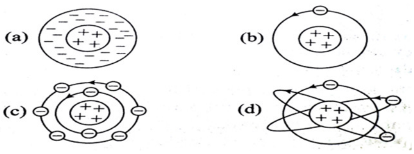
Chapter

12 ATOMS

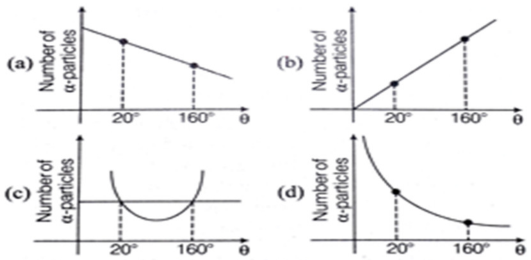
1. Order of ratio of e/m ratio of proton, ∝ - particles and electrons is

(a) $\left(\frac{e}{m}\right)_p > \left(\frac{e}{m}\right)_\propto > \left(\frac{e}{m}\right)_e$
(b) $\left(\frac{e}{m}\right)_e > \left(\frac{e}{m}\right)_P > \left(\frac{e}{m}\right)_\propto$
(c) $\left(\frac{e}{m}\right)_\propto > \left(\frac{e}{m}\right)_e > \left(\frac{e}{m}\right)_P$
(d) All are equal

2. Rutherford's atomic model can be visualized as



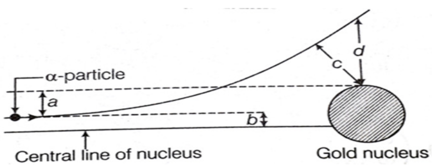
3. Graph of total number of ∝ - particles scattered at different angles is



4. When an ∝ - 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

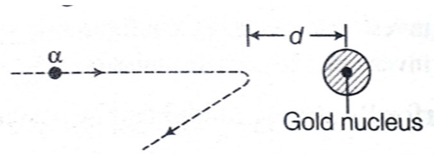
(a) $\frac{1}{\sqrt{m}}$ (b) $\frac{1}{m^2}$ (c) m (d) $\frac{1}{m}$

5. Trajectory of an ∝ - particle is shown in figure below . Then , impact parameter is



(a) a (b) b (c) c (d) d

6. In the diagram shown , dimension d is known as



(a) Impact parameter
(b) Distance of closest approach
(c) Atomic radius
(d) Nuclear radius

7. In Rutherford's model , if F_e indicates electrostatic force between electron and nucleus and F_c indicates the centripetal force on revolving electron , then

(a) $F_e = F_c$ (b) $F_e > F_c$
(c) $F_e < F_c$ (d) None of these

8. In an atom , the ratio of radius of orbit of electron to the radius of nucleus is

(a) 10^3 (b) 10^4 (c) 10^5 (d) 10^6

9. In Rutherford's model , potential energy of the electron in an hydrogen atom of radius r is given by

(a) $K = \frac{e^2}{4\pi\varepsilon_0 r}$ (b) $K = \frac{e^2}{8\,\pi\varepsilon_0\, r^2}$

(c) $K = \frac{-\,e^2}{8\,\pi\varepsilon_0\, r}$ (d) $K = \frac{e^2}{8\,\pi\varepsilon_0\; r}$

10. In Rutherford's model , potential energy of the electron in an hydrogen atom of radius r is given by

(a) $U = \frac{e^2}{4\pi\varepsilon_0 r}$ (b) $= \frac{e^2}{4\;\pi\varepsilon_0\, r^2}$
(c) $U = -\frac{e^2}{4\pi\varepsilon_0 r}$ (d) $= -\frac{e^2}{4\;\pi\varepsilon_0\, r^2}$

11. A line spectrum is observed when

(a) A gas is excited by heating or by passing a discharge through it
(b) A gas is excited by applying pressure
(c) A gas under low pressure condition is excited by heating or by passing a discharge through it
(d) A gas under high pressure condition is excited by heating or by passing a discharge through it

12. A line emission spectrum consists of

(a) Bright lines on a dark background
(b) Dark lines on a bright background
(c) Alternate dark and bright lines
(d) A dark patch followed by a coloured band

13. A line emission spectrum of a material is

(a) Unique like fingerprint
(b) Same for all
(c) May be same for few elements
(d) Depends on excitation produced

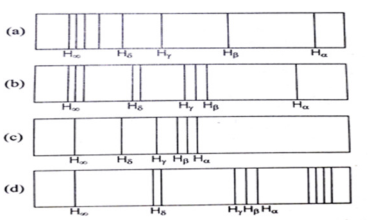
14. When white light is passed through an unexcited gas (in verified state) , then transmitted light consists of

(a) Few bright lines dark background
(b) Few dark lines in bright background
(c) Alternate dark and bright lines
(d) Alternate dark and bright bands

15. In Blamer series , $H_{\propto}$ - line is of

(a) red colour (b) yellow colour
(c) orange colour (d) green colour

16. Which of the following shows a spectrum of hydrogen gas?



17. Blamer formula is valid for

(a) Hydrogen
(b) Singly ionized helium
(c) Doubly ionized lithium
(d) All of these

18. In Bracket series , ratio of maximum to minimum wavelength ($\lambda_{max}/\lambda_{min}$) is

(a) 4/3 (b) 25/9 (c) 16 / 7 (d) 36 /11

19. In a stable orbit , angular momentum of an electron is

(a) A whole number multiple of $h/2\pi$
(b) A prime number multiple of $h/2\pi$
(c) An odd number multiple of $h/2\pi$
(d) An integral multiple of $h/2\pi$

20. As an electron makes a transition from an excited state to the ground state of a hydrogen like atom / ion .

(a) Its kinetic energy increases but potential energy and total energy decreases
(b) Kinetic energy , potential energy and total energy decreases
(c) Kinetic energy decreases , potential energy increases but total energy remains same
(d) Kinetic energy and total energy decreases but potential energy increases

21. The ratio of an electron in ground state in Bhor's first orbit of hydrogen atom to the velocity of light in air is

(a) $\frac{e^2}{2\pi hc}$ (b) $\frac{2e\pi}{hc}$ (c) $\frac{e^3}{2\pi hc}$ (d) $\frac{2\pi e^2}{hc}$

22. If radius of first Bohr orbit is r , then the radius of second Bohr's orbit will be

(a) 2 r (b) 8r (c) 4 r (d) $2\sqrt{2r}$

23. Ratio of wavelengths emitted for transition 2 → 1 in Li^{2+} , He^{2+} and H is

(a) 1:2 :3 (b) 1:4: 9

(c) 4 : 9 : 36 (d) 3:2:1

24. Energy of an electron in an stationary state of the hydrogen atom can be given by

(a) $\frac{13.6}{n^2}J$, n = 1,2,3, ……
(b) $-\frac{13.6}{n^2}J, n =$ 1,2,3 ……
(c) $\frac{13.6}{n^2}eVn=$ 1,2,3 ……
(d) $(-13.6/n^2)eV, n = 1,2,3,$…….

25. If the potential energy of the electron in the hydrogen atom is $\frac{-Ke^2}{r}$, its kinetic energy is

(a) $\frac{-Ke^2}{2r}$ (b) $\frac{-Ke^2}{r}$ (c) $\frac{Ke^2}{2r}$ (d) $\frac{Ke^2}{r}$

26. Which of the following atoms has the lowest ionization potential ?

(a) $^{133}_{55}Cs$ (b) $^{40}_{18}Am$ (c) $^{16}_{8}O$ (d) $^{14}_{7}N$

27. Which of the following is true for kinetic energy (K) and potential energy (U) of electron moving in a orbit around the nucleus is

(a) U = - K (b) U = - 2 K
(c) U = - 3 K (d) U = - $\frac{1}{2}K$

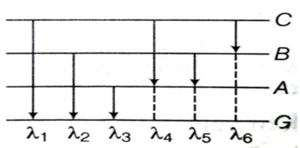
28. Ionization energy of an electron is

(a) Maximum possible energy stored by an electron
(b) Energy required to liberate an electron
(c) Energy required to excite an electron
(d) Minimum energy required to free the electron from the ground state of the hydrogen atom

29. Highest energy level of an electron corresponds to n = ∞ and it has an energy of

(a) zero (b) ∞ (c) 13.6 eV (d) - 13.6eV

30. The figure shows energy levels of an atoms with six transitions of wavelengths λ_1 , λ_2, λ_3, λ_4, λ_5, λ_6 . The following wavelengths also occur in absorption spectrum



(a) λ_1 , λ_2, λ_3 (b) λ_4 , λ_5, λ_6
(c) λ_1 , λ_4, λ_6 (d) λ_1 , λ_2, λ_3, λ_4 , λ_5, λ_6

31. When an atom makes a transition from the higher energy state (n_i) to the lower energy state (n_f) , the difference of energy is carried away by a photon of frequency v_{if} such that

(a) $v_{if} \geq E_i - E_f$ (b) $v_{if} \geq E_i - E_f$

(c) $v_{if} \geq \frac{E_i - E_f}{h}$ (d) $v_{if} = \frac{E_{ni} - E_{nf}}{h}$

32. In the spectrum of hydrogen , the ratio of the longest wavelength in the Lyman series to the longest wavelength in the Blamer series is

(a) $\frac{4}{9}$ (b) $\frac{9}{4}$ (c) $\frac{27}{5}$ (d) $\frac{5}{27}$

33. Electron in hydrogen atom first jumps from third excited state to second excited state and then from second excited to the first excited stat . the ratio of the wavelengths $\lambda_1 : \lambda_2$ emitted in the two cases is

(a) $\frac{7}{5}$ (b) $\frac{27}{20}$ (c) $\frac{27}{5}$ (d) $\frac{20}{7}$

34. The ground state energy of hydrogen atom is -13.6 eV . What are the kinetic and potential energies of the electron in this state ?

(a) KE = 13.6 eV , PE = - 27.2eV
(b) KE = 15.6 eV , PE = - 3.0eV
(c) KE = -27.2 eV , PE = 13.6 eV
(d) None of the above

35. Taking Bohr radius , a_0 = 53 pm , the radius of Li^{2+} ion in its ground state on the basis of Bohr model will be

(a) 53 pm (b) 27 pm (c) 18 pm (d) 13 pm

36. Positronium is just like a H-atom with the proton replaced by the positively charged anti-particle of the electron (called the positron which is as massive as the electron). What would be the ground state energy of positronium ?

(a) 1.3 eV (b) -6.8 eV (c) 2.5 eV (d) 13.6 eV

Hints and Explanations

1. (b)

For an electron,
$e = 1.6 \times 10^{-19}\ C$, $m_e = 9.1 \times 10^{-31} kg$
For a proton,
$e = 1.6 \times 10^{-19}\ C$, $m_p = 1.6 \times 10^{-27} kg$
For an ∝ - particle ,
$e = 2 \times 1.6 \times 10^{-19}\ C$,
$m_\propto \approx 4 \times 1.6 \times 10^{-27} kg$
Clearly , $\left(\frac{e}{m}\right)_e > \left(\frac{e}{m}\right)_p > \left(\frac{e}{m}\right)_\propto$

2. (d)
Rutherford's atom had a positively charged centre and electrons were revolving outside it. It is also called the planetary model of the atom.

3. (d)

4. (d)

5. (b)
The impact parameter is the perpendicular distance of the initial velocity vector of the $\propto$ - particle from the centre line of the nucleus of atom, when the $\propto$ - particle is far away from nucleus at line.

6. (b)

7. (a)
The electrostatic force of attraction, F_e between the evolving electrons and the nucleus provides the requisite centripetal force (F_c) to keep them in their orbits. Thus, for a dynamically stable orbit in a hydrogen atom $F_e = F_c$.

8. (c)

9. (d)
The kinetic energy (K) of the electron in hydrogen atom is
$K = \frac{1}{2}mv^2 = \frac{e^2}{8\pi\varepsilon_0 r}$

10. (c)
U = Potential energy = $\frac{e^2}{4\pi\varepsilon_0 r}$

11. (c)
Each element has a characteristic spectrum of radiation, which it emits. When an atomic gas or vapour is excited at low pressure, usually by passing an electric current through it, the emitted radiation has a spectrum which contains certain specific wavelengths only. A spectrum of this kind is termed as emission line spectrum.

12. (a)
Line emission spectrum consists of bright lines on a dark background. The study of emission line spectra of a material can therefore serve as a type of fingerprint for identification of the gas.

13. (a)

14. (b)
When white light passes through a gas and we analyse the transmitted light using a spectrometer, we find some dark lines in the spectrum . These dark lines correspond precisely to those wavelengths which were found in the emission line spectrum of the gas This is called the absorption spectrum of the material of the material of the gas.

15. (a)
In Balmer series, $H_\propto$ - line is obtained using formula
$\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{n^2}\right)$
R = $1.097 \times 10^7 m^{-1}$, n = 3 for $H_\propto$
λ = 656.3nm which corresponds to red colour.

16. (a)
A regular pattern of increasing spacing is observed in option (a) whereas others are irregular.

17. (d)
Balmer formula is applicable for all single electron atom or ions. However, it is difficult to apply it in multi electrons system

18. (b)
In Bracket series, $\frac{1}{\lambda} = R\left(\frac{1}{4^2} - \frac{1}{n^2}\right)$
Maximum wavelength, λ_{max} transition n=5
$\frac{1}{\lambda_{max}} = R\left(\frac{1}{4^2} - \frac{1}{5^2}\right) = R\left(\frac{25-16}{16\times25}\right) = \frac{R\times9}{16\times25}$ --- (i)
Minimum wavelength, λ_{min} transition n= ∞
$\frac{1}{\lambda_{max}} = R\left(\frac{1}{4^2} - \frac{1}{\infty^2}\right) = R\left(\frac{1}{16}\right)$ -------- (ii)
$(i) and\ (ii)$
$\frac{\lambda_{min}}{\lambda_{max}} = \frac{25}{9}$

19. (d)

20. (a)
Kinetic energy of an electron is
$KE \propto \left(\frac{Z}{n}\right)^2$
When the electron makes transition from an excited state to the ground state, then n decreases and KE increases. We know that PE is lowest for ground state. As TE = - KE, TE also decreases

21. (d)
In hydrogen atom, speed of an electron
$v_n = \frac{2\pi Ze^2}{nh}$

$v = \frac{2\pi e^2}{h} \quad \Rightarrow \frac{v}{c} = \frac{2\pi e^2}{hc}$

22. (c)
According to Bohr atomic radius, r_n i.e., $r_n \propto n^2$
$\therefore \quad \frac{r_n}{r} = \frac{n^2}{I^2}$ or $r_n = n^2 r$
n = 2 gives r_2 = 4r

23. (c)
According to Rydberg's formula ,
$\frac{1}{\lambda} = RZ^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) \quad \Rightarrow \lambda \propto \frac{1}{Z^2}$
$\frac{1}{3^2} : \frac{1}{2^2} : \frac{1}{1^2} = \frac{1}{9} : \frac{1}{4} : \frac{1}{1}$ = 4 :9 :36
$\lambda_{Li^{2+}} : \lambda_{He^{2+}} : \lambda_H$ = 4 : 9 : 36

24. (d)

25. (c)
The kinetic energy is equal to half of magnitude of potential energy.
$KE = \frac{1}{2}\left|\frac{Ke^2}{r}\right| = \frac{Ke^2}{2r}$

26. (a)
$E_N \propto \frac{Z^2}{n^2}$

27. (b)

28. (d)

29. (a)
n = ∞ energy of an electron at $n\,th$ level i.e.,
$E_n = -\frac{13.6}{n^2} \quad \Rightarrow E_\infty = 0$

30. (a)
Absorption lines are obtained when an e^- absorbs a photon in ground state and is excited to a higher state . Initially e^- is in ground state.

31. (d)

32. (d)
In hydrogen atom , wavelength of characteristic spectrum .
$\frac{1}{\lambda} = RZ^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$
For Lyman series n_1 = 1, n_2= 2
$\frac{1}{\lambda_1} = RZ^2\left(\frac{1}{(1)^2} - \frac{1}{(2)^2}\right)$ --------- (i)
Balmer series n_1 = 2 , n_2 = 3

$\frac{1}{\lambda_2} = RZ^2\left(\frac{1}{(2)^2} - \frac{1}{(3)^2}\right)$ --------- (ii)
$(ii) by \ (i)$
$\frac{\lambda_1}{\lambda_2} = \frac{RZ^2\left(\frac{1}{4} - \frac{1}{9}\right)}{RZ^2\left(1 - \frac{1}{4}\right)} = \frac{\frac{5}{36}}{\frac{3}{4}}$

$\frac{\lambda_1}{\lambda_2} = \frac{5}{36} \times \frac{4}{3} = \frac{5}{27}$

33. (d)
Wavelength λ_1 , n_1 = 4 and n_2 = 3 and for λ_2 , n_1 = 3 and n_2 = 2
$\frac{1}{\lambda} = -R\left(\frac{1}{n_2^2} - \frac{1}{n_1^2}\right)$
λ_1
$\Rightarrow \frac{1}{\lambda_1} = -R\left(\frac{1}{(4)^2} - \frac{1}{(3)^2}\right)$
$\frac{1}{\lambda_1} = R\left(\frac{7}{144}\right)$ ------- (i)
λ_2

$\Rightarrow \frac{1}{\lambda_2} = -R\left(\frac{1}{(3)^2} - \frac{1}{(2)^2}\right)$
$\frac{1}{\lambda_2} = R\left[\frac{5}{36}\right]$ ----------- (ii)
$(i) and \ (ii)$
$\frac{\lambda_1}{\lambda_2} = \frac{20}{7}$

34. (a,b)
The Bohr model for the spectra of a H- atom will not be applicable to hydrogen in the molecular form . And also, it will not be applicable for multielectron atom .

35. (c)
For a hydrogen like atom
$r_n = 0.53\frac{n^2}{Z}$ Å = $53\frac{n^2}{Z} pm$
Li^{2+} , n = 1 (ground state)
$Z = 3$
$\therefore \quad r_n = \frac{53}{3} \approx 18pm$

36. (b)
The total energy of the electron in the stationary states of the hydrogen atom is given by
$E_n = -\frac{me^4}{8n^2\varepsilon_0^2 h^2} \approx \frac{13.6Z^2}{n} \frac{\mu}{m_e}$
μ = reduced mass = $\frac{m_e}{2}$
$E_1 = -\frac{13.6}{2} = -6.8\ eV$