N.B.Navale

Date : 01.04.2025
Time : 00:18:00
Marks : 20

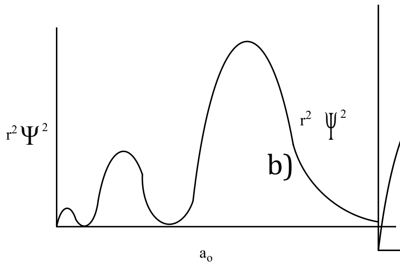
TEST ID: 68
CHEMISTRY

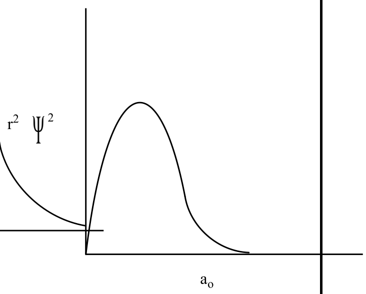
STRUCTURE OF ATOM

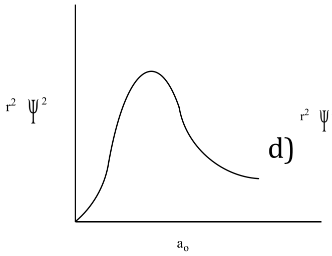
Single Correct Answer Type

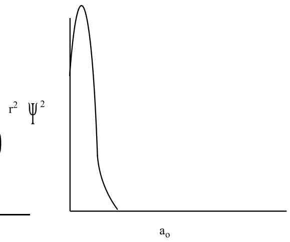
1. What is the maximum number of emission lines when the excited electron of a H-atom in $n=6$ drops to the ground state?
   a) 2 b) 10
   c) 15 d) 20
2. The kinetic energy of an electron in the second Bohr orbit of a hydrogen atom is [a_0 is Bohr radius]
   a) $\frac{h^2}{4\pi^2 ma_0^2}$ b) $\frac{h^2}{16\pi^2 ma_0^2}$
   c) $\frac{h^2}{32\pi^2 ma_0^2}$ d) $\frac{h^2}{64\pi^2 ma_0^2}$
3. The first line in the Balmer series in the H-atom will have the frequency
   a) $3.29 \times 10^{15}\ s^{-1}$ b) $4.57 \times 10^{14}\ s^{-1}$
   c) $8.22 \times 10^{15}\ s^{-1}$ d) $8.02 \times 10^{14}\ s^{-1}$
4. Which of the following electron transition in hydrogen atom will require largest amount of energy?
   a) From $n=1$ to $n=2$ b) From $n=2$ to $n=3$
   c) From $n=\infty$ to $n=1$ d) From $n=3$ to $n=5$
5. For emission line of atomic hydrogen from $n_i=8$ to $n_t=n$, the plot of wave number (v) against $(1/n^2)$ will be (The Rydberg constant, R_H is in wave number unit)
   a) non-linear b) linear with slope $-R_H$
   c) linear with slope R_H d) linear with intercept $-R_H$
6. According to de-Broglie, matter should exhibit dual behavior, that is both particle and wave like properties. However, a cricket ball of mass 100 g does not move like a wave when it is thrown by a bowler at a speed of 100 km/h. Calculate the wavelength of the ball.
   a) 2.385×10^{-36} m b) 23.85×10^{-36} m
   c) 238.5×10^{-36} m d) 2385×10^{-36} m
7. With the saturation of 3d orbitals, the filling of the 4p-orbitals starts at A and is completed at B. Here, A and B refer to
   a) $A \rightarrow Ga; B \rightarrow Kr$ b) $A \rightarrow Ga; B \rightarrow X_e$
   c) $A \rightarrow Zn; B \rightarrow Br$ d) $A \rightarrow Zn; B \rightarrow Kr$
8. The effect of Heisenberg uncertainty principle is significant
   a) only for motion of microscopic objects b) negligible for that of macroscopic objects
   c) Both (a) and (b) d) None of the above
9. Find the electronic configuration of the O^{2-} ion
   a) $1s^2, 2s^2, 2p^4$ b) $1s^2, 2s^2, 2p^6$
   c) $1s^2, 2s^2, 2p^5$ d) $1s^2, 2s^2$
10. Which of the given statements correctly represents the effect of rise in temperature on the emitted radiations of a hot body?
    a) The radiations move towards shorter wavelengths b) The radiations move towards shorter frequency
    c) The radiations move towards lower energy d) The frequency of radiations does not change
11. Which of the following series of transitions in the spectrum of hydrogen atom fall in visible region?
    a) Balmer series b) Paschen series
    c) Brackett series d) Lyman series
12. Rutherford's nuclear model of an atom is like a small scale solar system. Further coulombic force between electron and the nucleus is mathematically similar to the
    a) gravity $\left(\frac{Gr^2}{m_1 m_2}\right)$ b) gravity $\left(\frac{Gm_1 \cdot m_2}{r}\right)$
    c) gravitational force $\left(\frac{Gm_1 \cdot m_2}{r^2}\right)$ d) gravitational force $\left(\frac{r^2}{G \cdot m_1 \cdot m_2}\right)$
13. An electron can move only in those orbits for which its angular momentum is integral multiple of
    a) $\frac{h}{4\pi}$ b) $\frac{h}{2\pi}$
    c) $\frac{h}{\sqrt{2\pi}}$ d) $h \cdot 2\pi$
14. According to Bohr's theory, the angular momentum for an electron of 3 rd orbit is
    a) $3\hbar$ b) $1.5\ \hbar$
    c) $9\ \hbar$ d) $2\frac{h}{\pi}$

15. Which of the following radial distribution graphs correspond to $n = 3, l = 2$ for an atom?

a) 

b) 

c) 

d) 

16. Consider the following statements :
1. Electron density in xy plane in $3d_{x^2-y^2}$ orbital is zero.
2. Electron density in xy plane in $3d_{z^2}$ orbital is zero.
3. 2s orbital has only one spherical node.
4. For $2p_z$ orbital yz is the nodal plane.
The correct statements are

a) 2 and 3 b) 1, 2, 3, 4
c) Only 2 d) 1 and 3

17. The stability of an electron in multielectron atom is due to

a) total attractive interactions > repulsive interactions
b) total attractive interactions = repulsive interactions
c) total attractive interactions < repulsive interactions
d) total of attractive and repulsive interactions only

18. Arrange the following type of radiations in increasing order of frequency.
(i) Radiation from microwave oven
(ii) Amber light from traffic signal
(iii) Radiation from FM radio
(iv) Cosmic rays from outer space and
(v) X-rays
The correct order is

a) (i) < (iii) < (ii) < (iv) < (v)
b) (iii) < (i) < (v) < (ii) < (iv)
c) (iii) < (i) < (ii) < (v) < (iv)
d) (iii) < (v) < (i) < (ii) < (iv)

19. Emission transitions in the Paschen series end at orbit $n = 3$ and start from orbit n and can be represented as $v = 3.29 \times 10^{15}(\text{ Hz})\left[\frac{1}{3^2} - \frac{1}{n^2}\right]$. Calculate the value of n if the transition is observed at 1285 nm. Find the region of the spectrum.

a) 4, Infra-red b) 5 , Infra-red
c) 6, Visible d) 3 , Infra-red

20. Increasing order (lowest first) for the values of e/m_e for electron (e), proton (p), neutron (n) and α-particles is

a) e, p, n, α b) n, α, p, e
c) n, p, e, α d) n, p, α, e

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: ANSWER KEY :

1)	**c**	**2)**	**c**	**3)**	**b**	**4)**	**a**
5)	**c**	**6)**	**c**	**7)**	**a**	**8)**	**c**
9)	**b**	**10)**	**a**	**11)**	**a**	**12)**	**c**
13)	**b**	**14)**	**a**	**15)**	**b**	**16)**	**a**
17)	**a**	**18)**	**c**	**19)**	**b**	**20)**	**b**

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STRUCTURE OF ATOM

: HINTS AND SOLUTIONS :

Single Correct Answer Type

1 **(c)**
Number of lines produced when electron from nth shell drops to ground state $= \frac{n(n-1)}{2}$
When $n = 6$, number of lines produced
$= \frac{6(6-1)}{2} = \frac{6 \times 5}{2} = 15$

2 **(c)**
According to Bohr's model, $mvr = nh/2\pi$
$\Rightarrow (mv)^2 = n^2h^2/4\pi^2r^2$
$\Rightarrow \quad KE = \frac{1}{2}mv^2 = \frac{n^2h^2}{8\pi^2r^2m}$
……..(i)
Also, Bohr's radius for H-atom is,
$r = n^2a_0$
On substituting ' r ' in Eq. (i), we get
$KE = \frac{h^2}{8\pi^2n^2a_0^2m}$
when, $n = 2, KE = \frac{h^2}{32\pi^2a_0^2m}$

3 **(b)**
Frequency of first line in Balmer series can be calculated as
$v = 3.29 \times 10^{15}\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]s^{-1}$
$= 3.29 \times 10^{15}\left[\frac{1}{(2)^2} - \frac{1}{(3)^2}\right] = 3.29 \times 10^{15}\left[\frac{1}{4} - \frac{1}{9}\right]$
$= 3.29 \times 10^{15} \times \frac{5}{36} = 4.57 \times 10^{14}\ s^{-1}$.

4 **(a)**
$E \propto \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$ or $E \propto \frac{1}{n^2}$

5 **(c)**
According to Rydberg's formula,
wave number $(\bar{v}) = R_HZ^2\left[\frac{1}{n_i^2} - \frac{1}{n_f^2}\right]$
Given, $n_i = n, n_f = 8$ [$\because$ it is the case of emission]
$\bar{v} = R_H \times (1)^2\left[\frac{1}{n^2} - \frac{1}{8^2}\right] \Rightarrow \bar{v} = R_H\left[\frac{1}{n^2} - \frac{1}{64}\right]$
$= \frac{R_H}{n^2} - \frac{R_H}{64}$
On comparing with equation of straight line,
$y = mx + C$, we get
Slope $= R_H$, intercept $= -R_H/64$
Thus, plot of wave number $(\bar{v})$ against $1/n^2$ will be linear with slope $(+R_H)$.

6 **(c)**
Given, $m = 100g = 0.1kg$
$v = 100\ km/h = \frac{100\times1000}{60\times60} = \frac{1000}{36}\ ms^{-1}$
From de-Broglie equation, wavelength,
$\lambda = \frac{h}{mv}$
$\lambda = \frac{6.626\times10^{-34}\ kg\ m^2\ s^{-1}}{0.1\ kg\times\frac{1000}{36}\ ms^{-1}} = 238.5 \times 10^{-36}\ m$
(As the wavelength is very small so wave nature cannot be detected)

7 **(a)**
With the saturation of 3 d orbitals, the filling up of the 4p orbitals starts at Ga and is completed at kr.

8 **(c)**
The effect of Heisenberg uncertainty principle is significant only for motion of microscopic objects and negligible for the motion of macroscopic objects.

9 **(b)**
(i) (c) ${}_8O = 1s^2, 2s^2, 2p^4; O^{2-} = 1s^2, 2s^2, 2p^6$

10 **(a)**
The intensities of radiations emitted by hot body depends on temperature. As the temperature is raised, the emitted radiations move towards shorter wavelengths. It shows that, as the temperature is raised, the maxima of the curve shifts shorter wavelengths.

11 **(a)**
Balmer series of transitions in the spectrum of hydrogen atom fall in visible region. Lyman series fall in ultraviolet while Paschen, Brackett and Pfund fall in infrared region.

12 **(c)**
Rutherford model of an atom is like small scale solar system with the nucleus acts as massive sun and the electrons similar to the lighter planets.
It is mathematically similar to the gravitational force
$\left(\frac{G.m_1m_2}{r^2}\right)$.

where, m_1 and m_2 are the masses, r is the distance of separation of the masses and G is the gravitational constant.

13 **(b)**

An electron can move only in those orbits for which its angular momentum is integral multiple of $h/2\pi$.

This means angular momentum is quantized.

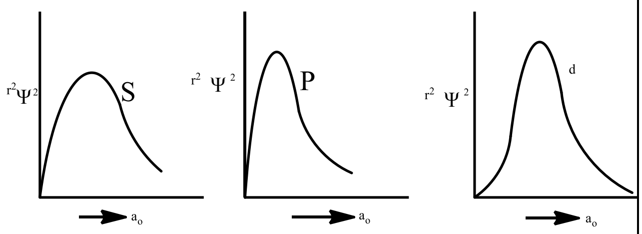
14 **(a)**

Angular momentum, $mvr = \frac{nh}{2\pi} = \frac{3\times h}{2\pi} = \frac{1.5h}{\pi}$

$= 3\hbar \qquad \left[\because \hbar = \frac{h}{2\pi}\right]$

15 **(b)**

The electron density is directly proportional to ψ^2. The larger the electron density, the larger the value of ψ^2 and more is the probability of finding the electrons.



16 **(a)**

The four lobes of $d_{x^2-y^2}$ orbital are lying along x and y axes, while the two lobes of d_{z^2} orbital are lying along z-axis, and contain a ring of negative charge surrounding the nucleus in xy plane.

2s-orbital has only one spherical node, where electron density is zero.

p-orbital have directional character.

orbital $\longrightarrow$	p_z	p_x	p_y
m $\longrightarrow$	0	± 1	± 1
Nodal plane $\longrightarrow$	xy	yz	zx

17 **(a)**

The stability of an electron in multielectron system is because total attractive interactions are more than the total repulsive interactions.

18 **(c)**

The order of frequency is :

Radiation from FM radio

<microwaves <amber colour <X- rays < cosmic rays.

19 **(b)**

Given, frequency $v = \frac{c}{\lambda} = 3.29 \times 10^{15}\ \text{Hz}\left(\frac{1}{3^2} - \frac{1}{n^2}\right)$

$$v = \frac{3.0 \times 10^8\ \text{ms}^{-1}}{1285 \times 10^{-9}\ \text{m}} = 3.29 \times 10^{15}\ \text{Hz}\left(\frac{1}{9} - \frac{1}{n^2}\right)$$

$$\frac{3.0 \times 10^8\ \text{ms}^{-1}}{1285 \times 10^{-9}\ \text{m} \times 3.29 \times 10^{15}\ \text{Hz}} = \left(\frac{1}{9} - \frac{1}{n^2}\right)$$

$$0.0709 = 0.1111 - \frac{1}{n^2}$$

$$\frac{1}{n^2} = 0.1111 - 0.0709 = 0.0402 \approx 0.04 = \frac{1}{25}$$

$n^2 = 25$ or $n = 5$

$\therefore$ The electron jumps from $n = 5$ to $n = 3$, i.e. the transition occurs in Paschen series and lies in infrared region.

Note The radiation 1285 nm lies in the infrared region.

20 **(b)**

Electrons (e) and protons (p) have the same charge (1.602×10^{-19} C) but protons are 1840 times heavier than electrons.

e/m_e of any particle decreases, if the mass is increased. So, the e/m_e of electron is higher than the proton.

Alpha particle ($\propto$) is a helium nucleus which consists of two protons and two electrons. It has $+2$ charge and the mass of 4 protons. So, the $\propto$ -particle has the least e/m because of its large mass.

Neutron (n) has to charge thus its e/m_e values is zero.

Thus, the increasing order of e/m_e value is

$n < \propto < p < e$