Solution

HALF YEARLY

Class 11 - Chemistry

Section A

1.

(d) sum of atomic masses of the elements present in a molecule

Explanation: Since the constituent particles in a molecule are atoms, hence its molecular mass is calculated by multiplying the atomic masses of each element by the number of atoms and adding them together.

2.

(b) J K^{-1} mol^{-1}

Explanation: J K^{-1} mol^{-1}

3.

(c) $\frac{14}{6.023 \times 10^{23}}$

Explanation: The atomic mass of Nitrogen ($_7N^{14}$) is 14.

$\therefore$1 atomic mass unit (amu) of N would contain 6.023×10^{23} atoms

or, 6.023×10^{23} atoms of nitrogen (N) would weight= 14 amu

& atom of nitrogen (N) would weight

= [$\frac{14}{6.023 \times 10^{23}}$] amu

4.

(d) 1.988×10^{-18}J

Explanation: We know Planck's equation is $E = h\nu$

where E is energy, h is Planck's constant and ν is frequency.

Put the given values,

E = $6.626 \times 10^{-34} \times 3 \times 10^{15} = 1.988 \times 10^{-18} J$

5.

(d) Both A and R are false.

Explanation: In case of isoelectronic ions, i.e., ions, having the same number of electrons and different nuclear charge, the size decreases with increase in atomic number.

Ion	**At. No.**	**No. of electrons**	**Ionic radii**
Na^+	11	10	$0.95\ \overset{o}{A}$
Mg^{2+}	12	10	$0.65\ \overset{o}{A}$
Al^{3+}	13	10	$0.50\ \overset{o}{A}$

6. **(a)** Atomic weight

Explanation: Mendeleev's used atomic weight as the basis of classification of elements in the periodic table. He arranged 63 elements known at that time in the periodic table on the basis of the order of their increasing atomic weights and he placed elements with similar nature in same group.

7.

(b) Sr

Explanation: Sr falls under the same group as Ca. Hence, Sr and Ca have similar chemical properties.

8.

(d) Both A and R are false.

Explanation: Greater the effective nuclear charge, more tightly the electrons are held with the nucleus and thus more is the energy required to remove electron and hence higher is the ionisation energy. Nuclear charge tells about the number of proton.

9. **(a)** SF_2O

Explanation: SF_2O has pyramidal shape as it is sp^3 hybridised and it has 3bp and 1 lp.

10. **(a)** H-C < H-N < H-O.

Explanation: O is more electronegative than N which is more electronegative than C.

11.

(c) A

Explanation: Octate of A is completely filled.

12.

(d) $H_2O > HF > NH_3$

Explanation: Strength of H-bond is in the order
H...F > H.... O > H....N.
But each H_2O molecule is linked to four other H_2O molecules through H-bonds whereas each HF molecule is linked only to two other HF molecules.
Hence, b.p of H_2O > b.p of HF > b.p. of NH_3

13.

(b) Both A and R are true but R is not the correct explanation of A.

Explanation: Both A and R are true but R is not the correct explanation of A.

14.

(c) 322 K

Explanation: Argon is monoatomic, Here, $C_p = \frac{5}{2}R = \frac{5}{2} \times 8.314JK^{-1}mol^{-1} = 20.79JK^{-1}mol^{-1}$
As pressure is kept constant, $q_p = nC_p\Delta T$
$\Rightarrow 1000J = (2.00mol) \times \left(20.79JK^{-1}mol^{-1}\right) \times \Delta T$
$\Rightarrow \Delta T = 24.05K$
$\Rightarrow T_f = 298 + 24.05 = 322.05K$

15.

(b) ΔS (system) decreases but ΔS (surroundings) increases.

Explanation: For freezing of process since process is spontaneous therefore if ΔS (system) decreases but ΔS (surroundings) increases.Also, Freezing is exothermic process. The heat released increases the entropy of surrounding.

16. **(a)** Both A and R are true and R is the correct explanation of A.

Explanation: A process for which $\Delta S_{system} > 0$, as well as ΔH>0 passes from non-spontaneous to spontaneous state as temperature, is increased. This is so at higher temperatures TΔS exceeds ΔH.

Section B

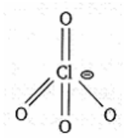
17.
1. **Molarity:** It is the number of moles of solute dissolved per litre of solution. It is denoted by 'M'. Molarity (M) = $\frac{\text{Number of moles of solute}}{\text{Volume of solution in L}}$.
2. **Molality:** It is the number of moles of solute present per kg of solvent. It is denoted by 'm'. Molality (m)= $\frac{\text{Number of moles of solute}}{\text{Mass of solvent in kg}}$.

18. Na^+ and Mg^{2+} are iso-electronic species (have 10 electrons) K^+, Ca^{2+}, S^{2-} are iso- electronic species (have 18 electrons).

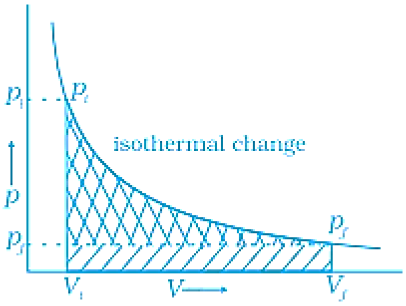
19. The atomic number (Z) of the element is 16.

The electronic configuration of the element is $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$.
1. Since, last electron enters to 'p' subshell, Therefore, element belongs to ‘p-block’.
2. Here, last electron enters to 3rd main shell (n=3), so it belongs to 3rd period.
3. Group number = (10 +2+4 =16) i.e.16th group of the periodic table.

20. The structure of perchlorate ion is given below:



21.



i. Reversible Work is represented by the combined areas of two shaded regions.
ii. Work against constant pressure, p is represented by the area with only diagonal line Work(i) >Work(ii).

Section C

22. Vapour density of the mixture of NO_2 and N_2O_4 = 38.3. (given)

Molecular mass of the mixture =2 $\times$ 38.3 = 76.6 u = 76.6 g, (since molecular mass = 2 x vapour density)
Mass of the mixture = 100 g
No. of moles of the mixture = $\frac{100}{76.6}$ ie. ,(number of moles = given weight / molecular weight) eqn. (i)
Let the mass of NO_2 it the mixture = x g

$\therefore$ Mass of N_2O_4 in the mixture = (100 - x) g

Molar mass of NO_2 = 14 + 32 = 46 u = 46 g

Molar mass of N_2O_4 = 28 + 64 = 92 u = 92 g

No. of moles of NO_2=$\frac{x}{46}$

No. of moles of N2O4 = $\frac{(100-x)}{92}$

Total No. of moles in the mixtue = $\frac{x}{46}+\frac{(100-x)}{92}$ ....eqn. (ii)

Equating (i) and (ii) we get,
$\frac{x}{46}+\frac{(100-x)}{92}=\frac{100}{76.6}$
or,92x + 46(100 - x) = $\frac{100}{76.6}\times 46\times 92$
46 x = (5524.80 - 4600) = 924.80
therefore, x = [924.80 /46] = 20.10
Hence , the mass of NO_2 in the mixture is 20.10 g

23. i. 1 mole of H_2O = 18g = 18cm^3 ($\because$ density of H_2O = 1g/cm^3)

= 6.022 $\times$ 10^{23} molecules of H_2O

Thus, 6.022 $\times$ 10^{23} molecules of H_2O have volume

= 18 cm^3
$\therefore$ 1 molecule of H_2O will have volume

= $\frac{18}{6.022\times 10^{23}}$ cm^3 = 2.989 $\times$ 10^{-23} cm^3

ii. As water molecule is assumed to be spherical, if R is its radius, then its volume will be
$\frac{4}{3}\pi R^2$ = 2.989 $\times$ 10^{-23}cm^3
or R^3 = 7133 $\times$ 10^{-24}
or R = $(7133)^{1/3}$ $\times$ 10^{-8} = 1.925 $\times$ 10^{-8} cm
$\therefore$ Diameter of water molecule
= 2 $\times$ 1.925 $\times$ 10^{-8} cm = 3.85 $\times$ 10^{-8} cm

iii. As oxygen atom occupies half of the volume occupied by water molecule, hence if r is the radius of oxygen atom, then $\frac{4}{3}\pi r^3=\frac{1}{2}\times 2.989\times 10^{-23}$
or r^3 = 3.566 $\times$ 10^{-24} which gives
r = 1.528 $\times$ 10^{-8} cm
Diameter of oxygen atom
= 2 $\times$ 1.528 $\times$ 10^{-8} cm
= 3.056 $\times$ 10^{-8} cm

OR

Step 1

The chemical equation for the reaction of Ag NO_3 with NaCl is represented stoichiometrically as :

$$\underset{23\ +35.5\ =\ 58.5\ g}{AgNO_3 + NaCl} \rightarrow \underset{108\ +35.5\ =\ 143.5\ g}{AgCl + NaNO_3}$$

Let the masses of NaCl and KCl in the mixture be "a" g and "b" g, respectively.

$\therefore$ a + b = 0.93 g, (given)

(i) For NaCl - Since, 58.5 g of NaCl give AgCl = 143.5 g

$\therefore$ "a" g of NaCl will give AgCl = [{(143.5 g) / (58.5 g)} $\times$ a] g

(ii) For KCl, Similarly, 74.5 g of KCl gives AgCl = 143.5 g

(as ,Gram molar mass of KCl = (39 + 35.5) = 74.5 g)

"b" g of KCl will give AgCl = [{ (143.5 g) / (74.5 g) } $\times$ b] g

Step 2

But mass of AgCl actually formed = 1.865 g (given)

$\therefore \frac{143.5\times a}{58.5} + \frac{143.5\times b}{74.5}$ = 1.865 g [since, b = (0.93 - a) g]

$\Rightarrow$ 2.453 a + 1.93 (0.93 - a) = 1.865 $\Rightarrow$ 2.453 a + 1.795 - 1.93 a = 1.865

$\Rightarrow$ 0.523 a = 0.07 g

$\therefore$ a = [0.07 / 0.523] g

= 0.14 g

Mass of NaCl in the mixture = 0.14 g

Mass of KCl in the mixture = (0.93 - 0.14) = 0.79 g

Hence, "The mass of NaCl in 10 ml of this solution is 0.14 g"

24. i. n = 0, l = 0, m_l = 0, ms = +1/2 is not possible because n cannot have zero value.
    ii. n = 1, l = 0, m_l = 0, m_s = -1/2 is possible.
    iii. n = 1, l = 1, m_l = -0, m_s = +1/2 is not possible because for n = 1, l = 1 is not possible. l can have values 0, 1 ... (n - 1) only.
    iv. n = 2, l = 1, m_l = 0, ms = -1/2 is possible.
    v. n = 3, l = 3, m_l = -3, m_s = +1/2 is not possible because for n = 3, l cannot have 3 value.
    vi. n = 3, l = 2, m_l = 0, m_s = +1/2 is possible.

25. **Limitations of Rutherford model:**

(i) When a body is moving in a orbit, it achieves acceleration (even if body is moving with constant speed in an orbit, it achieves acceleration due to change in direction). So an electron moving around nucleus in an orbit is under acceleration. However, according radiation theory of Maxwell, the charged particles when accelerated must emit energy as electromagnetic radiations. This means that the revolving electron must also lose energy continuously in the form of electromagnetic radiation. The loss of energy in energy revolution of the electron around the nucleus must bring it closer to the nucleus and the electron must ultimately fall into the nucleus by the spiral path. This means that the atom must collapse. But we all know that atom is quite stable in nature.

(ii) Rutherford's model could not explain the existence of different spectral lines in the hydrogen spectrum.

OR

According to Balmer formula, $\bar{\mathrm{v}} = \frac{1}{\lambda} = \mathrm{R_H}\left[\frac{1}{\mathrm{n}_1^2} - \frac{1}{\mathrm{n}_2^2}\right]$

In order that the wavelength (λ)may be the maximum, wave number (v)must be the least. This is possible in case n_2 - n_1 is minimum. Now, for Balmer series, n_1= 2 and n_2 must be 3. Substituting these values in the Balmer formula,

$$\bar{\mathrm{v}} = \left(1.097 \times 10^7 \mathrm{m}^{-1}\right)\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$$

$$= 1.097 \times 10^7 \mathrm{m}^{-1}\left(\frac{5}{36}\right) = 1.523 \times 10^6 \mathrm{m}^{-1}$$

26. Element belonging to Group 15 with outer electronic configuration as ns^2 np^3 e.g., nitrogen.

OR

In a multielectron atom, the electrons present in the inner shells shield the electrons in the valence shell from the attraction of the nucleus or they act as a screen between the nucleus and these electrons. This is known as shielding effect or screening effect. As the screening effect increases, the effective nuclear charge decreases. Consequently, the force of attraction by the nucleus for the valence shell electrons decreases and hence the ionization enthalpy decreases.

27. i. $\underset{Tetrahedral}{CCI_4(109.5^\circ)},\ \underset{Pyramidal}{NH_3\ (107^\circ)},\ \underset{Angular}{H_2O(104.5^\circ\ )},\underset{Octahedral}{SF_6\ (90^\circ)}$

ii. $BF_3(120^\circ)$, $CH_4(109.5^\circ)$, $NH_3(107^\circ)$, $H_2O\ (104.5^\circ)$
$\underset{Planar}{}$ $\underset{Tetrahedral}{}$ $\underset{Pyramidal}{}$ $\underset{Angular}{}$

Planar, Tetrahedral, Pyramidal, Angular

iii. $BeH_2(180^\circ)$, $AICI_3(120^\circ\ )$, $H_2O(104.5^\circ)$, $H_2S(100^\circ)$,

Linear, Planar, Angular, Angular but S is less electronegative Than O

28. Given, n = 10, P_1 = 5 atm, P_2 = 1 atm, T = 300 K.

We know that, $W_{\exp} = -2.303nRT\log\frac{P_1}{p_2}$

$= -2.303(10\text{mol}) \times \left(8.314\text{JK}^{-1}\text{mol}^{-1}\right)(300\text{K})\log\frac{5}{1}$

$= -40.15 \times 10^3\text{J}$

If M is the mass that can be lifted by this work through a height of 1 m, then work done = Mgh

$40.15 \times 10^3 = M \times 9.81 \times 1$

$\Rightarrow M = \frac{40.15 \times 10^3}{9.81 \times 1}$

= 4092.76 kg.

Section D

29. i. Electronegativity increases on moving left to right in a period and decreases from top to bottom in a group.
(N and C) and (Si and P) respectively belongs to (n = 2) and (n = 3)
$\because$ Electronegativity of N > electronegativity of C and electronegativity of P > electronegativity of Si.

ii. As we move from top to bottom in group the atomic radius will be increased, because the in coming electron enters into a new sub shell.
Li, Na, K, Rb, Cs are IA group elements from Li to Rb the atomic radius will be increased. So the correct order of atomic radius is Li < Na < K < Rb < Cs

iii. Oxygen has lower ionization enthalpy than nitrogen because by removing one electron from the 2p-orbital, oxygen acquires a stable configuration.

OR

As we go down the group, the size of atoms increases. Due to this the nuclear force of attraction on the electrons in the outermost shell decreases, because of which they can be easily lost. Therefore, metallic character increases down the group.

30. i. Temperature of a crystalline solid is raised from 0 K to 115 K. At 0 K, the constituent particles are static, and entropy is minimum. If temperature is raised to 115 K, the constituent particles begin to move and oscillate about their equilibrium positions in the lattice and system becomes more disordered, therefore entropy increases.

ii. The compound NH_4Cl exists in crystalline form but after dissociation in water ions move in a random direction which means the entropy increases i.e. positive $\Delta S>0$ and the Gibbs energy is negative $\Delta G < 0$. Hence, the process is **spontaneous**. Therefore, the dissolution of ammonium chloride in water is an **endothermic change**.

iii. A liquid crystallizing into a solid is a freezing process and after freezing, the molecules attain an ordered state and therefore, entropy decreases.

OR

Greater entropy of graphite is related to its structure as graphite is less compact and rigid than diamond. ΔH_f^O for graphite is zero, but the ΔH_f^O for diamond is 2 kJ/mol. That is because graphite is the standard state of carbon, not diamond.

Section E

31. Atomic mass = $\frac{\%\text{ of element}}{\text{relative number of moles}}$

Given % of element of A = 70 % ,

% of element of B = 30%

Relative number of moles of A = 1.25 while that of B = 1.88.

By putting the values in the formula we have,

Atomic mass of A = $\frac{70}{1.25} = 56$, and Atomic mass of B = $\frac{30}{1.88} = 16$

Calculation of Empirical Formula

Element	**Relative number of moles**	**Simplest molar ratio**	**Simplest whole number molar ratio**
A	1.25	$\frac{1.25}{1.25} = 1$	2
B	1.88	$\frac{1.88}{1.25} = 1.5$	3

$\therefore$ Empirical formula = A_2B_3

Calculation of molecular formula:

Empirical formula mass = 2 $\times$ 56 + 3 $\times$ 16 = 160

n = $\frac{\text{molecular mass}}{\text{empirical formula mass}} = \frac{160}{160} = 1$

$\therefore$ Molecular formula = A_2B_3

OR

Amount of carbon in 3.38 g of CO_2 = $\frac{12}{44} \times 3.38$ g = 0.9218 g

Amount of hydrogen in 0.690 g of H2O = $\frac{2}{18} \times 0.690$ g = 0.0767 g

As compound contains only C and H, therefore, the total mass of the compound

= 0.9218 + 0.0767 g = 0.9985 g

% of C in the compound = $\frac{0.9218}{0.9985} \times 100$ = 92.32

% of H in the compound = $\frac{0.0767}{0.9985} \times$ 100 = 7.68

i. Calculation of Empirical Formula

Element	% bt mass	Atomic mass	Moles of the element	Simplest molar ratio	Simplest whole no. molar ratio
C	92.32	12	$\frac{92.32}{12}$ = 7.69	1	1
H	7.68	1	$\frac{7.68}{1}$ = 7.68	1	1

$\therefore$ Empirical formula = CH

Hence, the empirical formula of the gas is 'CH'

ii. Given,

10.0 L of the gas at STP weighs = 11.6 g

$\therefore$ 22.4 L of the gas at S.T.P. will weigh = $\frac{11.6}{10.0} \times 22.4$ = 25.984 g = 26 g (approx.)

Hence, the molar mass of the gas = 26 g mol^{-1}

iii. Empirical formula mass of CH = 12 + 1 = 13, (calculated as above)

$\therefore$ n = $\frac{\text{Molecular mass}}{\text{E.F.Mass}} = \frac{26}{13}$ = 2

$\therefore$ Molecular formula = (CH)n

or, = 2 $\times$ CH = C_2H_2

32. Limitations of Bohr's model of an atom:

i. It could not explain spectrum of multi-electron atoms.
ii. It could not explain Zeeman and Stark effects.
iii. It could not explain shape of molecules.
iv. It was not in accordance with Heisenberg's uncertainty principle.

Quantum Mechanical Model: It was developed on the basis of Heisenberg's uncertainty principal and dual behaviour of matter. Main features of this model are given below:

i. The energy of electrons in an atoms is quantized i.e. can only have certain values.
ii. The existence of quantized electronic energy levels is a direct result of the wave like properties of electrons.
iii. Both the exact position and velocity of an electron in an atom cannot be determined simultaneously.
iv. The orbitals are filled in increasing order of energy. All the information about the electron in an atom is stored in orbital wave function Ψ.
v. From the value of ψ^2 at different points within atom, it is possible to predict the region around the nucleus where electron most probably will be found.

OR

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.

33.

Bonding Molecular Orbitals	Antibonding Molecular Orbitals
The bonding molecular orbitals (BMOs) are obtained by the addition of atomic orbitals and are represented by σ and π.	The antibonding molecular orbitals (AMOs) are obtained by the subtraction of atomic orbitals and are represented by σ^* and π^*.

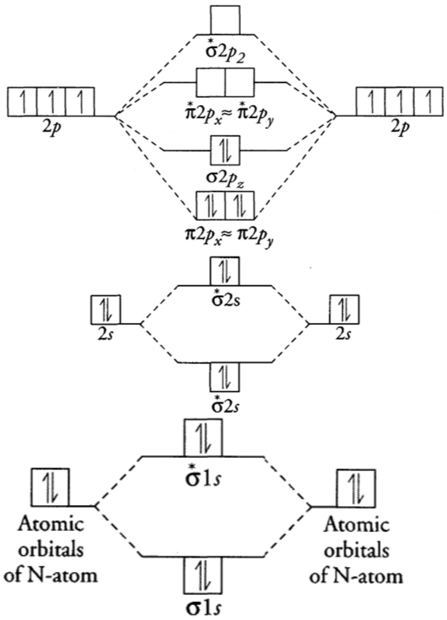
The electron density is located between the nuclei of the bonded atoms.	Most of the electron density is located away from the space in between the nuclei.
A bonding molecular orbital has always lower energy than either of the atomic orbitals that have combined to form it.	An antibonding molecular orbital has higher energy than either of the atomic orbitals that have combined to form it.

i. $H_2^+(1) = (\sigma 1s)^1 \Rightarrow$ Bond order = $\frac{1}{2}$ (1 - 0) = 0.5, It is paramagnetic due to presence of 1 lone electron
ii. Li_2 (6) $= (\sigma 1s)^2(\overset{*}{\sigma} 1s)^2(\sigma 2s)^2 \Rightarrow$ Bond order = $\frac{1}{2}$(4 - 2) = $\frac{2}{2}$ = 1, It is diamagnetic as all electrons are paired.
iii. B_2 (10) = $(\sigma 1s)^2(\dot{\sigma} 1s)^2(\sigma 2s)^2(\dot{\sigma} 2s)^2 \left(\pi 2p_x^1 = \pi 2p_y^1\right) \Rightarrow$ Bond order = $\frac{1}{2}$ (6 - 4) = 1, It is paramagnetic due to presence of unpaired electrons.
iv. C_2 (12) = $(\sigma 1s)^2(\dot{\sigma} 1s)^2(\sigma 2s)^2(\dot{\sigma} 2s)^2 \left(\pi 2p_x^2 \approx \pi 2p_y^2\right) \Rightarrow$ Bond order = $\frac{1}{2}$ (8 - 4) = 2, It is diamagnetic due to absence of unpaired electrons.

OR

Formation of N_2 molecular

$_7$ N $= 1s^2, 2s^2, 2p_x^1, 2p_y^1, 2p_z^1$
N_2 = $\sigma 1s^2, \overset{*}{\sigma} 1s^2, \sigma 2s^2, \overset{*}{\sigma} 2s^2, \pi 2p_x^2 \approx \pi 2p_y^2, \sigma 2p_z^2$

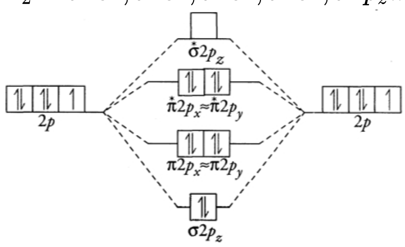


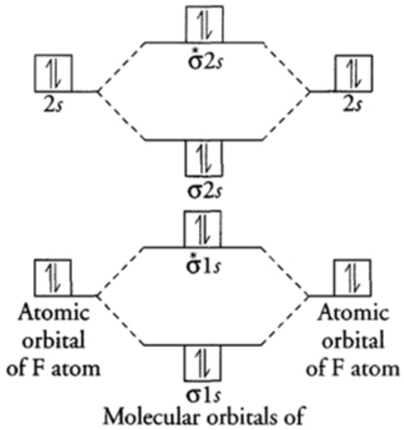
Molecular orbitals of N_2 molecule

Bond order = $\frac{1}{2}[N_b - N_a] = \frac{1}{2}(10 - 4) = 3$

Bond order value of 3 means that N_2 contains a triple bond. Formation of F_2 molecule 9 F $= 1s^2, 2s^2, 2p_x^2, 2p_y^2, 2p_z^1$

$F_2 = \sigma 1s^2, \overset{*}{\sigma} 1s^2, \sigma 2s^2, \overset{*}{\sigma} 2s^2, \sigma 2p_z^2 \pi 2p_x^2 \approx \pi 2p_y^2, \overset{*}{\pi} 2p_x^2 \approx \overset{*}{\pi} 2p_y^2$





Molecular orbitals of F_2 molecule

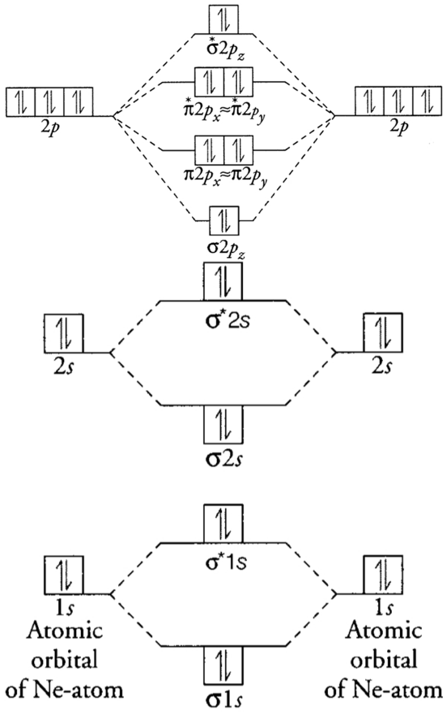
Bond order = $\frac{1}{2}[N_b - N_a] = \frac{1}{2}(10-8) = 1$

Bond order value 1 means that F_2 contains single bond

Formation of Ne_2 molecular

${}_{10}\text{Ne} = 1s^2, 2s^2, 2p_x^2, 2p_y^2, 2p_z^2$

$Ne_2 = \sigma 1s^2, \overset{*}{\sigma}1s^2, \sigma 2s^2, \overset{*}{\sigma}2s^2, \sigma 2p_z^2 \pi 2p_x^2 \approx \pi 2p_y^2, \overset{*}{\pi}2p_x^2 \approx \overset{*}{\pi}2p_y^2,\ \overset{*}{\sigma}2p_z^2$



Molecular orbital of Ne_2 molecule

Bond order = $\frac{1}{2}[N_b - N_a] = \frac{1}{2}(10-10) = 0$

Bond order value zero means that there is no formation of bond between two Ne atoms. Hence, Ne_2 molecular does not exist.