JEE
ADVANCED

48
YEARS
2025–1978

CHAPTER-WISE & TOPIC-WISE SOLVED PAPERS

WITH RESPONSE TAGGING

Analyse the question-wise difficulty level in real-time with Correct (C), Wrong (W) and Unattempted (UA) questions response tagging provided by IIT-JEE

CHEMISTRY

ANSWER KEY VERIFIED FROM OFFICIAL WEBSITE OF JEE ADVANCED

PW

JEE ADVANCED-**6** Year (2024-19) Paper Analysis

Explanation of ★**Unique**★ Feature

C – Correct, W – Wrong, UA – Unattempted, PC – Partial Correct

C-31 W-22 UA-10 PC-36 represents the % of distribution of correct, wrong, unattempted and partial correct responses by students at any specific question in real time.(Data is taken from JEE Advanced website: https://jeeadv.ac.in/reports.html)

Classification helps students understand the varying **levels of difficulty**.

Easy
C > 20%

Medium
10% < C ≤ 20%
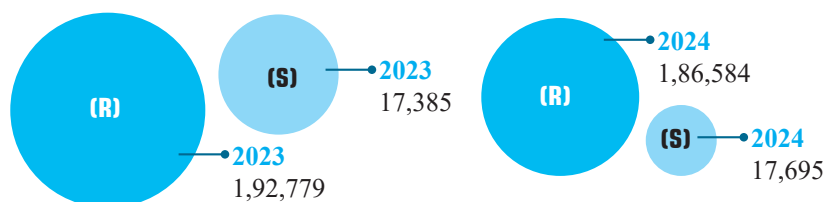
Hard
C ≤ 10%
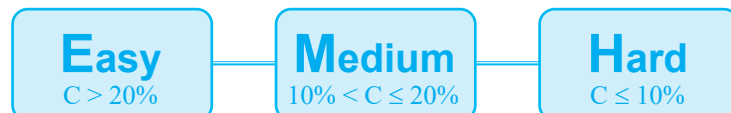
For Example

22. Which of the following statement(s) is (are) correct regarding the root mean square speed (U_{rms}) and average translational kinetic energy (E_{av}) of a molecule in a gas at equilibrium?
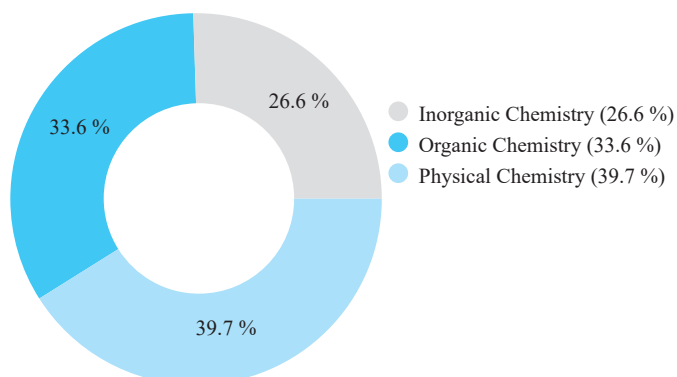
C-31 W-22 UA-10 PC-36 (JEE Adv. 2019)

(a) U_{rms} is inversely proportional to the square root of its molecular mass

(b) U_{rms} is doubled when its temperature is increased four times

(c) E_{av} is doubled when its temperature is increased four times

(d) E_{av} at a given temperature does not depend on its molecular mass

Question is considered EASY as Correct response recorded was greater than **20%**
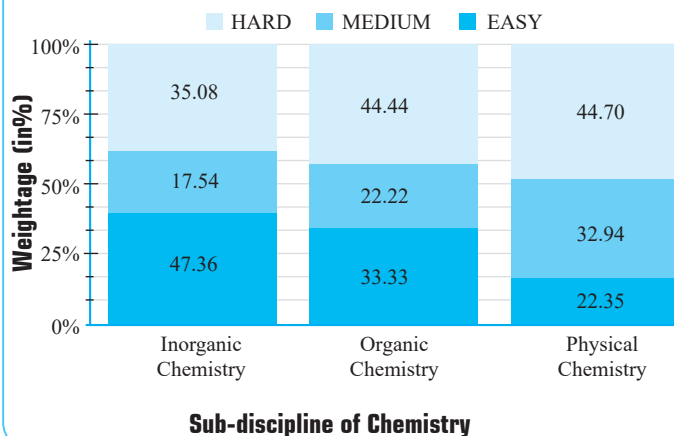
- ● **Registered Candidates (R)**
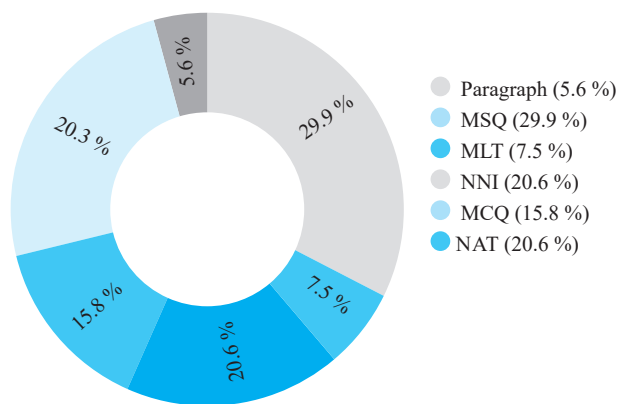- ● **Seat Capacity (S)**

(R) **2023** 1,92,779

(S) **2023** 17,385

(R) **2024** 1,86,584

(S) **2024** 17,695

How Chemistry Marks Shape UP Across Sub-disciplines (2024-19)

- 26.6 %
- 33.6 %
- 39.7 %

○ Inorganic Chemistry (26.6 %)
● Organic Chemistry (33.6 %)
● Physical Chemistry (39.7 %)

How Difficulty Level Vary in Subdiscipline (2024-19)

HARD | MEDIUM | EASY

Weightage (in%)

Sub-discipline	HARD	MEDIUM	EASY
Inorganic Chemistry	35.08	17.54	47.36
Organic Chemistry	44.44	22.22	33.33
Physical Chemistry	44.70	32.94	22.35

Sub-discipline of Chemistry

Distribution of Question Type

- Paragraph (5.6 %)
- MSQ (29.9 %)
- MLT (7.5 %)
- NNI (20.6 %)
- MCQ (15.8 %)
- NAT (20.6 %)

5.6 %
29.9 %
20.3 %
15.8 %
7.5 %
20.6 %

Weightage of Difficulty Level Based on Type of Questions

HARD | MEDIUM | EASY

Weightage (in%)

Type	EASY	MEDIUM	HARD
MCQ	64.07	23.52	11.76
MSQ	17.18	31.25	51.56
NNI	20.45	36.36	43.18
MLT	93.75		6.25
Paragraph	58.33	8.33	33.33
NAT	13.63	18.18	68.18
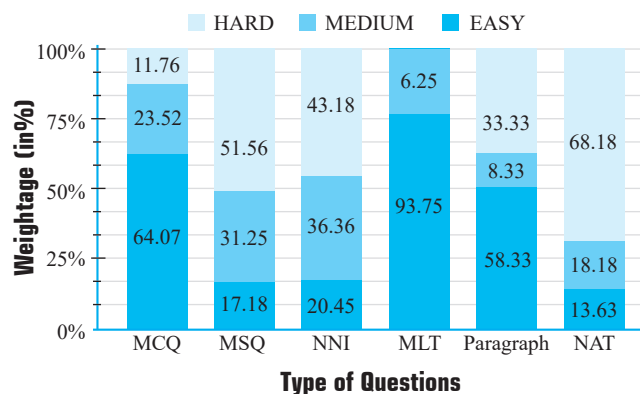
Type of Questions

Distribution of Question Based on Difficulty

- EASY (32.68%)
- MEDIUM (25.22%)
- HARD (42.09%)

32.68 %
42.09 %
25.22 %
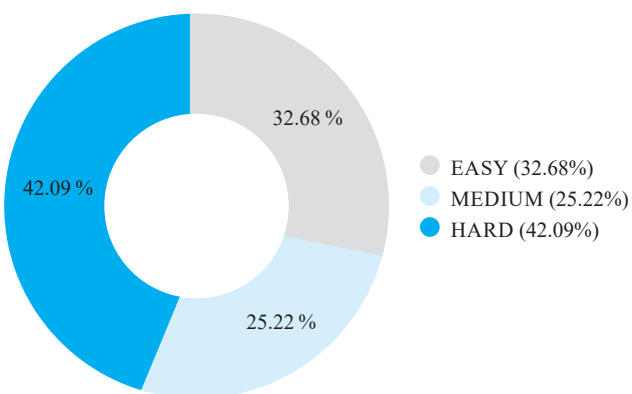
Distribution of Level of Questions Yearwise

HARD | MEDIUM | EASY

Weightage (in%)

Year (Name of IIT)	EASY	MEDIUM	HARD
2024 (IITM)	55.88	20.58	23.52
2023 (IITG)	26.47	26.47	47.06
2022 (IITB)	25	19.44	55.56
2021 (IITKGP)	18.42	26.32	55.26
2020 (IITD)	22.22	30.56	47.22
2019 (IITR)	50	27.78	22.22

Year (Name of IIT)
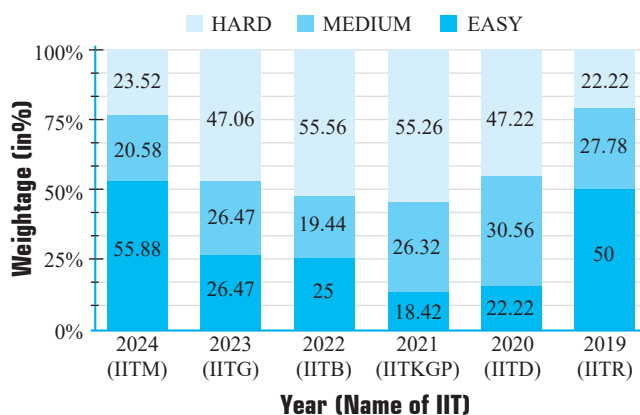
Chapter wise Weightage and count of Difficulty level of JEE Advanced Questions

Chapters Name	EASY	MEDIUM	HARD	Chapterwise Weightage(in %)
Aldehydes, Ketones and Carboxylic acids	6	4	10	9.34
Hydrocarbons	6	2	5	6.07
The d- and f-Block Elements and Qualitative analysis of Inorganic salts	6	3	5	6.54
Thermodynamics	0	5	7	5.60
The p-Block Elements (Group 15 to 18)	8	2	4	6.54
Electrochemistry	0	4	7	5.14
Equilibrium	0	2	7	4.20
Coordination Compounds	7	3	3	6.07
Amines	3	2	5	4.67
General Principles and Processes of Isolation of Elements	1	2	5	3.73
Chemical Kinetics	4	1	5	4.67
Organic Chemistry-Some Basic Principles and Techniques	2	2	4	3.73
Chemical Bonding and Molecular Structure	4	2	1	3.27
Biomolecules	3	2	3	3.73
Structure of Atom	4	2	2	3.73
Solutions	3	1	3	3.27

CONTENTS

HINTS AND SOLUTIONS

SECTION 1 (Maximum Marks: 12)

❍ This section contains **FOUR (04)** questions.

❍ Each question has **FOUR** options (*a*), (*b*), (*c*) and (*d*). **ONLY ONE** of these four options is the correct answer.

❍ For each question, choose the option corresponding to the correct answer.

❍ Answer to each question will be evaluated <u>according to the following marking scheme:</u>

Full Marks   : +3 If **ONLY** the correct option is chosen;

Zero Marks   : 0 If none of the options is chosen (i.e. the question is unanswered);

Negative Marks : –1 In all other cases.

1. The heating of NH_4NO_2 at 60 −70° C and NH_4NO_3 at 200 −250°C is associated with the formation of nitrogen containing compounds **X** and **Y**, respectively. **X** and **Y**, respectively, are

(*a*) N_2 and N_2O (*b*) NH_3 and NO_2

(*c*) NO and N_2O (*d*) N_2 and NH_3

2. The correct order of the wavelength maxima of the absorption band in the ultraviolet-visible region for the given complexes is

(*a*) $[Co(CN)_6]^{3-} < [Co(NH_3)_6]^{3+} < [Co(NH_3)_5(H_2O)]^{3+} < [Co(NH_3)_5(Cl)]^{2+}$

(*b*) $[Co(NH_3)_5(Cl)]^{2+} < [Co(NH_3)_5(H_2O)]^{3+} < [Co(NH_3)_6]^{3+} < [Co(CN)_6]^{3-}$

(*c*) $[Co(CN)_6]^{3-} < [Co(NH_3)_5(Cl)]^{2+} < [Co(NH_3)_5(H_2O)]^{3+} < [Co(NH_3)_6]^{3+}$

(*d*) $[Co(NH_3)_6]^{3+} < [Co(CN)_6]^{3-} < [Co(NH_3)_5(Cl)]^{2+} < [Co(NH_3)_5(H_2O)]^{3+}$

3. One of the products formed from the reaction of permanganate ion with iodide ion in neutral aqueous medium is

(*a*) I_2 (*b*) IO_3^- (*c*) IO_4^- (*d*) IO_2^-

4. Consider the depicted hydrogen (**H**) in the hydrocarbons given below. The most acidic hydrogen (**H**) is

(*a*)   (*b*)

(*c*)   (*d*)

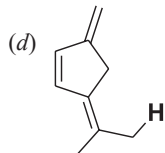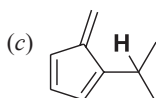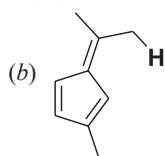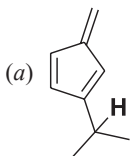## SECTION 2 (Maximum Marks: 12)

❍ This section contains **THREE (03)** questions.

❍ Each question has **FOUR** options (*a*), (*b*), (*c*) and (*d*). **ONE OR MORE THAN ONE** of these four option(s) is(are) correct answer(s).

❍ For each question, choose the option(s) corresponding to (all) the correct answer(s).

❍ Answer to each question will be evaluated <u>according to the following marking scheme:</u>

Full Marks   : +4 **ONLY** if (all) the correct option(s) is(are) chosen;

Partial Marks   : +3 If all the four options are correct but **ONLY** three options are chosen;

Partial Marks   : +2 If three or more options are correct but **ONLY** two options are chosen, both of which are correct;

Partial Marks   : +1 If two or more options are correct but **ONLY** one option is chosen and it is a correct option;

Zero Marks   : 0 If none of the options is chosen (i.e. the question is unanswered);

Negative Marks: –2 In all other cases.

❍ For example, in a question, if (*a*), (*b*) and (*d*) are the **ONLY** three options corresponding to correct answers, then

choosing ONLY (*a*), (*b*) and (*d*) will get +4 marks;

choosing ONLY (*a*) and (*b*) will get +2 marks;

choosing ONLY (*a*) and (*d*) will get +2 marks;

choosing ONLY (*b*) and (*d*) will get +2 marks;

choosing ONLY (*a*) will get +1 mark;

choosing ONLY (*b*) will get +1 mark;

choosing ONLY (*d*) will get +1 mark;

choosing no option (i.e. the question is unanswered) will get 0 marks; and choosing any other combination of options will get –2 marks.

5. Regarding the molecular orbital (MO) energy levels for homonuclear diatomic molecules, the **INCORRECT** statement(s) is(are)

(*a*) Bond order of Ne_2 is zero.

(*b*) The highest occupied molecular orbital (HOMO) of F_2 is σ-type.

(*c*) Bond energy of O_2^+ is smaller than the bond energy of O_2.

(*d*) Bond length of Li_2 is larger than the bond length of B_2.

6. The pair(s) of diamagnetic ions is(are)

(*a*) La^{3+}, Ce^{4+} (*b*) Yb^{2+}, Lu^{3+}

(*c*) La^{2+}, Ce^{3+} (*d*) Yb^{3+}, Lu^{2+}

7. For the reaction sequence given below, the correct statement (s) is(are)
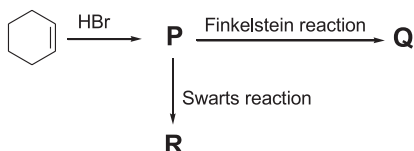
(In the options, X is any atom other than carbon and hydrogen, and it is different in **P**, **Q** and **R**)

(a) C−X bond length in **P**, **Q** and **R** follows the order **Q** > **R** > **P**.

(b) C−X bond enthalpy in **P**, **Q** and **R** follows the order **R** > **P** > **Q**.

(c) Relative reactivity toward S_N2 reaction in **P**, **Q** and **R** follows the order **P** > **R** > **Q**.

(d) pK_a value of the conjugate acids of the leaving groups in **P**, **Q** and **R** follows the order **R** > **Q** > **P**.

SECTION 3 (Maximum Marks: 24)

❍ This section contains **SIX (06)** questions.

❍ The answer to each question is a **NON-NEGATIVE INTEGER**.

❍ For each question, enter the correct integer corresponding to the answer using the mouse and the on screen virtual numeric keypad in the place designated to enter the answer.

❍ Answer to each question will be evaluated according to the following marking scheme:

Full Marks : +4 If **ONLY** the correct integer is entered;

Zero Marks : 0 In all other cases.

8. In an electrochemical cell, dichromate ions in aqueous acidic medium are reduced to Cr^{3+}. The current (in amperes) that flows through the cell for 48.25 minutes to produce 1 mole of Cr^{3+} is _____.

Use: 1 Faraday = 96500 C mol^{-1}

9. At 25°C, the concentration of H^+ ions in 1.00×10^{-3} M aqueous solution of a weak monobasic acid having acid dissociation constant (K_a) of 4.00×10^{-11} is $X \times 10^{-7}$ M. The value of **X** is _____.

Use: Ionic product of water $(K_w) = 1.00 \times 10^{-14}$ at 25°C

10. Molar volume (V_m) of a van der Waals gas can be calculated by expressing the van der Waals equation as a cubic equation with V_m as the variable. The ratio (in mol dm^{-3}) of the coefficient of V_m^2 to the coefficient of V_m for a gas having van der Waals constants $a = 6.0$ dm^6 atm mol^{-2} and $b = 0.060$ dm^3 mol^{-1} at 300 K and 300 atm is _____.

**Use:** Universal gas constant (R) = 0.082 dm^3 atm mol^{-1} K^{-1}.

11. Considering ideal gas behavior, the expansion work done (in kJ) when 144 g of water is electrolyzed completely under constant pressure at 300 K is _____.

Use: Universal gas constant (R) = 8.3 J K^{-1} mol^{-1}; Atomic mass (in amu): H = 1, O = 16

12. The monomer (**X**) involved in the synthesis of Nylon 6,6 gives positive carbylamine test. If 10 moles of **X** are analyzed using Dumas method, the amount (in grams) of nitrogen gas evolved is _____.

Use: Atomic mass of N (in amu) = 14

13. The reaction sequence given below is carried out with 16 moles of X. The yield of the major product in each step is given below the product in parentheses. The amount (in grams) of S produced is_____.
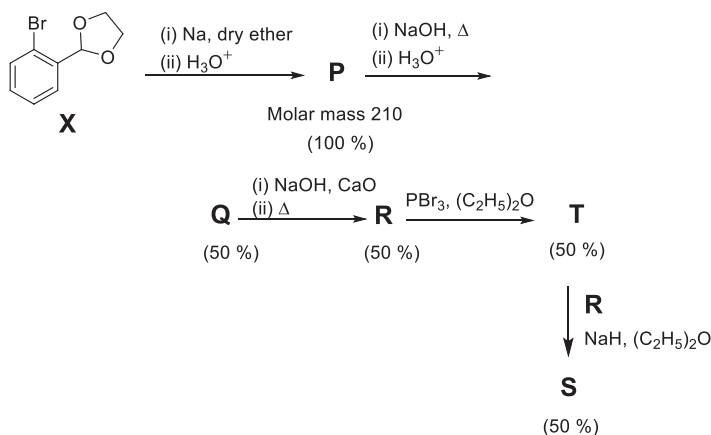
Use: Atomic mass (in amu): H = 1, C = 12, O = 16, Br = 80

SECTION 4 (Maximum Marks: 12)

❍ This section contains **FOUR (04)** Matching List Sets.

❍ Each set has **ONE** Multiple Choice Question.

❍ Each set has **TWO** lists: **List-I** and **List-II**.

❍ **List-I** has **Four** entries (P), (Q), (R) and (S) and **List-II** has **Five** entries (1), (2), (3), (4) and (5).

❍ **FOUR** options are given in each Multiple Choice Question based on **List-I** and **List-II** and **ONLY ONE** of these four options satisfies the condition asked in the Multiple Choice Question.

❍ Answer to each question will be evaluated according to the following marking scheme:

Full Marks : +3 **ONLY** if the option corresponding to the correct combination is chosen;

Zero Marks : 0 If none of the options is chosen (i.e. the question is unanswered);

Negative Marks : –1 In all other cases.

14. The correct match of the group reagents in List-I for precipitating the metal ion given in List-II from solutions, is

List - I		List - II	
(P)	Passing H_2S in the presence of NH_4OH	(1)	Cu^{2+}
(Q)	$(NH_4)_2CO_3$ in the presence of NH_4OH	(2)	Al^{3+}
(R)	NH_4OH in the presence of NH_4Cl	(3)	Mn^{2+}
(S)	Passing H_2S in the presence of dilute HCl	(4)	Ba^{2+}
		(5)	Mg^{2+}

(a) (P) → (3); (Q) → (4); (R) → (2); (S) → (1)

(b) (P) → (4); (Q) → (2); (R) → (3); (S) → (1)

(c) (P) → (3); (Q) → (4); (R) → (1); (S) → (5)

(d) (P) → (5); (Q) → (3); (R) → (2); (S) → (4)

15. The major products obtained from the reactions in **List-II** are the reactants for the named reactions mentioned in **List-I**. Match each entry in **List-I** with the appropriate entry in **List-II** and choose the correct option.

List - I		List - II	
(P)	Stephen reaction	(1)	Toluene $\xrightarrow{\text{(i) } CrO_2Cl_2/CS_2 \quad \text{(ii) } H_3O^+}$
(Q)	Sandmeyer reaction	(2)	Benzoic acid $\xrightarrow{\text{(i) } PCl_5 \quad \text{(ii) } NH_3 \quad \text{(iii) } P_4O_{10}.\Delta}$

(R)	Hoffmann bromamide degradation reaction	(3)	Nitrobenzene $\xrightarrow[\text{(ii) HCl, NaNO}_2]{\text{(i) Fe, HCl}} \xrightarrow{(273-278\,\text{K}), \text{H}_2\text{O}}$
(S)	Cannizzaro reaction	(4)	Toluene $\xrightarrow[\text{(iii) SO}_2\text{Cl}_2]{\substack{\text{(i) Cl}_2/\text{hv, H}_2\text{O} \\ \text{(ii) Tollen's reagent}}} \xrightarrow{\text{(iv) NH}_3}$
		(5)	Aniline $\xrightarrow[\text{(ii) HNO}_3, \text{H}_2\text{SO}_4, 288\text{K}]{\text{(i) (CH}_3\text{CO)}_2\text{O, Pyridine}} \xrightarrow{\text{(iii) aq. NaOH}}$

(a) (P) → (2); (Q) → (4); (R) → (1); (S) → (3)
(b) (P) → (2); (Q) → (3); (R) → (4); (S) → (1)
(c) (P) → (5); (Q) → (3); (R) → (4); (S) → (2)
(d) (P) → (5); (Q) → (4); (R) → (2); (S) → (1)

16. Match the compounds in List-I with the appropriate observations in List-II and choose the correct option.

List - I		List - II
(P)	![NH2 ... OMe structure]	(1) Reaction with phenyl diazonium salt gives yellow dye.
(Q)	![acetyl NH ... OMe structure]	(2) Reaction with ninhydrin gives purple color and it also reacts with $FeCl_3$ to give violet color.

(R)	![$NH_3^+Cl^-$ benzene structure]	(3) Reaction with glucose will give corresponding hydrazone.
(S)	![$NHNH_2$ mesityl structure]	(4) Lassiagne extract of the compound treated with dilute HCl followed by addition of aqueous $FeCl_3$ gives blood red color.
		(5) After complete hydrolysis, it will give ninhydrin test and it **DOES NOT** give positive phthalein dye test.

(a) (P) → (1); (Q) → (5); (R) → (4); (S) → (2)
(b) (P) → (2); (Q) → (5); (R) → (1); (S) → (3)
(c) (P) → (5); (Q) → (2); (R) → (1); (S) → (4)
(d) (P) → (2); (Q) → (1); (R) → (5); (S) → (3)

Chemistry Paper-2

SECTION 1 (Maximum Marks: 12)

❍ This section contains **FOUR (04)** questions.
❍ Each question has **FOUR** options (a), (b), (c) and (d). **ONLY ONE** of these four options is the correct answer.
❍ For each question, choose the option corresponding to the correct answer.
❍ Answer to each question will be evaluated **according to the following marking scheme:**
Full Marks : +3 If **ONLY** the correct option is chosen;
Zero Marks : 0 If none of the options is chosen (i.e. the question is unanswered);
Negative Marks : –1 In all other cases.

1. During sodium nitroprusside test of sulphide ion in an aqueous solution, one of the ligands coordinated to the metal ion is converted to
(a) NOS^- (b) SCN^- (c) SNO^- (d) NCS^-

2. The complete hydrolysis of ICl, ClF_3 and BrF_5, respectively, gives
(a) IO^-, ClO_2^- and BrO_3^- (b) IO_3^-, ClO_2^- and BrO_3^-
(c) IO^-, ClO^- and BrO_2^- (d) IO_3^-, ClO_4^- and BrO_2^-

3. Monocyclic compounds P, Q, R and S are the major products formed in the reaction sequences given below.

![Ph-CH2CH2-COOH] $\xrightarrow[\text{(ii) H}_2\text{O}]{\text{(i) Br}_2/\text{Red Phosphorus}}$ P

![Ph-COH] + ![CH3CHO] $\xrightarrow{\text{aq. NaOH, 293 K}}$ Q

![Ph-C≡CH] $\xrightarrow[\text{(ii) Hg}^{2+}, \text{H}_3\text{O}^+]{\text{(i) NaNH}_2 \text{ allyl Br}}$ R

![indene structure] $\xrightarrow[\text{(iii) H}^+, \Delta]{\substack{\text{(i) O}_3, \text{Zn}-\text{H}_2\text{O} \\ \text{(ii) CH}_3\text{MgBr (2 equiv.)}}}$ S
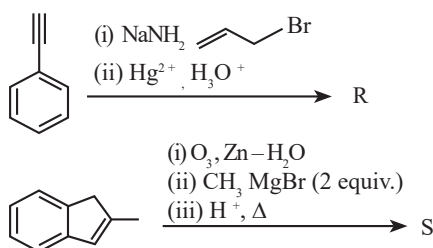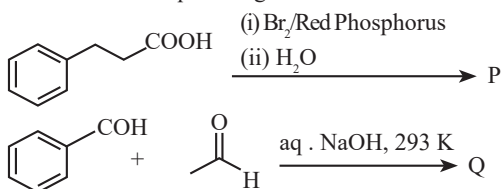
The product having the highest number of unsaturated carbon atom(s) is
(a) P   (b) Q   (c) R   (d) S

4. The correct reaction/reaction sequence that would produce a dicarboxylic acid as the major product is

(a) ![HO-CH2CH2-Cl] $\xrightarrow[\text{(iii) H}_3\text{O}^+]{\substack{\text{(i) NaCN} \\ \text{(ii) HO}^-, \text{H}_2\text{O}}}$

(b) $\underset{CH_2OH}{\overset{CHO}{(CHOH)_4}}$ $\xrightarrow{Br_2, H_2O}$

(c) ![cyclohexyl-Br] $\xrightarrow[\text{(ii) KMnO}_4, \text{H}_2\text{SO}_4\Delta]{\text{(i) KOH, EtOH}}$

(d) ![ketone-OH structure] $\xrightarrow{H_2CrO_4}$
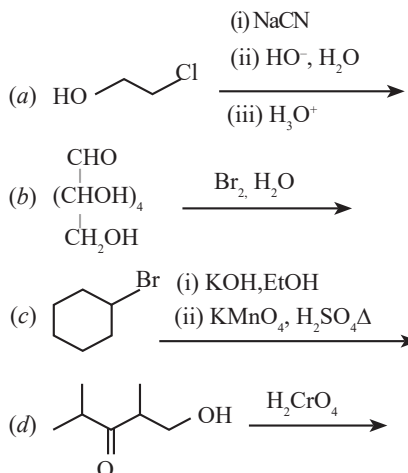
1. (*a*) The reactions may be represented as:

$$\underset{\text{(Ammonium nitrite)}}{NH_4NO_2} \xrightarrow{\Delta} \underset{\text{(X)}}{N_2 + 2H_2O}$$

$$\underset{\text{(Ammonium nitrate)}}{NH_4NO_3} \xrightarrow{\Delta} \underset{\text{(Y)}}{N_2O + 2H_2O}$$
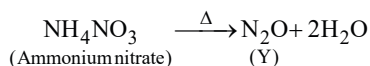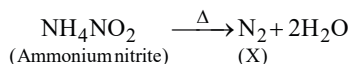
Hence, compounds X and Y are N_2 and N_2O respectively.

2. (*a*) The order of ligands with decreasing field strength in spectrochemical series is:

$(CN^-) > NH_3 > H_2O > Cl^-$
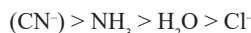
Stronger the ligand, more will be the crystal field splitting energy. Therefore, the order of Δ_0 is:

$[Co(CN)_6]^{3-} > [Co(NH_3)_6]^{3+} > [Co(NH_3)_5(H_2O)]^{3+} > [Co(NH_3)_5(Cl)]^{2+}$

$\because$ Energy $\propto \dfrac{1}{\lambda}$

$\therefore$ Order of λ_{max} will be:

$[Co(CN)_6]^{3-} < [Co(NH_3)_6]^{3+} < [Co(NH_3)_5(H_2O)]^{3+} < [Co(NH_3)_5Cl]^{2+}$

3. (*b*) In neutral aqueous medium, the reaction can be represented as:

$2KMnO_4 + H_2O + Kl \rightarrow 2MnO_2 + 2KOH + KIO_3$
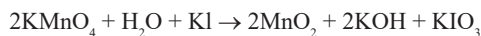
4. (*b*) Since, the conjugate base formed in (*b*) is the most stable, therefore hydrogen (H) is the most acidic in (*b*).

(aromatic compound)

5. (*b, c*)

(*a*) (*a*) is correct.

$Ne_2 \Rightarrow (\sigma ls)^2 (\sigma^* ls)^2 (\sigma 2s)^2 (\sigma^* 2s)^2 (\sigma 2p_z)^2 (\pi 2p_x^2 = \pi 2p_y^2) (\pi^* 2p_x^2 = \pi^* 2p_y^2) (\sigma^* 2p_z)^2$
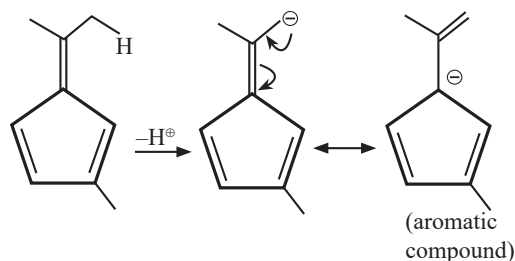
As, bond order, BO $= \dfrac{N_b - N_a}{2}$

$\therefore$ B.O $= \dfrac{10-10}{2} = 0$

(*b*) (*b*) is incorrect.

$F_2 \Rightarrow \left(\sigma_{1s}^2\right)\left(\sigma_{1s}^{*2}\right)\left(\sigma_{2s}^2\right)\left(\sigma_{2s}^{*2}\right)\left(\sigma_{2p_z}^2\right)\left(\pi_{2p_x}^2 = \pi_{2p_y}^2\right)$
$\left(\pi_{2p_x}^{*2} = \pi_{2p_y}^{*2}\right)$

Therefore, the highest occupied molecular orbital (HOMO) of F_2 is π–type not σ–type

(*c*) (*c*) is incorrect.

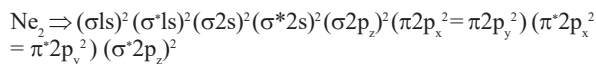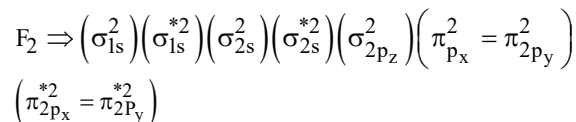Bond energy is directly proportional to the bond order.

Bond order of O_2 is = 2

Bond order of O_2^+ is = 2.5

Hence, bond energy of O_2^+ > bond energy of O_2

(*d*) (*d*) is correct.

Bond length increase with increase in size of the atom. Size of Li is greater than that of B. Therefore, Bond length of Li_2 is larger than that of B_2.

6. (*a, b*)

(*a*) Electronic configuration of La^{3+} : $[Xe]4f^0$

Electronic configuration of Ce^{4+} : $[Xe]4f^0$

Hence, both species are diamagnetic in nature

(*b*) Electronic configuration of Yb^{2+} : $[Xe]4f^{14}$

Electronic configuration of Lu^{3+} : $[Xe]4f^{14}$

Hence, both these species also diamagnetic in nature.

(*c*) Electronic configuration of La^{2+} : $[Xe]5d^1$

Electronic configuration of Ce^{3+} : $[Xe]4f^1$

Hence, both these species are paramagnetic in nature.

(*d*) Electronic configuration of Yb^{3+} : $[Xe]4f^{13}$

Electronic configuration of Lu^{2+} : $[Xe]4f^{14}5d^1$

Hence, both species are paramagnetic in nature.

7. (*b*) The given reaction sequence is:
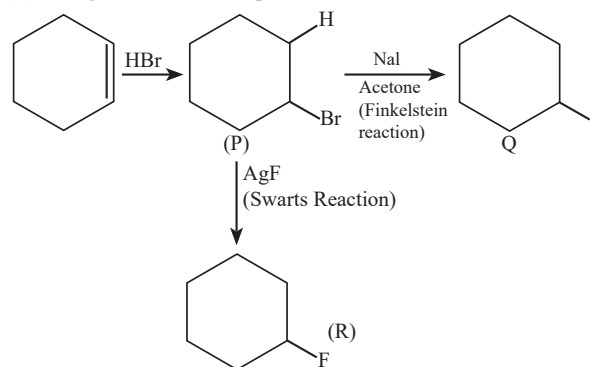
(*a*) Since, the bond length follows the order: C – F < C – Br < C – I

Therefore, the C – X bond length in P, Q and R follows the order: R < P < Q

(*b*) Since, bond enthalpy $\propto \dfrac{1}{\text{bond length}}$

Therefore, the correct order of C–X bond enthalpy $\Rightarrow$ R > P > Q

(*c*) The correct order of reactivity towards S_N2 reaction is:

C – I > C – Br > C – F
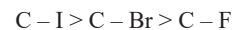
Therefore, the reactivity will follow the order: Q > P > R

(*d*)

Compound	P	Q	R
Leaving group	Br^-	I^-	F^-
conjugate acid	HBr	Hl	HF

The correct order of acidity is: HF < HBr < HI

As, lesser the value of pK_a, more will be the acidity.

Therefore, pKa order: Hl < HBr < HF

Q < P < R

8. (100.00)

The balanced chemical reaction is:

$$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^- \longrightarrow 2Cr^{3+}(aq) + 7H_2O(l)$$
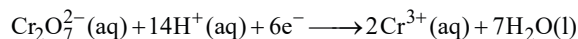
$$\therefore n_{factor} = 3$$

gram equivalent of Cr^{3+} produced = Faraday of charge passed

Number of Moles × n-factor $\dfrac{I \times t}{96500}$

Given, number of moles = 1

$$1 \times 3 = \frac{I \times 2895}{96500} \quad [t = 48.25 \text{ min} = 2895 \text{ sec}]$$

$$I = \frac{1 \times 3 \times 96500}{2895}$$

$$\Rightarrow I = 100 \text{ A}$$

9. (02.24)

Since, the concentration of H^+ from the weak acid is very less, the contribution of H^+ from the self-ionization of water must be considered.

From acid dissociation :

HX (aq.) $\rightleftharpoons$ H⁺ (aq.) + X⁻ (aq.)

At t = 0 10^{-3} —   —

At t = eq. 10^{-3}–x   x + y   x

From water ionization :

H₂O (l) $\rightleftharpoons$ H⁺ (aq.) + OH⁻ (aq.)

           x + y   y

Using approximation, $(10^{-3}-x) \approx 10^{-3}$

$$\therefore K_a = \frac{x(x+y)}{10^{-3}} = 4 \times 10^{-11}$$

$K_a = x(x + y) = 4 \times 10^{-14}$ ...(i)

Now, from ionization of water:

$K_w = y(x + y) = 10^{-14}$ ...(ii)

On adding eq. (i) and (ii), we get:

$(x + y)^2 = (4 \times 10^{-14}) + (1 \times 10^{-14})$

$(x + y)^2 = 5 \times 10^{-14}$

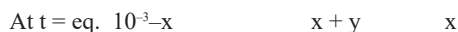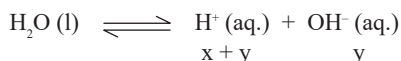$(x + y) = [H^+] = 5 \times 10^{-14}$

$$\Rightarrow [H^+] = \sqrt{5} \times 10^{-7}$$

$$\therefore x = \sqrt{5} = 2.236 \approx 2.24$$

10. (–07.10)

Van der Waals equation is:

$$\left(P + \frac{a}{V_m^2} \right)(V_m - b) = RT$$

$$\left[\frac{PV_m^2 + a}{Vm^2} \right](V_{m-b}) = RT$$

$$PV_m^3 - PbV_m^2 - RTV_m^2 + aV_m - ab = 0$$

On dividing this equation by P, we get:

$$V_m^3 - \left(b + \frac{RT}{p} \right)V_m^2 + \frac{aV_m}{P} - \frac{ab}{P} = 0$$

Therefore, ratio of coefficient of V_m^2 to that of the coefficient of V_m is:

$$\frac{\text{coefficient of } V_m^2}{\text{coefficient of } V_m} = \frac{-\left(b + \dfrac{RT}{P} \right)}{+\dfrac{a}{P}} = \frac{-\left[\dfrac{bP + RT}{P} \right]}{\dfrac{a}{P}}$$

$$= -\left(\frac{bP + RT}{a} \right)$$

$$= -\left(\frac{0.06 \times 300 + 0.082 \times 300}{a} \right)$$

(Given: b = 0.060 dm³ mol⁻¹, P = 300 atm and T = 300 K)

$$= -\frac{42.6}{6} = -7.10$$

11. (29.88)

No. of moles of $H_2O = \dfrac{144}{18} = 8$ moles

$$2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$$

According to the reaction,

2 moles water → 3 moles of gases

Therefore, 8 moles water → $\dfrac{3}{2} \times 8 = 12$ moles of gases

i.e; change in gaseous moles = 12

As, we know that,

$W = -P\Delta V = -(\Delta n)_g RT$

$\therefore W = -12 \times 8.3 \times 300$ J $= -29880$ J

$= -29880 \times 10^{-3}$ kJ $= -29.88$ kJ

12. (280.00)

The monomers of Nylon 6,6 are hexamethylene diamine and adipic acid. Hexamethylene diamine is a primary amine and hence, can give positive carbylamine test. Therefore, the monomer (X) is hexamethylene diamine.

$$H_2N(CH_2)_6 NH_2 \xrightarrow{\text{Dumas}} N_2$$
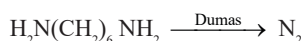
According to the reaction, 1 mole of X gives 1 mole of N_2

$\therefore$ 10 moles of X will give 10 moles of N_2

$\therefore$ Mass of N_2 formed = 10 × 28 = 280 g

13. (175.00)

The given reaction sequence is :
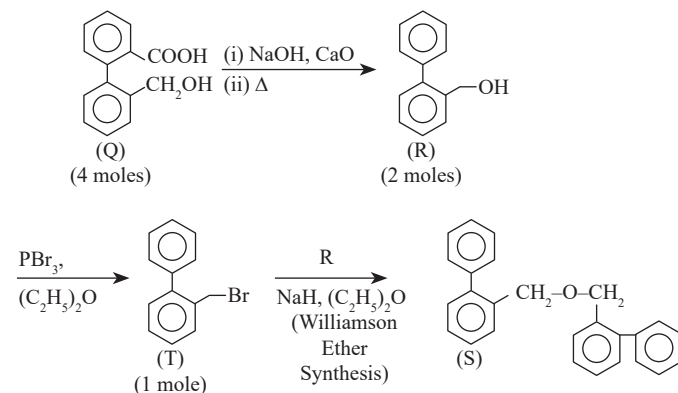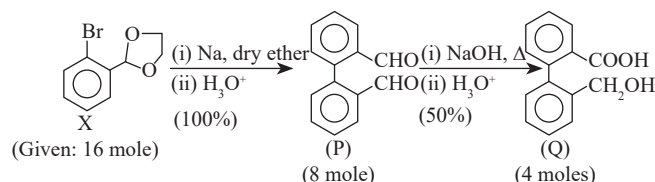
Molecular formula of S is $(C_6H_4)_2 (C_6H_5)_2 C_2H_4O$

$\therefore$ Molecular mass = 350 g mol⁻¹

As, the yield is 50%

$\therefore$ Mass of S produced is $= \dfrac{1}{2} \times 350 = 175$ g

1 SOME BASIC CONCEPTS OF CHEMISTRY

JEE-Advanced

Mole Concept, Percentage Composition, Molar Masses, and Empirical Formula

Single Correct

1. An aqueous solution of 6.3 g oxalic acid dihydrate is made up to 250 mL. The volume of 0.1 N NaOH required to completely neutralise 10 mL of this solution is **(IIT JEE 2001)**
   (a) 40 mL (b) 20 mL (c) 10 mL (d) 4 mL

2. The normality of 0.3M phosphorus acid (H_3PO_3) is **(IIT JEE 1999)**
   (a) 0.1 (b) 0.9 (c) 0.3 (d) 0.6

3. In which mode of expression, the concentration of a solution remains independent of temperature? **(IIT JEE 1998)**
   (a) Molarity (b) Normality
   (c) Formality (d) Molality

4. The volume strength of 1.5 N H_2O_2 is **(IIT JEE 1990)**
   (a) 4.8 (b) 8.4 (c) 3.0 (d) 8.0

5. A molal solution is one that contains one mole of solute in **(IIT JEE 1986)**
   (a) 1000 g of solvent (b) 1.0 L of solvent
   (c) 1.0 L of solution (d) 22.4 L of solution

6. If 0.50 mole of $BaCl_2$ is mixed with 0.20 mole of Na_3PO_4, the maximum number of moles of $Ba_3(PO_4)_2$ that can be formed is **(IIT JEE 1981)**
   (a) 0.70 (b) 0.50 (c) 0.20 (d) 0.10

7. The total number of electrons in one molecule of carbon dioxide is **(IIT JEE 1979)**
   (a) 22 (b) 44 (c) 68 (d) 88

Numerical/Integer Type

8. To form a complete monolayer of acetic acid on 1g of charcoal, 100 mL of 0.5M acetic acid was used. Some of the acetic acid remained unadsorbed. To neutralize the unadsorbed acetic acid, 40 mL of 1 M NaOH solution was required. If each molecule of acetic acid occupies $P \times 10^{-23}$ m^2 surface area on charcoal, the value of P is _____.
   [Use given data: Surface area of charcoal = 1.5×10^2 m^2g^{-1}; Avogadro's number (N_A) = 6.0×10^{23} mol^{-1}]
   C-15.73 W-60.25 UA-24.03 (JEE Adv. 2024)

9. Aluminium reacts with sulphuric acid to form aluminium sulphate and hydrogen. What is the volume of hydrogen gas in litre (L) produced at 300 K and 1.0 atm pressure, when 5.4 g of aluminium and 50.0 mL of 5.0 M sulphuric acid are combined for the reaction? (Use molar mass of aluminium as 27.0 g mol^{-1}, R = 0.082 atm L mol^{-1} K^{-1}) **C-18.21 W-64.19 UA-17.6 PC-0 (JEE Adv. 2020)**

10. The mole fraction of urea in an aqueous urea solution containing 900 g of water is 0.05. If the density of the solution is 1.2 g cm^{-3}, the molarity of urea solution is ____.
    (Given data: Molar masses of urea and water are 60 g mol^{-1} and 18 g mol^{-1}, respectively)
    C-17.05 W-70.35 UA-12.61 (JEE Adv. 2019)

11. The mole fraction of a solute in a solution is 0.1. At 298 K, molarity of this solution is the same as its molality. Density of this solution at 298 K is 2.0 g cm^{-3}. The ratio of the molecular weights of the solute and solvent, $\left(\dfrac{m_{solute}}{m_{solvent}} \right)$ is ... **C-28.66 W-66.23 UA-5.11 (JEE Adv. 2016)**

12. A compound H_2X with molar weight of 80 g is dissolved in a solvent having density of 0.4 g mL^{-1}. Assuming no change in volume upon dissolution, the molality of a 3.2 molar solution is **C-39.97 W-51.56 UA-8.47 (JEE Adv. 2014)**

13. 29.2% (w/W) HCl stock solution has density of 1.25 g mL^{-1}. The molecular weight of HCl is 36.5 g mol^{-1}. The volume (mL) of stock solution required to prepare a 200 mL solution 0.4 M HCl is **C-15.53 W-67.67 UA-16.8 (IIT JEE 2012)**

Fill in the Blanks

14. 3.0 g of a salt of molecular weight 30 is dissolved in 250 g water. The molality of the solution is .... **(IIT JEE 1983)**

15. The total number of electrons present in 18 mL of water is .... **(IIT JEE 1980)**

Subjective

16. 20% surface sites have adsorbed N_2. On heating N_2 gas evolved from sites and were collected at 0.001 atm and 298 K in a container of volume is 2.46 cm^3. Density of surface sites is 6.023×10^{14}/cm^2 and surface area is 1000 cm^2, find out the number of surface sites occupied per molecule of N_2. **(IIT JEE 2005)**

17. Calculate the amount of calcium oxide required when it reacts with 852 g of P_4O_{10}. **(IIT JEE 2005)**

18. In a solution of 100 mL 0.5 M acetic acid, one gram of active charcoal is added, which adsorbs acetic acid. It is found that the concentration of acetic acid becomes 0.49M. If surface area of charcoal is 3.01×10^2 m^2, calculate the area occupied by a single acetic acid molecule on the surface of charcoal. **(IIT JEE 2003)**

19. Find the molarity of water. Given: $\rho = 1000$ kg/m^3 **(IIT JEE 2003)**

20. How many millilitres of 0.5M H_2SO_4 are needed to dissolve 0.5 g of copper (II) carbonate? **(IIT JEE 1999)**

21. An aqueous solution containing 0.10 g KIO_3 (formula weight = 214.0) was treated with an excess of KI solution. The solution was acidified with HCl. The liberated I_2 consumed 45.0 mL of thiosulphate solution decolourise the blue starch-iodine complex. Calculate the molarity of the sodium thiosulphate solution. **(IIT JEE 1998)**

22. To a 25 mL H_2O_2 solution, excess of acidified solution of potassium iodide was added. The iodine liberated required 20 mL of 0.3 N sodium thiosulphate solution. Calculate the volume strength of H_2O_2 solution **(IIT JEE 1997)**

23. A 5.0 cm^3 solution of H_2O_2 liberates 0.508 g of iodine from an acidified KI solution. Calculate the strength of H_2O_2 solution in terms of volume strength at STP. **(IIT JEE 1995)**

24. 8.0575×10^{-2} kg of Glauber's salt is dissolved in water to obtain 1 dm^3 of solution of density 1077.2 kg m^{-3}. Calculate the molality, molarity and mole fraction of Na_2SO_4 in solution. **(IIT JEE 1994)**

25. Upon mixing 45.0 mL, 0.25 M lead nitrate solution with 25.0 mL of a 0.10 M chromic sulphate solution, precipitation of lead sulphate takes place. How many moles of lead sulphate are formed? Also calculate the molar concentrations of species left behind in the final solution. Assume that lead sulphate is completely insoluble. **(IIT JEE 1993)**

26. Calculate the molality of 1.0 L solution of 93% H_2SO_4, (weight/volume). The density of the solution is 1.84 g/mL. **(IIT JEE 1990)**

27. n-butane is produced by monobromination of ethane followed by Wurtz's reaction. Calculate volume of ethane at NTP required to produce 55 g n-butane, if the bromination takes place with 90% yield and the Wurtz's reaction with 85% yield. **(IIT JEE 1989)**

28. A sugar syrup of weight 214.2 g contains 34.2 g of sugar ($C_{12}H_{22}O_{11}$). Calculate (i) molal concentration and (ii) mole fraction of sugar in syrup **(IIT JEE 1988)**

29. An unknown compound of carbon, hydrogen and oxygen contains 69.77%C and 11.63%H and has a molecular weight of 86. It does not reduce Fehling's solution but forms a bisulfite addition compound and gives a positive iodoform test. What is the possible structure(s) of unknown compounds? **(IIT JEE 1987)**

30. The density of a 3M sodium thiosulphate solution ($Na_2S_2O_3$) is 1.25 g per mL. Calculate (i) the percentage by weight of sodium thiosulphate (ii) the mole fraction of sodium thiosulphate and (iii) the molalities of Na^+ and $S_2O_3^{2-}$ ions. **(IIT JEE 1983)**

31. In the analysis of 0.5 g sample of feldspar, a mixture of chlorides of sodium and potassium is obtained, which weighs 0.1180 g. Subsequent treatment of the mixed chlorides with silver nitrate gives 0.2451 g of silver chloride. What is the percentage of sodium oxide and potassium oxide in the sample? **(IIT JEE 1979)**

32. The vapor density (hydrogen = 1) of a mixture consisting of NO_2 and N_2O_4 is 38.3 at 26.7°C. Calculate the number of moles of NO_2 in 100 g of the mixture. **(IIT JEE 1979)**

Uncertainty in Measurement and Laws of Chemical Combinations, Atomic and Molecular Masses, Stoichiometry and Stoichiometric Calculation

Single Correct

33. 2.76 g of silver carbonate on being strongly heated yields a residue weighing **(IIT JEE 1979)**
   (a) 2.16 g (b) 2.48 g (c) 2.32 g (d) 2.64 g

34. When the same amount of zinc is treated separately with excess of sulphuric acid and excess of sodium hydroxide, the ratio of volumes of hydrogen evolved is **(IIT JEE 1979)**
   (a) 1:1 (b) 1:2
   (c) 2:1 (d) 9 : 4

35. The largest number of molecules is in **(IIT JEE 1979)**
   (a) 36 g of water
   (b) 28 g of CO
   (c) 46 g of ethyl alcohol
   (d) 54 g of nitrogen pentoxide (N_2O_5)

36. A gaseous mixture contains oxygen and nitrogen in the ratio of 1:4 by weight. Therefore, the ratio of their number of molecules is **(IIT JEE 1979)**
   (a) 1:4 (b) 1:8 (c) 7:32 (d) 88

Multiple Correct

37. To check the principle of multiple proportions, a series of pure binary compounds (P_mQ_n) were analyzed and their composition is tabulated below. The correct option(s) is(are)
   C-14.77 W-26.73 UA-39.64 (JEE Adv. 2022)

Compound	Weight % of P	Weight % of Q
1	50	50
2	44.4	55.6
3	40	60

   (a) If empirical formula of compound 3 is P_3Q_4. then the empirical formula of compound 2 is P_3Q_5.
   (b) If empirical formula of compound 3 is P_3Q_2 and atomic weight of clement P is 20, then the atomic weight of Q is 45.
   (c) If empirical formula of compound 2 is PQ, then the empirical formula of the compound 1 is P_5Q_4.
   (d) If atomic weight of P and Q are 70 and 35, respectively, then the empirical formula of compound 1 is P_2Q.

Numerical/Integer Type

38. The stoichiometric reaction of 516 g of dimethyldi-chlorosilane with water results in a tetrameric cyclic product X in 75% yield. The weight (in g) of X obtained is___.
   [Use, molar mass (g mol^{-1}): H = 1, C = 12, O = 16, Si = 28, Cl = 35.5]
   C-3.16 W-59.71 UA-37.13 (JEE Adv. 2023)

39. Dissolving 1.24 g of white phosphorous in boiling NaOH solution in an inert atmosphere gives gas Q. The amount of $CuSO_4$ (in g) required to completely consume the gas Q is____.
   [Given: Atomic mass of H = 1, 0 = 16, Na = 23, P = 31, S = 32, Cu = 63] **C1.78 W53.98 UA44.24 (JEE Adv. 2022)**

40. Galena (an ore) is partially oxidized by passing air through it at high temperature. After some time, the passage of air is stopped, but the heating is continued in a closed furnace such that the contents undergo self-reduction. The weight (in Kg) of Pb produced per kg of O_2 consumed is

(Atomic weights in g/mol :O = 16, S = 32, Pb = 207)

C-8.91 W-71.9 UA-19.2 (JEE Adv. 2018)

41. In the following reaction sequence, the amount of D (in gram) formed from 10 moles of acetophenone is ....

(Atomic weights in g mol^{-1} : H = 1, C = 12, N = 14, O = 16, Br = 80. The yield (%) corresponding to the product in each step is given in the parenthesis)

C-7.27 W-72.1 UA-20.63 (JEE Adv. 2018)
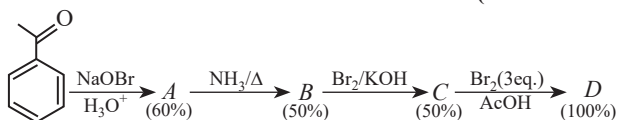
42. A student performs a titration with different burettes and finds titrate values of 25.2 mL, 25.25 mL, and 25.0 mL. The number of significant figures in the average titrate value is **(IIT JEE 2010)**

Fill in the Blanks

43. The compound $YBa_2Cu_3O_7$, which shows super conductivity, has copper in oxidation state .... Assume that the rare earth element yttrium is in its usual +3 oxidation state. **(IIT JEE 1994)**

44. The weight of 1×10^{22} molecules of $CuSO_4 \cdot 5H_2O$ is _____ **(IIT JEE 1991)**

45. The modern atomic mass unit is based on the mass of _____ **(IIT JEE 1980)**

Subjective

46. A plant virus is found to consist of uniform cylindrical particles of 150 in diameter and 5000 angstrom long. The specific volume of the virus is 0.75 cm^3/g. If the virus is considered to be a single particle, find its molar mass. **(IIT JEE 1999)**

47. A 3.00 g sample containing Fe_3O_4 , Fe_2O_3 and an inert impure substance, is treated with excess of KI solution in presence of dilute H_2SO_4. The entire iron is converted into Fe^{2+} along with the liberation of iodine. The resulting solution is diluted to 100 mL. A 20 mL of the diluted solution requires 11.0 mL of 0.5M$Na_2 S_2O_3$ solution to reduce the iodine present. A 50 mL of the dilute solution, after complete extraction of the

iodine required 12.80 mL of 0.25M$KMnO_4$ solution in dilute H_2SO_4 medium for the oxidation of Fe^{2+}. Calculate the percentage of Fe_2O_3 and Fe_3O_4 in the original sample. **(IIT JEE 1996)**

48. A 20.0 cm^3 mixture of CO, CH_4 and He gases is exploded by an electric discharge at room temperature with excess of oxygen. The volume contraction is found to be 13.0 cm^3.
A further contraction of 14.0 cm^3 occurs when the residual gas is treated with KOH solution. Find out the composition of the gaseous mixture in terms of volume percentage.

(IIT JEE 1995)

49. A is a binary compound of a univalent metal. 1.422 g of A reacts completely with 0.321 g of sulphur in an evacuated and sealed tube to give 1.743 g of a white crystalline solid B, that forms a hydrated double salt, C with $Al_2(SO_4)_3$. Identify A, B and C. **(IIT JEE 1994)**

50. One gram of commercial $AgNO_3$ is dissolved in 50 mL of water. It is treated with 50 mL of a KI solution. The silver iodide thus precipitated is filtered off. Excess of KI in the filtrate is titrated with (M/10) KIO_3 solution in presence of 6 M HCl till all I^- ions are converted into ICl. It requires 50 mL of (M/10) KIO_3 solution, 20 mL of the same stock solution of KI requires 30 mL of (M/10) KIO_3 under similar conditions. Calculate the percentage of $AgNO_3$ in the sample.

Reaction $KIO_3 + 2KI + 6HCl \rightarrow 3ICl + 3KCl + 3H_2O$

(IIT JEE 1991)

51. A solid mixture (5.0 g) consisting of lead nitrate and sodium nitrate was heated below 600°C until the weight of the residue was constant. If the loss in weight is 28.0 per cent, find the amount of lead nitrate and sodium nitrate in the mixture. **(IIT JEE 1990)**

52. 1.0 L of a mixture of CO and CO_2 is taken. This mixture is passed through a tube containing red hot charcoal. The volume now becomes 1.6 L. The volumes are measured under the same conditions. Find the composition of the mixture by volume.

(IIT JEE 1980)

53. 5.00 mL of a gas containing only carbon and hydrogen were mixed with an excess of oxygen (30 mL) and the mixture exploded by means of electric spark. After explosion, the volume of the mixed gases remaining was 25 mL. On adding a concentrated solution of KOH, the volume further diminished to 15 mL, the residual gas being pure oxygen. All volumes have been reduced to NTP. Calculate the molecular formula of the hydrocarbon gas. **(IIT JEE 1979)**

54. Accounts for the following. Limit your answer to two sentences, "Atomic weights of most of the elements are fractional".

(IIT JEE 1979)

ANSWER KEY

1. (a) 2. (d) 3. (d) 4. (b) 5. (a) 6. (d) 7. (a) 8. [2500] 9. [6.15]
10. [2.98 or 2.99] 11. [9] 12. [8] 13. [8] 14. [0.4] 15. [6.023 × 10^{24}] 33. (a) 34. (a)
35. (a) 36. (c) 37. (b,c) 38. [222] 39. [2.385] 40. [6.47] 41. [495] 42. [3] 43. [7/3] 44. [4.14 g]
45. C-12 isotopes

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