

Focus Questions - Acids & Bases 1.

1. Write ionic equations for the following reactions, and give your observations:
 - a) zinc is added to a 4 mol L⁻¹ solution and heated gently
 - b) a dilute solution of sulfuric acid solution is added to solid potassium sulfide
 - c) sulfur dioxide gas is bubbled into a solution of sodium hydroxide
 - d) a solution of sodium hydroxide is added to aluminium hydroxide
 - e) acetic acid is added to copper carbonate
 - f) an excess of sodium hydroxide solution is added to a solution of nickel chloride
 - g) 1 L of 1 mol L⁻¹ phosphoric acid is added to 1 L of 2 mol L⁻¹ sodium hydroxide
2. Identify each reactant as a Bronsted-Lowry acid or a Bronsted-Lowry base in the following reactions:
 - a) $\text{HCOOH(aq)} + \text{HS}^-(\text{aq}) \rightarrow \text{HCOO}^-(\text{aq}) + \text{H}_2\text{S(g)}$
 - b) $\text{C}_6\text{H}_5\text{OH(aq)} + \text{CN}^-(\text{aq}) \rightarrow \text{C}_6\text{H}_5\text{O}^-(\text{aq}) + \text{HCN(aq)}$
 - c) $2\text{Na(s)} + 2\text{H}_2\text{O(l)} \rightarrow 2\text{Na}^+(\text{aq}) + 2\text{OH}^-(\text{aq}) + \text{H}_2(\text{g})$
3. Identify the following statements as true or false:
 - a) If 1 mol L⁻¹ HCN has a smaller pH than 1 mol L⁻¹ HF, it follows that HCN must be a weaker acid than HF
 - b) 0.1 mol L⁻¹ Ca(OH)₂ solution has a larger pH than 0.1 mol L⁻¹ KOH solution.
 - c) 0.1 mol L⁻¹ HNO₂ solution has a smaller pH than 0.1 mol L⁻¹ HNO₃ solution.
 - d) The concentration of H₃O⁺ in 0.1 mol L⁻¹ NaHSO₄ is greater than the concentration of H₃O⁺ in NaHCO₃.
 - e) If HF is a stronger acid than HNO₂, then it follows that 0.1 mol L⁻¹ NaF solution would have a larger pH than 0.1 mol L⁻¹ NaNO₂ solution.
 - f) Cl₂O, Al₂O₃ and P₄O₁₀ are examples of acidic oxides.
 - g) Na₂O and CaO will react with an acid because they are basic oxides, but Al₂O₃ will not react with an acid because it is an amphoteric oxide.
 - h) 1.0 mol L⁻¹ NH₃ is a better conductor of electricity than 1.0 mol L⁻¹ NH₄Cl.
 - i) 0.1 mol L⁻¹ H₂SO₄ will have the same pH as 0.1 mol L⁻¹ HCl.
4. The self ionization reaction of water is an endothermic process. Would the pH of boiling pure water be greater than, less than or equal to 7?

5. 20.0 mL of 0.400 mol L⁻¹ H₂SO₄ is reacted with 30.0 mL of 0.750 mol L⁻¹ KOH. Calculate the pH of the resulting solution.
6. 25.0 mL of a solution of HNO₃ has a pH of 2. If 0.0380 g of NaOH is added to the HNO₃ solution and the solution is made up to 100 mL, what will be the pH of the resulting solution?
7. Each of the following salts are added to water. Answer the following questions for each salt:
- what is the equation for the dissociation reaction
 - what is the equation for the hydrolysis reaction (that occurs after dissociation)
 - will the resulting solution have a pH greater than, equal to or less than 7?
- a) NaHCO₃
- b) NH₄NO₃
- c) MgF₂

ANSWERS

1.
 - a) $\text{Zn(s)} + 2\text{OH}^-(\text{aq}) + 2\text{H}_2\text{O(l)} \rightarrow \text{Zn(OH)}_4^{2-}(\text{aq}) + \text{H}_2(\text{g})$
silver solid dissolves to form colourless, odourless gas and colourless solution
 - b) $2\text{H}^+(\text{aq}) + \text{K}_2\text{S(s)} \rightarrow 2\text{K}^+(\text{aq}) + \text{H}_2\text{S(g)}$
white solid dissolves to form colourless evil-smelling gas and colourless solution
 - c) $\text{SO}_2(\text{g}) + 2\text{OH}^-(\text{aq}) \rightarrow \text{SO}_3^{2-}(\text{aq}) + \text{H}_2\text{O(l)}$
colourless solution forms, pungent smell of gas disappears
 - d) $\text{OH}^-(\text{aq}) + \text{Al(OH)}_3(\text{s}) \rightarrow \text{Al(OH)}_4^-(\text{aq})$
white solid dissolves to form colourless solution
 - e) $2\text{CH}_3\text{COOH(aq)} + \text{CuCO}_3(\text{s}) \rightarrow \text{CO}_2(\text{g}) + \text{H}_2\text{O(l)} + \text{Cu}^{2+}(\text{aq}) + 2\text{CH}_3\text{COO}^-(\text{aq})$
green solid dissolves to form colourless, odourless gas and blue solution, vinegar smell disappears
 - f) $2\text{OH}^-(\text{aq}) + \text{Ni}^{2+}(\text{aq}) \rightarrow \text{Ni(OH)}_2(\text{s})$
green precipitate forms (Ni(OH)₂ is not amphoteric, so cannot react to form a complex ion)
 - g) $\text{H}_3\text{PO}_4(\text{aq}) + 2\text{OH}^-(\text{aq}) \rightarrow 2\text{H}_2\text{O(l)} + \text{HPO}_4^{2-}(\text{aq})$
no observable change (The acid and hydroxide are mixed in a 1:2 mole ratio, so only 2 of possible 3 hydrogen ions are removed from the triprotic acid)
2.
 - a) HCOOH(aq) - acid $\text{HS}^-(\text{aq})$ - base
 - b) $\text{C}_6\text{H}_5\text{OH(aq)}$ - acid $\text{CN}^-(\text{aq})$ - base
 - c) not an acid/base reaction
3.
 - a) smaller pH means larger conc of H^+ , so HCN must be stronger - FALSE
 - b) Ca(OH)_2 has a larger conc of OH^- , or a smaller conc of H^+ i.e. it will have a larger pH - TRUE
 - c) HNO_2 is the weaker acid, so has smaller conc of H^+ i.e. larger pH - FALSE
 - d) HSO_4^- is a weak acid, so will produce H^+ when added to water, but HCO_3^- is a weak base so will form - TRUE
 - e) F^- will be a weaker base than NO_2^- , so NO_2^- will have greater conc of OH^- i.e. larger pH - FALSE
 - f) Cl_2O and P_4O_{10} are non-metal oxides, so are acidic, but Al_2O_3 is amphoteric - FALSE
 - g) Na_2O and CaO will react with an acid, but so will Al_2O_3 because amphoteric oxides react with both acids and bases - FALSE
 - h) NH_3 is a weak molecular gas and so will form few ions when dissolved in water, but NH_4Cl is an ionic substance and so completely dissociates and forms many ions when dissolved in water - FALSE
 - i) H_2SO_4 loses its 'first H^+ ' completely and 'partially' loses its second one i.e. H_2SO_4 will produce a greater conc of H^+ i.e. smaller pH - FALSE
4. $2\text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+(\text{aq}) + \text{OH}^-(\text{aq})$ is endothermic i.e. ΔH is positive
When temp increases the value of the ionization constant increases i.e. equilibrium shifts towards products, so conc of H^+ will increase i.e. pH will be less than 7.

5. $\text{moles H}_2\text{SO}_4 = 0.400 \times 0.0200 = 0.00800$

$\text{moles of H}^+ = 2 \times 0.00800 = 0.0160$

$\text{moles KOH} = 0.750 \times 0.0300 = 0.0225 = \text{moles OH}^-$



$0.0160 \text{ moles of H}^+ \text{ will react with } 0.0160 \text{ moles of OH}^-$

i.e. after this reaction, will be left with $0.0225 - 0.0160 = 0.0065 \text{ moles of OH}^-$ in a volume of 0.0500 L

$\text{conc of OH}^- \text{ in final solution} = 0.0065/0.0500 = 0.130 \text{ mol L}^{-1}$

$[\text{H}^+] \text{ in final solution} = 1 \times 10^{-14}/0.130 = 7.692 \times 10^{-14} \text{ mol L}^{-1}$

$\text{pH} = -\log[\text{H}^+] = \mathbf{13.1}$

6. $\text{pH of 2 means } [\text{H}^+] = 1 \times 10^{-2} \text{ mol L}^{-1}$

i.e. in 25.0 mL of this solution $\text{moles H}^+ = c \times V = 0.01 \times 0.0250 = 0.000250 \text{ moles of H}^+$

$\text{moles NaOH} = 0.0380/39.998 = 0.000950 = \text{moles of OH}^-$



$0.000250 \text{ moles of H}^+ \text{ will react with } 0.000250 \text{ moles of OH}^-$

i.e. after this reaction, will be left with $0.000950 - 0.000250 = 0.000700 \text{ moles of OH}^-$ in a volume of 0.100

L

$\text{conc of OH}^- \text{ in final solution} = 0.0007/0.100 = 0.00700 \text{ mol L}^{-1}$

$[\text{H}^+] \text{ in final solution} = 1 \times 10^{-14}/0.007 = 1.429 \times 10^{-12} \text{ mol L}^{-1}$

$\text{pH} = -\log[\text{H}^+] = \mathbf{11.8}$

7. a) i) $\text{NaHCO}_3 \rightarrow \text{Na}^+ + \text{HCO}_3^-$
 ii) $\text{HCO}_3^- + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3 + \text{OH}^-$ Na^+ do not significantly hydrolyse
 iii) because OH^- ions have been formed, $[\text{OH}^-]$ will be greater than $[\text{H}_3\text{O}^+]$ i.e. **pH greater than 7**
- b) i) $\text{NH}_4\text{NO}_3 \rightarrow \text{NH}_4^+ + \text{NO}_3^-$
 ii) $\text{NH}_4^+ + \text{H}_2\text{O} \rightarrow \text{NH}_3 + \text{H}_3\text{O}^+$ NO_3^- do not significantly hydrolyse
 iii) because H_3O^+ ions have been formed, $[\text{H}_3\text{O}^+]$ will be greater than $[\text{OH}^-]$ i.e. **pH less than 7**
- c) i) $\text{MgF}_2 \rightarrow \text{Mg}^{2+} + 2\text{F}^-$
 ii) $\text{F}^- + \text{H}_2\text{O} \rightarrow \text{HF} + \text{OH}^-$ Mg^{2+} ions do not significantly hydrolyse
 iii) because OH^- ions have been formed, $[\text{OH}^-]$ will be greater than $[\text{H}_3\text{O}^+]$ i.e. **pH greater than 7**