

**ACIDS AND BASES - 1. - Problem Sheet**

1. Write ionic equations and give observations for the following reactions:
  - a) dilute hydrochloric acid is added to calcium carbonate
  - b) a solution of sodium sulfide is added to a solution of nitric acid
  - c) small pieces of magnesium are added to a solution of hydrochloric acid
  - d) dilute sulfuric acid is added to copper hydroxide
2. Write ionic equations and give observations for the following reactions:
  - a) an excess of sodium hydroxide solution is added to zinc hydroxide
  - b) a solution of potassium hydroxide is added to aluminium and the mixture is heated.
  - c) a solution of potassium hydroxide is added to a solution of copper sulfate
  - d) a solution of sodium hydroxide is added to a solution of aluminium nitrate
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3. Identify each of the reactants in the following reactions as a Bronsted-Lowry acid or base.
  - a)  $\text{HCl(aq)} + \text{H}_2\text{O(l)} \rightarrow \text{H}_3\text{O}^+(\text{aq}) + \text{Cl}^-(\text{aq})$
  - b)  $\text{NH}_3(\text{aq}) + \text{H}_2\text{O(l)} \rightarrow \text{NH}_4^+(\text{aq}) + \text{OH}^-(\text{aq})$
  - c)  $\text{HSO}_4^-(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{SO}_4^{2-}(\text{aq}) + \text{H}_2\text{O(l)}$
  - d)  $2 \text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O(l)}$
  - e)  $\text{HCO}_3^-(\text{aq}) + \text{H}_2\text{O(l)} \rightarrow \text{H}_2\text{CO}_3(\text{aq}) + \text{OH}^-(\text{aq})$
  - f)  $\text{HF(aq)} + \text{HNO}_3(\text{aq}) \rightarrow \text{F}^-(\text{aq}) + \text{H}_2\text{NO}_3^+(\text{aq})$
4.
  - a) Write an equation showing nitric acid ( $\text{HNO}_3$ ) acting as an acid according to the Arrhenius theory.
  - b) Write an equation showing calcium hydroxide acting as a base according to the Arrhenius theory.
  - c) Write an equation to show nitric acid acting as an acid according to the Bronsted-Lowry theory

4. d) Write an equation to show ammonia, NH<sub>3</sub>, acting as a base according to the Bronsted-Lowry theory
5. a) Give the conjugate acids of the following species -  

Br<sup>-</sup>HCO<sub>3</sub><sup>-</sup>HF

b) Give the conjugate bases of the following species  

OH<sup>-</sup>NH<sub>4</sub><sup>+</sup>H<sub>2</sub>PO<sub>4</sub><sup>-</sup>
6. For the reactions below, list the conjugate pairs involved in each reaction, and state for each pair, which is the acid and which is the base:  

a) HCl(aq) + H<sub>2</sub>O(l) ⇌ H<sub>3</sub>O<sup>+</sup>(aq) + Cl<sup>-</sup>(aq)

b) NH<sub>3</sub>(aq) + H<sub>2</sub>O(l) ⇌ NH<sub>4</sub><sup>+</sup>(aq) + OH<sup>-</sup>(aq)

c) HSO<sub>4</sub><sup>-</sup>(aq) + OH<sup>-</sup>(aq) ⇌ SO<sub>4</sub><sup>2-</sup>(aq) + H<sub>2</sub>O(l)
7. 0.100 mole of hydrogen chloride is dissolved in 1.00 litre of solution. Calculate the concentrations, in moles per litre, of H<sup>+</sup> ions and OH<sup>-</sup> ions in the solution.
8. Calculate the concentrations, in moles per litre, of Ca<sup>2+</sup>, OH<sup>-</sup> and H<sup>+</sup> in a 0.0300 mol L<sup>-1</sup> Ca(OH)<sub>2</sub> solution.
9. 25.0 mL of 0.467 mol L<sup>-1</sup> H<sub>2</sub>SO<sub>4</sub> is added to 14.0 mL of 0.600 mol L<sup>-1</sup> NaOH. Calculate the concentrations, in mole per litre, of hydrogen ions and hydroxide ions in the resulting solution.
10. Calculate the pH of the following solutions  
a) a solution of nitric acid in which [H<sup>+</sup>] is 1.00 x 10<sup>-3</sup>.  
b) 0.0100 mol L<sup>-1</sup> HCl solution  
c) a solution of potassium hydroxide in which [OH<sup>-</sup>] is 1.00 x 10<sup>-2</sup>.  
d) 0.0500 mol L<sup>-1</sup> Ca(OH)<sub>2</sub> solution
11. Calculate the hydrogen ion and hydroxide ion concentrations in a solution with a pH of 9.00.
12. a) Calculate the pH of the solutions with the following concentrations of H<sup>+</sup>:  
i) 3.76 x 10<sup>-3</sup> mol L<sup>-1</sup>  
ii) 0.000592 mol L<sup>-1</sup>  
b) Calculate the concentration of H<sup>+</sup> in solutions that have the following pH values:  
i) pH of 2.31  
ii) pH of 0.843

13. Calculate the hydrogen ion and the hydroxide ion concentrations and the pH of the solutions which form when the following solutions are mixed:
- a) 0.500 L of 0.200 mol L<sup>-1</sup> HCl and 0.500 L of 0.200 mol L<sup>-1</sup> NaOH.
  - b) 1.00 L of 0.400 mol L<sup>-1</sup> HCl and 1.00 L of 0.200 mol L<sup>-1</sup> NaOH.
  - c) 1.00 L of 0.0200 mol L<sup>-1</sup> HCl and 1.00 L of 0.0200 mol L<sup>-1</sup> Ca(OH)<sub>2</sub>.
14. Calculate the pH of the following solutions:
- a) a solution in which the concentration of hydroxide ions is  $3.25 \times 10^{-2}$  mol L<sup>-1</sup>.
  - b) 20.0 mL of 0.00482 mol L<sup>-1</sup> HCl solution
  - c) 1.58 mol L<sup>-1</sup> KOH solution
  - d) a solution that has been prepared by dissolving 0.589 g of HCl in 2.50 L of solution.
  - e) a solution formed by reacting 32.0 mL of 2.89 mol L<sup>-1</sup> HNO<sub>3</sub> with 0.560 g of NaOH.
15. Identify each of the following as a strong acid, weak acid, strong base or weak base, and give an equation to support your answer.
- a) KOH
  - b) HNO<sub>2</sub>
  - c) NH<sub>3</sub>
  - d) MgO
  - e) HNO<sub>3</sub>
  - f) CH<sub>3</sub>CH<sub>2</sub>COOH
  - g) CO<sub>3</sub><sup>2-</sup>
  - h) HBr
  - i) HCO<sub>3</sub><sup>-</sup>
  - j) NH<sub>4</sub><sup>+</sup>
  - k) HSO<sub>4</sub><sup>-</sup>

16. Summarise the acid/base properties of substances by placing the following substances/labels in the correct columns:

most acids	negative ions of strong acids
$\text{NH}_4^+$	$\text{HSO}_4^-$ , $\text{H}_2\text{PO}_4^-$
positive ions of Groups 1 and 2	$\text{HCl}$ , $\text{HNO}_3$ , $\text{H}_2\text{SO}_4$ , $\text{HClO}_4$
transition metal ions and +3 metal ions	metal hydroxides and oxides
negative ions of weak acids	$\text{NH}_3$

Strong Acids	Weak Acids	Strong Bases	Weak Bases	Neutral

17. Place the following in the correct column:

$\text{CH}_3\text{COOH}$	$\text{HCl}$	$\text{NaOH}$	$\text{HNO}_2$	$\text{HClO}$
$\text{HClO}_4$	$\text{HSO}_4^-$	$\text{CO}_3^{2-}$	$\text{CaO}$	$\text{NH}_3$
$\text{NH}_4^+$ $\text{KOH}$	$\text{PO}_4^{3-}$	$\text{SO}_3^{2-}$	$\text{HCO}_3^-$	
$\text{HNO}_3$	$\text{HBr}$	$\text{Al}^{3+}$	$\text{HCOOH}$	$\text{Na}^+$
$\text{Cl}^-$	$\text{NO}_3^-$	$\text{SO}_4^{2-}$		

STRONG ACIDS	WEAK ACIDS	STRONG BASES	WEAK BASES	NEUTRAL

18.

0.03 mol L <sup>-1</sup> $\text{HNO}_3$ solution	14 mol L <sup>-1</sup> $\text{CH}_3\text{COOH}$ solution
0.001 mol L <sup>-1</sup> $\text{Ca}(\text{OH})_2$ solution	16 mol L <sup>-1</sup> $\text{H}_2\text{SO}_4$ solution
0.1 mol L <sup>-1</sup> $\text{H}_2\text{SO}_3$ solution	0.01 mol L <sup>-1</sup> $\text{NH}_3$ solution

From the above list choose

- |   |   |
|---|---|
| a) a dilute solution of a weak acid       | b) a concentrated solution of a strong acid |
| c) a dilute solution of a strong acid     | d) a dilute solution of a weak base         |
| e) a concentrated solution of a weak acid | f) a dilute solution of a strong base.      |

19. Name the salt formed in each of the following reactions:

- sodium hydroxide + nitric acid
- magnesium hydroxide + hydrochloric acid
- potassium hydroxide + ethanoic acid
- ammonia + hydrobromic acid
- sodium carbonate + sulfuric acid

20. For each of the following salts, decide whether they would form acidic, basic or neutral solutions, giving equations to support your answers.



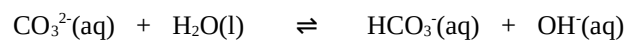
21. Describe the difference between “dissociation” and “hydrolysis”.

22. a) Which is the stronger base:  $\text{Cl}^-(\text{aq})$  or  $\text{NH}_3(\text{aq})$ ?

b) Which is the weaker acid:  $\text{HF}(\text{aq})$  or  $\text{HCl}(\text{aq})$ ?

c) Which is the weaker base:  $\text{F}^-(\text{aq})$  or  $\text{Cl}^-(\text{aq})$ ?

23.  $\text{H}_2\text{O}$  is a weaker acid than  $\text{HCO}_3^-$ . Would you expect the reactants or the products to be favoured in the following equilibrium system?



Which base would be the stronger?

**ANSWERS: ACIDS AND BASES - 1. - Problem Sheet.**

- $2\text{H}^+(\text{aq}) + \text{CaCO}_3(\text{s}) \rightarrow \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) + \text{Ca}^{2+}(\text{aq})$   
White solid dissolves to form colourless gas and colourless solution
  - $2\text{H}^+(\text{aq}) + \text{S}^{2-}(\text{aq}) \rightarrow \text{H}_2\text{S}(\text{g})$   
Colourless solution and a "rotten" smelling colourless gas form.
  - $2\text{H}^+(\text{aq}) + \text{Mg}(\text{s}) \rightarrow \text{H}_2(\text{g}) + \text{Mg}^{2+}(\text{aq})$   
Grey solid dissolves to form colourless solution and of colourless gas
  - $2\text{H}^+(\text{aq}) + \text{Cu}(\text{OH})_2(\text{s}) \rightarrow 2\text{H}_2\text{O}(\text{l}) + \text{Cu}^{2+}(\text{aq})$   
Green solid dissolves to form blue solution
- $\text{Zn}(\text{OH})_2(\text{s}) + 2\text{OH}^-(\text{aq}) \rightarrow \text{Zn}(\text{OH})_4^{2-}(\text{aq})$   
White solid dissolves to form colourless solution
  - $2\text{Al}(\text{s}) + 2\text{OH}^-(\text{aq}) + 6\text{H}_2\text{O}(\text{l}) \rightarrow 3\text{H}_2(\text{g}) + 2\text{Al}(\text{OH})_4^-(\text{aq})$   
Silver metal dissolves to form colourless solution and colourless gas
  - $\text{Cu}^{2+}(\text{aq}) + 2\text{OH}^-(\text{aq}) \rightarrow \text{Cu}(\text{OH})_2(\text{s})$   
A blue precipitate forms
  - $\text{Al}^{3+}(\text{aq}) + 4\text{OH}^-(\text{aq}) \rightarrow \text{Al}(\text{OH})_4^-(\text{aq})$   
A white precipitate first forms. It then dissolves to form a colourless solution
- $\text{HCl}(\text{aq})$  - acid       $\text{H}_2\text{O}(\text{l})$  - base
  - $\text{HSO}_4^-(\text{aq})$  - acid       $\text{OH}^-(\text{aq})$  - base
  - $\text{HCO}_3^-(\text{aq})$  - base       $\text{H}_2\text{O}(\text{l})$  - acid
  - $\text{NH}_3(\text{aq})$  - base       $\text{H}_2\text{O}(\text{l})$  - acid
  - not an acid/base reaction
  - $\text{HF}(\text{aq})$  - acid       $\text{HNO}_3(\text{aq})$  - base
- $\text{HNO}_3 \rightarrow \text{H}^+ + \text{NO}_3^-$
  - $\text{HNO}_3 + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+ + \text{NO}_3^-$
  - $\text{Ca}(\text{OH})_2 \rightarrow \text{Ca}^{2+} + 2\text{OH}^-$
  - $\text{NH}_3 + \text{H}_2\text{O} \rightarrow \text{NH}_4^+ + \text{OH}^-$
- $\text{Br}^-$  -  **$\text{HBr}$**        $\text{HCO}_3^-$  -  **$\text{H}_2\text{CO}_3$**        $\text{HF}$  -  **$\text{H}_2\text{F}^+$**
  - $\text{OH}^-$  -  **$\text{O}^{2-}$**        $\text{NH}_4^+$  -  **$\text{NH}_3$**        $\text{H}_2\text{PO}_4^-$  -  **$\text{HPO}_4^{2-}$**
- $\text{HCl}(\text{A}) / \text{Cl}^-(\text{B})$        $\text{H}_2\text{O}(\text{B}) / \text{H}_3\text{O}^+(\text{A})$
  - $\text{HSO}_4^-(\text{A}) / \text{SO}_4^{2-}(\text{B})$        $\text{H}_2\text{O}(\text{A}) / \text{OH}^-(\text{B})$
  - $\text{NH}_3(\text{B}) / \text{NH}_4^+(\text{A})$        $\text{OH}^-(\text{B}) / \text{H}_2\text{O}(\text{A})$
- $\text{HCl} \rightarrow \text{H}^+ + \text{Cl}^-$       moles of  $\text{H}^+$  formed = 0.100      i.e. conc of  $\text{H}^+$  =  **$0.100 \text{ mol L}^{-1}$**   
 $[\text{OH}^-] = 1 \times 10^{-13} \text{ mol L}^{-1}$
- $\text{Ca}(\text{OH})_2 \rightarrow \text{Ca}^{2+} + 2\text{OH}^-$       conc of  $\text{Ca}^{2+}$  =  **$0.0300 \text{ mol L}^{-1}$**   
conc of  $\text{OH}^-$  =  $2 \times 0.0300 =$   **$0.0600 \text{ mol L}^{-1}$**       conc of  $\text{H}^+$  =  **$1.67 \times 10^{-13} \text{ mol L}^{-1}$**
- moles  $\text{H}_2\text{SO}_4 = 0.467 \times 0.025 = 0.01167$       i.e. moles of  $\text{H}^+ = 2 \times 0.01167 = 0.02335$   
moles  $\text{NaOH} = 0.600 \times 0.0140 = 0.0084 =$  moles of  $\text{OH}^-$   
 $\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}$        $\text{OH}^-$  is the limiting reagent  
i.e. 0.0084 moles of  $\text{OH}^-$  will react with 0.0084 moles of  $\text{H}^+$   
moles of  $\text{H}^+$  left after the reaction =  $0.02335 - 0.0084 = 0.01495$       vol of new solution = 39.0 mL  
conc of  $\text{H}^+$  in new solution =  **$0.383 \text{ mol L}^{-1}$**   
conc of  $\text{OH}^- = 2.61 \times 10^{-14} \text{ mol L}^{-1}$
- pH = **3**
  - $[\text{H}^+] = 0.0100 \text{ mol L}^{-1}$       i.e. pH = **2**
  - $[\text{H}^+] = 1 \times 10^{-12} \text{ mol L}^{-1}$       i.e. pH = **12**
  - $[\text{OH}^-] = 2 \times 0.0500 = 0.100 \text{ mol L}^{-1}$        $[\text{H}^+] = 1 \times 10^{-13} \text{ mol L}^{-1}$       i.e. pH = **13**
- $[\text{H}^+] = 1 \times 10^{-9} \text{ mol L}^{-1}$        $[\text{OH}^-] = 1 \times 10^{-5} \text{ mol L}^{-1}$
- i) pH =  $-\log 3.76 \times 10^{-3} =$  **2.42**      ii) pH =  $-\log 0.000592 =$  **3.23**
  - i)  $[\text{H}^+] =$   **$0.00490 \text{ mol L}^{-1}$**       ii)  $[\text{H}^+] =$   **$0.144 \text{ mol L}^{-1}$**

13. a) moles HCl =  $0.500 \times 0.200 = 0.100$  = moles of  $\text{H}^+$   
 moles NaOH =  $0.500 \times 0.200 = 0.100$  = moles of  $\text{OH}^-$   
 $\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}$  0.100 moles of  $\text{H}^+$  will react with 0.100 moles of  $\text{OH}^-$   
 i.e. there will be no  $\text{H}^+$  or  $\text{OH}^-$  remaining from this reaction  
 But there will be  $\text{H}^+$  and  $\text{OH}^-$  from the self-ionisation of water  
 i.e.  $[\text{H}^+] = [\text{OH}^-] = 1 \times 10^{-7} \text{ mol L}^{-1}$  (i.e. it is a neutral solution)  
 $\text{pH} = -\log [\text{H}^+] = -\log 1 \times 10^{-7} = 7$
- b) moles HCl =  $0.400 \times 1.00 = 0.400$  = moles of  $\text{H}^+$   
 moles NaOH =  $0.200 \times 1.00 = 0.200$  = moles of  $\text{OH}^-$   
 $\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}$   $\text{OH}^-$  is the limiting reagent  
 i.e. 0.200 moles of  $\text{OH}^-$  will react with 0.200 moles of  $\text{H}^+$   
 After the reaction there will be  $0.400 - 0.200 = 0.200$  moles of  $\text{H}^+$  remaining vol of new solution = 2.00 L  
 $[\text{H}^+] \text{ in new solution} = 0.100 \text{ mol L}^{-1}$   $[\text{OH}^-] = 1.00 \times 10^{-13} \text{ mol L}^{-1}$   
 $\text{pH} = -\log [\text{H}^+] = 1$
- c) moles HCl =  $0.0200 \times 1.00 = 0.0200$  = moles of  $\text{H}^+$   
 moles  $\text{Ca}(\text{OH})_2 = 0.0200 \times 1.00 = 0.0200$  moles of  $\text{OH}^- = 2 \times 0.0200 = 0.0400$   
 $\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}$   $\text{H}^+$  is the limiting reagent  
 0.0200 moles of  $\text{H}^+$  will react with 0.0200 moles of  $\text{OH}^-$   
 i.e. will be left with  $0.0400 - 0.0200 = 0.0200$  moles of  $\text{OH}^-$  new volume = 2.00 L  
 new  $[\text{OH}^-] = 0.0100 \text{ mol L}^{-1}$   
 $[\text{H}^+] = 1 \times 10^{-12} \text{ mol L}^{-1}$   $\text{pH} = -\log [\text{H}^+] = 12$
14. a)  $[\text{H}^+] = 3.077 \times 10^{-13} \text{ mol L}^{-1}$   $\text{pH} = -\log (3.077 \times 10^{-13}) = 12.5$   
 b)  $[\text{H}^+] = 0.00482 \text{ mol L}^{-1}$   $\text{pH} = -\log 0.00482 = 2.32$   
 c)  $[\text{OH}^-] = 1.58 \text{ mol L}^{-1}$   $[\text{H}^+] = 6.329 \times 10^{-15} \text{ mol L}^{-1}$   $\text{pH} = 14.2$   
 d) moles of HCl = 0.01615 = moles of  $\text{H}^+$   
 conc of  $\text{H}^+ = 0.006462 \text{ mol L}^{-1}$   $\text{pH} = 2.19$
- e) moles of  $\text{HNO}_3 = 2.89 \times 0.032 = 0.09248$  = moles of  $\text{H}^+$   
 moles of NaOH = 0.0140 = moles of  $\text{OH}^-$   
 $\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}$   $\text{OH}^-$  is the limiting reagent  
 0.0140 moles of  $\text{OH}^-$  will react with 0.0140 moles of  $\text{H}^+$   
 i.e. will be left with  $0.09248 - 0.0140 = 0.07848$  moles of  $\text{H}^+$  volume = 32.0 mL  
 $[\text{H}^+] = 2.452 \text{ mol L}^{-1}$   $\text{pH} = -0.390$
15. a) KOH - strong base  $\text{KOH} \rightarrow \text{K}^+ + \text{OH}^-$   
 b)  $\text{HNO}_2$  - weak acid  $\text{HNO}_2 \rightleftharpoons \text{NO}_2^- + \text{H}^+$   
 c)  $\text{NH}_3$  - weak base  $\text{NH}_3 + \text{H}_2\text{O} \rightleftharpoons \text{NH}_4^+ + \text{OH}^-$   
 d) MgO - strong base  $\text{MgO} + \text{H}_2\text{O} \rightarrow \text{Mg}^{2+} + 2 \text{OH}^-$   
 e)  $\text{HNO}_3$  - strong acid  $\text{HNO}_3 \rightarrow \text{H}^+ + \text{NO}_3^-$   
 f)  $\text{CH}_3\text{CH}_2\text{COOH}$  - weak acid  $\text{CH}_3\text{CH}_2\text{COOH} \rightleftharpoons \text{CH}_3\text{CH}_2\text{COO}^- + \text{H}^+$   
 g)  $\text{CO}_3^{2-}$  - weak base  $\text{CO}_3^{2-} + \text{H}_2\text{O} \rightleftharpoons \text{HCO}_3^- + \text{OH}^-$   
 h) HBr - strong acid  $\text{HBr} \rightarrow \text{H}^+ + \text{Br}^-$   
 i)  $\text{HCO}_3^-$  - weak base  $\text{HCO}_3^- + \text{H}_2\text{O} \rightleftharpoons \text{H}_2\text{CO}_3 + \text{OH}^-$   
 j)  $\text{NH}_4^+$  - weak acid  $\text{NH}_4^+ + \text{H}_2\text{O} \rightleftharpoons \text{NH}_3 + \text{H}_3\text{O}^+$   
 k)  $\text{HSO}_4^-$  - weak acid  $\text{HSO}_4^- + \text{H}_2\text{O} \rightleftharpoons \text{SO}_4^{2-} + \text{H}_3\text{O}^+$

16.

Strong Acids	Weak Acids	Strong Bases	Weak Bases	Neutral
HCl, HNO <sub>3</sub> , H <sub>2</sub> SO <sub>4</sub> , HClO <sub>4</sub>	most acids NH <sub>4</sub> <sup>+</sup> HSO <sub>4</sub> <sup>-</sup> , H <sub>2</sub> PO <sub>4</sub> <sup>-</sup> transition metal ions and +3 metal ions	metal hydroxides and oxides	negative ions of weak acids NH <sub>3</sub>	negative ions of strong acids positive ions of Groups 1 and 2

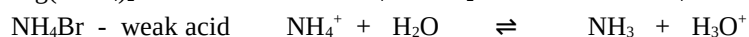
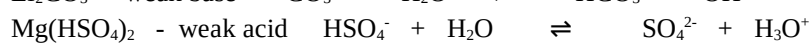
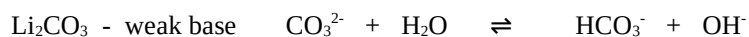
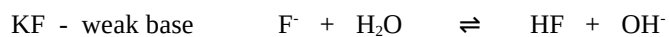
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STRONG ACIDS	WEAK ACIDS	STRONG BASES	WEAK BASES	NEUTRAL
HCl HClO <sub>4</sub> HNO <sub>3</sub> HBr	CH <sub>3</sub> COOH HNO <sub>2</sub> HClO HSO <sub>4</sub> <sup>-</sup> NH <sub>4</sub> <sup>+</sup> Al <sup>3+</sup> HCOOH	NaOH CaO KOH	CO <sub>3</sub> <sup>2-</sup> NH <sub>3</sub> PO <sub>4</sub> <sup>3-</sup> SO <sub>3</sub> <sup>2-</sup> HCO <sub>3</sub> <sup>-</sup>	Na <sup>+</sup> Cl <sup>-</sup> NO <sub>3</sub> <sup>-</sup> SO <sub>4</sub> <sup>2-</sup>

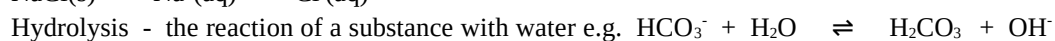
18. a) 0.1 mol L<sup>-1</sup> H<sub>2</sub>SO<sub>3</sub> solution                      b) 16 mol L<sup>-1</sup> H<sub>2</sub>SO<sub>4</sub> solution  
 c) 0.03 mol L<sup>-1</sup> HNO<sub>3</sub> solution                      d) 0.01 mol L<sup>-1</sup> NH<sub>3</sub> solution  
 e) 14 mol L<sup>-1</sup> CH<sub>3</sub>COOH solution                      f) 0.001 mol L<sup>-1</sup> Ca(OH)<sub>2</sub> solution

19. a) sodium nitrate                      b) magnesium chloride                      c) potassium ethanoate  
 d) ammonium bromide                      e) sodium sulfate

20. NaCl - neutral



21. Dissociation - the breaking up of an ionic lattice that occurs when an ionic substance is dissolved in water e.g.  
 $\text{NaCl(s)} \rightarrow \text{Na}^+(\text{aq}) + \text{Cl}^-(\text{aq})$



22. a) NH<sub>3</sub>(aq)                      b) HF (aq)                      c) Cl<sup>-</sup>(aq)

23. reactants                      OH<sup>-</sup>