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Science — Class 9

Chapter(s): Atoms and Molecules

Maximum Marks: 39 **Time Allowed: 1 Hour 10 Minutes**

Section A — MCQ & Assertion-Reason (1 mark each)

Q1. A student writes the formula of aluminium sulphate as AlSO_4 by directly writing one Al, one S and one O group. Which option gives the correct formula after balancing charges using valencies Al^{3+} and SO_4^{2-}? [1 mark]

A) AlSO_4

B) $Al_2(SO_4)_3$

C) $Al_3(SO_4)_2$

D) $Al(SO_4)_3$

Q2. A sample of carbon dioxide is analysed. Which statement correctly links the mass ratio to the atomic ratio in CO_2? (Atomic masses: C = 12 u, O = 16 u.) [1 mark]

A) Mass ratio C:O is 12:16 and atomic ratio C:O is 1:1

B) Mass ratio C:O is 3:8 and atomic ratio C:O is 1:2

C) Mass ratio C:O is 1:2 and atomic ratio C:O is 3:8

D) Mass ratio C:O is 3:8 and atomic ratio C:O is 2:1

Q3. A chemist wants to prepare 27 g of water by combining hydrogen and oxygen directly. Using the constant mass ratio H:O = 1:8 in water, what masses of hydrogen and oxygen are required? [1 mark]

A) 3 g H and 24 g O

B) 6 g H and 21 g O

C) 1 g H and 26 g O

D) 9 g H and 18 g O

Q4. Which pair correctly matches the type of particle with the term used for its mass calculation, as per NCERT? [1 mark]

A) H_2O → formula unit mass; NaCl → molecular mass

B) H_2O → molecular mass; NaCl → formula unit mass

C) H_2O → atomic mass; NaCl → molecular mass

D) H_2O → formula unit mass; NaCl → atomic mass

Q5. A compound has formula X(OH)_2 where X is a metal. Using the charge on hydroxide ion (OH), what must be the charge (valency) on X and which statement

best justifies the use of brackets? [1 mark]

A) X is 1+; brackets show OH is diatomic

B) X is 2+; brackets show two hydroxide ions are present as a group

C) X is 3+; brackets prevent writing subscripts on oxygen

D) X is 2-; brackets indicate covalent bonding

Q6. Assertion (A): When writing the chemical formula of calcium hydroxide, Ca(OH)_2 is correct but CaOH_2 is not.
Reason (R): Brackets are used in a chemical formula when a polyatomic ion occurs more than once in the compound. [1 mark]

A) Both A and R are true and R is the correct explanation of A.

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

C) A is true but R is false.

D) A is false but R is true.

Q7. Assertion (A): In a chemical reaction carried out in a closed container, the total mass of reactants equals the total mass of products.
Reason (R): Atoms are indivisible particles and cannot be created or destroyed in a chemical reaction. [1 mark]

A) Both A and R are true and R is the correct explanation of A.

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

C) A is true but R is false.

D) A is false but R is true.

Q8. Assertion (A): The relative number and kinds of atoms are constant in a given compound.
Reason (R): Atoms combine in the ratio of small whole numbers to form compounds. [1 mark]

A) Both A and R are true and R is the correct explanation of A.

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

C) A is true but R is false.

D) A is false but R is true.

Q9. Assertion (A): The chemical symbol of cobalt is Co, not CO.
Reason (R): The first letter of an element's symbol is written in uppercase and the second letter (if present) is written in lowercase. [1 mark]

A) Both A and R are true and R is the correct explanation of A.

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

C) A is true but R is false.

D) A is false but R is true.

Q10. Assertion (A): For an ionic compound like sodium chloride, it is correct to talk about formula unit mass rather than molecular mass.
Reason (R): Ionic compounds consist of ions arranged in a lattice and do not exist as discrete molecules under ordinary conditions. [1 mark]

A) Both A and R are true and R is the correct explanation of A.
B) Both A and R are true but R is not the correct explanation of A.
C) A is true but R is false.
D) A is false but R is true.

Section B — Very Short Answer (2 marks each)

Q11. A sealed conical flask contains solution X in a small ignition tube and solution Y outside it (both inside the flask). The total mass of the closed setup is 125.60 g before mixing. After tilting, X and Y react completely. What will be the total mass of the closed setup after the reaction? Answer in exactly 2 sentences with SI unit. [2 marks]

Q12. A student has 20 g of oxygen available to form water. Using the law of constant proportions for water (H:O = 1:8 by mass), calculate (i) the mass of hydrogen needed and (ii) the mass of water formed. Answer in exactly 2 sentences with SI unit. [2 marks]

Q13. A compound has formula $(NH_4)_2SO_4$. Calculate its molecular mass using atomic masses H = 1 u, N = 14 u, S = 32 u, O = 16 u. Answer in exactly 2 sentences. [2 marks]

Section C — Short Answer (3 marks each)

Q14. A student is given three unlabeled compounds: magnesium hydroxide, sodium nitrate and ammonium sulphate. Write the correct chemical formula of each by using ion charges/valencies, and show charge-balance for any one of them. Answer in exactly 3 numbered points. [3 marks]

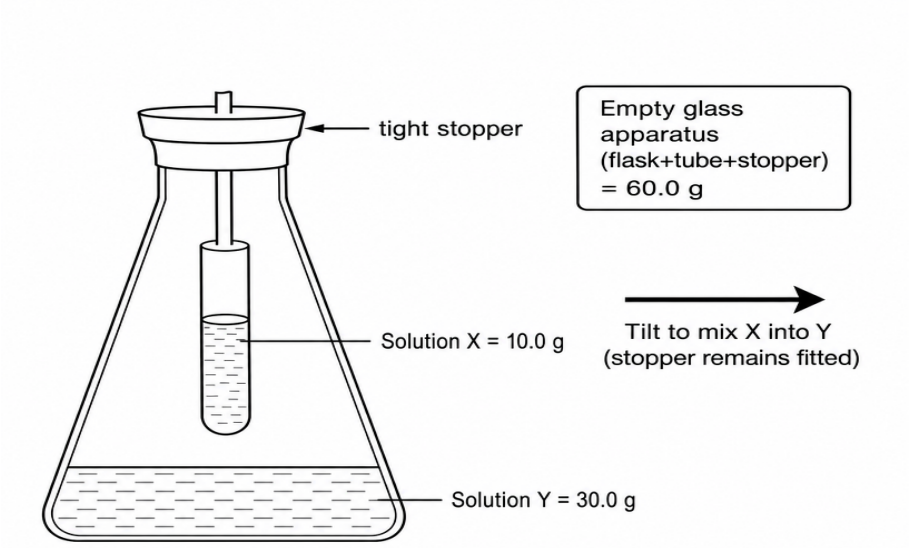
Q15. A lab report shows that 10.0 g of calcium combines with oxygen to form calcium oxide, and the compound is known to have mass ratio Ca:O = 5:2. (a) Calculate the mass of oxygen required. (b) Calculate the mass of CaO formed. Answer in exactly 3 numbered points. [3 marks]

Q16. A student confuses 'atomic mass', 'molecular mass' and 'formula unit mass' while solving numericals. Differentiate these three by giving (i) what each refers to and (ii) one correct example calculation expression (not full calculation). Answer in exactly 3 numbered points. [3 marks]

Section D — Long Answer (5 marks each)

Q17. A student is asked to prepare a pure sample of magnesium hydroxide in the laboratory and then verify that its chemical formula is consistent with charge balance and mass calculations. Answer the following in one combined response:
(a) Using the valencies of Mg^2 and OH, write the chemical formula of magnesium hydroxide and justify the use of brackets.
(b) Calculate the formula unit mass of Mg(OH)_2 using atomic masses: Mg = 24 u, O = 16 u, H = 1 u.
(c) If 5.80 g of Mg(OH)_2 is completely decomposed to give MgO and H_2O, calculate the mass of MgO formed (use atomic masses above and show full working). Write your answer as: Introduction (1 sentence) + 5 numbered headed points (2 sentences each) + Conclusion (1 sentence). [5 marks]

Q18. The given figure shows a closed apparatus used to verify the law of conservation of mass. A sealed conical flask is connected to a small ignition tube inside it. The total mass of the sealed apparatus (flask + contents) is measured before and after mixing the solutions. In the figure:
- Ignition tube contains Solution X: 10.0 g
- Conical flask contains Solution Y: 30.0 g
- Empty glass apparatus (flask + tube + stopper): 60.0 g
After tilting, X mixes with Y and a reaction occurs producing a gas, but the stopper remains tightly fitted. Answer the following in one response:
(a) Calculate the total mass of the sealed apparatus before mixing.
(b) Predict the total mass after the reaction and justify using the relevant law.
(c) The student repeats the experiment with a loose stopper and finds the final mass is 99.2 g. Calculate the mass of gas that escaped, with SI unit.
(d) State one experimental precaution (other than 'keep it closed') that improves reliability of the conclusion. Write your answer as: Introduction (1 sentence) + 5 numbered headed points (2 sentences each) + Conclusion (1 sentence). [5 marks]



Section E — Case Study (4 marks each)

Q19. Read the following passage and answer the questions that follow: [4 marks]

A sports drink company claims that its effervescent tablets produce a fixed ionic compound in water, regardless of which factory makes the tablets. To test this, a student dissolves one tablet and evaporates the water to obtain 11.7 g of a white crystalline solid identified as sodium chloride. The student checks the label: the tablet contained only sodium and chlorine in a sealed blister pack.

The student uses the chapter ideas: sodium chloride is an ionic compound made of Na and Cl, so its formula unit is NaCl. The atomic masses to be used are Na = 23 u and Cl = 35.5 u. Another student argues that if 11.7 g of NaCl formed, then the masses of sodium and chlorine that combined must follow a definite ratio, and any major deviation would indicate contamination or a measurement error.

Assume all of the solid obtained is dry NaCl and no material is lost during evaporation.

(i) Using valency/charge balance, state the formula of the compound formed and name the constituent ions. (1 mark)

(ii) Calculate the formula unit mass of NaCl (in u). (1 mark)

(iii) If 11.7 g of NaCl is obtained, calculate the masses of Na and Cl present in it (in g) using the constant mass ratio implied by the formula unit masses. Show the key steps. (2 marks)

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Science — Class 9

Chapter(s): Atoms and Molecules

Section A — MCQ & Assertion-Reason (1 mark each)

A1.

Answer:

Correct option: (B)

$Al_2(SO_4)_3$

Explanation:

Al has charge +3 and sulphate has charge -2, so LCM of 3 and 2 is 6; we need 2 Al^{3+} (total +6) and 3 SO_4^{2-} (total -6) to make a neutral compound, giving $Al_2(SO_4)_3$. Hence, option (B) is correct.

A2.

Answer:

Correct option: (B)

Mass ratio C:O is 3:8 and atomic ratio C:O is 1:2

Explanation:

In CO_2, there is 1 C atom and 2 O atoms, so atomic ratio C:O = 1:2. Corresponding mass ratio = 12 : (2×16) = 12:32 = 3:8. Hence, option (B) is correct.

A3.

Answer:

Correct option: (A)

3 g H and 24 g O

Explanation:

In water, total parts by mass = 1+8 = 9 parts; for 27 g water, hydrogen = (1/9)×27 = 3 g and oxygen = (8/9)×27 = 24 g. Hence, option (A) is correct.

A4.

Answer:

Correct option: (B)

H_2O → molecular mass; NaCl →

Formula: unit mass

Explanation:

Molecular mass is used for substances made of molecules like H_2O, while

Formula: unit mass is used for ionic compounds like NaCl whose basic entity is a

Formula: unit. Hence, option (B) is correct.

A5.

Answer:

Correct option: (B)

X is 2+; brackets show two hydroxide ions are present as a group

Explanation:

Each OH has charge -1, so two OH contribute -2; to make the compound neutral, X must be 2+. Brackets are used because the polyatomic ion OH occurs more than once, so X(OH)_2 indicates two hydroxide ions. Hence, option (B) is correct.

A6.

Answer:

Correct option: (A)

Both A and R are true and R is the correct explanation of A.

Explanation:

Ca(OH)_2 correctly shows two hydroxide (OH) ions; without brackets, CaOH_2 would incorrectly suggest separate atoms rather than two OH groups. The reason states the exact rule for using brackets with repeated polyatomic ions, which explains the assertion.

A7.

Answer:

Correct option: (A)

Both A and R are true and R is the correct explanation of A.

Explanation:

The assertion states the law of conservation of mass for reactions in a closed system. Dalton's postulate that atoms are not created or destroyed during chemical reactions provides the particle-level explanation for why total mass remains constant.

A8.

Answer:

Correct option: (A)

Both A and R are true and R is the correct explanation of A.

Explanation:

A compound has a fixed composition, meaning it contains a fixed kind and number ratio of atoms. This constancy arises because atoms combine in simple whole-number ratios (e.g., H:O = 2:1 in water), which directly explains the assertion.

A9.

Answer:

Correct option: (A)

Both A and R are true and R is the correct explanation of A.

Explanation:

The assertion applies the IUPAC convention for writing element symbols. The reason correctly states the capitalization rule that makes cobalt's symbol Co; CO would represent a compound

Formula: -like pattern, not the element symbol.

A10.

Answer:

Correct option: (A)

Both A and R are true and R is the correct explanation of A.

Explanation:

The assertion is correct because NaCl is represented by a

Formula: unit, not a molecule. The reason correctly explains that ionic compounds form extended ionic lattices, so mass is calculated per

Formula: unit.

Section B — Very Short Answer (2 marks each)

A11.

Answer:

The total mass after the reaction remains 125.60 g. By the law of conservation of mass, in a closed container mass is neither created nor destroyed, so the measured mass stays the same (125.60 g).

A12.

Answer:

Hydrogen needed = (1/8)×20 g = 2.5 g. Mass of water formed = 20 g + 2.5 g = 22.5 g (by conservation of mass in a closed system).

Water always forms with fixed mass ratio H:O = 1:8, so hydrogen mass is obtained by proportional scaling. The product mass equals the sum of reactant masses when all of the limiting reactant is consumed in a closed setup.

A13.

Answer:

Molecular mass = 2×(N + 4H) + (S + 4O) = 2×(14 + 4×1) + (32 + 4×16) = 2×18 + 96 = 132 u.

Substitution: check: 2×18 = 36 and 32 + 64 = 96, so total = 36 + 96 = 132 u.

The bracket indicates two ammonium ions, so all atoms inside must be multiplied by 2 before adding sulphate's contribution. Molecular mass is the sum of atomic masses of all atoms present in one

Formula: unit of the molecule.

Section C — Short Answer (3 marks each)

A14.

Answer:

1) Magnesium hydroxide: Mg(OH)_2. Mg has charge +2 and hydroxide OH has charge -1, so two OH are needed per Mg^{2}.

2) Sodium nitrate: NaNO_3. Na has charge +1 and nitrate NO_3 has charge -1, so a 1:1 combination makes the compound neutral.

3) Ammonium sulphate: (NH_4)_$2SO_4$. Charge-balance check: 2×(+1) from two NH_4^{+} equals +2 and SO_4^{2-} contributes -2, so net charge = 0.

A15.

Answer:

1) (a) Using constant proportion Ca:O = 5:2, oxygen required = (2/5)×10.0 g = 4.0 g.

2) (b) Mass of CaO formed = mass of Ca + mass of O = 10.0 g + 4.0 g = 14.0 g (closed-system assumption).

3) Verification: obtained ratio = 10.0:4.0 = 5:2, so the calculated oxygen mass is consistent with the definite proportion of CaO.

A16.

Answer:

1) Atomic mass: refers to the relative mass of one atom of an element compared to 1/12 of a carbon-12 atom; example expression: atomic mass of O = 16 u.

2) Molecular mass: refers to the sum of atomic masses of all atoms in one molecule (covalent substances); example expression: for HNO_3, M = 1 + 14 + 3×16 u.

3)

Formula: unit mass: refers to the sum of atomic masses in one

Formula: unit of an ionic compound (ions in a lattice); example expression: for NaCl, F.U. mass = 23 + 35.5 u.

Section D — Long Answer (5 marks each)

A17.

Answer:

Magnesium hydroxide is an ionic compound whose

Formula: and mass can be fixed by charge balance and

Formula: unit mass

Calculation: s.

1)

Formula: from charge balance: Magnesium forms Mg^{2} and hydroxide is OH, so two OH ions are needed to balance one Mg^{2} ion. Therefore the

Formula: is Mg(OH)_2, showing the compound is neutral overall.

2) Why brackets are necessary: The hydroxide ion is polyatomic (OH) and appears more than once in the

Formula: . Brackets in Mg(OH)_2 indicate that the subscript 2 multiplies both O and H, giving 2 O atoms and 2 H atoms.

3)

Formula: unit mass of Mg(OH)_2:

Formula: unit mass = 1×Mg + 2×(O + H) = 1×24 u + 2×(16 u + 1 u). = 24 u + 2×17 u = 24 u + 34 u = 58 u.

4) Reaction and mass ratio idea: On decomposition, Mg(OH)_2 → MgO + H_2O, so 1

Formula: unit of Mg(OH)_2 gives 1

Formula: unit of MgO. Hence, mass of MgO formed is proportional to

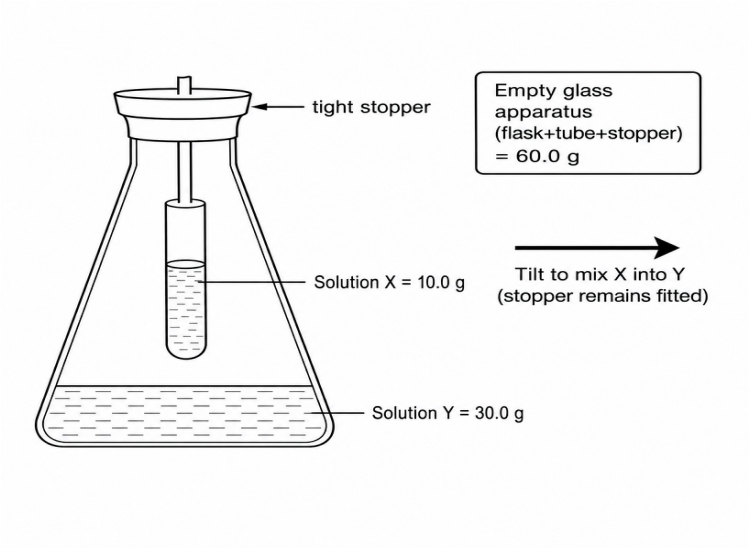
Formula: unit masses.

5) Mass of MgO from 5.80 g Mg(OH)_2:

Formula: unit mass of MgO = 24 u + 16 u = 40 u, and Mg(OH)_2 = 58 u. Mass of MgO = 5.80 g × (40/58) = 5.80 g × 0.689655… = 4.00 g (to 3 s.f.).; Thus, Mg(OH)_2 is correctly written with brackets, has

Formula: unit mass 58 u, and 5.80 g yields 4.00 g MgO on complete decomposition.

A18.



Answer:

The law of conservation of mass can be tested by measuring total mass of reactants and products in a sealed system.

1) Reading

Given: values from the figure: Mass of Solution X = 10.0 g, mass of Solution Y = 30.0 g, and mass of empty glass apparatus = 60.0 g. These three together make the initial total mass of the closed setup.

2) Initial total mass (before mixing): Total mass = 60.0 g + 10.0 g + 30.0 g = 100.0 g. This is the mass that should be compared with the final mass.

3) Predicted mass after reaction in sealed condition: By the law of conservation of mass, mass can neither be created nor destroyed in a chemical reaction in a closed system. Therefore the total mass after reaction should remain 100.0 g.

4) Gas escape case and

Calculation: in SI unit: With a loose stopper, final measured mass = 99.2 g, so mass lost = 100.0 g - 99.2 g = 0.8 g. Converting to SI unit, 0.8 g = 0.8×10^{-3} kg = 8.0×10^{-4} kg of gas escaped.

5) Precaution to improve reliability: The apparatus should be dry and the stopper fitting should be checked for leaks before weighing to avoid loss of vapour or gas. Also, the balance should be zeroed (tared) and readings taken when the setup is at rest to reduce measurement error.; Hence, a sealed system shows constant total mass (100.0 g), while any decrease (8.0×10^{-4} kg here) indicates matter has escaped and does not disprove the law itself.

Section E — Case Study (4 marks each)

A19.

(i) Using valency/charge balance, state the formula of the compound formed and name the constituent ions.

Answer:

The compound is NaCl, made of sodium ion Na (cation) and chloride ion Cl (anion).

(ii) Calculate the formula unit mass of NaCl (in u).

Answer:

Formula: unit mass of NaCl = 23 u + 35.5 u = 58.5 u.

(iii) If 11.7 g of NaCl is obtained, calculate the masses of Na and Cl present in it (in g) using the constant mass ratio implied by the formula unit masses. Show the key steps.

Answer:

In NaCl, mass ratio Na:Cl = 23:35.5.; Total parts = 23 + 35.5 = 58.5 parts.; Mass of Na = 11.7 g × (23/58.5) = 11.7 g × 0.393162… = 4.60 g.; Mass of Cl = 11.7 g × (35.5/58.5) = 11.7 g × 0.606838… = 7.10 g.