

## Concentrations, pH, Acids, Bases and Redox - *Answers at end*

1. If 10.0 mL of 0.100 M HCl is titrated with 0.200 M NaOH, what volume of sodium hydroxide solution is required to neutralize the acid?



2. If 20.0 mL of 0.500 M KOH is titrated with 0.250 M HNO<sub>3</sub>, what volume of nitric acid is required to neutralize the base?



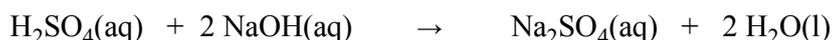
3. If 25.0 mL of 0.100 M HCl is titrated with 0.150 M Ba(OH)<sub>2</sub>, what volume of barium hydroxide is required to neutralize the acid?



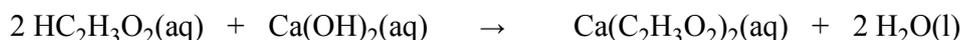
4. If 25.0 mL of 0.100 M Ca(OH)<sub>2</sub> is titrated with 0.200 M HNO<sub>3</sub>, what volume of nitric acid is required to neutralize the base?



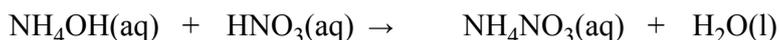
5. If 20.0 mL of 0.200 M H<sub>2</sub>SO<sub>4</sub> is titrated with 0.100 M NaOH, what volume of sodium hydroxide is required to neutralize the acid?



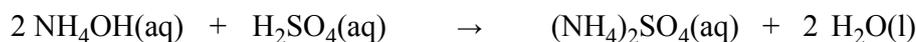
6. If 30.0 mL of 0.100 M Ca(OH)<sub>2</sub> is titrated with 0.150 M HC<sub>2</sub>H<sub>3</sub>O<sub>2</sub>, what volume of acetic acid is required to neutralize the base?



7. If a 50.0 mL sample of ammonium hydroxide is titrated with 25.0 mL of 0.200 M nitric acid to a methyl red endpoint, what is the molarity of the base?



8. If a 50.0 mL sample of ammonium hydroxide is titrated with 25.0 mL of 0.200 M sulfuric acid to a methyl red endpoint, what is the molarity of the base?



9. If a 25.0 mL sample of sulfuric acid is titrated with 50.0 mL of 0.200 M potassium hydroxide to a phenolphthalein endpoint, what is the molarity of the acid?



10. What is the molarity of a hydrochloric acid solution if 20.00 mL of HCl is required to neutralize 0.424 g of sodium carbonate (105.99 g/mol)?



11. What is the molarity of a nitric acid solution if 25.00 mL of HNO<sub>3</sub> is required to neutralize 0.424 g of sodium carbonate (105.99 g/mol)?



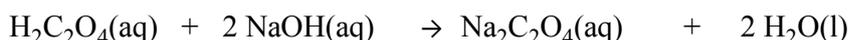
12. What is the molarity of a sulfuric acid solution if 30.00 mL of H<sub>2</sub>SO<sub>4</sub> is required to neutralize 0.840 g of sodium hydrogen carbonate (84.01 g/mol)?



13. What is the molarity of a hydrochloric acid solution if 25.00 mL of HCl is required to neutralize 0.500 g of calcium carbonate (100.09 g/mol)?



14. What is the molarity of a sodium hydroxide solution if 40.00 mL of NaOH is required to neutralize 0.900 g of oxalic acid, H<sub>2</sub>C<sub>2</sub>O<sub>4</sub>, (90.04 g/mol)?



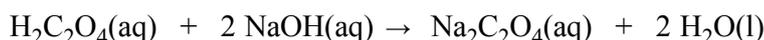
15. What is the molarity of a sodium hydroxide solution if 35.00 mL of NaOH is required to neutralize 1.555 g of KHP, that is KHC<sub>8</sub>H<sub>4</sub>O<sub>4</sub> (204.23 g/mol)?



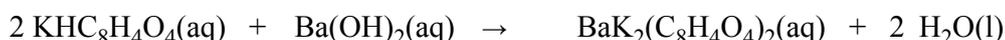
16. If a 0.200 g sample of sodium hydroxide (40.00 g/mol) is completely neutralized with 0.100 M H<sub>2</sub>SO<sub>4</sub>, what volume of sulfuric acid is required?



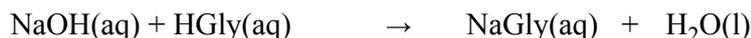
17. If 0.900 g of oxalic acid, H<sub>2</sub>C<sub>2</sub>O<sub>4</sub>, (90.04 g/mol) is completely neutralized with 0.300 M NaOH, what volume of sodium hydroxide is required?



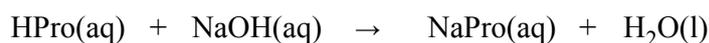
18. If 1.020 g of KHC<sub>8</sub>H<sub>4</sub>O<sub>4</sub> (204.23 g/mol) is completely neutralized with 0.200 M Ba(OH)<sub>2</sub>, what volume of barium hydroxide is required?



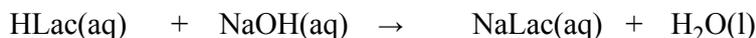
19. Glycine is an amino acid that can be abbreviated HGly. If 27.50 mL of 0.120 M NaOH neutralizes 0.248 g of HGly, what is the molar mass of the amino acid? HGly(aq) +



20. Proline is an amino acid that can be abbreviated HPro. If 33.55 mL of 0.150 M NaOH neutralizes 0.579 g of HPro, what is the molar mass of the amino acid?



21. Lactic acid is found in sour milk and can be abbreviated HLac. If 47.50 mL of 0.275 M NaOH neutralizes 1.180 g of HLac, what is the molar mass of the acid?



22. What is the pH of an aqueous solution if the  $[\text{H}^+] = 5.5 \times 10^{-3} \text{ M}$ ?

23. What is the pH of an aqueous solution if the  $[\text{H}^+] = 4.2 \times 10^{-5} \text{ M}$ ?

24. What is the pH of an aqueous solution if the  $[\text{H}^+] = 7/5 \times 10^{-8} \text{ M}$ ?

25. What is the  $[\text{H}^+]$  in an acid rain sample that has a pH = 3.22?

26. What is the  $[\text{H}^+]$  in a blood sample that has a pH = 7.30?

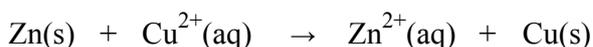
27. What is the  $[\text{H}^+]$  in a bleach sample that has a pH = 9.55?

28. What is the  $[\text{OH}^-]$  in a seawater sample that has a pH = 8.65?

29. What is the  $[\text{OH}^-]$  in an ammonia solution that has a pH = 10.20?

30. What is the  $[\text{OH}^-]$  in an oven-cleaning solution that has a pH = 12.35?

31. What substance is oxidized in the following redox reaction?



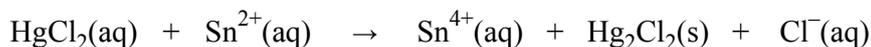
32. What substance is reduced in the following redox reaction?



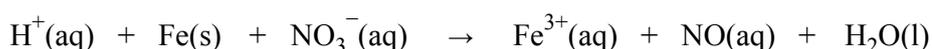
33. What substance is oxidized in the following redox reaction?



34. What substance is oxidized in the following redox reaction?



35. What substance is reduced in the following redox reaction?



## Acids, Bases, pH, and Redox - Answers

1. If 10.0 mL of 0.100 M HCl is titrated with 0.200 M NaOH, what volume of sodium hydroxide solution is required to neutralize the acid?



$$(0.100\text{M})(0.010\text{L}) = (0.200\text{M})(V_2)$$

$$V_2 = 0.005 \text{ L} = \mathbf{5 \text{ mL}}$$

2. If 20.0 mL of 0.500 M KOH is titrated with 0.250 M HNO<sub>3</sub>, what volume of nitric acid is required to neutralize the base?



$$(0.500\text{M})(0.020\text{L}) = (0.250\text{M})(V_2)$$

$$V_2 = 0.040 \text{ L} = \mathbf{40 \text{ mL}}$$

3. If 25.0 mL of 0.100 M HCl is titrated with 0.150 M Ba(OH)<sub>2</sub>, what volume of barium hydroxide is required to neutralize the acid?



$$(0.100\text{M})(0.025\text{L}) = (0.150\text{M})(V_2)$$

$$V_2 = 0.0166 \text{ L} = 16.6 \text{ mL OH}^-$$

But there are 2 OH's per Ba(OH)<sub>2</sub> so it takes half this volume = **8.33 mL of Ba(OH)<sub>2</sub>**

4. If 25.0 mL of 0.100 M Ca(OH)<sub>2</sub> is titrated with 0.200 M HNO<sub>3</sub>, what volume of nitric acid is required to neutralize the base?



$$(0.100\text{M})(0.025\text{L}) = (0.200\text{M})(V_2)$$

$$V_2 = 0.0125 \text{ L} = 12.5 \text{ mL H}^+$$

But it takes 2 HNO<sub>3</sub>'s per Ca(OH)<sub>2</sub> so it takes twice this volume = **25 mL of HNO<sub>3</sub>**

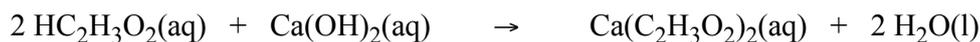
5. If 20.0 mL of 0.200 M H<sub>2</sub>SO<sub>4</sub> is titrated with 0.100 M NaOH, what volume of sodium hydroxide is required to neutralize the acid?



$$0.200 \text{ M H}_2\text{SO}_4 = 0.400 \text{ MH}^+$$

$$M_1V_1 = M_2V_2 \quad (0.40\text{M})(0.020\text{L}) = (0.100\text{M})(V_2) \quad V_2 = 0.080 \text{ L} = \mathbf{80 \text{ mL NaOH}}$$

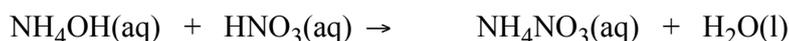
6. If 30.0 mL of 0.100 M Ca(OH)<sub>2</sub> is titrated with 0.150 M HC<sub>2</sub>H<sub>3</sub>O<sub>2</sub>, what volume of acetic acid is required to neutralize the base?



$$0.100 \text{ M Ca}(\text{OH})_2 = 0.200 \text{ M OH}^-$$

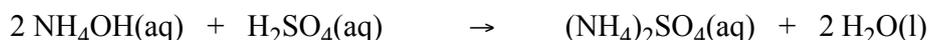
$$M_1V_1 = M_2V_2 \quad (0.200\text{M})(0.030\text{L}) = (0.150\text{M})(V_2) \quad V_2 = 0.040 \text{ L} = \mathbf{40 \text{ mL NaOH}}$$

7. If a 50.0 mL sample of ammonium hydroxide is titrated with 25.0 mL of 0.200 M nitric acid to a methyl red endpoint, what is the molarity of the base?



$$M_1V_1 = M_2V_2 \quad (0.200\text{M})(0.025\text{L}) = (M_2)(0.050\text{L}) \quad M_2 = 0.100 \text{ M NH}_4\text{OH}$$

8. If a 50.0 mL sample of ammonium hydroxide is titrated with 25.0 mL of 0.200 M sulfuric acid to a methyl red endpoint, what is the molarity of the base?



$$0.200 \text{ M H}_2\text{SO}_4 = 0.400 \text{ M H}^+$$

$$M_1V_1 = M_2V_2 \quad (0.400\text{M})(0.025\text{L}) = (M_2)(0.050\text{L}) \quad M_2 = \mathbf{0.200 \text{ M NH}_4\text{OH}}$$

9. If a 25.0 mL sample of sulfuric acid is titrated with 50.0 mL of 0.200 M potassium hydroxide to a phenolphthalein endpoint, what is the molarity of the acid?



$$(0.200\text{M})(0.050\text{L}) = (M_2)(0.025\text{L}) \quad M_2 = 0.400 \text{ M H}^+$$

But, there are 2 H's per H<sub>2</sub>SO<sub>4</sub> so [H<sub>2</sub>SO<sub>4</sub>] = **0.200M**

10. What is the molarity of a hydrochloric acid solution if 20.00 mL of HCl is required to neutralize 0.424 g of sodium carbonate (105.99 g/mol)?

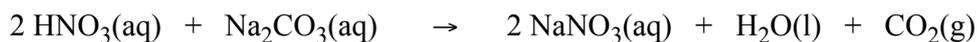


$$0.424 \text{ g}/105.99 \text{ g/mol} = 0.0040 \text{ mol Na}_2\text{CO}_3$$

Each Na<sub>2</sub>CO<sub>3</sub> requires 2 HCl so we need 0.0080 mol HCl

$$MV = \text{moles} \quad (M)(0.020\text{L}) = 0.0080 \text{ mole HCl} \quad M = \mathbf{0.40 \text{ M HCl}}$$

11. What is the molarity of a nitric acid solution if 25.00 mL of HNO<sub>3</sub> is required to neutralize 0.424 g of sodium carbonate (105.99 g/mol)?



$$0.424 \text{ g} / 105.99 \text{ g/mol} = 0.0040 \text{ mol Na}_2\text{CO}_3$$

Each Na<sub>2</sub>CO<sub>3</sub> requires 2 HNO<sub>3</sub> so we need 0.0080 mol HNO<sub>3</sub>

$$MV = \text{moles} \quad (M)(0.025\text{L}) = 0.0080 \text{ mole HNO}_3 \quad M = \mathbf{0.32 \text{ M HNO}_3}$$

12. What is the molarity of a sulfuric acid solution if 30.00 mL of H<sub>2</sub>SO<sub>4</sub> is required to neutralize 0.840 g of sodium hydrogen carbonate (84.01 g/mol)?



$$0.840 \text{ g} / 84.01 \text{ g/mol} = 0.010 \text{ mol NaHCO}_3$$

It takes 2 NaHCO<sub>3</sub> per H<sub>2</sub>SO<sub>4</sub> so you need 0.005 mol H<sub>2</sub>SO<sub>4</sub>

$$MV = \text{moles} \quad M(0.030\text{L}) = 0.005 \text{ moles} \quad M = \mathbf{0.167 \text{ M H}_2\text{SO}_4}$$

13. What is the molarity of a hydrochloric acid solution if 25.00 mL of HCl is required to neutralize 0.500 g of calcium carbonate (100.09 g/mol)?



$$0.500 \text{ g} / 100.09 \text{ g/mol} = 0.005 \text{ mol CaCO}_3$$

Each mole of CaCO<sub>3</sub> requires 2 mol HCl so you need 0.005 x 2 = 0.010 mol HCl MV = moles

$$M(0.025\text{L}) = 0.010 \text{ mol} \quad M = \mathbf{0.40 \text{ M HCl}}$$

14. What is the molarity of a sodium hydroxide solution if 40.00 mL of NaOH is required to neutralize 0.900 g of oxalic acid, H<sub>2</sub>C<sub>2</sub>O<sub>4</sub>, (90.04 g/mol)?



$$\text{g/mol} = 0.010 \text{ mol Oxalic acid}$$

It takes 2 mole NaOH for every mole of Oxalic acid so you need 2 x

$$0.010 \text{ mol} = 0.02 \text{ mol NaOH}$$

$$MV = \text{moles} \quad M(0.040\text{L}) = 0.020 \text{ mole NaOH} \quad M = \mathbf{0.50 \text{ M NaOH}}$$

15. What is the molarity of a sodium hydroxide solution if 35.00 mL of NaOH is required to neutralize 1.555 g of KHP, that is  $\text{KHC}_8\text{H}_4\text{O}_4$  (204.23 g/mol)?



$$1.555\text{g} / 204.23 \text{ g/mol} = 0.00761 \text{ mol KHP}$$

1 mole KHP needs 1 mole of NaOH so, 0.00761 mole KHP = 0.00761 mole NaOH 0.00761 mole NaOH /

$$0.0351 \text{ L} = \mathbf{0.2175 \text{ M NaOH}}$$

16. If a 0.200 g sample of sodium hydroxide (40.00 g/mol) is completely neutralized with 0.100 M  $\text{H}_2\text{SO}_4$ , what volume of sulfuric acid is required?



$$0.200 \text{ g NaOH} / 40 \text{ g/mol} = 0.005 \text{ mol NaOH}$$

1.mole of  $\text{H}_2\text{SO}_4$  needs 2 mole NaOH so 0.005 mole NaOH needs 0.0025 mole  $\text{H}_2\text{SO}_4$  MV = moles

$$(0.100 \text{ M } \text{H}_2\text{SO}_4) (V) = 0.0025 \text{ mole}$$

$$V = 0.0250 \text{ L} = \mathbf{25 \text{ mL}}$$

17. If 0.900 g of oxalic acid,  $\text{H}_2\text{C}_2\text{O}_4$ , (90.04 g/mol) is completely neutralized with 0.300 M NaOH, what volume of sodium hydroxide is required?  $\text{H}_2\text{C}_2\text{O}_4(\text{aq}) + 2 \text{NaOH}(\text{aq})$



$$0.900 \text{ g} / 90.04 \text{ g/mol} = 0.010 \text{ mol Oxalic acid}$$

It takes 2 mole NaOH for every mole of Oxalic acid so you need 2 x

$$0.010 \text{ mol} = 0.02 \text{ mol NaOH}$$

MV = moles

$$(0.300\text{M}) (V) = 0.020 \text{ mole NaOH}$$

$$V = 0.0666 \text{ L} = \mathbf{66.6 \text{ mL}}$$

18. If 1.020 g of  $\text{KHC}_8\text{H}_4\text{O}_4$  (204.23 g/mol) is completely neutralized with 0.200 M  $\text{Ba}(\text{OH})_2$ , what volume of barium hydroxide is required?



$$1.020\text{g} / 204.23 \text{ g/mol} = 0.0050 \text{ mol KHP}$$

2.mole KHP needs 1 mole of  $\text{Ba}(\text{OH})_2$  so, 0.0050 mole KHP needs 0.0025 mole  $\text{Ba}(\text{OH})_2$

MV = moles

$$(0.200 \text{ M}) (V) = 0.0025 \text{ mole } \text{Ba}(\text{OH})_2$$

$$V = 0.01250 \text{ L} = \mathbf{12.5 \text{ mL}}$$

19. Glycine is an amino acid that can be abbreviated HGly. If 27.50 mL of 0.120 M NaOH neutralizes 0.248 g of HGly, what is the molar mass of the amino acid? HGly(aq) +



$$MV = \text{moles} \quad (0.120 \text{ M})(0.02750\text{L}) = 0.033 \text{ mole NaOH} = 0.0033 \text{ mole HGly}$$

$$0.248 \text{ g} / 0.0033 \text{ mole HGly} = 75.12 \text{ g/mol HGly}$$

20. Proline is an amino acid that can be abbreviated HPro. If 33.55 mL of 0.150 M NaOH neutralizes 0.579 g of HPro, what is the molar mass of the amino acid? HPro(aq) +



$$MV = \text{moles} \quad (0.150 \text{ M})(0.03355\text{L}) = 0.005033 \text{ mole NaOH} = 0.005033 \text{ mole HPro}$$

$$0.579 \text{ g} / 0.005033 \text{ mole HPro} = \mathbf{115.05 \text{ g/mol HPro}}$$

21. Lactic acid is found in sour milk and can be abbreviated HLac. If 47.50 mL of 0.275 M NaOH neutralizes 1.180 g of HLac, what is the molar mass of the acid?



$$(0.275 \text{ M})(0.0475\text{L}) = 0.01306 \text{ mole NaOH} = 0.01306 \text{ mole HLac}$$

$$1.180 \text{ g} / 0.01306 \text{ mole HLac} = \mathbf{90.33 \text{ g/mol HLac}}$$

22. What is the pH of an aqueous solution if the  $[\text{H}^+] = 5.5 \times 10^{-3} \text{ M}$ ?  $\text{pH} = -\log [\text{H}^+]$

$$\text{pH} = -\log [5.5 \times 10^{-3}] = \mathbf{2.26}$$

23. What is the pH of an aqueous solution if the  $[\text{H}^+] = 4.2 \times 10^{-5} \text{ M}$ ?  $\text{pH} = -\log [\text{H}^+]$

$$\text{pH} = -\log [4.2 \times 10^{-5}] = \mathbf{4.38}$$

24. What is the pH of an aqueous solution if the  $[\text{H}^+] = 7.5 \times 10^{-8} \text{ M}$ ?  $\text{pH} = -\log [\text{H}^+]$

$$\text{pH} = -\log [7.5 \times 10^{-8}] = \mathbf{7.12}$$

25. What is the  $[\text{H}^+]$  in a blood sample that has a pH = 3.22?

$$[\text{H}^+] = 10^{-\text{pH}} \quad [\text{H}^+] = 10^{-3.22} \quad [\text{H}^+] = \mathbf{6.03 \times 10^{-4} \text{ M}}$$

26. What is the  $[\text{H}^+]$  in a blood sample that has a pH = 7.30?

$$[\text{H}^+] = 10^{-\text{pH}} \quad [\text{H}^+] = 10^{-7.30} \quad [\text{H}^+] = \mathbf{5.01 \times 10^{-8} \text{ M}}$$

25. What is the  $[H^+]$  in a bleach sample that has a pH = 9.55?

$$[H^+] = 10^{-pH} \quad [H^+] = 10^{-9.55} \quad [H^+] = \mathbf{2.82 \times 10^{-10} \text{ M}}$$

26. What is the  $[OH^-]$  in a seawater sample that has a pH = 8.65?  $[H^+] = 10^{-pH}$   $[H^+] =$

$$10^{-8.65} \quad [H^+] = 2.24 \times 10^{-9} \text{ M}$$

$$[H^+][OH^-] = 1 \times 10^{-14} \quad [2.24 \times 10^{-9} \text{ M}][OH^-] = 1 \times 10^{-14} \quad [OH^-] = \mathbf{4.46 \times 10^{-9} \text{ M}}$$

27. What is the  $[OH^-]$  in an ammonia solution that has a pH = 10.20?  $[H^+] = 10^{-pH}$   $[H^+] =$

$$10^{-10.20} \quad [H^+] = 6.31 \times 10^{-11} \text{ M}$$

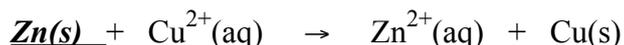
$$[H^+][OH^-] = 1 \times 10^{-14} \quad [6.31 \times 10^{-11} \text{ M}][OH^-] = 1 \times 10^{-14} \quad [OH^-] = \mathbf{1.58 \times 10^{-4} \text{ M}}$$

28. What is the  $[OH^-]$  in an oven-cleaning solution that has a pH = 12.35?  $[H^+] = 10^{-pH}$

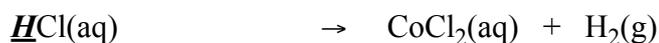
$$[H^+] = 10^{-12.35} \quad [H^+] = 4.47 \times 10^{-13} \text{ M}$$

$$[H^+][OH^-] = 1 \times 10^{-14} \quad [4.47 \times 10^{-13} \text{ M}][OH^-] = 1 \times 10^{-14} \quad [OH^-] = \mathbf{0.0224 \text{ M}}$$

29. What substance is oxidized in the following redox reaction?



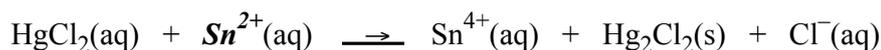
30. What substance is reduced in the following redox reaction?  $\text{Co(s)} + 2$



31. What substance is oxidized in the following redox reaction?



32. What substance is oxidized in the following redox reaction?



33. What substance is reduced in the following redox reaction?

