CHEMISTRY 12 – K_w, pH AND pOH WORKSHEET #2

1) What is the $[OH^-]$ in 0.025 M HCl? **(1 mark)**

$HCl \rightarrow H^+ + Cl^-$

0.025M 0.025M

$K_w = [H_3O^+][OH^-]$

$1.0\times10^{-14} = (0.025)x$

$x = 4.0\times10^{-13}$ M (1)

2) Calculate the pH of 0.250 M $Al(OH)_3$. **(2 marks)**

$Al(OH)_3 \rightarrow Al^{3+} + 3OH^-$

0.250M 0.750M

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

$= -\log(0.750)$

$= 0.125$ (1)

$pH + pOH = 14.00$

$x + 0.125 = 14.00$

$x = 13.88$ (1)

3) Which of the following is possible for an acid?

	ACID STRENGTH	CONCENTRATION	pH
(A.)	strong	0.01 M	2.0
B.	weak	0.01 M	1.0
C.	strong	3 M	5.5
D.	weak	3 M	–0.5

strong acid would ionize completely ∴

$HA \rightarrow H^+ + A^-$

0.01M 0.01M

$pH = -\log[H_3O^+] = -\log(0.01) = 2.0$

4) What is the $[H_3O^+]$ in ~~200.0 mL~~ of 0.0010 M KOH? **(2 marks)**

$KOH \rightarrow K^+ + OH^-$

0.0010M 0.0010M

$K_w = [H_3O^+][OH^-]$

$1.0\times10^{-14} = x(0.0010)$

$x = 1.0\times10^{-11}$ M (1)

5) Tomato juice has a pH of 4.20. Calculate the $[H_3O^+]$ and $[OH^-]$ in tomato juice. **(2 marks)**

$[H_3O^+] = 10^{-pH}$

$= 10^{-4.20}$

$= 6.3\times10^{-5}$ M (1)

$K_w = [H_3O^+][OH^-]$

$1.0\times10^{-14} = (6.3\times10^{-5})x$

$x = 1.6\times10^{-10}$ M (1)

6) A student records the pH of **0.1 M** solutions of two monoprotic acids:

Acid	pH
X	4.0
Y	2.0

if strong, 100% ionization would make $[H_3O^+] = 0.1$ M ∴

$pH = -\log[H_3O^+]$

$= -\log(0.1)$

$= 1.0$

What can be concluded from the above data? **(2 marks)**

Since both acids have a pH > 1.0, they did not undergo complete ionization ∴ both are weak acids, with acid Y being a stronger weak acid (1) (1)

7) What is the mass of NaOH required to prepare 100.0 mL of NaOH $_{(aq)}$ that has a pH = 13.62? **(2 marks)**

$pH + pOH = 14.00$
$13.62 + x = 14.00$
$x = 0.38$

$[OH^-] = 10^{-pOH}$
$= 10^{-0.38}$
$= 0.42\ M$ (1)

$NaOH \longrightarrow Na^+ + OH^-$
$0.42M \qquad 0.42M$

$g\ NaOH = 0.1000\ L \times \frac{0.42\ mol}{1\ L} \times \frac{40.0\ g}{1\ mol} = 1.7\ g$ (1)

8) In a solution at 25°C, the $[H_3O^+]$ is 3.5×10^{-6} M. Calculate the $[OH^-]$. **(1 mark)**

$K_w = [H_3O^+][OH^-]$
$1.0 \times 10^{-14} = (3.5 \times 10^{-6})x$
$x = 2.9 \times 10^{-9}\ M$ (1)

9) The pH of pure water is 6.52 at 60°C. Calculate the $[OH^-]$. **(2 marks)**

$[H_3O^+] = 10^{-pH}$
$= 10^{-6.52}$
$= 3.0 \times 10^{-7}\ M$ (1)

Since it is pure water,
$[H_3O^+] = [OH^-]$ ∴
$[OH^-] = 3.0 \times 10^{-7}\ M$ (1)

10) Calculate the pH of 0.25 M $Sr(OH)_2$. **(2 marks)**

$Sr(OH)_2 \longrightarrow Sr^{2+} + 2OH^-$
$0.25M \qquad 0.50M$

$pOH = -\log[OH^-]$
$= -\log(0.50)$
$= 0.30$ (1)

$pH + pOH = 14.00$
$x + 0.30 = 14.00$
$x = 13.70$ (1)

11) Calculate the $[H_3O^+]$ in ~~100.0 mL~~ of 0.0515 M KOH. **(2 marks)**

$KOH \longrightarrow K^+ + OH^-$
$0.0515M \qquad 0.0515M$

$K_w = [H_3O^+][OH^-]$
$1.0 \times 10^{-14} = x\ (0.0515)$
$x = 1.9 \times 10^{-13}\ M$ (1)

12) What is the concentration of $Sr(OH)_2$ in a solution with a pH = 11.00? **(2 marks)**

$pH + pOH = 14.00$
$11.00 + x = 14.00$
$x = 3.00$

$[OH^-] = 10^{-pOH}$
$= 10^{-3.00}$
$= 1.0 \times 10^{-3}\ M$ (1)

$Sr(OH)_2 \longrightarrow Sr^{2+} + 2OH^-$
$5.0 \times 10^{-4}\ M \qquad 1.0 \times 10^{-3}\ M$ (1)

13) What is the pOH of a 1.8 M $HClO_4$ solution? **(2 marks)**

$HClO_4 \longrightarrow H^+ + ClO_4^-$
$1.8M \qquad 1.8M$

$pH = -\log[H_3O^+]$
$= -\log(1.8)$
$= -0.26$ (1)

$pH + pOH = 14.00$
$-0.26 + x = 14.00$
$x = 14.26$ (1)

14) Calculate the $[H_3O^+]$ in a solution with a $[OH^-]$ of 1.5×10^{-4} M. **(1 mark)**

$K_w = [H_3O^+][OH^-]$

$1.0\times10^{-14} = X(1.5\times10^{-4})$

$X = 6.7\times10^{-11}$ M ①

15) What is the pOH of 0.2 M HNO_3? **(2 marks)**

$HNO_3 \rightarrow H^+ + NO_3^-$

0.2M 0.2M

$pH = -\log[H_3O^+]$

$= -\log(0.2)$

$= 0.7$ ①

$pH + pOH = 14.00$

$0.7 + X = 14.00$

$X = 13.3$ ①

16) Calculate the $[H_3O^+]$ in a ~~100.0 mL~~ sample of 0.0800 M NaOH. **(1 mark)**

$NaOH \rightarrow Na^+ + OH^-$

0.0800M 0.0800M

$K_w = [H_3O^+][OH^-]$

$1.0\times10^{-14} = X(0.0800)$

$X = 1.3\times10^{-13}$ M ①

17) Calculate the $[H_3O^+]$ of a solution with a pOH of 4.60. **(2 marks)**

$pH + pOH = 14.00$

$X + 4.60 = 14.00$

$X = 9.40$ ①

$[H_3O^+] = 10^{-pH}$

$= 10^{-9.40}$

$= 4.0\times10^{-10}$ M ①

18) Four monoprotic acids of the same concentration are labeled as follows:

SOLUTION	LABEL
A	$[OH^-] = 5.0\times10^{-11}$ M
B	$[H^+] = 0.20$ M
C	pOH = 11.30 M
D	pH = 1.20 M

List the four solutions in order of decreasing acidity. Use calculations to support your answer. **(4 marks)**

Calculate pH for all acids to be able to compare them

A: $K_w = [H_3O^+][OH^-]$

$1.0\times10^{-14} = X(5.0\times10^{-11})$

$X = 2.0\times10^{-4}$ M

$pH = -\log[H_3O^+]$

$= -\log(2.0\times10^{-4})$

$= 3.70$ ①

B: $pH = -\log[H_3O^+]$

$= -\log(0.20)$

$= 0.70$ ①

C: $pH + pOH = 14.00$

$X + 11.30 = 14.00$

$X = 2.70$ ①

In order of decreasing acidity means from most acidic (lowest pH) → least acidic (highest pH) ∴

B, D, C, A ①

19) At 10°C, $K_w = 2.95 \times 10^{-15}$.

(a) Determine the pH of water at 10°C. **(3 marks)**

$2H_2O(l) \rightleftharpoons H_3O^+ + OH^-$

$K_w = [H_3O^+][OH^-]$

$[H_3O^+] = [OH^-]$ (1)

$2.95 \times 10^{-15} = x^2$

$x = 5.43 \times 10^{-8} M$ (1)

$pH = -\log[H_3O^+]$

$= -\log(5.43 \times 10^{-8})$

$= 7.265$ (1)

(b) State whether water at this temperature is acidic, basic or neutral, and explain. **(1 mark)**

water is always neutral since the $[H_3O^+] = [OH^-]$ (1)

20) Calculate the value of K_w for a sample of water with a pH = 7.30. **(2 marks)**

$2H_2O(l) \rightleftharpoons H_3O^+ + OH^-$

$[H_3O^+] = 10^{-pH}$

$= 10^{-7.30}$

$= 5.0 \times 10^{-8} M$ (1)

$[H_3O^+] = [OH^-]$

$K_w = [H_3O^+][OH^-]$

$= (5.0 \times 10^{-8})^2$

$= 2.5 \times 10^{-15}$ (1)