Acid/Base I Review Key

Given data is underlined.

1.

	$[H_3O^+]$	pH	pOH	$[OH^-]$	Solution
a)	3.0×10^{-2} M	1.52	12.48	3.3×10^{-13} M	ACIDIC
b)	4.6×10^{-8} M	7.34	6.66	2.2×10^{-7} M	BASIC
c)	1.9×10^{-12} M	11.72	2.28	5.2×10^{-3} M	BASIC
d)	5.9×10^{-9} M	8.23	5.77	1.7×10^{-6} M	BASIC
e)	8.0×10^{-5} M	4.10	9.90	1.3×10^{-10} M	ACIDIC
f)	1.0×10^{-7} M	7.00	7.00	1.0×10^{-7} M	NEUTRAL
g)	1.0×10^{-3} M	3.00	11.00	1.0×10^{-11} M	ACIDIC
h)	10 M	-1.0	15.0	1×10^{-15} M	ACIDIC
i)	1.1×10^{-12} M	11.94	2.06	8.7×10^{-3} M	BASIC
j)	2.6×10^{-6} M	5.58	8.42	3.8×10^{-9} M	ACIDIC

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2. pH = 7.43 $\quad [H_3O^+] = [H^+] = \text{inv log}(-7.43) = \boxed{3.7 \times 10^{-8} \text{ M}}$

$$[OH^-] = \frac{K_w}{[H_3O^+]} = \frac{1.0 \times 10^{-14}}{3.7 \times 10^{-8} \text{ M}} = \boxed{2.7 \times 10^{-7} \text{ M}}$$

3a) $HCl + H_2O_{(l)} \longrightarrow H_3O^+ + Cl^-$ OR $HCl \longrightarrow H^+ + Cl^-$

2.0 M $\qquad$ 2.0 M

$pH = -\log(2.0) = \boxed{-0.30} \qquad pOH = 14.00 - (-0.30) = \boxed{14.30}$

b) $NaOH \longrightarrow Na^+ + OH^-$ or $NaOH + H_2O_{(l)} \longrightarrow NaOH_2^+ + OH^-$

3.5×10^{-4}M $\qquad$ 3.5×10^{-4}M

$pOH = -\log(3.5 \times 10^{-4} M) = \boxed{3.46} \qquad pH = 14.00 - 3.46 = \boxed{10.54}$

c) $H_2SO_4 + H_2O_{(l)} \longrightarrow H_3O^+ + HSO_4^-$

0.20M $\qquad$ 0.20M

$pH = -\log(0.20 M) = \boxed{0.70} \qquad pOH = 14.00 - 0.70 = \boxed{13.30}$

d) $Sr(OH)_2 \longrightarrow Sr^{2+} + 2OH^-$

1.25×10^{-6}M $\qquad$ 2.50×10^{-6} M

$pOH = -\log(2.50 \times 10^{-6} M) = \boxed{5.602} \qquad pH = 14.00 - 5.60 = \boxed{8.398}$

4. $H_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2H_2O$ NEUTRALIZATION EQUATION.

$NaOH \rightarrow Na^+ + OH^-$ ("monoprotic" base)

$mol\ H_2SO_4 = MV = (0.500\,M)(0.02500\,L) = 0.0125\ mol\ H_2SO_4$

$H_2SO_4 + 2H_2O \longrightarrow 2H_3O^+ + SO_4^{2-}$ (see * below)

$$\frac{0.0125\ mol\ H_2SO_4}{} \times \frac{2\ mol\ H_3O^+}{1\ mol\ H_2SO_4} = 0.0250\ mol\ H_3O^+ = 0.0250\ mol\ OH^- = mol\ NaOH$$

$$\frac{0.0250\ mol\ NaOH}{} \times \frac{40.0\ g\ NaOH}{1\ mol\ NaOH} = \boxed{1.00\ g\ NaOH}$$

* H_2SO_4 will dissociate BOTH protons in presence of strong Arrhenius base.

5. $HCl + H_2O \longrightarrow H_3O^+ + Cl^-$

$mol\ HCl = MV = (0.15\,M)(0.02500\,L) = 0.00375\ mol\ HCl = 0.00375\ mol\ H_3O^+$

$$[H_3O^+] = \frac{mol}{V} = \frac{0.00375\ mol}{0.100\ L} = 3.75 \times 10^{-2}\ M \quad \text{OR} \quad M_f = \frac{M_iV_i}{V_f}$$

$$pH = -\log(3.75 \times 10^{-2}\ M) = \boxed{1.43}$$

6. a) H_2S and H_2Te are the acids but since REACTANTS are favoured, H_2Te must be the stronger acid.

b) Since H_2Te is the stronger acid, it's conjugate base must be weaker (HTe^-).

7. $HCO_3^- + HF \rightleftharpoons H_2CO_3 + F^-$

HCO_3^-: Base; HF: (among others) Acid; H_2CO_3: Acid; F^-: Base

8. a) CONJUGATE BASE - The species A^- formed by loss of H^+ from the acid HA.

b) HCN, CN^-
A, B

9. $HNO_3 + KOH \longrightarrow KNO_3 + H_2O$

$HNO_3 + H_2O \longrightarrow H_3O^+ + NO_3^-$
$KOH \longrightarrow K^+ + OH^-$

mol HNO_3 = MV = (0.35 M)(0.25 L) = 0.0875 mol
mol H_3O^+ = 0.0875 mol
mol OH^- req'd = 0.0875 mol
mol KOH = 0.0875 mol

$$\text{Volume KOH} = \frac{\text{mol}}{M} = \frac{0.0875 \text{ mol}}{0.050 \text{ M}} = 1.75 \text{ L} = \boxed{1.8 \text{ L}}$$

10. $[H_3O^+]$ = inv log (−4.20) = $\boxed{6.3 \times 10^{-5} \text{ M}}$

$$[OH^-] = \frac{K_w}{[H_3O^+]} = \frac{1.0 \times 10^{-14}}{6.3 \times 10^{-5}} = \boxed{1.6 \times 10^{-10} \text{ M}}$$

11. $HCl + KOH \longrightarrow KCl + H_2O$

$HCl + H_2O \longrightarrow H_3O^+ + Cl^-$
$KOH \longrightarrow K^+ + OH^-$

mol H_3O^+ = MV = (0.150 M)(0.0600 L) = 0.00900 mol H_3O^+
mol OH^- = MV = (0.100 M)(0.1400 L) = 0.0140 mol OH^-

mol OH^- in excess = 0.0140 mol OH^- − 0.00900 mol H_3O^+ = 0.0050 mol OH^-

$$M = \frac{\text{mol}}{V} = \frac{0.0050 \text{ mol}}{0.200 \text{ L}} = 0.025 \text{ M}$$

pOH = −log (0.025 M) = 1.60
$\boxed{pH = 12.40}$

12.a) Amphiprotic - A substance that can act as either an acid or a base.

b) $H_2PO_4^-$, HCO_3^- etc...

13.a) $H_2C_2O_4 + 2NaOH \longrightarrow Na_2C_2O_4 + 2H_2O$

* str. base present
$H_2C_2O_4 + 2H_2O \rightarrow 2H_3O^+ + C_2O_4^{2-}$
$NaOH \longrightarrow Na^+ + OH^-$
strong base will dissociate and take both protons.

b) $\dfrac{1.00\text{g oxalic}}{} \left| \dfrac{1 \text{ mol oxalic}}{90.0\text{g oxalic}} \right.$ = $\dfrac{0.01111 \text{ mol } H_2C_2O_4}{} \left| \dfrac{2 \text{ mol } H_3O^+}{1 \text{ mol } H_2C_2O_4} \right.$ = 0.02222 mol H_3O^+

mol OH^- req'd = 0.02222 mol OH^- = 0.02222 mol NaOH

$$[NaOH] = \frac{\text{mol}}{V} = \frac{0.02222 \text{ mol}}{0.06000 \text{ L}} = \boxed{0.370 \text{ M}}$$

14. inv log (−6.51) = 3.090×10^{-7} M = $[H_3O^+]$ = $[OH^-]$ * Water is NEUTRAL

$$K_w = [H_3O^+][OH^-] = (3.090 \times 10^{-7} \text{ M})^2 = \boxed{9.5 \times 10^{-14}}$$

15. Firstly, throw out trial 2 data.
Secondly, average trial 1 & 3: $\frac{11.33\text{ mL} + 11.31\text{ mL}}{2} = 11.32\text{ mL}$ NaOH added.
* NaOH is a strong base that will dissociate (take) both protons from tartaric acid.

$$H_2C_4H_4O_6 + 2NaOH \longrightarrow Na_2C_4H_4O_6 + 2H_2O$$

mol NaOH = MV = (0.104 M)(0.01132 L) = 0.0011773 mol
mol OH^- = 0.0011773 mol
mol H_3O^+ req'd = 0.0011773 mol

$H_2C_4H_4O_6 + H_2O \longrightarrow 2H_3O^+ + C_4H_4O_6^{2-}$ *str. base present!
$NaOH \longrightarrow Na^+ + OH^-$

mol $H_2C_4H_4O_6$ = $\frac{0.0011773 \text{ mol } H^+ \mid 1 \text{ mol } H_2C_4H_4O_6}{\mid 2 \text{ mol } H_3O^+}$ = 5.8864×10^{-4} mol tartaric

$\frac{5.8864 \times 10^{-4} \text{ mol tartaric acid} \mid 150.0\text{ g tartaric acid}}{\mid 1 \text{ mol tartaric acid}} = 8.8296 \times 10^{-2}$ g tartaric acid (PURE)

2 sig figs!
$\frac{10.00\text{ mL} \mid 1.0\text{ g}}{\mid 1\text{ mL}} = 10.0$ g tartaric (IMPURE)

% PURITY = $\frac{\text{PURE MASS}}{\text{IMPURE MASS}} = \frac{8.8296 \times 10^{-2}\text{ g}}{10.0\text{ g}}$ = **0.88 %** (2 sig figs due to DENSITY value).

16. ① HBr (STRONG ACID = 100% dissociation).
② CH_3COOH (higher than HCN on acid column) → greater dissociation.
③ HCN.

17. a) $NH_4Br + KHCO_3 \longrightarrow KBr + NH_4HCO_3$

b) $\underset{\text{acid}}{NH_4^+} + \underset{\text{base}}{HCO_3^-} \rightleftharpoons \underset{\text{base}}{NH_3} + \underset{\text{acid}}{H_2CO_3}$

c) Reactants are favoured b/c H_2CO_3 is a stronger acid than NH_4^+.

18. * H_3O^+ is the DOMINANT species; focus calcs. on it!
pH 4.50: $[H_3O^+]$ = inv log (−4.50) = 3.1623×10^{-5} M H_3O^+
mol H_3O^+ = MV = $(3.1623 \times 10^{-5}\text{ M})(140\text{ L}) = 4.427 \times 10^{-3}$ mol H_3O^+
pH 6.80: $[H_3O^+]$ = inv log (−6.80) = 1.5849×10^{-7} M H_3O^+
mol H_3O^+ = MV: $(1.5849 \times 10^{-7}\text{ M})(140\text{ L}) = 2.2189 \times 10^{-5}$ mol H_3O^+

mol OH^- req'd = 4.427×10^{-3} mol H_3O^+ − 2.2189×10^{-5} mol H_3O^+
(= mol H_3O^+ added) = 4.4048×10^{-3} mol OH^-

DIPROTIC BASE
$Ca(OH)_2 \longrightarrow Ca^{2+} + 2OH^-$

$\frac{4.4028 \times 10^{-3} \text{ mol } OH^- \mid 1 \text{ mol } Ca(OH)_2 \mid 74.1\text{ g } Ca(OH)_2}{\mid 2 \text{ mol } OH^- \mid 1 \text{ mol } Ca(OH)_2}$ = **1.6×10^{-1} g $Ca(OH)_2$**
= **0.16 g $Ca(OH)_2$**

19. H_3O^+ is the strongest weak acid.
When any strong acid reacts w/ water, it dissociates 100% to form H_3O^+!

eg: $HCl + H_2O \xrightarrow{100\%} H_3O^+ + Cl^-$

∴ no strong acids exist in water

20. a) $K_W = 2.95 \times 10^{-15} = [H_3O^+][OH^-]$ * $[H_3O^+] = [OH^-]$ ⇒ WATER!

$2.95 \times 10^{-15} = [H_3O^+]^2$

$[H_3O^+] = 5.4314 \times 10^{-8}$ M pH = $-\log(5.4314 \times 10^{-8} M)$ = **7.265**

b) Water is NEUTRAL! $[H_3O^+] = [OH^-]$

21. a) $HSO_3^- + IO_3^- \rightleftharpoons SO_3^{2-} + HIO_3$

b) Acid Base Base Acid

c) Reactants are favoured b/c HIO_3 is higher than HSO_3^- in acid column on table

22. a) $2H_2O + \text{energy} \rightleftharpoons H_3O^+ + OH^-$ (ideal)

OR

$H_2O + \text{energy} \rightleftharpoons H^+ + OH^-$ (acceptable)

b) $K_W = [H_3O^+][OH^-]$

c) $K_W = 1.0 \times 10^{-14}$ $pK_W = 14$

d) If temp is increased, K_W increases and pK_W decreases.

23. a) Blood = 7-8 b) Rainwater = 5-7 c) Household cleaning products = 10-14
d) Battery Acid = 1-3 e) Coffee = 4-6

24 a) Arrhenius Acid - Any substance that releases H^+ in water.
b) Arrhenius Base - Any substance that releases OH^- in water.
c) B-L Acid - A substance that donates a proton (H^+) to another substance.
d) B-L Base - A substance that accepts a proton (H^+) from another substance.

25. i) $H_2O + CO_3^{2-} \rightleftharpoons HCO_3^- + OH^-$

ii) $Al(H_2O)_6^{3+} + H_2O \rightleftharpoons Al(H_2O)_5OH^{2+} + H_3O^+$

26. i) Measure electrical conductivity → Strong acid conducts better due to 100% dissociation.

ii) Measure the pH ⇒ Lower pH = Strong acid due to higher $[H_3O^+]$.