Solution

ATOMIC STRUCTURE

Class 11 - Chemistry

1.
   (c) very low pressure and very high voltage
   Explanation:
   very low pressure and very high voltage

2.
   (d) Zinc sulphide
   Explanation:
   Zinc sulphide

3. **(a)** Canal rays
   Explanation:
   Canal rays

4. **(a)** 1.759×10^8 C/g
   Explanation:
   Charge of an electron (e)
   $= 1.6 \times 10^{-19}$ C
   Mass of an electron (m) = 9.1×10^{-31} kg
   So, $\frac{e}{m} = \frac{1.6 \times 10^{-19}}{9.1 \times 10^{-31} \times 10^3} Cg^{-1} = 1.759 \times 10^8 C/g$

5.
   (c) 9
   Explanation:
   9

6. **(a)** Heisenberg
   Explanation:
   Heisenberg

7.
   (d) 2
   Explanation:
   2

8.
   (c) dark lines
   Explanation:
   dark lines

9.
   (b) de Broglie
   Explanation:
   de Broglie

10. **(a)** Hund's rule of maximum multiplicity
   Explanation:
   Hund's rule of maximum multiplicity

11. Let the number of electrons in an ion = x

$\therefore$ Number of neutrons $= x + \frac{30.4}{100}x = 1.304x$

($\because$ Number of neutrons are 30.4% more than the number of electrons).

In the netural atom, number of electrons = x + 3 ($\because$ The ion carries + 3 charge)

So, number of protons = x + 3

We know that, mass number = n + p

= 1.304x + x + 3 = 56

or $2.304x = 53, x = \frac{53}{2.304} = 23.003 \approx 23$

$\therefore$ Number of protons = 23 + 3 = 26 = Atomic number

Therefore, the symbol of the ion is $^{56}_{26}Fe^{3+}$.

12. Energy change, $\Delta E = E_f - E_i$

$\Delta E = 2.18 \times 10^{18}\ J \left(\frac{1}{n_i^2} - \frac{1}{n_f^2}\right)$

When $n_i = 5$ and $n_f = \infty$,

$\Delta E = 2.18 \times 10^{-18}\ J \left(\frac{1}{5^2} - \frac{1}{\infty}\right) = 0.0872 \times 10^{-18}\ J$

When $n_i = 1$ and $n_f = \infty$,

$\Delta E' = 2.18 \times 10^{-18}\ J \left(\frac{1}{1^2} - \frac{1}{\infty}\right)$

$\Delta E' = 2.18 \times 10^{-18}\ J$

$\frac{\Delta E'}{\Delta E} = \frac{2.18 \times 10^{-18}}{0.0872 \times 10^{-18}} = 25$

Hence, energy required to remove an electron from first orbit is 25 times greater than that required to remove an electron from fifth orbit.

13.

Quantum number	Subshell notation	n + 1
(i) $n = 4, l = 2, m_l = -2, m_s = -\frac{1}{2}$	4d	4 + 2 = 6
(ii) $n = 3, l = 2, m_l = 1, m_s = +\frac{1}{2}$	3d	3 + 2 = 5
(iii) $n = 4, l = 1, m_l = 0, m_s = +\frac{1}{2}$	4p	4 + 1 = 5
(iv) $n = 3, l = 2, m_l = -2, m_s = -\frac{1}{2}$	3d	3 + 2 = 5
(v) $n = 3, l = 1, m_l = -1, m_s = +\frac{1}{2}$	3p	3 + 1 = 4
(vi) $n = 4, l = 1, m_l = 0, m_s = +\frac{1}{2}$	4p	4 + 1 = 5

$\because$ (v) < (ii) = (iv) < (iii) = (vi) < (i)

$\therefore$ 3p < 3d = 3d < 4p = 4p < 4d

(Arrangement of orbitals in order of their increasing energies).

14. In general, number of waves in any orbit is

Number of waves $= \frac{\text{circumference of orbit}}{\text{wavelength}} = \frac{2\pi r}{\lambda}$

But, $\lambda = \frac{h}{mv}$

Number of waves $= \frac{2\pi r}{h/mv} = \frac{2\pi r \cdot mv}{h} = \frac{2\pi(mvr)}{h}$

The angular momentum of Bohr's 3rd orbit is

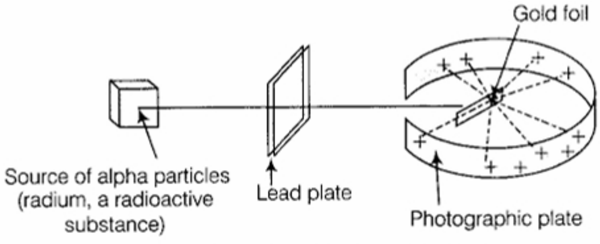
$mvr = \frac{3h}{2\pi}$

$\therefore$ Number of waves $= \frac{2\pi}{h} \times \frac{3h}{2\pi} = 3$

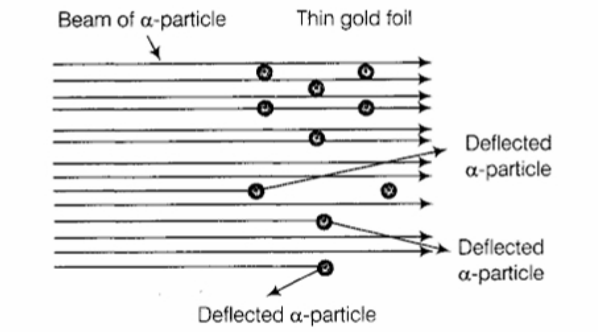
Number of waves in Bohr's 3rd orbit = 3.

15.
- It was unable to explain the spectra of atom containing more than one atom.
- It was unable to explain the fine spectrum of atoms.
- It was unable to explain the effect of electric and magnetic fields on the spectra of atom.
- He explained electrons are discrete particles moving in a well-defined orbit. This theory was later rejected by scientists. It is now believed that electrons have dual nature and the orbits are not well defined.
- Bohr's model is not in accordance with Heisenberg's uncertainty principle.
- It could not explain the mode of formation and geometry of molecules which are formed by union of two or more atoms.

16. Rutherford and his students [Hans Geiger and Ernest Marsden] performed some scattering experiments in which they bombarded thin foils (nearly 100 nm thick) of heavy metals like gold, silver, platinum or copper with a beam of fast moving α-particles.



Rutherford's scattering experiment



Schematic molecular view of the gold foil

Rutherford's Nuclear Model of Atom

On the basis of above observations and conclusions, Rutherford proposed the nuclear model of atom.
According to this model,

i. The positive charge and most of the mass of the atom was densely concentrated in extremely small region, called the nucleus by Rutherford.
ii. The nucleus is surrounded by electrons that move around the nucleus with a very high speed in circular paths, called orbits.
iii. Electrons and the nucleus are held together by electrostatic forces of attraction.

Drawbacks or Demerits of Rutherford's Model

According to Rutherford model, electrons move around the nucleus in well defined orbits.
However, a body when moving in an orbit, undergoes acceleration (if its speed is constant, it must be accelerated by change in direction). So an electron in the nuclear model is under acceleration.
Maxwell electromagnetic theory suggested that charged particles when accelerated should emit electromagnetic radiation (It is not applicable for planets because these are uncharged).
Therefore, an electron in an orbit will emit radiation, the energy carried by radiation comes from electronic motion. The orbit will thus continue to shrink (calculations show that it should take an electron only 10^{-8} s to spiral into the nucleus). But this does not happen.
Thus, the Rutherford model **fails to explain the stability of an atom.**
If the electrons are considered to be stationary, electrostatic attraction between the dense nucleus and the electrons would pull the electrons toward the nucleus to form a miniature version of Thomson's model of atom.
Further, **this model says nothing about the electronic structure of atoms,** i.e. how the electrons are arranged around the nucleus and with what energies these are associated.

17. i.
- The electrons move around the nucleus in certain specifically circular orbits called as energy levels or energy states.
- While moving in a particular energy level or energy state, an electron neither loses nor gains energy.
- Only those energy levels or energy states are permitted in which the angular momentum of an electron is an integral multiple of $\frac{h}{2\pi'}$, where h is Planck's constant.
- On absorption of energy from an external source, an electron may jump from a lower energy level to a higher energy level.

ii. **Zeeman Effect:** When a magnetic field is applied on an atom, its usually observed spectral lines get split. This is known as Zeeman's effect.
Stark Effect: When an electric field is applied on an atom, its usually observed spectral lines get split due to pressure of an electric field. This is known as Stark effect.

18. i. $14\ g^{14}C$ contains 6.023×10^{23} atoms
No. of atoms in $7mg$ of ^{14}C

$= \frac{6.023\times10^{23}}{14} \times \frac{7}{1000} = 3.012 \times 10^{20}$

In ^{14}C

Mass number $= 14$

Atomic number $= 6$

$\therefore$ No. of neutrons $= 14 - 6 = 8$

No. of neutrons in $7mg$ of ^{14}C

$= 8 \times 3.012 \times 10^{20}$

$= 24.096 \times 10^{20}$

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

$\therefore$ mass of neutrons in $7mg$ of ^{14}C

$= 24.096 \times 10^{20} \times 1.675 \times 10^{-27}$

$= 4.036 \times 10^{-6}\ kg$

19. i. Given, velocity of beam of helium atoms $= 2.0 \times 10^3\ msec^{-1}$

Mass of helium atom $= \frac{4}{6.022\times10^{23}}$

$= 6.64 \times 10^{-24}\ g = 6.64 \times 10^{-27}\ kg$

According to de-Broglie equation, $\lambda = \frac{h}{mv}$

$= \frac{6.626\times10^{-34}\ kg\ m^2\ s^{-1}}{(6.64\times10^{-27}\ kg)\times\left(2.0\times10^3\ ms^{-1}\right)}$

$= 4.99 \times 10^{-11}\ m = 49.9pm$

ii. Kinetic energy of electron,

$\frac{1}{2}mv^2 = 2.275 \times 10^{-25}\ J$

or $v^2 = \frac{2\times2.275\times10^{-25}}{9.1\times10^{-31}}$

$v = 0.707 \times 10^3\ ms^{-1}$

Now, $\lambda = \frac{h}{mv}$

$= \frac{6.6\times10^{-34}\ kg\ m^2\ s^{-1}}{(9.1\times10^{-31}\ kg)\times\left(0.707\times10^3\ m\ s^{-1}\right)}$

$= 1.029 \times 10^{-6}\ m = 1029\ nm$