3. \[ n_{\text{NaNO}_3} = \frac{m}{M} \]
\[ = \frac{(1.000 \text{ g})}{(85.0 \text{ g/mol})} \]
\[ = 0.011765 \text{ mol NaNO}_3 \]

\[ C = \frac{n}{V} \]
\[ = \frac{(0.011765 \text{ mol})}{(0.315 \text{ L})} \]
\[ = 0.037 \text{ M} \]

\[ \text{So the } [\text{NaNO}_3] \text{ is } 0.037 \text{ M} \]

4. \[ \text{Ca(NO}_3)_2(\text{aq}) \rightarrow \text{Ca}^{2+}(\text{aq}) + 2\text{NO}_3^{-}(\text{aq}) \]
\[ n = 5.0 \times 10^{-2} \text{ mol} \]

\[ \frac{2 \text{ mol \text{NO}_3}^{-}}{5.0 \times 10^{-2} \text{ mol}} \times x = 0.025 \text{ mol \text{Ca(NO}_3)_2} \]

\[ V = \frac{n}{C} \]
\[ = \frac{(0.025 \text{ mol})}{(4.00 \times 10^{-2} \text{ mol/L})} \]
\[ = 0.625 \text{ L} \]

\[ \text{So } 0.625 \text{ L of Ca(NO}_3)_2 \text{ contains } 5.0 \times 10^{-2} \text{ mol of NO}_3^{-} \]

5. \[ C_1V_1 = C_2V_2 \]
\[ C_2 = \frac{C_1V_1}{V_2} \]
\[ = \frac{(4.00 \text{ M})(0.080 \text{ L})}{(0.400 \text{ L})} \]
\[ = 0.8 \text{ M} \]

\[ \text{So the } [\text{H}_2\text{SO}_4] \text{ is } 0.8 \text{ M} \]

6. \[ n = CV \]
\[ = (0.00100 \text{ M})(0.100 \text{ L}) \]
\[ = 1.0 \times 10^{-4} \text{ mol NaOH} \]

\[ \text{So there are } 1.0 \times 10^{-4} \text{ mol of NaOH} \]
7. \( \frac{m}{m\%} = \frac{\text{mass of solute (g)}}{\text{mass of solution (g)}} \times 100 \)

\[
= \left( \frac{0.02 \text{g}}{70000 \text{g}} \right) \times 100
\]

\[
= 2.86 \times 10^{-5} \%
\]

\( \text{nic/day} = \text{nic./cig} \times \text{cig/day} \)

\[
= (0.001 \text{g}) \times 20
\]

\[
= 0.02 \text{g nic}
\]

8. \( n_{\text{Na}^+} = \frac{m}{M} \)

\[
= \left( \frac{3.4 \text{g}}{22.99 \text{g/mol}} \right)
\]

\[
= 0.1479 \text{ mol Na}^+
\]

\[
C = \frac{n}{V} = \frac{0.1479 \text{mol}}{1 \text{L}} = 0.1479 \text{ M}
\]

\( \therefore [\text{Na}^+] \text{ is } 0.1479 \text{ M} \)

9. a) \( \text{H}_2\text{SO}_4 (aq) \) sulphuric acid
    b) \( \text{HNO}_3(aq) \) nitric acid
    c) \( \text{HBr} (aq) \) hydrobromic acid
    d) \( \text{HCl} (aq) \) hydrochloric acid
    e) \( \text{HF} (aq) \) hydrofluoric acid

10. a) \( [\text{H}_3\text{O}^+] = 10^{-\text{pH}} \)

\[
= 10^{-2.5}
\]

\[
= 3.16 \times 10^{-3} \text{ M}
\]

\( \text{So the } [\text{H}_3\text{O}^+] \text{ is } 3.16 \times 10^{-3} \text{ M} \)

10. b) \( \text{NaOH} (aq) + \text{HCl} (aq) \rightarrow \text{H}_2\text{O}(e) + \text{NaCl} (aq) \)

\[
V = 0.032 \text{L} \quad V = 0.020 \text{L} \quad C = 1.0 \text{M}
\]

\[
\text{C} = \frac{n}{V} \quad \text{C} = \frac{0.020 \text{mol}}{0.032 \text{L}} = 0.625 \text{M}
\]

\[
\text{So } 0.032 \text{L is required}
\]
11. \[ \text{Ca(OH)}_2 (aq) \rightarrow \text{Ca}^{2+} (aq) + 2\text{OH}^- (aq) \]
\[ C = 1.0 \times 10^{-5} \text{M} \]
\[ [\text{OH}^-] = 2.0 \times 10^{-5} \text{M} \]
\[ \rho \text{OH} = -\log [\text{OH}^-] \]
\[ = -\log [2.0 \times 10^{-5}] \]
\[ = 4.70 \]
\[ \rho \text{H} = 14 - \rho \text{OH} \]
\[ = 14 - 4.70 \]
\[ = 9.3 \]

\[ \therefore \text{the pH of Ca(OH)}_2 \text{ is 9.3} \]

12. \[ n_{\text{NaOH}} = \frac{m}{M} \]
\[ = \frac{2.5 \text{g}}{40.01 \text{g/mol}} \]
\[ = 0.0625 \text{ mol NaOH} \]
\[ \rho \text{OH} = -\log [\text{OH}^-] \]
\[ = -\log [0.0625] \]
\[ = 0.204 \]
\[ \rho \text{H} = 14 - \rho \text{OH} \]
\[ = 12.8 \]

\[ \therefore \text{the pH is 12.8} \]

13. a) \[ \text{H}^\text{acid}(aq) + \text{NH}_3(aq) \rightarrow \text{NH}_4^+(aq) + \text{F}^-(aq) \]
\[ \text{acid} \quad \text{base} \quad \text{conj acid} \quad \text{conj base} \]

b) \[ \text{Fe(H}_2\text{O})_6^{3+}(aq) + \text{H}_2\text{O}(l) \rightarrow \text{Fe(H}_2\text{O})_5\text{(OH)}_2(aq) + \text{H}_3\text{O}^+(aq) \]
\[ \text{acid} \quad \text{base} \quad \text{conj base} \quad \text{conj acid} \]

c) \[ \text{NH}_4^+(aq) + \text{CN}^-(aq) \rightarrow \text{HCN}(aq) + \text{NH}_3 \]
\[ \text{acid} \quad \text{base} \quad \text{conj acid} \quad \text{conj base} \]
13. (a) \((\text{CH}_3)_3\text{N}^{\text{aq}} + \text{H}_2\text{O}(\ell) \rightarrow (\text{CH}_3)_3\text{NH}^{\text{aq}} + \text{OH}^{-}(\text{aq})\)

\[
\text{base} + \text{acid} \rightarrow \text{conjugate acid} + \text{conjugate base}
\]

\[
\text{HCl} + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+ + \text{Cl}^{-}
\]

14. \(n_{\text{HCl}} = CV\)

\[
= (4.00 \text{ M})(0.07 \text{ L})
\]

\[
= 0.28 \text{ mol HCl}
\]

\[
1 \text{ mol HCl} \rightarrow 1 \text{ mol H}_3\text{O}^+
\]

\[
\frac{0.28 \text{ mol}}{0.28 \text{ mol} \times x
\]

\[
x = 0.28 \text{ mol H}_3\text{O}^+
\]

\[
1 \text{ mol HNO}_3 = 1 \text{ mol H}_3\text{O}^+
\]

\[
\frac{0.24 \text{ mol}}{0.24 \text{ mol} \times x
\]

\[
x = 0.24 \text{ mol H}_3\text{O}^+
\]

\[
\eta_{\text{H}_3\text{O}^+ \text{total}} = 0.28 + 0.24
\]

\[
= 0.52 \text{ mol H}_3\text{O}^+
\]

\[
\eta_{\text{total}} = 0.070 + 0.030
\]

\[
= 0.100 L
\]

\[
[C_{\text{H}_3\text{O}^+}] = \frac{\eta}{V}
\]

\[
= \frac{0.52 \text{ mol}}{0.100 \text{ L}}
\]

\[
= 5.2 \text{ M}
\]

\[
\eta_{\text{C}_2} = \frac{C_{\text{i}_{\text{H}_3\text{O}^+}}}{V_2}
\]

\[
= \frac{(5.2 \text{ M})(0.100 \text{ L})}{(0.500 \text{ L})}
\]

\[
= 1.04 \text{ M}
\]

\[
\text{pH} = -\log[C_{\text{H}_3\text{O}^+}]
\]

\[
= -\log[1.04]
\]

\[
= -0.017
\]

\[
= 0
\]

So, the pH of the solution is 0.
Solutions & Solubility Sample Questions

1. \( \text{m/m\%} = \frac{\text{mass of solute (g)}}{\text{mass of solution (g)}} \times 100 \)
   
   \[ = \frac{4.58 \text{g}}{23.47 \text{g}} \times 100 \]
   
   \[ = 19.5\% \]

   \( \% \) the m/m\% of CaCl₂ is 19.5\%.

2. \( \text{ppb} = \frac{\text{mass of solute (g)}}{\text{mass of solution (g)}} \times 10^9 \)

   \[ \text{mass of solute} = \text{ppb} \times \text{mass of solution} \]
   
   \[ = 25 \times \frac{200000000}{10^9} \]
   
   \[ = 0.5 \text{g} \]

   \( \% \) 0.5g is the maximum mass allowed.

3. \( n_{\text{NaCl}} = \frac{M}{M} \)

   \[ = \frac{0.90 \text{g}}{58.44 \text{g/mol}} \]
   
   \[ = 0.0154 \text{ mol NaCl} \]

   \( \% \) the [NaCl] is 0.0154M.

4. \( V_1 = \frac{C_2 V_2}{C_1} \)

   \( V_{H_2O} = V_{\text{total}} - V_1 \)

   \[ V_{H_2O} = 2.0 - 0.0111 \]
   
   \[ = 1.989 \text{ L H}_2\text{O} \]

   \( \% \) Mr. Arthur needs 0.0111 L of 18M H₂SO₄ & 1.989 L of H₂O.
5. \[ \text{Na}_2\text{S} (aq) + \text{FeSO}_4 (aq) \rightarrow \text{Na}_2\text{SO}_4 (aq) + \text{FeS} (s) \]

\[ 2\text{Na}^+ (aq) + \text{S}^{2-} (aq) + \text{Fe}^{2+} (aq) + \text{SO}_4^{2-} (aq) \rightarrow 2\text{Na}^+ (aq) + \text{SO}_4^{2-} (aq) + \text{FeS} (s) \]

spectator ions: \( \text{Na}^+ (aq) \) \& \( \text{SO}_4^{2-} (aq) \)

\[ \text{Fe}^{2+} (aq) + \text{S}^{2-} (aq) \rightarrow \text{FeS} (s) \]

6. Add one crystal if it

- **dissolves = unsaturated**
- **does not dissolve = saturated**
- **recrystallizes = supersaturated**

7. \[ \text{Na}_2\text{S} (aq) + \text{Hg(NO}_3)_2 (aq) \rightarrow \text{HgS} (s) + 2\text{NaNO}_3 (aq) \]

\[ V = 0.025L \quad \text{V} = 0.0565L \]

C = 0.085M \quad C = 0.10M

\[ n_{\text{Na}_2\text{S}} = CV 
= (0.085)(0.025)
= 2.125 \times 10^{-3} \text{mol} \]

\[ n_{\text{Hg(NO}_3)_2} = CV
= (0.10)(0.0565)
= 5.65 \times 10^{-3} \text{mol} \]

\[ 1 \text{ mol Na}_2\text{S} = 1 \text{ mol HgS} \]

\[ \frac{1 \text{ mol Na}_2\text{S}}{2.125 \times 10^{-3}} \times \frac{1 \text{ mol HgS}}{5.65 \times 10^{-3} \text{ mol HgS}} \]

\[ x = 2.125 \times 10^{-3} \text{ mol HgS} \]

\[ 0.493 \text{ g of HgS is expected to precipitate} \]

8. \[ \text{HCN} (aq) + \text{H}_2\text{O} (l) \leftrightarrow \text{H}_3\text{O}^+ (aq) + \text{CN}^- (aq) \]

acid \hspace{1cm} base \hspace{1cm} conj acid \hspace{1cm} conj base

9. \[ \text{pH} = -\log \left[ \text{H}_3\text{O}^+ \right] \]

\[ = -\log \left[ 3.8 \times 10^{-3} \right] \]

\[ = 2.42 \text{ ; the pH of the solution is 2.42} \]
10. \( \text{HCl (aq)} + \text{NaOH (aq)} \rightarrow \text{NaCl (aq)} + \text{H}_2\text{O (l)} \)

\[ V = 0.01384 \text{ L} \quad V = 0.025 \text{ L} \]

\[ C = ? \quad C = 0.100 \text{ M} \]

\[ n_{\text{NaOH}} = CV \]
\[ = (0.100 \text{ M})(0.025 \text{ L}) \]
\[ = 2.5 \times 10^{-3} \text{ mol NaOH} \]

\[ 1 \text{ mol NaOH} = 1 \text{ mol HCl} \]
\[ \frac{1}{2.5 \times 10^{-3} \text{ mol}} = \frac{x}{1} \]
\[ x = 2.5 \times 10^{-3} \text{ mol HCl} \]

\[ C_{\text{HCl}} = \frac{n}{V} \]
\[ = \frac{(2.5 \times 10^{-3})}{(0.01384 \text{ L})} \]
\[ = 0.1806 \text{ M} \]

So the [HCl] is 0.1806 M.
### A. Fill in the blanks (use the following list)

<table>
<thead>
<tr>
<th>catalyser</th>
<th>ionization</th>
<th>acid</th>
<th>base</th>
<th>neutralization</th>
</tr>
</thead>
<tbody>
<tr>
<td>indicator</td>
<td>electrolyte</td>
<td>rate</td>
<td>pH</td>
<td>concentration</td>
</tr>
</tbody>
</table>

1. A(n) **ACID** is a substance that when dissolved in water ionizes to form H⁺ ions and anions.
2. The **pH** scale is used to determine the degree of acidity or alkalinity.
3. The amount of pure acid or base per 1 L of water is the definition of **CONCENTRATION**.
4. When an ionic substance is dissolved in water it undergoes the process of **IONIZATION**.
5. A(n) **BASE** is a substance that when dissolved in water ionizes to form cations and OH⁻ ions.
6. An aqueous solution that is capable of conducting electricity is known as a(n) **ELECTROLYTE**.
7. A substance that speeds up chemical reactions is called a **CATALYST**.
8. The speed at which a reaction occurs is the **RATE** of reaction.
9. A(n) **INDICATOR** is a substance that changes colour at a specific pH range.
10. Water and salt are the products of a **NEUTRALIZATION** reaction.

### B. True or False (If the statement is false, rewrite the statement to make it true)

<table>
<thead>
<tr>
<th>Statement</th>
<th>Correct Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>11. A strong base and a weak base could have the same pH level.</td>
<td><strong>T</strong></td>
</tr>
<tr>
<td>12. An acid with a pH of 2 is 20 times stronger than an acid with a pH of 4.</td>
<td><strong>F</strong> 200</td>
</tr>
<tr>
<td>13. Each 1 unit on the pH scale represents a tenfold increase in concentration.</td>
<td><strong>T</strong></td>
</tr>
<tr>
<td>14. Decreasing the surface area of a reactant would increase the rate of reaction.</td>
<td><strong>F</strong> INCREASING</td>
</tr>
<tr>
<td>15. Increasing the concentration of the reactants would increase the rate of reaction.</td>
<td><strong>T</strong></td>
</tr>
<tr>
<td>16. Decreasing the temperature of the reaction would increase the rate of reaction.</td>
<td><strong>F</strong> INCREASING</td>
</tr>
<tr>
<td>17. Phenolphthalein turns pink in an acid.</td>
<td><strong>F</strong></td>
</tr>
<tr>
<td>18. acid/base</td>
<td><strong>19. red litmus/blue litmus</strong></td>
</tr>
<tr>
<td>- BOTH DISSOCIATE TO FORM IONS</td>
<td>- BOTH INDICATE pH OF SOLUTION</td>
</tr>
<tr>
<td>- ACIDS FORM H₂O⁻</td>
<td>- RED LITMUS TURNS BLUE IN A BASE</td>
</tr>
<tr>
<td>- BASES FORM OH⁻</td>
<td>- BLUE LITMUS TURNS RED IN AN ACID</td>
</tr>
<tr>
<td>20. surface area/temperature</td>
<td><strong>21. concentration/ionization</strong></td>
</tr>
<tr>
<td>- BOTH AFFECT THE RATE OF REACTION</td>
<td>- BOTH INDICATE AMOUNT OF IONS IN SOL’N</td>
</tr>
<tr>
<td>- INCREASING SURFACE AREA INCREASES RATE</td>
<td>- [ ] IS AMOUNT OF SOLUTE (mol) / LITRE</td>
</tr>
<tr>
<td>- INCREASING TEMPERATURE INCREASES RATE</td>
<td>- IONIZATION IS AMOUNT OF IONS / MOLECULE</td>
</tr>
<tr>
<td>22. strong acid/weak acid</td>
<td><strong>23. bromothymol blue/phenolphptalein</strong></td>
</tr>
<tr>
<td>- BOTH INDICATE THE POTENTIAL TO IONIZE</td>
<td>- BOTH ARE INDICATORS</td>
</tr>
<tr>
<td>- STRONG ACIDS FULLY IONIZE</td>
<td>- BTB TURNS YELLOW IN ACIDS</td>
</tr>
<tr>
<td>- WEAK ACIDS PARTIALLY IONIZE</td>
<td>- PHENOLPHTHALEIN TURNS PINK IN A BASE</td>
</tr>
<tr>
<td>24. H⁺/OH⁻</td>
<td><strong>25. metal oxides/non-metal oxides</strong></td>
</tr>
<tr>
<td>- TOGETHER MAKE H₂O</td>
<td>- BOTH ARE OXIDES</td>
</tr>
<tr>
<td>- H⁺ RELEASED FROM ACIDS</td>
<td>- METAL OXIDES IN WATER MAKE BASES</td>
</tr>
<tr>
<td>- OH⁻ RELEASED FROM BASES</td>
<td>- NON-METAL OXIDES IN WATER MAKE ACIDS</td>
</tr>
</tbody>
</table>
D. Multiple choice (Choose the best answer)

26. Which of the following is an acid?
   a) NaOH
   b) H₂O
   c) HCH₃CO₂
   d) Mg(OH)₂

27. Which of the following would make an acid when dissolved in water?
   a) sulphur trioxide \( \text{SO}_3(g) + \text{H}_2\text{O}(l) \rightarrow \text{H}_2\text{SO}_4(aq) \)
   b) magnesium oxide
   c) aluminum oxide
   d) copper(II) oxide

28. Which of the following would make a base when dissolved in water?
   a) carbon dioxide
   b) sulphur trioxide
   c) sodium oxide \( \text{Na}_2\text{O}(s) + \text{H}_2\text{O}(l) \rightarrow 2\text{NaOH}(aq) \)
   d) nitrogen dioxide

29. What type of reaction occurs between NaOH + HCl?
   a) synthesis
   b) decomposition
   c) single displacement
   d) double displacement

30. The pH of the reaction in #29 should be
   a) 0
   b) 5
   c) 7
   d) 9

31. When Alkaseltzer is ground into a powder, it reacts more quickly in water. This is an example of the effect of:
   a) concentration
   b) surface area
   c) temperature
   d) a catalyst

32. Cake batter rises when the cake is baked. This is an example of the effect of:
   a) concentration
   b) surface area
   c) temperature
   d) a catalyst

33. Which of the following is a strong acid?
   a) HCH₃CO₂
   b) NaOH
   c) HCl
   d) HC₂H₅O₂
### E. Characteristics of Acids & Bases (fill in the following chart)

<table>
<thead>
<tr>
<th>INDICATOR/TEST</th>
<th>ACID</th>
<th>BASE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Litmus Paper</td>
<td>RED</td>
<td>BLUE</td>
</tr>
<tr>
<td>Blue Litmus Paper</td>
<td>RED</td>
<td>BLUE</td>
</tr>
<tr>
<td>Phenolphthalein</td>
<td>CLEAR</td>
<td>PINK</td>
</tr>
<tr>
<td>Bromothymol Blue</td>
<td>YELLOW</td>
<td>BLUE</td>
</tr>
<tr>
<td>Feel</td>
<td>N/A</td>
<td>SLIPPERY</td>
</tr>
<tr>
<td>Taste</td>
<td>SOUR</td>
<td>BITTER</td>
</tr>
<tr>
<td>Reaction with Mg</td>
<td>RELEASES $H_2(g)$</td>
<td>NR</td>
</tr>
<tr>
<td>Reaction with baking soda</td>
<td>RELEASES $CO_2(g)$</td>
<td>NR</td>
</tr>
<tr>
<td>Conductivity</td>
<td>STRONG = YES</td>
<td>STRONG = YES</td>
</tr>
<tr>
<td></td>
<td>WEAK = POOR</td>
<td>WEAK = POOR</td>
</tr>
</tbody>
</table>

### F. Making Acids & Bases (write out the acid or base product and then balance the equation)

34. $\text{SO}_3(g) + \text{H}_2\text{O}(l) \rightarrow \text{H}_2\text{SO}_4(aq)$

35. $\text{K}_2\text{O}(s) + \text{H}_2\text{O}(l) \rightarrow 2\text{KOH}(aq)$

36. $\text{Na}_2\text{O}(s) + \text{H}_2\text{O}(l) \rightarrow 2\text{NaOH}(aq)$

37. $\text{CO}(g) + \text{H}_2\text{O}(l) \rightarrow \text{H}_2\text{CO}_2(aq)$  **CARBONOUS ACID**

38. $\text{MgO}(s) + \text{H}_2\text{O}(l) \rightarrow \text{Mg(OH)}_2(aq)$
G. Neutralization (Write down the acid and base required to produce the following salts)

39. Na_2SO_4 + NaOH(aq) + H_2SO_4(aq)

40. MgCl_2 + Mg(OH)_2(aq) + HCl(aq)

41. NaNO_3 + NaOH(aq) + HNO_3(aq)

42. Li_3PO_4 + LiOH(aq) + H_3PO_4(aq)

43. KCl + KOH(aq) + HCl(aq)

H. Identification of unknowns. (Explain how to identify each substance in the beakers by using different tests)

44. Suppose you are given five beakers, each containing an unknown liquid. One is distilled water, one is a strong acid, one is a weak acid, one is a base and one is a salt solution. Describe how you would find out which was which.

- PHENOLPHTHALEIN: DISTILLED WATER = CLEAR, ACIDS = CLEAR, SALT = CLEAR, BASE = PINK
- CONDUCTIVITY TEST: DISTILLED WATER = NO, STRONG ACID = BRIGHT, WEAK ACID = POOR, SALT = BRIGHT
- BTB = STRONG ACID = YELLOW, SALT SOLUTION =

I. Acid-Base Application.

45. Explain why putting lemon on bitter tasting fish helps to minimize the bitter taste of fish.

- LEMON (ACID) NEUTRALIZES FISH (BASIC) MAKING IT TASTE LESS BASIC

46. A healthy pool has a pH level between 6.7 and 7.2. When a pool’s pH level becomes too basic, algae starts to grow. If algae began to grow in the pool, what would you recommend that the pool owner should do to counter act the algae growth?

- ADD CHLORINE OR BROMINE (ACID) TO MAKE IT LESS BASIC SO ALGAE STOPS GROWING.