ACIDS AND BASES

Check List

Make sure you….

- Can define acids and bases according to Arrhenius and Lowry-Bronsted.
- Can distinguish between strong and weak acids/bases with examples.
- Can distinguish between concentrated and dilute acids/bases.
- Can identify conjugate acid-base pairs for given compounds.
- Can write neutralisation reactions of common laboratory acids and bases.
- Can perform calculations based on titration reactions and motivate choice of indicator.
- Can determine the approximate pH of salts in salt hydrolysis.
- Can explain the pH scale and calculate pH values of strong acids/bases.
- Can define the concept of Kw and explain the auto -ionisation of water.
- Can compare the Ka and Kb values of strong and weak acids and bases.
- Can compare strong and weak acids by looking at pH, conductivity and reaction rate.

Exam Questions

Question 1

(Adapted from DBE Senior Certificate P2 HG 2013)

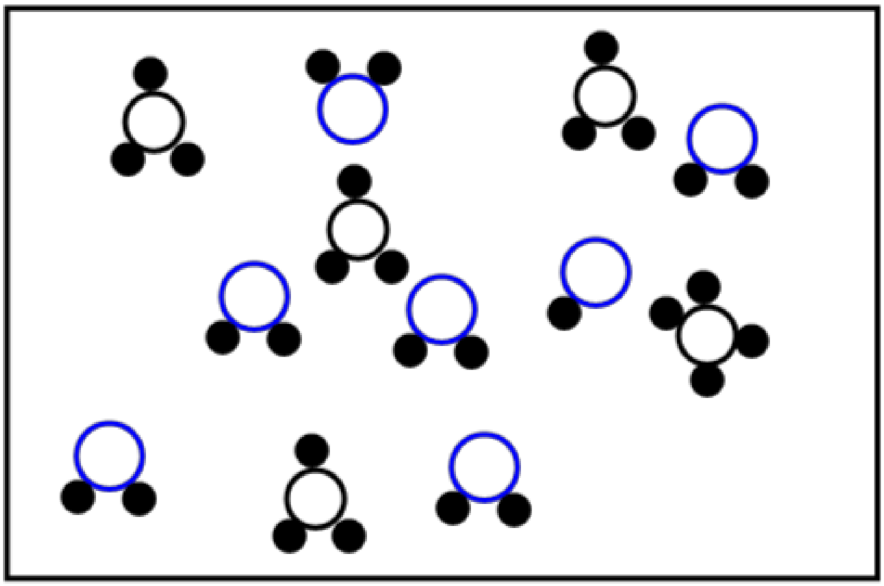
Ammonia is very soluble in water. This gas is bubbled through 500cm^3 of water to form a solution of ammonium hydroxide.The equation below represents the chemical reaction taking place.

NH_3 (g) + H_2O (ℓ) NH_4^+ (aq) + OH^- (aq)

1.1 How would you classify ammonia in terms of Bronsted-Lowry theory? Explain you answer

1.2 Identify the acid and its conjugate base for the reverse reaction.

The diagram below represents a micro-view of a sample of the molecules in the beaker.



1.3 Use the diagram to determine if ammonia is strong or weak base. Explain your answer fully

1.4 Predict the pH of the solution

1.5 Explain how you could prepare a more concentrated solution of ammonium hydroxide using the same amount of ammonia gas

1.6 If a few crystals of ammonia chloride are added to the ammonia solution, will the pH of the solution INCREASE, DECREASE or REMAIN THE SAME?

1.7 Give a reason for your answer to Question 1.6

In a second experiment hydrogen chloride gas is bubbled through a sample of water.

1.8 Write down a balanced chemical equation for this reaction

1.9 Identify the acid and its conjugate base for the forward reaction

In a second experiment hydrogen chloride gas is bubbled through a sample of water.

1.10 Draw a micro-view diagram to represent the molecules in this beaker

1.11 Which solution would have a higher conductivity? The ammonia solution or the solution of hydrogen chloride

Question 2

(Adapted from DBE from SC, Paper 2 HG March 2004)

Sodium carbonate crystals ($Na_2CO_3 . 10H_2O$) is used to neutralise hydrochloric acid with concentration of 0,1mol.dm^{-3}.

2.1 Write down the balanced chemical equation for the neutralisation reaction.

2.2 Calculate the mass of sodium carbonate crystals that will be required to neutralise 200 cm^3 of the hydrochloric acid solution.

The table below gives information about some common laboratory indicators

Indicator	pH range in which the colour changes
Methyl red	4,8 – 6,0
Neutral red	6,8 – 8,0
Chlorophenol red	7,0 – 8,8

2.3 Which indicator would you choose for this reaction? Explain your answer.

Question 3

(Adapted from DBE from SC, Paper 2 HG March 2013)

A learner prepares a potassium hydroxide (KOH) solution to titrate against a sulphuric acid (H_2SO_4) solution at 25°C.

The balanced equation for the reaction between potassium hydroxide and sulphuric acid is:

$$2KOH\ (aq) + H_2SO_4\ (aq) \rightarrow K_2SO_4\ (aq) + 2H_2O\ (l)$$

3.1 Calculate the mass of KOH needed to prepare 400 cm^3 of a 0, 15 $mol.dm^{-3}$ KOH solution.

3.2 2,25 cm^3 of the KOH solution prepared in Question 3.1 is used to neutralise 30 cm^3 of the sulphuric acid solution.

When only one drop of the sulphuric acid solution still had to be added to reach the equivalence point (end point) of the titration, the concentration of the OH^- in the mixture was $1{,}23 \times 10^{-4}$ $mol.dm^{-3}$

3.3 Calculate the pH of the solution at this specific point.

Question 4

(Adapted from DBE from SC, Paper 2 HG March 2004)

A 200 cm^3 solution of hydrochloric acid has a pH of 1. Calculate the volume of water that has to be added to this solution to change the pH to 2.

SOLUTIONS TO ACIDS AND BASES

Question 1

1.1 Ammonia is a base. It accepts a hydrogen ion / proton

1.2 For the reverse reaction: Ammonium ion is the acid and ammonia is the conjugate base

1.3 There are more ammonia molecules than ammonium ions (4:1 ratio). This means ammonia is a weak base as it does not ionise completely.

1.4 The pH of the solution will be greater than 7

1.5 Use a smaller volume of water.

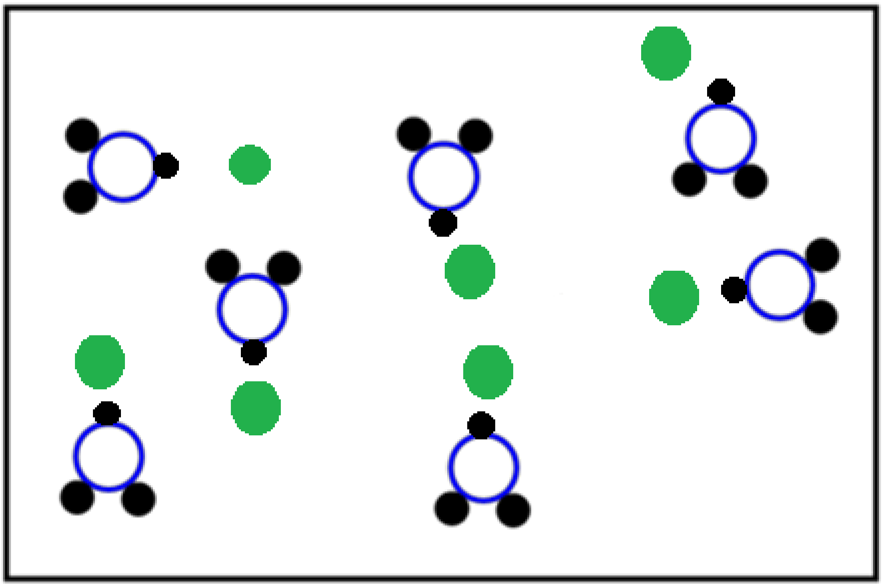
1.6 Decrease.

1.7 The original solution should be in a state of chemical equilibrium. The addition of ammonium chloride will increase the concentration of ammonium ions so the equilibrium will be disturbed. Le Chatelier's principle predicts that to reduce this increase, the reverse reaction will be favoured. This means more ammonia and hydrogen ions will be formed and pH will decrease since the Hydrogen ion concentration is greater.

1.8 HCl (g) + H_2O (l) H_3O^+ (aq) + Cl^- (aq)

1.9 Hydrogen chloride (HCl (g)) is the acid and Cl^- (aq) is the conjugate base

1.10



1.11 The hydrogen chloride solution will have a higher conductivity since there are more ions (charged particles) in this solution.

Question 2

2.1 $Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$

2.2 n (HCl) = 0,02 mol

n (Na_2CO_3) = 0,01 mol

m = n.M

= 0, 01 x 286

= 2, 86 g

2.3 Methyl red

2.4 The reaction between a strong acid (HCl) and a weak base (Na_2CO_3) will yield an acidic solution at the end point.

Question 3

3.1.1 n = cMV

= 0, 15 x 56 x 0, 4

= 3, 36 g

3.1.2 $\frac{C_aV_a}{C_bV_b} = \frac{n_a}{n_b}$

$\frac{C_a \times 30}{0,15 \times 25} = \frac{1}{2}$

$C_a = 0{,}063\ mol.dm^{-3}$

3.1.3 pOH = -log [OH^-]

= -log (1, 23 x 10^{-4})

= 3, 91

pH = 14 – 3,91

= 10, 09

3.2.1 Greater than 7

3.2.2 NH_3 or NH_4OH is a base

3.2.3 $NH_3 + H^+ \rightarrow NH_4^+$ OR $NH_3 + H_20 \rightarrow NH_4^+ + OH^-$

3.2.4 DECREASE

3.2.5 NH_4^+ is a proton donor/ weak acid

Question 4

pH = -log $[H^+]$

Original [H+] = 10^{-1} mol.dm^{-3} new [H+] = 10^{-2} mol.dm^{-3}

No. of moles of original [H+] = CV

= 10-1 X 0, 2

= 2×10^{-2} mol

No. of moles of new [H+] = CV

= 10^{-2}. V

No. of moles of original [H+] = no of moles of new [H+]

2×10^{-2} mol = 10^{-2}. V

V= 2 dm^3

Therefore amount of H_2O to be added = 2 000 cm^3 – 200 cm^3 = 1800 cm^3