Solution

STRUCTURE OF ATOM (DUPLICATE)

Class 11 - Chemistry

1. Electron has particle nature.
2. The photoelectric effect is a phenomenon where electrons are emitted from the metal surface when the light of sufficient frequency is incident upon. The concept of photoelectric effect was first documented in 1887 by **Heinrich Hertz** and later by **Lenard** in 1902.Einstein in 1905 was able to explain the photoelectric effect using Planck's quantum theory of electromagnetic radiation.
3. It is only applicable for subatomic particles because the energy provided by the photon is sufficient only for subatomic particles not for macroscopic objects.
4. We know that, Nuclear radius, r =R_0 $A^{1/3}$; where, R_0 =1.4×10^{-15} m.

   $\therefore$ r = $(1.4\times10^{-15}$ m$)\times(125)^{1/3}$ = $1.4 \times 5\times 10^{-15}$ m = 7.0×10^{-15} m
5. The intensity of the spectral line decreases with decreases in wavelength.
6. According to Heisenberg, the simultaneous position and momentum of a microscopic particle like an electron cannot be determined with certainty. Therefore, Heisenberg replace the concept of definite orbits by the concept of probability.
7. Two discoveries that put a strong challenge to the Bohr model are:
   i. Heisenberg's uncertainty principle.
   ii. de-Broglie's concept of dual nature of matter.
8. Planck's constant, symbolized h, relates the energy in one quantum (photon) of electromagnetic radiation to the frequency of that radiation. In the International System of units (SI), the constant is equal to approximately 6.626176 x 10^{-34} joule-seconds.
9. when that electron comes close to the nucleus ,the stability increases due to the loss of energy of electron and thus the energy of electron becomes less negative. That's why the electrons energy is taken as negative.The spacing between the energy levels decreases as we move outwards from the nucleus.
10. In the construction of electron microscope used for the measurement of objects of very small size.
11. If the uncertainty principle is applied to an object of mass, say about a mg (10^{-6} kg),
    Then $\Delta v\Delta x = \frac{h}{4\pi m} = \Delta v\cdot\Delta x = \frac{h}{4\times3.14\times m}$
    $\Delta v\Delta x = \frac{h}{4\times3.14\times10^{-6}} = \frac{6.626\times10^{-34}kgm^2s^{-1}}{4\times3.14\times10^{-6}} = 0.52\times10^{-28}\mathrm{m}^2\mathrm{s}^{-1}$.
    The value of $\Delta v\Delta x$ obtained is extremely small and is insignificant. Therefore, for milligram sized or heavier objects, he associated uncertainties are hardly of any real consequences.
12. v = $(3.29\times10^{15}$ Hz$)\left(\frac{1}{3^2}-\frac{1}{n^2}\right)$

    λ = 1285 nm = 1285×10^{-9} m = 1.285×10^{-6} m

    v = $\frac{c}{\lambda} = \frac{(3\times10^8\mathrm{ms}^{-1})}{(1.285\times10^{-6}\mathrm{m})}$ = $2.3346\times10^{14}\mathrm{s}^{-1}$

    $2.3346\times10^{14} = 3.29\times10^{15}\left[\frac{1}{3^2}-\frac{1}{\mathrm{n}^2}\right]$

    $\frac{2.3346}{32.9} = \frac{1}{3^2}-\frac{1}{\mathrm{n}^2}$ or $0.71 = \frac{1}{9}-\frac{1}{n^2}$

    $\frac{1}{n^2} = \frac{1}{9}$ - 0.071 = 0.111 - 0.071 = 0.04

    $n^2 = \frac{1}{0.04}$ = 25 or n = 5

    Paschen series lies in infrared region of the spectrum.
13. 1. 1s, 2s and 3s orbitals in Mg atom are not degenerate because these have different values of n i.e 1, 2 and 3 respectively.
    2. $2p_x$, $2p_y$ and $2p_z$ orbitals in C atom are degenerate because these belong to the same subshell and n=2 for each orbital.
    3. 3s, $3p_x$ and 3d orbitals in H atom are degenerate.The 3 in each of these orbitals is its "principal" quantum number. It seems that these three different designations, s, p, and d, as describing the different shapes of their orbitals while they all have the same energy when there is only one electron at the "3" level, such as in the hydrogen atom where there is only one electron.
14. Suppose the transition takes place between levels n_1 and n_2.

    Then, $n_1 + n_2 = 4$ and $n_1 - n_2 = 2$

    By solving there equations , we get $n_1 = 1$ $n_2 = 3$

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

For Li^{2+}, Z = 3

$\therefore \frac{1}{\lambda}$ = 109677 cm^{-1} $\left(\frac{1}{1^2} - \frac{1}{3^2}\right) \times 3^2$

= 109677 $\times$ $\left(\frac{1}{1} - \frac{1}{9}\right)$ $\times$ 9 cm^{-1}

= 109677 $\times$ 8 cm^{-1}

or $\lambda = \frac{1}{109677 \times 8\ \mathrm{cm}^{-1}}$

= 1.14 $\times$ 10^{-6} cm

15. i. For an electron, the energies in two orbits may be compared as:

$\frac{E_1}{E_2} = \left(\frac{n_2}{n_1}\right)^2$

According to available data: n_1 = 1,E_1 = - 2.17 $\times$ 10^{-18} J $atom^{-1}$, n_2 = 5

ii. $\therefore \frac{(-2.17 \times 10^{-18}\,\mathrm{J\ atom}^{-1})}{\mathrm{E}_2} = \left(\frac{5}{1}\right)^2$ = 255

E_5 = $\frac{(-2.17 \times 10^{-18}\,\mathrm{J\ atom}^{-1})}{25}$ = -8.77 $\times$ 10^{-20} J

iii. For hydrogen atom rn = 0.529 $\times$ n^2 $\mathring{A}$

r_5 = 0.529 $\times$ (5)2 = 13.225 $\mathring{A}$ = 1.3225 nm

16. i. P (Z = 15) : $[\mathrm{Ne}]^{10} 3\mathrm{s}^2 3\mathrm{p}^3$ No. of unpaired electrons = 3

ii. Si (Z = 14) : $[\mathrm{Ne}]^{10} 3\mathrm{s}^2 3\mathrm{p}^2$ No. of unpaired electrons = 2

iii. Cr (Z = 24) : $[Ar]^{18} 4s^1 3p^5$ No. of unpaired electrons = 6

iv. Fe (Z = 26) : $[Ar]^{18} 4s^2 3d^6$ No. of unpaired electrons = 4

v. Kr (Z = 36) : $[Ar]^{10} 4s^2 3d^{10} 4p^6$ No. of unpaired electrons = Nil.

17. i. E = hν

= (6.626 $\times$ 10^{-34} Js) $\times$ (3 $\times$ 10^{15} s^{-1})

= 1.988 $\times$ 10^{-18} J

ii. $E = hv = \frac{hc}{\lambda}$

= $\frac{(6.626 \times 10^{-34}\,\mathrm{Jg}) \times (3 \times 10^8\,\mathrm{ms}^{-1})}{(0.50 \times 10^{-10}\,\mathrm{m})}$

= 3.98 $\times$ 10^{-15} j

18. i. As we know in 1 molecule of methane, 1 carbon atom and 4 atoms of hydrogen is present.

In carbon, there are six electrons and hydrogen consist of one electron each.

So a total number of electrons in methane = 6 + 4 = 10 electrons

By Avogadro's Law, we know that

1 mole of methane contains 6.023$\times$$10^{23}$ atoms. So the total number of electrons of in 1-mole methane = 10$\times$ 6.023 $\times$ 1023 = 6.0^{23} $\times$ 10^{24} electrons

So the total number of electrons in 1 mole of methane is 6.023 $\times$ 10^{24} electrons

ii. Mass of one neutron = 1.675 $\times$ 10^{-27} kg

1 mole of Carbon atom = 6.023 $\times$ 10^{23} atoms

Number of neutrons in 1 carbon atom = 14 - 6= 8

So the total number of neutrons in 14g of Carbon = 6.023 $\times$ 10^{23} $\times$ 8 neutrons

So 7mg of Carbon will contain = $\frac{6.023 \times 10^{23} \times 8 \times 7 \times 10^{-3}}{14}$

= [3.37288$\times$$10^{22}$] / 14

= 2.4092 $\times$ 10^{21} neutrons

So, Mass of 2.4092 $\times$ 10^{21} neutrons = [2.4092 $\times$ 10^{21}] $\times$ [1.675 $\times$ 10^{-24}]

= 4.035 $\times$ 10^{-3} g

So, in 7 mg of carbon total number of neutrons is 2.41 $\times$ 10^{21} and the total mass of the neutrons is 4.035 $\times$ 10^{-3} g

iii. Molecular Mass of Ammonia = 17g

By Avogadro's Law,

1 mole of Ammonia = 17g of Ammonia = 6.023×10^{23} atoms

Total Number of Protons in Ammonia = 7 + 3= 10

So the total number of protons in Ammonia = 6.023×10^{24} protons

17g of Ammonia contains 6.023×10^{24} protons

So, 34 mg of Ammonia will contain X number of protons

$x = \frac{6.023 \times 10^{24} \times 34 \times 10^{-3}}{17}$

X = $[6.023 \times 10^{24}] \times [2 \times 10^{-3}]$

X = 1.2046×10^{22} protons

Mass of one proton = 1.6726×10^{-24}g

So, Mass of 1.2046×10^{22} protons = $[1.6726 \times 10^{-24}] \times [1.2046 \times 10^{22}]$

= 20.148×10^{-3} g

So, in 34 mg of ammonia total number of protons is 1.205×10^{22} and the total mass of the protons is 20.148×10^{-3} g.

No, the answer will not vary with the change in temperature and pressure because the number of subatomic particles like protons, neutrons, and electrons is fixed for each and every element and it does not vary with temperature and pressure.