CHAPTER 2

Structure of Atom

TRY YOURSELF

ANSWERS

Topic 1

1. Atoms combine in the ratio of small whole numbers to form compounds. In a compound, the relative number and kind of atoms remain constant. This indicates the law of definite proportion which says that in compound the combining elements are present in definite proportion.

2. According to Dalton's atomic theory, the elements combine in fixed whole-number ratios to form compounds. Therefore it suggested that compounds are made up of molecules which contain two or more atoms of different elements.

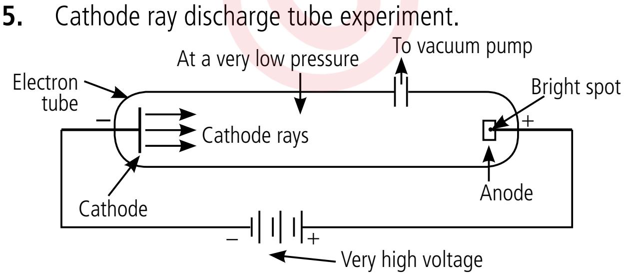
3. **(i) Electron :** An electron is a fundamental particle of an atom carrying one unit negative charge and having mass nearly equal to $\frac{1}{1837}$ of mass of an atom of hydrogen.

(ii) Proton : A proton is a fundamental particle of an atom carrying one unit positive charge and having mass nearly equal to the mass of an atom of hydrogen.

(iii) Neutron : A neutron is a sub-atomic particle carrying no charge and having mass 1.67×10^{-27} kg which is almost equal to that of a hydrogen atom.

4. Cathode ray discharge tube experiment by J.J. Thomson showed that electrons are negatively charged particles as on applying an electric field, they get deflected towards positively charged plate.

5. Cathode ray discharge tube experiment.



Cathode ray discharge tube experiment

In this experiment an electrical discharge is observed in partially evacuated tube which is made up of glass consisting of two thin pieces of metals called electrodes sealed in it. A very low pressure is maintained and a very high voltage is applied. A stream of particles starts moving from negative electrode (cathode) to the positive electrode (anode) called cathode rays. The behaviour of these rays are similar to negatively charged particles called electrons.

6.

Elements	Protons	Electrons	Neutrons
$^{40}_{18}Ar$	18	18	22
$^{39}_{19}K$	19	19	20
$^{23}_{11}Na$	11	11	12

7. Species X : $e = 18, p = 15$ and $n = 16$

Atomic number $(Z) = p = 15$

Mass number $(A) = p + n = 15 + 16 = 31$

Species X is not neutral as $p \neq e$. It is an anion with charge equal to excess electrons $= 18 - 15 = 3$.

So, symbol is $^{31}_{15}P^{3-}$.

Species Y : $e = 10, p = 13$ and $n = 14$

Atomic number $(Z) = p = 13$

Mass number $(A) = p + n = 13 + 14 = 27$

Species Y is not neutral as $p \neq e$.

It is a cation with charge equal to deficient electrons $= 13 - 10 = 3$

So, symbol is $^{27}_{13}Al^{3+}$.

Species Z : $e = 36, p = 36$ and $n = 48$

Atomic number $(Z) = p = 36$

Mass number $(A) = p + n = 36 + 48 = 84$

Species Z is neutral as $p = e$.

So, symbol is $^{84}_{36}Kr$.

8. Isoelectronic species are those which have the same number of electrons.

(i) $Sc^{3+} = 21 - 3 = 18$ and $Ti^{4+} = 22 - 4 = 18$

This pair is isoelectronic.

(ii) $Mn^{2+} = 25 - 2 = 23$ and $Fe^{2+} = 26 - 2 = 24$

This pair is not isoelectronic.

(iii) $Co^{3+} = 27 - 3 = 24$ and $Zn^{2+} = 30 - 2 = 28$

This pair is not isoelectronic.

9. Work function w_0 is the minimum energy required to eject the electron.

$$W_0 = h\nu_0 = \frac{hc}{\lambda_0}$$

$$= \frac{6.626 \times 10^{-34}\ \text{J s} \times 3 \times 10^{8}\ \text{m s}^{-1}}{280 \times 10^{-9}\ \text{m}} = 7.099 \times 10^{-19}\ \text{J}$$

10. $W_0 = 8.4$ eV $\quad (\because 1 \text{ eV} = 1.6 \times 10^{-19} \text{ J})$

$= 8.4 \times 1.6 \times 10^{-19}$ J

$= 1.344 \times 10^{-18}$ J

$$E = h\upsilon = \frac{hc}{\lambda} = \frac{6.626\times10^{-34}\times3\times10^{8}}{1000\times10^{-10}\,\text{m}} = 1.9878\times10^{-18}\ \text{J}$$

$$\text{K.E.} = 1.9878\times10^{-18} - 1.344\times10^{-18}$$
$$= 6.438\times10^{-19}\ \text{J}$$

11. When intensity is doubled, number of electrons emitted per second is also double but average energy of photoelectrons, emitted remains the same.

12. Longest wavelength means smallest wave number. In Lyman series it is for jump from $n_2 = 2$ to $n_1 = 1$

$$\bar{\upsilon} = R_{\text{H}}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) = 109677\left(\frac{1}{1^2} - \frac{1}{2^2}\right)$$

$$= 109677\times\frac{3}{4} = 82257.75\ \text{cm}^{-1}$$

$$\lambda = \frac{1}{\bar{\upsilon}} = \frac{1}{82257.75}\,\text{cm} = 1.216\times10^{-5}\ \text{cm} = 1216\ \text{Å}$$

13. $E_n = -\frac{2.18\times10^{-18}\ \text{J}}{n^2} \Rightarrow E_1 = -2.18\times10^{-18}\ \text{J}$

For the first excited state $n = 2$.

$$E_n = \frac{-2.18\times10^{-18}\ \text{J}}{2^2} = -5.45\times10^{-19}\ \text{J}$$

$$\Delta E = E_2 - E_1 = -5.45\times10^{-19}\ \text{J} - (-2.18\times10^{-18}\ \text{J})$$
$$= 1.635\times10^{-18}\ \text{J atom}^{-1}$$

14. $\lambda = \frac{h}{p} \Rightarrow \lambda = 3\text{Å} = 3\times10^{-10}\ \text{m}$

$$\Rightarrow\quad p = \frac{h}{\lambda} = \frac{6.626\times10^{-34}}{3\times10^{-10}} = 2.2\times10^{-24}\ \text{kg ms}^{-1}$$

15. $\lambda_X = \frac{h}{p_X}$ and $\lambda_Y = \frac{h}{p_Y}$

$$p_Y = \frac{p_X}{2} \Rightarrow \lambda_Y = \frac{2h}{p_X} \Rightarrow \frac{\lambda_Y}{\lambda_X} = \frac{2h}{p_X}\times\frac{p_X}{h} = 2$$

$$\lambda_Y = 2\lambda_X = 2\times5\times10^{-8}\ \text{m} = 10\times10^{-8}\ \text{m} = 10^{-7}\ \text{m}$$

16. $\Delta x\times\Delta p = \frac{h}{4\pi}$

$$\Rightarrow\quad \Delta p = \frac{h}{4\pi\Delta x} = \frac{6.626\times10^{-34}}{4\times3.14\times40\times10^{-12}}$$
$$= 1.3188\times10^{-24}\ \text{kg m s}^{-1}$$

17. $\Delta x\times\Delta p = \frac{h}{4\pi}$

$$\Delta v = 400\times\frac{0.02}{100} = 0.08\ \text{m s}^{-1}$$

$$\Delta x = \frac{6.626\times10^{-34}}{4\times3.14\times9.1\times10^{-31}\times0.08}$$
$$= 7.246\times10^{-4}\ \text{m}$$

18. Fourth shell *i.e.*, $n = 4$.

19. When, $l = 2$, the possible values of m_l are $-2, -1, 0, +1, +2$.

20. For 4*s* : $(n + l) = (4 + 0) = 4$

For 3*d* : $(n + l) = (3 + 2) = 5$

According to $(n + l)$ rule, lower the value of $(n + l)$ for an orbital, lower is its energy

$\therefore$ 4*s* has lower energy $(n + l = 4)$ than $3d(n + l = 5)$.

21. 6; electrons configuration is $1s^2, 2s^22p^6, 3s^23p^4$

So, number of *s*-electrons = 6

22. 25, electrons in an atom

18 + 4 + 3 = 25

i.e., atomic number (*Z*) = 25

23. The electronic configuration of Ni; $1s^22s^22p^63s^23p^63d^84s^2$

Ni^{2+}; $1s^22s^22p^63s^23p^63d^84s^0$

↑↓	↑↓	↑↓	↑	↑

3*d*

There are two unpaired electrons in Ni^{2+}.

24. According to the $(n + l)$ rule, lower is the value for $(n + l)$ for an orbital, lower is its energy. If $(n + l)$ value is same for two orbitals, then the orbital with lower value of *n* will have the lowest energy. For 4*f*, $n = 4$ and $l = 3$, $(n + l) = 4 + 3 = 7$

5*p*, $n = 5$ and $l = 1$, $(n + l) = 5 + 1 = 6$

5d, $n = 5$ and $l = 2$, $(n + l)$ $5 + 2 = 7$

6*s*, $n = 6$ and $l = 0$, $(n + l) = 6 + 0 = 6$

Between 5*p* and 6*s*, 5*p* will have the lower energy.

Between 4*f* and 5*d*, 4*f* will have the lower energy.

Therefore the order of increasing energy for the given orbitals is :

$5p < 6s < 4f < 5d$

25. de Broglie, in 1924 proposed that matter, like radiation, should also exhibit dual behaviour *i.e.*, both particle like and wave like properties.