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Some Basic Concepts in Chemistry — JEE (Main) Pattern Topic Test

FREE SAMPLE TEST · CHEMISTRY · PATTERN OF JEE (MAIN)

DURATION	MAXIMUM MARKS	QUESTIONS	NAME / ROLL NO.
60 minutes	100	25 (20 + 5)	

GENERAL INSTRUCTIONS

1. This question paper has two sections, A and B. All 25 questions are compulsory.
2. Section A has TWENTY (20) multiple-choice questions. Each has FOUR options, (1), (2), (3) and (4), of which ONLY ONE is correct.
3. Section B has FIVE (05) questions whose answer is a numerical value. Enter the value rounded off to the nearest integer.
4. Marking scheme for both sections: +4 for a correct answer, −1 for an incorrect answer, 0 if the question is not attempted.
5. Atomic masses (g/mol): H 1, C 12, N 14, O 16, Na 23, Mg 24, S 32, Cl 35.5, K 39, Ca 40. Molar volume of a gas at STP = 22.4 L. Avogadro constant = 6.022×10^{23} mol^{-1}. Use of a calculator, log tables or any other aid is not allowed.
6. The answer key and worked solutions are at the end of this booklet. Attempt the paper in 60 minutes before you look at them.

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Topics covered: Laws of chemical combination · Atomic and molecular masses · Mole concept · Percentage composition · Empirical and molecular formulae · Stoichiometry · Stoichiometry of gaseous reactions · Limiting reagent

SECTION A (Q1–20) · Multiple choice · +4 / 0 / −1

Each question has FOUR options. ONLY ONE of them is correct.

1. Which of the following contains the largest number of atoms?

(1) 3.4 g of NH_3

(2) 6.4 g of SO_2

(3) 4.6 g of C_2H_5OH

(4) 1.6 g of CH_4

2. A metal M forms two oxides. The first, of formula MO_2, contains 36.8% oxygen by mass. The second contains 30.4% oxygen by mass. The formula of the second oxide is

(1) MO

(2) M_3O_4

(3) M_2O_5

(4) M_2O_3

3. Chlorine (average atomic mass 35.5 u) is a mixture of ^{35}Cl and ^{37}Cl only. Taking the isotopic masses as 35 u and 37 u, the percentage of Cl_2 molecules in chlorine gas that have a molecular mass of 72 u is

(1) 37.5%

(2) 25%

(3) 56.25%

(4) 18.75%

4. 0.30 g of an organic compound containing only C, H and O gives 0.44 g of CO_2 and 0.18 g of H_2O on complete combustion. Its vapour density is 30. Its molecular formula is

(1) CH_2O

(2) $C_2H_4O_2$

(3) $C_3H_6O_3$

(4) C_2H_6O

5. 10 g of H_2 and 64 g of O_2 are made to react completely to form water. The mass of water formed and the reactant left over are

(1) 74 g of water, nothing left over

(2) 72 g of water, 2 g of H_2 left

(3) 90 g of water, 2 g of H_2 left

(4) 72 g of water, 8 g of O_2 left

6. The percentage by mass of water of crystallisation in blue vitriol, $CuSO_4 \cdot 5H_2O$, is about (Cu = 63.5)

(1) 18.0%

(2) 56.4%

(3) 64.0%

(4) 36.1%

7. The number of electrons in 1.8 mL of liquid water (density 1.0 g/mL) is about

(1) 6.02×10^{23}

(2) 6.02×10^{22}

(3) 1.08×10^{24}

(4) 3.01×10^{23}

8. Equal masses of methane and sulphur dioxide are taken. The ratio of the total number of atoms in the methane to that in the sulphur dioxide is

(1) 4 : 1

(2) 5 : 3

(3) 20 : 3

(4) 3 : 20

9. 20 mL of a gaseous hydrocarbon is exploded with 150 mL of oxygen (an excess). After cooling to the original temperature and pressure the volume is 110 mL, and it falls to 50 mL on treatment with KOH solution. The hydrocarbon is

(1) C_3H_6

(2) C_2H_6

(3) C_3H_4

(4) C_3H_8

10. Statement I: In N_2O, NO, N_2O_3, NO_2 and N_2O_5, the masses of oxygen that combine with a fixed mass of nitrogen are in the ratio 1 : 2 : 3 : 4 : 5.
Statement II: Hydrogen and oxygen combine to form both H_2O and H_2O_2; this is an example of the law of definite proportions.
In the light of the above statements, choose the correct answer from the options given below:

(1) Statement I is true but Statement II is false

(2) Both Statement I and Statement II are true

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

(4) Both Statement I and Statement II are false

11. The volume of 0.1 M HCl needed to convert 1.06 g of anhydrous Na_2CO_3 completely into NaCl, CO_2 and water is

(1) 100 mL

(2) 200 mL

(3) 400 mL

(4) 20 mL

12. Potassium chlorate is heated to give the oxygen needed to burn 4.8 g of magnesium completely to MgO. The least mass of $KClO_3$ needed is about (K = 39, Cl = 35.5)

(1) 12.3 g

(2) 4.1 g

(3) 8.2 g

(4) 24.5 g

13. An oxide of nitrogen contains 36.8% nitrogen by mass. Its empirical formula is

(1) N_2O_3

(2) NO_2

(3) N_2O_5

(4) N_2O

14. 1.5 g of an element X (atomic mass 75) combines with 0.48 g of oxygen. The formula of the oxide is

(1) XO

(2) X_2O_5

(3) X_2O_3

(4) XO_2

15. A 2.50 g sample of impure limestone gives 0.88 g of CO_2 on strong heating; the impurities do not give off any gas. The percentage purity of the limestone (as $CaCO_3$) is

(1) 88%

(2) 80%

(3) 35.2%

(4) 64%

16. The volume of oxygen at STP needed for the complete combustion of 2.8 g of ethene is

(1) 2.24 L

(2) 4.48 L

(3) 8.96 L

(4) 6.72 L

17. 4.48 L (at STP) of a mixture of methane and ethene needs 11.2 L of oxygen (at STP) for complete combustion. The volume of methane in the mixture is

(1) 1.12 L

(2) 3.36 L

(3) 2.24 L

(4) 4.48 L

18. Which of the following has the largest mass?

(1) 0.2 mol of NH_3

(2) 1.12 L of SO_2 at STP

(3) 3.011×10^{22} atoms of calcium

(4) 6.022×10^{22} molecules of CO_2

19. The mass of a sulphuric acid sample that is 70% H_2SO_4 by mass needed to neutralise 4.0 g of NaOH completely is

(1) 7.0 g

(2) 4.9 g

(3) 14.0 g

(4) 3.4 g

20. Consider the following statements.

(A) One atomic mass unit is exactly one-twelfth of the mass of one atom of carbon-12.

(B) The molar mass of a substance in g/mol is numerically equal to the mass of one of its molecules in u.

(C) One mole of any gas occupies 22.4 L at any temperature and pressure.

(D) Equal volumes of all gases at the same temperature and pressure contain equal numbers of molecules.

(E) 1 g of H_2 and 1 g of O_2 contain the same number of molecules.

Choose the correct answer from the options given below:

(1) (A), (C) and (D) only

(2) (B), (D) and (E) only

(3) (A), (B) and (D) only

(4) (A), (B), (C) and (D) only

SECTION B (Q21–25) · Numerical value · +4 / 0 / −1

The answer to each question is a NUMERICAL VALUE. Enter it rounded off to the nearest integer.

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21. The mass of water (in g) formed by the complete combustion of 11.6 g of butane (C_4H_{10}) is _____.

Answer: _____

22. 2.4 g of magnesium reacts with an excess of dilute HCl. The volume of hydrogen (in mL) evolved, measured at STP, is _____.

Answer: _____

23. The number of oxygen atoms in 4.9 g of H_2SO_4 is $x \times 10^{22}$. The value of x is _____ (to the nearest integer; $N_A = 6.022 \times 10^{23}\ mol^{-1}$).

Answer: _____

24. 3.0 g of a hydrocarbon on complete combustion gives 8.8 g of CO_2. The percentage of hydrogen by mass in the hydrocarbon is _____.

Answer: _____

25. 2.8 g of N_2 and 1.0 g of H_2 react to form NH_3 until the limiting reagent is used up ($N_2 + 3H_2 \rightarrow 2NH_3$). The mass (in mg) of the reactant left over is _____.

Answer: _____

END OF THE QUESTION PAPER

ANSWER KEY

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
(3)	(4)	(1)	(2)	(2)	(4)	(1)	(3)	(4)	(1)

Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
(2)	(3)	(1)	(3)	(2)	(4)	(3)	(4)	(1)	(3)

Q21	Q22	Q23	Q24	Q25
18	2240	12	20	400

WORKED SOLUTIONS

Q1. Answer (3). Moles of atoms = (mass/molar mass) × atoms per molecule. NH_3: 0.2 × 4 = 0.8; SO_2: 0.1 × 3 = 0.3; C_2H_5OH: 0.1 × 9 = 0.9; CH_4: 0.1 × 5 = 0.5. Ethanol has the most.

Q2. Answer (4). From MO_2: 32/(M + 32) = 0.368, so M ≈ 55 (manganese). In the second oxide, O : M by moles = (30.4/16) : (69.6/55) = 1.90 : 1.27 = 1.5 : 1, so the formula is M_2O_3. The masses of oxygen per fixed mass of metal in the two oxides are in the ratio 2 : 1.5 = 4 : 3, as the law of multiple proportions requires.

Q3. Answer (1). 35x + 37(1 − x) = 35.5 gives x = 0.75 for ^{35}Cl. A molecule of mass 72 u has one atom of each isotope, which can be picked in two orders: 2 × 0.75 × 0.25 = 0.375, i.e. 37.5%. (56.25% of the molecules are $^{35}Cl_2$ and 6.25% are $^{37}Cl_2$.)

Q4. Answer (2). C = 0.44 × 12/44 = 0.12 g (0.01 mol); H = 0.18 × 2/18 = 0.02 g (0.02 mol); O = 0.30 − 0.14 = 0.16 g (0.01 mol). Empirical formula CH_2O (30). Molar mass = 2 × 30 = 60, so the molecular formula is $C_2H_4O_2$.

Q5. Answer (2). $2H_2 + O_2 \rightarrow 2H_2O$. 64 g O_2 = 2 mol needs 4 mol (8 g) H_2; 5 mol of H_2 is present, so O_2 is limiting. Water = 4 mol = 72 g, and 10 − 8 = 2 g of H_2 is left over (mass is conserved: 74 = 72 + 2).

Q6. Answer (4). Molar mass = 63.5 + 32 + 64 + 5 × 18 = 249.5 g/mol. Water: 90/249.5 = 36.1%.

Q7. Answer (1). 1.8 g of water is 0.1 mol. Each H_2O molecule has 2 × 1 + 8 = 10 electrons, so there is 1 mol of electrons: 6.02×10^{23}.

Q8. Answer (3). For mass w: CH_4 has (w/16) × 5 mol of atoms and SO_2 has (w/64) × 3. Ratio = (5/16)/(3/64) = 20 : 3. (The ratio of molecules alone is 4 : 1.)

Q9. Answer (4). $C_xH_y + (x + y/4)O_2 \rightarrow xCO_2 + (y/2)H_2O$ (liquid after cooling). KOH absorbs CO_2: 110 − 50 = 60 mL, so x = 60/20 = 3. The 50 mL left is unused O_2, so 100 mL was used: 20(x + y/4) = 100, x + y/4 = 5, y = 8. The gas is C_3H_8.

Q10. Answer (1). Per 28 g of nitrogen the oxygen is 16, 32, 48, 64 and 80 g: 1 : 2 : 3 : 4 : 5, so Statement I is true. Two compounds of the same pair of elements with oxygen in the ratio 1 : 2 per fixed mass of hydrogen illustrate the law of multiple proportions, not of definite proportions, so Statement II is false.

Q11. Answer (2). $Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$. 1.06 g = 0.01 mol of Na_2CO_3 needs 0.02 mol HCl: V = 0.02/0.1 L = 200 mL.

Q12. Answer (3). $2Mg + O_2 \rightarrow 2MgO$: 0.2 mol Mg needs 0.1 mol O_2. $2KClO_3 \rightarrow 2KCl + 3O_2$: 0.1 mol O_2 needs 0.2/3 mol $KClO_3$ = (0.2/3) × 122.5 ≈ 8.2 g.

Q13. Answer (1). N : O by moles = 36.8/14 : 63.2/16 = 2.63 : 3.95 = 1 : 1.5 = 2 : 3. The formula is N_2O_3 (check: 28/76 = 36.8%).

Q14. Answer (3). X: 1.5/75 = 0.02 mol; O: 0.48/16 = 0.03 mol. X : O = 2 : 3, so the oxide is X_2O_3.

Q15. Answer (2). $CaCO_3 \rightarrow CaO + CO_2$. 0.88 g CO_2 = 0.02 mol, from 0.02 mol = 2.0 g $CaCO_3$. Purity = 2.0/2.5 = 80%.

Q16. Answer (4). $C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$. 2.8 g = 0.1 mol of ethene needs 0.3 mol O_2 = 0.3 × 22.4 = 6.72 L at STP.

Q17. Answer (3). Let a mol CH_4 (needs 2a O_2) and b mol C_2H_4 (needs 3b O_2). a + b = 0.2 and 2a + 3b = 0.5, so b = 0.1 and a = 0.1: 2.24 L of methane.

Q18. Answer (4). NH_3: 0.2 × 17 = 3.4 g. SO_2: 0.05 mol × 64 = 3.2 g. Ca: 0.05 mol × 40 = 2.0 g. CO_2: 0.1 mol × 44 = 4.4 g, the largest.

Q19. Answer (1). $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$. 0.1 mol NaOH needs 0.05 mol = 4.9 g of H_2SO_4, which is in 4.9/0.70 = 7.0 g of the sample.

Q20. Answer (3). (A) is the definition of the unit. (B) follows because one mole is 6.022×10^{23} entities and 1 g = 6.022×10^{23} u. (C) is false: 22.4 L is the molar volume only at 273 K and 1 atm. (D) is Avogadro's law. (E) is false: 1 g of H_2 is 1/2 mol and 1 g of O_2 is 1/32 mol.

Q21. Answer 18. $2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$. 11.6 g = 0.2 mol butane gives 5 × 0.2 = 1 mol of water = 18 g.

Q22. Answer 2240. $Mg + 2HCl \rightarrow MgCl_2 + H_2$. 0.1 mol Mg gives 0.1 mol H_2 = 0.1 × 22 400 = 2240 mL.

Q23. Answer 12. 4.9 g = 0.05 mol H_2SO_4, holding 0.2 mol of O atoms = $0.2 \times 6.022 \times 10^{23} = 1.204 \times 10^{23} = 12.04 \times 10^{22}$, so x = 12.

Q24. Answer 20. C = 8.8 × 12/44 = 2.4 g, so H = 3.0 − 2.4 = 0.6 g = 20% (the hydrocarbon is ethane, C_2H_6).

Q25. Answer 400. N_2: 0.1 mol; H_2: 0.5 mol. 0.1 mol N_2 needs only 0.3 mol H_2, so N_2 is limiting. H_2 left = 0.2 mol = 0.4 g = 400 mg.

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