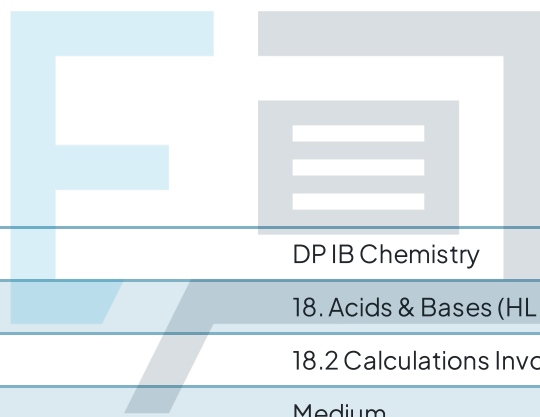




18.2 Calculations Involving Acids & Bases

Mark Schemes



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|------------|---|
| Course | DP IB Chemistry |
| Section | 18. Acids & Bases (HL only) |
| Topic | 18.2 Calculations Involving Acids & Bases |
| Difficulty | Medium |

Exam Papers Practice

To be used by all students preparing for DP IB Chemistry HL
Students of other boards may also find this useful

1

The correct answer is **A** because:

- The lower the pK_a value the stronger the acid
- The higher the pK_a value the weaker the acid
- We need to convert K_a to pK_a to compare the strength of the acids
- In order to convert K_a to pK_a without a calculator, work on:
 - $pK_a = -\log K_a$
 - Therefore**
 - $-\log 10^{-5} = 5$
 - 1.51×10^{-5} for butanoic acid will be 4.8
 - 1×10^{-10} for phenol will be 10

B, C & D are incorrect as

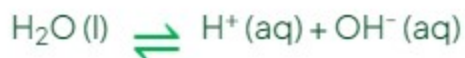
These are not the correct order of increasing strength of the acids

2

The correct answer is **A** because:

- The ionisation of water is a reversible process and therefore **Le Chatelier's** principle applies

endo



exo

- If the temperature of the water increases, then the equilibrium will move to oppose the change in temperature
 - Therefore, the forward reaction will be favoured
 - This produces more hydrogen ions and hydroxide ions
 - The higher the value for $[\text{H}^+]$, the lower the pH value



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|--------------------------|--|
| B is incorrect as | a decrease in temperature will increase the pH of water |
| C is incorrect as | the pH of water is affected by temperature. An increase in temperature will decrease pH (becomes more acidic) and a decrease in temperature will increase pH (becomes more alkaline) |
| D is incorrect as | despite the fact that pH will change with temperature, the concentration of H ⁺ ions and OH ⁻ ion are always equal |

3

The correct answer is **B** because:

- Statement II is incorrect
- The correct relationship is
 - $K_a \times K_b = K_w$
 - $K_w = 1 \times 10^{-14}$
- pK_a and pK_b have the relationship
 - $pK_a + pK_b = pK_w$
 - $pK_w = 14$
- The conjugate base of ethanoic acid is CH_3COO^- (aq) because
 - Ethanoic acid, CH_3COOH , will partially dissociate in water to give:
 - $\text{CH}_3\text{COOH} + \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{COO}^- + \text{H}_3\text{O}^+$
acid base conj. base conj. acid

| | |
|--------------------------------------|---------------------------|
| A, C & D are incorrect as | statement II is incorrect |
|--------------------------------------|---------------------------|

4

The correct answer is **B** because:

- Butanoic acid is a weak acid
- The acid dissociation constant, K_a , expression is

$$K_a = \frac{[H^+][C_3H_7COO^-]}{[C_3H_7COOH]}$$

- To determine $[H^+]$
 - $[H^+]^2 = K_a \times [C_3H_7COOH]$
 - $[H^+]^2 = 1.51 \times 10^{-5} \times 0.75$
 - $[H^+] = \sqrt{(1.51 \times 10^{-5} \times 0.75)}$
- To determine pH
 - $pH = -\log_{10}[H^+]$
- Therefore
 - $-\log_{10}\sqrt{(1.51 \times 10^{-5} \times 0.75)}$

| | |
|--------------------------|---|
| A is incorrect as | the square root of $(1.51 \times 10^{-5} \times 0.75)$ has not been included |
| C is incorrect as | this is used to calculate the pH of a strong acid, not a weak acid like butanoic acid |
| D is incorrect as | this expression has been incorrectly rearranged and the $-\log_{10}$ of $[H^+]$ has not been included |

5

The correct answer is **A** because:

- For the base dissociation constant, K_b , we use the equation for the dissociation of the weak base, in this case propylamine
 - **B (aq)** + $H_2O(l) \rightleftharpoons BH^+(aq) + OH^-(aq)$
 - **B (aq)** = $CH_3CH_2CH_2NH_2(aq)$
 - **BH⁺ (aq)** = $CH_3CH_2CH_2NH_3^+(aq)$
 - $CH_3CH_2CH_2NH_2(aq) + H_2O(l) \rightleftharpoons CH_3CH_2CH_2NH_3^+(aq) + OH^-(aq)$
- Water is a constant so is not included in the expression
 - $K_b = \frac{[CH_3CH_2CH_2NH_3^+][OH^-]}{[CH_3CH_2CH_2NH_2]}$

B, C & D are incorrect as

these are not the correct expressions for the base dissociation constant, K_b , of propylamine

Exam Papers Practice