



JEEEnius AI

PREVIOUS YEAR QUESTIONS · 2019–2026

JEE Main

Chapter-wise PYQs

Chemistry

2019–2026 Questions from 8 years · plus AIEEE 2002–2012 appendix

Chapter-wise previous year questions with full solutions · Appendix:
AIEEE 2002–2012

3,518

QUESTIONS

163

FIGURES

23

CHAPTERS



A Grey Neural product
jeenius.tech

Independent study aid · not affiliated with or endorsed by NTA, the IITs or any examination authority

JEE Main Chapter-wise PYQs · Chemistry

Chapter-wise previous year questions with full solutions · Appendix: AIEEE 2002–2012

Digital edition · First published October 2026

Published by

Grey Neural Technologies Private Limited

CIN U62011WR2026PTC296120

Registered office: Flat No. E-1/14, S.M. Nagar, Sarkarpool, South 24 Parganas, West Bengal 700143, India

Email support@jeenius.tech · Phone +91 93106 39425 · jeenius.tech

© 2026 Grey Neural Technologies Private Limited. All rights reserved. The selection and arrangement of questions, the chapter classification, the answer keys, the solutions, the study notes, the analysis tables and the design of this book are the work of Grey Neural Technologies Private Limited. No part of this book may be reproduced, stored in a retrieval system, sold or transmitted in any form or by any means — electronic, mechanical, photocopying, recording or otherwise — without the prior written permission of the publisher, except for brief quotations in a review or for a student's own private study.

JEEEnius, JEEEnius AI and the JEEEnius logo are brands of Grey Neural Technologies Private Limited. Grey Neural and the Grey Neural logo are brands of Grey Neural Technologies Private Limited.

Examination disclaimer

JEE (Main) is conducted by the National Testing Agency (NTA). AIEEE, its predecessor, was conducted by the Central Board of Secondary Education (CBSE). This book is an independent study aid. It is not published, sponsored, approved or endorsed by the National Testing Agency, the Indian Institutes of Technology, the Joint Admission Board, CBSE, the Ministry of Education or any examination authority, and is not affiliated with any of them. The questions come from previously held public examinations and are reproduced for educational reference; rights in the original question papers remain with their respective owners. Names of examinations and institutions are used only to identify the papers.

Accuracy

Questions have been transcribed and classified with care, and a few have been lightly reworded or had their figures redrawn for clarity. Answer keys follow the answers we hold for each question; where an official examination authority has published a final answer key, the official key prevails. Questions whose figure could not be recovered, questions found to be unanswerable or duplicated, and questions whose answer key is under review have been left out, so the questions in this book are not complete papers for any year or shift. Solutions, quick approaches, common-trap notes, difficulty ratings and suggested times were prepared with the assistance of AI and may contain errors. If you find one, write to support@jeenius.tech quoting the question's "Ref" number from its solution; corrections are made in later editions.

No guarantee

This book is provided for practice and revision. The publisher makes no promise of any rank, score or admission result, and is not liable for any loss arising from the use of, or reliance on, its contents. Exam patterns, syllabi and marking schemes change; confirm current rules with the official examination authority.

Grievances

Grievance Officer, Grey Neural Technologies Private Limited, Flat No. E-1/14, S.M. Nagar, Sarkarpool, South 24 Parganas, West Bengal 700143, India. Email support@jeenius.tech. Complaints are acknowledged within 48 hours and resolved within 30 days.

Typeset by JEEEnius · 3,518 questions · built 2026-10-16

How to use this book

- **Chapter-wise, newest first.** Every chapter opens with its questions, latest year first, followed by an answer key and then full solutions. Attempt the questions before turning to the key.
- **Source line.** Each question shows where it was asked — year, date and shift, and its type when it is not a single-correct MCQ.
- **Weightage table.** Chemistry opens with a table of how often every chapter was asked, overall and in the last five years. Use it to plan revision.
- **More than an answer.** Solutions carry a difficulty rating, a suggested time and the topic; many add a quick approach, the common traps students fall into, and what to revise.
- **Ref numbers.** Each solution carries a Ref number. Quote it to report an error.

Questions by year

2002 53	2003 66	2004 76	2006 47	2007 37	2008 31	2009 29	2010 25	2011 27	2012 29	2019 349	2020 271
2021 367	2022 341	2023 546	2024 423	2025 392	2026 409						



Practise these PYQs in the JEEEnius app

Timed tests, chapter practice, AI doubt solving and a mistake notebook. jeenius.tech

Contents

JEE Main 2019–2026	5	Principles Related to Practical Chemistry	35	1067
Chemistry	6	Other Chemistry questions	5	1079
Some Basic Concepts in Chemistry	159	Appendix · AIEEE 2002–2012		1081
Atomic Structure	149	Chemistry		1082
Chemical Bonding and Molecular Structure	254	Some Basic Concepts in Chemistry	20	1083
States of Matter	13	Atomic Structure	16	1090
Chemical Thermodynamics	165	Chemical Bonding and Molecular Structure	46	1095
Solid State	1	Chemical Thermodynamics	24	1109
Solutions	260	Solutions	27	1117
Equilibrium	220	Equilibrium	33	1126
Redox Reactions and Electrochemistry	223	Redox Reactions and Electrochemistry	35	1137
Chemical Kinetics	149	Chemical Kinetics	19	1148
Surface Chemistry	2	Classification of Elements and Periodicity in Properties	19	1154
Classification of Elements and Periodicity in Properties	147	p-Block Elements	11	1160
p-Block Elements	121	d- and f-Block Elements	41	1164
d- and f-Block Elements	321	Purification and Characterization of Organic Compounds	2	1177
Purification and Characterization of Organic Compounds	58	Some Basic Principles of Organic Chemistry	8	1178
Some Basic Principles of Organic Chemistry	54	Hydrocarbons	9	1181
Hydrocarbons	84	Organic Compounds Containing Halogens	26	1184
Organic Compounds Containing Halogens	138	Organic Compounds Containing Oxygen	49	1192
Organic Compounds Containing Oxygen	213	Organic Compounds Containing Nitrogen	15	1206
Organic Compounds Containing Nitrogen	148	Biomolecules	14	1211
Biomolecules	179	Principles Related to Practical Chemistry	6	1215
	1007			

JEE Main 2019–2026

3,098 questions

Chemistry

Chapter	All years	Last 5 years
Some Basic Concepts in Chemistry	159	91
Atomic Structure	149	111
Chemical Bonding and Molecular Structure	254	175
States of Matter	13	10
Chemical Thermodynamics	165	115
Solid State	1	1
Solutions	260	184
Equilibrium	220	158
Redox Reactions and Electrochemistry	223	157
Chemical Kinetics	149	110
Surface Chemistry	2	1
Classification of Elements and Periodicity in Properties	147	93
p-Block Elements	121	82
d- and f-Block Elements	321	197
Purification and Characterization of Organic Compounds	58	38
Some Basic Principles of Organic Chemistry	54	36
Hydrocarbons	84	61
Organic Compounds Containing Halogens	138	101
Organic Compounds Containing Oxygen	213	149
Organic Compounds Containing Nitrogen	148	90
Biomolecules	179	121
Principles Related to Practical Chemistry	35	25
Other Chemistry questions	5	5

CHEMISTRY · CHAPTER 1

Some Basic Concepts in Chemistry

159 questions · 2026 3 · 2025 9 · 2024 13 · 2023 39 · 2022 27 · 2021 19 · 2020 26 · 2019 23

1 JEE MAIN 2026

The ratio of mass percentage (w/w) of C : H in a hydrocarbon is 12 : 1. It has two carbon atoms. The weight (in g) of CO_2 formed when 3.38 g of this hydrocarbon is completely burnt in oxygen is : (Given: Molar mass in g mol^{-1} C: 12, H: 1, O: 16)

- (A) 5.68 g (B) 11.44 g
(C) 22.74 g (D) 17.05 g

2 JEE MAIN 2026

Given below are two statements for catalytic properties of transition metals.

Statement I: First row transition metals which act as catalyst utilise their 3d electrons only for formation of bonds between reactant molecules and atoms on the surface of catalyst.

Statement II: There is increase in the concentration of reactants on the surface of catalyst which strengthens the bonds in reacting molecules.

In the light of the above statements, choose the correct answer:

- (A) Both Statement I and Statement II are correct
(B) Both Statement I and Statement II are incorrect
(C) Statement I is correct but Statement II is incorrect
(D) Statement I is incorrect but Statement II is correct

3 JEE MAIN 2026 · ASSERTION-REASON

Given below are two statements for the following reaction sequence.

compound 'X' (molecular formula $\text{C}_3\text{H}_6\text{Cl}_2$) $\xrightarrow{(\text{excess NaNH}_2)}$
compound 'Y' $\xrightarrow{(\text{dil. H}_2\text{SO}_4, \text{Hg}^{2+})}$ compound 'Z'.

Also, compound 'Y' on passing through red-hot iron tube gives compound 'Q' (molecular formula C_9H_{12}).

Statement I: Compound 'Z' will give yellow precipitate with NaOI.

Statement II: Compound 'Q' has two different types of 'H' atoms (aromatic : aliphatic) in the ratio 1 : 3.

Choose the correct answer:

- (A) Statement I is true but Statement II is false
(B) Both Statement I and Statement II are false
(C) Statement I is false but Statement II is true
(D) Both Statement I and Statement II are true

4 JEE MAIN 2025

The elemental composition of a compound is 54.2% C, 9.2% H and 36.6% O. If the molar mass of the compound is 132 g mol^{-1} , the molecular formula of the compound is : [Given : The relative atomic mass of C : H : O = 12 : 1 : 16]

- (1) $\text{C}_4\text{H}_8\text{O}_3$ (2) $\text{C}_6\text{H}_{12}\text{O}_6$
(3) $\text{C}_4\text{H}_8\text{O}_2$ (4) $\text{C}_6\text{H}_{12}\text{O}_3$

5 JEE MAIN 2025

$2.8 \times 10^{-3} \text{ mol}$ of CO_2 is left after removing 10^{21} molecules from its $x \text{ mg}$ sample. The mass of CO_2 taken initially is Given: $N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$

- (1) 98.3 mg (2) 48.2 mg
(3) 196.2 mg (4) 150.4 mg

6 JEE MAIN 2025 · NUMERICAL

Consider the following reaction occurring in the blast furnace: $\text{Fe}_3\text{O}_4(s) + 4\text{CO}(g) \rightarrow 3\text{Fe}(l) + 4\text{CO}_2(g)$ 'x' kg of iron is produced when $2.32 \times 10^3 \text{ kg}$ Fe_3O_4 and $2.8 \times 10^2 \text{ kg}$ CO are brought together in the furnace. The value of 'x' is ____ (nearest integer) Given: molar mass of $\text{Fe}_3\text{O}_4 = 232 \text{ g mol}^{-1}$ molar mass of CO = 28 g mol^{-1} molar mass of Fe = 56 g mol^{-1} .

7 JEE MAIN 2025 · NUMERICAL

When 81.0 g of aluminum is allowed to react with 128.0 g of oxygen gas, the mass of aluminum oxide produced in grams is _____. (Nearest integer) Given: Molar mass of Al is 27.0 g mol^{-1} , Molar mass of O is 16.0 g mol^{-1} .

8 JEE MAIN 2025 · NUMERICAL

0.01 mole of an organic compound (X) containing 10% hydrogen, on complete combustion produced 0.9 g H_2O . Molar mass of (X) is ____ g mol^{-1} .

9 JEE MAIN 2025 · 29 JAN S1 · NUMERICAL

In the sulphur estimation, 0.20 g of a pure organic compound gave 0.40 g of barium sulphate. The percentage of sulphur in the compound is _____ $\times 10^{-1}\%$. (Molar mass: O = 16, S = 32, Ba = 137 in g mol^{-1})

10 JEE MAIN 2025 · APRIL S1

Which of the following statements are correct?

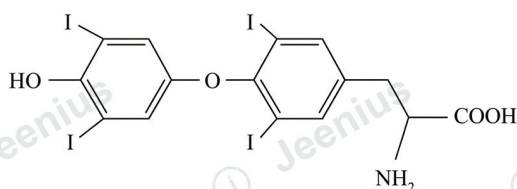
- A) The process of adding an electron to a neutral gaseous atom is always exothermic.
 B) The process of removing an electron from an isolated gaseous atom is always endothermic.
 C) The 1st ionization energy of boron is less than that of beryllium.
 D) The electronegativity of C is 2.5 in CH_4 and CCl_4 .
 E) Li is the most electropositive among elements of group I.

Choose the correct answer from the options given below:

- (A) B and D only (B) B, C and E only
 (C) B and C only (D) A, C and D only

11 JEE MAIN 2025

Thyroxine, the hormone, has the given structure (contains four iodine atoms). The percentage of iodine in thyroxine is % (nearest integer). (Given atomic masses in g mol^{-1} : C: 12, H: 1, O: 16, N: 14, I: 127)



- (A) 62% (B) 65%
 (C) 68% (D) 70%

12 JEE MAIN 2025 · NUMERICAL

20 mL of sodium iodide solution gave 4.74 g silver iodide when treated with excess of silver nitrate solution. The molarity of the sodium iodide solution is _____ M. (Nearest integer value) (Given: Na = 23, I = 127, Ag = 108, N = 14, O = 16 g mol^{-1})

- (A) 0 M (B) 1 M
 (C) 2 M (D) 3 M

13 JEE MAIN 2024

Number of metal ions characterized by flame test among the following is: Sr^{2+} , Ba^{2+} , Ca^{2+} , Cu^{2+} , Zn^{2+} , Co^{2+} , Fe^{2+}

- (A) 1 (B) 2
 (C) 3 (D) 4

14 JEE MAIN 2024 · NUMERICAL

Mass of methane required to produce 22 g of CO_2 after complete combustion is _____ g. (Given Molar mass in g/mol : C = 12.0, H = 1.0, O = 16.0)

15 JEE MAIN 2024 · NUMERICAL

The mass of silver (Molar mass of Ag: 108 g/mol) displaced by a quantity of electricity which displaces 5600 mL of O_2 at S.T.P. will be _____ g.

16 JEE MAIN 2024 · NUMERICAL

0.05 cm thick coating of silver is deposited on a plate of 0.05 m^2 area. The number of silver atoms deposited on plate are _____ $\times 10^{23}$. (At mass Ag = 108, $d = 7.9 \text{ g cm}^{-3}$) Round off to the nearest integer.

17 JEE MAIN 2024

Molar mass of the salt from NaBr, NaNO_3 , KI and CaF_2 which does not evolve coloured vapours on heating with concentrated H_2SO_4 is _____ g mol^{-1} . (Molar mass in g mol^{-1} : Na: 23, N: 14, K: 39, O: 16, Br: 80, I: 127, F: 19, Ca: 40)

- (A) 102 (B) 136
 (C) 166 (D) 78

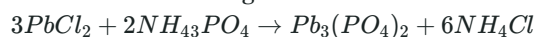
18 JEE MAIN 2024

The incorrect postulates of Dalton's atomic theory are: (A) Atoms of different elements differ in mass. (B) Matter consists of divisible atoms. (C) Compounds are formed when atoms of different elements combine in a fixed ratio. (D) All the atoms of a given element have different properties including mass. (E) Chemical reactions involve reorganization of atoms. Choose the correct answer from the options given below:

- (1) (C), (D), (E) only (2) (B), (D) only
 (3) (A), (B), (D) only (4) (B), (D), (E) only

19 JEE MAIN 2024 · NUMERICAL

Consider the following reaction:



If 72 mmol PbCl_2 is mixed with 50 mmol of NH_4PO_4 , then amount of $\text{Pb}_3(\text{PO}_4)_2$ formed in mmol. (nearest integer)

20 JEE MAIN 2024

Combustion of glucose ($\text{C}_6\text{H}_{12}\text{O}_6$) produces CO_2 and water. The amount of oxygen (in g) required for the complete combustion of 900 g of glucose is: [Molar mass of glucose in $\text{g mol}^{-1} = 180$]

- (1) 480 (2) 800
 (3) 960 (4) 32

21 JEE MAIN 2024

Choose the Incorrect Statement about Dalton's Atomic Theory

- (1) Chemical reactions involve reorganization of atoms
 (2) Matter consists of indivisible atoms
 (3) Compounds are formed when atoms of different elements combine in any ratio
 (4) All the atoms of a given element have identical properties including identical mass.

22 JEE MAIN 2024 · NUMERICAL

The half-life of radioisotopic bromine-82 is 36 hours. The fraction which remains after one day is $\text{_____} \times 10^{-2}$. (Given antilog 0.2006 = 1.587) Round off to the nearest integer.

23 JEE MAIN 2024

While preparing crystals of Mohr's salt, dil H_2SO_4 is added to a mixture of ferrous sulphate and ammonium sulphate, before dissolving this mixture in water, dil H_2SO_4 is added here to :

- (1) prevent the hydrolysis of ferrous sulphate
- (2) prevent the hydrolysis of ammonium sulphate
- (3) make the medium strongly acidic
- (4) increase the rate of formation of crystals

24 JEE MAIN 2024

The number of moles of methane required to produce 11 g CO_2 (g) after complete combustion is: (Given molar mass of methane in gmol^{-1} : 16)

- (1) 0.35
- (2) 0.5
- (3) 0.75
- (4) 0.25

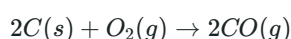
25 JEE MAIN 2024

A sample of CaCO_3 and MgCO_3 weighed 2.21 g is ignited to constant weight of 1.152 g. The composition of the mixture is: (Given molar mass in g mol^{-1} , CaCO_3 : 100, MgCO_3 : 84)

- (1) 1.187 g CaCO_3 + 1.023 g MgCO_3
- (2) 1.023 g CaCO_3 + 1.023 g MgCO_3
- (3) 1.187 g CaCO_3 + 1.187 g MgCO_3
- (4) 1.023 g CaCO_3 + 1.187 g MgCO_3

26 JEE MAIN 2023 · NUMERICAL

Assume carbon burns according to the following equation:



when 12 g carbon is burnt in 48 g of oxygen, the volume of carbon monoxide produced is $\text{_____} \times 10^{-1}$ L at STP [nearest integer] [Given: Assume CO as ideal gas, Mass of C is 12 g mol^{-1} , mass of O is 16 g mol^{-1} and molar volume of an ideal gas at STP is 22.7 L mol^{-1}]

27 JEE MAIN 2023

The delicate balance of CO_2 and O_2 is NOT disturbed by

- (A) Respiration
- (B) Burning of coal
- (C) Deforestation
- (D) Burning of petroleum

28 JEE MAIN 2023 · ASSERTION-REASON

Given below are two statements, one is labelled as Assertion A and the other is labelled as Reason R.

Assertion A : Isotopes of hydrogen have almost same chemical properties, but difference in their rates of reactions.

Reason R: Isotopes of hydrogen have different enthalpy of bond dissociation.

In the light of the above statements, choose the most appropriate answer from the options given below:

- (1) Both A and R are correct but R is NOT the correct explanation of A
- (2) Both A and R are correct and R is the correct explanation of A
- (3) A is not correct but R is correct
- (4) A is correct but R is not correct

29 JEE MAIN 2023 · NUMERICAL

1 g of a carbonate M_2CO_3 on treatment with excess HCl produces 0.01 mol of CO_2 . The molar mass of M_2CO_3 is gmol^{-1} . (Nearest integer)

30 JEE MAIN 2023 · NUMERICAL

The number of correct statements about modern adsorption theory of heterogeneous catalysis from the following is _____

- A. The catalyst is diffused over the surface of reactants.
- B. Reactants are adsorbed on the surface of the catalyst.
- C. Occurrence of chemical reaction on the catalyst's surface through formation of an intermediate.
- D. It is a combination of intermediate compound formation theory and the old adsorption theory.
- E. It explains the action of the catalyst as well as those of catalytic promoters and poisons.

31 JEE MAIN 2023 · NUMERICAL

A certain quantity of real gas occupies a volume of 0.15 dm^3 at 100 atm and 500 K when its compressibility factor is 1.07. Its volume at 300 atm and 300 K (When its compressibility factor is 1.4) is $\text{_____} \times 10^{-4}$ dm^3 (Nearest integer).

32 JEE MAIN 2023

What is the purpose of adding gypsum to cement?

- (A) To facilitate the hydration of cement
- (B) To slow down the process of setting
- (C) To give a hard mass
- (D) To speed up the process of setting

33 JEE MAIN 2023 · NUMERICAL

20 mL of calcium hydroxide was consumed when it was reacted with 10 mL of unknown solution of H_2SO_4 . Also 20 mL standard solution of 0.5 M HCl containing 2 drops of phenolphthalein was titrated with calcium hydroxide, the mixture showed pink colour when burette displayed the value of 35.5 mL whereas the burette showed 25.5 mL initially. The concentration of H_2SO_4 is _____ M. (Nearest integer)

34 JEE MAIN 2023 · NUMERICAL

The volume of HCl, containing 73 g L^{-1} , required to completely neutralise NaOH obtained by reacting 0.69 g of metallic sodium with water, is ____ mL. (Nearest Integer)
(Given : molar masses of Na, Cl, O, H are 23, 35.5, 16 and 1 g mol^{-1} respectively)

35 JEE MAIN 2023 · NUMERICAL

The energy of one mole of photons of radiation of frequency $2 \times 10^{12}\text{ Hz}$ in J mol^{-1} is _____. (Nearest integer) (Given: $h = 6.626 \times 10^{-34}\text{ J s}$, $N_A = 6.022 \times 10^{23}\text{ mol}^{-1}$)

36 JEE MAIN 2023 · NUMERICAL

When 0.01 mol of an organic compound containing 60% carbon was burnt completely, 4.4 g of CO_2 was produced. The molar mass of compound is ____ g mol^{-1} (Nearest integer).

37 JEE MAIN 2023

The number of molecules and moles in 2.8375 litres of O_2 at STP are respectively

- (1) 7.527×10^{23} and 0.125 mol
(2) 7.527×10^{22} and 0.250 mol
(3) 1.505×10^{23} and 0.250 mol
(4) 7.527×10^{22} and 0.125 mol

38 JEE MAIN 2023

Chlorides of which metal are soluble in organic solvents:

- (1) Ca (2) Mg
(3) K (4) Be

39 JEE MAIN 2023

Given below are two statements:

Statement I: Aqueous solution of $\text{K}_2\text{Cr}_2\text{O}_7$ is preferred as a primary standard in volumetric analysis over $\text{Na}_2\text{Cr}_2\text{O}_7$ aqueous solution.

Statement II: $\text{K}_2\text{Cr}_2\text{O}_7$ has a higher solubility in water than $\text{Na}_2\text{Cr}_2\text{O}_7$. In the light of the above statements, choose the correct answer from the options given below:

- (1) Statement I is false but Statement II is true
(2) Both Statement I and Statement II are true
(3) Statement I is true but Statement II is false
(4) Both Statement I and Statement II are false

40 JEE MAIN 2023

Arrange the following gases in increasing order of van der Waals constant a :

- (A) Ar
(B) CH_4
(C) H_2O
(D) C_6H_6

Choose the correct option from the following.

- (1) D, C, B and A (2) B, C, D and A
(3) C, D, B and A (4) A, B, C and D

41 JEE MAIN 2023 · MATCHING

Match List-I with List-II:

List-I:

- A. K
B. KCl
C. KOH
D. Li

List-II:

- I. Thermonuclear reactions
II. Fertilizer
III. Sodium potassium pump
IV. Absorbent of CO_2

Choose the correct answer from the options given below:

- (1) A-III, B-IV, C-II, D-I (2) A-III, B-II, C-IV, D-I
(3) A-IV, B-III, C-I, D-II (4) A-IV, B-I, C-III, D-II

42 JEE MAIN 2023

For a good quality cement, the ratio of lime to the total of the oxides of Si, Al and Fe should be as close as possible to :

- (A) 3 (B) 2
(C) 1 (D) 4

43 JEE MAIN 2023 · NUMERICAL

A 300 mL bottle of soft drink has 0.2 mol CO_2 dissolved in it. Assuming CO_2 behaves as an ideal gas, the volume of the dissolved CO_2 at STP is ____ mL. (Nearest integer)

Given: At STP, molar volume of an ideal gas is 22.7 L mol^{-1} .

44 JEE MAIN 2023

A metal chloride contains 55.0% of chlorine by weight.

100 mL vapours of the metal chloride at STP weigh 0.57 g.

The molecular formula of the metal chloride is (Given:

Atomic mass of chlorine is 35.5 u)

- (1) MCl_4 (2) MCl_3
(3) MCl_2 (4) MCl

45 JEE MAIN 2023

The total number of intensive properties from the following is: Volume, Molar heat capacity, molarity, E_{cell}^0 , Gibbs free energy change, Molar mass, Mole

- (A) 2 (B) 3
(C) 4 (D) 5

46 JEE MAIN 2023 · ASSERTION-REASON

Given below are two statements: one is labeled as Assertion (A) and the other is labeled as Reason (R).

Assertion (A): An aqueous solution of KOH when for volumetric analysis, its concentration should be checked before the use.

Reason (R): On aging, KOH solution absorbs atmospheric CO_2 .

In the light of the above statements, choose the correct answer from the options given below.

- (1) (A) is not correct but (R) is correct
- (2) Both (A) and (R) are correct but (R) is not the correct explanation of (A)
- (3) Both (A) and (R) are correct and (R) is the correct explanation of (A)
- (4) (A) is correct but (R) is not correct

47 JEE MAIN 2023 · NUMERICAL

On complete combustion, 0.492 g of an organic compound gave 0.792 g of CO_2 . The % of carbon in the organic compound is (Nearest integer)

48 JEE MAIN 2023

Which of the following reaction is correct?

- (1) $2\text{LiNO}_3 \xrightarrow{\Delta} 2\text{LiNO}_2 + \text{O}_2$
- (2) $4\text{LiNO}_3 \xrightarrow{\Delta} 2\text{Li}_2\text{O} + 2\text{N}_2\text{O}_4 + \text{O}_2$
- (3) $4\text{LiNO}_3 \xrightarrow{\Delta} 2\text{Li}_2\text{O} + 4\text{NO}_2 + \text{O}_2$
- (4) $2\text{LiNO}_3 \xrightarrow{\Delta} 2\text{Li} + 2\text{NO}_2 + \text{O}_2$

49 JEE MAIN 2023 · NUMERICAL

Zinc reacts with hydrochloric acid to give hydrogen and zinc chloride. The volume of hydrogen gas produced at STP from the reaction of 11.5 g of zinc with excess HCl is L (Nearest integer) (Given: Molar mass of Zn is 65.4 g mol^{-1} and Molar volume of H_2 at STP = 22.7 L)

50 JEE MAIN 2023 · NUMERICAL

Iron oxide FeO , crystallises in a cubic lattice with a unit cell edge length of $5.0 \text{ \AA}$. If density of the FeO in the crystal is 4.0 g cm^{-3} , then the number of FeO units present per unit cell is ____ (Nearest integer) Given : Molar mass of Fe and O is 56 and 16 g mol^{-1} respectively. $N_A = 6.0 \times 10^{23} \text{ mol}^{-1}$

51 JEE MAIN 2023 · ASSERTION-REASON

Given below are two statements, one is labelled as Assertion A and the other is labelled as Reason R

Assertion A: The alkali metals and their salts impart characteristic colour to reducing flame.

Reason R: Alkali metals can be detected using flame tests.

In the light of the above statements, choose the most appropriate answer from the options given below

- (1) Both A and R are correct but R is NOT the correct explanation of A.
- (2) A is correct but R is not correct.
- (3) A is not correct but R is correct.
- (4) Both A and R are correct and R is the correct explanation of A.

52 JEE MAIN 2023 · NUMERICAL

An organic compound gives 0.220 g of CO_2 and 0.126 g of H_2O on complete combustion. If the % of carbon is 24, then the % of hydrogen is _____ $\times 10^{-1}$. (Nearest integer)

53 JEE MAIN 2023 · NUMERICAL

When $\text{Fe}_{0.93}\text{O}$ is heated in presence of oxygen, it converts to Fe_2O_3 . The number of correct statement/s from the following is ____.

- A. The equivalent weight of $\text{Fe}_{0.93}\text{O}$ is $\frac{\text{Molecular weight}}{0.79}$
- B. The number of moles of Fe^{2+} and Fe^{3+} in 1 mole of $\text{Fe}_{0.93}\text{O}$ is 0.79 and 0.14 respectively.
- C. $\text{Fe}_{0.93}\text{O}$ is metal deficient with lattice comprising of cubic closed packed arrangement of O^{2-} ions.
- D. The % composition of Fe^{2+} and Fe^{3+} in $\text{Fe}_{0.93}\text{O}$ is 85% and 15% respectively.

54 JEE MAIN 2023 · NUMERICAL

The total pressure of a mixture of non-reacting gases X (0.6 g) and Y (0.45 g) in a vessel is 740 mm of Hg. The partial pressure of the gas X is ____ mm of Hg. (Nearest Integer) (Given: molar mass X = 20 and $Y = 45 \text{ g mol}^{-1}$)

55 JEE MAIN 2023

An evacuated glass vessel weighs 40.0 g when empty, 135.0 g when filled with a liquid of density 0.95 g mL^{-1} and 40.5 g when filled with an ideal gas at 0.82 atm at 250 K. The molar mass of the gas in g mol^{-1} is: (Given : $R = 0.082 \text{ L atm K}^{-1} \text{ mol}^{-1}$)

- | | |
|--------|---------|
| (A) 35 | (B) 50 |
| (C) 75 | (D) 125 |

56 JEE MAIN 2023

Compound A contains 8.7% Hydrogen, 74% Carbon and 17.3% Nitrogen. The molecular formula of the compound is, Given: Atomic masses of C, H and N are 12, 1 and 14 amu respectively. The molar mass of the compound A is 162g mol^{-1} .

- (1) $\text{C}_4\text{H}_6\text{N}_2$ (2) $\text{C}_2\text{H}_3\text{N}$
(3) $\text{C}_5\text{H}_7\text{N}$ (4) $\text{C}_{10}\text{H}_{14}\text{N}_2$

57 JEE MAIN 2023

Number of hydrogen atoms per molecule of a hydrocarbon A having 85.8% carbon is (Given: Molar mass of A = 84g mol^{-1})

- (A) 6 (B) 8
(C) 10 (D) 12

58 JEE MAIN 2023 · NUMERICAL

The strength of 50 volume solution of hydrogen peroxide is _____ g/L (Nearest integer).

59 JEE MAIN 2023 · ASSERTION-REASON

Given below are two statements:

Statement-I: Methane and steam passed over a heated Ni catalyst produces hydrogen gas.

Statement-II: Sodium nitrite reacts with NH_4Cl to give H_2 , O , N_2 and NaCl . In the light of the above statements, choose the most appropriate answer from the options given below:

- (1) Statement I is incorrect but Statement II is correct
(2) Both the statements I and II are incorrect
(3) Statement I is correct but Statement II is incorrect
(4) Both the statements I and II are correct

60 JEE MAIN 2023 · 29 JAN S1

The correct order of hydration enthalpies is

- (A) K^+
(B) Rb^+
(C) Mg^{2+}
(D) Cs^+
(E) Ca^{2+}

Choose the correct answer from the options given below:

- (1) $\text{C} > \text{A} > \text{E} > \text{B} > \text{D}$ (2) $\text{E} > \text{C} > \text{A} > \text{B} > \text{D}$
(3) $\text{C} > \text{E} > \text{A} > \text{D} > \text{B}$ (4) $\text{C} > \text{E} > \text{A} > \text{B} > \text{D}$

61 JEE MAIN 2023 · 30 JAN S1 · ASSERTION-REASON

Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A): In expensive scientific instruments, silica gel is kept in watch-glasses or in semipermeable membrane bags. Reason (R): Silica gel adsorbs moisture from air via adsorption, thus protects the instrument from water corrosion (rusting) and / or prevents malfunctioning. In the light of the above statements, choose the correct answer from the options given below:

- (1) (A) is false but (R) is true
(2) (A) is true but (R) is false
(3) Both (A) and (R) are true and (R) is the correct explanation of (A)
(4) Both (A) and (R) are true but (R) is not the correct explanation of (A)

62 JEE MAIN 2023 · 6 APR S1

Which one of the following elements will remain as liquid inside pure boiling water?

- (1) Ga (2) Br
(3) Li (4) Cs

63 JEE MAIN 2023 · 10 APR S2

Number of water molecules in washing soda and soda ash respectively are:

- (A) 1 and 10 (B) 10 and 1
(C) 10 and 0 (D) 1 and 0

64 JEE MAIN 2023 · 11 APR S1 · NUMERICAL

A solution of sugar is obtained by mixing 200 g of its 25% solution and 500 g of its 40% solution (both by mass).

The mass percentage of the resulting sugar solution is _____ (Nearest integer).

65 JEE MAIN 2022

Boiling of hard water is helpful in removing the temporary hardness by converting calcium hydrogen carbonate and magnesium hydrogen carbonate to

- (1) CaCO_3 and $\text{Mg}(\text{OH})_2$ (2) CaCO_3 and MgCO_3
(3) $\text{Ca}(\text{OH})_2$ and MgCO_3 (4) $\text{Ca}(\text{OH})_2$ and $\text{Mg}(\text{OH})_2$

66 JEE MAIN 2022 · NUMERICAL

A mixture of hydrogen and oxygen contains 40% hydrogen by mass when the pressure is 2.2 bar. The partial pressure of hydrogen is bar.

67 JEE MAIN 2022 · ASSERTION-REASON

Given below are two statements. One is labelled as Assertion A and the other is labelled as Reason R.

Assertion A: Activated charcoal adsorbs SO_2 more efficiently than CH_4 .

Reason R: Gases with lower critical temperatures are readily adsorbed by activated charcoal. In the light of the above statements, choose the correct answer from the options given below.

- (1) Both A and R are correct and R is the correct explanation of A.
 (2) Both A and R are correct but R is NOT the correct explanation of A.
 (3) A is correct but R is not correct.
 (4) A is not correct but R is correct.

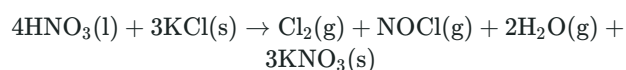
68 JEE MAIN 2022

Consider the above reaction. If 20g of dinitrogen reacts with 5g of dihydrogen, then the limiting reagent of the reaction and number of moles of NH_3 formed respectively are

- (1) H_2 , 1.42 moles (2) H_2 , 0.71 moles
 (3) N_2 , 1.42 moles (4) N_2 , 0.71 moles

69 JEE MAIN 2022

Consider the reaction



The amount of HNO_3 required to produce 110.0 g of KNO_3 is (Given: Atomic masses of H, O, N and K are 1, 16, 14 and 39, respectively.)

- (A) 32.2 g (B) 69.4 g
 (C) 91.5 g (D) 162.5 g

70 JEE MAIN 2022

120 g of an organic compound which contains only carbon and hydrogen on complete combustion gives 330 g of CO_2 and 270 g of water. The percentage of carbon and hydrogen in the organic compound are respectively.

- (1) 25 and 75 (2) 40 and 60
 (3) 60 and 40 (4) 75 and 25

71 JEE MAIN 2022 · NUMERICAL

The complete combustion of 0.492 g of an organic compound containing 'C', 'H' and 'O' gives 0.793 g of CO_2 and 0.442 g of H_2O . The percentage of oxygen composition in the organic compound is ____ (nearest integer).

72 JEE MAIN 2022

In the industrial production of which of the following, molecular hydrogen is obtained as a by product.

- (1) Na_2CO_3 (2) NaOH
 (3) Na metal (4) NaHCO_3

73 JEE MAIN 2022

In the flame test of a mixture of salts, a green flame with blue centre was observed. Which one of the following cations may be present?

- (1) Calcium (2) Copper
 (3) Barium (4) Strontium

74 JEE MAIN 2022

The gas produced by treating an aqueous solution of ammonium chloride with sodium nitrite is

- (1) NH_3 (2) N_2
 (3) N_2O (4) Cl_2

75 JEE MAIN 2022 · NUMERICAL

An element M crystallises in a body centred cubic unit cell with a cell edge of 300 pm. The density of the element is 6.0 g/cm^3 . The number of atoms present in 180 g of the element is ____ $\times 10^{23}$. (Nearest integer)

76 JEE MAIN 2022 · NUMERICAL

The pressure of a moist gas at 27°C is 4 atm. The volume of the container is doubled at the same temperature. The new pressure of the moist gas is ... $\times 10^{-1}$ atm. (Nearest integer) (Given: The vapour pressure of water at 27°C is 0.4 atm)

77 JEE MAIN 2022

A 10 g mixture of hydrogen and helium is contained in a vessel of capacity 0.0125 m^3 at 6 bar and 27°C . The mass of helium in the mixture is g.
 (Given : $R = 8.3 \text{ J K}^{-1} \text{ mol}^{-1}$ (Atomic masses of H and He are 1u and 4u, respectively))

- (A) 2 g (B) 4 g
 (C) 6 g (D) 8 g

78 JEE MAIN 2022

The metal that is not extracted from its sulphide ore is

- (A) Aluminium (B) Iron
 (C) Lead (D) Zinc

79 JEE MAIN 2022 · NUMERICAL

A sample of 4.5 mg of an unknown monohydric alcohol, R - OH was added to methylmagnesium iodide. A gas is evolved and is collected and its volume measured to be 3.1 mL. The molecular weight of the unknown alcohol is g/mol.

80 JEE MAIN 2022 · NUMERICAL

2 L of 0.2 M H_2SO_4 is reacted with 2 L of 0.1 M NaOH solution, the molarity of the resulting product Na_2SO_4 in the solution is ____ millimolar. (Nearest integer)

81 JEE MAIN 2022 · NUMERICAL

100 g of an ideal gas is kept in a cylinder of 416 L volume at 27°C under 1.5 bar pressure. The molar mass of the gas is g mol^{-1} . (Nearest integer)
 (Given : $R = 0.083 \text{ L bar K}^{-1} \text{ mol}^{-1}$)

82 JEE MAIN 2022

Amongst baking soda, caustic soda and washing soda carbonate anion is present in:

- (1) Washing Soda only
- (2) washing soda and caustic soda only.
- (3) washing soda and baking soda only.
- (4) baking soda, caustic soda and washing soda.

83 JEE MAIN 2022 · NUMERICAL

A sealed flask with a capacity of $2dm^3$ contains 11 g of propane gas. The flask is so weak that it will burst if the pressure becomes 2 MPa. The minimum temperature at which the flask will burst is °C. [Nearest integer] (Given: $R = 8.3JK^{-1}mol^{-1}$. Atomic masses of C and H are 12u and 1u respectively.) (Assume that propane behaves as an ideal gas.)

84 JEE MAIN 2022 · ASSERTION-REASON

Given below are two statements: One is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A): Clothes containing oil or grease stains cannot be cleaned by water wash.

Reason (R): Because the angle of contact between the oil/grease and water is obtuse. In the light of the above statements, choose the correct answer from the option given below.

- (1) Both (A) and (R) are true and (R) is the correct explanation of (A)
- (2) Both (A) and (R) are true but (R) is not the correct explanation of (A)
- (3) (A) is true but (R) is false
- (4) (A) is true but (R) is true

85 JEE MAIN 2022 · NUMERICAL

The number of N atoms in 681 g of $C_7H_5N_3O_6$ is $x \times 10^{24}$. The value of x is $N_A = 6.02 \times 10^{23} mol^{-1}$ (Nearest Integer)

86 JEE MAIN 2022

A white precipitate was formed when $BaCl_2$ was added to water extract of an inorganic salt. Further, a gas X with characteristic odour was released when the formed white precipitate was dissolved in dilute HCl. The anion present in the inorganic salt is:

- | | |
|--------------|-----------------|
| (1) I^- | (2) SO_3^{2-} |
| (3) S^{2-} | (4) NO_2^- |

87 JEE MAIN 2022 · NUMERICAL

CNG is an important transportation fuel. When 100 g CNG is mixed with 208 g oxygen in vehicles, it leads to the formation of CO_2 and H_2O and produces large quantity of heat during this combustion, then the amount of carbon dioxide, produced in grams is [nearest integer] [Assume CNG to be methane]

88 JEE MAIN 2022 · ONE OR MORE CORRECT

Given below are two statements:

Statement I: Hydrogen peroxide can act as an oxidizing agent in both acidic and basic conditions.

Statement II: Density of hydrogen peroxide at 298 K is lower than that of D_2O .

In the light of the above statements. Choose the correct answer from the options.

- (1) Both statement I and Statement II are true
- (2) Both statement I and Statement II are false
- (3) Statement I is true but Statement II is false
- (4) Statement I is false but Statement II is true

89 JEE MAIN 2022 · MATCHING

Match List I with List II.

List I (Pollutant)

- A. Sulphate (>500 ppm)
- B. Nitrate (>50 ppm)
- C. Lead (>50 ppb)
- D. Fluoride (>2 ppm)

List II (Disease/sickness)

- I. Methemoglobinemia
- II. Brown mottling of teeth
- III. Laxative effect
- IV. Kidney damage

Choose the correct answer from the options given below :

- | | |
|------------------------------------|------------------------------------|
| (1) A – IV, B – I, C – II, D – III | (2) A – III, B – I, C – IV, D – II |
| (3) A – II, B – IV, C – I, D – III | (4) A – II, B – IV, C – III, D – I |

90 JEE MAIN 2022 · NUMERICAL

56.0 L of nitrogen gas is mixed with excess of hydrogen gas and it is found that 20 L of ammonia gas is produced. The volume of unused nitrogen gas is found to be ____ L.

91 JEE MAIN 2022

Hemoglobin contains 0.34% of iron by mass. The number of Fe atoms in 3.3 g of hemoglobin is (Given : Atomic mass of Fe is 56u, $N_A = 6.022 \times 10^{23} mol^{-1}$)

- | | |
|---------------------------|---------------------------|
| (1) 1.21×10^5 | (2) 12.0×10^{16} |
| (3) 1.21×10^{20} | (4) 3.4×10^{22} |

92 JEE MAIN 2021 · NUMERICAL

The volume occupied by 4.75 g of acetylene gas at 50°C and 740 mm Hg pressure is ____ L. (Rounded off to the nearest integer) [Given $R = 0.0826 L atm K^{-1}mol^{-1}$]

93 JEE MAIN 2021 · NUMERICAL

The ratio of number of water molecules in Mohr's salt and potash alum is $\times 10^{-1}$. (Integer answer)

94 JEE MAIN 2021 · NUMERICAL

The formula of a gaseous hydrocarbon which requires 6 times of its own volume of O_2 for complete oxidation and produces 4 times its own volume of CO_2 is C_xH_y . The value of y is _____.

95 JEE MAIN 2021

The INCORRECT statement(s) about heavy water is (are):

- (A) used as a moderator in nuclear reactor
(B) obtained as a by-product in fertilizer industry.
(C) used for the study of reaction mechanism
(D) has a higher dielectric constant than water

Choose the correct answer from the options given below:

- (1) (B) only (2) (C) only
(3) (D) only (4) (B) and (D) only

96 JEE MAIN 2021

Complete combustion of 1.80 g of an oxygen containing compound ($C_xH_yO_z$) gave 2.64 g of CO_2 and 1.08 g of H_2O . The percentage of oxygen in the organic compound is:

- (1) 53.33 (2) 50.33
(3) 51.63 (4) 63.53

97 JEE MAIN 2021 · NUMERICAL

The molarity of the solution prepared by dissolving 6.3 g of oxalic acid ($H_2C_2O_4 \cdot 2H_2O$) in 250 mL of water in $mol\ L^{-1}$ is $x \times 10^{-2}$. The value of x is _____. (Nearest integer)

[Atomic mass: H : 1.0, C : 12.0, O : 16.0]

98 JEE MAIN 2021 · NUMERICAL

At $25^\circ C$, 50 g of iron reacts with HCl to form $FeCl_2$. The evolved hydrogen gas expands against a constant pressure of 1 bar. The work done by the gas during this expansion is _____. J. (Round off to the Nearest Integer).

[Given: $R = 8.314\ J\ mol^{-1}\ K^{-1}$. Assume, hydrogen is an ideal gas] [Atomic mass of Fe is 55.85 u]

99 JEE MAIN 2021 · NUMERICAL

250 mL of 0.5M NaOH was added to 500 mL of 1M HCl. The number of unreacted HCl molecules in the solution after the complete reaction is $p \times 10^{21}$. Find out p (Nearest integer) ($N_A = 6.022 \times 10^{23}$)

100 JEE MAIN 2021 · NUMERICAL

The number of chlorine atoms in 20 mL of chlorine gas at STP is _____ $\times 10^{21}$. (Round off to the Nearest Integer). [Assume chlorine is an ideal gas at STP $R = 0.083\ L\ bar\ mol^{-1}\ K^{-1}$, $N_A = 6.023 \times 10^{23}$]

101 JEE MAIN 2021

A hard substance melts at high temperature and is an insulator in both solid and in molten state. This solid is most likely to be a/an:

- (1) Ionic solid (2) Molecular solid
(3) Metallic solid (4) Covalent solid

102 JEE MAIN 2021 · NUMERICAL

In Duma's method of estimation of nitrogen, 0.1840 g of an organic compound gave 30 mL of nitrogen collected at 287 K and 758 mm of Hg pressure. The percentage composition of nitrogen in the compound is _____. (Round off to the Nearest Integer).

[Given: Aqueous tension at 287 K = 14 mm of Hg]

103 JEE MAIN 2021 · NUMERICAL

An organic compound is subjected to chlorination to get compound A using 5.0 g of chlorine. When 0.5 g of compound A is reacted with $AgNO_3$ [Carius Method], the percentage of chlorine in compound A is when it forms 0.3849 g of $AgCl$. (Round off to the Nearest Integer) (Atomic masses of Ag and Cl are 107.87 and 35.5 respectively)

104 JEE MAIN 2021 · NUMERICAL

The pressure exerted by a non-reactive gaseous mixture of 6.4 g of methane and 8.8 g of carbon dioxide in a 10 L vessel at $27^\circ C$ is _____ kPa. (Round off to the Nearest Integer). [Assume gases are ideal, $R = 8.314\ J\ mol^{-1}\ K^{-1}$ Atomic masses: C = 12.0 u, H = 1.0 u, O = 16.0 u]

105 JEE MAIN 2021 · NUMERICAL

Consider the complete combustion of butane, the amount of butane utilized to produce 72.0 g of water is _____ $\times 10^{-1}g$ (in nearest integer).

106 JEE MAIN 2021 · NUMERICAL

Complete combustion of 3 g of ethane gives $x \times 10^{22}$ molecules of water. The value of x is _____ (Round off to the Nearest Integer).

[Use: $N_A = 6.023 \times 10^{23}$; Atomic masses in u : C : 12.0; O : 16.0; H : 1.0]

107 JEE MAIN 2021 · NUMERICAL

The number of atoms in 8 g of sodium is $x \times 10^{23}$. The value of x is _____. (Nearest integer) Given : $N_A = 6.02 \times 10^{23}\ mol^{-1}$ Atomic mass of Na = 23.0u

108 JEE MAIN 2021

The water having more dissolved O_2 is:

- (1) boiling water (2) water at $80^\circ C$
(3) polluted water (4) water at $4^\circ C$

109 JEE MAIN 2021

The volume V of an enclosure contains a mixture of three gases, 16 g of oxygen, 28 g of nitrogen and 44 g of carbon dioxide at absolute temperature T . Consider R as universal gas constant. The pressure of the mixture of gases is:

- (A) $\frac{8RT'}{V}$ (B) $\frac{3RT'}{V}$
 (C) $\frac{5}{2} \frac{RT'}{V}$ (D) $\frac{4RT'}{V}$

110 JEE MAIN 2021

A mixture of hydrogen and oxygen has volume 500cm^3 , temperature 300 K, pressure 400 kPa and mass 0.76 g. The ratio of masses of oxygen to hydrogen will be:

- (1) 16 : 3 (2) 3 : 8
 (3) 8 : 3 (4) 3 : 16

111 JEE MAIN 2020 · NUMERICAL

The volume (in mL) of 0.1 N NaOH required to neutralise 10 mL of 0.1 N phosphinic acid is _____.

112 JEE MAIN 2020

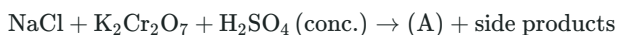
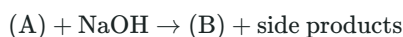
The incorrect statement(s) among (a) - (d) regarding acid rain is (are):

- (a) It can corrode water pipes.
 (b) It can damage structures made up of stone.
 (c) It cannot cause respiratory ailments in animals.
 (d) It is not harmful for trees.

- (A) (a), (c) and (d) (B) (c) only
 (C) (a), (b) and (d) (D) (c) and (d)

113 JEE MAIN 2020 · NUMERICAL

Consider the following reactions:



The sum of the total number of atoms in one molecule each of (A), (B) and (C) is _____.

114 JEE MAIN 2020

While titrating dilute HCl solution with aqueous NaOH, which of the following will not be required?

- (1) Clamp and phenolphthalein
 (2) Pipette and distilled water
 (3) Burette and porcelain tile
 (4) Bunsen burner and measuring cylinder

115 JEE MAIN 2020

Determine total number of neutrons in three isotopes of hydrogen.

- (A) 1 (B) 2
 (C) 3 (D) 4

116 JEE MAIN 2020 · NUMERICAL

In an estimation of bromine by Carius method, 1.6 g of an organic compound gave 1.88 g of AgBr. The mass percentage of bromine in the compound is _____. (Atomic mass, Ag=108, Br=80 g mol⁻¹)

117 JEE MAIN 2020

A mixture of one mole each of H₂, He and O₂ are enclosed in a cylinder of volume V at temperature T . If the partial pressure of H₂ is 2 atm, the total pressure of the gases in the cylinder is:

- (A) 14 atm (B) 22 atm
 (C) 6 atm (D) 38 atm

118 JEE MAIN 2020

In a box a mixture containing H₂, O₂ and CO along with charcoal is present then variation of pressure with the time will be as follows:

- (A) Graph showing constant pressure (1)
 (B) Graph showing linearly decreasing pressure (2)
 (C) Graph showing exponentially decreasing pressure (3)
 (D) Graph showing increasing pressure (4)

119 JEE MAIN 2020

The strength of an aqueous NaOH solution is most accurately determined by titrating:

(Note: consider that an appropriate indicator is used)

- (1) Aq. NaOH in a pipette and aqueous oxalic acid in a burette
 (2) Aq. NaOH in a burette and aqueous oxalic acid in a conical flask
 (3) Aq. NaOH in a burette and concentrated H₂SO₄ in a conical flask
 (4) Aq. NaOH in a volumetric flask and concentrated H₂SO₄ in a conical flask

120 JEE MAIN 2020

Determine degree of hardness in term of ppm of CaCO₃ of 10⁻³ molar MgSO₄ (aq).

- (A) 100 (B) 200
 (C) 300 (D) 400

121 JEE MAIN 2020 · NUMERICAL

6.023×10^{22} molecules are present in 10 g of substance 'x'. The molarity of a solution containing 5 g of substance 'x' in 2 L solution is _____ $\times 10^{-3}$.

122 JEE MAIN 2020

The average molar mass of chlorine is 35.5 g mol^{-1} . The ratio of ^{35}Cl to ^{37}Cl in naturally occurring chlorine is close to:

- (A) 4 : 1 (B) 1 : 1
(C) 2 : 1 (D) 3 : 1

123 JEE MAIN 2020 · NUMERICAL

Given following reaction, $\text{NaClO}_3 + \text{Fe} \rightarrow \text{O}_2 + \text{FeO} + \text{NaCl}$ In the above reaction 492 L of O_2 is obtained at 1 atm & 300 K temperature. Determine mass of NaClO_3 required (in kg). ($R = 0.082 \text{ L atm mol}^{-1} \text{ K}^{-1}$)

124 JEE MAIN 2020

Find percentage nitrogen by mass in Histamine?

- (A) 30% (B) 35%
(C) 37.84% (D) 40%

125 JEE MAIN 2020

$\text{NaOH} + \text{Cl}_2 \rightarrow A + \text{other products (Hot \& conc.)}$
 $\text{Ca(OH)}_2 + \text{Cl}_2 \rightarrow B + \text{other products (Cold \& dil.)}$
 A & B are respectively

- (1) NaClO_3 , Ca(OCl)_2 (2) NaClO_3 , $\text{Ca(ClO}_3)_2$
(3) NaCl , $\text{Ca(ClO}_3)_2$ (4) NaClO , $\text{Ca(ClO}_3)_2$

126 JEE MAIN 2020

0.6 g of urea on strong heating with NaOH evolves NH_3 . Liberated NH_3 will combine completely with which of the following HCl solution?

- (A) 100 mL of 0.2 N HCl (B) 400 mL of 0.2 N HCl
(C) 100 mL of 0.1 N HCl (D) 200 mL of 0.2 N HCl

127 JEE MAIN 2020

Dihydrogen of high purity (> 99.95%) is obtained through:

- (A) The electrolysis of warm Ba(OH)_2 solution using Ni electrodes.
(B) The reaction of Zn with dilute HCl .
(C) The electrolysis of brine solution.
(D) The electrolysis of acidified water using Pt electrodes.

128 JEE MAIN 2020 · NUMERICAL

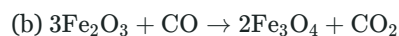
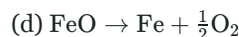
0.3 g $[\text{ML}_6]\text{Cl}_3$ of molar mass 267.46 g/mol is reacted with 0.125 M $\text{AgNO}_3(\text{aq})$ solution, calculate volume of AgNO_3 required in mL.

129 JEE MAIN 2020

One litre sea water ($d = 1.03 \text{ g/cm}^3$) contains 10.3 mg O_2 gas. Determine concentration of O_2 in ppm.

130 JEE MAIN 2020

Among the reactions (a) - (d), the reaction(s) that does/do not occur in the blast furnace during the extraction of iron is/are:



- (1) (a) (2) (a) and (d)
(3) (c) and (d) (4) (d)

131 JEE MAIN 2020 · NUMERICAL

The mass of ammonia in grams produced when 2.8 kg of dinitrogen quantitatively reacts with 1 kg of dihydrogen is _____.

132 JEE MAIN 2020

Amongst the following which is not a postulate of Dalton's atomic theory?

- (1) Matter is formed of indivisible atoms
(2) Under identical conditions of pressure and temperature gases combine and give gaseous products in simple volume ratio.
(3) During chemical reactions atoms remain conserved and only pass through rearrangement
(4) Some atoms have same properties including atomic mass

133 JEE MAIN 2020 · NUMERICAL

Ferrous sulphate heptahydrate is used to fortify foods with iron. The amount (in grams) of the salt required to achieve 10 ppm of iron in 100 kg of wheat is _____.

Atomic weight : Fe = 55.85; S = 32.00; O = 16.00

134 JEE MAIN 2020 · NUMERICAL

The ratio of the mass percentages of 'C & H' and 'C & O' of a saturated acyclic organic compound 'X' are 4 : 1 and 3 : 4 respectively. Then, the moles of oxygen gas required for complete combustion of two moles of organic compound 'X' is _____.

- (A) 4 moles (B) 5 moles
(C) 6 moles (D) 7 moles

135 JEE MAIN 2020

The correct statement with respect to dinitrogen is:

- (A) liquid dinitrogen is not used in cryosurgery.
(B) it can be used as an inert diluent for reactive chemicals.
(C) it can combine with dioxygen at 25°C
(D) N_2 is paramagnetic in nature.

136 JEE MAIN 2020 · NUMERICAL

The minimum number of moles of O_2 required for complete combustion of 1 mole of propane and 2 moles of butane is _____.

137 JEE MAIN 2019 · 10 JAN S2

The amount of sugar $C_{12}H_{22}O_{11}$ required to prepare 2L of its 0.1 M aqueous solution is:

- (A) 17.1 g (B) 136.8 g
(C) 68.4 g (D) 34.2 g

138 JEE MAIN 2019 · 8 APR S2

The maximum prescribed concentration of copper in drinking water is:

- (A) 3 ppm (B) 5 ppm
(C) 0.5 ppm (D) 0.05 ppm

139 JEE MAIN 2019

At 300 K and 1 atmospheric pressure, 10 mL of a hydrocarbon required 55 mL of O_2 for complete combustion, and 40 mL of CO_2 is formed. The formula of the hydrocarbon is:

- (1) C_4H_8 (2) C_4H_{10}
(3) C_4H_6 (4) C_4H_7Cl

140 JEE MAIN 2019

For the following reaction, the mass of water produced from 445 g of $C_{57}H_{110}O_6$ is: $2C_{57}H_{110}O_6(s) + 163O_2(g) \rightarrow 114CO_2(g) + 110H_2O(l)$

- (1) 490 g (2) 890 g
(3) 445 g (4) 495 g

141 JEE MAIN 2019

The percentage composition of carbon by mole in methane is:

- (A) 75 % (B) 20 %
(C) 80 % (D) 25 %

142 JEE MAIN 2019

At 100°C , copper (Cu) has FCC unit cell structure with cell edge length of $x \text{ \AA}$. What is the approximate density of Cu (in g cm^{-3}) at this temperature? [Atomic Mass of Cu = 63.55 u]

- (A) $\frac{105}{x^3}$ (B) $\frac{205}{x^3}$
(C) $\frac{422}{x^3}$ (D) $\frac{211}{x^3}$

143 JEE MAIN 2019

If Dichloromethane (DCM) and water H_2O are used for differential extraction, which one of the following statements is correct?

- (1) DCM and H_2O would stay as upper and lower layer respectively in the separating funnel (S.F.)
(2) DCM and H_2O will be miscible clearly
(3) DCM and H_2O would stay as lower and upper layer respectively in the S.F.
(4) DCM and H_2O will make turbid/colloidal mixture

144 JEE MAIN 2019

The correct order of hydration enthalpies of alkali metal ions is:

- (A) $Na^+ > Li^+ > K^+ > Rb^+$ (B) $Li^+ > Na^+ > K^+ > Cs^+$
(C) $Li^+ > Rb^+ > Na^+ > K^+$ (D) $Li^+ > Na^+ > K^+ > Cs^+ > Rb^+$

145 JEE MAIN 2019

10 mL of 1 mM surfactant solution forms a monolayer covering 0.24 cm^2 on a polar substrate. If the polar head is approximated as a cube, what is its edge length?

- (1) 1.0 pm (2) 0.1 nm
(3) 2.0 pm (4) 2.0 nm

146 JEE MAIN 2019

The aerosol is a kind of colloid in which

- (1) solid is dispersed in gas. (2) liquid is dispersed in water.
(3) gas is dispersed in solid. (4) gas is dispersed in liquid.

147 JEE MAIN 2019

100 mL of a water sample contains 0.81 g of calcium bicarbonate and 0.73 g of magnesium bicarbonate. The hardness of this water sample expressed in terms of equivalents of $CaCO_3$ is: (molar mass of calcium bicarbonate is 162 g mol^{-1} and magnesium bicarbonate is 146 g mol^{-1})

- (1) 100 ppm (2) 1,000 ppm
(3) 5,000 ppm (4) 10,000 ppm

148 JEE MAIN 2019

The synonym for water gas when used in the production of methanol is:

- (A) syn gas (B) laughing gas
(C) natural gas (D) fuel gas

149 JEE MAIN 2019

25 g of an unknown hydrocarbon upon burning produces 88 g of CO_2 and 9 g of H_2O . This unknown hydrocarbon contains:

- (1) 24 g of carbon and 1 g of hydrogen
(2) 18 g of carbon and 7 g of hydrogen
(3) 22 g of carbon and 3 g of hydrogen
(4) 20 g carbon and 5 g of hydrogen

150 JEE MAIN 2019

For a reaction, $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$, identify dihydrogen (H_2) as a limiting reagent in the following reaction mixtures.

- (1) 28 g of N_2 + 6 g of H_2 (2) 35 g of N_2 + 8 g of H_2
(3) 56 g of N_2 + 10 g of H_2 (4) 14 g of N_2 + 4 g of H_2

151 JEE MAIN 2019

5 moles of AB_2 weigh 125×10^{-3} kg and 10 moles of A_2B_2 weigh 300×10^{-3} kg. The molar mass of A (M_A) in kg mol^{-1} are:

- (1) $M_A = 5 \times 10^{-3}$ and $M_B = 10 \times 10^{-3}$
 (2) $M_A = 25 \times 10^{-3}$ and $M_B = 50 \times 10^{-3}$
 (3) $M_A = 50 \times 10^{-3}$ and $M_B = 25 \times 10^{-3}$
 (4) $M_A = 10 \times 10^{-3}$ and $M_B = 5 \times 10^{-3}$

152 JEE MAIN 2019

The strength of 11.2 volume solution of H_2O_2 is [Given that, the molar mass of H = 1 g mol^{-1} and O = 16 g mol^{-1}]

- (1) 1.7 % (2) 13.6 %
 (3) 34 % (4) 3.4 %

153 JEE MAIN 2019

The temporary hardness of a water sample is due to compound X. Boiling this sample converts X to compound Y. X and Y, respectively, are:

- (1) $\text{Mg}(\text{HCO}_3)_2$ and MgCO_3 (2) $\text{Ca}(\text{HCO}_3)_2$ and $\text{Ca}(\text{OH})_2$
 (3) $\text{Mg}(\text{HCO}_3)_2$ and $\text{Mg}(\text{OH})_2$ (4) $\text{Ca}(\text{HCO}_3)_2$ and CaO

154 JEE MAIN 2019

The concentration of dissolved oxygen (DO) in cold water can go up to

- (A) 14 ppm (B) 8 ppm
 (C) 10 ppm (D) 16 ppm

155 JEE MAIN 2019

The ore that contains the metal in the form of fluoride is known as which of the following?

- (1) cryolite (2) magnetite
 (3) malachite (4) sphalerite

156 JEE MAIN 2019

A 10mg effervescent tablet containing sodium bicarbonate and oxalic acid releases 0.25 mL of CO_2 at $T = 298.15 \text{ K}$ and $P = 1 \text{ bar}$. If molar volume of CO_2 is 25.0 L under such condition, what is the percentage of sodium bicarbonate in each tablet? [Molar mass of $\text{NaHCO}_3 = 84 \text{ g mol}^{-1}$]

- (A) 0.84 (B) 33.6
 (C) 16.8 (D) 8.4

157 JEE MAIN 2019

The minimum amount of O_2 consumed per gram of reactant is for the reaction:

(Given atomic mass: Fe = 56, O = 16, Mg = 24, P = 31, C = 12, H = 1)

- (A) $\text{P}_4\text{S} + 5\text{O}_{2(g)} \rightarrow \text{P}_4\text{O}_{10(s)}$
 (B) $2\text{Mg}_{(s)} + \text{O}_{2(g)} \rightarrow 2\text{MgO}_{(s)}$
 (C) $4\text{Fe}_{(s)} + 3\text{O}_{2(g)} \rightarrow 2\text{Fe}_2\text{O}_{3(s)}$
 (D) $\text{C}_3\text{H}_{8(g)} + 5\text{O}_{2(g)} \rightarrow 3\text{CO}_{2(g)} + 4\text{H}_2\text{O}_{(l)}$

158 JEE MAIN 2019

An example of solid sol is:

- (A) Paint (B) Gem stones
 (C) Butter (D) Hair cream

159 JEE MAIN 2019

Consider the van der Waals constants, a and b , for the following gases.

Gas: Ar, Ne, Kr, Xe

$a / (\text{atm dm}^6 \text{ mol}^{-2})$: 1.3, 0.2, 5.1, 4.1

$b / (10^{-2} \text{ dm}^3 \text{ mol}^{-1})$: 3.2, 1.7, 1.0, 5.0

Which gas is expected to have the highest critical temperature?

- (1) Ne (2) Kr
 (3) Xe (4) Ar

Answer key · Some Basic Concepts in Chemistry

1 B	2 B	3 D	4 4	5 3	6 420
7 153	8 100	9 275	10 C	11 B	12 B
13 D	14 8	15 108	16 11	17 D	18 2
19 24	20 3	21 3	22 63	23 1	24 4
25 1	26 227	27 A	28 2	29 100	30 3
31 393	32 B	33 1	34 15	35 798	36 200
37 4	38 4	39 3	40 4	41 2	42 B
43 4540	44 3	45 C	46 3	47 44	48 3
49 4	50 4	51 3	52 56	53 4	54 555
55 D	56 4	57 D	58 152	59 4	60 4
61 3	62 1	63 C	64 36	65 1	66 2
67 3	68 3	69 C	70 4	71 46	72 2
73 2	74 2	75 22	76 22	77 D	78 A
79 33	80 25	81 4	82 1	83 1655	84 1

85 5	86 2	87 143	88 3	89 2	90 46
91 3	92 5	93 5	94 8	95 3	96 1
97 20	98 2218	99 226	100 1	101 4	102 19
103 19	104 150	105 464	106 18	107 2	108 4
109 C	110 1	111 10	112 D	113 18	114 4
115 C	116 50	117 C	118 C	119 2	120 A
121 25	122 D	123 2.13 kg	124 C	125 1	126 A
127 A	128 26.92	129 10	130 3	131 3400	132 2
133 4.96	134 B	135 B	136 18	137 C	138 A
139 3	140 4	141 B	142 C	143 3	144 B
145 3	146 1	147 4	148 A	149 1	150 3
151 1	152 4	153 3	154 C	155 1	156 D
157 C	158 B	159 2			

Solutions · Some Basic Concepts in Chemistry

1 Answer: B

Ref 12529

Medium ~1 min

Step 1: Use the mass ratio to find empirical formula.

Assume 13 g of compound: C = 12 g, H = 1 g.

$$n_C = \frac{12}{12}$$

$$n_C = 1 \text{ mol}$$

$$n_H = \frac{1}{1}$$

$$n_H = 1 \text{ mol}$$

Empirical formula is CH.

Step 2: Given the molecule has two carbon atoms, the molecular formula is C₂H₂.

Step 3: Find moles of hydrocarbon in 3.38 g.

$$M_{C_2H_2} = 2 \times 12 + 2 \times 1$$

$$M_{C_2H_2} = 26 \text{ g/mol}$$

$$n_{\text{hydrocarbon}} = \frac{3.38}{26}$$

$$n_{\text{hydrocarbon}} = 0.13 \text{ mol}$$

Step 4: Combustion stoichiometry: 1 mol C₂H₂ produces 2 mol CO₂.

$$n_{CO_2} = 2 \times 0.13$$

$$n_{CO_2} = 0.26 \text{ mol}$$

Step 5: Mass of CO₂ produced.

$$m_{CO_2} = 0.26 \times 44$$

$$m_{CO_2} = 11.44 \text{ g}$$

Therefore the correct answer is 11.44 g (option B).

2 Answer: B

Ref 13042

Medium ~1 min

QUICK APPROACH Start by understanding the role of valence orbitals in bonding during catalysis and the effect of adsorption on bond strength in reactant molecules.

Statement I is incorrect because transition metal catalysts use available valence orbitals (including 3d, 4s and sometimes 4p) and not 3d electrons 'only' for forming bonds with reactants; wording 'only' makes it false. Statement II is incorrect because adsorption on the catalyst surface usually weakens or polarises bonds in reactant molecules (facilitating bond breaking and reaction) rather than strengthening them. Hence both statements are incorrect.

3 Answer: D

Ref 11851

Hard ~1.5 min

QUICK APPROACH Start by applying the concept of elimination reactions to find compound Y from X, and then use hydration of alkynes to determine compound Z.

X (C₃H₆Cl₂) on treatment with excess NaNH₂ undergoes double dehydrohalogenation to give the terminal alkyne Y = propyne (CH₃-C≡CH). Hydration of a terminal alkyne in presence of Hg²⁺ (oxymercuration of alkynes) yields the corresponding methyl ketone by Markovnikov hydration; thus Y → Z = acetone (CH₃-CO-CH₃). Acetone is a methyl ketone and gives positive iodoform test (yellow precipitate of CHI₃) with NaOI, so Statement I is true. Passing propyne through a red-hot iron tube causes trimerization (cyclotrimerization) of the alkyne to give 1,3,5-trimethylbenzene (mesitylene), C₉H₁₂, as Q. Mesitylene has 3 aromatic H (one on each unsubstituted ring carbon) and 9 aliphatic H (three methyl groups × 3 H each) → aromatic : aliphatic = 3 : 9 = 1 : 3. Hence Statement II is true. Therefore both statements are true.

COMMON TRAPS

- **Treating NaNH₂ as a substitution reagent instead of causing double dehydrohalogenation.** For a suitable geminal/vicinal dihalide, excess NaNH₂ removes two molecules of HCl: C₃H₆Cl₂ – 2HCl = C₃H₄, so Y is propyne, CH₃–C≡CH. *Avoid it:* Before deciding substitution/elimination, do an atom-count check: subtract 2 H and 2 Cl from C₃H₆Cl₂ and see whether the formula C₃H₄ matches an alkyne.
- **Ignoring the terminal nature of propyne and predicting the wrong hydration product.** The exact solution step says "Hydration of a terminal alkyne in presence of Hg²⁺ ... yields the corresponding methyl ketone by Markovnikov hydration". Thus propyne gives acetone, CH₃–CO–CH₃, not propanal. *Avoid it:* For terminal alkyne + dil. H₂SO₄/Hg²⁺, write enol first, then tautomerize to a methyl ketone.

REVIEW Reagent-specific alkyne reactions: NaNH₂ elimination, Hg²⁺/acid hydration, and red-hot tube trimerization. · Practice iodoform-test identification from structures, especially methyl ketones like acetone.

4 Answer: 4

Ref 10653

Medium ~3 min Mole concept, Chemical equations and stoichiometry

Get the empirical formula from the percentages and scale it to the molar mass of 132.

Step 1. In 100 g: C = 54.2/12 = 4.52 mol, H = 9.2/1 = 9.2 mol, O = 36.6/16 = 2.29 mol.

Step 2. Divide by 2.29: C : H : O = 2 : 4 : 1. The empirical formula is C₂H₄O, mass 44.

Step 3. $n = \frac{132}{44} = 3$, so the molecular formula is C₆H₁₂O₃.

Step 4. Check: carbon in C₆H₁₂O₃ is $\frac{72}{132} \times 100 = 54.5\%$, close to the given 54.2%.

Answer: (4) C₆H₁₂O₃

5 Answer: 3

Ref 10815

Medium ~2 min Mole concept, Chemical equations and stoichiometry

QUICK APPROACH Start by calculating the moles of CO₂ removed using Avogadro's number and then use the mole concept to find the initial moles before converting to mass.

The initial amount equals what was removed plus what is left.

Step 1. Moles removed = $\frac{10^{21}}{6.02 \times 10^{23}} = 1.66 \times 10^{-3}$ mol.

Step 2. Initial moles = $2.8 \times 10^{-3} + 1.66 \times 10^{-3} = 4.46 \times 10^{-3}$ mol.

Step 3. Initial mass = $4.46 \times 10^{-3} \times 44 = 0.1962$ g = 196.2 mg.

Answer: (3) 196.2 mg

COMMON TRAPS

- **Subtracting the removed molecules.** The moles left plus the moles removed give the starting amount. *Avoid it:* Write initial = removed + left before substituting.
- **Leaving the answer in grams.** The options are in milligrams, so 0.1962 g is 196.2 mg. *Avoid it:* Convert the units to match the options.

REVIEW Conversions between molecules, moles and mass. · Unit conversion between grams and milligrams.

6 Answer: 420

Ref 10836

Medium ~4 min Mole concept, Chemical equations and stoichiometry

QUICK APPROACH Start by identifying the limiting reagent using mole concept and stoichiometry from the balanced chemical equation.

Two reactant amounts are given, so find the limiting reagent first.

Step 1. Moles of Fe₃O₄ = $\frac{2.32 \times 10^6}{232} = 1.0 \times 10^4$ mol. Moles of CO = $\frac{2.8 \times 10^5}{28} = 1.0 \times 10^4$ mol.

Step 2. One mole of Fe₃O₄ needs 4 mol of CO. All the oxide would need 4.0×10^4 mol of CO, but only 1.0×10^4 mol is present. CO is limiting.

Step 3. 4 mol of CO give 3 mol of Fe, so Fe formed = $\frac{3}{4} \times 1.0 \times 10^4 = 7500$ mol.

Step 4. Mass of Fe = 7500 × 56 = 4.2 × 10⁵ g = 420 kg.

Answer: 420

7 Answer: 153

Ref 10925

Medium ~3 min Chemical equations and stoichiometry

QUICK APPROACH Start by writing the balanced chemical equation for the reaction between aluminum and oxygen, then calculate the moles of each reactant to find the limiting reactant.

Find the limiting reagent, then convert it to aluminium oxide.

Step 1. 4Al + 3O₂ → 2Al₂O₃.

Step 2. Moles of Al = 81/27 = 3 mol. Moles of O₂ = 128/32 = 4 mol.

Step 3. 3 mol of Al need $\frac{3}{4} \times 3 = 2.25$ mol of O₂. Oxygen is in excess, so Al is limiting.

Step 4. Moles of Al₂O₃ = $3 \times \frac{2}{4} = 1.5$ mol.

Step 5. Molar mass of Al₂O₃ = 54 + 48 = 102 g mol⁻¹, so the mass is 1.5 × 102 = 153 g.

Answer: 153

COMMON TRAPS

- **Taking oxygen as limiting by mass.** Compare moles with the equation ratio, not the masses given. *Avoid it:* Divide each amount of moles by its coefficient first.
- **Using the wrong mole ratio for the product.** 4 mol of Al give 2 mol of Al_2O_3 , so 3 mol give 1.5 mol. *Avoid it:* Read the product ratio from the balanced equation.

REVIEW The limiting reagent concept. · Mole ratios in balanced equations.

8 Answer: 100

Ref 11032

Medium ~6 min Mole concept

All the hydrogen of the compound appears in the water formed.

Step 1. Mass of H in 0.9 g of water = $\frac{2}{18} \times 0.9 = 0.1$ g.

Step 2. This 0.1 g of hydrogen is in 0.01 mol of X, so one mole of X contains 10 g of hydrogen.

Step 3. Hydrogen is 10% of the molar mass: $0.10 \times M = 10$.

Step 4. $M = 100 \text{ g mol}^{-1}$.

Answer: 100

COMMON TRAPS

- **Using the mass of water as hydrogen.** Only 2/18 of the water mass is hydrogen. *Avoid it:* Convert the product mass to the element mass first.
- **Forgetting to scale to one mole.** 0.1 g of H in 0.01 mol means 10 g of H per mole. *Avoid it:* Divide by the moles of compound before using the percentage.

REVIEW Combustion analysis for hydrogen. · Percentage composition and molar mass.

9 Answer: 275

Ref 11035

Medium ~4 min Stoichiometry

In the Carius method all the sulphur ends up as BaSO_4 .

Step 1. Molar mass of $\text{BaSO}_4 = 137 + 32 + 64 = 233 \text{ g mol}^{-1}$.

Step 2. Mass of S in 0.40 g of $\text{BaSO}_4 = \frac{32}{233} \times 0.40 = 0.0549$ g.

Step 3. Percentage of S = $\frac{0.0549}{0.20} \times 100 = 27.47\%$.

Step 4. $27.47 = 274.7 \times 10^{-1}$, which rounds to 275.

Answer: 275

10 Answer: C

Ref 12203

Hard ~1 min

QUICK APPROACH Start by recalling the definitions and general trends of electron affinity, ionization energy, and electronegativity in atoms and how these properties vary across elements and groups.

Evaluate each statement:

A) False. Adding an electron to a neutral gaseous atom corresponds to electron affinity; many atoms release energy (exothermic) on gaining an electron, but not always. Some atoms (e.g., Be, and partially N) have endothermic or near-zero electron affinities. So it is not always exothermic.

B) True. Removing an electron from an isolated gaseous atom

is ionization and always requires input of energy (ionization energy) to overcome nuclear attraction — hence endothermic.

C) True. Electronic configurations: Be = $1s^2 2s^2$, B = $1s^2 2s^2 2p^1$. The outer electron in B is a 2p electron which is higher in energy and better shielded than Be's 2s electrons, so the 1st ionization energy of B is less than that of Be ($\text{IEB} < \text{IEBe}$).

D) False (for the exact wording). While carbon's Pauling electronegativity is about 2.5 (≈ 2.55), quoting the identical numeric value "2.5 in CH_4 and CCl_4 " as an absolute statement is not strictly correct in the strictest sense because measured/derived electronegativity values depend on the scale/method and the chemical environment can affect effective electron-attracting tendency. The statement as given (exactly 2.5 in both molecules) is therefore not strictly valid for a JEE conceptual check.

E) False. Electropositivity in Group 1 increases down the group; Li is the least electropositive and Cs the most. So Li is not the most electropositive.

Conclusion: Only B and C are correct. Hence answer: B and C only.

COMMON TRAPS

- **Treating electron gain by any neutral atom as always exothermic.** First electron affinity/electron gain enthalpy is often exothermic but can be endothermic or near zero for stable configurations such as Be/N/noble gases. *Avoid it:* Whenever a statement says 'always', test it against exceptions with filled/half-filled subshells.
- **Confusing ionization energy sign with electron affinity sign.** Removing an electron from an isolated gaseous atom always requires energy input, so ionization enthalpy is positive/endothermic. *Avoid it:* Write the process explicitly: $\text{M(g)} \rightarrow \text{M}^+(\text{g}) + \text{e}^-$; bond/attraction is being broken, so energy must be supplied.

REVIEW Electron affinity exceptions: Be, Mg, N, noble gases. · Practice writing valence configurations before comparing first ionization energies.

11 Answer: B

Ref 12415

Medium ~1 min Percentage composition (elemental analysis)

Determine the molecular formula and molar mass. Thyroxine has formula $\text{C}_{15}\text{H}_{11}\text{O}_4\text{N}_4\text{I}_4$ (4 iodine atoms).

Calculate molar mass: C: $15 \times 12 = 180$; H: $11 \times 1 = 11$; O: $4 \times 16 = 64$; N: $4 \times 14 = 56$; I: $4 \times 127 = 508$.

Total molar mass = $180 + 11 + 64 + 56 + 508 = 777 \text{ g mol}^{-1}$.

Mass of iodine = 508 g per mole. Percentage of iodine = $(508 / 777) \times 100 \approx 65.36\%$, which rounds to 65% (nearest integer).

COMMON TRAPS

- **Using one iodine atom instead of four.** Percentage of an element = (mass of all atoms of that element in one molecule / molar mass of compound) $\times 100$. Here iodine mass is $4 \times 127 = 508$. *Avoid it:* Circle the word "four" and write I₄ before calculating the percentage.
- **Arithmetic error in 4×127 .** $4 \times 127 = 4 \times 100 + 4 \times 20 + 4 \times 7 = 400 + 80 + 28 = 508$. *Avoid it:* Break atomic mass multiplication into hundreds, tens, and units before adding to the molar mass.

REVIEW Percentage composition formula with multi-atom subscripts. · Practice converting biomolecule skeletal structures into molecular formulae.

12 Answer: B

Ref 12487

Medium ~1 min Molarity / Precipitation (AgI formation)

Reaction: $\text{NaI} + \text{AgNO}_3 \rightarrow \text{AgI(s)} + \text{NaNO}_3$. Moles of $\text{AgI} = \text{mass} / \text{molar mass} = 4.74 \text{ g} / (\text{Ag} + \text{I}) = 4.74 / (108 + 127) = 4.74 / 235 = 0.02017 \text{ mol}$. Stoichiometry is 1:1, so moles of I⁻ (in NaI) = 0.02017 mol. Volume of NaI solution = 20 mL = 0.020 L. Molarity = moles / volume = $0.02017 / 0.020 = 1.0085 \text{ M} \approx 1 \text{ M}$ (nearest integer).

COMMON TRAPS

- **Using molar mass of NaI instead of AgI.** The mass given is of AgI(s), so its molar mass is $108 + 127 = 235 \text{ g mol}^{-1}$. NaI only relates through 1:1 stoichiometry. *Avoid it:* Before using any mass, underline the compound whose mass is given and compute that compound's molar mass only.
- **Forgetting to convert 20 mL to 0.020 L.** Molarity unit M means mol L^{-1} , so $20 \text{ mL} = 20/1000 = 0.020 \text{ L}$. *Avoid it:* Write the unit in the denominator: mol/mL is not molarity; convert to L before division.

REVISE In precipitation stoichiometry, always identify the weighed precipitate before computing molar mass. · In molarity problems, write $\text{M} = \text{mol L}^{-1}$ and convert mL to L before substitution.

13 Answer: D

Ref 9089

Medium ~2 min Chemical equations and stoichiometry

QUICK APPROACH Recall that metal ions characterized by flame tests are typically alkaline earth metals and certain transition metals with distinctive flame colors.

Step 1: Identify which metal ions can be characterized by a flame test. Metal ions that show color in flame tests are typically alkaline earth metals and copper. Step 2: Analyze the given list of ions: Sr^{2+} - Red flame
 Ba^{2+} - Green flame
 Ca^{2+} - Orange-red flame
 Cu^{2+} - Blue-green flame
 Zn^{2+} , Co^{2+} , and Fe^{2+} typically do not show clear colors. Step 3: Count the ions that can be characterized: Sr^{2+} , Ba^{2+} , Ca^{2+} , Cu^{2+} total to 4 ions. Therefore, the correct option is D: 4.

14 Answer: 8

Ref 9127

Medium ~3 min Chemical equations and stoichiometry

QUICK APPROACH Write the balanced equation for complete combustion and use the 1 : 1 mole ratio between methane and carbon dioxide.

Complete combustion turns each carbon atom of methane into one molecule of carbon dioxide.

Step 1. Reaction: $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$, so 1 mol of methane gives 1 mol of CO_2 .

Step 2. Molar mass of $\text{CO}_2 = 12.0 + 2(16.0) = 44 \text{ g/mol}$, so 22 g is $\frac{22}{44} = 0.5 \text{ mol}$.

Step 3. Methane needed = 0.5 mol.

Step 4. Molar mass of $\text{CH}_4 = 12.0 + 4(1.0) = 16 \text{ g/mol}$, so the mass is $0.5 \times 16 = 8 \text{ g}$.

Answer: 8

COMMON TRAPS

- **Using the mass ratio directly.** Equal moles, not equal masses, of methane and CO_2 are linked, so 22 g of CO_2 does not need 22 g of methane. *Avoid it:* Convert mass to moles before using the equation.
- **Taking carbon monoxide as the product.** Complete combustion gives CO_2 ; carbon monoxide forms only when oxygen is short. *Avoid it:* Read 'complete combustion' as full oxidation to CO_2 and water.

REVISE Mole calculations from combustion equations.

15 Answer: 108

Ref 9466

Medium ~3 min

The same charge passes through both cells, so compare the moles of electrons.

Step 1. Moles of $\text{O}_2 = \frac{5600}{22400} = 0.25 \text{ mol}$.

Step 2. $2\text{H}_2\text{O} \rightarrow \text{O}_2 + 4\text{H}^+ + 4\text{e}^-$, so each mole of O_2 needs 4 mol of electrons. Charge passed = $0.25 \times 4 = 1 \text{ mol}$ of electrons, that is 1 F.

Step 3. $\text{Ag}^+ + \text{e}^- \rightarrow \text{Ag}$, so 1 F deposits 1 mol of silver.

Step 4. Mass of silver = $1 \times 108 = 108 \text{ g}$.

Answer: 108

COMMON TRAPS

- **Taking one electron per O_2 .** Forming one O_2 from water releases four electrons. *Avoid it:* Write the half-reaction to count electrons.
- **Comparing masses instead of charge.** Cells in series pass the same charge, not the same mass. *Avoid it:* Equate moles of electrons in both cells.

REVISE Faraday's second law of electrolysis. · Half-reactions at the anode and cathode.

16 Answer: 11

Ref 9485

Medium ~2 min Mole concept

QUICK APPROACH Start by converting all measurements to consistent units and use density = mass/volume to find the mass of the silver coating before calculating moles and atoms. Apply the mole concept here.

Find the volume of the coating, then its mass and the number of atoms.

Step 1. Area = $0.05 \text{ m}^2 = 0.05 \times 10^4 = 500 \text{ cm}^2$.

Step 2. Volume = $500 \times 0.05 = 25 \text{ cm}^3$.

Step 3. Mass = $25 \times 7.9 = 197.5 \text{ g}$.

Step 4. Moles of Ag = $\frac{197.5}{108} = 1.829 \text{ mol}$.

Step 5. Atoms = $1.829 \times 6.022 \times 10^{23} = 11.01 \times 10^{23}$, which is 11 to the nearest integer.

Answer: 11

17 Answer: D

Ref 9492

Medium ~2 min Chemical equations and stoichiometry

Concentrated H_2SO_4 oxidises bromide and iodide to coloured halogens, but it cannot oxidise fluoride.

Step 1. NaBr gives red-brown Br₂ vapour.

Step 2. NaNO₃ gives nitric acid, which breaks down on heating to brown NO₂.

Step 3. KI gives violet I₂ vapour.

Step 4. CaF₂ gives only HF: $\text{CaF}_2 + \text{H}_2\text{SO}_4 \rightarrow \text{CaSO}_4 + 2\text{HF}$. HF is colourless.

Step 5. Molar mass of CaF₂ = 40 + 2 × 19 = 78 g mol⁻¹.

Answer: (D) 78

COMMON TRAPS

- **Expecting fluorine gas from CaF₂.** Sulphuric acid cannot oxidise fluoride, so only colourless HF forms. *Avoid it:* Recall which halides the acid can oxidise.
- **Thinking nitrate gives no colour.** Nitric acid formed from nitrate breaks down to brown NO₂ on heating. *Avoid it:* Track what each product does on heating.

REVISE Reactions of halides with concentrated sulphuric acid. · Tests for nitrate and halide ions.

18 Answer: 2

Ref 9534

Medium ~2 min Dalton's theory

Step 1: Evaluate each statement against Dalton's atomic theory.

Step 2: Identify the incorrect statements:

- Statement (B) 'Matter consists of divisible atoms' is incorrect as Dalton proposed that atoms are indivisible.
- Statement (D) 'All the atoms of a given element have different properties including mass' is incorrect, according to Dalton, atoms of an element are identical in mass and properties.

Step 3: Validate other statements:

- Statement (A) is correct: Atoms of different elements do differ in mass, according to Dalton.
- Statement (C) is correct: Compounds are formed by atoms combining in fixed ratios, which aligns with Dalton's postulates.
- Statement (E) is correct: Chemical reactions involve reorganization of atoms, consistent with Dalton's theory.

Thus, the incorrect statements are (B) and (D). The correct option is (2).

19 Answer: 24

Ref 9557

Medium ~3 min Chemical equations and stoichiometry

Compare how much product each reactant can make; the smaller amount is what forms.

Step 1. $3\text{PbCl}_2 + 2(\text{NH}_4)_3\text{PO}_4 \rightarrow \text{Pb}_3(\text{PO}_4)_2 + 6\text{NH}_4\text{Cl}$.

Step 2. From PbCl₂: $72/3 = 24$ mmol of product.

Step 3. From (NH₄)₃PO₄: $50/2 = 25$ mmol of product.

Step 4. PbCl₂ gives less, so it is the limiting reagent. It needs only 48 mmol of phosphate, so phosphate is in excess.

Step 5. Pb₃(PO₄)₂ formed = 24 mmol.

Answer: 24

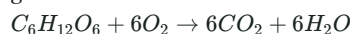
20 Answer: 3

Ref 9743

Medium ~3 min Chemical equations and stoichiometry

QUICK APPROACH Start by writing the balanced chemical equation for glucose combustion and use mole ratios to relate glucose and oxygen amounts.

Step 1: The balanced chemical equation for the combustion of glucose is:



Step 2: According to the balanced equation, 1 mole of glucose requires 6 moles of oxygen.

Step 3: Calculate the moles of glucose in 900 g.

• Moles of glucose = $\frac{\text{mass}}{\text{molar mass}} = \frac{900}{180} = 5$ moles.

Step 4: Determine the moles of oxygen required.

- Since 1 mole of glucose requires 6 moles of oxygen, 5 moles of glucose will require $5 \times 6 = 30$ moles of oxygen.

Step 5: Calculate the mass of oxygen required.

- Molar mass of oxygen (O₂) = 32 g/mol.
- Mass of oxygen = 30 moles × 32 g/mol = 960 g.

The amount of oxygen required is 960 g.

21 Answer: 3

Ref 10010

Easy ~1 min Dalton's theory

QUICK APPROACH Recall what Dalton said about the ratio in which atoms combine to form a compound.

Compare each statement with Dalton's postulates; the one that contradicts them is the answer.

Step 1. Dalton held that chemical reactions only rearrange atoms; atoms are neither made nor destroyed. Statement 1 agrees with the theory.

Step 2. Dalton held that matter is made of indivisible atoms. Statement 2 agrees.

Step 3. Dalton held that atoms of different elements combine in a fixed, simple whole-number ratio to form compounds, which is why compounds obey the law of definite proportions. 'Any ratio' contradicts this, so statement 3 is incorrect.

Step 4. Dalton held that all atoms of one element are identical, including in mass. Statement 4 agrees.

Answer: (3) Compounds are formed when atoms of different elements combine in any ratio

COMMON TRAPS

- **Judging by modern knowledge.** The question asks what Dalton's theory states, not what is true today, so 'indivisible atoms' counts as a postulate. *Avoid it:* Test each statement against the postulates, not against later discoveries.
- **Missing a single changed word.** 'Any ratio' replaces Dalton's 'fixed ratio', and that one word makes the statement wrong. *Avoid it:* Read each option for the word that departs from the postulate.

REVISE The postulates of Dalton's atomic theory.

22 Answer: 63

Ref 10170

Medium ~2 min Radioactive Decay

Radioactive decay is first order, so the fraction left is $(1/2)^{t/t_{1/2}}$.**Step 1.** $t = 24$ h and $t_{1/2} = 36$ h, so $t/t_{1/2} = 2/3$.**Step 2.** Fraction left $f = 2^{-2/3}$. Then $\log f = -\frac{2}{3} \times 0.3010 = -0.2006$.**Step 3.** $f = \frac{1}{\text{antilog } 0.2006} = \frac{1}{1.587} = 0.630$.**Step 4.** $0.630 = 63 \times 10^{-2}$.

Answer: 63

23 Answer: 1

Ref 10261

Easy ~2 min Chemical equations and stoichiometry

QUICK APPROACH Recall the concept of hydrolysis in salts and why an acidic medium might be necessary to prevent hydrolysis in solutions containing ferrous sulfate.**Step 1:** Mohr's salt is a double salt of ferrous sulphate and ammonium sulphate with water of crystallization.**Step 2:** Ferrous sulphate tends to hydrolyze in water, and to prevent this hydrolysis, an acidic medium is required.**Step 3:** The addition of dilute H_2SO_4 provides this acidic medium, thus preventing the hydrolysis of ferrous sulphate.**Step 4:** Therefore, the primary reason dilute H_2SO_4 is added is to prevent hydrolysis, ensuring the stability and accuracy of Mohr's salt.**24 Answer: 4**

Ref 10335

Medium ~2 min Chemical equations and stoichiometry

One mole of methane gives one mole of CO_2 on complete combustion.**Step 1.** $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$.**Step 2.** Moles of $\text{CO}_2 = \frac{11}{44} = 0.25$ mol.**Step 3.** By the 1 : 1 ratio, moles of CH_4 needed = 0.25 mol.**Step 4.** The given molar mass of methane is not needed, because the question asks for moles.

Answer: (4) 0.25

25 Answer: 1

Ref 10395

Medium ~8 min Stoichiometry

QUICK APPROACH Start by using the law of conservation of mass and set up equations based on the initial total mass and the mass after loss of CO_2 upon heating.Both carbonates lose CO_2 on ignition and leave their oxides, so set up one equation for the residue.**Step 1.** Let the mass of CaCO_3 be x g. Then MgCO_3 is $(2.21 - x)$ g.**Step 2.** CaCO_3 (100) leaves CaO (56), and MgCO_3 (84) leaves MgO (40).**Step 3.** Residue: $\frac{56}{100}x + \frac{40}{84}(2.21 - x) = 1.152$.**Step 4.** $0.560x + 1.0524 - 0.4762x = 1.152$, so $0.0838x = 0.0996$ and $x = 1.187$ g.**Step 5.** $\text{MgCO}_3 = 2.21 - 1.187 = 1.023$ g.Answer: (1) 1.187 g CaCO_3 + 1.023 g MgCO_3 **COMMON TRAPS**• **Treating 1.152 g as CO_2 lost instead of residue mass.**The constant weight after ignition is the oxide residue, not the gas evolved. CO_2 mass is initial mass minus final mass. *Avoid it:* Before writing the stoichiometric equation, label every mass as initial sample, final residue, or gas lost.• **Using equal CO_2 fractions for CaCO_3 and MgCO_3 .**Each carbonate releases 44 g CO_2 per mole, but the mass fraction depends on that carbonate's molar mass: 44/100 for CaCO_3 , 44/84 for MgCO_3 . *Avoid it:* Write the decomposition equations and attach molar masses under each compound before substituting.**REVISE** Carbonate decomposition: metal carbonate $\rightarrow$ metal oxide + CO_2 with 1:1 mole ratio of carbonate to CO_2 . Practice deriving mass fractions from molar masses instead of memorizing one fraction.**26 Answer: 227**

Ref 7289

Medium ~3 min Chemical equations and stoichiometry

Carbon is the limiting reagent, so it fixes the moles of CO formed.**Step 1.** Moles of C = $12/12 = 1$ mol. Moles of $\text{O}_2 = 48/32 = 1.5$ mol.**Step 2.** From $2\text{C} + \text{O}_2 \rightarrow 2\text{CO}$, 1 mol of C needs only 0.5 mol of O_2 . Oxygen is in excess and carbon is limiting.**Step 3.** Two moles of C give two moles of CO , so 1 mol of C gives 1 mol of CO .**Step 4.** Volume of CO at STP = $1 \times 22.7 = 22.7$ L = 227×10^{-1} L.

Answer: 227

27 Answer: A

Ref 7298

Easy ~1 min

Step 1: Consider the processes given in the options.Respiration is a natural process where oxygen is consumed and carbon dioxide is released, balancing the levels of both gases as part of the natural cycle. **Step 2:** Burning of coal and petroleum are combustion processes releasing excess CO_2 , contributing to an imbalance in the natural equilibrium of gases. **Step 3:** Deforestation reduces the amount of trees that convert CO_2 back into O_2 , thereby disturbing the balance. Therefore, respiration is the only process that maintains the balance.**28 Answer: 2**

Ref 7301

Medium ~2 min Chemical isotopes

Isotopes have the same electron configuration but different masses.

Step 1. Check the Assertion. Protium, deuterium and tritium all have the configuration $1s^1$. So their chemical properties are almost the same. Their masses differ a lot, and so their reactions run at different rates. The Assertion is correct.

Step 2. Check the Reason. The bond dissociation enthalpies differ: H_2 is about $435.9 \text{ kJ mol}^{-1}$ and D_2 about $443.4 \text{ kJ mol}^{-1}$. The Reason is correct.

Step 3. Link the two. A bond that needs more energy to break is broken more slowly. So the difference in bond dissociation enthalpy is the main cause of the difference in reaction rates. The Reason explains the Assertion.

Answer: (2) Both A and R are correct and R is the correct explanation of A

29 Answer: 100

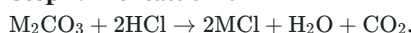
Ref 7339

Medium ~3 min Mole concept, Chemical equations and stoichiometry

QUICK APPROACH Start by writing the balanced chemical equation and use the mole ratio between the carbonate and carbon dioxide to relate moles of each substance.

The carbonate and the CO_2 it releases are in a 1 : 1 mole ratio.

Step 1. The reaction is



Step 2. One mole of carbonate gives one mole of CO_2 . So 0.01 mol of CO_2 comes from 0.01 mol of M_2CO_3 .

Step 3. Molar mass = $\frac{\text{mass}}{\text{moles}} = \frac{1}{0.01} = 100 \text{ g mol}^{-1}$.

Answer: 100

COMMON TRAPS

- **Using a 2 : 1 ratio for the carbonate.** One mole of M_2CO_3 releases exactly one mole of CO_2 . *Avoid it:* Balance the equation before reading any mole ratio.
- **Dividing moles by mass.** Molar mass is mass divided by moles, so it is $1/0.01$. *Avoid it:* Check that the units come out as g mol^{-1} .

REVISE Mole ratios from balanced equations. · Reactions of carbonates with acids.

30 Answer: 3

Ref 7445

Medium ~3 min Adsorption

QUICK APPROACH Recall the steps of the theory in order: diffusion to the surface, adsorption, reaction through an intermediate, desorption.

The modern adsorption theory pictures the reactants moving to the catalyst surface, reacting there through a surface intermediate, and the products leaving.

Step 1. A is wrong: the reactants diffuse to the surface of the catalyst, not the catalyst over the reactants.

Step 2. B is right: the reactants are adsorbed on the catalyst surface.

Step 3. C is right: the adsorbed reactants react on the surface through an intermediate.

Step 4. D is right: the theory joins the intermediate compound formation theory with the old adsorption theory.

Step 5. E is wrong: the theory explains how a catalyst acts, but it does not account for the action of promoters and poisons.

Step 6. Correct statements: B, C and D, so the number is 3.

Answer: 3

COMMON TRAPS

- **Swapping who diffuses where.** The reactants move to the fixed catalyst surface; the catalyst does not spread over the reactants. *Avoid it:* Picture a solid catalyst with gas molecules arriving at it.
- **Overstating what the theory explains.** The theory explains the catalytic action itself, not the effects of promoters and poisons. *Avoid it:* Check each claim of scope against what the theory is said to explain.

REVISE The adsorption theory of heterogeneous catalysis.

31 Answer: 393

Ref 7544

Medium ~4 min

The amount of gas is fixed, so use $PV = ZnRT$ for both states.

Step 1. For a real gas, $n = \frac{PV}{ZRT}$. Since n does not change, $\frac{P_1V_1}{Z_1T_1} = \frac{P_2V_2}{Z_2T_2}$.

Step 2. So $V_2 = \frac{P_1V_1Z_2T_2}{P_2Z_1T_1}$.

Step 3. Substitute: $V_2 = \frac{100 \times 0.15 \times 1.4 \times 300}{300 \times 1.07 \times 500} = \frac{6300}{160500} = 0.03925 \text{ dm}^3$.

Step 4. In the required form, $0.03925 \text{ dm}^3 = 392.5 \times 10^{-4} \text{ dm}^3$, which rounds to 393.

Answer: 393

32 Answer: B

Ref 7618

Medium ~2 min Chemical equations and stoichiometry

Step 1: Gypsum is added to cement primarily to slow down the setting process of cement.

Step 2: Without gypsum, cement sets rapidly, which can lead to cracking since it reduces the time for proper hydration.

Step 3: This delayed setting by gypsum allows for better handling and application, ensuring that the cement mix can be transported and applied properly.

In conclusion, gypsum's role in cement is to regulate the set time by slowing it down, thus improving workability and preventing immediate hardening.

COMMON TRAPS

- **Thinking gypsum speeds up setting.** Gypsum reacts with tricalcium aluminate and slows the setting of cement. *Avoid it:* Link gypsum to delayed setting, not faster hardening.
- **Confusing setting with hydration.** Hydration still happens, and gypsum only controls how fast cement sets. *Avoid it:* Separate the role of water from the role of gypsum.

REVISE The composition and setting of cement. · The role of gypsum in cement.

33 Answer: 1

Ref 7870

Medium ~4 min Mole concept, Chemical equations and stoichiometry

First find the strength of the calcium hydroxide from the HCl titration, then use it for the acid.

Step 1. Volume of $Ca(OH)_2$ used with $HCl = 35.5 - 25.5 = 10.0 \text{ mL}$.

Step 2. HCl taken = $20 \times 0.5 = 10$ mmol, so 10 mL of the base holds 10 mmol of OH^- . The base has $[\text{OH}^-] = 1$ M, so $\text{Ca}(\text{OH})_2$ is 0.5 M.

Step 3. For the sulphuric acid, 20 mL of base supplies $20 \times 1 = 20$ mmol of OH^- .

Step 4. Each H_2SO_4 gives two H^+ , so $2 \times M \times 10 = 20$, which gives $M = 1$ M.

Answer: 1

34 Answer: 15

Ref 7907

Medium ~3 min Chemical equations and stoichiometry

QUICK APPROACH Start by calculating the moles of sodium using its mass and molar mass, then use the stoichiometry of the reaction between sodium and water to find moles of NaOH produced, and finally apply the concept of neutralization to relate moles of NaOH to moles of HCl.

Sodium gives an equal number of moles of NaOH, which needs the same moles of HCl.

Step 1. Moles of Na = $0.69/23 = 0.03$ mol.

Step 2. $2\text{Na} + 2\text{H}_2\text{O} \rightarrow 2\text{NaOH} + \text{H}_2$, so 0.03 mol of NaOH forms.

Step 3. $\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O}$, so 0.03 mol of HCl is needed.

Step 4. Molar mass of HCl = 36.5 g mol^{-1} . Molarity of the acid = $73/36.5 = 2$ M.

Step 5. Volume = $0.03/2 = 0.015 \text{ L} = 15 \text{ mL}$.

Answer: 15

COMMON TRAPS

- **Taking the acid as 73% by mass.** The 73 is grams of HCl per litre, which is 2 mol per litre. *Avoid it:* Read the concentration units before converting to molarity.
- **Using the moles of hydrogen gas.** NaOH, not H_2 , reacts with the acid, and 0.03 mol of Na gives 0.03 mol of NaOH. *Avoid it:* Follow the species that actually reacts with the titrant.

REVISE The reaction of sodium with water. · Molarity and volume calculations in neutralisation.

35 Answer: 798

Ref 8028

Medium ~3 min

One mole of photons carries N_A times the energy of one photon.

Step 1. Energy of one photon, $E = h\nu = 6.626 \times 10^{-34} \times 2 \times 10^{12} = 1.3252 \times 10^{-21} \text{ J}$.

Step 2. Energy per mole = $N_A h\nu = 6.022 \times 10^{23} \times 1.3252 \times 10^{-21} \text{ J mol}^{-1}$.

Step 3. $6.022 \times 1.3252 = 7.980$, and the power of ten is 10^2 . So the energy is 798.0 J mol^{-1} .

Answer: 798

COMMON TRAPS

- **Leaving out Avogadro's number.** $h\nu$ is the energy of one photon, so a mole needs $N_A h\nu$. *Avoid it:* Check whether the question asks per photon or per mole.
- **Slipping the power of ten.** $10^{-34} \times 10^{12} \times 10^{23}$ gives 10^1 before the digits are multiplied. *Avoid it:* Add the exponents separately from the digits.

REVISE Planck's equation for photon energy. · Powers of ten in scientific notation.

36 Answer: 200

Ref 8061

Medium ~3 min Mole concept and stoichiometry

The carbon in the CO_2 tells you how many carbon atoms one molecule contains.

Step 1. Moles of $\text{CO}_2 = 4.4/44 = 0.1$ mol, so 0.1 mol of C came from 0.01 mol of compound.

Step 2. Each molecule therefore has $0.1/0.01 = 10$ carbon atoms, that is 120 g of carbon per mole of compound.

Step 3. Carbon is 60% of the molar mass, so $0.60 \times M = 120$.

Step 4. $M = 120/0.60 = 200 \text{ g mol}^{-1}$.

Answer: 200

COMMON TRAPS

- **Using the compound's mass of carbon directly.** The carbon count comes from moles of CO_2 divided by moles of compound. *Avoid it:* Find carbon atoms per molecule before using the percentage.
- **Setting the percentage against the wrong mass.** 60% of the molar mass equals 120 g, so $M = 120/0.6$. *Avoid it:* Write the percentage equation in symbols before substituting.

REVISE Combustion analysis for carbon. · Percentage composition and molar mass.

37 Answer: 4

Ref 8113

Medium ~2 min Mole concept

Divide the volume by the molar volume at STP, then multiply the moles by N_A .

Step 1. Moles of $\text{O}_2 = \frac{2.8375}{22.7} = 0.125$ mol.

Step 2. Number of molecules = $0.125 \times 6.022 \times 10^{23} = 0.75275 \times 10^{23}$.

Step 3. In standard form this is 7.527×10^{22} molecules.

Step 4. Option (1) has the same digits with 10^{23} , which forgets to shift the decimal point.

Answer: (4) 7.527×10^{22} and 0.125 mol

38 Answer: 4

Ref 8114

Medium ~2 min Chemical Reactions

Step 1: Identify the solubility properties of chlorides. Most metal chlorides such as CaCl_2 , MgCl_2 , and KCl are soluble in water but not in organic solvents. Step 2: Consider the unique case of Beryllium chloride (BeCl_2). Unlike many other metal chlorides, BeCl_2 is covalent in nature due to the small size and

high charge density of the Be^{2+} ion, which allows it to dissolve in organic solvents rather than water. Step 3: Conclude that the chloride of Beryllium (BeCl_2) is the only one among the options that is highly soluble in organic solvents.

COMMON TRAPS

- **Assuming all chlorides are ionic.** BeCl_2 is covalent because the small Be^{2+} ion polarises chloride strongly. *Avoid it:* Apply Fajans' rules to the smallest cation.
- **Choosing magnesium as the anomalous member.** Beryllium, not magnesium, shows the anomalous covalent behaviour in group 2. *Avoid it:* Recall that the first member of a group is the odd one.

REVISE The anomalous behaviour of beryllium. · Fajans' rules and covalent character.

39 Answer: 3

Ref 8126

Medium ~2 min

QUICK APPROACH Start by understanding the properties of a primary standard in volumetric analysis and how they relate to solubility and hygroscopic nature of compounds.

A primary standard must be pure, stable and non-hygroscopic so that it can be weighed exactly.

Step 1. $\text{Na}_2\text{Cr}_2\text{O}_7$ is hygroscopic and absorbs moisture from air, so its weighed mass is not reliable.

Step 2. $\text{K}_2\text{Cr}_2\text{O}_7$ is not hygroscopic and can be obtained pure. It is preferred as a primary standard, so Statement I is true.

Step 3. Sodium dichromate is far more soluble in water than potassium dichromate, which is only moderately soluble. Statement II is false.

Answer: (3) Statement I is true but Statement II is false

40 Answer: 4

Ref 8143

Medium ~2 min Van der Waals equation

Step 1: The van der Waals constant a represents the magnitude of attractive forces between gas molecules.

Step 2: For different gases, this constant varies based on the inter-molecular forces.

Step 3: Argon (Ar) is a noble gas with very weak inter-molecular attractions, so it has the lowest a value.

Step 4: Methane (CH_4) has slightly stronger attractions than Argon due to its molecular structure.

Step 5: Water (H_2O) exhibits hydrogen bonding, which significantly increases its a value compared to Ar and CH_4 .

Step 6: Benzene (C_6H_6) has significant π -bonding interactions, resulting in a much higher a value.

Step 7: Therefore, the order from lowest to highest is Argon (A), Methane (B), Water (C), Benzene (D).

Thus, the correct option is (4): A, B, C, and D.

41 Answer: 2

Ref 8211

Medium ~2 min Applications of Compounds

QUICK APPROACH Think of where each substance is used: biology, farming, gas absorption and nuclear fusion.

Match each substance to its best-known use.

Step 1. A, K: potassium ions, together with sodium ions, run the sodium potassium pump across cell membranes. A-III.

Step 2. B, KCl: potassium chloride is the common potash fertilizer. B-II.

Step 3. C, KOH: potassium hydroxide is a strong base that absorbs carbon dioxide, $2\text{KOH} + \text{CO}_2 \rightarrow \text{K}_2\text{CO}_3 + \text{H}_2\text{O}$. C-IV.

Step 4. D, Li: lithium (as lithium deuteride) is the source of tritium in thermonuclear reactions. D-I.

Step 5. The match A-III, B-II, C-IV, D-I is option 2.

Answer: (2) A-III, B-II, C-IV, D-I

COMMON TRAPS

- **Swapping KCl and KOH.** KCl is a neutral salt used as fertilizer; KOH is the strong base that absorbs CO_2 . *Avoid it:* Ask which one is basic enough to react with an acidic gas.
- **Linking lithium to the ion pump.** The membrane pump moves sodium and potassium ions, not lithium. *Avoid it:* Match the pump to the element named in it.

REVISE Uses of alkali metals and their compounds.

42 Answer: B

Ref 8265

Medium ~2 min Chemical equations and stoichiometry

QUICK APPROACH Recall the two composition ratios quoted for good quality Portland cement and keep the lime ratio apart from the silica to alumina ratio.

The quality of Portland cement is judged by the ratio of lime to the other main oxides.

Step 1. Portland cement is mainly CaO (lime) with SiO_2 , Al_2O_3 and Fe_2O_3 .

Step 2. For good quality cement the ratio of SiO_2 to Al_2O_3 should be between 2.5 and 4, and the ratio of lime (CaO) to the total of the oxides of Si, Al and Fe should be as close as possible to 2.

Step 3. Too much lime makes the cement crack on setting; too little makes it weak.

Answer: (B) 2

COMMON TRAPS

- **Confusing the lime ratio with the SiO_2 to Al_2O_3 ratio.** Two ratios are quoted for cement: $\text{SiO}_2 : \text{Al}_2\text{O}_3$ between 2.5 and 4, and CaO to the total of $\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3$ close to 2. *Avoid it:* Write both ratios side by side and check which oxides the question names.
- **Guessing that more lime is always better.** Excess lime leaves free CaO , which expands and cracks set cement. The lime ratio is kept near 2. *Avoid it:* Remember that each cement ratio is a target, not a minimum.

REVISE The composition, manufacture and setting of Portland cement.

43 Answer: 4540

Ref 8274

Easy ~2 min Mole concept

The amount of CO_2 is given in moles, so multiply by the molar volume at STP.

Step 1. $V = n \times V_m = 0.2 \times 22.7 = 4.54 \text{ L}$.

Step 2. Convert to millilitres: $4.54 \times 1000 = 4540 \text{ mL}$.

Step 3. The 300 mL bottle volume is not needed. It only shows how much gas is packed into the drink.

Answer: 4540

COMMON TRAPS

- **Using the bottle volume in the answer.** The 300 mL is the drink, not the gas volume at STP. *Avoid it:* Use only the data the formula needs.
- **Using 22.4 L per mole.** The current STP molar volume at 1 bar is 22.7 L. *Avoid it:* Note which value of STP the question uses.

REVISE Molar volume of gases at STP. · Conversion between litres and millilitres.

44 Answer: 3

Ref 8285

Medium ~4 min Mole concept

Find the molar mass from the vapour data, then count chlorine atoms from the mass percentage.

Step 1. 100 mL of vapour at STP weighs 0.57 g. One mole occupies 22400 mL, so $M = 0.57 \times \frac{22400}{100} = 127.7 \text{ g mol}^{-1}$.

Step 2. Chlorine is 55.0% of this mass: $0.55 \times 127.7 = 70.2 \text{ g}$.

Step 3. Number of Cl atoms = $\frac{70.2}{35.5} = 1.98$, that is 2.

Step 4. The formula is MCl_2 . The metal part is $127.7 - 71 \approx 57 \text{ g}$, which is reasonable.

Answer: (3) MCl_2

45 Answer: C

Ref 8327

Medium ~1.5 min Mole concept

QUICK APPROACH Start by recalling the definition of intensive and extensive properties and classify each given property accordingly based on whether it depends on the amount of substance.

An intensive property does not change when the amount of the system changes.

Step 1. Volume grows with the amount of matter, so it is extensive.

Step 2. Molar heat capacity is per mole, so it is intensive.

Step 3. Molarity is a ratio of moles to volume, so it is intensive.

Step 4. E_{cell}^0 is a potential and does not depend on the size of the cell, so it is intensive.

Step 5. Gibbs free energy change grows with the amount reacting, as $\Delta G = -nFE$, so it is extensive.

Step 6. Molar mass is mass per mole, so it is intensive. The mole, an amount of substance, is extensive.

Step 7. The intensive ones are molar heat capacity, molarity, E_{cell}^0 and molar mass, which makes 4.

Answer: (C) 4

COMMON TRAPS

- **Calling every molar quantity extensive.** A molar quantity is per mole, so it does not depend on the amount. *Avoid it:* Ask whether doubling the system doubles the value.
- **Treating E_{cell}^0 like ΔG .** ΔG grows with the amount reacting, but the cell potential does not. *Avoid it:* Compare $\Delta G = -nFE$ with E alone.

REVISE Intensive and extensive properties. · The link between cell potential and Gibbs energy.

46 Answer: 3

Ref 8366

Medium ~3 min Chemical equations and stoichiometry

Step 1: Examine Assertion (A): An aqueous solution of KOH should indeed have its concentration checked before use in volumetric analysis because KOH is hygroscopic and absorbs atmospheric CO_2 , forming potassium carbonate (K_2CO_3). This changes the concentration of the solution.

Step 2: Examine Reason (R): The reason states that on aging, a KOH solution absorbs atmospheric CO_2 . This is correct as KOH can react with CO_2 in the air to form carbonates, thereby reducing the effective concentration of KOH.

Step 3: Relation between (A) and (R): The reason provided directly explains why the concentration of KOH solutions must be checked before use. Therefore, both Assertion (A) and Reason (R) are correct, and Reason (R) is the correct explanation of Assertion (A).

Correct choice is option 3.

47 Answer: 44

Ref 8425

Medium ~3 min Chemical equations and stoichiometry

QUICK APPROACH Start by using the concept of conservation of mass and relate the mass of CO_2 produced to the mass of carbon in the compound using molar masses.

All the carbon of the compound ends up in CO_2 , and 44 g of CO_2 holds 12 g of carbon.

Step 1. Mass of C = $\frac{12}{44} \times 0.792 = 0.216 \text{ g}$.

Step 2. Percentage of C = $\frac{0.216}{0.492} \times 100 = 43.9\%$.

Step 3. To the nearest integer, this is 44.

Answer: 44

COMMON TRAPS

- **Using the mass of CO₂ as carbon.** Only 12/44 of the CO₂ mass is carbon. *Avoid it:* Convert the product mass to the element mass first.
- **Dividing by the wrong mass.** The percentage is carbon mass over the 0.492 g sample. *Avoid it:* Put the sample mass in the denominator.

REWISE Liebig's method for carbon estimation. · Percentage composition from combustion data.

48 Answer: 3

Ref 8428

Medium ~1.5 min Chemical equations and stoichiometry

QUICK APPROACH Use the concept of thermal decomposition of alkali metal nitrates and balance the chemical equation by verifying atom conservation on both sides.

Step 1: Understand the decomposition of nitrates. Under heating (Δ), alkali metal nitrates decompose.

Step 2: Generally, for lithium nitrate (LiNO₃), the decomposition is as follows:



Step 3: Verify the stoichiometry: Check that the mole balance for all atoms is correct.

Result: Option 3 is the balanced and correct decomposition reaction for LiNO₃ under heating.

49 Answer: 4

Ref 8471

Medium ~2 min Stoichiometry and Chemical Reactions

Step 1: Write the balanced chemical equation for the reaction:
 $\text{Zn} + 2\text{HCl} \rightarrow \text{ZnCl}_2 + \text{H}_2$.

Step 2: Calculate the moles of zinc reacting:

$$\text{Moles of Zn} = (\text{mass of Zn}) / (\text{molar mass of Zn}) = 11.5 \text{ g} / 65.4 \text{ g mol}^{-1} = 0.1758 \text{ mol}.$$

Step 3: Determine the moles of hydrogen gas produced:
 From the balanced equation, 1 mole of Zn produces 1 mole of H₂. So, 0.1758 mol of Zn will produce 0.1758 mol of H₂.

Step 4: Calculate the volume of hydrogen gas at STP:
 $\text{Volume of H}_2 = (\text{moles of H}_2) \times (\text{molar volume of H}_2 \text{ at STP})$
 $= 0.1758 \text{ mol} \times 22.7 \text{ L mol}^{-1} = 3.99 \text{ L}.$

Step 5: Round the answer to the nearest integer:

$$\text{Volume of H}_2 \approx 4 \text{ L}.$$

50 Answer: 4

Ref 8552

Medium ~3 min Chemical equations and stoichiometry

Step 1: Calculate the volume of the cubic unit cell. The edge length is given as $5.0 \text{ \AA} = 5.0 \times 10^{-8} \text{ cm}$. Volume (V) = (edge length)³ = $(5.0 \times 10^{-8} \text{ cm})^3 = 1.25 \times 10^{-23} \text{ cm}^3$.

Step 2: Use the density formula. Density (ρ) = mass/volume, so

$$\text{mass of FeO per unit cell} = \text{density} \times \text{volume} = 4 \text{ g cm}^{-3} \times 1.25 \times 10^{-23} \text{ cm}^3 = 5.0 \times 10^{-23} \text{ g}.$$

Step 3: Calculate the molar mass of FeO. Molar mass of Fe = 56 g/mol, Molar mass of O = 16 g/mol.
 Therefore, molar mass of FeO = 56 + 16 = 72 g/mol.

Step 4: Use the formula: Number of formula units per unit cell (Z) = (mass of unit cell $\times N_A$) / molar mass of FeO = $(5.0 \times 10^{-23} \text{ g} \times 6.0 \times 10^{23} \text{ mol}^{-1}) / 72 \text{ g mol}^{-1} = 4.167$.

Since we're asked for the nearest integer, the number of FeO units in the unit cell is 4.

51 Answer: 3

Ref 8554

Easy ~1.5 min Classification of Elements and Periodicity in Properties

QUICK APPROACH Check which part of the flame is used to see the colours of alkali metal salts.

Flame colours are seen in the oxidising (non-luminous) part of a flame, so the flame named in the assertion decides it.

Step 1. Heat excites the outer electron of an alkali metal atom; when it falls back it gives off visible light of a set colour (lithium crimson, sodium yellow, potassium lilac).

Step 2. These colours are observed in the oxidising flame, not the reducing flame. So Assertion A, which says reducing flame, is not correct.

Step 3. Reason R is correct: the characteristic colours let alkali metals be detected by flame tests.

Step 4. A is not correct and R is correct, which is option 3.

Answer: (3) A is not correct but R is correct.

COMMON TRAPS

- **Overlooking the type of flame.** The colours are seen in the oxidising flame; naming the reducing flame makes the assertion false. *Avoid it:* Read every qualifier in an assertion, not just the main idea.
- **Assuming a true reason makes the assertion true.** R can be correct on its own while A is wrong in a detail. *Avoid it:* Judge A and R separately before asking whether R explains A.

REWISE Flame tests of alkali metals.

52 Answer: 56

Ref 8588

Medium ~4 min Chemical equations and stoichiometry

QUICK APPROACH The mass of the compound is not given directly; get it from the carbon content and the stated percentage of carbon.

The carbon percentage fixes the mass of the sample, and the water gives the mass of hydrogen.

$$\text{Step 1. Carbon in } 0.220 \text{ g of CO}_2: 0.220 \times \frac{12}{44} = 0.060 \text{ g}.$$

$$\text{Step 2. This carbon is 24\% of the sample, so the sample mass is } \frac{0.060}{0.24} = 0.25 \text{ g}.$$

$$\text{Step 3. Hydrogen in } 0.126 \text{ g of H}_2\text{O}: 0.126 \times \frac{2}{18} = 0.014 \text{ g}.$$

Step 4. Percentage of hydrogen:

$$\frac{0.014}{0.25} \times 100 = 5.6\% = 56 \times 10^{-1}\%$$

Note that the oxygen content is never needed: the carbon

figure alone fixes the sample mass.

Answer: 56

COMMON TRAPS

- **Taking hydrogen's share of water as 1/18.** Each water molecule has two hydrogen atoms, so hydrogen is 2/18 of its mass. *Avoid it:* Count atoms in the formula before taking a mass fraction.
- **Forgetting the scale factor.** The blank is in units of 10^{-1} , so 5.6% is entered as 56. *Avoid it:* Divide the result by the stated power of ten before entering it.

REVISE Percentage composition from combustion analysis.

53 Answer: 4

Ref 8613

Medium ~4 min Chemical equations and stoichiometry

QUICK APPROACH Use the total iron and charge neutrality to find how much of the iron is Fe^{2+} and how much is Fe^{3+} .

Split the iron in $\text{Fe}_{0.93}\text{O}$ into Fe^{2+} and Fe^{3+} by charge balance, then test each statement.

Step 1. Let x mol be Fe^{2+} and y mol be Fe^{3+} : $x + y = 0.93$ and $2x + 3y = 2$. So $y = 0.14$ and $x = 0.79$. B is correct.

Step 2. On heating to Fe_2O_3 only the Fe^{2+} is oxidised, each losing one electron, so the n-factor is 0.79 and the equivalent weight is the molecular weight divided by 0.79. A is correct.

Step 3. There is less than one iron per oxide ion, so the solid is metal deficient; it keeps the rock salt structure with oxide ions in cubic close packing. C is correct.

Step 4. $\frac{0.79}{0.93} \times 100 = 84.9\% \approx 85\%$ and $\frac{0.14}{0.93} \times 100 = 15.1\% \approx 15\%$. D is correct.

Step 5. All four statements are correct.

Answer: 4

COMMON TRAPS

- **Taking 0.93 as the n-factor.** Only the Fe^{2+} ions are oxidised; the Fe^{3+} ions are already in their final state. *Avoid it:* Count electrons lost only by the species whose oxidation state changes.
- **Percentages out of one mole of compound.** The 85% and 15% are shares of the total iron (0.93 mol), not of one mole of formula units. *Avoid it:* Divide each ion's moles by the total iron, 0.93.

REVISE Non-stoichiometric oxides and n-factor calculations.

54 Answer: 555

Ref 8626

Medium ~2 min Dalton's theory, Mole concept

Partial pressure depends on mole fraction, so turn each mass into moles first.

Step 1. $n_X = \frac{0.6}{20} = 0.03$ mol and $n_Y = \frac{0.45}{45} = 0.01$ mol.

Step 2. Total moles = 0.04 mol, so the mole fraction of X is $\chi_X = \frac{0.03}{0.04} = 0.75$.

Step 3. By Dalton's law, $p_X = \chi_X \times P_{\text{total}} = 0.75 \times 740 = 555$ mm of Hg.

Answer: 555

COMMON TRAPS

- **Using mass fraction instead of mole fraction.** Dalton's law uses mole fraction, so masses must first become moles. *Avoid it:* Divide each mass by its molar mass before finding fractions.
- **Using the mole fraction of Y.** The partial pressure of X needs the mole fraction of X, 0.75. *Avoid it:* Label each fraction with its gas.

REVISE Dalton's law of partial pressures. · Mole fraction calculations for gas mixtures.

55 Answer: D

Ref 8630

Medium ~4 min Mole concept, Chemical equations and stoichiometry

The mass of liquid in the vessel is calculated as $135.0 \text{ g} - 40.0 \text{ g} = 95.0 \text{ g}$. With a density of 0.95 g mL^{-1} , the internal volume is $V = \frac{95.0}{0.95} = 100 \text{ mL} = 0.1 \text{ L}$.

The mass of the contained ideal gas is $40.5 \text{ g} - 40.0 \text{ g} = 0.5 \text{ g}$. Substitute into the ideal gas law $PV = nRT$ with $P = 0.82$ atm, $V = 0.1 \text{ L}$, $T = 250 \text{ K}$ and $R = 0.082 \text{ L atm K}^{-1} \text{ mol}^{-1}$:

$$n = \frac{(0.82)(0.1)}{(0.082)(250)} = \frac{0.082}{20.5} = 0.004$$

mol.

Molar mass is then $M = \frac{0.5}{0.004} = 125 \text{ g mol}^{-1}$. Option B (50) encodes the specific mistake of erroneously inserting $T = 100 \text{ K}$ into RT (instead of 250 K), which doubles n to 0.01 mol and halves M to 50. Correct substitution of all given values confirms 125 g mol^{-1} .

Correct option: D

56 Answer: 4

Ref 8951

Medium ~3 min Mole concept

Get the empirical formula from the percentages, then scale it to the molar mass.

Step 1. In 100 g: $\text{C} = 74/12 = 6.17 \text{ mol}$, $\text{H} = 8.7/1 = 8.7 \text{ mol}$, $\text{N} = 17.3/14 = 1.24 \text{ mol}$.

Step 2. Divide by 1.24: $\text{C} : \text{H} : \text{N} = 5 : 7 : 1$. The empirical formula is $\text{C}_5\text{H}_7\text{N}$.

Step 3. Empirical formula mass = $60 + 7 + 14 = 81 \text{ g mol}^{-1}$.

Step 4. $n = \frac{162}{81} = 2$, so the molecular formula is $\text{C}_{10}\text{H}_{14}\text{N}_2$.

Answer: (4) $\text{C}_{10}\text{H}_{14}\text{N}_2$

57 Answer: D

Ref 9006

Medium ~4 min Mole concept, Chemical equations and stoichiometry

In a hydrocarbon everything that is not carbon is hydrogen.

Step 1. Mass of carbon in one mole = $0.858 \times 84 = 72.1 \text{ g}$, which is $72.1/12 = 6$ carbon atoms.

Step 2. Mass of hydrogen in one mole = $84 - 72 = 12 \text{ g}$, which is 12 hydrogen atoms.

Step 3. The formula is C_6H_{12} . Check: $\frac{72}{84} \times 100 = 85.7\%$,

which matches the data.

Answer: (D) 12

58 Answer: 152

Ref 9039

Medium ~4 min Chemical equations and stoichiometry

A 50 volume solution of H_2O_2 gives 50 L of O_2 at STP from 1 L of solution.

Step 1. $2\text{H}_2\text{O}_2 \rightarrow 2\text{H}_2\text{O} + \text{O}_2$. So 68 g of H_2O_2 gives 22.4 L of O_2 at STP.

Step 2. Mass of H_2O_2 that gives 50 L of $\text{O}_2 = \frac{68 \times 50}{22.4} = 151.8$ g.

Step 3. This mass is in 1 L of solution, so the strength is 151.8 g L^{-1} , which is 152 to the nearest integer.

Step 4. The shortcut, strength = $\frac{17 \times \text{volume strength}}{5.6}$, gives the same value.

Answer: 152

COMMON TRAPS

- **Reading 50 volume as 50 g per litre.** Volume strength is litres of O_2 at STP given by 1 L of solution. *Avoid it:* Convert volume strength using the decomposition equation.
- **Using a 1 : 1 ratio for H_2O_2 and O_2 .** Two moles of H_2O_2 , 68 g, give one mole of O_2 . *Avoid it:* Balance the decomposition before using it.

REVISE Volume strength of hydrogen peroxide. · The decomposition of hydrogen peroxide.

59 Answer: 4

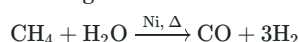
Ref 9073

Medium ~3 min Chemical reactions

QUICK APPROACH Use the concept of steam reforming for Statement I and the principle of in-situ formation and decomposition of ammonium nitrite for Statement II.

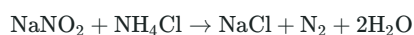
Write the reaction for each statement and check the products.

Step 1. Methane and steam over a heated nickel catalyst undergo steam reforming:



Hydrogen gas forms, so Statement I is correct.

Step 2. Sodium nitrite and ammonium chloride first give ammonium nitrite, which decomposes on warming:



Step 3. The products are H_2O , N_2 and NaCl , exactly as stated. So Statement II is correct.

Answer: (4) Both the statements I and II are correct

60 Answer: 4

Ref 7448

Medium ~2 min Chemical equations and stoichiometry

QUICK APPROACH Compare charge first, then size within ions of the same charge.

Hydration enthalpy grows with charge density: a higher charge and a smaller ion attract water molecules more strongly.

Step 1. The two dipositive ions, Mg^{2+} and Ca^{2+} , have far more

charge density than any of the unipositive ions, so they come first.

Step 2. Mg^{2+} is smaller than Ca^{2+} , so $\text{C} > \text{E}$.

Step 3. Among the alkali metal ions, size grows from K^+ to Rb^+ to Cs^+ , so hydration enthalpy falls in that order: $\text{A} > \text{B} > \text{D}$.

Step 4. Combined order: $\text{Mg}^{2+} > \text{Ca}^{2+} > \text{K}^+ > \text{Rb}^+ > \text{Cs}^+$, that is $\text{C} > \text{E} > \text{A} > \text{B} > \text{D}$.

Answer: (4) $\text{C} > \text{E} > \text{A} > \text{B} > \text{D}$

COMMON TRAPS

- **Ranking a larger ion higher.** Within a group, hydration enthalpy falls as the ion gets bigger, so Mg^{2+} beats Ca^{2+} . *Avoid it:* Smaller ion of the same charge means stronger hydration.
- **Letting size outweigh charge.** Doubling the charge raises hydration enthalpy far more than a modest change in radius. *Avoid it:* Sort by charge first, then by size.

REVISE Hydration enthalpy trends of s-block ions.

61 Answer: 3

Ref 8593

Easy ~2 min Chemical applications of silica gel

Step 1: Understand the Assertion. Silica gel is commonly used in various instruments to control humidity and prevent moisture-related damage. This supports the validity of the statement in Assertion (A). **Step 2:** Evaluate the Reason. Silica gel's ability to adsorb moisture from the air is well-known, preventing moisture-induced issues like rusting or electronic malfunctions. This makes Reason (R) true. **Step 3:** Correlate Assertion and Reason. Reason (R) provides the direct basis for why Assertion (A) is true—the primary purpose of using silica gel in instruments. Therefore, both (A) and (R) are true, and (R) is the correct explanation of (A).

COMMON TRAPS

- **Treating silica gel as an absorber rather than an adsorbent.** Silica gel is a porous, high-surface-area desiccant; water molecules are held on its surface, so the correct term is adsorption. *Avoid it:* When the substance is silica gel/charcoal/catalyst surface, check for surface phenomenon: adsorption, not bulk absorption.
- **Marking the Reason true but not the explanation.** Here the Assertion is about keeping silica gel near instruments; the Reason gives the direct purpose: removing moisture to prevent rusting/malfunctioning. *Avoid it:* After truth checking A and R, add “because” between them and see if it forms a causal sentence.

REVISE Adsorption vs absorption with examples: silica gel, activated charcoal, sponge, anhydrous salts. · Use a fixed assertion-reason workflow: check A truth, check R truth, then test whether R explains A using a “because” sentence.

62 Answer: 1

Ref 8042

Easy ~1 min Chemical Properties of Elements

QUICK APPROACH Start by comparing the melting and boiling points of the elements with 100°C , and consider their chemical stability in water at this temperature.

An element stays liquid in boiling water only if it melts below 100°C , boils above 100°C and does not react with water.

Step 1. Gallium melts at about 30°C and boils above 2000°C .

It does not react with water, so it stays liquid at 100 °C.

Step 2. Bromine boils at about 59 °C. At 100 °C it turns to vapour.

Step 3. Lithium melts at about 181 °C, so it is solid at 100 °C. It also reacts with water.

Step 4. Caesium melts at about 28 °C, but it reacts violently with water to form CsOH and H₂. It does not remain as the element.

Answer: (1) Ga

COMMON TRAPS

- **Choosing caesium for its low melting point.** Caesium melts near 28 °C but reacts violently with water. *Avoid it:* Check reactivity with water as well as the melting point.
- **Choosing bromine because it is a liquid.** Bromine boils at about 59 °C, so it turns to vapour at 100 °C. *Avoid it:* Compare both the melting and boiling points with 100 °C.

REVISE Physical properties of group 13 elements. · Reactivity of alkali metals with water.

63 Answer: C

Ref 8013

Easy ~1 min Chemical formulas

Step 1: Identify the chemical formula of washing soda.

Washing soda is sodium carbonate decahydrate with the formula Na₂CO₃·10H₂O, which contains 10 water molecules.

Step 2: Identify the chemical formula of soda ash. Soda ash is sodium carbonate anhydrous with the formula Na₂CO₃, which contains 0 water molecules.

Step 3: Therefore, the number of water molecules in washing soda and soda ash is 10 and 0 respectively.

64 Answer: 36

Ref 8742

Medium ~3 min Mole concept, Chemical equations and stoichiometry

Step 1: Calculate the mass of sugar in the first solution:

$$25\% \text{ of } 200 \text{ g} = 0.25 \times 200 = 50 \text{ g.}$$

Step 2: Calculate the mass of sugar in the second solution:

$$40\% \text{ of } 500 \text{ g} = 0.4 \times 500 = 200 \text{ g.}$$

Step 3: Calculate the total mass of the resulting solution:

$$\text{Total mass} = 200 \text{ g} + 500 \text{ g} = 700 \text{ g.}$$

Step 4: Calculate the total mass of sugar present in the resulting solution:

$$\text{Total mass of sugar} = 50 \text{ g} + 200 \text{ g} = 250 \text{ g.}$$

Step 5: Calculate the mass percentage of the sugar in the resulting solution:

$$\text{Mass percentage} = \left(\frac{\text{Total mass of sugar}}{\text{Total mass of solution}} \right) \times 100 = \left(\frac{250}{700} \right) \times 100 \approx 35.71.$$

Rounding this to the nearest integer, we get 36.

65 Answer: 1

Ref 6113

Medium ~2 min Chemical equations and stoichiometry

QUICK APPROACH Start by applying the concept of thermal decomposition of bicarbonates during boiling to identify the precipitates formed from calcium and magnesium hydrogen carbonates.

On boiling, hydrogen carbonates decompose and the hardness-causing ions precipitate.

Step 1. $\text{Ca}(\text{HCO}_3)_2 \rightarrow \text{CaCO}_3 + \text{H}_2\text{O} + \text{CO}_2$. Calcium carbonate is insoluble and settles out.

Step 2. $\text{Mg}(\text{HCO}_3)_2 \rightarrow \text{Mg}(\text{OH})_2 + 2\text{CO}_2$. Magnesium carbonate is fairly soluble and hydrolyses in hot water, so the precipitate is the much less soluble Mg(OH)₂.

Step 3. So the products are CaCO₃ and Mg(OH)₂.

Step 4. Boiling never gives Ca(OH)₂ here, and MgCO₃ does not stay as the final product.

Answer: (1) CaCO₃ and Mg(OH)₂

COMMON TRAPS

- **Assuming both salts give carbonates.** Calcium ends as CaCO₃, but magnesium ends as Mg(OH)₂ because MgCO₃ hydrolyses on boiling. *Avoid it:* Treat calcium and magnesium separately when writing the boiling reactions.
- **Choosing calcium hydroxide.** Boiling does not turn Ca(HCO₃)₂ into Ca(OH)₂; it gives CaCO₃, CO₂ and water. *Avoid it:* Balance each decomposition before choosing an option.

REVISE Removal of temporary hardness by boiling. · Clark's method and lime treatment.

66 Answer: 2

Ref 6143

Medium ~3 min Dalton's Law of Partial Pressures

QUICK APPROACH Start by converting the mass percentages of hydrogen and oxygen into moles using their molar masses, then apply Dalton's Law of Partial Pressures using mole fractions.

Partial pressure needs the mole fraction, so convert the masses to moles.

Step 1. In 100 g of mixture there are 40 g of H₂ and 60 g of O₂.

Step 2. Moles of H₂ = $\frac{40}{2} = 20$ mol. Moles of O₂ = $\frac{60}{32} = 1.875$ mol. Total = 21.875 mol.

Step 3. Mole fraction of H₂ = $\frac{20}{21.875} = \frac{32}{35} = 0.914$.

Step 4. $p_{\text{H}_2} = 0.914 \times 2.2 = 2.01$ bar, which is 2 bar to the nearest integer.

Answer: 2

COMMON TRAPS

- **Using the mass fraction as the mole fraction.** 40% by mass of hydrogen is about 91% by moles, because hydrogen has a much smaller molar mass. *Avoid it:* Convert each mass to moles before finding a mole fraction.
- **Finding the oxygen value instead.** The partial pressure of oxygen is $2.2 - 2.01 = 0.19$ bar, but the question asks for hydrogen. *Avoid it:* Check which gas the question names before giving the answer.

REVISE Dalton's law with mass percentages.

67 Answer: 3

Ref 6147

Medium ~2 min Adsorption

In physical adsorption, a gas that liquefies more easily is adsorbed more. Ease of liquefaction rises with critical temperature.

Step 1. Compare critical temperatures. SO_2 has $T_c \approx 430$ K and CH_4 has $T_c \approx 191$ K.

Step 2. SO_2 has stronger van der Waals forces and liquefies more easily. So activated charcoal adsorbs SO_2 more than CH_4 . The Assertion is correct.

Step 3. The Reason says gases with lower critical temperatures are adsorbed more readily. This reverses the rule: gases with higher critical temperatures are adsorbed more. The Reason is not correct.

Answer: (3) A is correct but R is not correct.

68 Answer: 3

Ref 6153

Medium ~2 min

Compare the moles with the ratio in $\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$.

Step 1. Moles of $\text{N}_2 = \frac{20}{28} = 0.714$ mol. Moles of $\text{H}_2 = \frac{5}{2} = 2.5$ mol.

Step 2. 0.714 mol of N_2 needs $3 \times 0.714 = 2.14$ mol of H_2 . More than this is present, so N_2 is the limiting reagent.

Step 3. Moles of $\text{NH}_3 = 2 \times 0.714 = 1.43$ mol, which matches 1.42 in the options.

Answer: (3) N_2 , 1.42 moles

69 Answer: C

Ref 6175

Medium ~3 min Chemical equations and stoichiometry

Use the 4 : 3 mole ratio of HNO_3 to KNO_3 .

Step 1. Molar mass of $\text{KNO}_3 = 39 + 14 + 48 = 101 \text{ g mol}^{-1}$, so moles $= \frac{110.0}{101} = 1.089$ mol.

Step 2. Moles of $\text{HNO}_3 = \frac{4}{3} \times 1.089 = 1.452$ mol.

Step 3. Molar mass of $\text{HNO}_3 = 1 + 14 + 48 = 63 \text{ g mol}^{-1}$.

Step 4. Mass of $\text{HNO}_3 = 1.452 \times 63 = 91.5$ g.

Answer: (C) 91.5 g

COMMON TRAPS

- **Using the product coefficient 3 as a mass multiplier instead of mole coefficient.** Balanced equation coefficients are mole ratios, not gram ratios. The relationship is 4 mol HNO_3 : 3 mol KNO_3 . *Avoid it:* Convert 110.0 g KNO_3 to mol using molar mass 101 g/mol before applying 4/3.
- **Inverting the stoichiometric ratio 4/3.** To find required HNO_3 from known KNO_3 , use $\frac{4 \text{ mol HNO}_3}{3 \text{ mol KNO}_3}$. *Avoid it:* Write units in the conversion factor so mol KNO_3 cancels and mol HNO_3 remains.

REVISE Mass-mole-mass stoichiometry using dimensional analysis with unit cancellation. · Practice molar masses of common nitrate compounds and acids.

70 Answer: 4

Ref 6272

Medium ~4 min Chemical equations and stoichiometry

In the analysis of organic compounds, the percentage of carbon and hydrogen are calculated from the masses of CO_2 and H_2O obtained on combustion using the formulae:

$$\%C = \frac{12}{44} \times \frac{\text{mass of CO}_2}{\text{mass of compound}} \times 100 = \frac{12}{44} \times \frac{330}{120} \times 100 =$$

$$\%H = \frac{2}{18} \times \frac{\text{mass of H}_2\text{O}}{\text{mass of compound}} \times 100 = \frac{2}{18} \times \frac{270}{120} \times 100 =$$

Mass of C is $(12/44) \times 330 = 90$ g and mass of H is $(2/18) \times 270 = 30$ g in the 120 g sample, confirming the percentages add to 100% with no other elements present. Option [2] (40 and 60) encodes the specific mistake of misremembering the formula with wrong denominators (e.g., using $12/30=40\%$ directly). Therefore, the correct option is [4] 75 and 25.

71 Answer: 46

Ref 6283

Medium ~3 min Chemical equations and stoichiometry

QUICK APPROACH Use the combustion analysis concept to find the masses of carbon and hydrogen from CO_2 and H_2O , then determine oxygen by difference.

Find carbon and hydrogen from the products, and get oxygen by difference.

Step 1. Mass of C $= \frac{12}{44} \times 0.793 = 0.2163$ g.

Step 2. Mass of H $= \frac{2}{18} \times 0.442 = 0.0491$ g.

Step 3. Mass of O $= 0.492 - (0.2163 + 0.0491) = 0.2266$ g.

Step 4. Percentage of O $= \frac{0.2266}{0.492} \times 100 = 46.06\%$, which is 46 to the nearest integer.

Answer: 46

COMMON TRAPS

- **Counting oxygen in the products as oxygen of the compound.** Much of the oxygen in CO_2 and water comes from the air, so the compound's oxygen must be found by difference. *Avoid it:* Find C and H first, then subtract from the sample mass.
- **Rounding too early.** Small masses like 0.2163 g lose accuracy if rounded to 0.2 g before the subtraction. *Avoid it:* Keep four significant figures until the final percentage.

REVISE Estimation of oxygen by difference.

72 Answer: 2

Ref 6299

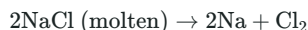
Medium ~1 min Chemical equations and stoichiometry

In the chlor-alkali process for industrial NaOH production, brine is electrolysed:



H_2 evolves at the cathode as a byproduct while NaOH forms in solution. This directly yields molecular hydrogen.

Sodium metal is obtained via Down's cell electrolysis of molten NaCl :



with no H_2 formed. Option 3 (Na metal) encodes the common error of conflating this with aqueous electrolysis or misremembering Castner's molten-NaOH process (which yields O_2 , not H_2).

Na_2CO_3 and NaHCO_3 arise from the Solvay process ($\text{NH}_3 + \text{CO}_2 + \text{NaCl} + \text{H}_2\text{O} \rightarrow \text{NaHCO}_3 + \text{NH}_4\text{Cl}$, heating to Na_2CO_3), involving no hydrogen at all.

Thus, only option [2] matches the production where H_2 is a byproduct. The correct option is [2] NaOH.

COMMON TRAPS

- **Thinking sodium metal production gives hydrogen.** Sodium is made by electrolysis of molten NaCl, which gives Na and Cl_2 but no H_2 . *Avoid it:* Ask whether water is present in the process before expecting hydrogen.
- **Linking the Solvay process with hydrogen.** Na_2CO_3 and NaHCO_3 come from the Solvay process, which forms no hydrogen gas. *Avoid it:* Write the overall reaction of each industrial process.

REVISE The chlor-alkali process and its products.

73 Answer: 2

Ref 6317

Medium ~1 min Chemical equations and stoichiometry

Step 1: A flame test is a procedure used to test qualitatively for the presence of certain metals in chemical compounds. When the compound is heated in a flame, the flame can exhibit a characteristic color.

Step 2: Copper salts give a green flame with a blue centre during a flame test because they excite electrons to a higher energy state. When those electrons return to their ground state, they emit light at a characteristic frequency.

Step 3: Calcium gives a brick-red flame, Barium gives a green flame but without the blue center, and Strontium gives a crimson flame.

Conclusion: Based on the flame color described (green with blue centre), Copper is the correct cation that can be present.

74 Answer: 2

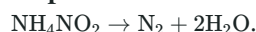
Ref 6326

Easy ~1 min Chemical equations and stoichiometry

Ammonium nitrite forms in solution and breaks down on warming.



Step 2. Ammonium nitrite is unstable:



Step 3. The gas given off is dinitrogen. This is a common laboratory method for preparing N_2 .

Step 4. N_2O comes from heating ammonium nitrate, not ammonium nitrite.

Step 5. NH_3 would need a base, and Cl_2 would need an oxidising agent strong enough to oxidise chloride; neither is present.

Answer: (2) N_2

75 Answer: 22

Ref 6365

Medium ~4 min Mole concept

QUICK APPROACH Use density times cell volume to get the mass of one unit cell, and remember how many atoms a bcc cell holds.

The mass of one unit cell is its density times its volume, and a body centred cubic cell holds two atoms.

Step 1. Edge $a = 300 \text{ pm} = 3.00 \times 10^{-8} \text{ cm}$, so the cell volume is $a^3 = 2.7 \times 10^{-23} \text{ cm}^3$.

Step 2. Mass of one cell $= 6.0 \times 2.7 \times 10^{-23} = 1.62 \times 10^{-22} \text{ g}$.

Step 3. A bcc cell has $Z = 2$ atoms (8 corners at one eighth each, plus one at the centre), so the mass of one atom is $\frac{1.62 \times 10^{-22}}{2} = 8.1 \times 10^{-23} \text{ g}$.

Step 4. Number of atoms in 180 g:

$$\frac{180}{8.1 \times 10^{-23}} = 2.22 \times 10^{24} = 22.2 \times 10^{23}$$

Step 5. To the nearest integer, the number is 22.

Answer: 22

COMMON TRAPS

- **Wrong number of atoms per cell.** A body centred cubic cell holds 2 atoms, not 1 (simple cubic) or 4 (face centred). *Avoid it:* Count corner and body atoms with their shares before dividing.
- **Leaving the edge in picometres.** Density is in g/cm^3 , so the edge must be converted to cm before cubing. *Avoid it:* Convert $1 \text{ pm} = 10^{-10} \text{ cm}$ first, then cube.

REVISE Density and atoms per unit cell in cubic lattices.

76 Answer: 22

Ref 6413

Medium ~2 min

Only the dry gas obeys Boyle's law; the water vapour pressure stays fixed at a given temperature.

Step 1. Pressure of dry gas $= 4 - 0.4 = 3.6 \text{ atm}$.

Step 2. Doubling the volume at the same temperature halves this: $\frac{3.6}{2} = 1.8 \text{ atm}$.

Step 3. The vapour pressure of water depends only on temperature, so it stays 0.4 atm .

Step 4. New pressure $= 1.8 + 0.4 = 2.2 \text{ atm} = 22 \times 10^{-1} \text{ atm}$.

Answer: 22

COMMON TRAPS

- **Applying Boyle's law to the total moist-gas pressure instead of only the dry-gas pressure.** For moist gas, $P_{\text{total}} = P_{\text{dry}} + P_{\text{vapour}}$. Only P_{dry} changes with volume; at the same temperature, P_{vapour} of water remains fixed at 0.4 atm. *Avoid it:* Before applying Boyle's law, subtract water vapour pressure: $P_{\text{dry}} = 4 - 0.4 = 3.6$ atm; after halving dry pressure, add 0.4 atm back.
- **Forgetting to add water vapour pressure back after finding dry-gas pressure.** The final moist-gas pressure is dry gas pressure plus water vapour pressure: $1.8 + 0.4 = 2.2$ atm. *Avoid it:* Underline "moist gas" in the final ask and write a last line $P_{\text{total, new}} = P_{\text{dry, new}} + P_{\text{vapour}}$.

REVISE Dalton's law for moist gases: $P_{\text{moist}} = P_{\text{dry}} + P_{\text{H}_2\text{O}}$. Practise problems where only the dry gas obeys Boyle's law while saturated vapour pressure stays fixed at constant temperature.

77 Answer: D

Ref 6484

Medium ~4 min Mole concept, Chemical equations and stoichiometry

QUICK APPROACH Start by applying the ideal gas law for the mixture and express the total pressure in terms of moles of hydrogen and helium gases.

The total moles come from $PV = nRT$; the mass then fixes how they split.

$$\text{Step 1. } n = \frac{PV}{RT} = \frac{6 \times 10^5 \times 0.0125}{8.3 \times 300} = \frac{7500}{2490} = 3.01 \text{ mol.}$$

$$\text{Step 2. Let the mass of He be } m \text{ g. Then H}_2 \text{ is } (10 - m) \text{ g, and } \frac{10 - m}{2} + \frac{m}{4} = 3.01.$$

$$\text{Step 3. } 5 - \frac{m}{4} = 3.01, \text{ so } \frac{m}{4} = 1.99 \text{ and } m = 7.95 \approx 8 \text{ g.}$$

Step 4. Check: 2 g of H_2 is 1 mol and 8 g of He is 2 mol, total 3 mol.

Answer: (D) 8 g

78 Answer: A

Ref 6552

Easy ~1 min Chemical equations and stoichiometry

Check which ore each metal comes from.

Step 1. Lead is extracted from galena, PbS , a sulphide ore.

Step 2. Zinc is extracted from zinc blende, ZnS , a sulphide ore.

Step 3. Iron is extracted from its oxides, haematite Fe_2O_3 and magnetite Fe_3O_4 , though it also occurs as iron pyrites, FeS_2 .

Step 4. Aluminium has no sulphide ore in use. It is extracted from bauxite, $\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$, by electrolysis of alumina.

Answer: (A) Aluminium

79 Answer: 33

Ref 6575

Medium ~6 min Mole concept

QUICK APPROACH Each OH group releases one molecule of methane with a Grignard reagent, so the gas volume gives the moles of alcohol.

An alcohol reacts with methylmagnesium iodide to give one molecule of methane per OH group, so the methane counts the moles of alcohol.

Step 1. Reaction: $\text{R-OH} + \text{CH}_3\text{MgI} \rightarrow \text{CH}_4 + \text{R-OMgI}$. For a monohydric alcohol, moles of methane equal moles of alcohol.

Step 2. Taking the gas volume at STP (22400 mL per mol):

$$n_{\text{CH}_4} = \frac{3.1}{22400} = 1.384 \times 10^{-4} \text{ mol}$$

Step 3. Mass of alcohol = 4.5 mg = 4.5×10^{-3} g.

Step 4. Molar mass:

$$M = \frac{4.5 \times 10^{-3}}{1.384 \times 10^{-4}} = 32.5 \text{ g/mol}$$

Step 5. To the nearest integer this is 33 g/mol (close to methanol, 32 g/mol).

Answer: 33

COMMON TRAPS

- **Leaving the mass in milligrams.** With moles of order 10^{-4} , the mass must be in grams (4.5×10^{-3} g) to give g/mol. *Avoid it:* Convert mg to g and mL to L before dividing.
- **Thinking the alcohol gives hydrogen gas.** With a Grignard reagent the acidic hydrogen of OH is taken by the methyl group, so the gas is methane. *Avoid it:* Write the reaction before counting moles of gas.

REVISE The Zerewitinoff estimation of active hydrogen.

80 Answer: 25

Ref 6650

Medium ~3 min Chemical equations and stoichiometry

QUICK APPROACH Decide which reactant runs out first, then use the combined volume of both solutions.

Find the limiting reagent, then divide the moles of salt by the total volume.

Step 1. Moles of $\text{H}_2\text{SO}_4 = 2 \times 0.2 = 0.4$ mol; moles of $\text{NaOH} = 2 \times 0.1 = 0.2$ mol.

Step 2. $\text{H}_2\text{SO}_4 + 2\text{NaOH} \rightarrow \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}$. The 0.4 mol of acid would need 0.8 mol NaOH , so NaOH is limiting.

Step 3. 0.2 mol NaOH gives $0.2/2 = 0.1$ mol Na_2SO_4 .

Step 4. Total volume = $2 + 2 = 4$ L, so molarity = $0.1/4 = 0.025$ M.

Step 5. $0.025 \text{ M} = 25$ millimolar.

Answer: 25

COMMON TRAPS

- **Ignoring the 1 : 2 ratio.** One mole of Na_2SO_4 needs two moles of NaOH , so 0.2 mol NaOH gives only 0.1 mol salt. *Avoid it:* Use the balanced equation to find the limiting reagent.
- **Using the volume of one solution.** After mixing, the salt is spread over 4 L, not 2 L. *Avoid it:* Add the volumes before finding molarity.

REVISE Limiting reagent and molarity after mixing.

81 Answer: 4

Ref 6655

Medium ~3 min

Use $PV = \frac{m}{M}RT$ and solve for M.

$$\text{Step 1. } M = \frac{mRT}{PV}.$$

$$\text{Step 2. } T = 27 + 273 = 300 \text{ K.}$$

$$\text{Step 3. } M = \frac{100 \times 0.083 \times 300}{1.5 \times 416} = \frac{2490}{624} = 3.99 \text{ g mol}^{-1}.$$

Step 4. To the nearest integer, the molar mass is 4 g mol^{-1} , which fits helium.

Step 5. Check the units: L bar in the denominator cancels L bar in R, and K cancels, leaving g mol^{-1} .

Answer: 4

82 Answer: 1

Ref 6676

Easy ~1 min Chemical Compounds

Write the formula of each compound and look for the CO_3^{2-} ion.

Step 1. Baking soda is sodium hydrogen carbonate, NaHCO_3 . It contains the hydrogen carbonate ion HCO_3^- , not the carbonate ion.

Step 2. Caustic soda is sodium hydroxide, NaOH . It contains Na^+ and OH^- and has no carbon at all.

Step 3. Washing soda is sodium carbonate decahydrate, $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$. It contains the carbonate ion CO_3^{2-} .

Step 4. Only washing soda contains the carbonate anion.

Answer: (1) Washing Soda only

COMMON TRAPS

- **Counting baking soda as a carbonate.** Baking soda is NaHCO_3 , which has the hydrogen carbonate ion HCO_3^- , not CO_3^{2-} . *Avoid it:* Write each formula and look for the exact ion asked.
- **Counting caustic soda because of the word soda.** Caustic soda is NaOH , which has no carbon at all. *Avoid it:* Do not judge composition from a common name.

REVISE Common names and formulas of sodium compounds.

83 Answer: 1655

Ref 6679

Medium ~4 min Mole concept, Chemical equations and stoichiometry

QUICK APPROACH Put the bursting pressure into $PV = nRT$ with every quantity in SI units, then convert the temperature to $^\circ\text{C}$.

The flask bursts when the gas pressure reaches 2 MPa, so solve the ideal gas equation for the temperature at that pressure.

Step 1. Molar mass of propane, C_3H_8 , is $3(12) + 8(1) = 44 \text{ g/mol}$, so $n = \frac{11}{44} = 0.25 \text{ mol}$.

Step 2. In SI units: $P = 2 \times 10^6 \text{ Pa}$ and $V = 2 \text{ dm}^3 = 2 \times 10^{-3} \text{ m}^3$.

Step 3. From $PV = nRT$:

$$T = \frac{PV}{nR} = \frac{2 \times 10^6 \times 2 \times 10^{-3}}{0.25 \times 8.3} = \frac{4000}{2.075} = 1927.7 \text{ K}$$

Step 4. In degrees Celsius: $1927.7 - 273 = 1654.7$, which rounds to 1655.

Answer: 1655

COMMON TRAPS

- **Mixing units.** With $R = 8.3 \text{ J/(K mol)}$, pressure must be in Pa and volume in m^3 . *Avoid it:* Convert MPa to Pa and dm^3 to m^3 before substituting.
- **Stopping at kelvin.** The blank asks for $^\circ\text{C}$, so 273 must be subtracted from the kelvin value. *Avoid it:* Read the unit of the blank before rounding.

REVISE The ideal gas equation with SI units.

84 Answer: 1

Ref 6730

Medium ~2 min Chemical Properties

QUICK APPROACH Start by understanding the concept of angle of contact and its relationship with wettability and adhesion between liquids and solids.

Step 1: Analyze Assertion (A).

Clothes containing oil or grease stains cannot be cleaned by water wash because oil and grease are non-polar substances and water is polar. Therefore, they do not mix or interact well, making it difficult for water to remove such stains through normal washing.

Step 2: Analyze Reason (R).

The angle of contact between oil/grease and water being obtuse indicates poor wettability and adhesion, which is why water alone cannot dislodge these materials effectively.

Step 3: Correlate Assertion and Reason.

Since the reason given justifies why water wash cannot clean oil or grease stains due to the obtuse angle of contact, both the assertion and reason are true and the reason is the correct explanation.

85 Answer: 5

Ref 6798

Medium ~3 min Mole concept

Find the moles of compound, then count three N atoms per molecule.

Step 1. Molar mass of $\text{C}_7\text{H}_5\text{N}_3\text{O}_6 = 84 + 5 + 42 + 96 = 227 \text{ g mol}^{-1}$.

$$\text{Step 2. Moles} = \frac{681}{227} = 3 \text{ mol.}$$

Step 3. Moles of N atoms = $3 \times 3 = 9 \text{ mol}$.

Step 4. Number of N atoms = $9 \times 6.02 \times 10^{23} = 5.42 \times 10^{24}$.

Step 5. So $x = 5.42$, which is 5 to the nearest integer.

Answer: 5

86 Answer: 2

Ref 6809

Medium ~2 min Detection of anions

Step 1: When BaCl_2 is added to an aqueous solution, a white precipitate of BaSO_3 is formed if sulfate or sulfite ions are present.

Step 2: To distinguish between sulfate and sulfite, dissolve the precipitate in dilute HCl . If a gas with a characteristic odor (sulfur dioxide, SO_2) is released, it indicates the presence of sulfite ions (SO_3^{2-}).

Step 3: The reaction is:



Step 4: SO_2 has a characteristic pungent odor. Hence, the anion present is SO_3^{2-} .

COMMON TRAPS

- **Treating the BaCl_2 white precipitate test as conclusive for sulfate instead of sulfite.** BaSO_4 remains insoluble in dilute HCl and does not liberate SO_2 ; BaSO_3 dissolves in dilute HCl giving SO_2 gas. *Avoid it:* After any BaCl_2 precipitate, always ask: does it dissolve in acid and is any gas evolved? Here "gas X with characteristic odour" points to SO_2 from SO_3^{2-} .
- **Confusing SO_2 pungent smell with H_2S rotten-egg smell.** Sulfite with dilute acid gives SO_2 , which has a pungent choking odour; sulfide gives H_2S with rotten-egg odour. The preceding BaCl_2 white precipitate fits sulfite, not sulfide. *Avoid it:* Attach the smell to the full sequence: BaCl_2 white ppt + dilute HCl gas = sulfite/ SO_2 , not sulfide/ H_2S .

REVISE Confirmatory tests for anions with BaCl_2 followed by dilute HCl . · Memorize gas identity and smell pairs: SO_2 pungent/choking for sulfite, H_2S rotten egg for sulfide, NO_2 brown pungent fumes for nitrite.

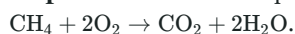
87 Answer: 143

Ref 6818

Medium ~3 min Chemical equations and stoichiometry

Find the limiting reagent first, then use it to get the moles of CO_2 .

Step 1. The combustion equation is



Step 2. Moles of $\text{CH}_4 = 100/16 = 6.25$ mol. Moles of $\text{O}_2 = 208/32 = 6.5$ mol.

Step 3. All the methane would need $2 \times 6.25 = 12.5$ mol of O_2 . Only 6.5 mol is present, so oxygen is the limiting reagent.

Step 4. Two moles of O_2 give one mole of CO_2 , so CO_2 formed = $6.5/2 = 3.25$ mol.

Step 5. Mass of $\text{CO}_2 = 3.25 \times 44 = 143$ g.

Answer: 143

COMMON TRAPS

- **Using methane as the limiting reagent because 100 g looks smaller than 208 g.** Limiting reagent is found by comparing $n/\text{coefficient}$: CH_4 : $6.25/1 = 6.25$; O_2 : $6.5/2 = 3.25$, so O_2 limits. *Avoid it:* Before choosing a limiting reagent, divide each reactant's moles by its balanced-equation coefficient.
- **Treating oxygen as atomic O instead of molecular O_2 .** Combustion uses molecular oxygen O_2 ; the balanced equation contains O_2 , not O. *Avoid it:* Write the actual formula from the balanced equation before assigning molar mass.

REVISE Diatomic elemental gases, especially O_2 molar mass = 32 g/mol. · Practice limiting reagent tests using $n/\text{coefficient}$ rather than comparing masses.

88 Answer: 3

Ref 6858

Medium ~3 min Chemical properties

Step 1: Evaluate Statement I:

Hydrogen peroxide (H_2O_2) is known to act as an oxidizing agent in both acidic and basic conditions. This is due to its ability to release oxygen, thereby oxidizing other compounds. Hence, Statement I is true.

Step 2: Evaluate Statement II:

The density of hydrogen peroxide (H_2O_2) at 298 K is approximately 1.448 g/cm^3 . The density of deuterium oxide (D_2O) is about 1.104 g/cm^3 . Therefore, hydrogen peroxide is denser than deuterium oxide. Hence, Statement II is false.

Conclusion: Statement I is true, but Statement II is false.

89 Answer: 2

Ref 7009

Medium ~2 min Pollutants and Their Effects

QUICK APPROACH Recall which pollutant causes blue baby syndrome and which one marks the teeth.

Each pollutant in drinking water has a known effect above its limit.

Step 1. Sulphate above 500 ppm has a laxative effect: A-III.

Step 2. Nitrate above 50 ppm causes methemoglobinemia, the blue baby syndrome: B-I.

Step 3. Lead above 50 ppb damages the kidneys, liver and nervous system: C-IV.

Step 4. Fluoride above 2 ppm causes brown mottling of teeth: D-II.

Answer: (2) A – III, B – I, C – IV, D – II

COMMON TRAPS

- **Linking blue baby syndrome to sulphate.** Methemoglobinemia is caused by excess nitrate; excess sulphate only has a laxative effect. *Avoid it:* Memorise each drinking-water pollutant with its limit and effect as a set.

REVISE Drinking water standards and their health effects.

90 Answer: 46

Ref 7138

Easy ~3 min Chemical equations and stoichiometry

QUICK APPROACH Use Gay-Lussac's law: gas volumes react in the ratio of the coefficients of the balanced equation.

For gases at the same temperature and pressure, volumes react in the ratio of the coefficients.

Step 1. Reaction: $\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$. One volume of nitrogen gives two volumes of ammonia.

Step 2. Nitrogen used to make 20 L of ammonia = $\frac{20}{2} = 10$ L.

Step 3. Hydrogen is in excess, so the only limit on nitrogen is what reacted. Unused nitrogen:

$$56.0 - 10 = 46 \text{ L}$$

As a check, the 10 L of nitrogen used and the 30 L of hydrogen it needs give exactly 20 L of ammonia, as stated.

Answer: 46

COMMON TRAPS

- **Reading the ratio backwards.** Two volumes of ammonia come from one volume of nitrogen, so 20 L of ammonia uses 10 L, not 40 L. *Avoid it:* Write the balanced equation and place each volume under its formula.
- **Subtracting the ammonia volume.** The nitrogen consumed is 10 L, not the 20 L of ammonia formed. *Avoid it:* Convert the product volume to reactant volume before subtracting.

REVISE Gay-Lussac's law of gaseous volumes.

91 Answer: 3

Ref 7172

Medium ~2 min Mole concept, Chemical equations and stoichiometry

QUICK APPROACH Start by calculating the mass of iron in the given amount of hemoglobin using the percentage composition, then apply the mole concept to find the number of atoms.

Convert the mass percentage into the mass of iron, then count atoms with the mole concept.

Step 1. Mass of Fe = $\frac{0.34}{100} \times 3.3 = 0.01122$ g.

Step 2. Moles of Fe = $\frac{0.01122}{56} = 2.004 \times 10^{-4}$ mol.

Step 3. Number of Fe atoms = $2.004 \times 10^{-4} \times 6.022 \times 10^{23} = 1.21 \times 10^{20}$.

Step 4. The order of magnitude is sensible: only a tiny fraction of the sample is iron.

Answer: (3) 1.21×10^{20}

COMMON TRAPS

- **Using the sample mass as the iron mass.** Only 0.34% of the 3.3 g sample is iron, so the iron mass is $0.34/100 \times 3.3$ g. *Avoid it:* Convert the percentage to a mass before finding moles.
- **Forgetting Avogadro's number.** Moles give atoms only after multiplying by 6.022×10^{23} . *Avoid it:* Write the units at each step so the last step gives atoms.

REVISE The mole concept and percentage composition. · Conversions between mass, moles and particles.

92 Answer: 5

Ref 4840

Medium ~3 min Mole concept, Chemical equations and stoichiometry

QUICK APPROACH Start by applying the ideal gas law $PV = nRT$, converting the given mass to moles and temperature to

Kelvin.

Use $PV = nRT$ with pressure in atm and temperature in kelvin.

Step 1. Molar mass of $\text{C}_2\text{H}_2 = 26 \text{ g mol}^{-1}$, so $n = \frac{4.75}{26} = 0.1827$ mol.

Step 2. $T = 50 + 273 = 323 \text{ K}$ and $P = \frac{740}{760} = 0.9737$ atm.

Step 3. $V = \frac{nRT}{P} = \frac{0.1827 \times 0.0826 \times 323}{0.9737}$.

Step 4. $nRT = 4.874 \text{ L atm}$, so $V = \frac{4.874}{0.9737} = 5.01 \text{ L}$, which is 5 L to the nearest integer.

Answer: 5

93 Answer: 5

Ref 4860

Medium ~2 min Chemical formulas and hydrates

QUICK APPROACH Start by identifying the number of water molecules of crystallization in the chemical formulas of Mohr's salt and potash alum and then use ratio concepts to compare them.

Count the water of crystallisation in each salt, then take the ratio.

Step 1. Mohr's salt is $\text{FeSO}_4 \cdot (\text{NH}_4)_2\text{SO}_4 \cdot 6\text{H}_2\text{O}$, with 6 water molecules.

Step 2. Potash alum is $\text{KAl}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$, with 12 water molecules. Written as $\text{K}_2\text{SO}_4 \cdot \text{Al}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$ it is twice this unit, so the count per $\text{KAl}(\text{SO}_4)_2$ is still 12.

Step 3. Ratio = $\frac{6}{12} = 0.5 = 5 \times 10^{-1}$.

Answer: 5

COMMON TRAPS

- **Using wrong hydrate formula for Mohr's salt.** Mohr's salt is ferrous ammonium sulphate hexahydrate: $(\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$. *Avoid it:* When a named salt is asked, first write the full double-salt formula and circle the coefficient before H_2O .
- **Counting sulphate or ammonium subscripts as water molecules.** The number of water molecules in a hydrate is only the coefficient after the dot, e.g., $\cdot 6\text{H}_2\text{O}$ and $\cdot 12\text{H}_2\text{O}$. *Avoid it:* Ignore all subscripts before the hydration dot when asked for 'number of water molecules'.

REVISE Common hydrated salts and their water of crystallization: Mohr's salt = $6\text{H}_2\text{O}$, potash alum = $12\text{H}_2\text{O}$. · Practice converting ratios/fractions to requested powers of ten before entering integer-type answers.

94 Answer: 8

Ref 4917

Medium ~3 min Chemical equations and stoichiometry

For gases at the same conditions, volumes are in the ratio of moles.

Step 1. $\text{C}_x\text{H}_y + \left(x + \frac{y}{4}\right) \text{O}_2 \rightarrow x \text{CO}_2 + \frac{y}{2} \text{H}_2\text{O}$.

Step 2. One volume gives 4 volumes of CO_2 , so $x = 4$.

Step 3. One volume needs 6 volumes of O_2 , so $x + \frac{y}{4} = 6$, which gives $\frac{y}{4} = 2$.

Step 4. So $y = 8$ and the hydrocarbon is C_4H_8 .

Answer: 8

95 Answer: 3

Ref 4952

Medium ~2 min Chemical Reactions

QUICK APPROACH Recall the uses of heavy water and compare its physical constants with those of ordinary water.

Check each use and property of D_2O against what is known about heavy water.

Step 1. (A) D_2O slows fast neutrons without absorbing many of them, so it is used as a moderator in nuclear reactors. Correct.

Step 2. (B) Heavy water is obtained as a by-product in some fertilizer industries, where hydrogen is made by electrolysis of water. Correct.

Step 3. (C) Deuterium exchange with D_2O is used to trace reaction mechanisms. Correct.

Step 4. (D) The dielectric constant of D_2O (about 78.06) is slightly lower than that of H_2O (about 78.39). The statement is incorrect.

Step 5. Only (D) is incorrect.

Answer: (3) (D) only

COMMON TRAPS

- **Assuming heavy water has larger values for every property.** Heavier D_2O has higher melting and boiling points but a slightly lower dielectric constant. *Avoid it:* Learn the table of H_2O and D_2O properties property by property.
- **Doubting the fertilizer industry origin.** Heavy water is indeed obtained as a by-product in some fertilizer plants. *Avoid it:* Recall how heavy water is obtained, as listed under hydrogen.

REVISE Heavy water: preparation, properties and uses. · Isotopes of hydrogen.

96 Answer: 1

Ref 4968

Medium ~3 min Chemical equations and stoichiometry

In complete combustion, all C from the organic compound forms CO_2 and all H forms H_2O ; O in the compound is determined by mass difference.

Mass of C = $(12/44) \times 2.64 \text{ g} = 0.72 \text{ g}$.

Mass of H = $(2/18) \times 1.08 \text{ g} = 0.12 \text{ g}$.

Mass of C + H = 0.84 g. For 1.80 g of compound $C_xH_yO_z$, mass of O = $1.80 - 0.84 = 0.96 \text{ g}$.

Percentage of oxygen = $(0.96/1.80) \times 100 = 53.33$.

Equivalently, $\%C = (0.72/1.80) \times 100 = 40$, $\%H = (0.12/1.80) \times 100 \approx 6.67$, so $\%O = 100 - 46.67 = 53.33$.

Option 3 (51.63) encodes the specific mistake of incorrect

difference calculation (e.g., wrongly apportioning O from CO_2/H_2O without subtracting external O_2 supply via mass balance, or using H mass as 0.11 g via rounding/atomic mass error). This is a common pitfall students were taught from faulty solutions. The correct difference method confirms 0.96 g O, matching empirical formula CH_2O (O fraction $16/30 = 53.33\%$).

Thus, the answer is option [1] 53.33.

97 Answer: 20

Ref 5049

Medium ~3 min Mole concept

QUICK APPROACH Use the molar mass of the dihydrate, since that is the substance weighed, and divide the moles by the volume in litres.

Molarity is moles of solute per litre of solution; the solute weighed here is the dihydrate.

Step 1. Molar mass of $H_2C_2O_4 \cdot 2H_2O = 2(1) + 2(12) + 4(16) + 2(18) = 126 \text{ g mol}^{-1}$.

Step 2. Moles = $\frac{6.3}{126} = 0.05 \text{ mol}$.

Step 3. Taking the solution volume as 250 mL = 0.25 L, molarity = $\frac{0.05}{0.25} = 0.2 \text{ mol L}^{-1}$.

Step 4. $0.2 = 20 \times 10^{-2}$, so $x = 20$. Had the anhydrous mass of 90 been used, the result would be 28, which shows why the water of crystallisation matters.

Answer: 20

COMMON TRAPS

- **Leaving out the water of crystallisation.** The weighed solid is the dihydrate, molar mass 126, not anhydrous oxalic acid of 90. *Avoid it:* Include water of crystallisation whenever the formula shows it.
- **Not converting mL to L.** Molarity is per litre, so 250 mL must be written as 0.25 L. *Avoid it:* Convert volumes to litres before dividing.

REVISE Molarity and molar mass of hydrated salts. · Preparation of standard solutions.

98 Answer: 2218

Ref 5166

Medium ~3 min Chemical equations and stoichiometry

QUICK APPROACH Find the moles of hydrogen formed from the iron, then use $W = P\Delta V = nRT$ for the gas pushing back the atmosphere.

Work against a constant external pressure is $P\Delta V$, and for an ideal gas formed from nothing $P\Delta V = nRT$.

Step 1. $Fe + 2HCl \rightarrow FeCl_2 + H_2$, so one mole of Fe gives one mole of H_2 .

Step 2. Moles of Fe = $\frac{50}{55.85} = 0.8953 \text{ mol}$, so $n_{H_2} = 0.8953 \text{ mol}$.

Step 3. The gas expands from nearly zero volume against 1 bar, so the work done by the gas is $P\Delta V = nRT$.

Step 4. $nRT = 0.8953 \times 8.314 \times 298 = 2218 \text{ J}$.

Answer: 2218

COMMON TRAPS

- **Using an approximate atomic mass of iron.** With Fe = 56 the result is 2212 J, but the data give 55.85 u. *Avoid it:* Use the atomic mass supplied in the question.
- **Using the Celsius temperature.** 25°C must be written as 298 K in nRT . *Avoid it:* Convert every temperature to kelvin before using gas laws.

REVISE Work done in irreversible expansion. · Stoichiometry of metal and acid reactions.

99 Answer: 226

Ref 5168

Medium ~3 min Mole concept

QUICK APPROACH Use the concept of limiting reactant in a titration and calculate moles of each reactant first to find unreacted quantity after the reaction.

NaOH and HCl react 1 : 1, so find the HCl left over.

Step 1. Moles of HCl = $0.5 \text{ L} \times 1 \text{ M} = 0.5 \text{ mol}$.

Step 2. Moles of NaOH = $0.25 \text{ L} \times 0.5 \text{ M} = 0.125 \text{ mol}$.

Step 3. $\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O}$, so 0.125 mol of HCl reacts and $0.5 - 0.125 = 0.375 \text{ mol}$ is left.

Step 4. Molecules left = $0.375 \times 6.022 \times 10^{23} = 2.258 \times 10^{23} = 225.8 \times 10^{21}$.

Step 5. To the nearest integer, $p = 226$.

Answer: 226

COMMON TRAPS

- **Subtracting volumes instead of moles.** The two solutions have different molarities, so compare 0.5 mol of HCl with 0.125 mol of NaOH. *Avoid it:* Convert each solution to moles before deciding what is left.
- **Writing the answer with the wrong power of ten.** 2.258×10^{23} written as $p \times 10^{21}$ gives $p = 225.8$. *Avoid it:* Shift the decimal point by the difference in powers of ten.

REVISE Limiting reagent in acid-base mixing.

100 Answer: 1

Ref 5272

Medium ~2 min

QUICK APPROACH Start by applying the Ideal Gas Law ($PV = nRT$) to find the number of moles of chlorine gas in 20 mL at STP.

Find the moles of Cl_2 from $PV = nRT$, then count two atoms per molecule.

Step 1. At STP, $P = 1 \text{ bar}$ and $T = 273 \text{ K}$. $V = 20 \text{ mL} = 0.020 \text{ L}$.

Step 2. $n = \frac{PV}{RT} = \frac{1 \times 0.020}{0.083 \times 273} = \frac{0.020}{22.66} = 8.83 \times 10^{-4} \text{ mol}$.

Step 3. Molecules = $8.83 \times 10^{-4} \times 6.023 \times 10^{23} = 5.32 \times 10^{20}$.

Step 4. Atoms = $2 \times 5.32 \times 10^{20} = 1.06 \times 10^{21}$, which is 1 to the nearest integer.

Answer: 1

101 Answer: 4

Ref 5280

Medium ~1 min Properties of Solids

Covalent solids, also known as network solids, are characterized by a network of covalent bonds extending in three dimensions throughout the solid. This leads to a hard and rigid structure. These solids have high melting points due to the strength of the covalent bonds. They act as insulators in both solid and molten states because the electrons are localized within the bonds and there are no free carriers for conduction.

COMMON TRAPS

- **Confusing “insulator in molten state” with the usual property of ionic solids.** Ionic solids are insulators in the solid state, but conduct electricity in the molten state because ions become mobile. The phrase “in both solid and in molten state” rules out option 1 / A. *Avoid it:* For every property listed in the stem, make a tick/cross table: hard, high melting point, solid-state insulator, molten-state insulator. Ionic gets crossed at molten-state insulator.
- **Overgeneralizing “hard substance” to ionic or metallic solids.** Hardness alone cannot identify the solid type. Covalent network solids like diamond and SiC are very hard; many metals are malleable rather than simply hard, and some metals are soft. *Avoid it:* Do not decide from the first adjective. Underline all three clues in the exact stem: “hard”, “melts at high temperature”, and “insulator in both solid and in molten state.” The last clue is the most discriminating one.

REVISE A four-type property table for ionic, molecular, metallic, and covalent/network solids with columns for hardness, melting point, solid conductivity, and molten conductivity. · Memorize the discriminating conductivity rule: ionic = non-conducting solid but conducting molten; metallic = conducting solid and molten; molecular = usually insulating but soft/low melting; covalent network = hard/high melting and usually insulating.

102 Answer: 19

Ref 5296

Medium ~5 min Chemical equations and stoichiometry

Correct the nitrogen volume to dry gas at STP, then find its mass.

Step 1. Pressure of dry $\text{N}_2 = 758 - 14 = 744 \text{ mm Hg}$.

Step 2. Volume at STP: $V = \frac{744 \times 30 \times 273}{287 \times 760} = 27.94 \text{ mL}$.

Step 3. Mass of $\text{N}_2 = \frac{28}{22400} \times 27.94 = 0.0349 \text{ g}$.

Step 4. Percentage of N = $\frac{0.0349}{0.1840} \times 100 = 18.98\%$, which is 19 to the nearest integer.

Answer: 19

COMMON TRAPS

- **Ignoring aqueous tension.** The gas is collected over water, so the pressure of nitrogen alone is $758 - 14 = 744$ mm Hg. *Avoid it:* Subtract the aqueous tension before using the gas equation.
- **Using 14 g for a mole of nitrogen gas.** Nitrogen is collected as N_2 , so 22400 mL at STP has 28 g. *Avoid it:* Use the molar mass of the gas as it is collected.

REVISE Dumas method calculations with aqueous tension.

103 Answer: 19

Ref 5312

Medium ~3 min Chemical equations and stoichiometry

QUICK APPROACH Find what fraction of the mass of AgCl is chlorine, then compare that chlorine with the mass of compound A taken.

In the Carius method all the chlorine of the sample ends up in the silver chloride precipitate, so the chlorine in the precipitate is the chlorine in the sample.

Step 1. Molar mass of AgCl = $107.87 + 35.5 = 143.37$ g/mol.

Step 2. Mass of chlorine in the precipitate:

$$m_{Cl} = 0.3849 \times \frac{35.5}{143.37} = 0.0953 \text{ g}$$

Step 3. This chlorine came from 0.5 g of compound A:

$$\% Cl = \frac{0.0953}{0.5} \times 100 = 19.06\%$$

Step 4. The 5.0 g of chlorine used to make compound A plays no part: only the mass of A taken and the mass of AgCl formed matter. Rounded to the nearest integer, the percentage is 19.

Answer: 19

COMMON TRAPS

- **Using the chlorine used in the reaction.** The 5.0 g of chlorine used for chlorination is not the chlorine present in the 0.5 g sample analysed. *Avoid it:* Use only the mass of sample taken and the mass of AgCl it gives.
- **Dividing by the molar mass of Ag.** The chlorine fraction of AgCl is 35.5 out of 143.37, not 35.5 out of 107.87. *Avoid it:* Write the full formula mass of the precipitate before taking the element's share.

REVISE The Carius method for halogen estimation.

104 Answer: 150

Ref 5388

Medium ~3 min Mole concept

Add the moles of the two gases and use $PV = nRT$.

Step 1. Moles of $CH_4 = \frac{6.4}{16} = 0.4$ mol. Moles of $CO_2 = \frac{8.8}{44} = 0.2$ mol. Total $n = 0.6$ mol.

Step 2. $T = 300$ K and $V = 10$ L = 0.010 m³.

Step 3. $P = \frac{nRT}{V} = \frac{0.6 \times 8.314 \times 300}{0.010} = 1.497 \times 10^5$ Pa.

Step 4. This is 149.7 kPa, which is 150 kPa to the nearest integer.

Answer: 150

COMMON TRAPS

- **Mixing litres with the SI value of R.** With $R = 8.314$ J mol⁻¹ K⁻¹, volume must be in m³ to get pressure in Pa. *Avoid it:* Convert 10 L to 0.010 m³, or use 1 J = 1 kPa L.
- **Adding masses instead of moles.** Pressure depends on the total moles, $0.4 + 0.2 = 0.6$ mol, not on the total mass. *Avoid it:* Convert each gas to moles before using the gas equation.

REVISE The ideal gas equation in SI units.

105 Answer: 464

Ref 5413

Medium ~3 min Chemical equations and stoichiometry

QUICK APPROACH Start by writing the balanced chemical equation for the complete combustion of butane and use stoichiometry to relate moles of water produced to moles of butane consumed.

Relate water formed to butane burnt through the balanced equation.

Step 1. $2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$.

Step 2. Moles of water = $\frac{72.0}{18} = 4.0$ mol.

Step 3. Moles of butane = $\frac{2}{10} \times 4.0 = 0.80$ mol.

Step 4. Mass of butane = $0.80 \times 58 = 46.4$ g = 464×10^{-1} g.

Step 5. Check: 0.8 mol of butane has $0.8 \times 10 = 8$ mol of H atoms, which make 4 mol of water, as given.

Answer: 464

106 Answer: 18

Ref 5548

Medium ~3 min Mole concept

QUICK APPROACH Find moles of ethane, use the 1 : 3 ratio of ethane to water, and write the answer as a multiple of 10^{22} .

Use the balanced combustion equation to get moles of water, then multiply by Avogadro's number.

Step 1. Molar mass of $C_2H_6 = 2 \times 12 + 6 \times 1 = 30$ g mol⁻¹, so 3 g is 0.1 mol.

Step 2. $C_2H_6 + \frac{7}{2}O_2 \rightarrow 2CO_2 + 3H_2O$, so 1 mol ethane gives 3 mol water.

Step 3. Water formed = $0.1 \times 3 = 0.3$ mol.

Step 4. Molecules = $0.3 \times 6.023 \times 10^{23} = 1.807 \times 10^{23} = 18.07 \times 10^{22}$.

Step 5. So $x = 18.07$, which rounds to 18.

Answer: 18

COMMON TRAPS

- **Using the wrong power of ten.** The answer must be expressed as $x \times 10^{22}$, so 1.807×10^{23} becomes 18.07×10^{22} . *Avoid it:* Match the power of ten in the question before rounding.
- **Taking one water per ethane.** Each ethane has six hydrogens, which form three water molecules. *Avoid it:* Balance hydrogen first when writing a combustion equation.

REVISE Mole concept with balanced equations.

107 Answer: 2

Ref 5654

Medium ~1.5 min Mole concept

Convert mass to moles, then multiply by Avogadro's number.

Step 1. Moles of Na = $\frac{8}{23} = 0.348$ mol.

Step 2. Atoms = $0.348 \times 6.02 \times 10^{23} = 2.09 \times 10^{23}$.

Step 3. So $x = 2.09$, which is 2 to the nearest integer.

Step 4. Check the size: 8 g is about a third of the 23 g in one mole, so the count should be about a third of 6.02×10^{23} , which it is.

Answer: 2

108 Answer: 4

Ref 5862

Easy ~0.5 min

Step 1: Understand the relationship between temperature and gas solubility. Generally, the solubility of gases in water decreases with increasing temperature.

Step 2: Compare the conditions given:

- Boiling water: At boiling point, the solubility of gases like O_2 is minimal.
- Water at 80°C : Similar high temperature, less O_2 solubility.
- Polluted water: 'Polluted' is a qualitative term and doesn't specify temperature, but generally solubility is lower if temperature is assumed higher.
- Water at 4°C : At lower temperatures, the solubility of gases increases.

Step 3: Conclude that water at 4°C has the highest dissolved O_2 content.

Hence, option 4 is correct.

109 Answer: C

Ref 5864

Medium ~3 min

Total pressure depends on the total moles of gas.

Step 1. Moles of $O_2 = \frac{16}{32} = 0.5$ mol.

Step 2. Moles of $N_2 = \frac{28}{28} = 1$ mol and moles of $CO_2 = \frac{44}{44} = 1$ mol.

Step 3. Total $n = 0.5 + 1 + 1 = 2.5$ mol.

Step 4. $P = \frac{nRT}{V} = \frac{5RT}{2V}$.

Step 5. Taking all three masses as one mole each would give

$3\frac{RT}{V}$, but 16 g of O_2 is only half a mole.

Answer: (C) $\frac{5RT}{2V}$

COMMON TRAPS

- **Counting gases instead of moles.** In $PV = nRT$, n is total moles, not number of components. Here $n_{total} = 16/32 + 28/28 + 44/44 = 2.5$ mol. *Avoid it:* Before applying $PV = nRT$, write a separate mole calculation for each gas mass.
- **Using atomic masses for diatomic gases.** Oxygen gas is O_2 with molar mass 32 g/mol; nitrogen gas is N_2 with molar mass 28 g/mol. *Avoid it:* For elemental gases, ask whether they are diatomic under normal molecular form: O_2 , N_2 , H_2 , Cl_2 , etc.

REVISE Molar masses of common molecular gases: O_2 , N_2 , CO_2 . Practice Dalton's law problems where masses, not moles, are given.

110 Answer: 1

Ref 6033

Medium ~4 min

QUICK APPROACH Start by using the ideal gas equation to find the total number of moles in the gas mixture and set up equations based on total moles and total mass of hydrogen and oxygen.

Find the total moles from $PV = nRT$, then split them using the total mass.

Step 1. $P = 4 \times 10^5$ Pa, $V = 5 \times 10^{-4}$ m³, so $PV = 200$ J.
 $RT = 8.314 \times 300 = 2494$ J mol⁻¹, so $n = 0.08$ mol.

Step 2. Let x mol be H_2 and y mol be O_2 . Then $x + y = 0.08$ and $2x + 32y = 0.76$.

Step 3. From the second, $x + 16y = 0.38$. Subtracting the first gives $15y = 0.30$, so $y = 0.02$ and $x = 0.06$.

Step 4. Mass of $O_2 = 0.64$ g and mass of $H_2 = 0.12$ g, so the ratio is $0.64 : 0.12 = 16 : 3$.

Answer: (1) 16 : 3

COMMON TRAPS

- **Using atomic masses for the gases.** Hydrogen and oxygen are diatomic, so their molar masses are 2 and 32 g mol⁻¹, not 1 and 16. *Avoid it:* Write the molecular formula of each gas before its molar mass.
- **Mixing cm³ and kPa with the SI value of R.** $500 \text{ cm}^3 = 5 \times 10^{-4} \text{ m}^3$ and $400 \text{ kPa} = 4 \times 10^5 \text{ Pa}$ when $R = 8.314$. *Avoid it:* Put every quantity in SI units before using $PV = nRT$.

REVISE Gas mixture problems using total moles and mass.

111 Answer: 10

Ref 3571

Easy ~1 min Mole concept, Chemical equations, Stoichiometry

With normalities given, equal equivalents of acid and base react.

Step 1. Phosphinic acid is H_3PO_2 , with structure $H_2P(=O)OH$. Only the H on oxygen is acidic, so it is monobasic.

Step 2. Normality already counts the replaceable H, so use $N_1V_1 = N_2V_2$.

Step 3. $0.1 \times 10 = 0.1 \times V_2$, so $V_2 = 10$ mL.

Step 4. Treating it like H_3PO_4 with three acidic H atoms would give a wrong, larger volume.

Answer: 10

112 Answer: D

Ref 3578

Medium ~3 min Acid Rain

QUICK APPROACH List what acid rain does to metals, carbonate stone, living organisms and soil, then pick the statements that deny these effects.

Acid rain contains sulphuric and nitric acids, so it attacks metals, carbonate stone, living tissue and soil.

Step 1. (a) The acids react with metal pipes and corrode them. Correct statement.

Step 2. (b) Marble and limestone are calcium carbonate, which the acids dissolve:
 $CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + H_2O + CO_2$. Correct statement.

Step 3. (c) The acidic oxides and aerosols that form acid rain irritate the respiratory tract and cause ailments in animals and people. The statement is incorrect.

Step 4. (d) Acid rain leaches nutrients from soil and damages leaves, so it harms trees and forests. The statement is incorrect.

Step 5. The incorrect statements are (c) and (d).

Answer: (D) (c) and (d)

COMMON TRAPS

- **Choosing the correct statements instead of the incorrect ones.** The question asks for the incorrect statements, and here the false ones are the negative claims. *Avoid it:* Underline the word incorrect before marking any statement.
- **Thinking acid rain affects only buildings.** Acid rain also harms soil, plants and the respiratory system. *Avoid it:* Recall effects on living things as well as on materials.

REVISE Acid rain: causes and effects. · Atmospheric pollution in environmental chemistry.

113 Answer: 18

Ref 3621

Medium ~2 min Chemical equations and stoichiometry

QUICK APPROACH Identify the red vapour of the chloride test, what it gives in alkali, and the blue compound formed with acidified hydrogen peroxide.

This is the chromyl chloride test for chloride followed by the peroxide test for chromate.

Step 1. Chloride with dichromate and concentrated sulphuric acid gives red vapours of chromyl chloride: (A) is CrO_2Cl_2 , with $1 + 2 + 2 = 5$ atoms.

Step 2. Chromyl chloride in NaOH gives yellow sodium chromate: $CrO_2Cl_2 + 4NaOH \rightarrow Na_2CrO_4 + 2NaCl + 2H_2O$. (B) is Na_2CrO_4 , with $2 + 1 + 4 = 7$ atoms.

Step 3. Acidified chromate with H_2O_2 gives blue chromium pentoxide, (C) = CrO_5 , which has one $Cr=O$ and two peroxo groups. It has $1 + 5 = 6$ atoms.

Step 4. Total = $5 + 7 + 6 = 18$.

Answer: 18

COMMON TRAPS

- **Taking (A) as chlorine gas.** With dichromate and concentrated acid, chloride gives chromyl chloride, not free chlorine. *Avoid it:* Link the red-brown vapour with CrO_2Cl_2 .
- **Writing the blue compound as a dichromate.** Acidified chromate with H_2O_2 gives the peroxo compound CrO_5 . *Avoid it:* Remember the deep blue colour belongs to CrO_5 .

REVISE The chromyl chloride test for chloride ions. · Compounds of chromium and their colours.

114 Answer: 4

Ref 3623

Easy ~1 min Chemical equations and stoichiometry

Step 1: During a typical acid-base titration involving HCl and NaOH, the essential apparatus includes items that can measure, deliver, and indicate the endpoint of the titration.

Step 2: Required apparatus:

- A pipette to accurately measure and transfer a specific volume of NaOH.
- A burette to dispense HCl solution accurately and control the volume delivered.
- Phenolphthalein as an indicator to determine the endpoint of the titration by color change.
- A porcelain tile can be used to observe the color change against a white background.

Step 3: Items not required:

- A Bunsen burner is not needed as no heating is involved in the reaction.
- A measuring cylinder, while useful for approximate volume measurements, is not suitable for the precise measurements required in titrations.

Conclusion: The items not required are Bunsen burner and measuring cylinder, making option 4 the correct answer.

115 Answer: C

Ref 3652

Easy ~1 min Dalton's theory, Mole concept

Neutrons equal mass number minus atomic number, and hydrogen has $Z = 1$.

Step 1. Protium, ${}^1_1H$: neutrons = $1 - 1 = 0$.

Step 2. Deuterium, ${}^2_1H$: neutrons = $2 - 1 = 1$.

Step 3. Tritium, ${}^3_1H$: neutrons = $3 - 1 = 2$.

Step 4. Total = $0 + 1 + 2 = 3$. Protium has no neutron, but it is still one of the three isotopes.

Answer: (C) 3

COMMON TRAPS

- **Taking “three isotopes” to mean the answer is automatically 3.** “Three isotopes” means three species—protium, deuterium, tritium. The neutrons must be calculated separately using “Number of neutrons = Mass number - Atomic number” and then added: $0 + 1 + 2 = 3$. *Avoid it:* Do not select an option just because a number in the question appears in the options. Write the neutron count for each isotope before summing.
- **Assuming protium has one neutron because hydrogen has atomic number 1.** Atomic number 1 means one proton, not one neutron. For protium, neutrons = $1 - 1 = 0$. *Avoid it:* For each isotope, explicitly label A = mass number and Z = atomic number, then compute $N = A - Z$.

REVISE Isotope notation ${}_Z^AX$: A = mass number, Z = atomic number, $N = A - Z$. · Memorize hydrogen isotopes: protium has 0 neutrons, deuterium has 1, tritium has 2.

116 Answer: 50

Ref 3712

Medium ~3 min Chemical equations and stoichiometry

In the Carius method all the bromine ends up as AgBr.

Step 1. Molar mass of AgBr = $108 + 80 = 188 \text{ g mol}^{-1}$, so 188 g of AgBr holds 80 g of Br.

Step 2. Mass of Br in 1.88 g of AgBr = $\frac{80}{188} \times 1.88 = 0.80 \text{ g}$.

Step 3. Percentage of Br = $\frac{0.80}{1.6} \times 100 = 50\%$.

Step 4. A quick check: Br is $\frac{80}{188}$, about 43%, of AgBr, and the mass of AgBr is a little more than the sample mass, so a value near half is sensible.

Answer: 50

COMMON TRAPS

- **Using the mass of AgBr directly as mass of bromine.** Only 80/188 of AgBr's mass is bromine because molar mass AgBr = $108 + 80 = 188 \text{ g mol}^{-1}$. *Avoid it:* Before percentage calculation, always extract analyte mass from precipitate mass using mass fraction of analyte in the precipitate.
- **Wrong molar mass of AgBr.** AgBr has one Ag atom and one Br atom; molar mass = $108 + 80 = 188 \text{ g mol}^{-1}$. *Avoid it:* Write the formula AgBr and add the atomic masses atom-by-atom before substituting into moles = mass/molar mass.

REVISE Gravimetric factor: mass of element = mass of precipitate $\times$ (atomic mass of element / molar mass of precipitate). · Practice final-denominator identification in percentage composition problems.

117 Answer: C

Ref 3775

Easy ~2 min Dalton's theory, Mole concept

QUICK APPROACH Use Dalton's Law of Partial Pressures and apply the ideal gas law to relate partial pressures to the number of moles and given conditions.

At fixed V and T, each gas's partial pressure is proportional to its moles.

Step 1. For any gas in the mixture, $p_i = n_i \frac{RT}{V}$.

Step 2. For H_2 , $n = 1$ and $p = 2 \text{ atm}$, so $\frac{RT}{V} = 2 \text{ atm per mole}$.

Step 3. He and O_2 are also 1 mol each, so each has a partial pressure of 2 atm. Molar mass does not enter.

Step 4. By Dalton's law, $P = 2 + 2 + 2 = 6 \text{ atm}$.

Answer: (C) 6 atm

COMMON TRAPS

- **Treating different gases as having different partial pressures because of molar mass.** For ideal gases in the same volume and temperature, partial pressure is $P_i = n_i RT/V$, so it depends on moles, not molar mass. *Avoid it:* Write $P_i/n_i = RT/V$ for every gas before considering any mass data.
- **Using mole fraction incorrectly as 1/2 or 2/3 instead of 1/3.** Total moles = $1 + 1 + 1 = 3 \text{ mol}$; mole fraction of $\text{H}_2 = 1/3$. *Avoid it:* Make a mole table: $\text{H}_2 = 1$, He = 1, $\text{O}_2 = 1$, total = 3 before applying $P_{\text{H}_2} = x_{\text{H}_2} P_{\text{total}}$.

REVISE Dalton's law: $P_{\text{total}} = \sum P_i$ and $P_i = x_i P_{\text{total}} = n_i RT/V$. · Practice mole fraction calculations for mixtures with monoatomic and diatomic gases.

118 Answer: C

Ref 3836

Medium ~3 min

QUICK APPROACH Apply the concept of adsorption and how gases' pressure changes over time when adsorbed onto a solid like charcoal.

Step 1: Understand that the mixture contains H_2 , O_2 , and CO gases along with charcoal. Charcoal acts as an adsorbent.

Step 2: When gases are in contact with a solid adsorbent like charcoal, they get adsorbed, leading to a decrease in pressure inside the box.

Step 3: Initially, the adsorption rate is high, and a significant decrease in pressure is observed.

Step 4: As time passes, the rate of adsorption slows down as the surface becomes saturated, leading to a leveling off of the pressure decrease.

Step 5: The correct graph representation of this behavior is an exponentially decreasing pressure, which matches option (3).

119 Answer: 2

Ref 3877

Medium ~2 min

QUICK APPROACH Decide which solution is a primary standard and which one has an unknown strength, and where each belongs in a titration.

An accurate result needs a primary standard of known strength measured exactly, and the solution of unknown strength delivered from the burette.

Step 1. NaOH absorbs moisture and carbon dioxide from air, so its strength is not known from its mass. It must be standardised.

Step 2. Oxalic acid is a primary standard: it can be weighed accurately and its solution is stable. A known volume of it is taken in the conical flask.

Step 3. NaOH, whose strength is unknown, is run in from the burette until the indicator changes colour.

Step 4. Concentrated H_2SO_4 is not a primary standard and gives large heat on dilution, so options with it are not

accurate. A volumetric flask cannot deliver a titre.

Answer: (2) Aq. NaOH in a burette and aqueous oxalic acid in a conical flask

COMMON TRAPS

- **Using concentrated sulphuric acid as the standard.** Concentrated H_2SO_4 absorbs water and its strength is not exactly known. *Avoid it:* Choose a primary standard such as oxalic acid for standardising a base.
- **Placing the standard in the burette and the unknown in the flask.** The known standard is measured into the flask and the unknown is titrated against it. *Avoid it:* Keep the solution of unknown strength in the burette.

REVISE Primary and secondary standards in volumetric analysis. · Acid-base titration technique.

120 Answer: A

Ref 3880

Easy ~1 min Chemical equations and stoichiometry

Hardness in ppm of CaCO_3 is the mass of CaCO_3 , in mg, equivalent to the hardness salt in 1 L of water.

Step 1. One mole of MgSO_4 gives one mole of Mg^{2+} , which is equivalent to one mole of CaCO_3 (both are divalent).

Step 2. A 10^{-3} M solution has 10^{-3} mol of MgSO_4 per litre. This equals 10^{-3} mol of CaCO_3 per litre.

Step 3. Mass of $\text{CaCO}_3 = 10^{-3} \times 100 = 0.1 \text{ g} = 100 \text{ mg}$ per litre.

Step 4. One litre of dilute solution has a mass of about 10^6 mg, so 100 mg per litre is 100 ppm.

Answer: (A) 100

121 Answer: 25

Ref 3907

Medium ~2 min Mole concept, Chemical equations and stoichiometry

QUICK APPROACH Start by using Avogadro's number to find the moles present in 10 g of the substance, then use that to determine the molar mass before calculating molarity with the given mass and volume.

Use the molecule count to find the molar mass of x, then the molarity.

Step 1. Moles in 10 g = $\frac{6.023 \times 10^{22}}{6.023 \times 10^{23}} = 0.1 \text{ mol}$.

Step 2. Molar mass of x = $\frac{10}{0.1} = 100 \text{ g mol}^{-1}$.

Step 3. 5 g of x is $\frac{5}{100} = 0.05 \text{ mol}$.

Step 4. Molarity = $\frac{0.05}{2} = 0.025 \text{ M} = 25 \times 10^{-3} \text{ M}$.

Step 5. To write 0.025 as a multiple of 10^{-3} , multiply by 1000: the coefficient is 25. Forgetting to divide by the 2 L would give 50 instead.

Answer: 25

122 Answer: D

Ref 3909

Easy ~3 min Mole concept

Step 1: Let the ratio of ^{35}Cl to ^{37}Cl be x:1. The average molar mass is calculated using:

$$\text{Av. molar mass} = \frac{n_1 M_1 + n_2 M_2}{n_1 + n_2}$$

where n_1 and n_2 are the numbers of moles of ^{35}Cl and ^{37}Cl , and M_1 and M_2 are their molar masses (35 g/mol and 37 g/mol, respectively).

Step 2: Substituting the given average molar mass of 35.5 g/mol:

$$35.5 = \frac{x \times 35 + 1 \times 37}{x + 1}$$

Step 3: Simplifying the equation:

$$35.5(x + 1) = 35x + 37$$

$$35.5x + 35.5 = 35x + 37$$

$$0.5x = 1.5$$

$$x = 3$$

Step 4: Therefore, the ratio of ^{35}Cl to ^{37}Cl is 3:1.

COMMON TRAPS

- **Treating the average as a simple 1:1 mean.** The equation must be a weighted average: "Av. molar mass = $(n_1 M_1 + n_2 M_2)/(n_1 + n_2)$ ". Since 35.5 is closer to 35 than 37, ^{35}Cl must be more abundant. *Avoid it:* Before solving, compare the given average with the two isotope masses: 35.5 is only 0.5 above 35 but 1.5 below 37, so the lighter isotope should be about 3 times more abundant.
- **Reversing the requested ratio order.** The asked order is explicitly $^{35}\text{Cl} : ^{37}\text{Cl}$. In the solution, "Let the ratio of ^{35}Cl to ^{37}Cl be x:1" means x multiplies 35, not 37. *Avoid it:* Write labels under the ratio: $^{35}\text{Cl} : ^{37}\text{Cl} = x : 1$, then write the numerator as $x \times 35 + 1 \times 37$.

REVISE Weighted average as total mass divided by total moles, not simple averaging. · For isotope-ratio questions, label coefficients with isotope symbols before substitution.

123 Answer: 2.13 kg

Ref 4040

Medium ~3 min Chemical equations and stoichiometry

Step 1: According to the ideal gas law, $PV = nRT$, where n is the number of moles, P is pressure, V is volume, R is the gas constant, and T is temperature.

Step 2: First, calculate the moles of O_2 using the given parameters:

- $P = 1 \text{ atm}$
- $V = 492 \text{ L}$
- $T = 300 \text{ K}$
- $R = 0.082 \text{ L atm mol}^{-1} \text{ K}^{-1}$

Using the formula: $n = PV/RT = (1 \times 492) / (0.082 \times 300) = 20 \text{ mol}$

Step 3: From the balanced chemical equation, 1 mole of

NaClO_3 produces 1 mole of O_2 .

- Therefore, 20 moles of NaClO_3 are required to produce 20 moles of O_2 .

Step 4: Calculate the mass of NaClO_3 :

- Molar mass of $\text{NaClO}_3 \approx 106.5 \text{ g/mol}$
- Total mass = $20 \text{ mol} \times 106.5 \text{ g/mol} = 2130 \text{ g}$
- Convert to kg: $2130 \text{ g} = 2.13 \text{ kg}$

Thus, the mass of NaClO_3 required is 2.13 kg.

COMMON TRAPS

- **Using 22.4 L per mole at 300 K.** The gas is at 300 K, not 273 K, so the moles must come from $n = \frac{PV}{RT} = \frac{0.082 \times 300}{492} = 20 \text{ mol}$. *Avoid it:* Use 22.4 L mol^{-1} only when the conditions are STP.
- **Leaving the mass in grams.** 20 mol of NaClO_3 is $20 \times 106.5 = 2130 \text{ g}$, which must be written as 2.13 kg. *Avoid it:* Check the unit the question asks for before writing the answer.

REVISE The ideal gas equation with consistent units. · Checking atom balance before using mole ratios.

124 Answer: C

Ref 4074

Easy ~3 min Mole concept

Percentage of N is the mass of N in one mole over the molar mass.

Step 1. Histamine is $\text{C}_5\text{H}_9\text{N}_3$.

Step 2. Molar mass = $5(12) + 9(1) + 3(14) = 60 + 9 + 42 = 111 \text{ g mol}^{-1}$.

Step 3. Mass of N per mole = $3 \times 14 = 42 \text{ g}$.

Step 4. Percentage of N = $\frac{42}{111} \times 100 = 37.84\%$.

Step 5. Nitrogen is heavy compared with hydrogen and there are three N atoms, so a value well above a third is reasonable.

Answer: (C) 37.84%

COMMON TRAPS

- **Using the wrong molecular formula for histamine.** For this question, histamine must be treated as $\text{C}_5\text{H}_9\text{N}_3$: 5 C atoms, 9 H atoms, and 3 N atoms. *Avoid it:* Before calculating, write the molecular formula explicitly and count C, H, N atoms from it; do not start percentage calculation from memory of a related biomolecule.
- **Counting only one nitrogen atom instead of three.** In one mole of $\text{C}_5\text{H}_9\text{N}_3$, there are 3 moles of nitrogen atoms, so nitrogen mass is $3 \times 14 = 42 \text{ g}$, not 14 g. *Avoid it:* Circle the subscript in N_3 and multiply atomic mass by it before forming the percentage fraction.

REVISE Percentage composition as “mass of element in 1 mole / molar mass of compound $\times 100$ ”. · Memorize or derive the formula of histamine separately from histidine to avoid formula confusion.

125 Answer: 1

Ref 4082

Medium ~3 min Chemical equations and stoichiometry

Step 1: When NaOH reacts with Cl_2 under hot and concentrated conditions, the products are NaCl , NaClO_3 , and H_2O . This happens because Cl_2 undergoes

disproportionation.

Step 2: The reaction is: $6\text{NaOH} + 3\text{Cl}_2 \rightarrow 5\text{NaCl} + \text{NaClO}_3 + 3\text{H}_2\text{O}$.

Step 3: For $\text{Ca}(\text{OH})_2$ and Cl_2 under cold and dilute conditions, the main products are $\text{Ca}(\text{OCl})_2$ and CaCl_2 . Again, Cl_2 undergoes disproportionation.

Step 4: The reaction is: $2\text{Ca}(\text{OH})_2 + \text{Cl}_2 \rightarrow \text{Ca}(\text{OCl})_2 + \text{CaCl}_2 + \text{H}_2\text{O}$.

Thus, the correct pair (A & B) is NaClO_3 and $\text{Ca}(\text{OCl})_2$.

126 Answer: A

Ref 4092

Medium ~2 min Mole concept

QUICK APPROACH Start by calculating the moles of urea and use the stoichiometry of the reaction to find moles of NH_3 ; then apply the concept of normality to find the equivalent moles of HCl required to neutralize that NH_3 .

Each urea molecule gives two molecules of ammonia, and each ammonia takes one HCl .

Step 1. Moles of urea = $\frac{0.6}{60} = 0.01 \text{ mol}$.

Step 2. $\text{NH}_2\text{CONH}_2 + 2\text{NaOH} \rightarrow \text{Na}_2\text{CO}_3 + 2\text{NH}_3$, so NH_3 formed = 0.02 mol.

Step 3. $\text{NH}_3 + \text{HCl} \rightarrow \text{NH}_4\text{Cl}$, so 0.02 mol, or 0.02 equivalents, of HCl is needed.

Step 4. Check the options: 100 mL of 0.2 N HCl has $0.2 \times 0.1 = 0.02$ equivalents. The others give 0.08, 0.01 and 0.04.

Answer: (A) 100 mL of 0.2 N HCl

COMMON TRAPS

- **Taking one ammonia per urea.** Urea has two NH_2 groups, so 1 mol of urea releases 2 mol of NH_3 . *Avoid it:* Write the balanced reaction of urea with NaOH before using the ratio.
- **Multiplying normality by mL.** Equivalents = $N \times V$ with V in litres, so 100 mL of 0.2 N is 0.02 equivalents. *Avoid it:* Convert every volume to litres before multiplying by normality.

REVISE Estimation of nitrogen as ammonia. · Equivalents with normality and volume.

127 Answer: A

Ref 4205

Medium ~1 min

Very pure hydrogen needs an electrolysis that gives no other gas at the cathode and no impurity from the electrolyte.

Step 1. Electrolysis of warm aqueous $\text{Ba}(\text{OH})_2$ with nickel electrodes gives hydrogen purer than 99.95%.

Step 2. Zn with dilute HCl gives hydrogen mixed with acid spray and other impurities, so it is a laboratory method only.

Step 3. Electrolysis of brine gives hydrogen as a by-product along with chlorine, so it is not the source of the purest gas.

Step 4. Acidified water with Pt electrodes gives hydrogen,

but the hydroxide route with Ni electrodes is the one used for the highest purity.

Answer: (A) The electrolysis of warm $\text{Ba}(\text{OH})_2$ solution using Ni electrodes.

COMMON TRAPS

- **Treating any electrolysis of water as the purest route.** Many methods give hydrogen, but warm $\text{Ba}(\text{OH})_2$ with Ni electrodes is the one for purity above 99.95%. *Avoid it:* Match the electrolyte and the electrodes in the option, not just the word electrolysis.
- **Choosing brine electrolysis.** Brine electrolysis makes NaOH and chlorine, with hydrogen as a by-product, so it is not the high-purity method. *Avoid it:* Ask what else forms in the cell before calling a method pure.

REVISE The methods of preparing dihydrogen and their purity.

128 Answer: 26.92

Ref 4302

Medium ~3 min Mole concept

QUICK APPROACH Start by calculating the moles of the complex compound using its mass and molar mass, then apply stoichiometry based on the balanced chemical equation for the reaction with AgNO_3 .

In $[\text{ML}_6]\text{Cl}_3$ all three chlorides lie outside the coordination sphere, so each formula unit precipitates 3 AgCl .

Step 1. Moles of complex = $\frac{0.3}{267.46} = 1.122 \times 10^{-3}$ mol.

Step 2. The complex ionises as $[\text{ML}_6]\text{Cl}_3 \rightarrow [\text{ML}_6]^{3+} + 3\text{Cl}^-$.
Moles of free $\text{Cl}^- = 3 \times 1.122 \times 10^{-3} = 3.365 \times 10^{-3}$ mol.

Step 3. Each Cl^- reacts with one Ag^+ : $\text{Ag}^+ + \text{Cl}^- \rightarrow \text{AgCl}$.
So moles of AgNO_3 needed = 3.365×10^{-3} mol.

Step 4. Volume = $\frac{3.365 \times 10^{-3}}{0.125} = 2.692 \times 10^{-2}$ L = 26.92 mL.

Answer: 26.92

129 Answer: 10

Ref 4429

Easy ~2 min Concentration Units

QUICK APPROACH Start by calculating the mass of sea water using its density and volume, then apply the definition of ppm as mass of solute per mass of solution multiplied by 10^6 .

ppm by mass is the mass of solute per million parts by mass of solution.

Step 1. Mass of 1 L of sea water = $1000 \text{ cm}^3 \times 1.03 \text{ g cm}^{-3} = 1030 \text{ g}$.

Step 2. Mass of $\text{O}_2 = 10.3 \text{ mg} = 10.3 \times 10^{-3} \text{ g}$.

Step 3. ppm = $\frac{10.3 \times 10^{-3}}{1030} \times 10^6 = 10$.

Step 4. The density matters here: 1 L of sea water has a mass of 1030 g, not 1000 g.

Answer: 10

COMMON TRAPS

- **Taking 1 L of sea water as 1000 g.** Sea water has a density of 1.03 g cm^{-3} , so 1 L has a mass of 1030 g. *Avoid it:* Use the given density to find the mass of the solution.
- **Using the wrong power of ten.** ppm means parts per 10^6 , so multiply the mass ratio by 10^6 . *Avoid it:* Write mg and g in the same unit before forming the ratio.

REVISE Ppm as a mass ratio times a million.

130 Answer: 3

Ref 4447

Medium ~3 min Stoichiometry and Reactions

QUICK APPROACH Follow the reduction of iron oxides by CO and the job of the flux, then ask which reactions would waste iron or need free oxygen.

In the blast furnace iron oxides are reduced by CO and silica is removed by lime as slag.

Step 1. (a) Lime from limestone combines with the silica gangue to form calcium silicate slag. This occurs.

Step 2. (b) In the upper, cooler zone CO reduces Fe_2O_3 partly to Fe_3O_4 . This occurs.

Step 3. (c) FeO is reduced by CO to iron as soon as it forms, and silica is taken up by lime, so iron silicate slag is not formed. This does not occur.

Step 4. (d) FeO does not split into iron and oxygen on heating; the furnace atmosphere is reducing and FeO is reduced by CO or C. This does not occur.

Step 5. The reactions that do not occur are (c) and (d).

Answer: (3) (c) and (d)

COMMON TRAPS

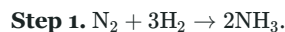
- **Thinking FeO decomposes by heat alone.** Iron oxides are reduced by CO and carbon; they do not lose oxygen on simple heating. *Avoid it:* Look for a reducing agent in every reduction step.
 - **Taking iron silicate as the slag.** The slag in iron extraction is calcium silicate from the lime flux. *Avoid it:* Remember limestone is added to remove silica as CaSiO_3 .
- REVISE** Extraction of iron in the blast furnace. · Roles of flux, slag and reducing agents.

131 Answer: 3400

Ref 4452

Medium ~2 min Chemical equations and stoichiometry

Find the limiting reagent, then use it to find the ammonia formed.



Step 2. Moles of $\text{N}_2 = \frac{2800}{28} = 100$ mol. Moles of $\text{H}_2 = \frac{1000}{2} = 500$ mol.

Step 3. 100 mol of N_2 needs 300 mol of H_2 , and 500 mol is present. So N_2 is the limiting reagent.

Step 4. Moles of $\text{NH}_3 = 2 \times 100 = 200$ mol. Mass = $200 \times 17 = 3400$ g.

Answer: 3400

COMMON TRAPS

- **Using hydrogen to find the product.** Hydrogen is in excess here; the product is fixed by the 100 mol of N_2 . *Avoid it:* Compare each reactant's moles with the ratio 1 to 3 before calculating the product.
- **Giving the answer in kg.** The mass is 3.4 kg, but the question asks for grams, so the value is 3400. *Avoid it:* Convert to the unit asked before writing the answer.

REVISE Limiting reagent problems with masses in kg.**132 Answer: 2**

Ref 4482

Medium ~1 min Dalton's theory

Step 1: Review Dalton's atomic theory which includes postulates like matter is composed of indivisible atoms, atoms of the same element are identical in mass and properties, chemical reactions are rearrangements of atoms.

Step 2: Identify if any choices contravene these postulates.

Step 3: Verify the statement 'Under identical conditions of pressure and temperature gases combine and give gaseous products in simple volume ratio' is related to Gay-Lussac's law of combining volumes, not Dalton's atomic theory.

Conclusion: The correct answer is option 2.

133 Answer: 4.96

Ref 4503

Medium ~3 min Mole concept

QUICK APPROACH Turn 10 ppm into a mass of iron for 100 kg of wheat, then scale by the ratio of the salt's molar mass to the mass of Fe in it.

Find the mass of iron needed, then the mass of $FeSO_4 \cdot 7H_2O$ that carries it.

Step 1. 10 ppm by mass means 10 g of Fe in 10^6 g of wheat.

For 100 kg = 10^5 g of wheat, mass of Fe = $\frac{10 \times 10^5}{10^6} = 1$ g.

Step 2. Molar mass of $FeSO_4 \cdot 7H_2O = 55.85 + 32.00 + 4(16.00) + 7(18.00) = 277.85$ g mol^{-1} , which contains 55.85 g of Fe.

Step 3. Mass of salt = $\frac{277.85}{55.85} \times 1 = 4.97$ g, that is about 4.96 to 4.97 g.

Answer: 4.96

COMMON TRAPS

- **Misreading 10 ppm of iron.** 10 ppm by mass is 10 g per 10^6 g, so 10^5 g of wheat needs only 1 g of Fe. *Avoid it:* Write ppm as a fraction over 10^6 before scaling it to 100 kg.
- **Using the molar mass of anhydrous $FeSO_4$.** The seven waters of crystallisation add 126 g mol^{-1} , so the salt is 277.85 g mol^{-1} , not 151.85 g mol^{-1} . *Avoid it:* Include the water of crystallisation whenever the formula is a hydrate.

REVISE Ppm by mass and molar masses of hydrated salts.**134 Answer: B**

Ref 4522

Medium ~5 min Chemical equations and stoichiometry

Turn the mass ratios into a mole ratio, find the formula, then balance the combustion.

Step 1. C : H = 4 : 1 and C : O = 3 : 4 by mass, so C : H : O = 12 : 3 : 16 by mass.

Step 2. Mole ratio = $\frac{12}{12} : \frac{3}{1} : \frac{16}{16} = 1 : 3 : 1$, so the empirical formula is CH_3O .

Step 3. A saturated acyclic compound needs $H \leq 2n + 2$. CH_3O is not a stable molecule, so the formula is $C_2H_6O_2$, ethylene glycol.

Step 4. $C_2H_6O_2 + \frac{5}{2}O_2 \rightarrow 2CO_2 + 3H_2O$.

Step 5. For 2 mol of X, O_2 needed = $2 \times 2.5 = 5$ mol.

Answer: (B) 5 moles

135 Answer: B

Ref 4617

Easy ~1 min Properties of Dinitrogen

Step 1: Analyze each option related to the properties and uses of dinitrogen.

Step 2: Liquid dinitrogen is indeed used in cryosurgery due to its low temperature. So, option A is incorrect.

Step 3: Dinitrogen can be used as an inert diluent for reactive chemicals because it is generally unreactive at room temperature due to its strong triple bond, making option B correct.

Step 4: Dinitrogen does not readily combine with dioxygen at $25^\circ C$ due to the stability of its triple bond. Therefore, option C is incorrect.

Step 5: N_2 is diamagnetic because all electrons are paired; hence, option D is incorrect.

The correct answer is B.

COMMON TRAPS

- **Missing the negative wording in option A.** Liquid dinitrogen/liquid nitrogen is used in cryosurgery because of its very low temperature; therefore the statement with "not used" is false. *Avoid it:* Underline negation words such as "not", "does not", "incorrect", and compare the full option statement, not just the keyword association.
- **Thinking inert diluent means chemically reactive reagent.** An inert diluent lowers concentration or provides an inert atmosphere without reacting significantly, and N_2 is generally unreactive at room temperature due to its strong $N \equiv N$ bond. *Avoid it:* Replace "for" with "in the presence of" and ask whether the gas is acting as a medium/diluent or as a reactant.

REVISE Properties of dinitrogen with emphasis on $N \equiv N$ bond strength, inertness at room temperature, uses of liquid nitrogen, and magnetic nature. · For every statement-based inorganic question, mark negations and conditions before recalling facts.

136 Answer: 18

Ref 4620

Medium ~2.5 min Chemical equations and stoichiometry

Add the oxygen needed for each fuel, using $x + \frac{y}{4}$ mol of O_2 per mole of C_xH_y .

Step 1. Propane: $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$. 1 mol needs 5 mol of O_2 .

Step 2. Butane: $2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$. 1 mol

needs 6.5 mol, so 2 mol needs 13 mol of O_2 .

Step 3. Total $O_2 = 5 + 13 = 18$ mol. Less than this leaves fuel unburnt, so 18 mol is the minimum.

Answer: 18

COMMON TRAPS

- **Forgetting that there are 2 moles of butane.** One mole of butane needs 6.5 mol of O_2 , so 2 mol needs 13 mol. *Avoid it:* Multiply each fuel's oxygen need by its own number of moles.
- **Using 13 mol for one mole of butane.** The balanced equation has 2 mol of butane taking 13 mol of O_2 , so one mole takes 6.5 mol. *Avoid it:* Divide by the fuel's coefficient to get the oxygen per mole.

REVISE Balancing combustion equations of alkanes.

137 Answer: C

Ref 2400

Medium ~2 min Mole concept

Find the moles from molarity and volume, then convert to mass.

Step 1. Moles of sucrose = $M \times V = 0.1 \times 2 = 0.2$ mol.

Step 2. Molar mass of $C_{12}H_{22}O_{11} = 12(12) + 22(1) + 11(16) = 144 + 22 + 176 = 342$ g mol⁻¹.

Step 3. Mass = $0.2 \times 342 = 68.4$ g.

Step 4. The value 34.2 g is the mass for only 1 L, so it misses the factor of 2 L.

Answer: (C) 68.4 g

COMMON TRAPS

- **Using 1 L instead of 2 L while applying molarity.** Molarity is moles per litre of solution: $M = n/V$, so $n = M \times V$. For 2 L, the moles are doubled compared to 1 L. *Avoid it:* Before calculating mass, write the unit expansion: $0.1 \text{ M} = 0.1 \text{ mol L}^{-1}$, then multiply by 2 L to cancel litres.
- **Choosing half the correct answer by missing volume factor.** For "2L of its 0.1 M aqueous solution", total moles = $0.1 \text{ mol/L} \times 2 \text{ L} = 0.2$ mol, not 0.1 mol. *Avoid it:* Ask: if the volume doubles at the same molarity, should the mass of solute double? Yes, so 34.2 g for 1 L must become 68.4 g for 2 L.

REVISE The definition $M = n/V$ and always rewrite M as mol L⁻¹ during calculations. · Practice molar mass calculations using molecular formula subscripts.

138 Answer: A

Ref 2802

Medium ~1 min Chemical Standards

QUICK APPROACH Recall the table of maximum prescribed concentrations of metals in drinking water and keep copper apart from zinc and manganese.

The limit asked for is the maximum prescribed concentration of copper in drinking water.

Step 1. The standards for drinking water list a maximum concentration for each metal: Fe 0.2 ppm, Mn 0.05 ppm, Al 0.2 ppm, Cu 3.0 ppm, Zn 5.0 ppm, Cd 0.005 ppm.

Step 2. Copper is a trace element the body needs, so its limit is relatively high, 3.0 ppm. Above this it damages the liver

and kidneys.

Step 3. The value 5 ppm is the limit for zinc, not copper, and 0.05 ppm is the limit for manganese.

Answer: (A) 3 ppm

COMMON TRAPS

- **Swapping the copper and zinc limits.** In the standard table copper is 3.0 ppm and zinc is 5.0 ppm; the two sit next to each other and are often exchanged. *Avoid it:* Learn the table as pairs: Cu 3, Zn 5, Fe 0.2, Mn 0.05, Cd 0.005 ppm.
- **Assuming every metal has a tiny limit.** Toxic metals like Cd and Pb have very low limits, but copper is an essential trace element and its limit is much higher. *Avoid it:* Separate essential trace metals (Cu, Zn, Fe) from purely toxic ones (Cd, Pb, Hg) before picking a value.

REVISE The environmental chemistry table of maximum prescribed concentrations of metals in drinking water. · Practise recall questions that mix the Cu, Zn, Fe and Mn limits.

139 Answer: 3

Ref 2233

Medium ~4 min Mole concept, Chemical equations and stoichiometry

At the same temperature and pressure, gas volumes are in the ratio of moles.

Step 1. For $C_xH_y + \left(x + \frac{y}{4}\right) O_2 \rightarrow x CO_2 + \frac{y}{2} H_2O$, 1 volume of hydrocarbon gives x volumes of CO_2 .

Step 2. 10 mL gives 40 mL of CO_2 , so $x = 4$.

Step 3. 10 mL needs 55 mL of O_2 , so $x + \frac{y}{4} = 5.5$. With $x = 4$, $\frac{y}{4} = 1.5$ and $y = 6$.

Step 4. The hydrocarbon is C_4H_6 . C_4H_{10} would need 65 mL of O_2 , and C_4H_7Cl is not a hydrocarbon.

Answer: (3) C_4H_6

140 Answer: 4

Ref 2243

Medium ~3 min Chemical equations and stoichiometry

Molar mass of $C_{57}H_{110}O_6$ is calculated as $57 \times 12 + 110 \times 1 + 6 \times 16 = 684 + 110 + 96 = 890$ g mol⁻¹.

Given mass is 445 g, so moles of $C_{57}H_{110}O_6 = \frac{445}{890} = 0.5$ mol.

Balanced equation shows 2 mol $C_{57}H_{110}O_6$ produce 110 mol H_2O . Thus, 1 mol produces 55 mol H_2O , and 0.5 mol produces 27.5 mol H_2O .

Mass of water = $27.5 \times 18 = 495$ g.

Alternatively, from stoichiometry: $\frac{110 \times 18}{2 \times 890} \times 445 = \frac{1980}{1780} \times 445 = 495$ g.

Option (490 g) encodes the specific mistake of approximating the mass ratio $\frac{1980}{1780} \approx 1.1$ then $1.1 \times 445 \approx 490$, ignoring exact values. This is a common rounding error in stoichiometric calculations.

Thus, the correct option is [4] 495 g.

COMMON TRAPS

- **Ignoring the coefficient 2 of the fat.** The mole ratio is 2 mol $C_{57}H_{110}O_6$ to 110 mol H_2O , that is 1 to 55. *Avoid it:* Write the ratio from the coefficients before converting masses.
- **Taking the mass of water equal to the mass of fat.** Oxygen from the air also reacts, so 445 g of fat gives 495 g of water, not 445 g. *Avoid it:* Always go grams to moles, use the mole ratio, then go back to grams.

REVISE Mass-to-mass stoichiometry using mole ratios. · Molar mass calculation for large formulas.

141 Answer: B

Ref 2298

Easy ~1 min Mole concept

Percentage by mole means the fraction of atoms (moles of atoms) that are carbon.

Step 1. One molecule of CH_4 has 1 carbon atom and 4 hydrogen atoms, which is 5 atoms in all.

Step 2. One mole of methane therefore contains 1 mol of C atoms out of 5 mol of atoms.

Step 3. Mole percentage of carbon = $\frac{1}{5} \times 100 = 20\%$.

Step 4. The value 75% is the mass percentage of carbon ($\frac{12}{16} \times 100$), and 80% is the mole percentage of hydrogen. Neither is asked here.

Answer: (B) 20 %

COMMON TRAPS

- **Using mass percentage when mole percentage is asked.** By mass, carbon is $\frac{12}{16} \times 100 = 75\%$ of methane, but by moles of atoms it is $\frac{1}{5} \times 100 = 20\%$. *Avoid it:* Read whether the question says by mass or by mole before choosing a formula.
- **Reporting the hydrogen value for carbon.** In CH_4 , hydrogen atoms make up $\frac{4}{5} = 80\%$ of the atoms, which is not the carbon figure. *Avoid it:* Circle the element asked and count its atoms over the total atoms.

REVISE Mass percent versus mole percent of elements. · Counting atoms in a molecular formula.

142 Answer: C

Ref 2370

Medium ~3 min Mole concept

QUICK APPROACH Start by recalling the formula for density of a unit cell: density equals (number of atoms per unit cell $\times$ molar mass) divided by (Avogadro's number $\times$ cell volume).

To calculate the density of copper in an FCC unit cell:

Step 1: Recall the formula for density (ρ) of a unit cell:

$$\rho = \frac{Z \times M}{N_A \times a^3}$$

where:

- Z is the number of atoms per unit cell (for FCC, $Z = 4$).
- M is the molar mass (for Cu, 63.55 g/mol).
- N_A is Avogadro's number (6.022×10^{23} atom/mol).
- a is the cell edge length ($x \text{ \AA} = x \times 10^{-8} \text{ cm}$).

Step 2: Substitute the given values:

$$\rho = \frac{4 \times 63.55}{6.022 \times 10^{23} \times (x \times 10^{-8})^3}$$

Step 3: Simplify the expression:

$$\text{Convert } a^3 = (x \times 10^{-8})^3 = x^3 \times 10^{-24} \text{ cm}^3$$

• Evaluate the formula to find density:

$$\rho = \frac{4 \times 63.55}{6.022 \times 10^{23} \times x^3 \times 10^{-24}}$$

• Further simplification gives $\frac{422}{x^3}$ given in option C.

Thus, the correct answer is $\frac{422}{x^3}$.

COMMON TRAPS

- **Taking FCC as 1 atom per unit cell.** For FCC, total atoms per unit cell = 8 corners $\times 1/8$ + 6 faces $\times 1/2$ = 1 + 3 = 4. *Avoid it:* Whenever the question says "FCC", write the atom-count expansion explicitly before substitution: $Z = 8(1/8) + 6(1/2) = 4$.
- **Confusing FCC with BCC and using $Z = 2$.** BCC has $Z = 2$; FCC has $Z = 4$. The given phrase is exactly "FCC unit cell structure", so Z must be 4. *Avoid it:* Before doing density calculation, annotate the question text: FCC $\rightarrow Z = 4$. Do not rely only on memory of the density formula.

REVISE Unit-cell atom counts: SC = 1, BCC = 2, FCC = 4, with contribution derivations. · Memorize and derive the density formula $\rho = ZM/(N_A a^3)$ using units, not just symbols.

143 Answer: 3

Ref 2373

Medium ~2 min Chemical equations and stoichiometry

Step 1: Understand the properties of Dichloromethane (DCM) and water.

Step 2: DCM has a density of approximately 1.33 g/cm³, which is higher than that of water (1 g/cm³).

Step 3: Due to the higher density, DCM will settle as the lower layer when mixed with water in a separating funnel.

Step 4: Water will be the upper layer due to its lower density compared to DCM.

Step 5: Therefore, the correct statement is that DCM would stay as the lower layer and water as the upper layer.

144 Answer: B

Ref 2399

Medium ~1.5 min Chemical Bonding and Molecular Structure

QUICK APPROACH Start by recalling the concept of hydration enthalpy and how it relates to the size of ions; smaller ions have higher hydration enthalpy due to stronger attraction with water molecules.

Step 1: Understand the concept of hydration enthalpy.

Hydration enthalpy is the amount of energy released when one mole of ions is dissolved in a large amount of water. The smaller the ion, the more it is hydrated and hence the higher is its hydration enthalpy.

Step 2: Analyze the ionic sizes for alkali metals.

In the alkali group, the ionic sizes increase down the group. This is because each element down the group has an additional electron shell compared to the previous one.

Step 3: Determine the order based on size.

Smaller ions have higher hydration enthalpies. In alkali metals, the order of increasing ionic size is: $Li^+ < Na^+ < K^+ < Rb^+ < Cs^+$.

Step 4: Apply the concept to find the order of hydration enthalpies.

Thus, the correct order of decreasing hydration enthalpies is:



Hence, the correct option is (B) $Li^+ > Na^+ > K^+ > Cs^+$.

145 Answer: 3

Ref 2417

Medium ~3 min Mole concept

Number of moles of surfactant = $10 \times 10^{-3} \text{ L} \times 1 \times 10^{-3} \text{ mol L}^{-1} = 10^{-5} \text{ mol}$.

Number of molecules $N = 10^{-5} \times 6.022 \times 10^{23} \approx 6.022 \times 10^{18}$.

These form a monolayer over 0.24 cm^2 , so area per polar head $A = \frac{0.24}{6.022 \times 10^{18}} \approx 4 \times 10^{-20} \text{ cm}^2$.

Approximating the head as a cube, edge length $l = \sqrt[3]{A} = \sqrt[3]{4 \times 10^{-20}} = 2 \times 10^{-10} \text{ cm} = 2 \times 10^{-12} \text{ m} = 2 \text{ pm}$.

(Option [2] encodes a common unit conversion error, e.g., mishandling cm-to-nm factors when converting $2 \times 10^{-10} \text{ cm}$.)

The correct option is [3] 2.0 pm.

COMMON TRAPS

- **Treating 1 mM as 1 mol/L.** mM means millimolar: $1 \text{ mM} = 10^{-3} \text{ mol/L}$. *Avoid it:* Before substituting in $n = C \times V$, rewrite all prefixes explicitly in powers of ten.
- **Using 10 mL as 10 L.** Molarity units are mol/L, so volume must be in L: $10 \text{ mL} = 0.010 \text{ L}$. *Avoid it:* Attach units during multiplication: $(\text{mol/L}) \times \text{L} = \text{mol}$.

REVISE Practise molarity problems with mM and mL conversions. · Drill squared-unit conversions such as cm^2 to m^2 .

146 Answer: 1

Ref 2430

Easy ~1 min Colloidal State

Step 1: Understand the definition of an aerosol. An aerosol is a colloidal system where tiny solid particles or liquid droplets are dispersed in a gas.

Step 2: Analyze the given options.

Option 1 (solid is dispersed in gas) describes a typical aerosol such as dust or smoke in the air, where solid particles are suspended in a gas.

Option 2 (liquid is dispersed in water) corresponds to an emulsion, not an aerosol.

Option 3 (gas is dispersed in solid) is incorrect as it does not describe a typical colloid.

Option 4 (gas is dispersed in liquid) is known as foam, not an aerosol.

Step 3: The correct answer is option 1.

COMMON TRAPS

- **Mixing up dispersed phase and medium.** In an aerosol the dispersion medium is a gas, and the dispersed phase is a solid or a liquid, as in smoke or fog. *Avoid it:* Name the medium first, then the dispersed phase, before matching a colloid name.
- **Calling a foam an aerosol.** Gas dispersed in a liquid is a foam, such as shaving cream, not an aerosol. *Avoid it:* Remember that aerosols always have gas as the medium.

REVISE The classification of colloids by phase and medium.

147 Answer: 4

Ref 2470

Medium ~3 min Chemical equations and stoichiometry

Hardness is expressed as mg of CaCO_3 equivalents per liter (ppm). For $\text{Ca}(\text{HCO}_3)_2$: moles = $0.81/162 = 0.005$. This equals $0.005 \text{ mol Ca}^{2+}$, equivalent to $0.005 \times 100 = 0.5 \text{ g CaCO}_3$. For $\text{Mg}(\text{HCO}_3)_2$: moles = $0.73/146 = 0.005$, also equivalent to 0.5 g CaCO_3 . Total CaCO_3 equivalent = 1 g in 100 mL sample. Scaling to 1 L : $1 \times 10 = 10 \text{ g/L} = 10,000 \text{ mg/L} = 10,000 \text{ ppm}$. Alternatively: equivalent mass = $[(100/162) \times 810 + (100/146) \times 730] = 1000 \text{ mg}$ in 100 mL , so per liter = $10,000 \text{ mg/L}$. Option 2 (1,000 ppm) encodes the common mistake of reporting mg CaCO_3 per 100 mL without scaling by 10 to a per-liter basis. Thus, the hardness is $10,000 \text{ ppm}$, option [4].

148 Answer: A

Ref 2478

Easy ~1 min Mole concept, Chemical equations and stoichiometry

Water gas is a mixture of CO and H_2 ; its use decides its name.

Step 1. Water gas is made by passing steam over red-hot coke: $\text{C} + \text{H}_2\text{O} \rightarrow \text{CO} + \text{H}_2$.

Step 2. The same mixture is used to make methanol: $\text{CO} + 2\text{H}_2 \rightarrow \text{CH}_3\text{OH}$, over a Cu/ZnO catalyst.

Step 3. Because this mixture is used to synthesise methanol and many other compounds, it is called synthesis gas, or syn gas.

Step 4. Laughing gas is N_2O , natural gas is mostly methane, and fuel gas is a general term.

Answer: (A) syn gas

149 Answer: 1

Ref 2788

Medium ~3 min Chemical equations and stoichiometry

A hydrocarbon contains only C and H. In combustion analysis, all C from the compound is converted to CO_2 and all H to H_2O . Thus, the masses in the 25 g sample are found directly from the products.

Mass of carbon = $\frac{12}{44} \times 88 \text{ g}$. Simplifying, $\frac{12 \times 88}{44} = 24 \text{ g}$.

Mass of hydrogen = $\frac{2}{18} \times 9 \text{ g}$. Simplifying, $\frac{2 \times 9}{18} = 1 \text{ g}$.

These add exactly to the sample mass ($24 \text{ g} + 1 \text{ g} = 25 \text{ g}$), confirming the hydrocarbon has no oxygen. The decisive steps are applying the stoichiometric mass fractions ($12/44$ from CO_2 , $2/18$ from H_2O) without assuming empirical formula steps.

Option [3] encodes the specific mistake of incorrect molar mass for CO_2 (using 48 instead of 44, yielding 22 g C) combined with a wrong hydrogen mass factor (yielding 3 g H). This is a common error from confusing atomic masses (O as 18) or combustion factors taught incorrectly. The correct masses match option [1].

COMMON TRAPS

- **Using wrong mass fractions.** Carbon is $\frac{12}{44}$ of the mass of CO_2 and hydrogen is $\frac{2}{18}$ of the mass of water. *Avoid it:* Write the fraction for each product before multiplying.
- **Forgetting that water has two hydrogen atoms.** 9 g of water has $\frac{2}{18} \times 9 = 1$ g of hydrogen, not 0.5 g. *Avoid it:* Check that the C and H masses add up to the sample mass.

REVIEW Estimation of carbon and hydrogen from combustion data.

150 Answer: 3

Ref 2791

Medium ~3 min Chemical equations and stoichiometry

Step 1: Calculate moles of reactants in each option based on their masses.

- For option (1):

$$\text{Moles of } N_2 = \frac{28}{28} = 1 \text{ mole}$$

$$\text{Moles of } H_2 = \frac{6}{2} = 3 \text{ moles}$$

- For option (2):

$$\text{Moles of } N_2 = \frac{35}{28} \approx 1.25 \text{ moles}$$

$$\text{Moles of } H_2 = \frac{8}{2} = 4 \text{ moles}$$

- For option (3):

$$\text{Moles of } N_2 = \frac{56}{28} = 2 \text{ moles}$$

$$\text{Moles of } H_2 = \frac{10}{2} = 5 \text{ moles}$$

Stoichiometric requirement for H_2 is 3 times that of N_2 . Here, H_2 is 5 which is less than required (6 moles) for 2 moles of N_2 , so H_2 is limiting.

- For option (4):

$$\text{Moles of } N_2 = \frac{14}{28} = 0.5 \text{ mole}$$

$$\text{Moles of } H_2 = \frac{4}{2} = 2 \text{ moles}$$

Step 2: Compare the given moles with the stoichiometric ratio required ($N_2 : H_2 = 1:3$).

Step 3: In option (3), H_2 runs out first based on the stoichiometric requirement, making it the limiting reagent.

151 Answer: 1

Ref 2812

Medium ~3 min Mole concept, Chemical equations and stoichiometry

Set up two equations from the molar masses of the two compounds.

Step 1. Molar mass of $\text{AB}_2 = \frac{125 \times 10^{-3}}{5} = 25 \times 10^{-3} \text{ kg mol}^{-1}$, so $M_A + 2M_B = 25 \times 10^{-3}$.

Step 2. Molar mass of $\text{A}_2\text{B}_2 = \frac{300 \times 10^{-3}}{10} = 30 \times 10^{-3} \text{ kg mol}^{-1}$, so $2M_A + 2M_B = 30 \times 10^{-3}$, that is $M_A + M_B = 15 \times 10^{-3}$.

Step 3. Subtract: $M_B = 10 \times 10^{-3} \text{ kg mol}^{-1}$.

Step 4. Then $M_A = 15 \times 10^{-3} - 10 \times 10^{-3} = 5 \times 10^{-3} \text{ kg mol}^{-1}$.

Answer: (1) $M_A = 5 \times 10^{-3}$ and $M_B = 10 \times 10^{-3}$

152 Answer: 4

Ref 2848

Medium ~3 min Chemical equations and stoichiometry

Volume strength tells how many litres of O_2 at STP one litre of solution gives.

Step 1. 11.2 volume means 1 L of solution gives 11.2 L of O_2 at STP, that is 0.5 mol of O_2 .

Step 2. From $2\text{H}_2\text{O}_2 \rightarrow 2\text{H}_2\text{O} + \text{O}_2$, 0.5 mol of O_2 comes from 1 mol of H_2O_2 . So the solution is 1 M.

Step 3. Molar mass of $\text{H}_2\text{O}_2 = 34 \text{ g mol}^{-1}$, so the solution has 34 g per litre.

Step 4. Per 100 mL this is 3.4 g, so the strength is 3.4% (w/v). Reading 34 g per litre as 34% forgets the change to 100 mL.

Answer: (4) 3.4 %

COMMON TRAPS

- **Treating 34 g L^{-1} as 34%.** For 11.2 volume H_2O_2 , 1 L solution contains 34 g H_2O_2 . That is 34 g per 1000 mL = 3.4 g per 100 mL = 3.4% w/v, not 34%. *Avoid it:* After finding a mass, write the denominator explicitly: 34 g per 1000 mL/1000 g solution, then multiply by 100.
- **Using the wrong stoichiometric ratio for H_2O_2 to O_2 .** The coefficient ratio is $\text{H}_2\text{O}_2:\text{O}_2 = 2:1$, so moles of H_2O_2 consumed are double the moles of O_2 evolved. *Avoid it:* Before substituting, write the mole ratio directly under the balanced equation: $2 \text{ mol H}_2\text{O}_2 \rightarrow 1 \text{ mol O}_2$.

REVIEW Volume strength of H_2O_2 : V-volume means 1 volume solution gives V volumes O_2 at STP. Practice converting volume strength to g/L and % w/v.

153 Answer: 3

Ref 2871

Medium ~1.5 min Chemical equations and stoichiometry

Temporary hardness is caused by hydrogen carbonates, which decompose on boiling.

Step 1. Calcium hydrogen carbonate gives the carbonate: $\text{Ca}(\text{HCO}_3)_2 \rightarrow \text{CaCO}_3 + \text{H}_2\text{O} + \text{CO}_2$.

Step 2. Magnesium hydrogen carbonate gives the hydroxide: $\text{Mg}(\text{HCO}_3)_2 \rightarrow \text{Mg}(\text{OH})_2 + 2\text{CO}_2$. Any MgCO_3 formed is fairly soluble and hydrolyses in hot water, while $\text{Mg}(\text{OH})_2$ is far less soluble.

Step 3. So $X = \text{Mg}(\text{HCO}_3)_2$ and $Y = \text{Mg}(\text{OH})_2$.

Step 4. $\text{Ca}(\text{OH})_2$ and CaO are not formed by boiling water; CaO needs strong heating of CaCO_3 .

Answer: (3) $\text{Mg}(\text{HCO}_3)_2$ and $\text{Mg}(\text{OH})_2$

154 Answer: C

Ref 3038

Easy ~1 min Mole concept, Chemical equations and stoichiometry

QUICK APPROACH Recall the maximum dissolved oxygen that cold natural water can hold, which is the textbook value used for water quality.

Dissolved oxygen depends on how much oxygen water can hold at a given temperature; cold water holds more.

Step 1. The solubility of a gas in water rises as the temperature falls, so cold water holds the most oxygen.

Step 2. For natural water this maximum is about 10 ppm, the figure used for clean cold water.

Step 3. Clean water usually has a dissolved oxygen level near 5 to 6 ppm or more; below about 6 ppm fish growth is affected.

Step 4. Values of 14 ppm or 16 ppm are above what natural cold water holds, and 8 ppm is below the maximum.

Answer: (C) 10 ppm

COMMON TRAPS

- **Picking the largest value for cold water.** Cold water holds more oxygen, but the upper limit for natural water is about 10 ppm. *Avoid it:* Remember the textbook figure rather than assuming more is always possible.
- **Mixing up dissolved oxygen and BOD limits.** Dissolved oxygen is the oxygen present; BOD is the oxygen demanded by microbes. *Avoid it:* Keep the two water quality numbers separate in your notes.

REVISE Water pollution and dissolved oxygen. · BOD and indicators of water quality.

155 Answer: 1

Ref 3194

Easy ~1 min Chemical equations and stoichiometry

Step 1: Understand the composition of the ores:

- Cryolite (Na_3AlF_6) is composed of sodium, aluminum, and fluoride ions.
- Magnetite (Fe_3O_4) does not contain any fluorides; it is an iron oxide.
- Malachite is a copper carbonate hydroxide [$\text{Cu}_2\text{CO}_3(\text{OH})_2$], lacking fluorides.
- Sphalerite is primarily zinc sulfide (ZnS) without any fluorides.

Step 2: Identify the ore with fluoride:

- Since cryolite has the chemical formula Na_3AlF_6 , it contains aluminum in the form of a fluoride compound.

Conclusion: The correct answer is cryolite because it contains the metal in the form of fluoride.

156 Answer: D

Ref 3290

Medium ~4 min Mole concept, Chemical equations and stoichiometry

Find the moles of CO_2 , which equal the moles of NaHCO_3 .

Step 1. The reaction is

$2\text{NaHCO}_3 + \text{H}_2\text{C}_2\text{O}_4 \rightarrow \text{Na}_2\text{C}_2\text{O}_4 + 2\text{CO}_2 + 2\text{H}_2\text{O}$, so 1 mol of NaHCO_3 gives 1 mol of CO_2 .

Step 2. Moles of $\text{CO}_2 = \frac{0.25 \times 10^{-3} \text{ L}}{25.0 \text{ L mol}^{-1}} = 1.0 \times 10^{-5} \text{ mol}$.

Step 3. Mass of $\text{NaHCO}_3 = 1.0 \times 10^{-5} \times 84 = 8.4 \times 10^{-4} \text{ g} = 0.84 \text{ mg}$.

Step 4. Percentage in the 10 mg tablet = $\frac{0.84}{10} \times 100 = 8.4\%$.

Answer: (D) 8.4

157 Answer: C

Ref 3369

Medium ~2 min Chemical equations and stoichiometry

To determine the reaction with minimum O_2 consumed per gram of reactant, compute mass of O_2 (in g) divided by mass of the non- O_2 reactant (in g) for each.

For [A]: Molar mass of $\text{P}_4\text{S} = 4 \times 31 + 32 = 156$ (S taken as 32). $5 \text{ mol O}_2 = 5 \times 32 = 160 \text{ g}$. Ratio: $160/156 \approx 1.026$.

For [B]: $2 \text{ Mg} = 2 \times 24 = 48 \text{ g}$ requires 32 g O_2 . Ratio: $32/48 = 0.667$.

For [C]: $4 \text{ Fe} = 4 \times 56 = 224 \text{ g}$ requires $3 \times 32 = 96 \text{ g O}_2$. Ratio: $96/224 = 0.429$.

For [D]: $\text{C}_3\text{H}_8 = 3 \times 12 + 8 \times 1 = 44 \text{ g}$ requires 160 g O_2 . Ratio: $160/44 \approx 3.636$.

The values show minimum for [C]. Option [B] encodes the mistake of identifying the lightest metal reactant without properly applying stoichiometry (0.5 mol O_2 per 24 g Mg gives higher ratio than 0.75 mol O_2 per 56 g Fe).

The correct option is [C] $4\text{Fe}_{(s)} + 3\text{O}_{2(g)} \rightarrow 2\text{Fe}_2\text{O}_{3(s)}$.

158 Answer: B

Ref 3408

Easy ~1 min Mole concept

A solid sol has a solid dispersed in a solid medium.

Step 1. Colloids are named by the dispersed phase and the dispersion medium. Solid in solid is a solid sol.

Step 2. Gem stones and coloured glass are solid sols: tiny particles of metal oxides are spread through a solid such as silica or alumina.

Step 3. Paint is a solid in a liquid, which is a sol.

Step 4. Butter is a liquid in a solid, which is a gel, and hair cream is a liquid in a liquid, which is an emulsion.

Answer: (B) Gem stones

COMMON TRAPS

- **Treating “solid sol” as any solid-looking colloid.** A solid sol specifically means solid dispersed phase in solid dispersion medium, not merely a substance that appears solid or thick. *Avoid it:* Before selecting, write the two states: dispersed phase = solid, dispersion medium = solid. Then test each option against both states.
- **Confusing sol with solid sol and picking Paint.** Paint is a sol: solid dispersed phase in liquid dispersion medium. Solid sol requires a solid medium too. *Avoid it:* Underline the second word in the colloid type: in solid sol, the medium is solid. Check whether the medium of paint is liquid.

REVISE The colloid classification table by dispersed phase and dispersion medium. · Memorize standard examples: sol—paint, gel—butter/jelly/cheese, emulsion—cream/milk, solid sol—gemstones/coloured glass.

159 Answer: 2

Ref 3520

Medium ~3 min

QUICK APPROACH Write the critical temperature in terms of a and b and compare the ratio a/b for the four gases.

The critical temperature of a van der Waals gas is $T_c = \frac{8a}{27Rb}$, so it is proportional to a/b .

Step 1. Ar: $a/b = 1.3/3.2 = 0.41$.

Step 2. Ne: $a/b = 0.2/1.7 = 0.12$.

Step 3. Kr: $a/b = 5.1/1.0 = 5.1$.

Step 4. Xe: $a/b = 4.1/5.0 = 0.82$.

Step 5. The ratio is largest for Kr, so Kr has the highest critical temperature. A large a means strong attraction, so the

gas liquefies easily; a small b means small molecules, which also raises T_c .

Answer: (2) Kr

COMMON TRAPS

- **Ranking by a alone.** Xe has a large a , but its large b lowers a/b and so lowers T_c . *Avoid it:* Compare a/b , not a , for critical temperature.
- **Ranking by molar mass.** Heavier gases often have higher T_c , but the given constants decide here. *Avoid it:* Use the data in the table rather than general trends.

REVISE Critical constants in terms of van der Waals constants. · The meaning of van der Waals a and b .



The full JEE Main: Chemistry has every chapter, chapter-wise and year-wise, in the Jeenius app.
