation: assumes that the angular momentum of electrons is quantised

35.

(b) the P.E. increases and K.E. decreases

Explanation: The potential and kinetic energies of the electron in an orbit of radius r of the hydrogen atom are given by

$E_p = -\frac{1}{4\pi\varepsilon_0} \cdot \frac{e^2}{r}$

and $E_k = \frac{1}{4\pi\varepsilon_0} \cdot \frac{e^2}{2r}$

When the atom goes to excited state, r increases. As a result, potential energy increases (becomes less negative) and kinetic energy decreases.

36.

(b) non stationary

Explanation: According to the Rutherford model, the electrons inside an atom cannot be stationary. The electrostatic attraction between electrons and the nucleus gets used up in revolving the electrons around the nucleus.

37. **(a)** -3.4 eV

Explanation: Energy of the electron in nth orbit of hydrogen atom,

$E_n = -\frac{13.6}{n^2}eV$

For the first excited state, n = 2

$\therefore$ Hence energy is given by ,$E_2 = -\frac{13.6}{2^2}$ = - 3.4 eV

38.

(c) $f \propto Z^2$

Explanation: According to Moseley's law, $f = a^2(Z - b)^2$ i.e; $f \propto Z^2$ (approximately).

39.

(d) $\frac{4}{3\times1.097\times10^7}$ m

Explanation: For first member of Lyman series, $n_1 = 1$ $n_2 = 2$

$\therefore \quad \frac{1}{\lambda} = R\left[\frac{1}{1^2} - \frac{1}{2^2}\right] = R \times \frac{3}{4}$

or $\lambda = \frac{4}{3R} = \frac{4}{3 \times 1.097 \times 10^7}$ m

40.

(b) X-rays

Explanation: When the cathode rays strike heavy target atoms, they knock out some electrons of the inner orbits. Then the electrons of the outer orbits jump to the inner orbits giving characteristic X-ray photons.

41.

(b) $\frac{20}{7}\lambda$

Explanation: For transition $3 \to 2$

$\frac{1}{\lambda} = R\left[\frac{1}{2^2} - \frac{1}{3^2}\right] = \frac{5}{36}R$

For transition $4 \to 3$

$\frac{1}{\lambda'} = R\left[\frac{1}{3^2} - \frac{1}{4^2}\right] = \frac{7}{144}R$

$\therefore \frac{\lambda'}{\lambda} = \frac{5}{36} \times \frac{144}{7} = \frac{20}{7} \Rightarrow \lambda' = \frac{20}{7}\lambda$

42. **(a)** directly proportional to z_1z_2

Explanation: $K = \frac{1}{2}M_1v^2$

$= \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r_0} = \frac{1}{4\pi\varepsilon_0}\frac{z_1e \cdot z_2e}{r_0}$

For a given r_0, $K \propto z_1z_2$

43.

(b) 18 pm

Explanation: According to Bohr's model of atom, radius of an atom in its ground state is r = $\frac{r_0}{Z}$ where r_0 is Bohr's radius, and Z is atomic number. As r_0 = 53 pm and atomic number of Lithium atom is 3 so, hence radius of lithium ion is r = $\frac{53}{3}$ = 17.67 pm =18 pm

44.

(c) 1.52 $\times 10^{-16}$ s

Explanation: Orbital period for orbit n is given by:

$T_n = \frac{2\pi r}{v_n}$, where $r_1 = 0.53 \times 10^{-10}\ m$

So, $T_1 = \frac{2\pi \times 0.53 \times 10^{-10}}{2.19 \times 10^6} = 1.52 \times 10^{-16}\ s$

45. **(a)** 1.51 eV

Explanation: For second excited state, n = 3

$\therefore E_3 = -\frac{13.6}{3^2} = -1.51\text{eV}$

I.E. = E_∞ - E_3 = 0 + 1.51 = 1.51 eV

46. **(a)** 1 : 4 : 9

Explanation: $r_n \propto n^2$

or $1^2 : 2^2 : 3^2$

47.

(c) 4

Explanation: $\Delta E = hv = K_{\max} + W_0$

$13.6\text{eV}\left[\frac{1}{1^2} - \frac{1}{n^2}\right] = 10\text{eV} + 2.75\text{eV}$

or $\frac{13.6n^2 - 13.6}{n^2} = 12.75$

or 13.6 n^2-13.6 = 12.75 n^2

or 13.6 n^2 - 12.75 n^2 = 13.6

or n^2(13.6 - 12.75) = 13.6

or n^2(0.85) = 13.6

n^2 = 16

$\therefore$ n = 4

48. **(a)** $v_1 - v_2 = v_3$

Explanation: For the series limit of Lyman series, $n_1 = 1$, $n_2 = \infty$

$\therefore v_1 = \mathrm{Rc}\left[\frac{1}{1^2} - \frac{1}{\infty^2}\right] = Rc$

For the first line of Lyman series, $n_1 = 1$, $n_2 = 2$

$\therefore v_2 = \mathrm{Rc}\left[\frac{1}{1^2} - \frac{1}{2^2}\right] = \frac{3}{4}Rc$

For the series limit of Balmer series, $n_1 = 2$, $n_2 = \infty$

$v_3 = Rc\left[\frac{1}{2^2} - \frac{1}{\infty^2}\right] = \frac{Rc}{4}$

Clearly, $v_1 = v_2 + v_3 \Rightarrow v_1 - v_2 = v_3$

49.

(b) n^2

Explanation: n^2

50.

(b) 3.4 eV

Explanation: The kinetic energy of the electron in a orbit is numerically equal to its total energy.

51.

(c) - 54.4 eV

Explanation: For hydrogen like atoms or ions, $E_n = -\frac{13.6Z^2}{n^2}$eV

For He^+, Z = 2 and n = 1

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

52.

(d) is emitted in the transition from the second excited state to the first excited state

Explanation: The H_α line is emitted when the electron jumps from n = 3 orbit (second excited state) to the n = 2 orbit (first excited state).

53. **(a)** $\frac{9}{5}$

Explanation: $\frac{9}{5}$

54.

(d) $6\pi x$

Explanation: $r_n = n^2 r_1$

$r_3 = 9r_1 = 9x$

$\text{mvr} = \frac{nh}{2\pi}$

$\text{mv9x} = 3\frac{h}{2\pi}$

$\frac{h}{mv} = 6\pi x$

$\lambda = 6\pi x$

55.

(b) 656 nm

Explanation: Balmer series of spectra for hydrogen is represented by the formula

$\frac{1}{\lambda} = R(\frac{1}{2^2} - \frac{1}{n^2})$, λ is the wavelength, R is Rydberg constant & R = 1.097×10^7 m^{-1}, n = 3,4,5,...

Longest wavelength in this series is got by taking n = 3,

$\frac{1}{\lambda} = (1.097 \times 10^7)(\frac{1}{2^2} - \frac{1}{3^2})$ m^{-1}

= 1.522×10^6 m^{-1}

$\lambda = 656.3nm$

56.

(c) 5.6×10^{14} Hz

Explanation: If electron jumps from n_2 orbit to n_1 orbit, then $E_2 - E_1 = h\nu$,

$E_2 - E_1 = 2.3 \text{ eV} = 2.3 \times 1.6 \times 10^{-19}$ J

Also, planck's constant (h) = 6.63 $\times$ 10^{-34} Js

Therefore, frequency of the emitted photon, ν = $\frac{E_2-E_1}{h} = \frac{2.3\times1.6\times10^{-19}}{6.6\times10^{-34}} = 5.6\times10^{14}\text{Hz}$

57. **(a)** 2.6 $\times 10^{74}$

Explanation: Angular momentum, $mvr = \frac{nh}{2\pi}$

Or, $n = \frac{2\pi mvr}{h} = 2\times\frac{22}{7}\times\frac{6.0\times10^{24}\times3\times10^{4}\times1.5\times10^{11}}{6.6\times10^{-34}} = 2.57\times10^{74}$

58. **(a)** $4\rightarrow3$

Explanation: Infrared radiation is emitted when transition occurs from any higher energy level to n = 3, 4 or 5 level.

59.

(b) three

Explanation: When photon of energy 12.1 eV is incident, the hydrogen atom will be raised to the excited state having energy -13.6 + 12.1 i.e. - 1.5 eV. This state corresponds to n = 3. Therefore, three spectral line (corresponding to the transitions from n = 3 to n = 2, n = 3 to n = 1 and n = 1 states) will be emitted.

60.

(c) The stability of atom was established by the model.

Explanation: Rutherford was not able to explain stability of atom

61.

(d) $T\propto n^3$

Explanation: In Bohr's atomic model, $T\propto n^3$

62. **(a)** number of protons in nucleus.

Explanation: number of protons in nucleus.

63. **(a)** 1.46 $\times$ 10^6 m/s

Explanation: For H-like atoms, $v = \frac{Z}{n}\times2.189\times10^6\ \text{m/s}$

For He^{2+}, Z = 2, n = 3

v = $\frac{2}{3}$ $\times$ 2.189 $\times$ 10^6 = 1.46 $\times$ 10^6ms

64.

(b) 4 E_n

Explanation: For H-atom, $E_n\propto1^2$ (Z = 1)

For He-atom $E\propto1^2$ (Z = 2)

$\therefore\frac{E}{E_n} = 4\Rightarrow E = 4E_n$

65.

(d) 3.4 eV

Explanation: Kinetic energy of electron = $\frac{kze^2}{2r}$

Potential energy of electron = $\frac{kze^2}{r}$

$\Rightarrow P.E = -2(K.E)$

Total energy = P.E +K.E $= -2K.E + K.E = -K.E$

Total energy in the first excited state $= -3.4\ ev$

$KE = -(-3.4ev) = 3.4eV$

66.

(c) 4 a_0

Explanation: Since r $\propto$ n^2, the radius of the second orbit is 4 a_0

67.

(c) 1.05 $\times$ 10^{-34} Js

Explanation: By absorbing 10.2 eV of energy, an electron jumps from ground level (n = 1) to the first excited state (n = 2).

$\therefore$ Increase in angular momentum

$= \frac{2h}{2\pi} - \frac{h}{2\pi} = \frac{h}{2\pi} = \frac{6.6\times10^{-34}}{2\times3.14}$

= 1.05 $\times$ 10^{-34} Js

68.

(c) -0.54 eV

Explanation: Energy of the electron in nth orbit of hydrogen atom,

$E_n = -\frac{13.6}{n^2}$eV

Therefore, energy of the electron in n = 5 orbit,

$E_5 = -\frac{13.6}{5^2}$ = -0.54 eV

69.

(b) 2.8×10^{15}

Explanation: When the electron jumps from n = 3 to n = 1 orbit, $v = Rhc\left[\frac{1}{1^2} - \frac{1}{3^2}\right]$

or $2.7 \times 10^{15} = Rhc \times \frac{8}{9}$

When the electron jumps from n = 4 to n - 1 orbit,

$x = Rhc\left[\frac{1}{1^2} - \frac{1}{4^2}\right] = Rhc \times \frac{15}{16}$

$\therefore \frac{x}{2.7\times 10^{15}} = \frac{15}{16} \times \frac{9}{8}$

or x = $\frac{15}{16} \times \frac{9}{8} \times 2.7 \times 10^{15}$

= 2.8×10^{15} Hz

70.

(c) 10^{-10} m

Explanation: An atom is a million times smaller than the thickest human hair. The diameter of an atom ranges from about 0.1 to 0.5 nanometers (1×10^{-10} m to 5×10^{-10} m).

71.

(c) $1s^2 2s^2 2p^6 3s^2 3p^2$

Explanation: ^{14}Si has electronic configuration $1s^2 2s^2 2p^6 3s^2 3p^2$

72.

(b) $3.16 \times 10^{-34} kgm^2/s$

Explanation: Energy in n^{th} orbit = $-13.6 / n^2$

n^2 = -13.6/-1.51eV = 9

or n = 3

Angular momentum, $L = \frac{nh}{2\pi}$

L = $\frac{(3\times 6.626\times 10^{-34})}{2\times 3.14}$

L = 3.16×10^{-34} kgm^2/sec

73.

(c) 10.20 eV

Explanation: Initial K.E. of each of two hydrogen atom in ground state =13.6 eV.

Total energy of two H-atom in ground state

= 2(13.6) = 27.2 eV

The maximum amount by which their combined kinetic energy is reduced when any one H-atom goes into first excited state after the inelastic collision i.e., the total energy of two H-atom after inelastic collision

E = $\frac{13.6}{n^2} + 13.6$

= $\frac{13.6}{2^2}$ + 13.6 [$\because$ for excited state (n = 2)]

= 3.4 + 13.6 = 17.0 eV

So loss in KE due to inelastic collision

= 27.2 - 17.0 = 10.2 eV

74. **(a)** 1.058 $\overset{\circ}{A}$

Explanation: $r_n = \frac{n^2}{Z} r_1$

For He^+ ion, n = 2, Z = 2

$\therefore r_2 = \frac{4}{2} \times 0.529 \ \mathring{A} = 1.058\mathring{A}$

75.

(c) in general to any of the states with lower energy

Explanation: A set of atoms in an excited state decays in general to any of the states with lower energy.