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) $HCOOH(aq) + HS^-(aq) \rightarrow HCOO(aq) + H_2S(g)$

   b) $C_6H_5OH(aq) + CN^-(aq) \rightarrow C_6H_5O^-(aq) + HCN(aq)$

   c) $2Na(s) + 2H_2O(l) \rightarrow 2\ Na^+(aq) + 2OH^-(aq) + H_2(g)$

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 that 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} HNO_2 solution has a smaller pH than 0.1 mol L^{-1} HNO_3 solution.

   d) The concentration of H_3O^+ in 0.1 mol L^{-1} $NaHSO_4$ is greater than the concentration of H_3O^+ in $NaHCO_3$.

   e) If HF is a stronger acid than HNO_2, then it follows that 0.1 mol L^{-1} NaF solution would have a larger pH than 0.1 mol L^{-1} $NaNO_2$ solution.

   f) Cl_2O, Al_2O_3 and P_4O_{10} are examples of acidic oxides.

   g) Na_2O and CaO will react with an acid because they are basic oxides, but Al_2O_3 will not react with an acid because it is an amphoteric oxide.

   h) 1.0 mol L^{-1} NH_3 is a better conductor of electricity than 1.0 mol L^{-1} NH_4Cl.

   i) 0.1 mol L^{-1} H_2SO_4 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} H_2SO_4 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 HNO_3 has a pH of 2. If 0.0380 g of NaOH is added to the HNO_3 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:

i) what is the equation for the dissociation reaction

ii) what is the equation for the hydrolysis reaction (that occurs after dissociation)

iii) will the resulting solution have a pH greater than, equal to or less than 7?

a) $NaHCO_3$

b) NH_4NO_3

c) MgF_2

ANSWERS

1. a) $Zn(s) + 2OH^-(aq) + 2\,H_2O(l) \rightarrow Zn(OH)_4^{2-}(aq) + H_2(g)$

silver solid dissolves to form colourless, odourless gas and colourless solution

b) $2H^+(aq) + K_2S(s) \rightarrow 2K^+(aq) + H_2S(g)$

white solid dissolves to form colourless evil-smelling gas and colourless solution

c) $SO_2(g) + 2OH(aq) \rightarrow SO_3^{2-}(aq) + H_2O(l)$

colourless solution forms, pungent small of gas disappears

d) $OH^-(aq) + Al(OH)_3(s) \rightarrow Al(OH)_4^-(aq)$

white solid dissolves to form colourless solution

e) $2CH_3COOH(aq) + CuCO_3(s) \rightarrow CO_2(g) + H_2O(l) + Cu^{2+}(aq) + 2\,CH_3COO^-(aq)$

green solid dissolves to form colourless, odourless gas and blue solution, vinegar smell disappears

f) $2OH^-(aq) + Ni^{2+}(aq) \rightarrow Ni(OH)_2(s)$

green precipitate forms ($Ni(OH)_2$ is not amphoteric, so cannot react to form a complex ion)

g) $H_3PO_4(aq) + 2OH^-(aq) \rightarrow 2H_2O(l) + HPO_4^-(aq)$

no observable change (The acid and hydroxide are mixed in a 1:2 mole ratio, so only 2 of the possible 3 hydrogen ions are removed from the triprotic acid)

2. a) $HCOOH(aq)$ - acid $HS^-(aq)$ - base

b) $C_6H_5OH(aq)$ - acid $CN^-(aq)$ - 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 OH^-, - TRUE

e) F^- will be a weaker base than NO_2^-, soNO_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 substances 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. $2H_2O \rightarrow H_3^+(aq) + OH^-(aq)$ 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. moles H_2SO_4 = 0.400 x 0.0200 = 0.00800

moles of H^+ = 2 x 0.00800 = 0.0160

moles KOH = 0.750 x 0.0300 = 0.0225 = moles OH^-

$H^+ + OH^- \rightarrow H_2O$

0.0160 moles of H^+ will react with 0.0160 moles of OH^-

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

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

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

pH = -log$[H^+]$ = **13.1**

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

i.e. in 25.0 mL of this solution moles H^+ = c x V = 0.01 x 0.0250 = 0.000250 moles of H^+

moles NaOH = 0.0380/39.998 = 0.000950 = moles of OH^-

$H^+ + OH \rightarrow H_2O$

0.000250 moles of H^+ will react with 0.000250 moles of OH^-

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

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

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

pH = -log$[H^+]$ = **11.8**

7. a) i) $NaHCO_3 \rightarrow Na^+ + HCO_3^-$

ii) $HCO_3^- + H_2O \rightarrow H_2CO_3 + OH$ Na^+ do not significantly hydrolyse

iii) because OH^- ions have been formed, $[OH]$ will be greater than $[H_3O^+]$ i.e. **pH greater than 7**

b) i) $NH_4NO_3 \rightarrow NH_4^+ + NO_3^-$

ii) $NH_4^+ + H_2O \rightarrow NH_3 + H_3O^+$ NO_3^- do not significantly hydrolyse

iii) because H_3O^{+-} ions have been formed, $[H_3O^+]$ will be greater than $[OH^-]$ i.e. **pH less than 7**

c) i) $MgF_2 \rightarrow Mg^{2+} + 2F^-$

ii) $F + H_2O \rightarrow HF + OH^-$ Mg^{2+} ions do not significantly hydrolyse

iii) because OH^- ions have been formed, $[OH]$ will be greater than $[H_3O^+]$ i.e. **pH greater than 7**