Chemistry · Chemical Analysis

Quantitative Chemical Analysis

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Multiple choice questions — 90 questions

1 What is the number of moles in 26.5 g of sodium carbonate?
[Na = 23 , C = 12 , O = 16]

(A) 0.1 mol (B) 0.5 mol (C) 0.25 mol (D) 0.125 mol

2 What is the number of atoms in 1 mol of hydrogen gas?

(A) 1 atom
(B) 6.02×10^{23} atom
(C) 2 atom
(D) 12.04×10^{23} atom

3 What is the volume of 16 g of oxygen gas (at STP)?
[O = 16]

(A) 22.4 L (B) 44.8 L (C) 11.2 L (D) 5.6 L

4 What is the atomic mass of an active gas whose density is 3.1696 g/L (at STP)?

(A) 71 g/mol (B) 35.5 g/mol (C) 106.5 g/mol (D) 170 g/mol

5 Hot conc. sulphuric acid was added to 0.05 mol of a chloride salt (X), and 6.02×10^{22} molecules of hydrogen chloride gas were given off. Which of the following represents salt (X)?

(A) NaCl (B) $BaCl_2$ (C) $AlCl_3$ (D) $TiCl_4$

6 What is the number of water molecules produced from the reaction of 0.1 mol of hydrochloric acid with excess sodium hydroxide?

(A) 0.1 molecule
(B) 6.02×10^{22} molecule
(C) 6.02×10^{23} molecule
(D) 6.02×10^{24} molecule

7 When 0.02 L of NO gas is mixed with 0.01 L of O_2 gas,
what is the volume of the gas produced (at STP) after the reaction ends?

(A) 0.05 L (B) 0.03 L (C) 0.02 L (D) 0.01 L

8 From the opposite reaction: $3Mg(s) + N_2(g) \rightarrow Mg_3N_2(s)$ (on heating)
What is the number of moles of nitrogen gas needed to react with 18 g of magnesium?
[Mg = 24]

(A) 0.25 mol (B) 0.5 mol (C) 1 mol (D) 2 mol

9 An aqueous solution of volume 500 mL contains 0.5 mol of $CuSO_4$. The concentration of this solution equals .....

(A) 0.25 M (B) 1 M (C) 0.5 M (D) 2 M

10 What is the concentration of the solution formed by adding 9 L of water to 1 L of 5 M H_2SO_4 solution?

(A) 0.1 M (B) 0.5 M (C) 1 M (D) 5 M

11 What is the concentration of the nitric acid produced by adding 200 mL of water to 40 mL of 0.2 M nitric acid?

(A) 0.033 M (B) 0.08 M (C) 0.1 M (D) 0.15 M

12 A 0.5 M caustic soda solution of volume 200 mL was diluted with water until it became 0.25 M.
What is the total volume of the resulting solution?

(A) 400 mL (B) 300 mL (C) 350 mL (D) 250 mL

13 What volume of water must be added to 20 mL of 3 M hydrochloric acid solution so that its concentration becomes 0.5 M?

(A) 50 mL (B) 100 mL (C) 120 mL (D) 290 mL

14 250 mL of 3 M hydrochloric acid was added to 350 mL of 2 M hydrochloric acid.
What is the concentration of the resulting solution?

(A) 1.45 M (B) 2.42 M (C) 2.5 M (D) 2.9 M

15 200 mL of distilled water was added to 300 mL of 0.23 M magnesium nitrate solution.
What is the concentration of the nitrate anion in the solution after dilution with water?

(A) 0.138 M (B) 0.276 M (C) 0.184 M (D) 0.46 M

16 The number of potassium ions in 300 mL of 0.2 M potassium sulphate equals .....

(A) 7.2×10^{22} ion (B) 3.6×10^{22} ion (C) 2.7×10^{22} ion (D) 6.3×10^{22} ion

17 What is the percentage of iron in a mole of red iron oxide?

[Fe = 55.86 , O = 16]

(A) 72% (B) 50% (C) 42% (D) 69.9%

18 Excess hot conc. H_2SO_4 was added to an impure sample of magnetite ore of mass 20 g, and 15 g of the sample was consumed.

What is the percentage of impurities in the sample?

(A) 75% (B) 25% (C) 30% (D) 7.5%

19 Which substance is completely consumed in the titration process?

(A) The standard solution.

(B) The acid.

(C) The solution of unknown concentration.

(D) The base.

20 All of the following are oxidation-reduction reactions, except .....

(A) preparing iron(III) chloride from its elements.

(B) titrating an acidic solution with a standard solution.

(C) thermal decomposition of iron(II) sulphate.

(D) titrating sodium nitrite with acidified $KMnO_4$.

21 Which of the following can be used as a 0.1 M standard solution to determine the concentration of chloride ions in an aqueous solution of one of its salts?

(A) HNO_3 (B) Na_2SO_4 (C) NaOH (D) $AgNO_3$

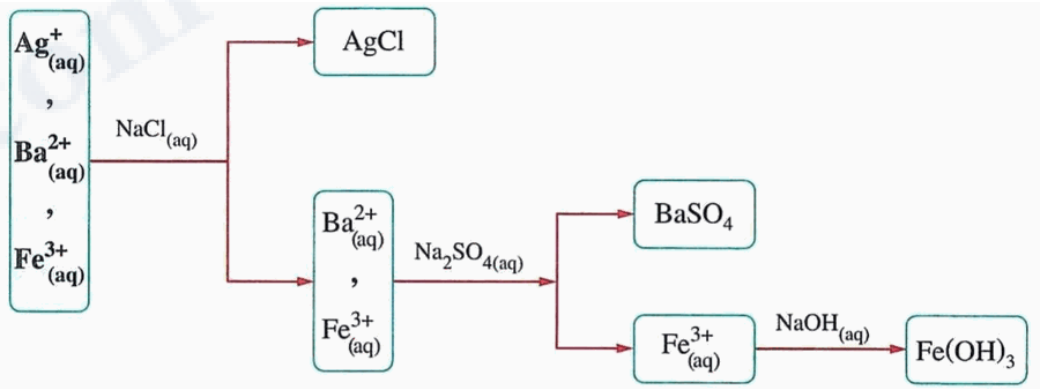
22 What is the standard solution used to determine the concentration of a sodium carbonate solution?

(A) HCl(aq) (B) KOH(aq) (C) NaCl(aq) (D) $KHCO_3$(aq)

23 From the following chart:

What term describes the 1 M solutions of NaOH, Na_2SO_4 and NaCl,

and what type of reactions led to the formation of the compounds AgCl, $BaSO_4$ and $Fe(OH)_3$?



(A) Standard solutions , oxidation-reduction reactions.

(B) Acidic solutions , neutralization reactions.

(C) Basic solutions , precipitation reactions.

(D) Standard solutions , precipitation reactions.

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24 The following equations represent three chemical reactions:

(1) $2Fe(s) + 3Br_2(l) \rightarrow 2FeBr_3(s)$

(2) $AgNO_3(aq) + NaCl(aq) \rightarrow NaNO_3(aq) + AgCl(s)$

(3) $Sr(OH)_2(aq) + 2HCl(aq) \rightarrow SrCl_2(aq) + 2H_2O(l)$

Which of the following represents the type of each of reactions (1), (2) and (3)?

(A) (1) : oxidation-reduction , (2) : precipitation , (3) : neutralization.

(B) (1) : oxidation-reduction , (2) : precipitation , (3) : oxidation-reduction.

(C) (1) : precipitation , (2) : neutralization , (3) : neutralization.

(D) (1) : neutralization , (2) : neutralization , (3) : oxidation-reduction.

---

25 Which of the following is used to distinguish between pure water and 0.01 M HCl acid?

(A) A piece of copper.

(B) A piece of scandium.

(C) Phenolphthalein indicator.

(D) Bromothymol blue indicator.

---

26 Indicator (W) was added to solution (X) and it turned yellow, and indicator (Y) was added to solution (Z) and it also turned yellow.

Which of the following is correct?

(A) Indicator (W): bromothymol blue ; solution (X): CH_3COOH ; indicator (Y): methyl orange ; solution (Z): ammonia solution

(B) Indicator (W): methyl orange ; solution (X): NaOH ; indicator (Y): bromothymol blue ; solution (Z): ammonia solution

(C) Indicator (W): phenolphthalein ; solution (X): NaOH ; indicator (Y): litmus ; solution (Z): H_2CO_3

(D) Indicator (W): litmus ; solution (X): CH_3COOH ; indicator (Y): phenolphthalein ; solution (Z): H_2CO_3

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27 Solution (X) is used to distinguish between $Fe^{2+}(aq)$ and $Fe^{3+}(aq)$ solutions.

What is the effect of adding drops of the indicators (Y) and (Z) - each separately - to solution (X)?

(A) Effect of adding (Y) to (X): the solution turns yellow ; effect of adding (Z) to (X): the solution turns light green

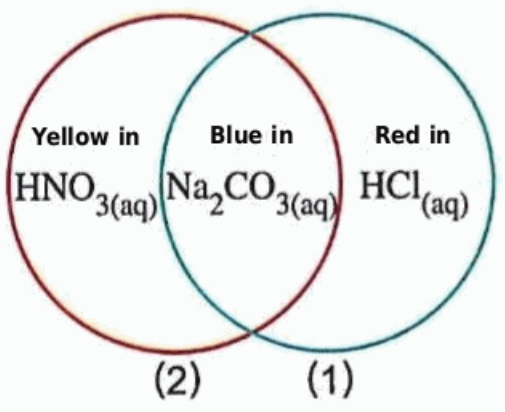
(B) Effect of adding (Y) to (X): the solution turns blue ; effect of adding (Z) to (X): the solution turns yellow

(C) Effect of adding (Y) to (X): the solution turns pinkish red ; effect of adding (Z) to (X): the solution turns orange

(D) Effect of adding (Y) to (X): the solution turns blue ; effect of adding (Z) to (X): the solution turns light green

---

28 Which of the following represents each of the indicators (1) and (2) in the opposite Venn diagram?



(A) (1) : methyl orange , (2) : litmus.

(B) (1) : litmus , (2) : methyl orange.

(C) (1) : phenolphthalein , (2) : bromothymol blue.

(D) (1) : litmus , (2) : bromothymol blue.

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29 Phenolphthalein solution is used to distinguish between .....

(A) HCl(aq) , NaOH(aq)

(B) $H_2O(l)$, HCl(aq)

(C) the basic reagent of NO_3^- , $H_2O(l)$

(D) the basic reagent of $Fe^{2+}(aq)$ and the confirmatory reagent of $Fe^{3+}(aq)$.

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30 Potassium hydroxide solution is used to distinguish between each of the following, except .....

(A) methyl orange and bromothymol blue.

(B) phenolphthalein and litmus.

(C) bromothymol blue and litmus.

(D) phenolphthalein and methyl orange.

---

31 Litmus indicator and bromothymol blue indicator cannot be distinguished after adding .....

(A) the reagent of the Hg^+ cation

(B) $H_2SO_4(aq)$

(C) the reagent of the Al^{3+} cation

(D) $H_2O(l)$

---

32 Which of the following gases colours methyl orange and litmus indicators differently when passed through each of them?

(A) $NH_3(g)$ (B) $HCl(g)$ (C) $CO_2(g)$ (D) $SO_2(g)$

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33 A container holding 10 mL of 1 M hydrochloric acid with drops of methyl orange indicator, to which 5 mL of 1 M sodium hydroxide solution was added.

What change takes place in this mixture?

(A) The colour of methyl orange changes from red to yellow.

(B) The concentration of H^+ ions increases.

(C) The colour of methyl orange changes from yellow to red.

(D) The colour becomes less intense.

---

34 Indicator (X) was added to an aqueous solution containing 0.25 mol of sodium hydroxide and 0.2 mol of hydrochloric acid.

Which indicator (X) was used, and what is its colour in this aqueous solution?

(A) (X) : litmus, red.

(B) (X) : bromothymol blue, blue.

(C) (X) : methyl orange, red.

(D) (X) : phenolphthalein, colourless.

---

35 Solution (X) is used as a basic reagent for the thiosulphate anion, and solution (Y) is used as a confirmatory reagent for the cations of the third analytical group.

What colour forms when drops of methyl orange indicator are added to each of solutions (X) and (Y)?

(A) (X) : orange , (Y) : red.

(B) (X) : red , (Y) : yellow.

(C) (X) : red , (Y) : orange.

(D) (X) : yellow , (Y) : red.

---

36 Three identical samples each contain a mixture of 40 mL of 0.5 M sulphuric acid with 50 mL of 0.4 M sodium hydroxide solution. What is the colour of each of them with the following indicators?

(A) Methyl orange indicator: yellow ; litmus indicator: blue ; bromothymol blue indicator: blue

(B) Methyl orange indicator: orange ; litmus indicator: purple ; bromothymol blue indicator: light green

(C) Methyl orange indicator: red ; litmus indicator: red ; bromothymol blue indicator: blue

(D) Methyl orange indicator: red ; litmus indicator: red ; bromothymol blue indicator: yellow

37 Bromothymol blue indicator turns green in the mixture made of .....

(A) 25 mL of 0.1 M $Ba(OH)_2$ solution + 25 mL of 0.1 M HNO_3 acid

(B) 25 mL of 0.1 M NaOH solution + 25 mL of 0.1 M H_2SO_4 acid

(C) 25 mL of 0.1 M KOH solution + 25 mL of 0.1 M HCl acid

(D) 25 mL of 0.1 M $Ca(OH)_2$ solution + 25 mL of 0.1 M H_3PO_4 acid

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38 The following statements describe the steps of a titration process (not in order):

(1) : The acid is added dropwise from the burette into the conical flask until the colour of the indicator changes.

(2) : Add a suitable chemical indicator.

(3) : Transfer a known volume of the alkali into a conical flask using the pipette.

(4) : Record the initial burette reading of the acid.

(5) : Record the final burette reading of the acid.

What is the correct order of the steps of the titration process?

(A) (2) → (4) → (1) → (5) → (3)

(B) (3) → (2) → (4) → (1) → (5)

(C) (3) → (4) → (1) → (5) → (2)

(D) (4) → (3) → (1) → (2) → (5)

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39 When 10 mL of 0.5 M sulphuric acid is added to 5 mL of 2 M sodium hydroxide solution during titration, ...

(A) number of moles of $H^+(aq)$ = number of moles of $OH^-(aq)$

(B) nb < na

(C) number of moles of H_2SO_4 < number of moles of NaOH

(D) (Mb Vb) = (Ma Va)

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40 From the following reaction:

$3KOH(aq) + H_3PO_4(aq) \rightarrow K_3PO_4(aq) + 3H_2O(l)$

What volume of 0.2 M potassium hydroxide is needed to titrate 25 mL of 0.1 M phosphoric acid?

(A) 37.5 mL (B) 25 mL (C) 12.5 mL (D) 18.75 mL

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41 30 mL of 0.15 M nitric acid was titrated using 0.1 M sodium bicarbonate solution.

What volume of sodium bicarbonate solution is needed for the titration?

(A) 30 mL (B) 35 mL (C) 40 mL (D) 45 mL

42 Sodium bisulphate solution reacts with sodium hydroxide solution according to the following equation:

$NaHSO_4(aq) + NaOH(aq) \rightarrow Na_2SO_4(aq) + H_2O(l)$

What volume of 0.2 M NaOH solution is needed to react completely with 0.01 mol of sodium bisulphate solution?

(A) 20 mL (B) 50 mL (C) 100 mL (D) 500 mL

43 23 mL of 1.63 M barium hydroxide solution was titrated with sulphuric acid solution, and the volume of acid consumed at the end point of the reaction was 75 mL. The molarity of the acid equals .....

(A) 0.5 M (B) 0.25 M (C) 0.125 M (D) 0.05 M

44 From the opposite reaction:

$Na_2CO_3(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$

On complete titration of 20 mL of 0.5 M sodium carbonate, 50 mL of the standard solution was consumed, whose concentration is .....

(A) 0.4 M (B) 0.2 M (C) 0.02 M (D) 0.04 M

45 25 mL of 0.1 M sodium hydroxide is completely neutralized by 20 mL of sulphuric acid. What is the concentration of the sulphuric acid used?

(A) 0.0313 M (B) 0.0625 M (C) 0.125 M (D) 0.25 M

46 When 100 mL of 0.1 M HCl acid is mixed with 100 mL of 0.2 M NaOH solution, the result is .....

(A) a 0.01 M basic solution
(B) a 0.01 M acidic solution
(C) a 0.05 M basic solution
(D) a 0.05 M acidic solution

47 When 25 mL of sodium hydroxide solution is added to 50 mL of sulphuric acid, all the reactants are consumed.

Which of the following describes the concentration of the sodium hydroxide solution?

(A) Four times the concentration of the sulphuric acid.
(B) Equal to the concentration of the sulphuric acid.
(C) Twice the concentration of the sulphuric acid.
(D) Half the concentration of the sulphuric acid.

48 22.52 mL of 0.015 M MnO_4^- solution was needed to calculate the concentration of Fe^{2+} in 25 mL of a solution of one of its salts, according to the following equation:

$MnO_4^-(aq) + 5Fe^{2+}(aq) + 8H^+(aq) \rightarrow Mn^{2+}(aq) + 5Fe^{3+}(aq) + 4H_2O(l)$

What is the concentration of the Fe^{2+} solution used?

(A) 0.136 M (B) 0.068 M (C) 1.689×10^{-3} M (D) 3.378×10^{-4} M

49 From the opposite reaction:

$2MnO_4^- + 5H_2C_2O_4 + 6H^+ \rightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$

Titrating 0.134 g of oxalic acid $H_2C_2O_4$ needed 24.7 mL of permanganate solution, whose concentration is .....

[$H_2C_2O_4$ = 90 g/mol]

(A) 5.96×10^{-4} M (B) 1.49×10^{-3} M (C) 2.41×10^{-2} M (D) 6.03×10^{-2} M

50 A mixture of mass 50 g made of the two salts sodium carbonate and sodium chloride needed 1 L of 0.45 M HCl acid to react completely with it, so the concentration of NaCl in the resulting solution is .....

[NaCl = 58.5 g/mol , Na_2CO_3 = 106 g/mol]

(A) 0.364 M (B) 0.447 M (C) 0.6 M (D) 0.9 M

51 What volume and concentration of sodium hydroxide solution are needed to completely neutralize 20 mL of 0.5 M sulphuric acid?

(A) Volume: 20 mL ; concentration: 0.5 M (B) Volume: 40 mL ; concentration: 0.5 M
(C) Volume: 40 mL ; concentration: 0.1 M (D) Volume: 20 mL ; concentration: 0.1 M

52 Which of the following represents the volume and concentration of each of the calcium hydroxide solution and the hydrochloric acid needed for neutralization?

(A) Calcium hydroxide: volume x mL , concentration 2y M ; hydrochloric acid: volume 2x mL , concentration y M

(B) Calcium hydroxide: volume 2x mL , concentration y M ; hydrochloric acid: volume x mL , concentration 2y M

(C) Calcium hydroxide: volume x mL , concentration y M ; hydrochloric acid: volume 2x mL , concentration y M

(D) Calcium hydroxide: volume 2x mL , concentration 2y M ; hydrochloric acid: volume x mL , concentration 2y M

53 What is the number of moles of KOH needed to completely neutralize 20 mL of 1 M H_2SO_4 acid?

(A) 0.01 mol (B) 0.02 mol (C) 0.03 mol (D) 0.04 mol

54 What volume of 0.1 M HCl acid is needed to react completely with 1 g of pure calcium carbonate?

[$CaCO_3$ = 100 g/mol]

(A) 100 mL (B) 150 mL (C) 200 mL (D) 250 mL

55 What is the concentration of hydrochloric acid, 25 mL of which neutralizes 0.84 g of sodium bicarbonate?

[$NaHCO_3$ = 84 g/mol]

(A) 0.02 M (B) 0.04 M (C) 0.2 M (D) 0.4 M

56 What volume of 0.2 M sulphuric acid is needed to titrate 500 mL of sodium hydroxide solution, each litre of which contains 1.2 g of the dissolved substance?

[NaOH = 40 g/mol]

(A) 37.5 mL (B) 50 mL (C) 75 mL (D) 100 mL

57 What mass of $Ca(OH)_2$ completely neutralizes 100 mL of 0.1 M phosphoric acid?

[Ca = 40 , O = 16 , H = 1]

(A) 0.49 g (B) 0.74 g (C) 1.11 g (D) 2.22 g

58 15 mL of sodium hydroxide solution is needed to titrate 25 mL of 0.1 M sulphuric acid. What is the mass of NaOH dissolved in 450 mL of the sodium hydroxide solution used in the titration?

[Na = 23 , O = 16 , H = 1]

(A) 2 g (B) 4.5 g (C) 6 g (D) 6.3 g

59 0.512 g of a monoprotic acid of molar mass 204.22 g/mol is needed to completely neutralize 36.78 mL of NaOH solution. What is the concentration of the NaOH solution used?

(A) 0.00251 M (B) 0.0139 M (C) 0.0682 M (D) 0.092 M

60 Titrating 0.307 g of a triprotic acid needed 35.2 mL of 0.106 M NaOH solution.
What is the molar mass of the acid used?

(A) 151.28 g/mol (B) 165 g/mol (C) 171 g/mol (D) 246.84 g/mol

61 0.45 g of a mineral acid of molar mass 90 g/mol is completely neutralized by 20 mL of 0.5 M KOH solution, so the acid is .....

(A) monoprotic. (B) diprotic. (C) triprotic. (D) tetraprotic.

62 0.06 g of a monohydroxy base was dissolved in water to make a solution, and this solution was used up in titrating 15 mL of a 0.1 M monoprotic acid.
What is the molar mass of the base used?

(A) 40 g/mol (B) 56 g/mol (C) 60 g/mol (D) 98 g/mol

63 When titrating a solution containing 1 g of an impure sample of sodium bicarbonate, 7.15 mL of 0.1 M sulphuric acid was needed to reach the neutralization point.
What is the mass percentage of sodium bicarbonate in the sample?
[$NaHCO_3$ = 84 g/mol]

(A) 3% (B) 6% (C) 12% (D) 24%

64 A 0.2 g sample of a mixture containing sodium chloride and sodium hydroxide needed 10 mL of 0.2 M hydrochloric acid to react completely with it.
What is the mass percentage of sodium chloride in the mixture?
[Na = 23 , O = 16 , H = 1]

(A) 80% (B) 60% (C) 40% (D) 20%

65 10 mL of HCl acid is needed to neutralize 0.3 g of an impure sample of magnesium oxide, and 3 mL of the same acid is needed to neutralize 0.045 g of pure calcium carbonate.
What is the percentage of magnesium oxide in the impure sample?
[MgO = 40 g/mol , $CaCO_3$ = 100 g/mol]

(A) 20% (B) 30% (C) 60% (D) 80%

66 Excess dilute hydrochloric acid was added to an impure sample of calcium carbonate of mass 12 g, and 2.64 L of carbon dioxide gas formed (at STP).

What is the degree of purity of the calcium carbonate sample?

[$CaCO_3$ = 100 g/mol]

(A) 42.75% (B) 47.88% (C) 70% (D) 98.2%

67 A sample of calcium carbonate of purity 85% and mass 100 g needs, for its titration, 2.5 L of hydrochloric acid of concentration .....

[$CaCO_3$ = 100 g/mol]

(A) 0.34 M (B) 0.4 M (C) 0.68 M (D) 0.8 M

68 An aqueous solution containing 6.5 g of 90% pure NaCl was electrolysed according to the following equation:

$2NaCl(aq) + 2H_2O(l) \rightarrow Cl_2(g) + H_2(g) + 2NaOH(aq)$

What volume of 1 M hydrochloric acid is needed to completely neutralize the NaOH produced?

[NaCl = 58.5 g/mol]

(A) 100 mL (B) 200 mL (C) 1000 mL (D) 2000 mL

69 A sample of magnesium carbonate of mass 1.68 g was divided into two equal parts, and the following was added:

- to the first part, 25 mL of 2 M HCl acid (first case).
- to the second part, 25 mL of 0.25 M H_2SO_4 acid (second case).

What is the volume of the gas produced in each case (at STP)?

[$MgCO_3$ = 84 g/mol]

(A) In the first case: 140 mL , in the second case: equal to the volume of gas in the first case.

(B) In the first case: 140 mL , in the second case: greater than the volume of gas in the first case.

(C) In the first case: 224 mL , in the second case: less than the volume of gas in the first case.

(D) In the first case: 224 mL , in the second case: equal to the volume of gas in the first case.

70 A sample of a hydrated salt of mass 4.92 g was heated until its mass became constant at 2.4 g. What is the number of molecules of water of crystallization in the sample?
[H_2O = 18 g/mol]

(A) 8.428×10^{22} Molecule (B) 4.34×10^{24} Molecule
(C) 14 Molecule (D) 7 Molecule

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71 When a sample of hydrated calcium chloride was strongly heated, 24.5% of the mass of the sample was lost. What is the molecular formula of the hydrated salt?
[$CaCl_2$ = 111 g/mol , H_2O = 18 g/mol]

(A) $CaCl_2.4H_2O$ (B) $CaCl_2.3H_2O$ (C) $CaCl_2.2H_2O$ (D) $CaCl_2.6H_2O$

---

72 When 2.68 g of sodium sulphate crystals were strongly heated, 1.26 g of water evaporated. It is concluded from this that the molecular formula of these crystals is .....
[Na = 23 , S = 32 , O = 16 , H = 1]

(A) $Na_2SO_4.H_2O$ (B) $2Na_2SO_4.H_2O$ (C) $Na_2SO_4.7H_2O$ (D) $Na_2SO_4.8H_2O$

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73 What is the number of moles of water of crystallization in one mole of hydrated zinc sulphate crystals whose molar mass is 287.4 g/mol?
[Zn = 65.4 , S = 32 , O = 16 , H = 1]

(A) 5 mol (B) 6 mol (C) 7 mol (D) 8 mol

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74 A sample of hydrated cobalt chloride $CoCl_2.6H_2O$ was strongly heated until its mass became constant at 1.7 g.
What is the number of moles of water vapour driven off from the sample?
[$CoCl_2$ = 130 g/mol]

(A) 0.156 mol (B) 0.0156 mol (C) 0.078 mol (D) 0.78 mol

---

75 If the percentage of water of crystallization in hydrated magnesium sulphate equals 51.22%, what is the value of (X) in $MgSO_4.XH_2O$?
[$MgSO_4$ = 120 g/mol , H_2O = 18 g/mol]

(A) 1 (B) 2 (C) 3 (D) 7

---

76 A sample of hydrated sodium carbonate $Na_2CO_3.XH_2O$ was completely neutralized by 50 mL of 0.1 M hydrochloric acid. What is the number of moles of water of crystallization in the sample?

(A) 0.025X mol (B) 0.05X mol (C) 0.0025X mol (D) 0.052X mol

77 A 2 g sample of crystalline sodium carbonate $Na_2CO_3.XH_2O$ needs 0.025 mol of HCl acid for its titration.

What is the value of the number of moles of water of crystallization (X)?

[Na_2CO_3 = 106 g/mol , H_2O = 18 g/mol]

(A) 3 mol (B) 5 mol (C) 7 mol (D) 10 mol

78 0.2537 g of washing soda crystals (crystalline sodium carbonate) was dissolved in water to make a solution of volume 20 mL. Titrating this volume of the solution needed 10.8 mL of 0.05 M sulphuric acid.

What is the percentage of water of crystallization in these crystals?

[Na_2CO_3 = 106 g/mol]

(A) 22.56% (B) 34.32% (C) 46.12% (D) 77.44%

79 A sample of $CuSO_4.XH_2O$ of mass 8.84 g was completely dried and its mass became 5.65 g.

What is the number of water molecules in a mole of the hydrated salt?

[$CuSO_4$ = 159.5 g/mol , H_2O = 18 g/mol]

(A) 1.204×10^{24} Molecule (B) 1.07×10^{23} Molecule

(C) 3.01×10^{24} Molecule (D) 2.14×10^{23} Molecule

80 Gravimetric analysis by the precipitation method is carried out by reacting dilute sulphuric acid with .....

(A) barium chloride solution. (B) sodium hydroxide solution.

(C) sodium nitrate solution. (D) copper(II) carbonate salt.

81 15 mL of 1 M $AgNO_3$ solution was added to 10 mL of 1 M K_2CrO_4 solution, and a precipitate formed.

Which ions are present in the reaction mixture after the reaction ends?

(A) Ag^+ , NO_3^- , K^+ , CrO_4^{2-} (B) Ag^+ , NO_3^- , K^+

(C) K^+ , CrO_4^{2-} (D) NO_3^- , K^+ , CrO_4^{2-}

82 In a laboratory experiment, 4 mL of 1 M iron(III) chloride solution was mixed with 4 mL of 1 M sodium hydroxide solution.

What can be observed when the reaction ends?

(A) A reddish-brown precipitate forms in a solution of one compound.

(B) A greenish-white precipitate forms in a solution of one compound.

(C) A reddish-brown precipitate forms in a solution of two compounds.

(D) A greenish-white precipitate forms in a solution of two compounds.

---

83 When excess silver nitrate solution is added to a water sample containing chloride ions, 1 g of silver chloride precipitates.

What is the mass of the chloride ions in the sample?

Molar mass: AgCl = 143.5 g/mol , Cl^- = 35.5 g/mol

(A) 0.25 g (B) 0.34 g (C) 0.5 g (D) 0.75 g

---

84 Excess hot conc. H_2SO_4 was added to a pure sample of sodium bromide salt of mass 25.75 g.

What is the mass of the fumes given off that turn a moistened starch paper yellow?

[Na = 23 , Br = 80]

(A) 20 g (B) 40 g (C) 80 g (D) 160 g

---

85 All the chloride ions [Cl = 35.5] in a 3.734 g sample of a metal chloride precipitate after 70.9 mL of 0.2 M $AgNO_3$ solution is added to it. What is the mass percentage of chloride ions in the sample?

(A) 50.52 % (B) 13.48 % (C) 1.425 % (D) 7.391 %

---

86 A 3 g sample of an alloy made of Pb and Sn was dissolved in nitric acid, then sulphuric acid was added to it, and 2.37 g of $PbSO_4$ precipitated, assuming that all the lead was precipitated.

What is the percentage of the element Sn in the sample?

[$PbSO_4$ = 303 g/mol , Pb = 207 g/mol]

(A) 54% (B) 1.62% (C) 1.38% (D) 46%

---

87 To precipitate 80% of the silver ions in 0.5 L of 0.1 M $AgNO_3$ solution, we use .....

(A) 1 L of HCl solution (0.05 M).

(B) 0.1 L of $CaCl_2$ solution (0.2 M).

(C) 0.25 L of NH_4Cl solution (0.15 M).

(D) 0.3 L of $MgCl_2$ solution (0.2 M).

---

88 2 mol of iron(III) hydroxide can be obtained by reacting 1 mol of red iron oxide with hot conc. nitric acid, then reacting the iron salt produced with sodium hydroxide solution.
What mass of iron(III) oxide is needed to precipitate 53.6 g of iron(III) hydroxide?
[Fe_2O_3 = 159.7 g/mol , $Fe(OH)_3$ = 106.85 g/mol]

(A) 80 g (B) 71.6 g (C) 40 g (D) 35.8 g

89 A solid mixture of NaCl and Na_2CO_3 of mass 11.15 g was titrated using 200 mL of 0.5 M HCl(aq), then excess lead(II) nitrate solution was added to the solution formed.
What is the mass of the precipitate formed?
[NaCl = 58.5 g/mol , $PbCl_2$ = 278 g/mol , Na_2CO_3 = 106 g/mol]

(A) 2.78 g (B) 27.8 g (C) 13.9 g (D) 55.6 g

90 Iron can be extracted from magnetite ore in the same way as iron is extracted from haematite ore in the blast furnace. If 4.959 ton of iron can be produced from 7.87 ton of magnetite ore, then the percentage purity of the ore equals .....
[Fe = 55.85 , Fe_3O_4 = 231.55 g/mol]

(A) 31% (B) 45% (C) 68% (D) 87%

Essay questions — 7 questions

1 One mole of sodium hydroxide solution reacts completely with one mole of acid (X), and 25 mL of acid (X) is needed to react completely with 20 mL of 0.1 M sodium hydroxide solution. Calculate the concentration of the acid (X) used.

2 20.2 mL of 0.1 M NaOH solution reacts completely with 20.2 mL of a dibasic acid. Calculate the concentration of the acid used.

3 Each litre of a solution contains 12.6 g of the acid H_3XO_3, and 25 mL of this acid reacts with 25 mL of 0.1 M NaOH solution according to the equation:

$H_3XO_3 + NaOH \rightarrow NaH_2XO_3 + H_2O$

[H = 1 , O = 16]

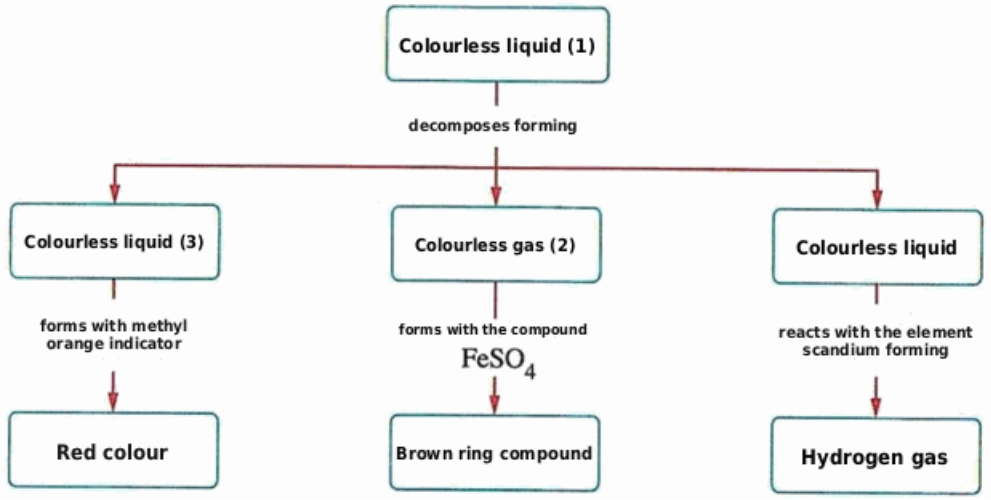
Calculate the gram atomic mass of the element (X).

4 The following chart shows the results of the decomposition of the unstable compound (1):

Write the balanced symbolic equation for the reaction of each of:

(1) gas (2) with oxygen.

(2) the hot concentrated liquid (3) with copper.



5 Calculate the mass of the solid remaining after strongly heating a 5 g sample of the compound $Na_2B_4O_7.10H_2O$, after all the water of hydration has evaporated.

[$Na_2B_4O_7$ = 201.2 g/mol , H_2O = 18 g/mol]

6 An impure sample of hydrogen peroxide of mass 5 g decomposes in the presence of MnO_2, forming 1.12 L of oxygen gas (at STP), according to the equation:

$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$

[H = 1 , O = 16]

Calculate the percentage purity of the hydrogen peroxide in the sample.

7 Calculate the mass of the precipitate formed by adding 10 mL of 0.25 mol/L sodium hydroxide solution to excess aluminium nitrate solution.

[Al = 27 , O = 16 , H = 1]

Past exam questions — 46 questions

1 When 200 mL of 0.2 M sulphuric acid is added to 300 mL of 0.2 M calcium hydroxide according to the following equation:

$H_2SO_4 + Ca(OH)_2 \rightarrow CaSO_4 + 2H_2O$

Which of the following represents the concentration of the substance left unreacted?

(Sample exam 2026)

(A) 0.080 M (B) 0.040 M (C) 0.066 M (D) 0.0100 M

---

2 44.8 g of potassium hydroxide was dissolved in water to make 500 mL of solution, and 10 mL of this solution was titrated using 0.2 M sulphuric acid.

Which of the following represents the volume of acid consumed?

[K = 39 , H = 1 , O = 16]

(Sample exam 2026)

(A) 8 mL (B) 40 mL (C) 180 mL (D) 160 mL

---

3 14.3 g of hydrated sodium carbonate $Na_2CO_3.10H_2O$ was dissolved in water to form a solution of volume 500 mL, and 25 mL of this solution was titrated with 25 mL of hydrochloric acid.

Which of the following represents the concentration of the hydrochloric acid?

[Na = 23 , C = 12 , O = 16 , H = 1]

(Sample exam 2026)

(A) 0.1 M (B) 0.2 M (C) 0.3 M (D) 0.4 M

---

4 A 200 mL solution of 0.01 M sodium hydroxide: which of the following represents the mass of sodium hydroxide that must be added so that the concentration of the solution becomes 0.7 M?

[NaOH = 40 g/mol]

(Sample exam 2026)

(A) 0.138 g (B) 0.381 g (C) 5.52 g (D) 52.5 g

---

5 0.5 g of a metal chloride salt (MCl) was dissolved in water, and excess silver nitrate was added to the solution, so 0.963 g of silver chloride precipitated. The gram atomic mass of the metal M equals .....

[Ag = 108 g/mol , Cl = 35.5 g/mol]

(Sample exam 2026)

(A) 39 (B) 23 (C) 40 (D) 24

6 A 0.2 M potassium hydroxide solution of volume (X) had 20 mL of distilled water added to it, and 20 mL of the resulting solution was titrated with a sulphuric acid solution containing 0.1176 g of the acid.

Which of the following represents the volume of potassium hydroxide (X)?

[H = 1 , S = 32 , O = 16]

(Sample exam 2026)

(A) 30 mL (B) 20 mL (C) 50 mL (D) 40 mL

7 100 mL of 0.5 M calcium hydroxide was added to 200 mL of 0.6 M hydrochloric acid according to the following equation:

$2HCl + Ca(OH)_2 \rightarrow CaCl_2 + 2H_2O$

Which of the following represents the concentration of the reactant left over?

(Sample exam 2026)

(A) 0.2 M (B) 0.0667 M (C) 0.633 M (D) 0.316 M

8 A sample of hydrated crystals of acid (A) ($A.XH_2O$) of mass 2.52 g was dissolved in distilled water to make a solution of volume 250 mL. 25 mL of this solution was titrated with 0.08 M sodium hydroxide solution containing 0.16 g of the solute.

Which of the following represents the number of molecules of water of crystallization (X) and the type of the acid?

[NaOH = 40 g/mol , molar mass of the acid = 90 g/mol]

(Sample exam 2026)

(A) X = 2 and the acid is diprotic.
(B) X = 1 and the acid is monoprotic.
(C) X = 2 and the acid is triprotic.
(D) X = 3 and the acid is triprotic.

9 An impure sample of aluminium sulphate $Al_2(SO_4)_3$ of mass 5 g was dissolved in water, then excess ammonia solution was added until aluminium hydroxide was completely precipitated. The precipitate was separated and dried, and its mass was 2.03 g.
Which of the following represents the percentage of aluminium in the sample?
[Al = 27 , S = 32 , N = 14 , O = 16 , H = 1]
(Sample exam 2026)

(A) 85.95% (B) 14.05% (C) 52.5% (D) 8.75%

10 A mixture of sodium phosphate and potassium iodide of mass 12 g was dissolved in water, and excess silver nitrate solution was added to it, forming a yellow precipitate of mass X g. Then excess ammonium hydroxide solution was added, and a precipitate of mass 8.5 g remained.
Which of the following represents the mass of the precipitate (X)?
[Ag = 108 , K = 39 , Na = 23 , I = 127 , P = 31 , O = 16 , N = 14]
(Sample exam 2026)

(A) 6 g (B) 8.5 g (C) 15.252 g (D) 23.82 g

11 Given that 16 mL of potassium hydroxide solution is needed to titrate 32 mL of sulphuric acid,
which of the following represents the concentration of the sulphuric acid?
(Sample exam 2026)

(A) Equal to the concentration of the potassium hydroxide.
(B) Half the concentration of the potassium hydroxide.
(C) A quarter of the concentration of the potassium hydroxide.
(D) Four times the concentration of the potassium hydroxide.

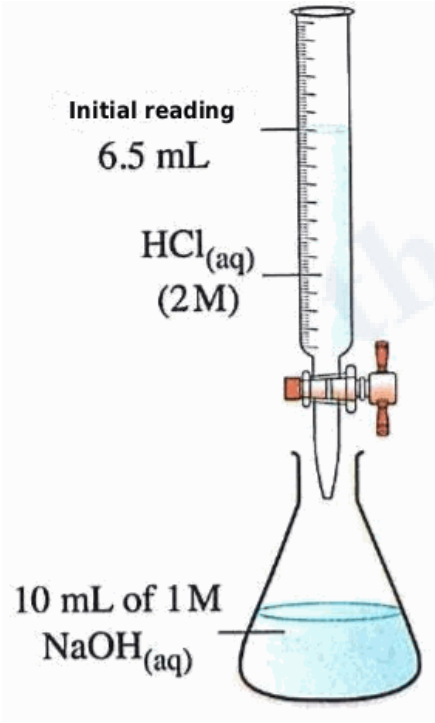
12 Four solutions are produced by dissolving equal masses of four different substances in distilled water, and all of them have the same volume.
Which of these solutions has the lowest concentration?
[Ca = 40 , K = 39 , O = 16 , H = 1 , Li = 7 , Na = 23 , Cl = 35.5]
(Sample exam 2026)

(A) LiCl (B) KOH (C) NaCl (D) $Ca(OH)_2$

13 When 45 g of a pure sample of hydrated barium chloride $BaCl_2.2H_2O$ is dissolved in 500 mL of distilled water, 84.2 mL of the resulting solution is needed to precipitate all the sulphate anions produced by dissolving 10 g of hydrated sodium sulphate $Na_2SO_4.XH_2O$ in water.
Which of the following represents the chemical formula of the hydrated sodium sulphate?
[$BaCl_2.2H_2O$ = 244 g/mol , $BaCl_2$ = 208 g/mol , Na_2SO_4 = 142 g/mol]
(Sample exam 2026)

(A) $Na_2SO_4.5H_2O$ (B) $Na_2SO_4.7H_2O$ (C) $Na_2SO_4.10H_2O$ (D) $Na_2SO_4.8H_2O$

14 The opposite figure shows the titration of a sodium hydroxide solution using hydrochloric acid.
When the neutralization point is reached, the burette reading becomes .....
(Sample exam 2026)



(A) 5 mL (B) 6.5 mL (C) 1.5 mL (D) 11.5 mL

15 An impure sample of solid magnesium chloride of mass 10 g reacted completely with conc. sulphuric acid, then excess sodium carbonate solution was added to the solution of the salt produced, and a precipitate of mass 7 g formed.
Which of the following represents the percentage of magnesium chloride in the sample?
[Mg = 24 , Na = 23 , C = 12 , Cl = 35.5 , O = 16 , S = 32]
(Sample exam 2026)

(A) 16.79% (B) 20.84% (C) 79.16% (D) 83.84%

16 When a sample of hydrated iron chloride $FeClx.6H_2O$ of mass 5.34 g is strongly heated, 60.08% of the mass of the sample remains when the mass becomes constant. The oxidation number of iron (x) in this compound equals .....

[Fe = 56 , Cl = 35.5 , H = 1 , O = 16]

(Sample exam 2026)

(A) +1 (B) +2 (C) +3 (D) +6

17 When an alkaline solution of concentration (M) is titrated with a 0.5 M acid, at the neutralization point the volume of acid consumed was found to equal the volume of the alkali. Which of the following choices represents the acid and the alkali?

(Sample exam 2026)

(A) Hydrochloric acid and calcium hydroxide.

(B) Sulphuric acid and potassium hydroxide.

(C) Hydrochloric acid and potassium hydroxide.

(D) Sulphuric acid and calcium hydroxide.

18 12 g of a mixture of the salts potassium chloride and potassium carbonate was dissolved in water, then excess magnesium sulphate solution was added to the solution, and a precipitate of mass 5 g formed.

Which of the following represents the percentage of potassium chloride in the mixture?

[K = 39 , C = 12 , O = 16 , Mg = 24]

(Sample exam 2026)

(A) 35.44% (B) 68.45% (C) 31.55% (D) 40.91%

19 When 0.2 mol of the anhydrous salt XCl_2 combines with 7.2 g of water, a hydrated salt with the chemical formula $XCl_2.nH_2O$ forms.

Which of the following represents the value of (n)?

[H = 1 , O = 16]

(Sample exam 2026)

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

20 9.636 g of $CuSO_4.XH_2O$ was dissolved in water, then excess $BaCl_2$ solution was added to it, and a precipitate of mass 9 g formed.

Which of the following represents the value of (X)?

[Ba = 137 , S = 32 , O = 16 , Cu = 63.5 , Cl = 35.5 , H = 1]

(1st session 2025)

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

---

21 A pure sample of sodium carbonate of mass 5.3 g was dissolved in water, then 100 mL of HCl (0.5 M) was added to it, then excess magnesium chloride solution.

Which of the following represents the mass of the precipitate formed?

[Mg = 24 , C = 12 , O = 16 , H = 1 , Cl = 35.5 , Na = 23]

(1st session 2025)

(A) 4.20 g (B) 2.10 g (C) 1.05 g (D) 8.40 g

---

22 20 mL of 0.1 M clear limewater was added to 12 mL of 0.5 M hydrochloric acid, and after a sufficient period of time, 10 mL of sodium hydroxide solution was added to complete the titration.

Which of the following represents the concentration of the sodium hydroxide solution?

(Sample exam 2025)

(A) 0.05 M (B) 0.1 M (C) 0.2 M (D) 0.45 M

---

23 In the hydrated salt $MCl_2.XH_2O$, 0.4 mol of the anhydrous salt is bound to 14.4 g of water. Given that the molar mass of the hydrated salt is 244 g/mol, the atomic mass of the metal M equals .....

[Cl = 35.5 , O = 16 , H = 1]

(Sample exam 2025)

(A) 24 g/mol (B) 137 g/mol (C) 40 g/mol (D) 172 g/mol

---

24 A 10 mL solution of 0.5 M hydrochloric acid reacted completely with 20 mL of a solution containing 0.5 g of a mixture of sodium carbonate and sodium chloride.

The mass of the chloride ion in the mixture is .....

[Na = 23 , Na_2CO_3 = 106 , NaCl = 58.5 , Cl = 35.5]

(2nd session 2024)

(A) 0.143 g (B) 0.265 g (C) 0.235 g (D) 0.207 g

25 Excess $AgNO_3$ was added to a solution containing an equal number of moles of sodium chloride and magnesium chloride, and 12 g of a white precipitate formed. The masses of sodium chloride and magnesium chloride in grams are .....

[NaCl = 58.5 g/mol , $MgCl_2$ = 95 g/mol , AgCl = 143.5 g/mol]

(2nd session 2024)

(A) NaCl = 2.65 g , $MgCl_2$ = 1.63 g
(B) NaCl = 1.63 g , $MgCl_2$ = 2.65 g
(C) NaCl = 4.305 g , $MgCl_2$ = 3.65 g
(D) NaCl = 3.65 g , $MgCl_2$ = 4.305 g

26 An amount of water was added to 100 mL of 0.4 M sulphuric acid to dilute it. 8 mL of the diluted acid was neutralized by 20 mL of 0.2 M potassium hydroxide.

The volume of water that must be added to dilute the acid is .....

(1st session 2024)

(A) 40 mL
(B) 60 mL
(C) 100 mL
(D) 160 mL

27 When 200 mL of distilled water is added to 0.5 L of 0.1 M NaOH solution, the concentration of the solution becomes .....

(2nd session 2021)

(A) 0.714 M
(B) 0.0714 M
(C) 7.14 M
(D) 4.17 M

28 To determine the concentration of a silver nitrate solution, a standard solution of ..... is used.

(Trial exam / March 2023)

(A) Na_3PO_4
(B) $NaHCO_3$
(C) HNO_3
(D) CH_3COOK

29 Excess hot conc. sulphuric acid was added to 0.1 mol of magnetic iron oxide, then excess sodium hydroxide was added to the products. The total mass of the precipitates formed is .....

[Given the molecular masses: $Fe(OH)_3$ = 107 , $Fe(OH)_2$ = 90]

(2nd session 2023)

(A) 30.4 g
(B) 19.7 g
(C) 152 g
(D) 60.8 g

30 When sodium hydroxide solution is added to 10 mL of 0.1 M aluminium sulphate solution to obtain a clear solution, the mass of sodium hydroxide needed for the reaction equals .....
[Given that the molar mass of NaOH = 40 g/mol]
(Trial exam / March 2023)

(A) 2.40 g (B) 320 g (C) 0.320 g (D) 0.24 g

31 20 mL of 0.1 M NaOH solution was titrated with 0.1 M HCl acid solution. If the hydrochloric acid is replaced by 0.1 M sulphuric acid, the volume of sulphuric acid used is .....
(Trial exam / June 2021)

(A) half the volume of HCl acid
(B) twice the volume of HCl acid
(C) equal to the volume of HCl acid
(D) twice the volume of the alkali NaOH

32 When NaOH solution is titrated with dilute sulphuric acid solution, if the two solutions have the same concentration, then at neutralization the volume of acid used is .....
(1st session 2021)

(A) equal to the volume of the alkali.
(B) half the volume of the alkali.
(C) twice the volume of the alkali.
(D) four times the volume of the alkali.

33 0.125 mol of hot conc. sulphuric acid reacted with excess sodium nitrate, and when the nitric acid produced was titrated, it was neutralized by 200 mL of sodium hydroxide solution. The concentration of the sodium hydroxide is .....
[Given the molar masses: H_2SO_4 = 98 g/mol , HNO_3 = 63 g/mol]
(Trial exam / March 2023)

(A) 6.25 M (B) 0.12 M (C) 0.625 M (D) 1.25 M

34 14.3 g of hydrated sodium carbonate $Na_2CO_3.XH_2O$ was dissolved in water and the volume was made up to one litre, and 25 mL of this solution was neutralized with 25 mL of 0.1 mol/L hydrochloric acid.
The percentage of water of crystallization equals .....
[O = 16 , C = 12 , Na = 23]
(Trial exam / May 2021)

(A) 31.65% (B) 15.73% (C) 25.87% (D) 62.94%

35 A sample containing a mixture of the two salts sodium chloride and sodium phosphate of mass 10 g was dissolved in water, and excess aqueous barium chloride solution was added to it. The mass of the precipitate formed was 6 g, so the percentage of sodium phosphate in the sample is .....

[Ba = 137 , Na = 23 , P = 31 , O = 16]

(Trial exam / May 2021)

(A) 65.5% (B) 49.05% (C) 32.7% (D) 16.35%

---

36 To distinguish between two solutions that are both blue, one containing litmus indicator and the other containing bromothymol blue indicator, a solution of ..... can be used.

(2nd session 2023)

(A) H_2SO_4 (B) NH_4OH (C) Na_2CO_3 (D) NaCl

---

37 1 L of 0.3 M calcium chloride solution was added to 1 L of 0.4 M sulphuric acid, then barium hydroxide solution was added to neutralize the excess acid, and a precipitate formed. The number of moles of excess acid and the mass of the precipitate formed are .....

[Given the molar masses: $Ba(OH)_2$ = 171 g/mol , $BaSO_4$ = 233 g/mol , H_2SO_4 = 98 g/mol]

(1st session 2023)

(A) 46.6 g / 0.2 mol (B) 93.2 g / 0.1 mol (C) 23.3 g / 0.1 mol (D) 69.9 g / 0.3 mol

---

38 4 g of impure sodium chloride was dissolved in water, and excess silver nitrate solution was added to it, so 3.52 g of silver chloride precipitated. The mass percentage of the chloride ion in the sample equals .....

[Ag = 108 , Cl = 35.5]

(Trial exam / June 2021)

(A) 21.77% (B) 20.8% (C) 22.8% (D) 19.77%

---

39 2 g of (impure) barium chloride was dissolved in water, and excess lead(II) nitrate solution was added to it. The mass of the precipitate was 1 g, so the percentage of the chloride anion in the sample equals .....

[Cl = 35.5 , Ba = 137 , Pb = 207]

(2nd session 2021)

(A) 19.31% (B) 46.3% (C) 28.3% (D) 12.77%

---

40 3.4 g of (impure) potassium chloride was dissolved in water, and excess silver nitrate solution was added to it, so 6.7 g of silver chloride precipitated. The mass percentage of the chloride ion in the sample equals .....

[K = 39 , Cl = 35.5 , Ag = 108]

(1st session 2021)

(A) 24.5% (B) 46.7% (C) 48.7% (D) 94.1%

41 A mixture of calcium hydroxide and calcium chloride of mass 4 g needed 100 mL of 0.5 M HCl acid for its titration.

The percentage of calcium hydroxide in the mixture is .....

[Ca = 40 , O = 16 , H = 1 , Cl = 35.5]

(1st session 2022)

(A) 7.5% (B) 46.25% (C) 53.57% (D) 92.50%

42 Excess barium chloride solution was added to the solution of an impure sample of potassium sulphate of mass 4 g, and a precipitate of mass 4.66 g formed. The percentage of impurities in the sample equals .....

[Ba = 137 , S = 32 , O = 16 , K = 39 , H = 1]

(1st session 2022)

(A) 87% (B) 13% (C) 67.5% (D) 32.5%

43 A hydrated salt in which the percentage of water is 36.072%, and each mole of it is bound to five moles of water of crystallization. The molecular weight of the anhydrous salt equals .....

[H_2O = 18]

(1st session 2024)

(A) 90 g (B) 159.5 g (C) 249.5 g (D) 250 g

44 An impure sample of iron(III) chloride of mass 3 g was dissolved in water, then the reagent of the third analytical group was added to it, producing 1.6 g of precipitate. The percentage of iron in the sample equals .....

[H = 1 , Fe = 56 , Cl = 35.5 , O = 16]

(2nd session 2022)

(A) 80.7% (B) 62.76% (C) 27.9% (D) 33.1%

45 A mixture of sodium carbonate and sodium chloride of mass 0.4 g was titrated with 20 mL of 0.05 M hydrochloric acid, so the percentage of sodium chloride in the sample equals .....

[Na = 23 , O = 16 , H = 1 , C = 12 , Cl = 35.5]

(2nd session 2022)

(A) 86.75% (B) 73.5% (C) 26.5% (D) 13.25%

46 20 mL of 0.1 mol/L sodium hydroxide solution was added to a sulphuric acid solution of volume 10 mL and concentration 0.2 mol/L.

Which of the following represents the type of the resulting solution and its effect on the colour of the indicator?

(Trial exam / May 2021)

(A) Neutral , turns bromothymol blue green

(B) Acidic , turns phenolphthalein red

(C) Acidic , turns methyl orange red

(D) Basic , turns litmus solution blue

Answer key and solutions

Multiple choice questions

1 C	2 D	3 C	4 B	5 B	6 B	7 C	8 A	9 B	10 B
11 A	12 A	13 B	14 B	15 B	16 A	17 D	18 B	19 C	20 B
21 D	22 A	23 D	24 A	25 D	26 A	27 B	28 D	29 A	30 C
31 C	32 A	33 D	34 B	35 B	36 D	37 C	38 B	39 A	40 A
41 D	42 B	43 A	44 A	45 B	46 C	47 A	48 B	49 C	50 D
51 B	52 C	53 D	54 C	55 D	56 A	57 C	58 C	59 C	60 D
61 B	62 A	63 C	64 B	65 A	66 D	67 C	68 A	69 C	70 A
71 C	72 C	73 C	74 C	75 D	76 C	77 A	78 D	79 C	80 A
81 D	82 C	83 A	84 A	85 B	86 D	87 B	88 C	89 B	90 D

1 **Answer (C)**

Molar mass of Na_2CO_3 = 2×23 + 12 + 3×16 = 106 g/mol

Number of moles = 26.5 ÷ 106 = 0.25 mol

2 **Answer (D)**

A hydrogen molecule H_2 contains two atoms.

Number of atoms = $2 \times 6.02 \times 10^{23} = 12.04 \times 10^{23}$ atom

3 **Answer (C)**

Number of moles of O_2 = 16 ÷ 32 = 0.5 mol

Volume = 0.5 × 22.4 = 11.2 L

4 **Answer (B)**

Molar mass of the gas = density × 22.4 = 3.1696 × 22.4 ≈ 71 g/mol

The active gas is chlorine Cl_2 (a diatomic molecule), so the atomic mass = 71 ÷ 2 = 35.5 g/mol

5 **Answer (B)**

Number of moles of HCl = $6.02 \times 10^{22} \div 6.02 \times 10^{23} = 0.1$ mol

0.05 mol of the salt gave 0.1 mol of HCl, so the formula contains two chlorine atoms.

The salt is $BaCl_2$.

6 **Answer (B)**

$HCl + NaOH \rightarrow NaCl + H_2O$

Each 1 mol of HCl produces 1 mol of water, so it is 0.1 mol.

Number of molecules = $0.1 \times 6.02 \times 10^{23} = 6.02 \times 10^{22}$ molecule

7 **Answer (C)**

$2NO + O_2 \rightarrow 2NO_2$

0.01 L of O_2 reacts completely with 0.02 L of NO, so nothing is left of either gas.

Volume of NO_2 produced = 0.02 L

8 **Answer (A)**

Number of moles of Mg = $18 \div 24 = 0.75$ mol

Every 3 mol of Mg need 1 mol of N_2.

Number of moles of $N_2 = 0.75 \div 3 = 0.25$ mol

9 **Answer (B)**

Concentration = number of moles ÷ volume in litres = $0.5 \div 0.5 = 1$ M

10 **Answer (B)**

The number of moles is constant = $5 \times 1 = 5$ mol

Total volume = 9 + 1 = 10 L

Concentration = $5 \div 10 = 0.5$ M

11 **Answer (A)**

Number of moles = $0.2 \times 40 = 8$ mmol

Total volume = 40 + 200 = 240 mL

Concentration = $8 \div 240 \approx 0.033$ M

12 **Answer (A)**

Dilution does not change the number of moles: $M_1V_1 = M_2V_2$

$0.5 \times 200 = 0.25 \times V_2$, so the total volume = 400 mL

13 **Answer (B)**

$M_1V_1 = M_2V_2$, so $3 \times 20 = 0.5 \times V_2$, i.e. $V_2 = 120$ mL

Volume of water added = $120 - 20 = 100$ mL

14 **Answer (B)**

Total number of moles = $3 \times 0.25 + 2 \times 0.35 = 0.75 + 0.7 = 1.45$ mol

Total volume = 0.6 L

Concentration = $1.45 \div 0.6 \approx 2.42$ M

15 **Answer (B)**

$Mg(NO_3)_2$ gives two nitrate ions per formula unit.

Number of moles of nitrate = $2 \times 0.23 \times 300 = 138$ mmol

Volume after dilution = 500 mL

Concentration = $138 \div 500 = 0.276$ M

16 **Answer (A)**

Number of moles of $K_2SO_4 = 0.2 \times 0.3 = 0.06$ mol

Each formula unit gives two potassium ions, so the number of moles of $K^+ = 0.12$ mol

Number of ions = $0.12 \times 6.02 \times 10^{23} \approx 7.2 \times 10^{22}$ ion

17 **Answer (D)**

The formula is Fe_2O_3 and its molar mass = $2 \times 55.86 + 3 \times 16 = 159.72$ g/mol

Percentage of iron = $(111.72 \div 159.72) \times 100 \approx 69.9\%$

18 **Answer (B)**

Magnetite Fe_3O_4 is what reacts with the acid, and the impurities do not react.

Percentage purity = $(15 \div 20) \times 100 = 75\%$

Percentage of impurities = $100 - 75 = 25\%$

19 **Answer (C)**

At the end point of the titration, the solution of unknown concentration is completely consumed by the standard solution.

20 **Answer (B)**

Titrating an acidic solution with a standard solution is a neutralization reaction, not oxidation-reduction.

The other choices are reactions in which oxidation numbers change (oxidation and reduction).

21 **Answer (D)**

To determine chloride we use a reagent that precipitates it, which is $AgNO_3$, forming a white precipitate of AgCl.

22 **Answer (A)**

Sodium carbonate is a base, so we titrate it with a standard acid solution, HCl.

23 **Answer (D)**

The NaOH, Na_2SO_4 and NaCl solutions have a known concentration (1 M), so they are standard solutions.

The formation of the precipitates AgCl, $BaSO_4$ and $Fe(OH)_3$ shows precipitation reactions.

24 **Answer (A)**

(1) Iron is oxidised by bromine; it is oxidation-reduction.

(2) A precipitate of AgCl forms; it is precipitation.

(3) An acid with a base produces a salt and water; it is neutralization.

25 **Answer (D)**

Bromothymol blue is green in pure water and yellow in acid, so it distinguishes between them.

Phenolphthalein is colourless in water and in acid, so it does not distinguish.

26 **Answer (A)**

Bromothymol blue is yellow in acid (CH_3COOH).

Methyl orange is yellow in a base (ammonia solution).

27 **Answer (B)**

Solution (X) is the alkaline solution (NaOH or ammonia) that distinguishes between Fe^{2+} and Fe^{3+}.

In a base, litmus and bromothymol blue are blue, and methyl orange is yellow.

28 **Answer (D)**

(1) is red in HCl and blue in Na_2CO_3, so it is litmus.

(2) is yellow in HNO_3 and blue in Na_2CO_3, so it is bromothymol blue.

29 **Answer (A)**

Phenolphthalein is colourless in acid (HCl) and pink in a base (NaOH), so it distinguishes between them.

30 **Answer (C)**

KOH is a base that gives blue with both bromothymol blue and litmus,
so it does not distinguish between them, unlike the other pairs.

31 **Answer (C)**

After adding the Al^{3+} reagent (an alkaline solution), both are blue.
With acids, litmus is red and bromothymol blue is yellow, and in water they are violet and green.

32 **Answer (A)**

Ammonia NH_3 is a base: methyl orange turns yellow and litmus turns blue.
The acidic gases HCl and SO_2 give red with both.

33 **Answer (D)**

HCl: 10 mmol and NaOH: 5 mmol, so 5 mmol of HCl remain and the medium stays acidic.
Methyl orange stays red, and the colour becomes less intense as the H^+ concentration decreases.

34 **Answer (B)**

NaOH: 0.25 mol is more than HCl: 0.2 mol, so 0.05 mol of NaOH remains and the solution is basic.
Bromothymol blue is blue in a base.

35 **Answer (B)**

(X) The thiosulphate reagent is dilute HCl, which is acidic, so methyl orange turns red.
(Y) The third group reagent NH_4OH is alkaline, so methyl orange turns yellow.

36 **Answer (D)**

Number of moles of $H^+ = 2 \times (0.5 \times 40) = 40$ mmol
Number of moles of $OH^- = 0.4 \times 50 = 20$ mmol
The acid is in excess, so the solution is acidic: methyl orange is red, litmus is red and bromothymol blue is yellow.

37 **Answer (C)**

Bromothymol blue is green in a neutral solution (moles of H^+ = moles of OH^-).
KOH: 2.5 mmol of OH^- and HCl: 2.5 mmol of H^+, so they neutralize each other completely.

38 **Answer (B)**

The order: transfer the alkali with the pipette (3), then add the indicator (2), then the initial burette reading (4), then the dropwise addition (1), then the final reading (5).

39 **Answer (A)**

Number of moles of H^+ = 2 × 0.5 × 10 = 10 mmol

Number of moles of OH^- = 2 × 5 = 10 mmol

They are equal, i.e. neutralization is complete.

40 **Answer (A)**

Number of moles of the acid = 0.1 × 25 = 2.5 mmol

Number of moles of KOH = 3 × 2.5 = 7.5 mmol

Volume = 7.5 ÷ 0.2 = 37.5 mL

41 **Answer (D)**

$HNO_3 + NaHCO_3 \rightarrow NaNO_3 + H_2O + CO_2$ (ratio 1 : 1)

Number of moles of the acid = 0.15 × 30 = 4.5 mmol

Volume of $NaHCO_3$ = 4.5 ÷ 0.1 = 45 mL

42 **Answer (B)**

$NaHSO_4 + NaOH \rightarrow Na_2SO_4 + H_2O$ (ratio 1 : 1)

Number of moles of NaOH = 0.01 mol

Volume = 0.01 ÷ 0.2 = 0.05 L = 50 mL

43 **Answer (A)**

$Ba(OH)_2 + H_2SO_4 \rightarrow BaSO_4 + 2H_2O$ (ratio 1 : 1)

Number of moles of the base = 1.63 × 23 ≈ 37.5 mmol

Concentration of the acid = 37.5 ÷ 75 = 0.5 M

44 **Answer (A)**

Number of moles of Na_2CO_3 = 0.5 × 20 = 10 mmol

Number of moles of HCl = 2 × 10 = 20 mmol

Concentration of HCl = 20 ÷ 50 = 0.4 M

45 **Answer (B)**

$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

Number of moles of NaOH = 0.1 × 25 = 2.5 mmol , so the number of moles of the acid = 1.25 mmol

Concentration = 1.25 ÷ 20 = 0.0625 M

46 **Answer (C)**

Number of moles of HCl = 0.1 × 100 = 10 mmol , and number of moles of NaOH = 0.2 × 100 = 20 mmol

10 mmol of NaOH remain in 200 mL.

Concentration = 10 ÷ 200 = 0.05 M, and the solution is basic.

47 **Answer (A)**

$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

Moles of NaOH = 2 × moles of H_2SO_4 , i.e. M × 25 = 2 × M(acid) × 50

Concentration of NaOH = 4 × concentration of the acid

48 **Answer (B)**

Number of moles of MnO_4^- = 0.015 × 22.52 = 0.3378 mmol

Each 1 mol of MnO_4^- reacts with 5 mol of Fe^{2+} , so the number of moles of Fe^{2+} = 1.689 mmol

Concentration = 1.689 ÷ 25 ≈ 0.068 M

49 **Answer (C)**

Number of moles of $H_2C_2O_4$ = 0.134 ÷ 90 = 1.489 mmol

Every 5 mol of the acid react with 2 mol of MnO_4^- , so the number of moles of MnO_4^- = 1.489 × 2 ÷ 5 = 0.5956 mmol

Concentration = 0.5956 ÷ 24.7 ≈ 2.41×10^{-2} M

50 **Answer (D)**

$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$

Number of moles of HCl = 0.45 mol , so the number of moles of Na_2CO_3 = 0.225 mol, i.e. 23.85 g

Mass of the original NaCl = 50 − 23.85 = 26.15 g = 0.447 mol

NaCl produced from the reaction = 0.45 mol

Total = 0.897 mol in 1 L , so the concentration ≈ 0.9 M

51 **Answer (B)**

Number of moles of H_2SO_4 = 0.5 × 20 = 10 mmol , so 20 mmol of NaOH are needed.

40 mL × 0.5 M = 20 mmol , so this is the correct choice.

52 **Answer (C)**

$Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + 2H_2O$, i.e. moles of OH^- = moles of H^+

$Ca(OH)_2$: x mL and y M → 2xy mmol of OH^-

HCl: 2x mL and y M → 2xy mmol of H^+ , so the two amounts are equal.

53 **Answer (D)**

Number of moles of $H_2SO_4 = 1 \times 0.02 = 0.02$ mol

$H_2SO_4 + 2KOH \rightarrow K_2SO_4 + 2H_2O$, so the number of moles of KOH = $2 \times 0.02 = 0.04$ mol

54 **Answer (C)**

$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$

Number of moles of $CaCO_3 = 1 \div 100 = 0.01$ mol , so the number of moles of HCl = 0.02 mol

Volume = $0.02 \div 0.1 = 0.2$ L = 200 mL

55 **Answer (D)**

Number of moles of $NaHCO_3 = 0.84 \div 84 = 0.01$ mol

$HCl + NaHCO_3 \rightarrow NaCl + H_2O + CO_2$ (ratio 1 : 1)

Concentration = $0.01 \div 0.025 = 0.4$ M

56 **Answer (A)**

Mass of NaOH in 500 mL = $1.2 \times 0.5 = 0.6$ g , i.e. $0.6 \div 40 = 15$ mmol

$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$, so the number of moles of the acid = 7.5 mmol

Volume = $7.5 \div 0.2 = 37.5$ mL

57 **Answer (C)**

Number of moles of $H_3PO_4 = 0.1 \times 0.1 = 0.01$ mol , i.e. 0.03 mol of H^+

$Ca(OH)_2$ gives 2 OH^- , so its number of moles = $0.03 \div 2 = 0.015$ mol

Mass = $0.015 \times 74 = 1.11$ g

58 **Answer (C)**

Number of moles of $H_2SO_4 = 0.1 \times 25 = 2.5$ mmol , so the number of moles of NaOH = 5 mmol in 15 mL

Concentration of NaOH = $5 \div 15 = 0.333$ M

Moles of NaOH in 450 mL = $0.333 \times 450 = 150$ mmol , and the mass = $0.15 \times 40 = 6$ g

59 **Answer (C)**

Monoprotic acid: its number of moles = $0.512 \div 204.22 = 2.507$ mmol

This equals the number of moles of NaOH (ratio $1 : 1$).

Concentration = $2.507 \div 36.78 \approx 0.0682$ M

60 **Answer (D)**

Number of moles of NaOH = $0.106 \times 35.2 = 3.731$ mmol

The acid is triprotic, so its number of moles = $3.731 \div 3 = 1.244$ mmol

Molar mass = $0.307 \div 1.244 \times 1000 \approx 246.84$ g/mol

61 **Answer (B)**

Number of moles of the acid = $0.45 \div 90 = 5$ mmol

Number of moles of KOH = $0.5 \times 20 = 10$ mmol

Each mole of the acid uses 2 mol of KOH, so the acid is diprotic.

62 **Answer (A)**

Number of moles of the acid = $0.1 \times 15 = 1.5$ mmol , which equals the number of moles of the base $(1 : 1)$.

Molar mass = $0.06 \div 1.5 \times 1000 = 40$ g/mol

63 **Answer (C)**

$H_2SO_4 + 2NaHCO_3 \rightarrow Na_2SO_4 + 2H_2O + 2CO_2$

Number of moles of the acid = $0.1 \times 7.15 = 0.715$ mmol , so the number of moles of $NaHCO_3$ = 1.43 mmol

Mass = $1.43 \times 84 = 120$ mg = 0.12 g , so the percentage = 12%

64 **Answer (B)**

Number of moles of HCl = $0.2 \times 10 = 2$ mmol , which equals the number of moles of NaOH.

Mass of NaOH = $2 \times 40 = 80$ mg = 0.08 g

Mass of NaCl = $0.2 - 0.08 = 0.12$ g , so the percentage = $(0.12 \div 0.2) \times 100 = 60\%$

65 **Answer (A)**

Pure $CaCO_3$: $0.045 \div 100 = 0.45$ mmol needs 0.9 mmol of HCl in 3 mL , so the acid concentration = 0.3 M

10 mL contains 3 mmol of HCl , so the number of moles of MgO = 1.5 mmol (MgO + 2HCl)

Mass of MgO = $1.5 \times 40 = 60$ mg = 0.06 g , so the percentage = $(0.06 \div 0.3) \times 100 = 20\%$

66 **Answer (D)**

$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$

Number of moles of $CO_2 = 2.64 \div 22.4 = 0.1179$ mol , which equals the number of moles of $CaCO_3$

Pure mass = 11.79 g , so the purity = $(11.79 \div 12) \times 100 \approx 98.2\%$

67 **Answer (C)**

Mass of pure $CaCO_3 = 100 \times 0.85 = 85$ g = 0.85 mol

Number of moles of HCl = $2 \times 0.85 = 1.7$ mol

Concentration = $1.7 \div 2.5 = 0.68$ M

68 **Answer (A)**

Mass of pure NaCl = $6.5 \times 0.9 = 5.85$ g = 0.1 mol

From the equation: 2 mol of NaCl give 2 mol of NaOH , so the number of moles of NaOH = 0.1 mol

Moles of HCl needed = 0.1 mol , so the volume = $0.1 \div 1 = 0.1$ L = 100 mL

69 **Answer (C)**

Each part has a mass of 0.84 g, i.e. 0.01 mol of $MgCO_3$.

First case: HCl = 50 mmol, which is more than needed (20 mmol), so the gas = 0.01 mol = 224 mL

Second case: H_2SO_4 = 6.25 mmol, less than needed (10 mmol), so the gas = 6.25 mmol = 140 mL, less than the first.

70 **Answer (A)**

Mass of water lost = $4.92 - 2.4 = 2.52$ g

Number of moles = $2.52 \div 18 = 0.14$ mol

Number of molecules = $0.14 \times 6.02 \times 10^{23} = 8.428 \times 10^{22}$ molecule

71 **Answer (C)**

Assume a 100 g sample: mass of water 24.5 g, i.e. 1.36 mol

Mass of $CaCl_2$ = 75.5 g, i.e. 0.68 mol

Ratio = $1.36 \div 0.68 = 2$, so the formula is $CaCl_2.2H_2O$

72 **Answer (C)**

Number of moles of water = 1.26 ÷ 18 = 0.07 mol

Mass of Na_2SO_4 = 2.68 − 1.26 = 1.42 g = 0.01 mol (molar mass 142)

Number of moles of water per mole of salt = 0.07 ÷ 0.01 = 7 , so the formula is $Na_2SO_4.7H_2O$

73 **Answer (C)**

Mass of anhydrous $ZnSO_4$ = 65.4 + 32 + 64 = 161.4 g/mol

Mass of water of crystallization = 287.4 − 161.4 = 126 g

Number of moles = 126 ÷ 18 = 7 mol

74 **Answer (C)**

Mass of anhydrous $CoCl_2$ = 1.7 g, i.e. 1.7 ÷ 130 = 0.01308 mol

Each 1 mol of it is bound to 6 mol of water.

Number of moles of water vapour = 6 × 0.01308 ≈ 0.078 mol

75 **Answer (D)**

Assume 100 g of the salt: mass of water 51.22 g and mass of $MgSO_4$ = 48.78 g

X = (51.22 ÷ 18) ÷ (48.78 ÷ 120) = 2.846 ÷ 0.4065 = 7

76 **Answer (C)**

$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$

Number of moles of HCl = 0.1 × 0.05 = 0.005 mol , so the number of moles of Na_2CO_3 = 0.0025 mol

Each mole of the salt has X moles of water of crystallization, so the number of moles of water = 0.0025X mol

77 **Answer (A)**

Number of moles of Na_2CO_3 = 0.025 ÷ 2 = 0.0125 mol

Molar mass of the crystalline salt = 2 ÷ 0.0125 = 160 g/mol

Mass of water = 160 − 106 = 54 g , so the number of moles = 54 ÷ 18 = 3

78 **Answer (D)**

$Na_2CO_3 + H_2SO_4 \rightarrow Na_2SO_4 + H_2O + CO_2$ (ratio 1 : 1)

Number of moles of H_2SO_4 = 0.05 × 10.8 = 0.54 mmol , so the mass of Na_2CO_3 = 0.54 × 106 = 57.24 mg

Mass of water = 0.2537 − 0.05724 = 0.19646 g

Percentage = (0.19646 ÷ 0.2537) × 100 ≈ 77.44%

79 **Answer (C)**

Mass of water = 8.84 − 5.65 = 3.19 g, i.e. 0.1772 mol

Number of moles of $CuSO_4$ = 5.65 ÷ 159.5 = 0.03542 mol

Number of moles of water per mole of salt = 0.1772 ÷ 0.03542 = 5

Number of molecules = $5 \times 6.02 \times 10^{23} = 3.01 \times 10^{24}$ molecule

80 **Answer (A)**

$H_2SO_4 + BaCl_2 \rightarrow BaSO_4 + 2HCl$

A white precipitate of $BaSO_4$ forms, which is filtered and weighed.

81 **Answer (D)**

$2AgNO_3 + K_2CrO_4 \rightarrow Ag_2CrO_4 + 2KNO_3$

Number of moles of Ag^+ = 15 mmol, which needs 7.5 mmol of CrO_4^{2-}, and 10 mmol are available.

2.5 mmol of CrO_4^{2-} are in excess, NO_3^- and K^+ ions remain, and no Ag^+ remains.

82 **Answer (C)**

$FeCl_3 + 3NaOH \rightarrow Fe(OH)_3 + 3NaCl$

NaOH: 4 mmol needs only 1.33 mmol of $FeCl_3$, so $FeCl_3$ is in excess.

Reddish-brown $Fe(OH)_3$ precipitates, and two compounds remain in the solution: $FeCl_3$ and NaCl.

83 **Answer (A)**

Mass of Cl^- = mass of AgCl × (35.5 ÷ 143.5)

= 1 × 0.2474 ≈ 0.25 g

84 **Answer (A)**

Number of moles of NaBr = 25.75 ÷ 103 = 0.25 mol

Hot conc. H_2SO_4 oxidises HBr to reddish-brown bromine Br_2.

$2NaBr \rightarrow Br_2$, so the number of moles of Br_2 = 0.125 mol and its mass = 0.125 × 160 = 20 g

85 **Answer (B)**

Number of moles of Cl^- = number of moles of $AgNO_3$ = 0.2 × 70.9 = 14.18 mmol

Mass of Cl^- = 14.18 × 35.5 = 503.4 mg = 0.5034 g

Percentage = (0.5034 ÷ 3.734) × 100 ≈ 13.48%

86 **Answer (D)**

Number of moles of $PbSO_4$ = 2.37 ÷ 303 = 0.00782 mol , which are the moles of Pb

Mass of Pb = 0.00782 × 207 ≈ 1.62 g

Mass of Sn = 3 − 1.62 = 1.38 g , so the percentage = $(1.38 \div 3) \times 100 = 46\%$

87 **Answer (B)**

Number of moles of Ag^+ = 0.1 × 500 = 50 mmol , and 80% must be precipitated, i.e. 40 mmol of Cl^-

$CaCl_2$: 0.2 × 100 = 20 mmol, which gives 40 mmol of Cl^-, as required.

88 **Answer (C)**

Fe_2O_3 gives 2 mol of $Fe(OH)_3$.

Number of moles of $Fe(OH)_3$ = 53.6 ÷ 106.85 ≈ 0.5 mol , so the number of moles of Fe_2O_3 = 0.25 mol

Mass = 0.25 × 159.7 ≈ 40 g

89 **Answer (B)**

HCl: 0.5 × 200 = 100 mmol reacts with Na_2CO_3, so there are 50 mmol of it, i.e. 5.3 g

Mass of the original NaCl = 11.15 − 5.3 = 5.85 g = 0.1 mol

NaCl produced from the reaction = 0.1 mol , so the total = 0.2 mol

$2NaCl + Pb(NO_3)_2 \rightarrow PbCl_2 + 2NaNO_3$, so the number of moles of $PbCl_2$ = 0.1 mol and the mass = 27.8 g

90 **Answer (D)**

3 mol of Fe are produced from 1 mol of Fe_3O_4.

Number of moles of Fe = 4.959 ÷ 55.85 = 0.08879 , so the number of moles of Fe_3O_4 = 0.0296

Mass of pure Fe_3O_4 = 0.0296 × 231.55 ≈ 6.853 ton

Purity = $(6.853 \div 7.87) \times 100 \approx 87\%$

Essay questions

1 **Model answer**

∵ na = nb

∴ Ma Va = Mb Vb

∴ Ma × 0.025 = 0.1 × 0.02

Ma = $(0.1 \times 0.02) / 0.025 = 0.08$ M

Another method:

Number of moles of the acid = number of moles of NaOH = 0.02 × 0.1 = 0.002 mol

Concentration of the acid = number of moles / volume of solution = 0.002 / 0.025 = 0.08 M

2 **Model answer**

∵ The acid is dibasic.

∴ Each 1 mol of the acid is neutralized by 2 mol of NaOH

Ma Va / na = Mb Vb / nb

Ma = $(0.1 \times 20.2 \times 1) / (2 \times 20.2) = 0.05$ M

3 **Model answer**

Number of moles of NaOH = $0.025 \times 0.1 = 2.5 \times 10^{-3}$ mol

∵ The reaction equation shows that 1 mol of NaOH reacts with 1 mol of the acid

∴ Number of moles of the acid reacted = 2.5×10^{-3} mol

0.025 L of the acid contains 2.5×10^{-3} mol

1 L of the acid contains ? mol

Number of moles of the acid in one litre = $(2.5 \times 10^{-3}) / 0.025 = 0.1$ mol

Molar mass of the acid = 12.6 / 0.1 = 126 g/mol

$(1 \times 3) + X + (16 \times 3) = 126$ g

∴ Gram atomic mass of the element X = 75 g/mol

4 **Model answer**

(1) Compound (1): nitrous acid ; (2): nitric oxide ; (3): nitric acid.

$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$

(2) $Cu(s) + 4HNO_3(l) \rightarrow Cu(NO_3)_2(aq) + 2H_2O(l) + 2NO_2(g)$

(The reaction is on heating with conc. nitric acid.)

5 **Model answer**

$Na_2B_4O_7.10H_2O \rightarrow Na_2B_4O_7 + 10H_2O$

$201.2 + (10 \times 18) = 381.2$ g

Mass of the substance remaining after heating = $(5 \times 201.2) / 381.2 = 2.64$ g

6 **Model answer**

$2H_2O_2 \rightarrow O_2$

$2\ (2 + 2 \times 16) = 68$ g produce 22.4 L

? g produce 1.12 L

Mass of H_2O_2 decomposed = $(68 \times 1.12) / 22.4 = 3.4$ g

Percentage purity of hydrogen peroxide = 100% × 3.4 / 5 = 68%

7 **Model answer**

$3NaOH(aq) + Al(NO_3)_3(aq) \rightarrow 3NaNO_3(aq) + Al(OH)_3(s)$

Number of moles of NaOH = $0.01 \times 0.25 = 2.5 \times 10^{-3}$ mol

3 mol NaOH give $Al(OH)_3$ of mass $27 + (3 \times 16) + 3 = 78$ g

2.5×10^{-3} mol give ? g

$\therefore$ Mass of the precipitate formed = $(2.5 \times 10^{-3} \times 78) / 3 = 0.065$ g

Past exam questions

1	2	3	4	5	6	7	8	9	10
B	B	B	C	A	A	B	A	B	D
11	12	13	14	15	16	17	18	19	20
C	D	C	D	C	C	B	C	A	C
21	22	23	24	25	26	27	28	29	30
B	C	B	A	B	B	B	A	A	C
31	32	33	34	35	36	37	38	39	40
A	B	D	D	C	A	C	A	D	C
41	42	43	44	45	46				
B	B	B	C	A	C				

1 **Answer (B)**

H_2SO_4: $0.2 \times 200 = 40$ mmol , and $Ca(OH)_2$: $0.2 \times 300 = 60$ mmol (reaction ratio 1 : 1)

20 mmol of $Ca(OH)_2$ remain in the total volume of 500 mL.

Concentration = $20 \div 500 = 0.04$ M

2 **Answer (B)**

Concentration of KOH = $(44.8 \div 56) \div 0.5 = 1.6$ M

Number of moles of KOH in 10 mL = 16 mmol , so the number of moles of H_2SO_4 = 8 mmol

Volume = $8 \div 0.2 = 40$ mL

3 **Answer (B)**

Number of moles of $Na_2CO_3.10H_2O$ = $14.3 \div 286 = 0.05$ mol in 500 mL , so the concentration = 0.1 M

25 mL contains 2.5 mmol of Na_2CO_3 , so the number of moles of HCl = $2 \times 2.5 = 5$ mmol

Concentration of the acid = $5 \div 25 = 0.2$ M

4 **Answer (C)**

Number of moles required = 0.7 × 0.2 = 0.14 mol , and the amount present = 0.01 × 0.2 = 0.002 mol

Amount added = 0.138 mol

Mass = 0.138 × 40 = 5.52 g

5 **Answer (A)**

Number of moles of AgCl = 0.963 ÷ 143.5 = 6.71 mmol , which equals the number of moles of MCl

Molar mass of MCl = 0.5 ÷ 6.71 × 1000 = 74.5 g/mol

Atomic mass of M = 74.5 − 35.5 = 39

6 **Answer (A)**

Number of moles of H_2SO_4 = 0.1176 ÷ 98 = 1.2 mmol , so the number of moles of KOH = 2.4 mmol in 20 mL

Concentration of KOH after dilution = 2.4 ÷ 20 = 0.12 M

$0.2 \times X = 0.12 \times (X + 20)$, so X = 30 mL

7 **Answer (B)**

$Ca(OH)_2$: 0.5 × 100 = 50 mmol, which needs 100 mmol of HCl , and the HCl present: 0.6 × 200 = 120 mmol

20 mmol of HCl remain in 300 mL.

Concentration = 20 ÷ 300 = 0.0667 M

8 **Answer (A)**

Number of moles of NaOH = 0.16 ÷ 40 = 4 mmol , which is the amount of base in the titration of 25 mL

Mass of the acid crystals in 25 mL = 2.52 ÷ 10 = 0.252 g

If the acid is diprotic, its number of moles is 2 mmol, i.e. 0.18 g of anhydrous acid.

Mass of water = 0.252 − 0.18 = 0.072 g = 4 mmol , so X = 4 ÷ 2 = 2

9 **Answer (B)**

$Al(OH)_3$ = 78 g/mol , and its number of moles = 2.03 ÷ 78 = 0.026 mol, which is the number of moles of Al

Mass of Al = 0.026 × 27 = 0.702 g

Percentage = $(0.702 \div 5) \times 100 \approx 14.05\%$

10 **Answer (D)**

Ammonia dissolves Ag_3PO_4 and does not dissolve AgI , so the remaining 8.5 g precipitate is AgI.

Number of moles of AgI = 8.5 ÷ 235 = 0.0362 mol , so the mass of KI = 0.0362 × 166 = 6 g

Mass of Na_3PO_4 = 12 − 6 = 6 g = 0.0366 mol , so the Ag_3PO_4 formed = 0.0366 × 419 = 15.32 g

Total yellow precipitate X = 8.5 + 15.32 ≈ 23.82 g

11 **Answer (C)**

$H_2SO_4 + 2KOH \rightarrow K_2SO_4 + 2H_2O$, so the number of moles of KOH = 2 × the number of moles of the acid

M(base) × 16 = 2 × M(acid) × 32 , so M(acid) = M(base) ÷ 4

12 **Answer (D)**

Concentration of the solution = mass ÷ (molar mass × volume), so the greater the molar mass, the lower the concentration.

Molar masses: LiCl = 42.5 , KOH = 56 , NaCl = 58.5 , $Ca(OH)_2$ = 74

So $Ca(OH)_2$ has the lowest concentration.

13 **Answer (C)**

Number of moles of $BaCl_2.2H_2O$ = 45 ÷ 244 = 0.1844 mol in 0.5 L , so the concentration = 0.3689 M

Moles of Ba^{2+} in 84.2 mL = 31.06 mmol , which equals the moles of SO_4^{2-}

Molar mass of the hydrated salt = 10 ÷ 0.03106 = 322 g/mol

Mass of water = 322 − 142 = 180 g, i.e. 10 mol , so the formula is $Na_2SO_4.10H_2O$

14 **Answer (D)**

The flask contains 10 mL of 1 M NaOH , i.e. 10 mmol of NaOH

It is neutralized by 10 mmol of HCl , whose volume = 10 ÷ 2 = 5 mL

Final burette reading = 6.5 + 5 = 11.5 mL

15 **Answer (C)**

$MgCl_2 \rightarrow MgCO_3$ on adding Na_2CO_3 , and the precipitate has a mass of 7 g

Number of moles of $MgCO_3$ = 7 ÷ 84 = 0.0833 mol , which is the number of moles of $MgCl_2$

Mass of $MgCl_2$ = 0.0833 × 95 = 7.917 g

Percentage = $(7.917 \div 10) \times 100 \approx 79.16\%$

16 **Answer (C)**

Mass of water = 39.92% of 5.34 g = 2.132 g, i.e. 0.1184 mol , so the number of moles of the salt = 0.1184 ÷ 6 = 0.01974 mol

Mass of FeClx = 5.34 × 0.6008 = 3.208 g

Molar mass of FeClx = 3.208 ÷ 0.01974 = 162.5 = 56 + 35.5x

x = 3 , so the oxidation number of iron = +3

17 **Answer (B)**

18 **Answer (C)**

$K_2CO_3 + MgSO_4 \rightarrow MgCO_3 + K_2SO_4$, and the precipitate $MgCO_3$ has a mass of 5 g

Number of moles of $MgCO_3$ = 5 ÷ 84 = 0.0595 mol , so the mass of K_2CO_3 = 0.0595 × 138 = 8.21 g

Mass of KCl = 12 − 8.21 = 3.79 g , and the percentage = $(3.79 \div 12) \times 100 \approx 31.55\%$

19 **Answer (A)**

Number of moles of water = 7.2 ÷ 18 = 0.4 mol

n = 0.4 ÷ 0.2 = 2

20 **Answer (C)**

The precipitate is $BaSO_4$ (233 g/mol): 9 ÷ 233 ≈ 0.0386 mol, which is the number of moles of $CuSO_4.XH_2O$

Molar mass = 9.636 ÷ 0.0386 ≈ 249.5 g/mol

Mass of water = 249.5 − 159.5 = 90 g , i.e. 90 ÷ 18 = 5 , so X = 5

21 **Answer (B)**

Number of moles of Na_2CO_3 = 5.3 ÷ 106 = 0.05 mol , and number of moles of HCl = 0.5 × 0.1 = 0.05 mol

$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$, so the acid uses up 0.025 mol of Na_2CO_3

0.025 mol of Na_2CO_3 remain, which give with $MgCl_2$ a precipitate of $MgCO_3$ with the same number of moles.

Mass = 0.025 × 84 = 2.1 g

22 **Answer (C)**

$Ca(OH)_2$: 0.1 × 20 = 2 mmol, giving 4 mmol of OH^- , and HCl: 0.5 × 12 = 6 mmol

2 mmol of H^+ remain, neutralized by 2 mmol of NaOH.

Concentration of NaOH = 2 ÷ 10 = 0.2 M

23 **Answer (B)**

Number of moles of water = 14.4 ÷ 18 = 0.8 mol with 0.4 mol of the salt , so X = 2

Molar mass of the hydrated salt = M + 71 + 36 = 244

M = 244 − 107 = 137 g/mol

24 **Answer (A)**

HCl = 0.5 × 10 = 5 mmol , so the number of moles of Na_2CO_3 = 2.5 mmol

Mass of Na_2CO_3 = 2.5 × 106 = 265 mg = 0.265 g

Mass of NaCl = 0.5 − 0.265 = 0.235 g , and the mass of Cl^- = 0.235 × 35.5 ÷ 58.5 ≈ 0.143 g

25 **Answer (B)**

Number of moles of Cl^- in the precipitate = 12 ÷ 143.5 = 0.0836 mol

NaCl and $MgCl_2$ have the same number of moles n: total chloride = n + 2n = 3n , so n = 0.02787 mol

Mass of NaCl = 0.02787 × 58.5 = 1.63 g , and mass of $MgCl_2$ = 0.02787 × 95 = 2.65 g

26 **Answer (B)**

Number of moles of KOH = 0.2 × 20 = 4 mmol , so the number of moles of H_2SO_4 = 2 mmol in 8 mL

Concentration of the acid after dilution = 2 ÷ 8 = 0.25 M

0.4 × 100 = 0.25 × V_2 , so V_2 = 160 mL , and the water added = 160 − 100 = 60 mL

27 **Answer (B)**

Number of moles = 0.1 × 500 = 50 mmol

Total volume = 500 + 200 = 700 mL

Concentration = 50 ÷ 700 = 0.0714 M

28 **Answer (A)**

29 **Answer (A)**

Fe_3O_4 = $FeO.Fe_2O_3$, so one mole gives 1 mol of Fe^{2+} and 2 mol of Fe^{3+}

0.1 mol gives 0.1 mol of $Fe(OH)_2$, i.e. 9 g

and gives 0.2 mol of $Fe(OH)_3$, i.e. 21.4 g

Total = 9 + 21.4 = 30.4 g

30 **Answer (C)**

Number of moles of $Al_2(SO_4)_3$ = 0.1 × 10 = 1 mmol , so the number of moles of Al^{3+} = 2 mmol

Each Al^{3+} needs 3 OH^- to precipitate and a fourth OH^- to dissolve the precipitate, i.e. 4 moles.

Number of moles of NaOH = 8 mmol , and the mass = 8 × 40 = 320 mg = 0.32 g

31 **Answer (A)**

Number of moles of NaOH = 0.1 × 20 = 2 mmol

HCl gives one H^+ and H_2SO_4 gives two H^+, so the moles of H_2SO_4 needed = 1 mmol

Volume = 1 ÷ 0.1 = 10 mL , which is half the volume of HCl (20 mL)

32 **Answer (B)**

$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

At the same concentration, half the number of moles of acid is needed, so the volume is half the volume of the alkali.

33 **Answer (D)**

Hot conc. H_2SO_4 with excess $NaNO_3$ gives 2 mol of HNO_3 for every 1 mol of H_2SO_4.

Number of moles of HNO_3 = 2 × 0.125 = 0.25 mol , which is the number of moles of NaOH

Concentration = 0.25 ÷ 0.2 = 1.25 M

34 **Answer (D)**

In 25 mL: number of moles of HCl = 0.1 × 25 = 2.5 mmol , so the number of moles of Na_2CO_3 = 1.25 mmol

In the litre (40 times) = 50 mmol = 0.05 mol

Molar mass of the hydrated salt = 14.3 ÷ 0.05 = 286 g/mol

Mass of water = 286 − 106 = 180 g , so the percentage = (180 ÷ 286) × 100 ≈ 62.94%

35 **Answer (C)**

$3BaCl_2 + 2Na_3PO_4 \rightarrow Ba_3(PO_4)_2 + 6NaCl$, and the precipitate has a molar mass of 601 g/mol

Number of moles of the precipitate = 6 ÷ 601 = 0.00998 mol , so the number of moles of Na_3PO_4 = 0.01997 mol

Mass of Na_3PO_4 = 0.01997 × 164 = 3.27 g , and the percentage = 32.7%

36 **Answer (A)**

On adding an acid such as H_2SO_4, litmus turns red and bromothymol blue turns yellow.

Bases keep both of them blue.

37 **Answer (C)**

Number of moles of $CaCl_2$ = 0.3 mol, which uses up 0.3 mol of H_2SO_4

The acid remaining = 0.4 − 0.3 = 0.1 mol

$Ba(OH)_2 + H_2SO_4 \rightarrow BaSO_4 + 2H_2O$, so 0.1 mol of $BaSO_4$ forms

Mass = 0.1 × 233 = 23.3 g

38 **Answer (A)**

Mass of Cl^- = 3.52 × 35.5 ÷ 143.5 = 0.871 g

Percentage = $(0.871 \div 4) \times 100 \approx 21.77\%$

39 **Answer (D)**

$BaCl_2 + Pb(NO_3)_2 \rightarrow PbCl_2 + Ba(NO_3)_2$, and the precipitate $PbCl_2$ has a molar mass of 278 g/mol

Number of moles of $PbCl_2$ = 1 ÷ 278 = 0.0036 mol , so the number of moles of Cl^- = 0.0072 mol

Mass of Cl^- = 0.0072 × 35.5 = 0.2554 g , and the percentage = $(0.2554 \div 2) \times 100 \approx 12.77\%$

40 **Answer (C)**

Mass of Cl^- in the precipitate = 6.7 × 35.5 ÷ 143.5 = 1.657 g

Percentage = $(1.657 \div 3.4) \times 100 \approx 48.7\%$

41 **Answer (B)**

Number of moles of HCl = 0.5 × 100 = 50 mmol

$Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + 2H_2O$, so the number of moles of $Ca(OH)_2$ = 25 mmol

Mass = 25 × 74 = 1850 mg = 1.85 g , and the percentage = $(1.85 \div 4) \times 100 = 46.25\%$

42 **Answer (B)**

$K_2SO_4 + BaCl_2 \rightarrow BaSO_4 + 2KCl$

Number of moles of $BaSO_4$ = 4.66 ÷ 233 = 0.02 mol , so the mass of K_2SO_4 = 0.02 × 174 = 3.48 g

Percentage purity = $(3.48 \div 4) \times 100 = 87\%$, so the percentage of impurities = 13%

43 **Answer (B)**

Mass of water per mole = 5 × 18 = 90 g, which is 36.072% of the molar mass of the hydrated salt.

Molar mass of the hydrated salt = 90 ÷ 0.36072 ≈ 249.5 g

Molar mass of the anhydrous salt = 249.5 − 90 = 159.5 g

44 **Answer (C)**

The third group reagent is NH_4OH , and the precipitate is $Fe(OH)_3$ $(107\ g/mol)$

Number of moles of the precipitate = $1.6 \div 107 = 0.01495$ mol , so the mass of Fe = $0.01495 \times 56 = 0.837$ g

Percentage = $(0.837 \div 3) \times 100 \approx 27.9\%$

45 **Answer (A)**

Number of moles of HCl = $0.05 \times 20 = 1$ mmol , so the number of moles of $Na_2CO_3 = 0.5$ mmol

Mass of $Na_2CO_3 = 0.5 \times 106 = 53$ mg $= 0.053$ g

Mass of NaCl = $0.4 - 0.053 = 0.347$ g , and the percentage = $(0.347 \div 0.4) \times 100 \approx 86.75\%$

46 **Answer (C)**

Number of moles of NaOH = $0.1 \times 20 = 2$ mmol , and number of moles of $H^+ = 2 \times 0.2 \times 10 = 4$ mmol

2 mmol of H^+ remain, so the solution is acidic,

and methyl orange is red in an acidic medium.