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PREFACE

Whenever a student decides to prepare for any examination his/her first and foremost curiosity is to know about the type of questions that are expected in the exam. This becomes more important in the context of competitive entrance examinations where there is neck-to-neck competition.

We feel great pleasure in presenting before you this book containing Error Free Chapterwise Topicwise Solutions of **CBSE AIPMT/NEET Chemistry Questions** from the years 1988 to 2021.

It has been our efforts to provide correct solutions to the best of our knowledge and opinion. Detailed explanatory discussions follow the answers. Discussions are not just sketchy–rather, have been drafted in a manner that the students will surely be able to answer some other related questions too ! Going through this book, the students would be able to have the complete idea of the questions being asked in the test.

We hope this chapterwise solved papers would be highly beneficial to the students. We would be grateful if any discrepancies or mistakes in the questions or answers are brought to our notice so that these could be rectified in subsequent editions.

Publisher

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CLASS 12th

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1

Some Basic Concepts in Chemistry

TOPIC 1

Nature of Matter, Significant Figures and Laws of Chemical Combinations

01 The number of significant figures for the three numbers 161 cm, 0.161 cm, 0.0161 cm are **[CBSE AIPMT 1998]**

(a) 3,4 and 5 respectively
(b) 3,4 and 4 respectively
(c) 3,3 and 4 respectively
(d) 3,3 and 3 respectively

Ans. ***(d)***

(i) All non-zero digits are significant.
(ii) Non-zero digits to the right of the decimal point are significant.
(iii) Zeroes to the left of the first non-zero digit in a number are not significant.

So, the number of significant figures for the numbers 161 cm, 0.161 cm and 0.0161 cm are same, i.e. 3.

02 0.24 g of a volatile gas, upon vaporisation, gives 45 mL vapour at NTP. What will be the vapour density of the substance? (Density of $H_2 = 0.089$) **[CBSE AIPMT 1996]**

(a) 95.93
(b) 59.93
(c) 95.39
(d) 5.993

Ans. ***(b)***

Weight of gas $= 0.24$ g

Volume of gas $(V) = 45$ mL $= 0.045$ L

Density of $H_2 (d) = 0.089$

Weight of 45 mL of $H_2 = V \times d$

$$= 0.045 \times 0.089$$

$$= 4.005 \times 10^{-3} \text{ g}$$

Therefore, vapour density

$$= \frac{\text{Weight of certain volume of substance}}{\text{Weight of same volume of hydrogen}}$$

$$= \frac{0.24}{4.005 \times 10^{-3}} = 59.93$$

03 In the final answer of the expression

$$\frac{(29.2 - 20.2)(1.79 \times 10^5)}{1.37}$$

the number of significant figures is **[CBSE AIPMT 1994]**

(a) 1
(b) 2
(c) 3
(d) 4

Ans. ***(c)***

On calculation we find

$$\frac{(29.2 - 20.2)(1.79 \times 10^5)}{1.37} = 1.17 \times 10^6$$

As the least precise number contains 3 significant figures, therefore answer should also contains 3 significant figures.

04 The molecular weight of O_2 and SO_2 are 32 and 64 respectively. At 15°C and 150 mmHg pressure, 1 L of O_2 contains '*N*' molecules. The number of molecules in 2L of SO_2 under the same conditions of temperature and pressure will be **[CBSE AIPMT 1990]**

(a) $N/2$
(b) N
(c) $2N$
(d) $4N$

Ans. ***(c)***

According to Avogadro's law "equal volumes of all gases contain equal number of molecules under similar conditions of temperature and pressure." Thus, if 1 L of one gas contains *N* molecules, 2 L of any gas under similar conditions will contain 2 *N* molecules.

TOPIC 2

Atomic Mass, Molecular Mass and Formulae of Compounds

05 An organic compound contains 78% (by wt.) carbon and remaining percentage of hydrogen. The right option for the empirical formula of this compound is [At. wt. of C is 12, H is 1] **[NEET 2021]**

(a) CH
(b) CH_2
(c) CH_3
(d) CH_4

Ans. ***(c)***

Element	%	Atomic mass	Relative number of moles	Simple ratio of moles	Simplest whole number ratio
C	78	12	$\frac{78}{12} = 6.5$	$\frac{6.5}{6.5} = 1$	1
H	22	1	$\frac{22}{1} = 22$	$\frac{22}{6.5} = 3.3$	3

The empirical formula of the organic compound is CH_3.

06 The number of protons, neutrons and electrons in ${}^{175}_{71}\text{Lu}$, respectively, are **[NEET (Sep.) 2020]**

(a) 104, 71 and 71 (b) 71, 71 and 104
(c) 175, 104 and 71 (d) 71, 104 and 71

Ans. *(d)*

In ${}^{175}_{71}\text{Lu}$,

Mass number $(A) = 175 = n + p$
Atomic number $(Z) = 71 = p = e^-$
$\therefore$ Number of protons = 71
Number of neutrons
$= A - Z = 175 - 71 = 104$
Number of electrons = 71

07 Suppose the elements *X* and *Y* combine to form two compounds XY_2 and X_3Y_2. When 0.1 mole of XY_2 weighs 10 g and 0.05 mole of X_3Y_2 weighs 9 g, the atomic weights of *X* and *Y* are **[NEET Phase II 2016]**

(a) 40, 30 (b) 60, 40 (c) 20, 30 (d) 30, 20

Ans. *(a)*

Let atomic masses of *X* and *Y* be A_X and A_Y, respectively

For XY_2, $n_{XY_2} = 0.1 = \dfrac{10}{A_X + 2A_Y}$

or $A_X + 2A_Y = 100$ ...(i)

For X_3Y_2, $n_{X_3Y_2} = 0.05 = \dfrac{9}{3A_X + 2A_Y}$

or $3A_X + 2A_Y = 180$ ...(ii)

On solving Eqs. (i) and (ii), we get,

$A_X = 40 \text{ g mol}^{-1} \Rightarrow A_Y = 30 \text{ g mol}^{-1}$

08 An organic compound contains carbon, hydrogen and oxygen. Its elemental analysis gave C, 38.71% and H, 9.67%. The empirical formula of the compound would be **[CBSE AIPMT 2008]**

(a) CH_3O (b) CH_2O (c) CHO (d) CH_4O

Ans. *(a)*

Element	% abundance	At. wt.	Molar ratio	Simple ratio
C	38.71	12	$\frac{38.71}{12} = 3.23$	$\frac{3.23}{3.23} = 1$
H	9.67	1	$\frac{9.67}{1} = 9.67$	$\frac{9.67}{3.23} = 3$
O	[100 − (38.71 + 9.67)] = 51.62	16	$\frac{51.62}{16} = 3.23$	$\frac{3.23}{3.23} = 1$

Thus, the empirical formula of the compound is CH_3O.

09 An element, *X* has the following isotopic composition:
${}^{200}X$: 90%, ${}^{199}X$: 8.0%, ${}^{202}X$: 2.0%

The weighted average atomic mass of the naturally occurring element *X* is closest to **[CBSE AIPMT 2007]**

(a) 201 u (b) 202 u
(c) 199 u (d) 200 u

Ans. *(d)*

Weight of ${}^{200}X = 0.90 \times 200 = 180.00$ u
Weight of ${}^{199}X = 0.08 \times 199 = 15.92$ u
Weight of ${}^{202}X = 0.02 \times 202 = 4.04$ u
Total weight $= 199.96 \approx 200$ u

10 Which of the following is isoelectronic? **[CBSE AIPMT 2002]**

(a) CO_2, NO_2
(b) NO_2^-, CO_2
(c) CN^-, CO
(d) SO_2, CO_2

Ans. *(c)*

CN^- and CO are isoelectronic because they have equal number of electrons.
In CN^- the number of electrons
$= 6 + 7 + 1 = 14$
In CO the number of electrons
$= 6 + 8 = 14$

11 An organic compound containing C, H and N gave the following results on analysis C = 40%, H = 13.33%, N = 46.67%. Its empirical formula would be **[CBSE AIPMT 2002, 1999, 98]**

(a) $C_2H_7N_2$ (b) CH_5N
(c) CH_4N (d) C_2H_7N

Ans. *(c)*

Table for empirical formula

Element	%	At. wt.	Molar ratio	Simple ratio
C	40.00	12	$\frac{40}{12} = 3.33$	$\frac{3.33}{3.33} = 1$
H	13.33	1	$\frac{13.33}{1} = 13.33$	$\frac{13.33}{3.33} = 4$
N	46.67	14	$\frac{46.67}{14} = 3.33$	$\frac{3.33}{3.33} = 1$

Hence, empirical formula is CH_4N.

12 An organic compound contains C = 40%, O = 53.34% and H = 6.60%. The empirical formula of the compound is **[CBSE AIPMT 1994]**

(a) CH_2O (b) CHO
(c) CH_4O_2 (d) C_2H_2O

Ans. *(a)*

Element	%	At. wt.	Molar ratio	Simple ratio
C	40	12	$\frac{40}{12} = 3.33$	$\frac{3.33}{3.33} = 1$
H	6.60	1	$\frac{6.60}{1} = 6.60$	$\frac{6.60}{3.33} = 2$
O	53.34	16	$\frac{53.34}{16} = 3.33$	$\frac{3.33}{3.33} = 1$

Hence, empirical formula is
C : H : O = 1 : 2 : 1 = CH_2O

13 Boron has two stable isotopes, ${}^{10}B$ (19%) and ${}^{11}B$ (81%). Calculate average atomic weight of boron in the periodic table. **[CBSE AIPMT 1990]**

(a) 10.8 (b) 10.2
(c) 11.2 (d) 10.0

Ans. *(a)*

Average of atomic weight

$$= \frac{\%\text{ of }{}^{10}B \times \text{atomic mass of }{}^{10}B + \%\text{ of }{}^{11}B \times \text{atomic mass of }{}^{11}B}{\%\text{ of }{}^{10}B + \%\text{ of }{}^{11}B}$$

$$= \frac{19 \times 10 + 81 \times 11}{19 + 81}$$

$$= \frac{190 + 891}{100} = 10.81$$

14 While extracting an element from its ore, the ore is grind and leached with dil. KCN solution to form the soluble product potassium argento- cyanide. The element is **[CBSE AIPMT 1989]**

(a) lead
(b) chromium
(c) manganese
(d) silver

Ans. *(d)*

Silver metal is extracted from the argentite ore Ag_2S by cyanide process. In this method, the concentrated ore is treated with dilute solution of potassium cyanide, then a soluble complex potassium dicyanoargentate (I) is formed which when reacted with zinc, silver is extracted as a ppt.

$$Ag_2S + 4KCN \longrightarrow 2K[Ag(CN)_2] + Na_2S$$

$$2K[Ag(CN)_2] + Zn \longrightarrow K_2[Zn(CN)_4] + 2Ag\downarrow$$

15 A metal oxide has the formula Z_2O_3. It can be reduced by hydrogen to give free metal and water. 0.1596 g of the metal oxide requires 6 mg of hydrogen for complete reduction. The atomic weight of the metal is **[CBSE AIPMT 1989]**

(a) 27.9 (b) 159.6
(c) 79.8 (d) 55.8

Ans. ***(d)***

$$Z_2O_3 + 3H_2 \longrightarrow 2Z + 3H_2O$$

$\because$ 6×10^{-3} g H_2 reduces $= 0.1596$ g of Z_2O_3

$\therefore$ 1 g H_2 reduces $= \dfrac{0.1596}{6\times10^{-3}}$ g Z_2O_3

$= 26.6$ g of Z_2O_3

$\therefore$ Equivalent weight of $Z_2O_3 = 26.6$

Equivalent weight of Z + Equivalent weight of O $= 26.6$

Equivalent weight of $Z + 8 = 26.6$

Equivalent weight of $Z = (26.6 - 8) = 18.6$

Valency of metal in $Z_2O_3 = 3$

Equivalent weigh

$= \dfrac{\text{Atomic weight}}{\text{Valency}}$

Atomic weight

$= 18.6 \times 3 = 55.8$

TOPIC 3

Mole Concept and Concentration Terms

16 One mole of carbon atom weighs 12 g, the number of atoms in it is equal to, (Mass of carbon -12 is 1.9926×10^{-23} g) **[NEET (Oct.) 2020]**

(a) 1.2×10^{23} (b) 6.022×10^{22}
(c) 12×10^{22} (d) 6.022×10^{23}

Ans. ***(d)***

1 mole of carbon atoms weight 12 g, its contains Avogadro number of carbon atoms, i.e. 6.022×10^{23} number of carbon atoms.

17 Which one of the followings has maximum number of atoms? **[NEET (Sep.) 2020]**

(a) 1 g of Mg(*s*) [Atomic mass of Mg = 24]
(b) 1 g of $O_2(g)$ [Atomic mass of O = 16]
(c) 1 g of Li(*s*) [Atomic mass of Li = 7]
(d) 1 g of Ag(*s*) [Atomic mass of Ag = 108]

Ans. ***(c)***

Number of atoms (n)

$$= \frac{\text{Mass in g (1 g)} \times \text{Atomicity of the molecule}}{\text{Gram molar mass}\,(M)} \times N_A$$

$[\because N_A = \text{Avogadro's number}]$

$\Rightarrow n \propto \dfrac{\text{Atomicity}}{M}$

(a) $n_{Mg} = \dfrac{1}{24}$

(b) $n_O = \dfrac{2}{32} = \dfrac{1}{16}$

(c) $n_{Li} = \dfrac{1}{7}$

(d) $n_{Ag} = \dfrac{1}{108}$

So, $n_{Li} > n_O > n_{Mg} > n_{Ag}$

18 In which case is the number of molecules of water maximum? **[NEET 2018]**

(a) 0.00224 L of water vapours at 1 atm and 273 K
(b) 0.18 g of water
(c) 18 mL of water
(d) 10^{-3} mol of water

Ans. ***(c)***

Number of molecules = Mole × Avogadro's number (N_A)

The number of molecules of water in each of the given options is calculated as

(i) 18 mL of water

Number of moles (n_{H_2O})

$$= \frac{\text{Mass of substance in g}\,(w_{H_2O})}{\text{Molar mass in g mol}^{-1}\,(M_{H_2O})}$$

$w_{H_2O} = 18$g

$[\because \text{Density of water}\,(d_{H_2O}) = 1\text{ g L}^{-1}]$

$\therefore\quad n_{H_2O} = \dfrac{18}{18} = 1$

Number of molecules of water $= 1\times N_A$

(ii) 0.18 g of water

$$n_{H_2O} = \frac{w_{H_2O}}{M_{H_2O}} = \frac{0.18}{18} = 0.01$$

Number of molecules of water $= 0.01\times N_A$

(iii) 0.00224 L of water vapours at 1 atm and 273 K. At STP [1 atm and 273 K], Number of moles [with reference to volume]

$= \dfrac{\text{Volume of gas in litres}}{22.4}$

$= \dfrac{0.00224}{22.4} = 0.0001$

Number of molecules of water $= 0.0001\times N_A$

(iv) 10^{-3} mol of water

Number of molecules of water $= 10^{-3}\times N_A$

$\therefore$ Among the given options, option (i) contains the maximum number of water molecules.

19 If Avogadro number N_A, is changed from 6.022×10^{23} mol^{-1} to 6.022×10^{20} mol^{-1} this would change **[CBSE AIPMT 2015]**

(a) the definition of mass in units of grams
(b) the mass of one mole of carbon
(c) the ratio of chemical species to each other in a balanced equation
(d) the ratio of elements to each other in a compound

Ans. ***(b)***

If Avogadro number N_A, is changed from 6.022×10^{23} mol^{-1} to 6.022×10^{20} mol^{-1}, this would change the mass of one mole of carbon.

$\because$ 1 mole of carbon has mass = 12 g

or 6.022×10^{23} atoms of carbon have mass = 12 g

$\therefore 6.022\times10^{20}$ atoms of carbon have mass

$$= \frac{12}{6.022\times10^{23}}\times 6.022\times10^{20} = 0.012\text{ g}$$

20 How many grams of concentrated nitric acid solution should be used to prepare 250 mL of 2.0 M HNO_3? The concentrated acid is 70% HNO_3. **[NEET 2013]**

(a) 45.0 g conc. HNO_3
(b) 90.0 g conc. HNO_3
(c) 70.0 g conc. HNO_3
(d) 54.0 g conc. HNO_3

Ans. ***(a)***

Given, molarity of solution = 2

Volume of solution = 250 mL

$$=\frac{250}{1000}=\frac{1}{4}\text{ L}$$

Molar mass of

$HNO_3 = 1 + 14 + 3 \times 16 = 63 \text{ g mol}^{-1}$

∵ Molarity

$$=\frac{\text{Weight of } HNO_3}{\text{Molecular mass of } HNO_3 \times \text{volume of solution (L)}}$$

∴Weight of

HNO_3 = molarity × molecular mass × volume (L)

$$=2 \times 63 \times \frac{1}{4}\text{ g}$$

$$=31.5\text{ g}$$

It is the weight of 100% HNO_3

But the given acid is 70% HNO_3

$$\therefore \quad \text{Its weight} = 31.5 \times \frac{100}{70}\text{ g}$$

$$= 45\text{ g}$$

21 6.02×10^{20} molecules of urea are present in 100 mL of its solution. The concentration of solution is **[NEET 2013]**

(a) 0.02 M (b) 0.01 M

(c) 0.001 M (d) 0.1 M

Ans. ***(b)***

Given, number of molecules of urea $= 6.02 \times 10^{20}$

$$\therefore \quad \text{Number of moles} = \frac{6.02 \times 10^{20}}{N_A}$$

$$= \frac{6.02 \times 10^{20}}{6.023 \times 10^{23}}$$

$$= 0.999 \times 10^{-3}$$

$$\simeq 1 \times 10^{-3}\text{ mol}$$

Volume of the solution

$$= 100\text{ mL} = \frac{100}{1000}\text{ L} = 0.1\text{ L}$$

Concentration of urea solution (in mol L^{-1})

$$= \frac{1 \times 10^{-3}}{0.1}\text{ mol L}^{-1}$$

$$= 1 \times 10^{-2}\text{ mol L}^{-1}$$

$$= 0.01\text{ mol L}^{-1}$$

22 The number of atoms in 0.1 mole of a triatomic gas is ($N_A = 6.023 \times 10^{23}\text{ mol}^{-1}$) **[CBSE AIPMT 2010]**

(a) 6.026×10^{22} (b) 1.806×10^{23}

(c) 3.600×10^{23} (d) 1.800×10^{22}

Ans. ***(b)***

Number of atoms = number of moles $\times N_A \times$ atomicity

$$= 0.1 \times 6.023 \times 10^{23} \times 3$$

$$= 1.806 \times 10^{23}\text{ atoms}$$

23 Volume occupied by one molecule of water (density = 1 g cm^{-3}) is **[CBSE AIPMT 2008]**

(a) $9.0 \times 10^{-23}\text{ cm}^3$

(b) $6.023 \times 10^{-23}\text{ cm}^3$

(c) $3.0 \times 10^{-23}\text{ cm}^3$

(d) $5.5 \times 10^{-23}\text{ cm}^3$

Ans. ***(c)***

1 mole $= 6.023 \times 10^{23}$ molecule

18 g $= 6.02 \times 10^{23}$ molecule

18 g = mass of 6.02×10^{23} water molecules

Mass of one water molecule

$$= \frac{18}{6.023 \times 10^{23}}\text{ g}$$

Density $= 1\text{ g cm}^{-3}$

$$\text{Volume} = \frac{\text{Mass of one water molecule}}{\text{Density}}$$

$$= \frac{18}{6.023 \times 10^{23} \times 1}\text{ cm}^3$$

$$\approx 3.0 \times 10^{-23}\text{ cm}^3$$

24 The maximum number of molecules are present in **[CBSE AIPMT 2004]**

(a) 15 L of H_2 gas at STP

(b) 5 L of N_2 gas at STP

(c) 0.5 g of H_2 gas

(d) 10 g of O_2 gas

Ans. ***(a)***

In 15 L of H_2 gas at STP, the number of molecules

$$= \frac{6.023 \times 10^{23}}{22.4} \times 15$$

$$= 4.033 \times 10^{23}$$

In 5 L of N_2 gas at STP, the number of molecules

$$= \frac{6.023 \times 10^{23} \times 5}{22.4}$$

$$= 1.344 \times 10^{23}$$

In 0.5 g of H_2 gas, the number of molecules

$$= \frac{6.023 \times 10^{23} \times 0.5}{2}$$

$$= 1.505 \times 10^{23}$$

In 10 g of O_2 gas, the number of molecules

$$= \frac{6.023 \times 10^{23} \times 10}{32}$$

$$= 1.882 \times 10^{23}$$

Hence, maximum number of molecules are present in 15 L of H_2 at STP.

25 Percentage of Se in peroxidase anhydrase enzyme is 0.5% by weight (at. weight = 78.4), then minimum molecular weight of peroxidase anhydrase enzyme is **[CBSE AIPMT 2001]**

(a) 1.568×10^3 (b) 15.68

(c) 2.168×10^4 (d) 1.568×10^4

Ans. ***(d)***

Suppose the molecular weight of enzyme = x

0.5% by weight means in 100 g of enzyme weight of Se = 0.5 g

$$\therefore \text{ In } x\text{ g of enzyme weight of Se} = \frac{0.5}{100} \times x$$

$$\text{Hence,} \qquad 78.4 = \frac{0.5 \times x}{100}$$

$$\therefore \qquad x = 15680$$

$$= 1.568 \times 10^4$$

26 The number of atoms in 4.25 g of NH_3 is approximately **[CBSE AIPMT 1999]**

(a) 4×10^{23} (b) 2×10^{23}

(c) 1×10^{23} (d) 6×10^{23}

Ans. ***(d)***

Weight of $NH_3 = 4.25$ g

Number of moles of

$$NH_3 = \frac{\text{Weight}}{\text{Molecular weight}}$$

$$= \frac{4.25}{17} = 0.25\text{ mol}$$

Number of molecules in 0.25 mole of NH_3

$$= 0.25 \times 6.023 \times 10^{23}$$

So, number of atoms

$$= 4 \times 0.25 \times 6.023 \times 10^{23}$$

$$= 6.0 \times 10^{23}$$

27 Haemoglobin contains 0.33% of iron by weight. The molecular weight of haemoglobin is approximately 67200 g. The number of iron atoms (at. weight of Fe is 56) present in one molecule of haemoglobin are **[CBSE AIPMT 1998]**

(a) 1 (b) 6 (c) 4 (d) 2

Ans. ***(c)***

∵ 0.33 % of iron by weight means 100 g of haemoglobin has 0.33 g of iron

100 g of haemoglobin contains iron = 0.33 g

∴ 67200 g of haemoglobin contains iron

$$= \frac{0.33 \times 67200}{100}\text{ g}$$

$$= 221.76\text{ g of Fe}$$

Number of Fe-atoms $= \frac{221.76}{56}$

$= 3.96 \approx 4$

28 The number of moles of oxygen in 1 L of air containing 21% oxygen by volume, under standard conditions, is **[CBSE AIPMT 1995]**

(a) 0.0093 mole (b) 2.10 moles
(c) 0.186 mole (d) 0.21 mole

Ans. *(a)*

Volume of oxygen in 1 L of air

$= \frac{21}{100} \times 1000 = 210 \text{ mL}$

$\because$ 22400 mL volume at STP is occupied by oxygen = 1 mole

Therefore, number of moles occupied by 210 mL

$= \frac{210}{22400} = 0.0093 \text{ mol}$

29 The percentage weight of Zn in white vitriol $[ZnSO_4 \cdot 7H_2O]$ is approximately equal to (at. mass of Zn = 65, S = 32, O = 16 and H = 1) **[CBSE AIPMT 1995]**

(a) 33.65% (b) 32.56%
(c) 23.65% (d) 22.65%

Ans. *(d)*

Molecular weight of

$ZnSO_4 \cdot 7H_2O = 65 + 32 + (4 \times 16) + 7(18)$

$= 287$

$\therefore$ Percentage weight of Zn $= \frac{65}{287} \times 100$

$= 22.65\%$

30 The total number of valence electrons in 4.2 g of N_3^- ion is (N_A is the Avogadro's number) **[CBSE AIPMT 1994]**

(a) 2.1 N_A (b) 4.2 N_A (c) 1.6 N_A (d) 3.2 N_A

Ans. *(c)*

Moles of N_3^- ion $= \frac{4.2}{42} = 0.1$

Each nitrogen atom has 5 valence electrons. Therefore, total number of electrons in N_3^- ion = 16

Total number of electrons in 0.1 mole or 4.2 g of N_3^- ion $= 0.1 \times 16 \times N_A = 1.6\, N_A$

31 The number of gram molecules of oxygen in 6.02×10^{24} CO molecules is **[CBSE AIPMT 1990]**

(a) 10 g molecules (b) 5 g molecules
(c) 1 g molecule (d) 0.5 g molecule

Ans. *(b)*

6.023×10^{23} molecules of CO

= 1 mole of CO

6.02×10^{24} molecules of CO

= 10 moles of CO

= 10 g atoms of O = 5 g molecules of O_2

32 The number of oxygen atoms in 4.4 g of CO_2 is **[CBSE AIPMT 1990]**

(a) 1.2×10^{23} (b) 6×10^{22}
(c) 6×10^{23} (d) 12×10^{23}

Ans. *(a)*

1 mole of CO_2 = 44 g of CO_2

$= 6.023 \times 10^{23}$ molecules

$\therefore$ 4.4 g of CO_2 = 0.1 mole of CO_2

$= 6.023 \times 0.1 \times 10^{23}$ molecules

$= 6.023 \times 10^{22}$ molecules

$= 6.023 \times 10^{22}$ molecules of O_2

$= 2 \times 6.023 \times 10^{22}$ atoms of O

$\approx 1.2 \times 10^{23}$ atoms of O

33 Ratio of C_p and C_V of a gas 'X' is 1 : 4. The number of atoms of the gas 'X' present in 11.2 L of it at NTP will be **[CBSE AIPMT 1989]**

(a) 6.02×10^{23} (b) 1.2×10^{23}
(c) 3.01×10^{23} (d) 2.01×10^{23}

Ans. *(a)*

For the gas X ratio of $C_p / C_V = 1 : 4$

So, the gas X is diatomic.

At NTP, volume of 1 mole of a gas

= 22.4 L

1 mole of a gas $= 6.023 \times 10^{23}$ molecules

Thus, at NTP 22.4 L contains

$= 6.023 \times 10^{23}$ molecules

So, at NTP 11.2 L contains

$= \frac{6.023 \times 10^{23} \times 11.2}{22.4}$ molecules

$= 3.01 \times 10^{23}$ molecules

Hence, number of atoms of gas 'X' (diatomic)

$= 3.01 \times 10^{23} \times 2$ atoms

$= 6.02 \times 10^{23}$ atoms

34 1 cc N_2O at NTP contains **[CBSE AIPMT 1988]**

(a) $\frac{1.8}{224} \times 10^{22}$ atoms

(b) $\frac{6.02}{22400} \times 10^{23}$ molecules

(c) $\frac{1.32}{224} \times 10^{23}$ electrons

(d) All of the above

Ans. *(d)*

At NTP 22400 cc of N_2O contains

$= 6.02 \times 10^{23}$ molecules

$\therefore$ 1 cc N_2O will contain

$= \frac{6.02 \times 10^{23}}{22400}$ molecules

In N_2O molecule, number of atoms

$= 2 + 1 = 3$

Thus, number of atoms

$= \frac{3 \times 6.02 \times 10^{23}}{22400}$ atoms

$= \frac{1.8 \times 10^{22}}{224}$ atoms

In N_2O molecule, number of electrons

$= 7 + 7 + 8 = 22$

Hence, number of electrons

$= \frac{6.02 \times 10^{23}}{22400} \times 22$ electrons

$= \frac{1.32 \times 10^{23}}{224}$ electrons

35 At STP, the density of CCl_4 vapour in g/L will be nearest to **[CBSE AIPMT 1988]**

(a) 6.87 (b) 3.42 (c) 10.26 (d) 4.57

Ans. *(a)*

1 mole CCl_4 vapours

$= 12 + 4 \times 35.5 = 154$ g

At STP, volume of 1 mole of a gas

= 22.4 L

Thus, 154 g = 22.4 L

$\therefore$ Density of CCl_4 vapours $= \frac{154}{22.4}$ g L^{-1}

$= 6.87$ g L^{-1}

TOPIC 4

Stoichiometric and Volumetric Calculations

36 The number of moles of hydrogen molecules required to produce 20 moles of ammonia through Haber's process is **[NEET (National) 2019]**

(a) 20 (b) 30 (c) 40 (d) 10

Ans. *(b)*

According to Haber's process,

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

Now, according to above equations 2 moles of ammonia (NH_3) require = 3 moles of H_2

$\therefore$ 1 mole of NH_3 require = 3/2 moles of H_2

or, 20 moles of NH_3 require $= \frac{3}{2} \times 20$ moles of $H_2 = 30$ moles of H_2.

Note Involvement of any limiting reagent is not mentioned in question.

37 20.0 g of a magnesium carbonate sample decomposes on heating to give carbon dioxide and 8.0 g magnesium oxide. What will be the percentage purity of magnesium carbonate in the sample? (Atomic weight of Mg = 24)
[CBSE AIPMT 2015]

(a) 75 (b) 96 (c) 60 (d) 84

Ans. *(d)*

Key Concept *In the given problem we have provided practical yield of MgO. For calculation of percentage yield of MgO, we need theoretical yield of MgO. For this we shall use mole concept.*

$$MgCO_3(s) \longrightarrow MgO(s) + CO_2(g) \quad \text{...(i)}$$

$$\text{Moles of } MgCO_3 = \frac{\text{Weight in gram}}{\text{Molecular weight}} = \frac{20}{84} = 0.238 \text{ mol}$$

From Eq. (i)

1 mole of $MgCO_3$ gives = 1 mol MgO

$\therefore$ 0.238 mole $MgCO_3$ will give

$$= 0.238 \text{ mol MgO}$$
$$= 0.238 \times 40 \text{ g}$$
$$= 9.52 \text{ g MgO}$$

Now, practical yield of MgO = 8 g

$$\therefore \quad \% \text{ purity} = \frac{8}{9.52} \times 100 = 84\%$$

Alternate Method

$$\underset{84\text{ g}}{MgCO_3} \longrightarrow \underset{40\text{ g}}{MgO} + CO_2$$

$\therefore$ 8 g MgO will be form from $\frac{84}{5}$ g

$$\therefore \quad \% \text{ purity} = \frac{84}{5} \times \frac{100}{20} = 84\%$$

38 What is the mass of precipitate formed when 50 mL of 16.9% solution of $AgNO_3$ is mixed with 50 mL of 5.8% NaCl solution? (Ag = 107.8, N = 14, O = 16, Na = 23, Cl = 35.5)
[CBSE AIPMT 2015]

(a) 28 g (b) 3.5 g
(c) 7 g (d) 14 g

Ans. *(c)*

Plan For the calculation of mass of AgCl precipitated, we find mass of $AgNO_3$ and NaCl in equal volume with the help of mole concept.

16.9% solution of $AgNO_3$ means 16.9 g $AgNO_3$ is present in 100 mL solution.

$\therefore$ 8.45 g $AgNO_3$ will be present in 50 mL solution.

Similarly,

5.8 g NaCl is present in 100 mL solution

$\therefore$ 2.9 g NaCl is present in 50 mL solution

$$\begin{array}{lcccc} & AgNO_3 + & NaCl \longrightarrow & AgCl + & NaNO_3 \\ \text{Initial mole} & \frac{8.45}{169.8} & \frac{2.9}{58.5} & 0 & 0 \\ & = 0.049 & = 0.049 & & \\ \textbf{After reaction} & 0 & 0 & 0.049 & 0.049 \end{array}$$

$\therefore$ Mass of AgCl precipitated

$$= 0.049 \times 143.5 = 7 \text{ g}$$

39 When 22.4 L of $H_2(g)$ is mixed with 11.2 L of $Cl_2(g)$, each at STP, the moles of HCl(g) formed is equal to
[CBSE AIPMT 2014]

(a) 1 mole of HCl (g)
(b) 2 moles of HCl (g)
(c) 0.5 mole of HCl (g)
(d) 1.5 moles of HCl (g)

Ans. *(a)*

The given problem is related to the concept of stoichiometry of chemical equations. Thus, we have to convert the given volumes into their moles and then, identify the limiting reagent [possessing minimum number of moles and gets completely used up in the reaction]. The limiting reagent gives the moles of product formed in the reaction.

$$\begin{array}{lccc} & H_2(g) + & Cl_2(g) \longrightarrow & 2HCl(g) \\ \text{Initial vol.} & 22.4 \text{ L} & 11.2 \text{ L} & 2 \text{ mol} \end{array}$$

$\because$ 22.4 L volume at STP is occupied by

$Cl_2 = 1$ mole

$\therefore$ 11.2 L volume will be occupied by

$$Cl_2 = \frac{1 \times 11.2}{22.4} \text{ mol} = 0.5 \text{ mol}$$

22.4 L volume at STP is occupied by H_2 = 1 mol

$$\text{Thus, } \underset{1\text{ mol}}{H_2(g)} + \underset{0.5\text{ mol}}{Cl_2(g)} \longrightarrow 2HCl(g)$$

Since, Cl_2 possesses minimum number of moles, thus it is the limiting reagent.

As per equation,

1 mole of Cl_2 = 2 moles of HCl

$\therefore$ 0.5 mole of Cl_2 = 2×0.5 mole of HCl

= 1.0 mole of HCl

Hence, 1.0 mole of HCl(g) is produced by 0.5 mole of Cl_2 [or 11.2 L].

40 1.0 g of magnesium is burnt with 0.56 g of oxygen in a closed vessel. Which reactant is left in excess and how much? **[CBSE AIPMT 2014]**
(At. weight of Mg = 24, O = 16)

(a) Mg, 0.16 g
(b) O_2, 0.16 g
(c) Mg, 0.44 g
(d) O_2, 0.28 g

Ans. *(a)*

The balanced chemical equation is

$$\underset{24\text{ g}}{Mg} + \underset{16\text{ g}}{\frac{1}{2}O_2} \longrightarrow \underset{40\text{ g}}{MgO}$$

From the above equation, it is clear that, 24 g of Mg reacts with 16 g of O_2.

Thus, 1.0 g of Mg reacts with

$\frac{16}{24}$ g of O_2 = 0.67 g of O_2.

But only 0.56 g of O_2 is available which is less than 0.67 g. Thus, O_2 is the limiting reagent.

Further, 16 g of O_2 reacts with 24 g of Mg.

$\therefore$ 0.56 g of O_2 will react with Mg

$$= \frac{24}{16} \times 0.56$$
$$= 0.84 \text{ g}$$

$\therefore$ Amount of Mg left unreacted

$$= (1.0 - 0.84) \text{ g Mg}$$
$$= 0.16 \text{ g Mg}$$

41 10 g of hydrogen and 64 g of oxygen were filled in a steel vessel and exploded. Amount of water produced in this reaction will be
[CBSE AIPMT 2009]

(a) 2 moles (b) 3 moles
(c) 4 moles (d) 1 mole

Ans. *(c)*

$$\begin{array}{ccc} H_2 + & \frac{1}{2}O_2 \longrightarrow & H_2O \\ 1 \text{ mol} & \frac{1}{2} \text{ mol} & 1 \text{ mol} \\ \frac{10}{2} \text{ mol} & \frac{64}{32} \text{ mol} & ? \\ 5 \text{ mol} & 2 \text{ mol} & \end{array}$$

$\because$ $\frac{1}{2}$ mole of O_2 gives = 1 mole of H_2O

$\therefore$ 2 moles of O_2 will give = $1 \times 2 \times 2$

= 4 moles of water

42 How many moles of lead (II) chloride will be formed from a reaction between 6.5 g of PbO and 3.2 g of HCl? **[CBSE AIPMT 2008]**

(a) 0.044 (b) 0.333 (c) 0.011 (d) 0.029

Ans. ***(d)***

$$\underset{\substack{207+16\\=223\\(1\text{ mol})}}{\text{PbO}} + \underset{\substack{2\times 36.5\\=73\\(2\text{ mol})}}{2\text{HCl}} \longrightarrow \underset{(1\text{ mol})}{\text{PbCl}_2} + \text{H}_2\text{O}$$

$$\text{Mole of PbO} = \frac{6.5}{223} = 0.029$$

$$\text{Mole of HCl} = \frac{3.2}{36.5} = 0.087$$

Since, 1 mole of PbO reacts with 2 moles of HCl, thus in this reaction PbO is the limiting reagent.

Hence, 1 mole of PbO forms

$$= 1 \text{ mole of PbCl}_2$$

0.029 mole of PbO will form = 0.029 mole of PbCl_2

43 What volume of oxygen gas (O_2) measured at 0°C and 1 atm, is needed to burn completely 1L of propane gas (C_3H_8) measured under the same conditions? **[CBSE AIPMT 2008]**

(a) 7 L (b) 6 L

(c) 5 L (d) 10 L

Ans. ***(c)***

$$\underset{22.4\text{ L}}{\text{C}_3\text{H}_8} + \underset{5\times 22.4\text{ L}}{5\text{O}_2} \longrightarrow 3\text{CO}_2 + 4\text{H}_2\text{O}$$

For the combustion of 22.4 L propane, oxygen required = 5 × 22.4 L

For the combustion of 1 L of propane oxygen required

$$= \frac{5\times 22.4}{22.4}\text{ L} = 5\text{ L}$$

44 Number of moles of MnO_4^- required to oxidise one mole of ferrous oxalate completely in acidic medium will be **[CBSE AIPMT 2008]**

(a) 0.6 mole (b) 0.4 mole

(c) 7.5 moles (d) 0.2 mole

Ans. ***(b)***

In acidic medium MnO_4^- oxidises ferrous oxalate as follows:

$$2\text{MnO}_4^- + 5\text{C}_2\text{O}_4^{2-} + 16\text{H}^+ \longrightarrow 2\text{Mn}^{2+} + 10\text{CO}_2 + 8\text{H}_2\text{O}$$

∵ 5 moles of oxalate ions are oxidised by 2 moles of MnO_4^-.

∴ 1 mole of oxalate ion is oxidised by

$$= \frac{2}{5}\text{ mole of MnO}_4^- = 0.4\text{ mole of MnO}_4^-$$

45 The number of moles of KMnO_4 that will be needed to react with one mole of sulphite ion in acidic solution is **[CBSE AIPMT 2007]**

(a) 4/5 (b) 2/5

(c) 1 (d) 3/5

Ans. ***(b)***

$$2\text{KMnO}_4 + 3\text{H}_2\text{SO}_4 \longrightarrow \text{K}_2\text{SO}_4 + 2\text{MnSO}_4 + 3\text{H}_2\text{O} + 5[\text{O}]$$

$$[\text{MnO}_4^- + 8\text{H}^+ + 5e^- \longrightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O}] \times 2$$

$$[\text{SO}_3^{2-} + \text{H}_2\text{O} \longrightarrow \text{SO}_4^{2-} + 2\text{H}^+ + 2e^-] \times 5$$

$$2\text{MnO}_4^- + 6\text{H}^+ + 5\text{SO}_3^{2-} \longrightarrow 2\text{Mn}^{2+} + 5\text{SO}_4^{2-} + 3\text{H}_2\text{O}$$

5 moles of sulphite ions react with

$$= 2\text{ moles of MnO}_4^-$$

So, 1 mole of sulphite ions react with

$$= \frac{2}{5}\text{ moles of MnO}_4^-.$$

46 The number of moles of KMnO_4 reduced by one mole of KI in alkaline medium is **[CBSE AIPMT 2005]**

(a) one fifth (b) five

(c) one (d) two

Ans. ***(c)***

In alkaline medium, KMnO_4 is reduced to K_2MnO_4

$$\text{KI} + \text{H}_2\text{O} \longrightarrow \text{KOH} + \text{HI}$$

$$2\text{K}\overset{+7}{\text{Mn}}\text{O}_4 + 2\text{KOH} \longrightarrow 2\text{K}_2\overset{+6}{\text{Mn}}\text{O}_4 + \text{H}_2\text{O} + [\text{O}]$$

Hence, one mole of KMnO_4 is reduced by one mole of KI.

47 The mass of carbon anode consumed (giving only carbon dioxide) in the production of 270 kg of aluminium metal from bauxite by the Hall process is

(at. mass of Al = 27) **[CBSE AIPMT 2005]**

(a) 180 kg (b) 270 kg (c) 540 kg (d) 90 kg

Ans. ***(d)***

In Hall and Heroult process,

$$2\text{Al}_2\text{O}_3 + 4\text{C} \longrightarrow 4\text{Al} + 2\text{CO}_2 + 2\text{CO}$$

but for the removal of only CO_2, following equation is possible.

$$2\text{Al}_2\text{O}_3 + \underset{\substack{3\times 12\\=36}}{3\text{C}} \longrightarrow \underset{\substack{4\times 27\\=108}}{4\text{Al}} + 3\text{CO}_2$$

∵ For 108 g of Al, 36 g of C is required in above reaction.

∴ For 270×10^3 g of Al required amount of C

$$= \frac{36}{108} \times 270 \times 10^3$$

$$= 90 \times 10^3\text{ g} = 90\text{ kg}$$

48 In Haber process 30L of dihydrogen and 30L of dinitrogen were taken for reaction which yielded only 50% of the expected product. What will be the composition of gaseous mixture under the aforesaid condition in the end? **[CBSE AIPMT 2003]**

(a) 20 L ammonia, 10 L nitrogen, 30 L hydrogen

(b) 20 L ammonia, 25 L nitrogen, 15 L hydrogen

(c) 20 L ammonia, 20 L nitrogen, 20 L hydrogen

(d) 10 L ammonia, 25 L nitrogen, 15 L hydrogen

Ans. ***(d)***

$$\underset{\substack{1V\\10\text{ L}}}{\text{N}_2} + \underset{\substack{3V\\30\text{ L}}}{3\text{H}_2} \longrightarrow \underset{\substack{2V\\20\text{ L}}}{2\text{NH}_3}$$

As only 50% of the expected product is formed, hence only 10 L of NH_3 is formed.

Thus, for the production of 10 L of NH_3, 5 L of N_2 and 15 L of H_2 are used and composition of gaseous mixture under the aforesaid condition in the end is

$$\text{H}_2 = 30 - 15 = 15\text{ L}$$

$$\text{N}_2 = 30 - 5 = 25\text{ L}$$

$$\text{NH}_3 = 10\text{ L}$$

49 Which has maximum number of molecules? **[CBSE AIPMT 2002]**

(a) 7 g N_2 (b) 2 g H_2

(c) 16 g NO_2 (d) 16 g O_2

Ans. ***(b)***

In 7 g nitrogen, number of molecules

$$= \frac{7.0}{28}\text{ mol}$$

$$= 0.25 \times N_A \text{ molecules}$$

where, N_A = Avogadro numbe

$$= 6.023 \times 10^{23}$$

$$\text{In 2 g of H}_2 = \frac{2.0}{2}\text{ mol}$$

$$= 1 \times N_A \text{ molecules}$$

In 16 g of $NO_2 = \frac{16.0}{46}$ mol

$= 0.348 \times N_A$ molecules

In 16 g of

$O_2 = \frac{16}{32}$ mol $= 0.5 \times N_A$ molecules

Hence, maximum number of molecules are present in 2 g of H_2.

50 Assuming fully decomposed, the volume of CO_2 released at STP on heating 9.85 g of $BaCO_3$ (at. mass of Ba = 137) will be **[CBSE AIPMT 2000]**

(a) 1.12 L (b) 0.84 L
(c) 2.24 L (d) 4.96 L

Ans. *(a)*

On decomposition, $BaCO_3$ liberates CO_2 as

$$\underset{197\text{ g}}{BaCO_3} \longrightarrow BaO + \underset{22.4\text{ L at STP}}{CO_2 \uparrow}$$

$\because$ 197 g of $BaCO_3$ gives

$= 22.4$ L of CO_2 at STP

$\therefore$ 9.85 g of $BaCO_3$ will give

$$= \frac{22.4 \times 9.85}{197} = 1.12 \text{ L}$$

51 In the reaction,

$$4NH_3(g) + 5O_2(g) \longrightarrow 4NO(g) + 6H_2O(l)$$

When 1 mole of ammonia and 1 mole of O_2 are made to react to completion, then **[CBSE AIPMT 1998]**

(a) 1.0 mole of H_2O is produced
(b) 1.0 mole of NO will be produced
(c) all the oxygen will be consumed
(d) all the ammonia will be consumed

Ans. *(c)*

$$\underset{4\text{ mol}}{4NH_3(g)} + \underset{5\text{ mol}}{5O_2(g)} \longrightarrow \underset{4\text{ mol}}{4NO(g)} + \underset{6\text{ mol}}{6H_2O(l)}$$

According to equation,

5 moles of O_2 required = 4 moles of NH_3

1 mole of O_2 requires

$= \frac{4}{5} = 0.8$ mole of NH_3

While 1 mole of NH_3 requires $= \frac{5}{4}$

$= 1.25$ moles of O_2

As there is 1 mole of NH_3 and 1 mole of O_2, so all the oxygen will be consumed.

52 Liquid benzene (C_6H_6) burns in oxygen according to the equation,

$$2C_6H_6(l) + 15O_2(g) \longrightarrow 12CO_2(g) + 6H_2O(g)$$

How many litres of O_2 at STP are needed to complete the combustion of 39 g of liquid benzene? (Mol. weight of $O_2 = 32$, $C_6H_6 = 78$) **[CBSE AIPMT 1996]**

(a) 74 L (b) 11.2 L (c) 22.4 L (d) 84 L

Ans. *(d)*

$$\underset{\substack{2\times 78\\=156}}{2C_6H_6} + \underset{\substack{15\times 32\\=330}}{15O_2(g)} \longrightarrow 12CO_2(g) + 6H_2O(g)$$

$\because$ 156 g of benzene required oxygen

$= 15 \times 22.4$ L

$\therefore$ 1 g of benzene required oxygen

$= \frac{15 \times 22.4}{156}$ L

$\therefore$ 39 g of benzene required oxygen

$= \frac{15 \times 22.4 \times 39}{156}$

$= 84.0$ L

53 What is the weight of oxygen required for the complete combustion of 2.8 kg of ethylene? **[CBSE AIPMT 1989]**

(a) 2.8 kg (b) 6.4 kg
(c) 9.6 kg (d) 96 kg

Ans. *(c)*

$$\underset{\substack{12\times 2+4\times 1\\=28\text{ g}}}{C_2H_4} + \underset{\substack{16\times 6\\=96\text{ g}}}{3O_2} \longrightarrow 2CO_2 + 2H_2O$$

$\because$ For the combustion of 28×10^{-3} kg of ethylene oxygen required $= 96 \times 10^{-3}$ kg

$\therefore$ For the combustion of 2.8 kg of ethylene oxygen required

$$= \frac{96 \times 10^{-3} \times 2.8}{28 \times 10^{-3}}$$

$= 9.6$ kg

54 One litre hard water contains 12.00 mg Mg^{2+}. Milliequivalents of washing soda required to remove its hardness is **[CBSE AIPMT 1988]**

(a) 1
(b) 12.16
(c) 1×10^{-3}
(d) 12.16×10^{-3}

Ans. *(a)*

$$\underset{1\text{ g-eq}}{Mg^{2+}} + \underset{1\text{ g-eq}}{Na_2CO_3} \longrightarrow MgCO_3 + 2Na^+$$

1 g-equivalent of $Mg^{2+} = 12$ g of Mg^{2+}

$= 12000$ mg of Mg^{2+}

Now, 12000 mg of $Mg^{2+} \equiv 1000$ milliequivalent of Na_2CO_3

12 mg of $Mg^{2+} \equiv 1$ milliequivalent of Na_2CO_3

2

Atomic Structure

TOPIC 1

Preliminary Models

01 Which of the following is never true for cathode rays? **[CBSE AIPMT 1994]**

(a) They possess kinetic energy
(b) They are electromagnetic waves
(c) They produce heat
(d) They produce mechanical pressure

Ans. *(b)*

Cathode rays are not electromagnetic wave because they do not have electric and magnetic components perpendicular to each other.

TOPIC 2

Bohr's Model and Hydrogen Spectrum

02 The energies E_1 and E_2 of two radiations are 25 eV and 50 eV respectively. The relation between their wavelengths, i.e. λ_1 and λ_2 will be **[CBSE AIPMT 2011]**

(a) $\lambda_1 = 2\lambda_2$ (b) $\lambda_1 = 4\lambda_2$
(c) $\lambda_1 = \frac{1}{2}\lambda_2$ (d) $\lambda_1 = \lambda_2$

Ans. *(a)*

$$E_1 = 25\,\text{eV},\ E_2 = 50\,\text{eV}$$

$$E_1 = \frac{hc}{\lambda_1} \text{ and } E_2 = \frac{hc}{\lambda_2}$$

or $\dfrac{E_1}{E_2} = \dfrac{\lambda_2}{\lambda_1}$

or $\dfrac{25}{50} = \dfrac{\lambda_2}{\lambda_1}$

or $\lambda_1 = 2\lambda_2$

03 The energy absorbed by each molecule (A_2) of a substance is 4.4×10^{-19} J and bond energy per molecule is 4.0×10^{-19} J. The kinetic energy of the molecule per atom will be **[CBSE AIPMT 2009]**

(a) 2.0×10^{-20} J (b) 2.2×10^{-19} J
(c) 2.0×10^{-19} J (d) 4.0×10^{-20} J

Ans. *(a)*

Kinetic energy (KE) of molecule
= energy absorbed by molecule
− bond energy per molecule

$$= (4.4 \times 10^{-19}) - (4.0 \times 10^{-19})\ \text{J}$$
$$= 0.4 \times 10^{-19}\ \text{J}$$

KE per atom

$$= \frac{0.4 \times 10^{-19}}{2}\ \text{J}$$
$$= 2.0 \times 10^{-20}\ \text{J}$$

04 The energy of second Bohr orbit of the hydrogen atom is -328 kJ mol^{-1}, hence the energy of fourth Bohr orbit would be **[CBSE AIPMT 2005]**

(a) -41 kJ mol^{-1}
(b) -1312 kJ mol^{-1}
(c) -164 kJ mol^{-1}
(d) -82 kJ mol^{-1}

Ans. *(d)*

The energy of second Bohr orbit of hydrogen atom (E_2) is -328 kJ mol^{-1}

$$E_n = -\frac{1312}{n^2}\ \text{kJ mol}^{-1}$$

$$\therefore \quad E_2 = -\frac{1312}{2^2}\ \text{kJ mol}^{-1}$$

If $n = 4$

$$\therefore \quad E_4 = -\frac{1312}{4^2}\ \text{kJ mol}^{-1}$$
$$= -82\ \text{kJ mol}^{-1}$$

05 The frequency of radiation emitted when the electron falls from $n = 4$ to $n = 1$ in a hydrogen atom will be (Given ionisation energy of H = 2.18×10^{-18} J atom^{-1} and h = 6.625×10^{-34} Js) **[CBSE AIPMT 2004]**

(a) 1.54×10^{15} s^{-1} (b) 1.03×10^{15} s^{-1}
(c) 3.08×10^{15} s^{-1} (d) 2.00×10^{15} s^{-1}

Ans. *(c)*

Ionisation energy of H

$$= 2.18 \times 10^{-18}\ \text{J atom}^{-1}$$

$\therefore$ E_1 (Energy of Ist orbit of H-atom)

$$= -2.18 \times 10^{-18}\ \text{J atom}^{-1}$$

$$\therefore \quad E_n = \frac{-2.18 \times 10^{-18}}{n^2}\ \text{J atom}^{-1}$$

$Z = 1$ for H-atom

$$\Delta E = E_4 - E_1$$
$$= \frac{-2.18 \times 10^{-18}}{4^2} - \frac{-2.18 \times 10^{-18}}{1^2}$$
$$= -2.18 \times 10^{-18} \times \left[\frac{1}{4^2} - \frac{1}{1^2}\right]$$
$$\Delta E = -2.18 \times 10^{-18} \times -\frac{15}{16}$$
$$= +2.0437 \times 10^{-18}\ \text{J atom}^{-1}$$
$$\therefore \quad \nu = \frac{\Delta E}{h}$$
$$= \frac{2.0437 \times 10^{-18}\ \text{J atom}^{-1}}{6.625 \times 10^{-34}\ \text{J s}}$$
$$= 3.084 \times 10^{15}\ \text{s}^{-1}\ \text{atom}^{-1}$$

06 In hydrogen atom, energy of first excited state is -3.4 eV. Then, KE of same orbit of hydrogen atom is **[CBSE AIPMT 2002]**

(a) $+3.4$ eV (b) $+6.8$ eV
(c) -13.6 eV (d) $+13.6$ eV

Ans. *(a)*

$\because$ Total energy (E_n) = KE + PE

In first excited state $= \frac{1}{2}mv^2 + \left[-\frac{Ze^2}{r}\right]$

$$= +\frac{1}{2}\frac{Ze^2}{r} - \frac{Ze^2}{r}$$

Energy of first excited state is 3.4 eV

$$-3.4\,\text{eV} = -\frac{1}{2}\frac{Ze^2}{r}$$

$$\therefore \quad \text{KE} = \frac{1}{2}\frac{Ze^2}{r} = +3.4\,\text{eV}$$

07 Who modified Bohr's theory by introducing elliptical orbits for electron path? **[CBSE AIPMT 1999]**

(a) Hund (b) Thomson
(c) Rutherford (d) Sommerfeld

Ans. ***(d)***

Sommerfeld modified Bohr's theory. According to him electrons move in elliptical orbits in addition to circular orbits.

08 Bohr radius for the hydrogen atom ($n = 1$) is approximately 0.530Å. The radius for the first excited state ($n = 2$) is (in Å) **[CBSE AIPMT 1998]**

(a) 0.13 (b) 1.06 (c) 4.77 (d) 2.12

Ans. ***(d)***

$$r \propto n^2/Z$$

where, n = number of orbit

Z = atomic number

$\because \quad r_1 \propto n_1^2$

$r_2 \propto n_2^2$ ($Z = 1$ for H-atom)

So, $\frac{r_1}{r_2} = \frac{n_1^2}{n_2^2}$

$$\frac{0.530}{r_2} = \frac{1^2}{2^2}$$

$$\therefore \quad r_2 = 0.530 \times 4 = 2.120\,\text{Å}$$

09 The radius of hydrogen atom in the ground state is 0.53 Å. The radius of Li^{2+} ion (at. no. = 3) in a similar state is **[CBSE AIPMT 1995]**

(a) 0.17 Å (b) 0.53 Å
(c) 0.265 Å (d) 1.06 Å

Ans. ***(a)***

We know that r_n (H-like)

$$= \frac{r_n\,(\text{H-atom}) \times n^2}{Z}$$

For ground state, $n = 1$

$$\therefore \quad r_n\,(\text{Li}^{2+}) = \frac{0.53\,\text{Å} \times (1)^2}{3}$$

$(\text{Li}, Z = 3) = 0.17$ Å

10 When an electron of charge e and mass m moves with a velocity v about the nuclear charge Ze in circular orbit of radius r, the potential energy of the electrons is given by **[CBSE AIPMT 1994]**

(a) $\frac{Z^2e^2}{r}$ (b) $-\frac{Ze^2}{r}$ (c) $\frac{Ze^2}{r}$ (d) $\frac{mv^2}{r}$

Ans. ***(b)***

Potential energy = work done

$$= \int_{\infty}^{r} -\frac{Ze^2\,dr}{r^2} = -\frac{Ze^2}{r}$$

11 If ionisation potential for hydrogen atom is 13.6 eV, then ionisation potential for He^+ will be **[CBSE AIPMT 1993]**

(a) 54.4 eV (b) 6.8 eV
(c) 13.6 eV (d) 24.5 eV

Ans. ***(a)***

For hydrogen atom $Z = 1$

$$\therefore \text{ Ionisation energy, } E_H = \frac{2\pi^2 me^4}{n^2h^2} \quad \text{...(i)}$$

For He^+ ion, ($\text{He}^+ = 1s^1$)

so, (He^+ = H) ionisation energy,

$$E_{\text{He}^+} = \frac{2\pi^2 me^4 Z^2}{n^2h^2} \quad \text{...(ii)}$$

Eq (i)/Eq (ii), we get

$$E_{\text{He}^+} = E_H \times Z^2 = 13.6 \times 4 = 54.4\,\text{eV}$$

12 The energy of an electron in the nth Bohr orbit of hydrogen atom is **[CBSE AIPMT 1992]**

(a) $-\frac{13.6}{n^4}$ eV (b) $-\frac{13.6}{n^3}$ eV
(c) $-\frac{13.6}{n^2}$ eV (d) $-\frac{13.6}{n}$ eV

Ans. ***(c)***

Energy of an electron in an orbit,

$$E_n = -\frac{2\pi^2 me^4 Z^2}{n^2h^2} = -\frac{1311.8\,Z^2}{n^2}\,\text{kJ mol}^{-1}$$

$$E_n = -\frac{21.8 \times 10^{-12}\;Z^2}{n^2}\,\text{erg atom}^{-1}$$

$$E_n = -\frac{21.8 \times 10^{-19}\;Z^2}{n^2}\,\text{J atom}^{-1}$$

$$E_n = -\frac{13.6\,Z^2}{n^2}\,\text{eV atom}^{-1} = \frac{-13.6}{n^2}\,\text{eV atom}$$

($\because$ $Z = 1$ atomic number for hydrogen atom)

13 Which of the following statements do not form a part of Bohr's model of hydrogen atom? **[CBSE AIPMT 1989]**

(a) Energy of the electrons in the orbits are quantised
(b) The electron in the orbit nearest the nucleus has the lowest energy
(c) Electrons revolve in different orbits around the nucleus
(d) The position and velocity of electrons in the orbit cannot be determined simultaneously

Ans. ***(d)***

The main postulates of Bohr model of atom are

(i) The electrons in an atom revolve around the nucleus only in certain selected circular paths, called orbits.
(ii) The energy is emitted or absorbed only when the electrons jump from one energy level to another.
(iii) Only those orbits are permitted in which the angular momentum of the electron is a whole number multiple of $\frac{h}{2\pi}$ (where, h is Planck's constant) that's why only certain fixed orbits are allowed, i.e. the momentum of an electron is quantised.

14 If r is the radius of the first orbit, the radius of nth orbit of H-atom is given by **[CBSE AIPMT 1988]**

(a) rn^2 (b) rn
(c) $\frac{r}{n}$ (d) r^2n^2

Ans. ***(a)***

Radius of an orbit,

$$r_n = \frac{n^2h^2}{4\pi^2 me^2 Z}$$

$$= \frac{0.529n^2}{Z}\,\text{Å}$$

For H-atom, $Z = 1$

If $r_1 = r$

(according to question $r_1 = r$)

$$\therefore \quad r_n = \frac{r \times n^2}{1} = rn^2$$

15 The spectrum of helium is expected to be similar to that of **[CBSE AIPMT 1988]**

(a) H (b) Na
(c) Li^+ (d) He^+

Ans. ***(c)***

The spectrum of an atom depends on the number of electrons present in it. Here, helium has two electrons, so the spectrum of Li^+ ($Z = 3$) is similar to that of helium because both He and Li^+ have two electrons.

TOPIC 3

Wave Particle and Quality of Matter

16 A particular station of All India Radio, New Delhi, broadcasts on a frequency of 1,368 kHz (kilohertz). The wavelength of the electromagnetic radiation emitted by the transmitter is [Speed of light, $c = 3.0 \times 10^3 \text{ ms}^{-1}$] **[NEET 2021]**

(a) 219.3 m (b) 219.2 m

(c) 2192 m (d) 21.92 cm

Ans. ***(a)***

Frequency of electromagnetic radiation

$$\nu = 1368 \text{ kHz}$$
$$= 1368 \times 10^3 \text{ s}^{-1}$$

Speed of light, $c = 3 \times 10^8 \text{ ms}^{-1}$

Wavelength of electromagnetic radiation, $\lambda = \frac{c}{\nu}$

$$\lambda = \frac{3 \times 10^8 \text{ ms}^{-1}}{1368 \times 10^3 \text{ s}^{-1}} = 219.3 \text{ m}$$

17 In hydrogen atom, the de-Broglie wavelength of an electron in the second Bohr orbit is [Given that, Bohr radius, $a_0 = 52.9 \text{ pm}$] **[NEET (Odisha) 2019]**

(a) 211.6 pm (b) 211.6 π pm

(c) 52.9 π pm (d) 105.8 pm

Ans. ***(b)***

According to Bohr,

$$mvr = \frac{nh}{2\pi}$$

$$2\pi r = \frac{nh}{mv} = n\lambda \quad \text{...(i)} \left[\because \lambda = \frac{h}{mv}\right]$$

where, r = radius,
λ = wavelength
n = number of orbit

Also, $$r = \frac{a_0 n^2}{Z} \quad \text{...(ii)}$$

where, a_0 = Bohr radius = 52.9 pm
Z = atomic number

On substituting the value of 'r' from Eq. (ii) to Eq. (i), we get

$$n\lambda = \frac{2\pi n^2 a_0}{Z}$$

$$\lambda = \frac{2\pi n a_0}{Z}$$

$$\lambda = 2\pi \times 2 \times 52.9 \quad [\because n = 2, Z = 1]$$
$$= 211.6\pi \text{ pm}$$

18 Which one is the wrong statement? **[NEET 2017]**

(a) de-Broglie's wavelength is given by $\lambda = \frac{h}{mv}$, where
m = mass of the particle,
v = group velocity of the particle

(b) The uncertainty principle is $\Delta E \times \Delta t \geq h/4\pi$

(c) Half-filled and fully filled orbitals have greater stability due to greater exchange energy, greater symmetry and more balanced arrangement

(d) The energy of $2s$-orbital is less than the energy of $2p$-orbital in case of hydrogen like atoms

Ans. ***(d)***

(a) According to de-Broglie's equation,
Wavelength $(\lambda) = \frac{h}{mv}$
where, h = Planck's constant.
Thus, statement (a) is correct.

(b) According to Heisenberg uncertainty principle, the uncertainties of position (Δx) and momentum $(p = m\Delta v)$ are related as

$$\Delta x \,.\, \Delta p \geq \frac{h}{4\pi}$$

or, $$\Delta x \,.\, m\Delta v \geq \frac{h}{4\pi}$$

$$\Delta x \,.\, m \,.\, \Delta a \,.\, \Delta t \geq \frac{h}{4\pi}$$

$$\left[\frac{\Delta v}{\Delta t} = \Delta a, a = \text{acceleration}\right]$$

or, $$\Delta x \cdot F \cdot \Delta t \geq \frac{h}{4\pi} \quad [\because F = m \cdot \Delta a]$$

or, $$\Delta E \cdot \Delta t \geq \frac{h}{4\pi}$$

$$[\because \Delta E = F \cdot \Delta x, E = \text{ energy}]$$

Thus, statement (b) is correct.

(c) The half and fully filled orbitals have greater stability due to greater exchange energy, greater symmetry and more balanced arrangement. Thus statement (c) is correct.

(d) For a single electronic species like H, energy depends on value of n and does not depend on l. Hence energy of $2s$-orbital. and $2p$-orbital is equal in case of hydrogen like species. Therefore, statement (d) is incorrect.

19 How many electrons can fit in the orbital for which $n = 3$ and $l = 1$? **[NEET (Phase II) 2016]**

(a) 2 (b) 6

(c) 10 (d) 14

Ans. ***(a)***

According to Hund's rule of maximum multiplicity, An orbital can accommodate a maximum number of 2 electrons of exactly opposite spin. Hence, option (a) is correct.

Caution Remember, maximum number of electrons in an orbital do not depend upon the quantum numbers as given in the question.

20 The number of d-electrons in Fe^{2+} $(Z = 26)$ is not equal to the number of electrons in which one of the following? **[CBSE AIPMT 2015]**

(a) s-electrons in Mg $(Z = 12)$

(b) p-electrons in Cl $(Z = 17)$

(c) d-electrons in Fe $(Z = 26)$

(d) p-electrons in Ne $(Z = 10)$

Ans. ***(b)***

Electronic configuration of Fe^{2+} is $[Ar]3d^6 4s^0$.

$\therefore$ Number of electrons = 6

Mg – $1s^2 2s^2 2p^6 3s^2$ (6s electrons)

It matches with the 6d electrons of Fe^{2+}

Cl – $1s^2 2s^2 2p^6 3s^2 3p^5$ (11p electrons)

It does not match with the 6d electrons of Fe^{2+}.

Fe – $[Ar]3d^6 4s^2$ (6d electrons)

It matches with the 6d electrons of Fe^{2+}.

Ne – $1s^2 2s^2 2p^6$ (6p electrons)

It matches with the 6d electrons of Fe^{2+}.

Hence, Cl has 11p electrons which does not matches in number with 6d electrons of Fe^{2+}.

21 The angular momentum of electrons in d orbital is equal to **[CBSE AIPMT 2015]**

(a) $\sqrt{6}\,h$ (b) $\sqrt{2}\,h$ (c) $2\sqrt{3}\,h$ (d) $0\,h$

Ans. ***(a)***

Angular momentum of electron in d-orbital is

$$= \sqrt{l(l+1)}\,\frac{h}{2\pi} \text{ ; for } d\text{-orbital, } l = 2$$

$$= \sqrt{2(2+1} \qquad \left(\because \hbar = \frac{h}{2\pi}\right)$$

$$h = \sqrt{6}\,h$$

22 Calculate the energy in joule corresponding to light of wavelength 45 nm (Planck's constant, $h = 6.63 \times 10^{-34}$ Js; speed of light, $c = 3 \times 10^8 \text{ ms}^{-1}$). **[CBSE AIPMT 2014]**

(a) 6.67×10^{15} (b) 6.67×10^{11}

(c) 4.42×10^{-15} (d) 4.42×10^{-18}

Ans. *(d)*

The wavelength of light is related to its energy by the equation, $E = \frac{hc}{\lambda}$. $(E = h\nu)$

Given, $\lambda = 45\,\text{nm} = 45 \times 10^{-9}$ m

$[\because 1\,\text{nm} = 10^{-9}\,\text{m}]$

Hence, $E = \frac{6.63 \times 10^{-34}\ \text{Js} \times 3 \times 10^{8}\ \text{m s}^{-1}}{45 \times 10^{-9}\ \text{m}}$

$= 4.42 \times 10^{-18}$ J

Hence, the energy corresponds to light of wavelength 45 nm is 4.42×10^{-18} J.

23 The value of Planck's constant is 6.63×10^{-34} Js. The speed of light is 3×10^{17} nm s^{-1}. Which value is closest to the wavelength in nanometer of a quantum of light with frequency of $6 \times 10^{15}\ \text{s}^{-1}$? **[NEET 2013]**

(a) 10 (b) 25
(c) 50 (d) 75

Ans. *(c)*

Given, Planck's constant,

$h = 6.63 \times 10^{-34}$ Js

Speed of light, $c = 3 \times 10^{17}\ \text{nm s}^{-1}$

Frequency of quantam light

$\nu = 6 \times 10^{15}\ \text{s}^{-1}$

Wavelength, $\lambda = ?$

We know that, $\nu = \frac{c}{\lambda}$ or $\lambda = \frac{c}{\nu}$

$= \frac{3 \times 10^{17}}{6 \times 10^{15}}$

$= 0.5 \times 10^{2}$ nm $= 50$ nm

24 The measurement of the electron position is associated with an uncertainty in momentum, which is equal to 1×10^{-18} g cm s^{-1}. The uncertainty in electron velocity is (mass of an electron is 9×10^{-28} g) **[CBSE AIPMT 2008]**

(a) 1×10^{9} cm s^{-1}
(b) 1×10^{6} cm s^{-1}
(c) 1×10^{5} cm s^{-1}
(d) 1×10^{11} cm s^{-1}

Ans. *(a)*

Given, $\Delta p = 1 \times 10^{-18}$ g cm s^{-1} (uncertainty in momentum)

Mass $= 9 \times 10^{-28}$ g

$\Delta p = m\Delta v$

$1 \times 10^{-18} = 9 \times 10^{-28} \times \Delta v$

(uncertainty in velocity)

$\Delta v = 1 \times 10^{9}\ \text{cm s}^{-1}$

25 If uncertainty in position and momentum are equal, then uncertainty in velocity is **[CBSE AIPMT 2008]**

(a) $\frac{1}{2m}\sqrt{\frac{h}{\pi}}$ (b) $\sqrt{\frac{h}{2\pi}}$
(c) $\frac{1}{m}\sqrt{\frac{h}{\pi}}$ (d) $\sqrt{\frac{h}{\pi}}$

Ans. *(a)*

According to Heisenberg's uncertainty principle

$\Delta x \cdot \Delta p = \frac{h}{4\pi}$

Given, $\Delta x = \Delta p$ (Δx = uncertainty in position)

$(\Delta p)^2 = \frac{h}{4\pi}$ $(\Delta p = m \times \Delta v)$

$m^2 \Delta v^2 = \frac{h}{4\pi}$ m = mass

$\Delta v^2 = \frac{h}{m^2 4\pi} \Rightarrow \Delta v = \frac{1}{2m}\sqrt{\frac{h}{\pi}}$

(Δv = uncertainty in velocity)

26 Given, the mass of electron is 9.11×10^{-31} kg, Planck's constant is 6.626×10^{-34} Js, the uncertainty involved in the measurement of velocity within a distance of 0.1 Å is **[CBSE AIPMT 2006]**

(a) $5.79 \times 10^{6}\ \text{ms}^{-1}$ (b) $5.79 \times 10^{7}\ \text{ms}^{-1}$
(c) $5.79 \times 10^{8}\ \text{ms}^{-1}$ (d) $5.79 \times 10^{5}\ \text{ms}^{-1}$

Ans. *(a)*

By Heisenberg's uncertainty principle

$\Delta x \times \Delta p_x \geq \frac{h}{4\pi}$ or $\Delta x \times \Delta(mv_x) \geq \frac{h}{4\pi}$

$\Delta x \times \Delta v_x \geq \frac{h}{4\pi m}$

Δp = uncertainty in momentum
Δx = uncertainty in position
Δv = uncertainty in velocity
m = mass of particle

Given that,

$\Delta x = 0.1\,\text{Å} = 0.1 \times 10^{-10}$ m

$m = 9.11 \times 10^{-31}$ kg

h = Planck's constant $= 6.626 \times 10^{-34}$ Js

$\pi = 3.14$

Thus,

$\Delta v \times 0.1 \times 10^{-10} = \frac{6.626 \times 10^{-34}}{4 \times 3.14 \times 9.11 \times 10^{-31}}$

$\Delta v = \frac{6.626 \times 10^{-34}}{4 \times 3.14 \times 9.11 \times 10^{-31} \times 0.1 \times 10^{-10}}\ \text{ms}^{-1}$

$= 5.785 \times 10^{6}\ \text{ms}^{-1}$

$= 5.79 \times 10^{6}\ \text{ms}^{-1}$

27 The value of Planck's constant is 6.63×10^{-34} Js. The velocity of light is $3.0 \times 10^{8}\ \text{ms}^{-1}$. Which value is closest to the wavelength in nanometers of a quantum of light with frequency of $8 \times 10^{15}\ \text{s}^{-1}$? **[CBSE AIPMT 2003]**

(a) 4×10^{1} (b) 3×10^{7}
(c) 2×10^{-25} (d) 5×10^{-18}

Ans. *(a)*

Frequency $(\nu) = \frac{c}{\lambda} = \frac{3 \times 10^{8}\ \text{m s}^{-1}}{8 \times 10^{15}\ \text{s}^{-1}}$

$= 0.375 \times 10^{-7}$ m

$= 3.75 \times 10^{1}\ \text{nm} \approx 4 \times 10^{1}$ nm

28 The energy of photon is given as : Δe/atom $= 3.03 \times 10^{-19}$ J atom^{-1}, then the wavelength (λ) of the photon is **[CBSE AIPMT 2000]**

(Given, h (Planck's constant) $= 6.63 \times 10^{-34}$ Js, c (velocity of light) $= 3.00 \times 10^{8}\ \text{ms}^{-1}$)

(a) 6.56 nm (b) 65.6 nm
(c) 656 nm (d) 0.656 nm

Ans. *(c)*

According to formula, $E = \frac{hc}{\lambda}\left(\nu = \frac{c}{\lambda}\right)$

Energy $E = h\nu$

$3.03 \times 10^{-19} = \frac{hc}{\lambda}$

$\lambda = \frac{6.63 \times 10^{-34} \times 3.0 \times 10^{8}}{3.03 \times 10^{-19}}$

$= 6.56 \times 10^{-7}$ m

$= 6.56 \times 10^{-7} \times 10^{9}$ nm

$= 6.56 \times 10^{2}$ nm

$= 656$ nm

29 The de-Broglie wavelength of a particle with mass 1 g and velocity 100 m/s is **[CBSE AIPMT 1999]**

(a) 6.63×10^{-33} m (b) 6.63×10^{-34} m
(c) 6.63×10^{-35} m (d) 6.65×10^{-36} m

Ans. *(a)*

$p = \frac{h}{\lambda}$ (de-Broglie equation)

$\lambda = \frac{h}{mv}$ $(\because p = mv)$

$h = 6.625 \times 10^{-34}$

$\approx 6.63 \times 10^{-34}$ kg/s

$\lambda = \frac{6.63 \times 10^{-34}\ \text{kg m}^2/\text{s}}{10^{-3}\,\text{kg} \times 100\ \text{m/s}}$

$= 6.63 \times 10^{-33}$ m

30 The uncertainty in momentum of an electron is 1×10^{-5} kg m/s. The uncertainty in its position will be (Given, $h=6.62\times10^{-34}$ kg m^2/s) **[CBSE AIPMT 1999]**

(a) 1.05×10^{-28} m (b) 1.05×10^{-26} m
(c) 5.27×10^{-30} m (d) 5.25×10^{-28} m

Ans. ***(c)***

According to Heisenberg's uncertainty principle

$$\Delta p\times\Delta x\geq\frac{h}{4\pi}$$

Uncertainty in momentum

$$\Delta p=1\times10^{-5}\text{ kg m/s}$$

$$1\times10^{-5}\times\Delta x=\frac{6.62\times10^{-34}}{4\times\frac{22}{7}}\quad\text{(Given)}$$

$$\Delta x=\frac{6.62\times10^{-34}\times7}{1\times10^{-5}\times4\times22}$$

$$=5.265\times10^{-30}\text{ m}$$

$$\approx5.27\times10^{-30}\text{ m}$$

31 The position of both, an electron and a helium atom is known within 1.0 mm. Further the momentum of the electron is known within 5.0×10^{-26} kg ms^{-1}. The minimum uncertainty in the measurement of the momentum of the helium atom is **[CBSE AIPMT 1998]**

(a) 50 kg ms^{-1}
(b) 80 kg ms^{-1}
(c) 80×10^{-26} kg ms^{-1}
(d) 5.0×10^{-26} kg ms^{-1}

Ans. ***(d)***

By Heisenberg's uncertainty principle

$$\Delta x\times\Delta p\geq\frac{h}{4\pi}$$

when the position of electron and helium atom is same and momentum of electron is known within a range, therefore the momentum of helium atom is also equal to the momentum of electron, i.e.

$$5\times10^{-26}\text{ kg m s}^{-1}$$

32 The momentum of a particle having a de-Broglie wavelength of 10^{-17} m is **[CBSE AIPMT 1996]**

(Given, $h=6.625\times10^{-34}$ m)

(a) 3.3125×10^{-7} kg m s^{-1}
(b) 26.5×10^{-7} kg m s^{-1}
(c) 6.625×10^{-17} kg m s^{-1}
(d) 13.25×10^{-17} kg m s^{-1}

Ans. ***(c)***

According to de-Broglie relation,

$$\lambda=\frac{h}{mv}=\frac{h}{p}$$

where, λ = wavelength
h = Planck's constant
p = momentum

Here, $h=6.625\times10^{-34}$ J s
$\lambda=10^{-17}$ m

$$\therefore\quad p=\frac{h}{\lambda}=\frac{6.625\times10^{-34}}{10^{-17}}$$

$$=6.625\times10^{-34}\times10^{17}$$

$$=6.625\times10^{-17}\text{ kg m s}^{-1}$$

33 Uncertainty in position of an electron (mass of an electron is $=9.1\times10^{-28}$ g) moving with a velocity of 3×10^4 cm/s accurate upto 0.001% will be (use $\frac{h}{4\pi}$ in uncertainty expression where $h=6.626\times10^{-27}$ erg s) **[CBSE AIPMT 1995]**

(a) 1.93 cm (b) 3.84 cm
(c) 5.76 cm (d) 7.68 cm

Ans. ***(a)***

According to Heisenberg's uncertainty principle

$$\Delta x\times\Delta v=\frac{h}{4\pi m}$$

Here, Δx = uncertainty in position
Δv = uncertainty in velocity
h = Planck's constant (6.626×10^{-27} Js)
m = mass of electron (9.1×10^{-28} kg)

Here, $\Delta v=0.001\%$ of 3×10^4

$$=\frac{0.001}{100}\times3\times10^4=0.3\text{ cm/s}$$

$$\therefore\quad\Delta x=\frac{h}{4\pi m\Delta v}$$

$$=\frac{6.626\times10^{-27}}{4\times3.14\times9.1\times10^{-28}\times0.3}=1.93\text{ cm}$$

34 In the photoelectron emission, the energy of the emitted electron is **[CBSE AIPMT 1994]**

(a) greater than the incident photon
(b) same as that of the incident photon
(c) smaller than the incident photon
(d) proportional to the intensity of incident photon

Ans. ***(c)***

In the photoelectric effect, the energy of the emitted electron is smaller than that of the incident photon because some energy of photon is used to eject the electron and remaining energy is used to increase the kinetic energy of ejected electron.

35 The electron was shown experimentally to have wave properties by **[CBSE AIPMT 1994]**

(a) de-Broglie
(b) N Bohr
(c) Davisson and Germer
(d) Schrödinger

Ans. ***(c)***

The wave nature of an electron is proved by Davisson and Germer experiment. In this experiment the scattering pattern of an electron is similar to that of X-rays.

TOPIC 4

Quantum Mechanical, Model and Electronic Configuration

36 The number of angular nodes and radial nodes in 3s orbital are **[NEET (Oct.) 2020]**

(a) 0 and 2, respectively
(b) 1 and 0, respectively
(c) 3 and 0, respectively
(d) 0 and 1, respectively

Ans. ***(a)***

For 3s-orbital, $n=3, l=0$

Number of radial nodes

$$=(n-l-1)=3-0-1=2$$

Number of angular nodes $=l=0$.

Hence, option (a) is correct.

37 $4d$, $5p$, $5f$ and $6p$-orbitals are arranged in the order of decreasing energy. The correct option is **[NEET (National) 2019]**

(a) $6p>5f>5p>4d$
(b) $5p>5f>4d>5p$
(c) $5f>6p>4d>5p$
(d) $5f>6p>5p>4d$

Ans. ***(d)***

The order of energy of orbitals can be calculated from $(n+l)$ rule. The lower the value of $(n+l)$ for an orbital, lower is its energy. If two orbitals have same $(n+l)$ value, the orbital with lower value of n has the lower energy.

(i) $6p=6+1=7$ (ii) $5f=5+3=8$
(iii) $4d=4+2=6$ (iv) $5p=5+1=6$

$\therefore$ The order of decreasing energy will be $5f>6p>5p>4d$.

38 Orbital having 3 angular nodes and 3 total nodes is **[NEET (Odisha) 2019]**

(a) 5 *p* (b) 3 *d*
(c) 4 *f* (d) 6 *d*

Ans. *(c)*

Angular node $(l) = 3$

Total node = radial node + angular node

$$3 = (n - l - 1) + l$$

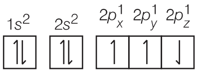
$$3 = n - 1$$

$$\Rightarrow \quad n = 4$$

∴ Orbital having 3 angular nodes and 3 total nodes is $= nl = 4f$ [∵ $l = 3$ for *f*-orbital]

39 Which one is a wrong statement? **[NEET 2018]**

(a) The electronic configuration of N-atom is



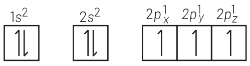
(b) An orbital is designated by three quantum numbers while an electron in an atom is designated by four quantum numbers

(c) Total orbital angular momentum of electron in 's' orbital is equal to zero

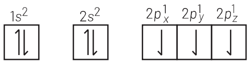
(d) The value of *m* for d_{z^2} is zero

Ans. *(a)*

According to Hund's rule "the pairing of electrons in the orbitals of a particular subshell does not takes place until all the orbitals of a subshell are singly occupied. Moreover, the singly orbitals must have the electrons with parallel spin. i.e.



or



∴ Option (a) is the incorrect option.

40 Two electrons occupying the same orbital are distinguished by **[NEET (Phase I) 2016]**

(a) Magnetic quantum number
(b) Azimuthal quantum number
(c) Spin quantum number
(d) Principal quantum number

Ans. *(c)*

Two electrons occupying the same orbital has equal spin but the directions of their spin are opposite. Hence, spin quantum number, *s*, (represented +1/2 and – 1/2) distinguishes them.

41 Which is the correct order of increasing energy of the listed orbitals in the atom of titanium? **[CBSE AIPMT 2015]**

(a) 3*s* 4*s* 3*p* 3*d* (b) 4*s* 3*s* 3*p* 3*d*
(c) 3*s* 3*p* 3*d* 4*s* (d) 3*s* 3*p* 4*s* 3*d*

Ans. *(c)*

According to Aufbau rule

$$3s < 3p < 3d < 4s$$

42 What is the maximum numbers of electrons that can be associated with the following set of quantum numbers?

$$n = 3, l = 1 \text{ and } m = -1$$

[NEET 2013]

(a) 10 (b) 6
(c) 4 (d) 2

Ans. *(d)*

The orbital of the electron having $n = 3$, $l = 1$ and $m = -1$ is $3p_z$ (as nl_m) and an orbital can have a maximum number of two electrons with opposite spins.

∴ $3p_z$ orbital contains only two electrons or only 2 electrons are associated with $n = 3$, $l = 1$, $m = -1$.

43 Maximum number of electrons in a subshell with $l = 3$ and $n = 4$ is **[CBSE AIPMT 2012]**

(a) 14 (b) 16 (c) 10 (d) 12

Ans. *(a)*

n represents the main energy level and *l* represents the subshell.

If $n = 4$ and $l = 3$, the subshell is 4*f*.

In *f*-subshell, there are 7 orbitals and each orbital can accommodate a maximum number of two electrons, so maximum number of electrons in 4*f* subshell $= 7 \times 2 = 14$.

44 The correct set of four quantum numbers for the valence electron of rubidium atom (at. no. = 37) is **[CBSE AIPMT 2012]**

(a) $5, 1, 1, +\frac{1}{2}$ (b) $6, 0, 0, +\frac{1}{2}$

(c) $5, 0, 0, +\frac{1}{2}$ (d) $5, 1, 0, +\frac{1}{2}$

Ans. *(c)*

$_{37}\text{Rb} = {}_{36}[\text{Kr}]\, 5s^1$

Its valence electron is $5s^1$.

$$n = 5$$

$$l = 0 \quad \text{(For } s\text{-orbital)}$$

$$m = 0 \quad (\text{As } m = -l \text{ to } + l)$$

$$s = +\frac{1}{2}$$

45 If $n = 6$, the correct sequence for filling of electrons will be **[CBSE AIPMT 2011]**

(a) $ns \longrightarrow (n-1)d \longrightarrow (n-2)f \longrightarrow np$
(b) $ns \longrightarrow (n-2)f \longrightarrow np \longrightarrow (n-1)d$
(c) $ns \longrightarrow np \longrightarrow (n-1)d \longrightarrow (n-2)f$
(d) $ns \longrightarrow (n-2)f \longrightarrow (n-1)d \longrightarrow np$

Ans. *(d)*

$6s \rightarrow 4f \rightarrow 5d \rightarrow 6p$ for $n = 6$

46 Which of the following is not permissible arrangement of electrons in an atom? **[CBSE AIPMT 2009]**

(a) $n = 4, l = 0, m = 0, s = -1/2$
(b) $n = 5, l = 3, m = 0, s = +1/2$
(c) $n = 3, l = 2, m = -3, s = -1/2$
(d) $n = 3, l = 2, m = -2, s = -1/2$

Ans. *(c)*

If $n = 3$,

$$l = 0 \text{ to } (3 - 1) = 0, 1, 2$$

$$m = -l \text{ to } +l = -2, -1, 0, +1, +2$$

$$s = \pm\frac{1}{2}$$

Therefore, option (c) is not a permissible set of quantum numbers.

47 Maximum number of electrons in a subshell of an atom is determined by the following **[CBSE AIPMT 2009]**

(a) $4l + 2$ (b) $2l + 1$
(c) $4l - 2$ (d) $2n^2$

Ans. *(a)*

Total number of subshells $= (2l + 1)$

∴ Maximum number of electrons in the subshell

$$= 2(2l + 1) = 4l + 2$$

48 Consider the following sets of quantum numbers.

	n	**l**	**m**	**s**
(i)	3	0	0	+1/2
(ii)	2	2	1	+1/2
(iii)	4	3	–2	–1/2
(iv)	1	0	–1	–1/2
(v)	3	2	3	+1/2

Which of the following sets of quantum number is not possible? **[CBSE AIPMT 2007]**

(a) (ii), (iii) and (iv) (b) (i), (ii), (iii) and (iv)
(c) (ii), (iv) and (v) (d) (i) and (iii)

Ans. *(d)*

The value of l varies from 0 to $(n-1)$ and the value of m varies from $-l$ to $+l$ through zero.

The value of 's' $\pm\frac{1}{2}$ which signifies the spin of electron. The correct sets of quantum number are following

	n	l	m	s
(ii)	2	1	1	$-\frac{1}{2}$
(iv)	1	0	0	$-\frac{1}{2}$
(v)	3	2	2	$+\frac{1}{2}$

49 The orientation of an atomic orbital is governed by **[CBSE AIPMT 2006]**

(a) azimuthal quantum number
(b) spin quantum number
(c) magnetic quantum number
(d) principal quantum number

Ans. *(c)*

The orientation of an atomic orbital is governed by magnetic quantum number.

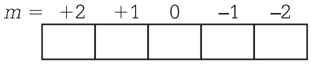
50 The following quantum numbers are possible for how many orbital(s) $n=3, l=2$ and $m=+2$? **[CBSE AIPMT 2001]**

(a) 1 (b) 2
(c) 3 (d) 4

Ans. *(a)*

$$n=3, l=2, m=+2, s=\pm 1/2$$

These values of quantum numbers are possible for only one of the five 3d-orbitals as +2 value of m is possible only for one orbital.



51 Which of the following configuration is correct for iron? **[CBSE AIPMT 1999]**

(a) $1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^5$
(b) $1s^2, 2s^2 2p^6, 3s^2 3p^6, 4s^2, 3d^5$
(c) $1s^2, 2s^2 2p^6, 3s^2 3p^6, 4s^2, 3d^7$
(d) $1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^6, 4s^2$

Ans. *(d)*

Firstly the electrons are filled in increasing order of energy and then rearrange the subshells in increasing order as

$${}_{26}\text{Fe} = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^6, 4s^2$$

52 The electronic configuration of gadolinium (at. no. = 64) is **[CBSE AIPMT 1997]**

(a) $[\text{Xe}]\,4f^8, 5d^9, 6s^2$
(b) $[\text{Xe}]\,4f^{7,}\,5d^1, 6s^2$
(c) $[\text{Xe}]\,4f^6, 5d^2, 6s^2$
(d) $[\text{Xe}]\,4f^3, 5d^5, 6s^2$

Ans. *(b)*

$$\begin{aligned}\text{Gd}_{64} &= 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^{10},\\ &\quad 4s^2 4p^6 4d^{10} 4f^7, 5s^2 5p^6 5d^1, 6s^2\\ &= [\text{Xe}]\,4f^7, 5d^1, 6s^2\end{aligned}$$

53 The orbitals are called degenerate when **[CBSE AIPMT 1996]**

(a) they have the same wave functions
(b) they have the same wave functions but different energies
(c) they have different wave functions but same energy
(d) they have the same energy

Ans. *(d)*

The orbitals having the same energy energy but different in orientation, are called degenerate orbitals. e.g. 3d-orbital, $l=2, m=-2, -1, 0, +1, +2$, i.e. there are five different orientations represented by d_{xy}, $d_{yz}, d_{zx}, d_{x^2-y^2}$ and d_{z^2}.

54 If an electron has spin quantum number $+\frac{1}{2}$ and magnetic quantum number −1, it cannot be present in **[CBSE AIPMT 1994]**

(a) d-orbital (b) f-orbital
(c) p-orbital (d) s-orbital

Ans. *(d)*

Spatial orientation of the orbital with respect to standard set of cordinate axis. Magnetic quantum number −1 is possible only when the azimuthal quantum number have value $l=1$, which is possible for p, d and f-subshells but not for s-subshell because the value of l for s-subshell is zero.

55 For which one of the following sets of four quantum numbers, an electron will have the highest energy? **[CBSE AIPMT 1994]**

	n	**l**	**m**	**s**
(a)	3	2	1	$\frac{1}{2}$
(b)	4	2	−1	$\frac{1}{2}$
(c)	4	1	0	$-\frac{1}{2}$
(d)	5	0	0	$-\frac{1}{2}$

Ans. *(b)*

For $n=3, l=2$ the subshell is 3d $(n+l=5)$

$n=4, l=2$ the subshell is 4d $(n+l=6)$

$n=4, l=1$ the subshell is 4p $(n+l=5)$

$n=5, l=0$, the subshell is 5s $(n+l=5)$

According to $(n+l)$ rule greater the $(n+l)$ value, greater the energy that is 6.

56 Electronic configuration of calcium atom can be written as **[CBSE AIPMT 1992]**

(a) $[\text{Ne}]\,4p^2$
(b) $[\text{Ar}]\,4s^2$
(c) $[\text{Ne}]\,4s^2$
(d) $[\text{Kr}]\,4p^2$

Ans. *(b)*

To write the electronic configuration of an atom, it is better if we remember the atomic number of noble gases and the orbitals follow the noble gas. The atomic number of Ca is 20 and its nearest noble gas is argon (Ar = 18).

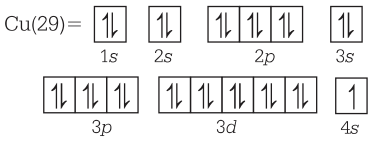
Hence, the electronic configuration of Ca = [Ar] $4s^2$.

57 The electronic configuration of Cu (at.no. = 29) is **[CBSE AIPMT 1991]**

(a) $1s^2, 2s^2 2p^6, 3s^2 3p^6, 4s^2, 3d^9$
(b) $1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^{10}, 4s^1$
(c) $1s^2, 2s^2 2p^6, 3s^2 3p^6, 4s^2 4p^6, 5s^2 5p^1$
(d) $1s^2, 2s^2 2p^6, 3s^2 3p^6, 4s^2 4p^6, 3d^3$

Ans. *(b)*

The electronic configuration of Cu (29) is an exceptional case due to exchange of energy and symmetrical distribution of electrons in orbital to acquire more stability.



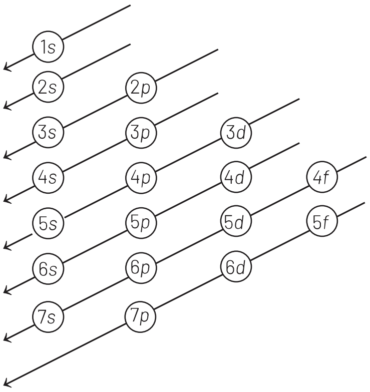
$$= 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^{10}, 4s^1$$

58 The order of filling of electrons in the orbitals of an atom will be **[CBSE AIPMT 1991]**

(a) $3d, 4s, 4p, 4d, 5s$
(b) $4s, 3d, 4p, 5s, 4d$
(c) $5s, 4p, 3d, 4d, 5s$
(d) $3d, 4p, 4s, 4d, 5s$

Ans. *(b)*

The sequence of energy level can be remembered by the systematic diagram as shown below



Hence, the correct order is

1*s*, 2*s*, 2*p*, 3*s*, 3*p*, 4*s*, 3*d*, 4*p*, 5*s*, 4*d*, 5*p*, 4*f*, 5*d*, 6*p*, 7*s*……

59 For azimuthal quantum number $l = 3$, the maximum number of electrons will be **[CBSE AIPMT 1991]**

(a) 2 (b) 6 (c) 0 (d) 14

Ans. ***(d)***

When azimuthal quantum number is 3

$$m = (2l + 1)$$
$$l = 3$$
$$m = (2 \times 3 + 1)$$
$$= 7 \text{ orbitals}$$

then total values of $m = (2 \times 3 + 1) = 7$ orbitals. We know that, one orbital contains two electrons. Hence, total number of electrons $= 7 \times 2 = 14$.

Alternative

Total number of electrons $= 4l + 2$

$$= 4 \times 3 + 2 = 12 + 2 = 14 \text{ electrons}$$

60 In a given atom no two electrons can have the same values of all the four quantum numbers. This is called **[CBSE AIPMT 1991]**

(a) Hund's rule

(b) Aufbau principle

(c) Uncertainty principle

(d) Pauli's exclusion principle

Ans. ***(d)***

According, to Pauli's exclusion principle "no two electrons in an atom can have the same values of all the four quantum numbers."

In $1s^2$

for I electron $n = 1, l = 0, m = 0, s = +\frac{1}{2}$

for II electron $n = 1$,

$$l = 0, m = 0, s = -\frac{1}{2}$$

It means if the values of *n*, *l*, and *m* are same, then the value of spin quantum number must be different, i.e. +1/2 and −1/2.

61 The total number of electrons that can be accommodated in all the orbitals having principal quantum number 2 and azimuthal quantum number 1 are **[CBSE AIPMT 1990]**

(a) 2 (b) 4

(c) 6 (d) 8

Ans. ***(c)***

When $n = 2$ and $l = 1$, then subshell is $2p$.

The number of orbitals in *p*-subshell

$$= (2l + 1) = (2 \times 1 + 1)$$
$$= 3$$

Total (maximum) number of electrons

$$= 2 \times \text{number of orbitals}$$
$$= 2 \times 3 = 6$$

(as each orbital contains 2 electrons)

62 The maximum number of electrons in a subshell is given by the expression **[CBSE AIPMT 1989]**

(a) $4l - 2$ (b) $4l + 2$

(c) $2l + 2$ (d) $2n^2$

Ans. ***(b)***

The number of orbitals in a subshell $= (2l + 1)$

where, l = azimuthal quantum number

Since, each orbital contains maximum two electrons, the number of electrons in any subshell

$$= 2 \times \text{number of orbitals}$$
$$= 2(2l + 1)$$
$$= 4l + 2$$

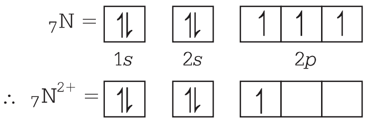
63 Number of unpaired electrons in N^{2+} is/are **[CBSE AIPMT 1989]**

(a) 2 (b) 0

(c) 1 (d) 3

Ans. ***(c)***

The electronic configuration of



Hence, the number of unpaired electron in N^{2+} is 1.

64 The number of spherical nodes in 3*p*-orbital is/are **[CBSE AIPMT 1988]**

(a) one

(b) three

(c) two

(d) None of the above

Ans. ***(a)***

The number of spherical nodes in any orbital $(= n - l - 1)$

For 3*p*-orbital, $n = 3$ and $l = 1$

∴ Number of spherical nodes $= n - l - 1$

$$= 3 - 1 - 1$$
$$= 3 - 2 = 1 \text{ node}$$

3

Chemical Bonding and Molecular Structure

TOPIC 1

Type of Bonds, Bond Parameter and Resonance

01 The correct sequence of bond enthalpy of 'C—*X*' bond is **[NEET 2021]**

(a) $CH_3—F < CH_3—Cl < CH_3—Br < CH_3—I$
(b) $CH_3—F > CH_3—Cl > CH_3—Br > CH_3—I$
(c) $CH_3—F < CH_3—Cl > CH_3—Br > CH_3—I$
(d) $CH_3—Cl > CH_3—F > CH_3—Br > CH_3—I$

Ans. *(b)*

On moving down the group from F to I, the size of atom increases. Order of the size of halogen atoms is I > Br > Cl > F.

So, the bond length of C—*X* bond also increases from F to I and hence, the bond enthalpy decreases from F to I.

Correct order of bond length of C—*X* bond is

$H_3C—I > H_3C—Br > H_3C—Cl > H_3C—F$.

Correct order of bond enthalpy is

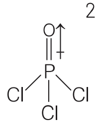
$H_3C—F > H_3C—Cl > CH_3—Br > H_3C—I$.

02 Which of the following molecules is non-polar in nature? **[NEET 2021]**

(a) $POCl_3$ (b) CH_2O
(c) $SbCl_5$ (d) NO_2

Ans. *(c)*

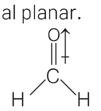
(a) $\mathbf{POCl_3}$ Hybridisation $= \frac{1}{2} \times 8 = 4(sp^3)$



Shape = Tetrahedral
Dipole moment, $\mu \neq 0$
$POCl_3$ is polar in nature.

(b) $\mathbf{CH_2O}$ Hybridisation $= \frac{1}{2}(6) = 3(sp^2)$

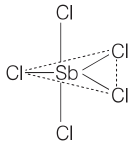
Shape = Trigonal planar.



Dipole moment, $\mu \neq 0$
CH_2O is polar in nature.

(c) $\mathbf{SbCl_5}$ Hybridisation $= \frac{1}{2} \times 10 = 5(sp^3d)$

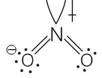
Shape = Trigonal bipyramidal



Dipole moment, $\mu = 0$
$SbCl_5$ is non-polar in nature.

(d) $\mathbf{NO_2}$ Hybridisation

$= \frac{1}{2} \times (4+2) = \frac{1}{2} \times 6 = 3(sp^2)$.



Shape = Trigonal planar
Dipole moment, $\mu \neq 0$
NO_2 is polar in nature.

03 Which of the following set of molecules will have zero dipole moment ? **[NEET (Sept.) 2020]**

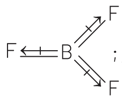
(a) Boron trifluoride, hydrogen fluoride, carbon dioxide, 1,3-dichlorobenzene
(b) Nitrogen trifluoride, beryllium difluoride, water, 1,3-dichlorobenzene
(c) Boron trifluoride, beryllium difluoride, carbon dioxide, 1, 4-dichlorobenzene
(d) Ammonia, beryllium difluoride, water, 1,4-dichlorobenzene

Ans. *(c)*

In option (c), for all molecules, [i, vi, iii, viii] $\mu = 0$.

The structure of all compounds are as follows :

(i) Boron trifluoride (BF_3)

⇒  ; $\mu = 0$

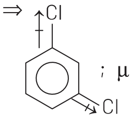
(ii) Hydrogen fluoride (HF)

⇒ $H \xrightarrow{\quad} F$; $\mu \neq 0$

(iii) Carbon dioxide (CO_2)

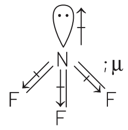
⇒ $\overset{\longleftarrow}{O} = C = \overset{\longrightarrow}{O}$; $\mu = 0$

(iv) 1,3-dichloro benzene (m-$C_6H_4Cl_2$) ⇒



; $\mu \neq 0$

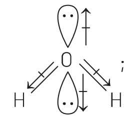
(v) Nitrogen trifluoride (NF_3)

⇒  ; $\mu \neq 0$

(vi) Beryllium difluoride (BeF_2)

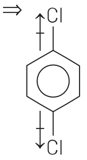
⇒ $F\overset{\longleftarrow}{—}Be\overset{\longrightarrow}{—}F$; $\mu = 0$

(vii) Water (H_2O)

⇒  ; $\mu \neq 0$

(viii) 1,4-dichloro benzene

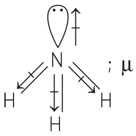
(p=$C_6H_4Cl_2$) ⇒



; μ=0

(ix) Ammonia (NH_3)

⇒



; $\mu \neq 0$

[∵ μ = Dipole moment]

04 Which of the following is the correct order of dipole moment?

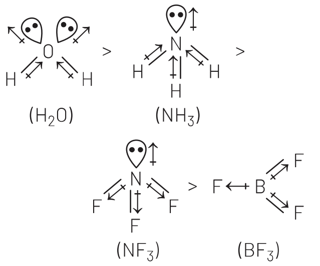
[NEET (Odisha) 2019]

(a) $NH_3 < BF_3 < NF_3 < H_2O$
(b) $BF_3 < NF_3 < NH_3 < H_2O$
(c) $BF_3 < NH_3 < NF_3 < H_2O$
(d) $H_2O < NF_3 < NH_3 < BF_3$

Ans. *(b)*

BF_3 has zero dipole moment as it is symmetrical in nature. H_2O has maximum dipole moment as it possess two lone pair of electrons. Between NH_3 and NF_3, NH_3 has greater dipole moment though in NH_3 and NF_3, both N possesses one lone pair of electrons.

This is beacuse in case of NF_3, the net N—H bond dipole is in the same direction as the direction of dipole of lone pair. But in case of NF_3, the direction of net dipole moment of three —N—F bonds is opposite to that of the dipole moment of the lone pair. Thus, the correct of dipole moment is



05 Which one of the following pairs of species have the same bond order?

[NEET 2017]

(a) CO, NO
(b) O_2, NO^+
(c) CN^-, CO
(d) N_2, O_2^-

Ans. *(c)*

Key concept *The species that have same number of electrons have same bond order.*

Species	Number of electrons
CO	6 + 8 = 14
NO	7 + 8 = 15
O_2	8 + 8 = 16
NO^+	7 + 8 − 1 = 14
CN^-	6 + 7 + 1 = 14
O_2^-	8 + 8 + 1 = 17

Thus, both CN^- and CO have equal number of electrons. So, their bond order will be same.

06 Predict the correct order among the following. **[NEET 2016, Phase I]**

(a) lone pair-lone pair > bond pair-bond pair > lone pair-bond pair
(b) bond pair-bond pair > lone pair-bond pair > lone pair-lone pair
(c) lone pair-bond pair > bond pair-bond pair > lone pair-lone pair
(d) lone pair-lone pair > lone pair-bond pair > bond pair-bond pair

Ans. *(d)*

According to the postulate of VSEPR theory, a lone pair occupies more space than a bonding pair, since it lies closer to the central atom. This means that the repulsion between the different electron pairs follow the order.

$$lp-lp > lp-bp > bp-bp$$

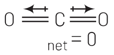
07 Which of the following molecules has the maximum dipole moment?

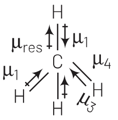
[CBSE AIPMT 2014]

(a) CO_2 (b) CH_4
(c) NH_3 (d) NF_3

Ans. *(d)*

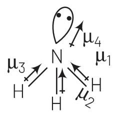
CO_2 and CH_4 have zero dipole moment as these are symmetrical in nature. Between NH_3 and NF_3, NF_3 has greater dipole moment though in NH_3 and NF_3 both, N possesses one lone pair of electrons.



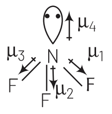


$$\because \mu_{res} = \mu_1 + \mu_2 + \mu_3 = -\mu_4$$
$$\text{and } \mu_{net} = \mu_{res} + \mu_4$$
$$\therefore \mu_{net} = \mu_1 + \mu_2 + \mu_3 + \mu_4$$
$$= -\mu_4 + \mu_4 = 0$$

net = 0



Resultant of
3N—H
bond lie in the same
direction as μ_4
Hence, $\mu_{net} = \mu_{res} + \mu_4$



Resultant of
3N—F
bond lie opposite to μ_4

This is because in case of NH_3, the net N—H bond dipole is in the same direction as the direction of dipole of lone pair but in case of NF_3, the direction of net bond dipole of three —N—F bonds is opposite than that of the dipole of the then lone pair.

08 Which one of the following molecules contain no π-bond?

[NEET 2013]

(a) CO_2 (b) H_2O
(c) SO_2 (d) NO_2

Ans. *(b)*

All the molecules have O-atom with lone pairs, but in H_2O the H-atom has no vacant orbital for π-bonding. That's why it does not have any π-bond.

In all other given molecules, the central atom because of the presence of vacant orbitals is capable to form π-bonds.

09 Which of the following is least likely to behave as Lewis base?

[CBSE AIPMT 2011]

(a) NH_3 (b) BF_3
(c) OH^- (d) H_2O

Ans. *(b)*

BF_3 is an electron deficient species, thus behaves like a Lewis acid.

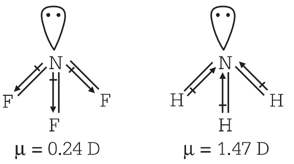
$$\because \text{Bond order} = \frac{N_b - N_a}{2}$$

10 The electronegativity difference between N and F is greater than that between N and H yet the dipole moment of NH_3 (1.5 D) is larger than that of NF_3 (0.2 D). This is because **[CBSE AIPMT 2006]**

(a) in NH_3 as well as in NF_3, the atomic dipole and bond dipole are in the same direction
(b) in NH_3, the atomic dipole and bond dipole are in the same direction whereas in NF_3 these are in opposite directions
(c) in NH_3 as well as NF_3, the atomic dipole and bond dipole are in opposite directions

(d) in NH_3 the atomic dipole and bond dipole are in the opposite directions whereas in NF_3 these are in the same directions

Ans. *(b)*



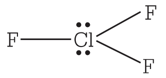
F is more electronegative than N, therefore direction of bond is from N to F whereas N is more electronegative than H, the direction of the bond is from H to N. Thus whereas resultant moment of N-H bonds adds up to the bond moment of lone pair, that of 3N-F bonds partly cancel the resultant moment of lone pair. Hence, the net dipole moment of NF_3 is less than that of NH_3.

11 In which of the following molecules are all the bonds not equal? **[CBSE AIPMT 2006]**

(a) ClF_3 (b) BF_3
(c) AlF_3 (d) NF_3

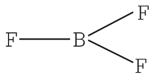
Ans. *(a)*

In ClF_3 all bonds are not equal due to its trigonal-bipyramidal (sp^3d hybridisation) geometry

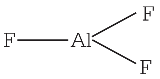


Trigonal bipyramidal geometry

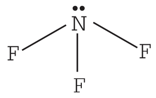
BF_3 and AlF_3 show trigonal symmetric structure due to sp^2 hybridisation.



and



NF_3 shows pyramidal geometry due to sp^3 hybridisation.

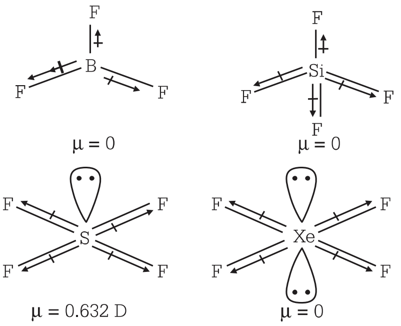


$3bp + 1lp$

12 Which of the following would have a permanent dipole moment? **[CBSE AIPMT 2005]**

(a) BF_3 (b) SiF_4
(c) SF_4 (d) XeF_4

Ans. *(c)*



(Permanent dipole moment)

∵ SF_4 have $\mu > 0$

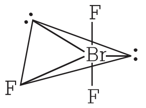
∴ It has permanent dipole moment.

13 In BrF_3 molecule, the lone pairs occupy equatorial positions to minimise **[CBSE AIPMT 2004]**

(a) lone pair-bond pair repulsion
(b) bond pair-bond pair repulsion
(c) lone pair-lone pair repulsion and lone pair-bond pair repulsion
(d) lone pair-lone pair repulsion

Ans. *(d)*

In BrF_3 molecule, Br is sp^3d hybridised, but its geometry is T-shaped due to distortion of geometry from trigonal bipyramidal to T-shaped by the involvement of lone pair-lone pair repulsion.



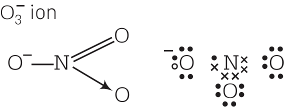
Here, $lp - lp$ repulsion = 0
$lp - bp$ repulsion = 4
$bp - bp$ repulsion = 2

14 In NO_3^- ion number of bond pair and lone pair of electrons on nitrogen atom are **[CBSE AIPMT 2002]**

(a) 2, 2 (b) 3, 1 (c) 1, 3 (d) 4, 0

Ans. *(d)*

In NO_3^- ion



Nitrogen has four bond pair and zero lone pair of electrons, due to the presence of one coordination bond.

15 In which of the following, bond angle is maximum? **[CBSE AIPMT 2001]**

(a) NH_3 (b) NH_4^+ (c) PCl_3 (d) SCl_2

Ans. *(b)*

In NH_4^+ bond angle is maximum (nearer 109°) due to its tetrahedral geometry.

16 In PO_4^{3-} ion, the formal charge on each oxygen atom and P—O bond order respectively are **[CBSE AIPMT 1998]**

(a) – 0.75, 0.6 (b) – 0.75, 1.0
(c) – 0.75, 1.25 (d) – 3, 1.25

Ans. *(c)*

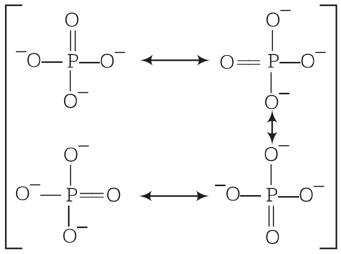
P—O bond order

$$= \frac{\text{Total Number of bonds in all possible direction between two atoms}}{\text{Total number of resonating structures}}$$

$$= \frac{2+1+1+1}{4} = \frac{5}{4} = 1.25$$

∴ Bond order = 1.25

Resonating structures are



Total charge on PO_4^{3-} ion is –3

$$= \frac{\text{Total charge}}{\text{Total entity of O-atom}}$$

So, the average formal charge on each O-atom is $= -\frac{3}{4} = -0.75$

17 Which one is not paramagnetic among the following? [at. no. of Be = 4, Ne = 10, As = 33, Cl = 17] **[CBSE AIPMT 1998]**

(a) Cl^- (b) Be
(c) Ne^{2+} (d) As^+

Ans. *(a)*

Paramagnetic character is based upon presence of unpaired electron.

$$_{17}Cl^- = 1s^2, 2s^2 2p^6, 3s^2 3p_x^2 3p_y^2 3p_z^2$$

In Cl^- no unpaired electron, so it is in nature diamagnetic.

$$_4Be = 1s^2, 2s^1 2p_x^1$$
$$_{10}Ne^{2+} = 1s^2, 2s^2 2p_x^2 2p_y^1 2p_z^1$$

$$_{33}As^+ = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^{10}, 4s^2 4p_x^1 4p_y^1 4p_z^0$$

While all others have unpaired electron, so they are paramagnetic in nature.