pH and pOH Worksheet

pH, pOH, $[H^+]$, $[OH^-]$, strong & weak acids, dilution & mixing • 15 parts • 150 questions • Answers at the back

Name: _____ Class: _____ Date: _____

The pH square (at 25 °C)

$[H^+]$	$pH = -\log[H^+] \rightarrow$ $\leftarrow [H^+] = 10^{-pH}$	**pH**
↑↓ $[H^+][OH^-] = 1.0 \times 10^{-14}$		↑↓ $pH + pOH = 14.00$
$[OH^-]$	$pOH = -\log[OH^-] \rightarrow$ $\leftarrow [OH^-] = 10^{-pOH}$	**pOH**

The pH scale

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14

← **more acidic** **neutral (7)** **more basic** →

Example: 0.0050 M $Ca(OH)_2$ → $[OH^-] = 2 \times 0.0050 = 0.010$ M → pOH = –log(0.010) = 2.00 → pH = 14.00 – 2.00 = **12.00**

Give pH and pOH to 2 decimal places and concentrations to 2–3 significant figures. All questions are at 25 °C.

What's inside

Part	Questions	Level	Score
Part 1: pH from $[H^+]$ (Powers of Ten)	1 – 10	Easy	_____ / 10
Part 2: pH from $[H^+]$	11 – 20	Easy	_____ / 10
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Part 6: Converting Between pH and pOH	51 – 60	Easy	_____ / 10
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Total			**_____ / 150**

Part 1: pH from $[H^+]$ (Powers of Ten)

Score: _____ / 10

$pH = -\log[H^+]$. When $[H^+] = 1 \times 10^{-n}$, $pH = n$.

1. Find the pH of a solution with $[H^+] = 1.0 \times 10^{-3}$ M.

Answer: _____

2. Find the pH of a solution with $[H^+] = 1.0 \times 10^{-7}$ M.

Answer: _____

3. Find the pH of a solution with $[H^+] = 1.0 \times 10^{-11}$ M.

Answer: _____

4. Find the pH of a solution with $[H^+] = 1.0 \times 10^{-1}$ M.

Answer: _____

5. Find the pH of a solution with $[H^+] = 1.0 \times 10^{-5}$ M.

Answer: _____

6. Find the pH of a solution with $[H^+] = 1.0 \times 10^{-9}$ M.

Answer: _____

7. Find the pH of a solution with $[H^+] = 1.0 \times 10^{-2}$ M.

Answer: _____

8. Find the pH of a solution with $[H^+] = 1.0 \times 10^{-13}$ M.

Answer: _____

9. Find the pH of a solution with $[H^+] = 1.0 \times 10^{-4}$ M.

Answer: _____

10. Find the pH of a solution with $[H^+] = 1.0 \times 10^{-12}$ M.

Answer: _____

Part 2: pH from $[H^+]$

Score: _____ / 10

Use the log key on your calculator. Give pH to 2 decimal places.

11. Find the pH of a solution with $[H^+] = 3.2 \times 10^{-4}$ M.

Answer: _____

12. Find the pH of a solution with $[H^+] = 5.0 \times 10^{-2}$ M.

Answer: _____

13. Find the pH of a solution with $[H^+] = 2.5 \times 10^{-6}$ M.

Answer: _____

14. Find the pH of a solution with $[H^+] = 7.8 \times 10^{-9}$ M.

Answer: _____

15. Find the pH of a solution with $[H^+] = 1.6 \times 10^{-3}$ M.

Answer: _____

16. Find the pH of a solution with $[H^+] = 4.0 \times 10^{-11}$ M.

Answer: _____

17. Find the pH of a solution with $[H^+] = 6.3 \times 10^{-5}$ M.

Answer: _____

18. Find the pH of a solution with $[H^+] = 9.1 \times 10^{-8}$ M.

Answer: _____

19. Find the pH of a solution with $[H^+] = 2.0 \times 10^{-1}$ M.

Answer: _____

20. Find the pH of a solution with $[H^+] = 8.5 \times 10^{-12}$ M.

Answer: _____

Part 3: pOH from $[OH^-]$

Score: _____ / 10

$pOH = -\log[OH^-]$

21. Find the pOH of a solution with $[OH^-] = 1.0 \times 10^{-2}$ M.

Answer: _____

22. Find the pOH of a solution with $[OH^-] = 3.5 \times 10^{-5}$ M.

Answer: _____

23. Find the pOH of a solution with $[OH^-] = 6.0 \times 10^{-3}$ M.

Answer: _____

24. Find the pOH of a solution with $[OH^-] = 2.2 \times 10^{-9}$ M.

Answer: _____

25. Find the pOH of a solution with $[OH^-] = 1.0 \times 10^{-6}$ M.

Answer: _____

26. Find the pOH of a solution with $[OH^-] = 4.7 \times 10^{-4}$ M.

Answer: _____

27. Find the pOH of a solution with $[OH^-] = 8.0 \times 10^{-11}$ M.

Answer: _____

28. Find the pOH of a solution with $[OH^-] = 1.5 \times 10^{-1}$ M.

Answer: _____

29. Find the pOH of a solution with $[OH^-] = 5.5 \times 10^{-7}$ M.

Answer: _____

30. Find the pOH of a solution with $[OH^-] = 9.9 \times 10^{-13}$ M.

Answer: _____

Part 4: $[H^+]$ from pH

Score: _____ / 10

$[H^+] = 10^{-pH}$. Use the 10^x (2nd log) key.

31. Find $[H^+]$ for a solution with pH = 4.00.

Answer: _____

32. Find $[H^+]$ for a solution with pH = 2.50.

Answer: _____

33. Find $[H^+]$ for a solution with pH = 9.30.

Answer: _____

34. Find $[H^+]$ for a solution with pH = 6.75.

Answer: _____

35. Find $[H^+]$ for a solution with pH = 1.20.

Answer: _____

36. Find $[H^+]$ for a solution with pH = 11.85.

Answer: _____

37. Find $[H^+]$ for a solution with pH = 3.62.

Answer: _____

38. Find $[H^+]$ for a solution with pH = 7.40.

Answer: _____

39. Find $[H^+]$ for a solution with pH = 0.85.

Answer: _____

40. Find $[H^+]$ for a solution with pH = 13.10.

Answer: _____

Part 5: $[OH^-]$ from pOH

Score: _____ / 10

$[OH^-] = 10^{-pOH}$

41. Find $[OH^-]$ for a solution with pOH = 3.00.

Answer: _____

42. Find $[OH^-]$ for a solution with pOH = 5.25.

Answer: _____

43. Find $[OH^-]$ for a solution with pOH = 1.80.

Answer: _____

44. Find $[OH^-]$ for a solution with pOH = 10.40.

Answer: _____

45. Find $[OH^-]$ for a solution with pOH = 4.66.

Answer: _____

46. Find $[OH^-]$ for a solution with pOH = 8.15.

Answer: _____

47. Find $[OH^-]$ for a solution with pOH = 2.33.

Answer: _____

48. Find $[OH^-]$ for a solution with pOH = 12.70.

Answer: _____

49. Find $[OH^-]$ for a solution with pOH = 6.05.

Answer: _____

50. Find $[OH^-]$ for a solution with pOH = 0.50.

Answer: _____

Part 6: Converting Between pH and pOH

Score: _____ / 10

At 25 °C, pH + pOH = 14.00

51. A solution has pH = 3.40. Find the pOH and state whether it is acidic, basic or neutral.

Answer: _____

52. A solution has pOH = 2.15. Find the pH and state whether it is acidic, basic or neutral.

Answer: _____

53. A solution has pH = 12.65. Find the pOH and state whether it is acidic, basic or neutral.

Answer: _____

54. A solution has pOH = 9.80. Find the pH and state whether it is acidic, basic or neutral.

Answer: _____

55. A solution has pH = 7.00. Find the pOH and state whether it is acidic, basic or neutral.

Answer: _____

56. A solution has pOH = 13.25. Find the pH and state whether it is acidic, basic or neutral.

Answer: _____

57. A solution has pH = 5.55. Find the pOH and state whether it is acidic, basic or neutral.

Answer: _____

58. A solution has pOH = 4.00. Find the pH and state whether it is acidic, basic or neutral.

Answer: _____

59. A solution has pH = 10.10. Find the pOH and state whether it is acidic, basic or neutral.

Answer: _____

60. A solution has pOH = 7.75. Find the pH and state whether it is acidic, basic or neutral.

Answer: _____

Part 7: Converting Between $[H^+]$ and $[OH^-]$

Score: _____ / 10

$K_w = [H^+][OH^-] = 1.0 \times 10^{-14}$ at 25 °C

61. A solution has $[H^+] = 1.0 \times 10^{-4}$ M. Find $[OH^-]$.

Answer: _____

62. A solution has $[OH^-] = 2.5 \times 10^{-3}$ M. Find $[H^+]$.

Answer: _____

63. A solution has $[H^+] = 6.0 \times 10^{-9}$ M. Find $[OH^-]$.

Answer: _____

64. A solution has $[OH^-] = 1.0 \times 10^{-11}$ M. Find $[H^+]$.

Answer: _____

65. A solution has $[H^+] = 3.3 \times 10^{-2}$ M. Find $[OH^-]$.

Answer: _____

66. A solution has $[OH^-] = 7.1 \times 10^{-6}$ M. Find $[H^+]$.

Answer: _____

67. A solution has $[H^+] = 4.5 \times 10^{-12}$ M. Find $[OH^-]$.

Answer: _____

68. A solution has $[OH^-] = 1.0 \times 10^{-7}$ M. Find $[H^+]$.

Answer: _____

69. A solution has $[H^+] = 8.2 \times 10^{-5}$ M. Find $[OH^-]$.

Answer: _____

70. A solution has $[OH^-] = 5.0 \times 10^{-1}$ M. Find $[H^+]$.

Answer: _____

Part 8: Complete the Set

Score: _____ / 10

Given one value, find the other three. Use the pH square on page 1.

71. pH = 2.80. Find the other three values (pH, pOH, $[H^+]$, $[OH^-]$) and classify the solution.

Answer: _____

72. $[H^+] = 4.2 \times 10^{-9}$ M. Find the other three values (pH, pOH, $[H^+]$, $[OH^-]$) and classify the solution.

Answer: _____

73. pOH = 3.65. Find the other three values (pH, pOH, $[H^+]$, $[OH^-]$) and classify the solution.

Answer: _____

74. $[OH^-] = 1.8 \times 10^{-2}$ M. Find the other three values (pH, pOH, $[H^+]$, $[OH^-]$) and classify the solution.

Answer: _____

75. pH = 8.20. Find the other three values (pH, pOH, $[H^+]$, $[OH^-]$) and classify the solution.

Answer: _____

76. $[H^+] = 7.5 \times 10^{-3}$ M. Find the other three values (pH, pOH, $[H^+]$, $[OH^-]$) and classify the solution.

Answer: _____

77. pOH = 11.40. Find the other three values (pH, pOH, $[H^+]$, $[OH^-]$) and classify the solution.

Answer: _____

78. $[OH^-] = 6.6 \times 10^{-10}$ M. Find the other three values (pH, pOH, $[H^+]$, $[OH^-]$) and classify the solution.

Answer: _____

79. pH = 13.00. Find the other three values (pH, pOH, $[H^+]$, $[OH^-]$) and classify the solution.

Answer: _____

80. $[H^+] = 1.0 \times 10^{-7}$ M. Find the other three values (pH, pOH, $[H^+]$, $[OH^-]$) and classify the solution.

Answer: _____

Part 9: Strong Acids

Score: _____ / 10

Strong acids ionise completely, so $[H^+]$ = concentration of the acid (for HCl, HNO_3, HBr, HI, $HClO_4$).

81. Find the pH and pOH of 0.010 M HCl (a strong acid).

Answer: _____

82. Find the pH and pOH of 0.0050 M HNO_3 (a strong acid).

Answer: _____

83. Find the pH and pOH of 0.25 M HBr (a strong acid).

Answer: _____

84. Find the pH and pOH of 1.5×10^{-4} M HI (a strong acid).

Answer: _____

85. Find the pH and pOH of 0.080 M $HClO_4$ (a strong acid).

Answer: _____

86. Find the pH and pOH of 3.0×10^{-5} M HCl (a strong acid).

Answer: _____

87. Find the pH and pOH of 0.75 M HNO_3 (a strong acid).

Answer: _____

88. Find the pH and pOH of 1.00 M HCl (a strong acid).

Answer: _____

89. Find the pH and pOH of 6.4×10^{-3} M HBr (a strong acid).

Answer: _____

90. Find the pH and pOH of 2.0×10^{-6} M $HClO_4$ (a strong acid).

Answer: _____

Part 10: Strong Bases

Score: _____ / 10

Strong bases dissociate completely. $Ca(OH)_2$, $Sr(OH)_2$ and $Ba(OH)_2$ give 2 OH^- per formula unit.

91. Find the pOH and pH of 0.010 M NaOH (a strong base).

Answer: _____

92. Find the pOH and pH of 0.0025 M KOH (a strong base).

Answer: _____

93. Find the pOH and pH of 0.010 M $Ca(OH)_2$ (a strong base).

Answer: _____

94. Find the pOH and pH of 0.0050 M $Ba(OH)_2$ (a strong base).

Answer: _____

95. Find the pOH and pH of 0.15 M LiOH (a strong base).

Answer: _____

96. Find the pOH and pH of 4.0×10^{-4} M NaOH (a strong base).

Answer: _____

97. Find the pOH and pH of 0.020 M $Sr(OH)_2$ (a strong base).

Answer: _____

98. Find the pOH and pH of 0.50 M KOH (a strong base).

Answer: _____

99. Find the pOH and pH of 1.5×10^{-3} M $Ba(OH)_2$ (a strong base).

Answer: _____

100. Find the pOH and pH of 2.5×10^{-4} M $Ca(OH)_2$ (a strong base).

Answer: _____

Part 11: Acidic, Basic or Neutral?

Score: _____ / 10

pH < 7 is acidic, pH = 7 is neutral, pH > 7 is basic. Each pH unit is a 10-fold change in $[H^+]$.

101. Is a solution with pH = 4.5 acidic, basic or neutral?

Answer: _____

102. Is a solution with pOH = 3.2 acidic, basic or neutral?

Answer: _____

103. Is a solution with $[H^+] = 1.0 \times 10^{-7}$ M acidic, basic or neutral?

Answer: _____

104. Is a solution with $[OH^-] = 2.0 \times 10^{-9}$ M acidic, basic or neutral?

Answer: _____

105. How many times more acidic is a solution of pH 3 than one of pH 5?

Answer: _____

106. How many times greater is $[H^+]$ at pH 2 than at pH 6?

Answer: _____

107. The pH of a lake falls from 6.0 to 4.0. How has $[H^+]$ changed?

Answer: _____

108. Arrange in order of increasing acidity: A (pH 9), B (pOH 9), C ($[H^+] = 1 \times 10^{-3}$ M), D ($[OH^-] = 1 \times 10^{-2}$ M).

Answer: _____

109. Which has the higher pH: 0.10 M HCl or 0.10 M NaOH? Give both pH values.

Answer: _____

110. Blood has a pH of 7.40. Is it acidic or basic, and what is $[H^+]$?

Answer: _____

Part 12: pH from Mass of Acid or Base

Score: _____ / 10

grams → moles → molarity → $[H^+]$ or $[OH^-]$ → pH

111. 0.365 g of HCl (M = 36.46 g/mol) is dissolved to make 1.00 L of solution. Find the pH.

Answer: _____

112. 4.00 g of NaOH (M = 40.00 g/mol) is dissolved to make 2.00 L of solution. Find the pH.

Answer: _____

113. 0.630 g of HNO_3 (M = 63.02 g/mol) is dissolved to make 500. mL of solution. Find the pH.

Answer: _____

114. 0.741 g of $Ca(OH)_2$ (M = 74.10 g/mol) is dissolved to make 1.00 L of solution. Find the pH.

Answer: _____

115. 2.81 g of KOH (M = 56.11 g/mol) is dissolved to make 250. mL of solution. Find the pH.

Answer: _____

116. 1.28 g of HI (M = 127.91 g/mol) is dissolved to make 100. mL of solution. Find the pH.

Answer: _____

117. 0.171 g of $Ba(OH)_2$ (M = 171.35 g/mol) is dissolved to make 500. mL of solution. Find the pH.

Answer: _____

118. 0.0479 g of LiOH (M = 23.95 g/mol) is dissolved to make 250. mL of solution. Find the pH.

Answer: _____

119. 5.00 g of HBr (M = 80.91 g/mol) is dissolved to make 2.00 L of solution. Find the pH.

Answer: _____

120. 0.100 g of NaOH (M = 40.00 g/mol) is dissolved to make 1.00 L of solution. Find the pH.

Answer: _____

Part 13: Dilution and pH

Score: _____ / 10

$C_1V_1 = C_2V_2$. Diluting a strong acid 10 times raises pH by 1; diluting a strong base 10 times lowers pH by 1.

121. 10.0 mL of 0.100 M HCl is diluted to 100. mL. What is the new pH?

Answer: _____

122. 25.0 mL of 0.0200 M NaOH is diluted to 500. mL. What is the new pH?

Answer: _____

123. 5.00 mL of 1.00 M HNO_3 is diluted to 1.00 L (1000 mL). What is the new pH?

Answer: _____

124. A strong acid solution with pH 2.00 is diluted 10 times. What is the new pH?

Answer: _____

125. A NaOH solution with pH 12.00 is diluted 100 times. What is the new pH?

Answer: _____

126. 50.0 mL of 0.050 M $Ba(OH)_2$ is diluted to 250. mL. What is the new pH?

Answer: _____

127. 1.00 mL of 6.0 M HCl is diluted to 600. mL. What is the new pH?

Answer: _____

128. What volume of water must be added to 10.0 mL of HCl with pH 1.00 to raise the pH to 2.00?

Answer: _____

129. 20.0 mL of 0.15 M KOH is diluted to 300. mL. What is the new pH?

Answer: _____

130. A strong acid with pH 1.50 is diluted from 50.0 mL to 500. mL. What is the new pH?

Answer: _____

Part 14: Weak Acids and Weak Bases

Score: _____ / 10

For a weak acid, $[H^+] \approx \sqrt{(K_a \times C)}$. For a weak base, $[OH^-] \approx \sqrt{(K_b \times C)}$. Check that less than 5% is ionised.

131. Find the pH of 0.100 M acetic acid, CH_3COOH ($K_a = 1.8 \times 10^{-5}$).

Answer: _____

132. Find the pH of 0.500 M hydrocyanic acid, HCN ($K_a = 4.9 \times 10^{-10}$).

Answer: _____

133. Find the pH of 0.200 M formic acid, HCOOH ($K_a = 1.8 \times 10^{-4}$).

Answer: _____

134. Find the pH of 0.0500 M benzoic acid, C_6H_5COOH ($K_a = 6.3 \times 10^{-5}$).

Answer: _____

135. Find the pH of 0.150 M hypochlorous acid, HOCl ($K_a = 3.0 \times 10^{-8}$).

Answer: _____

136. Find the pH of 1.00 M nitrous acid, HNO_2 ($K_a = 4.5 \times 10^{-4}$).

Answer: _____

137. Find the pH of 0.100 M ammonia, NH_3 ($K_b = 1.8 \times 10^{-5}$).

Answer: _____

138. Find the pH of 0.250 M methylamine, CH_3NH_2 ($K_b = 4.4 \times 10^{-4}$).

Answer: _____

139. Find the pH of 0.0500 M ammonia (dilute), NH_3 ($K_b = 1.8 \times 10^{-5}$).

Answer: _____

140. A 0.100 M solution of a weak acid HA has pH 3.00. Find K_a.

Answer: _____

Part 15: Mixing Strong Acids and Strong Bases

Score: _____ / 10

Find moles of H^+ and OH^-, subtract, divide the excess by the TOTAL volume, then find pH.

141. 25.0 mL of 0.100 M HCl + 20.0 mL of 0.100 M NaOH. Find the pH of the mixture.

Answer: _____

142. 50.0 mL of 0.200 M HCl + 50.0 mL of 0.200 M NaOH. Find the pH of the mixture.

Answer: _____

143. 30.0 mL of 0.150 M HNO_3 + 40.0 mL of 0.150 M KOH. Find the pH of the mixture.

Answer: _____

144. 100. mL of 0.050 M HCl + 25.0 mL of 0.100 M NaOH. Find the pH of the mixture.

Answer: _____

145. 20.0 mL of 0.100 M HCl + 15.0 mL of 0.100 M $Ba(OH)_2$. Find the pH of the mixture.

Answer: _____

146. 60.0 mL of 0.100 M HCl + 40.0 mL of 0.250 M NaOH. Find the pH of the mixture.

Answer: _____

147. 10.0 mL of 0.500 M HBr + 90.0 mL of 0.0500 M KOH. Find the pH of the mixture.

Answer: _____

148. 25.0 mL of 0.120 M HCl + 25.0 mL of 0.060 M $Ca(OH)_2$. Find the pH of the mixture.

Answer: _____

149. 15.0 mL of 1.00 M HCl + 250. mL of 0.0500 M NaOH. Find the pH of the mixture.

Answer: _____

150. 75.0 mL of 0.0400 M HNO_3 + 25.0 mL of 0.200 M NaOH. Find the pH of the mixture.

Answer: _____

Answer Key

Final answers in green, with working. pH values within ±0.01 are fine because of rounding.

Part 1: pH from $[H^+]$ (Powers of Ten)

1. pH = –log(1.0×10^{-3}) → **pH = 3.00**

2. pH = –log(1.0×10^{-7}) → **pH = 7.00**

3. pH = –log(1.0×10^{-11}) → **pH = 11.00**

4. pH = –log(1.0×10^{-1}) → **pH = 1.00**

5. pH = –log(1.0×10^{-5}) → **pH = 5.00**

6. pH = –log(1.0×10^{-9}) → **pH = 9.00**

7. pH = –log(1.0×10^{-2}) → **pH = 2.00**

8. pH = –log(1.0×10^{-13}) → **pH = 13.00**

9. pH = –log(1.0×10^{-4}) → **pH = 4.00**

10. pH = –log(1.0×10^{-12}) → **pH = 12.00**

Part 2: pH from $[H^+]$

11. pH = –log(3.2×10^{-4}) → **pH = 3.49** (acidic)

12. pH = –log(5.0×10^{-2}) → **pH = 1.30** (acidic)

13. pH = –log(2.5×10^{-6}) → **pH = 5.60** (acidic)

14. pH = –log(7.8×10^{-9}) → **pH = 8.11** (basic)

15. pH = –log(1.6×10^{-3}) → **pH = 2.80** (acidic)

16. pH = –log(4.0×10^{-11}) → **pH = 10.40** (basic)

17. pH = –log(6.3×10^{-5}) → **pH = 4.20** (acidic)

18. pH = –log(9.1×10^{-8}) → **pH = 7.04** (basic)

19. pH = –log(2.0×10^{-1}) → **pH = 0.70** (acidic)

20. pH = –log(8.5×10^{-12}) → **pH = 11.07** (basic)

Part 3: pOH from $[OH^-]$

21. pOH = –log(1.0×10^{-2}) → **pOH = 2.00**

22. pOH = –log(3.5×10^{-5}) → **pOH = 4.46**

23. pOH = –log(6.0×10^{-3}) → **pOH = 2.22**

24. pOH = –log(2.2×10^{-9}) → **pOH = 8.66**

25. pOH = –log(1.0×10^{-6}) → **pOH = 6.00**

26. pOH = –log(4.7×10^{-4}) → **pOH = 3.33**

27. pOH = –log(8.0×10^{-11}) → **pOH = 10.10**

28. pOH = –log(1.5×10^{-1}) → **pOH = 0.82**

29. pOH = –log(5.5×10^{-7}) → **pOH = 6.26**

30. pOH = –log(9.9×10^{-13}) → **pOH = 12.00**

Part 4: $[H^+]$ from pH

31. $[H^+] = 10^{-4.00} \rightarrow$ **1.00×10^{-4} M**

32. $[H^+] = 10^{-2.50} \rightarrow$ **3.16×10^{-3} M**

33. $[H^+] = 10^{-9.30} \rightarrow$ **5.01×10^{-10} M**

34. $[H^+] = 10^{-6.75} \rightarrow$ **1.78×10^{-7} M**

35. $[H^+] = 10^{-1.20} \rightarrow$ **6.31×10^{-2} M**

36. $[H^+] = 10^{-11.85} \rightarrow$ **1.41×10^{-12} M**

37. $[H^+] = 10^{-3.62} \rightarrow$ **2.40×10^{-4} M**

38. $[H^+] = 10^{-7.40} \rightarrow$ **3.98×10^{-8} M**

39. $[H^+] = 10^{-0.85} \rightarrow$ **1.41×10^{-1} M**

40. $[H^+] = 10^{-13.10} \rightarrow$ **7.94×10^{-14} M**

Part 5: $[OH^-]$ from pOH

41. $[OH^-] = 10^{-3.00} \rightarrow$ **1.00×10^{-3} M**

42. $[OH^-] = 10^{-5.25} \rightarrow$ **5.62×10^{-6} M**

43. $[OH^-] = 10^{-1.80} \rightarrow$ **1.58×10^{-2} M**

44. $[OH^-] = 10^{-10.40} \rightarrow$ **3.98×10^{-11} M**

45. $[OH^-] = 10^{-4.66} \rightarrow$ **2.19×10^{-5} M**

46. $[OH^-] = 10^{-8.15} \rightarrow$ **7.08×10^{-9} M**

47. $[OH^-] = 10^{-2.33} \rightarrow$ **4.68×10^{-3} M**

48. $[OH^-] = 10^{-12.70} \rightarrow$ **2.00×10^{-13} M**

49. $[OH^-] = 10^{-6.05} \rightarrow$ **8.91×10^{-7} M**

50. $[OH^-] = 10^{-0.50} \rightarrow$ **3.16×10^{-1} M**

Part 6: Converting Between pH and pOH

51. pOH = 14.00 – 3.40 → **pOH = 10.60**; **acidic**

52. pH = 14.00 – 2.15 → **pH = 11.85**; **basic**

53. pOH = 14.00 – 12.65 → **pOH = 1.35**; **basic**

54. pH = 14.00 – 9.80 → **pH = 4.20**; **acidic**

55. pOH = 14.00 – 7.00 → **pOH = 7.00**; **neutral**

56. pH = 14.00 – 13.25 → **pH = 0.75**; **acidic**

57. pOH = 14.00 – 5.55 → **pOH = 8.45**; **acidic**

58. pH = 14.00 – 4.00 → **pH = 10.00**; **basic**

59. pOH = 14.00 – 10.10 → **pOH = 3.90**; **basic**

60. pH = 14.00 – 7.75 → **pH = 6.25**; **acidic**

Part 7: Converting Between $[H^+]$ and $[OH^-]$

61. $[OH^-] = 1.0 \times 10^{-14} \div 1.0 \times 10^{-4} \rightarrow$ **1.00×10^{-10} M**

62. $[H^+] = 1.0 \times 10^{-14} \div 2.5 \times 10^{-3} \rightarrow$ **4.00×10^{-12} M**

63. $[OH^-] = 1.0 \times 10^{-14} \div 6.0 \times 10^{-9} \rightarrow$ **1.67×10^{-6} M**

64. $[H^+] = 1.0 \times 10^{-14} \div 1.0 \times 10^{-11} \rightarrow$ **1.00×10^{-3} M**

65. $[OH^-] = 1.0 \times 10^{-14} \div 3.3 \times 10^{-2} \rightarrow$ **3.03×10^{-13} M**

66. $[H^+] = 1.0 \times 10^{-14} \div 7.1 \times 10^{-6} \rightarrow$ **1.41×10^{-9} M**

67. $[OH^-] = 1.0 \times 10^{-14} \div 4.5 \times 10^{-12} \rightarrow$ **2.22×10^{-3} M**

68. $[H^+] = 1.0 \times 10^{-14} \div 1.0 \times 10^{-7} \rightarrow$ **1.00×10^{-7} M**

69. $[OH^-] = 1.0 \times 10^{-14} \div 8.2 \times 10^{-5} \rightarrow$ **1.22×10^{-10} M**

70. $[H^+] = 1.0 \times 10^{-14} \div 5.0 \times 10^{-1} \rightarrow$ **2.00×10^{-14} M**

Part 8: Complete the Set

71. **pOH = 11.20**; **$[H^+] = 1.58 \times 10^{-3}$**; **$[OH^-] = 6.31 \times 10^{-12}$**; acidic

72. **pH = 8.38**; **pOH = 5.62**; **$[OH^-] = 2.38 \times 10^{-6}$**; basic

73. **pH = 10.35**; **$[H^+] = 4.47 \times 10^{-11}$**; **$[OH^-] = 2.24 \times 10^{-4}$**; basic

74. **pH = 12.26**; **pOH = 1.74**; **$[H^+] = 5.56 \times 10^{-13}$**; basic

75. **pOH = 5.80**; **$[H^+] = 6.31 \times 10^{-9}$**; **$[OH^-] = 1.58 \times 10^{-6}$**; basic

76. **pH = 2.12**; **pOH = 11.88**; **$[OH^-] = 1.33 \times 10^{-12}$**; acidic

77. **pH = 2.60**; **$[H^+] = 2.51 \times 10^{-3}$**; **$[OH^-] = 3.98 \times 10^{-12}$**; acidic

78. **pH = 4.82**; **pOH = 9.18**; **$[H^+] = 1.52 \times 10^{-5}$**; acidic

79. **pOH = 1.00**; **$[H^+] = 1.00 \times 10^{-13}$**; **$[OH^-] = 1.00 \times 10^{-1}$**; basic

80. **pH = 7.00**; **pOH = 7.00**; **$[OH^-] = 1.00 \times 10^{-7}$**; neutral

Part 9: Strong Acids

81. $[H^+] = 0.010$ M; pH = –log(0.010) → **pH = 2.00**, **pOH = 12.00**

82. $[H^+] = 0.0050$ M; pH = –log(0.0050) → **pH = 2.30**, **pOH = 11.70**

83. $[H^+] = 0.25$ M; pH = –log(0.25) → **pH = 0.60**, **pOH = 13.40**

84. $[H^+] = 1.5 \times 10^{-4}$ M; pH = –log(1.5×10^{-4}) → **pH = 3.82**, **pOH = 10.18**

85. $[H^+] = 0.080$ M; pH = –log(0.080) → **pH = 1.10**, **pOH = 12.90**

86. $[H^+] = 3.0 \times 10^{-5}$ M; pH = –log(3.0×10^{-5}) → **pH = 4.52**, **pOH = 9.48**

87. $[H^+] = 0.75$ M; pH = –log(0.75) → **pH = 0.12**, **pOH = 13.88**

88. $[H^+] = 1.00$ M; pH = –log(1.00) → **pH = 0.00**, **pOH = 14.00**

89. $[H^+] = 6.4 \times 10^{-3}$ M; pH = –log(6.4×10^{-3}) → **pH = 2.19**, **pOH = 11.81**

90. $[H^+] = 2.0 \times 10^{-6}$ M; pH = –log(2.0×10^{-6}) → **pH = 5.70**, **pOH = 8.30**

Part 10: Strong Bases

91. $[OH^-] = 0.010$ M; pOH = 2.00 → **pOH = 2.00**, **pH = 12.00**

92. $[OH^-] = 0.0025$ M; pOH = 2.60 → **pOH = 2.60**, **pH = 11.40**

93. $[OH^-] = 2 \times 0.010 = 2.00 \times 10^{-2}$ M; pOH = 1.70 → **pOH = 1.70**, **pH = 12.30**

94. $[OH^-] = 2 \times 0.0050 = 1.00 \times 10^{-2}$ M; pOH = 2.00 → **pOH = 2.00**, **pH = 12.00**

95. $[OH^-] = 0.15$ M; pOH = 0.82 → **pOH = 0.82**, **pH = 13.18**

96. $[OH^-] = 4.0 \times 10^{-4}$ M; pOH = 3.40 → **pOH = 3.40**, **pH = 10.60**

97. $[OH^-] = 2 \times 0.020 = 4.00 \times 10^{-2}$ M; pOH = 1.40 → **pOH = 1.40**, **pH = 12.60**

98. $[OH^-] = 0.50$ M; pOH = 0.30 → **pOH = 0.30**, **pH = 13.70**

99. $[OH^-] = 2 \times 1.5 \times 10^{-3} = 3.00 \times 10^{-3}$ M; pOH = 2.52 → **pOH = 2.52**, **pH = 11.48**

100. $[OH^-] = 2 \times 2.5 \times 10^{-4} = 5.00 \times 10^{-4}$ M; pOH = 3.30 → **pOH = 3.30**, **pH = 10.70**

Part 11: Acidic, Basic or Neutral?

101. pH < 7 → **acidic**

102. pH = 14.00 – 3.2 = 10.8 → **basic**

103. pH = 7.00 → **neutral**

104. $[H^+] = 5.00 \times 10^{-6}$ M, pH = 5.30 → **acidic**

105. $10^{(5-3)} = 10^2$ → **100 times**

106. $10^{(6-2)} = 10^4$ → **10,000 times**

107. **increased 100 times** (each pH unit is a factor of 10)

108. pH values: A 9, B 5, C 3, D 12 → **D < A < B < C**

109. HCl pH = 1.00; NaOH pOH = 1.00, pH = 13.00 → **NaOH (pH 13.00)**

110. pH > 7 → **slightly basic**; $[H^+] = 10^{-7.40}$ = **3.98×10^{-8} M**

Part 12: pH from Mass of Acid or Base

111. $0.365 \div 36.46 = 1.00 \times 10^{-2}$ mol ÷ 1 L = 1.00×10^{-2} M; $[H^+] = 1.00 \times 10^{-2}$ M → **pH = 2.00**

112. $4.00 \div 40.00 = 1.00 \times 10^{-1}$ mol ÷ 2 L = 5.00×10^{-2} M; $[OH^-] = 5.00 \times 10^{-2}$ M; pOH = 1.30 → **pH = 12.70**

113. $0.630 \div 63.02 = 1.00 \times 10^{-2}$ mol ÷ 0.5 L = 2.00×10^{-2} M; $[H^+] = 2.00 \times 10^{-2}$ M → **pH = 1.70**

114. $0.741 \div 74.10 = 1.00 \times 10^{-2}$ mol ÷ 1 L = 1.00×10^{-2} M × 2 OH^-; $[OH^-] = 2.00 \times 10^{-2}$ M; pOH = 1.70 → **pH = 12.30**

115. $2.81 \div 56.11 = 5.01 \times 10^{-2}$ mol ÷ 0.25 L = 2.00×10^{-1} M; $[OH^-] = 2.00 \times 10^{-1}$ M; pOH = 0.70 → **pH = 13.30**

116. $1.28 \div 127.91 = 1.00 \times 10^{-2}$ mol ÷ 0.1 L = 1.00×10^{-1} M; $[H^+] = 1.00 \times 10^{-1}$ M → **pH = 1.00**

117. $0.171 \div 171.35 = 9.98 \times 10^{-4}$ mol ÷ 0.5 L = 2.00×10^{-3} M × 2 OH^-; $[OH^-] = 3.99 \times 10^{-3}$ M; pOH = 2.40 → **pH = 11.60**

118. $0.0479 \div 23.95 = 2.00 \times 10^{-3}$ mol ÷ 0.25 L = 8.00×10^{-3} M; $[OH^-] = 8.00 \times 10^{-3}$ M; pOH = 2.10 → **pH = 11.90**

119. $5.00 \div 80.91 = 6.18 \times 10^{-2}$ mol ÷ 2 L = 3.09×10^{-2} M; $[H^+] = 3.09 \times 10^{-2}$ M → **pH = 1.51**

120. $0.100 \div 40.00 = 2.50 \times 10^{-3}$ mol ÷ 1 L = 2.50×10^{-3} M; $[OH^-] = 2.50 \times 10^{-3}$ M; pOH = 2.60 → **pH = 11.40**

Part 13: Dilution and pH

121. $C_2 = 0.100 \times 10.0 \div 100. = 1.00 \times 10^{-2}$ M; pH = –log → **pH = 2.00**

122. $[OH^-] = 0.0200 \times 25.0 \div 500. = 1.00 \times 10^{-3}$ M; pOH = 3.00 → **pH = 11.00**

123. $C_2 = 1.00 \times 5.00 \div 1000 = 5.00 \times 10^{-3}$ M; pH = –log → **pH = 2.30**

124. $[H^+]$ falls from 1.0×10^{-2} to 1.0×10^{-3} M → **pH = 3.00**

125. $[OH^-]$: 1.0×10^{-2} → 1.0×10^{-4} M; pOH = 4.00 → **pH = 10.00**

126. $[OH^-] = 0.050 \times 2 \times 50.0 \div 250. = 2.00 \times 10^{-2}$ M; pOH = 1.70 → **pH = 12.30**

127. $C_2 = 6.0 \times 1.00 \div 600. = 1.00 \times 10^{-2}$ M; pH = –log → **pH = 2.00**

128. $[H^+]$ must fall 10 times, so total volume = 100. mL → **add 90.0 mL water**

129. $[OH^-] = 0.15 \times 20.0 \div 300. = 1.00 \times 10^{-2}$ M; pOH = 2.00 → **pH = 12.00**

130. 10 times dilution raises pH by 1 → **pH = 2.50**

Part 14: Weak Acids and Weak Bases

131. $x = \sqrt{(1.8 \times 10^{-5} \times 0.100)} = 1.34 \times 10^{-3}$ M = $[H^+]$ (1.3% ionised) → **pH = 2.87**

132. $x = \sqrt{(4.9 \times 10^{-10} \times 0.500)} = 1.57 \times 10^{-5}$ M = $[H^+]$ (0.0% ionised) → **pH = 4.81**

133. $x = \sqrt{(1.8 \times 10^{-4} \times 0.200)} = 6.00 \times 10^{-3}$ M = $[H^+]$ (3.0% ionised) → **pH = 2.22**

134. $x = \sqrt{(6.3 \times 10^{-5} \times 0.0500)} = 1.77 \times 10^{-3}$ M = $[H^+]$ (3.5% ionised) → **pH = 2.75**

135. $x = \sqrt{(3.0 \times 10^{-8} \times 0.150)} = 6.71 \times 10^{-5}$ M = $[H^+]$ (0.0% ionised) → **pH = 4.17**

136. $x = \sqrt{(4.5 \times 10^{-4} \times 1.00)} = 2.12 \times 10^{-2}$ M = $[H^+]$ (2.1% ionised) → **pH = 1.67**

137. $x = \sqrt{(1.8 \times 10^{-5} \times 0.100)} = 1.34 \times 10^{-3}$ M = $[OH^-]$ (1.3% ionised); pOH = 2.87 → **pH = 11.13**

138. $x = \sqrt{(4.4 \times 10^{-4} \times 0.250)} = 1.05 \times 10^{-2}$ M = $[OH^-]$ (4.2% ionised); pOH = 1.98 → **pH = 12.02**

139. $x = \sqrt{(1.8 \times 10^{-5} \times 0.0500)} = 9.49 \times 10^{-4}$ M = $[OH^-]$ (1.9% ionised); pOH = 3.02 → **pH = 10.98**

140. $[H^+] = 1.0 \times 10^{-3}$; $K_a = (1.0 \times 10^{-3})^2 \div (0.100 - 0.001)$ → **$K_a = 1.0 \times 10^{-5}$**

Part 15: Mixing Strong Acids and Strong Bases

141. mol H^+ = 2.50×10^{-3}; mol OH^- = 2.00×10^{-3}; excess H^+ = 5.00×10^{-4} mol ÷ 0.045 L = 1.11×10^{-2} M → **pH = 1.95**

142. mol H^+ = 1.00×10^{-2}; mol OH^- = 1.00×10^{-2}; exactly neutralised → **pH = 7.00**

143. mol H^+ = 4.50×10^{-3}; mol OH^- = 6.00×10^{-3}; excess OH^- = 1.50×10^{-3} mol ÷ 0.07 L = 2.14×10^{-2} M; pOH = 1.67 → **pH = 12.33**

144. mol H^+ = 5.00×10^{-3}; mol OH^- = 2.50×10^{-3}; excess H^+ = 2.50×10^{-3} mol ÷ 0.125 L = 2.00×10^{-2} M → **pH = 1.70**

145. mol H^+ = 2.00×10^{-3}; mol OH^- = 3.00×10^{-3} (2 OH per formula); excess OH^- = 1.00×10^{-3} mol ÷ 0.035 L = 2.86×10^{-2} M; pOH = 1.54 → **pH = 12.46**

146. mol H^+ = 6.00×10^{-3}; mol OH^- = 1.00×10^{-2}; excess OH^- = 4.00×10^{-3} mol ÷ 0.1 L = 4.00×10^{-2} M; pOH = 1.40 → **pH = 12.60**

147. mol H^+ = 5.00×10^{-3}; mol OH^- = 4.50×10^{-3}; excess H^+ = 5.00×10^{-4} mol ÷ 0.1 L = 5.00×10^{-3} M → **pH = 2.30**

148. mol H^+ = 3.00×10^{-3}; mol OH^- = 3.00×10^{-3} (2 OH per formula); exactly neutralised → **pH = 7.00**

149. mol H^+ = 1.50×10^{-2}; mol OH^- = 1.25×10^{-2}; excess H^+ = 2.50×10^{-3} mol ÷ 0.265 L = 9.43×10^{-3} M → **pH = 2.03**

150. mol H^+ = 3.00×10^{-3}; mol OH^- = 5.00×10^{-3}; excess OH^- = 2.00×10^{-3} mol ÷ 0.1 L = 2.00×10^{-2} M; pOH = 1.70 → **pH = 12.30**

Notes: 15 Key Points to Remember

01	**pH measures $[H^+]$** $pH = -\log[H^+]$. The minus sign makes pH a positive number for most solutions, and a lower pH means more H^+.
02	**pOH measures $[OH^-]$** $pOH = -\log[OH^-]$. It works exactly like pH but for hydroxide ions.
03	**pH + pOH = 14.00** At 25 °C, pH and pOH always add up to 14.00. Find one and you have the other.
04	**The water constant, K_w** $[H^+] \times [OH^-] = 1.0 \times 10^{-14}$ at 25 °C. Use it to change $[H^+]$ into $[OH^-]$ and back.
05	**Going backwards** $[H^+] = 10^{-pH}$ and $[OH^-] = 10^{-pOH}$. On most calculators this is SHIFT/2nd + log.
06	**The scale is logarithmic** Each pH unit is a 10-fold change in $[H^+]$. pH 3 is 10 times more acidic than pH 4 and 1000 times more acidic than pH 6.
07	**Acidic, neutral, basic** pH < 7: acidic ($[H^+] > [OH^-]$). pH = 7: neutral ($[H^+] = [OH^-]$). pH > 7: basic ($[OH^-] > [H^+]$).
08	**Strong acids ionise completely** For HCl, HBr, HI, HNO_3 and $HClO_4$, $[H^+]$ equals the acid concentration.
09	**Count the hydroxides** NaOH, KOH and LiOH give 1 OH^-; $Ca(OH)_2$, $Sr(OH)_2$ and $Ba(OH)_2$ give 2. Multiply before taking the log.
10	**For bases, find pOH first** Calculate $[OH^-]$, then pOH, then pH = 14.00 – pOH. A common mistake is to report the pOH as the pH.
11	**Weak acids ionise only partly** $[H^+] \approx \sqrt{(K_a \times C)}$. This shortcut is fine when less than 5% of the acid ionises; otherwise use the quadratic formula.
12	**Dilution** $C_1V_1 = C_2V_2$. Diluting a strong acid 10 times raises pH by 1, but it can never go above 7 by dilution.
13	**Mixing acids and bases** Subtract moles, not concentrations. Divide the leftover moles by the TOTAL volume of the mixture.
14	**Decimal places in pH** The number of decimal places in pH matches the significant figures in $[H^+]$: 2.5×10^{-4} M (2 s.f.) gives pH 3.60 (2 d.p.).
15	**Temperature matters** K_w and the value 14.00 apply at 25 °C. At other temperatures neutral water does not have pH exactly 7.