Exam Papers Practice

18.2 Calculations Involving Acids & Bases

Mark Schemes

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

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

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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

$$H_2O\,(l) \rightleftharpoons H^+\,(aq) + OH^-\,(aq)$$

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 $[H^+]$, the lower the pH value

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:
  - $CH_3COOH + H_2O \rightleftharpoons CH_3COO^- + H_3O^+$

    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

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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) ⇌ **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) ⇌ $CH_3CH_2CH_2NH_3^+$ (aq) + OH^- (aq)
- Water is a constant so is not included 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