HL ACIDS TEST Mark Scheme

1. In which of the following is the species in bold acting as a Brønsted-Lowry base?

A. $NH_3(aq) + CH_3COOH(aq) \rightleftharpoons \mathbf{NH_4^+}(aq) + CH_3COO^-(aq)$
B. $\mathbf{CH_3NH_2}(aq) + HCl(aq) \rightleftharpoons CH_3NH_3^+(aq) + Cl^-(aq)$
C. $\mathbf{HCO_3^-}(aq) + H_2O(l) \rightleftharpoons CO_3^{2-}(aq) + H_3O^+(aq)$
D. $SO_4^{2-}(aq) + \mathbf{H_2O}(l) \rightleftharpoons HSO_4^-(aq) + OH^-(aq)$

2. A 0.100 mol dm^{-3} solution of a weak acid, **HA**, has pH of 5.0. What is the $[OH^-]$ of this solution in mol dm^{-3} at 25 ^oC?

A. 9.0 B. $1.0x10^{-3}$ C. $1.0x10^{-9}$ D. $1.0x10^{-5}$

3. Which of the following is a correct word equation for the formation of sodium sulfate?

A. sodium hydroxide + sulfuric acid → sodium sulfate + hydrogen
B. sodium carbonate + hydrogen sulfide → sodium sulfate + carbon dioxide + water
C. sodium hydrogencarbonate + sulfuric acid → sodium sulfate + carbon dioxide + water
D. potassium sulfate + sodium hydroxide → sodium sulfate + water

4. The pH of pure water at its boiling point is 6.14. From this it can be deduced that

A. water is acidic at its boiling point
B. the value of pK_w for water at is boiling point is 12.28
C. water dissociates more at 25^{o}C than at 100 ^{o}C
D. At its boiling point pOH of water is 7.86

5. Which of the following is **not** amphiprotic?

A. HCO_3^- B. NO_3^- C. H_2O D. $H_2PO_4^-$

6. Which solution(s) has/have a pH greater than 7?

I $NH_4NO_3(aq)$ **II** $FeCl_3(aq)$ **III** $Na_2CO_3(aq)$ **IV** $NaCl(aq)$

A. IV only B. III only C. I and II only D. I only

7. The pH value of a 1.00 x 10^{-3} mol dm^{-3} solution of sodium hydroxide is

A 3 B 8 C 11 D 14

8. HA, HB, HC and HD are weak acids. HA has $K_a=2.0x10^{-5}$, HB has $pK_a=5.0$, HC has $K_a=3.0x10^{-3}$ and HD has $pK_a=6.0$. When the acids are arranged in order of increasing strength (weakest first) the order is

A HD, HB, HC, HA B HC, HB, HD, HA
C HD, HB, HA, HC D HC, HA, HB, HD

9. The pH values for some solutions are show in the table:

Solution	pH
Q	2.3
X	4.3
Y	8.3
Z	8.6

Which of the following statements is correct?

A the $[H^+(aq)]$ in solution Z is twice the $[H^+(aq)]$ in solution X
B the $[H^+(aq)]$ in solution X is 100 times the $[H^+(aq)]$ in solution Q
C the $[H^+(aq)]$ in solution Q is 10^6 times the $[H^+(aq)]$ in solution Y
D the $[H^+(aq)]$ in solution X is 40 times the $[H^+(aq)]$ in solution Y

10. When the following aqueous solutions are arranged in order of **increasing** electrical conductivity (lowest first), what is the correct order?

I 0.10 mol dm^{-3} $Ba(OH)_2$
II 0.10 mol dm^{-3} NH_3
III 0.10 mol dm^{-3} NaOH

A I, II, III B III, II, I C I, III, II D II, III, I

11. HOBr(aq), is a weak acid with pK_a=8.70

(a) Derive an equation for the dissociation of HOBr in aqueous solution [1]

$HOBr \rightleftharpoons H^+ + OBr^-$ *or equivalent equation involving* H_3O^+

(b) Determine the pH of a 0.0400 mol dm^{-3} solution of HOBr(aq). State any assumption you have made in your calculation. [4]

$K_a = 2.00x10^{-9}$;

$2.00x10^{-9} = [H^+]^2/0.0400$

$[H^+] = 8.93x10^{-6}$ mol dm^{-3} ;
pH = 5.05 ; *correct pH scores 3*

assume dissociation of acid is negligible compared to its conc [1]

(c) (i) State the pK_b value for OBr^- at 25ºC… 5.30 [1]

(ii) Determine the pH of a 0.0200 mol dm^{-3} solution of NaOBr(aq) [4]

$K_b = 5.01x10^{-6}$;

$5.01x10^{-6} = [OH^-]^2/0.0200$;

$[OH^-] = 3.17x10^{-4}$ mol dm^{-3} ;

pOH = 3.50

pH = 10.50 ; *Correct pH scores 4*

(d) 0.0400 mol dm^{-3} NaOH(aq) is gradually added to 25.00 cm^3 of 0.0400 mol dm^{-3} HOBr(aq). After each addition the pH was measured.

(i) Sketch a titration curve showing the variation in pH for addition of up to 50.00 cm^3 of NaOH(aq). Mark on your sketch, the initial pH, the pH at the equivalence point and the approximate pH after the addition of 50.00 cm^3 of NaOH(aq). [4]

Correct shape of curve and axes labelled ;

Initial pH = 5.05 (or answer from part b) ;

pH at equivalence point 10.50 (or answer form part c) ;

Final pH 12.6 ;

*If no answers to parts b and c **max 3** for first and last marks and sensible values for the other 2 marks.*

(ii) Deduce the pH of the solution formed when 12.50 cm^3 of NaOH(aq) had been added to 25.00 cm^3 of HOBr(aq). [1]

8.70

(e) This titration can also be followed by using an acid-base indicator. Explain, using an equation how an acid base indicator works. [3]

$HIn \rightleftharpoons H^+ + In^-$ or $In^- + H_2O \rightleftharpoons HIn + OH^-$ or $BOH \rightleftharpoons B^+ + OH^-$;

Ionized and unionized forms different colours;

Explanation of which colours appear as acid/alkali added…e.g. when acid added, the position of equilibrium shifts to the left and colour X is seen (this must be consistent with the equation labelling) ;

(e) A buffer solution can be formed when NaOH(aq) is added to HOBr(aq).

(i) Explain what is meant by the term *buffer solution*. [1]

Solution which resists change in pH when <u>small</u> amounts of acid/alkali added

(ii) Explain why adding 25.00 cm^3 of 0.100 mol dm^{-3} NaOH(aq) to 40.00 cm^3 of 0.0500 mol dm^{-3} HOBr(aq) will **not** produce a buffer solution. [3]

Buffer must contain weak acid and its salt/conjugate base;

More moles of NaOH than HOBr;

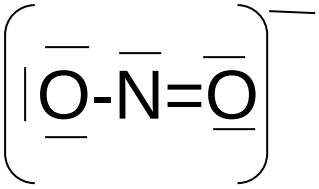
Therefore no HOBr present OWTTE;

12. One of the gases responsible for acid deposition is NO_2.

(a) Write an equation for the reaction of NO_2 with water. [1]

$2NO_2(g) + H_2O(l) \rightarrow HNO_2(aq) + HNO_3(aq)$ *state symbols not required*

(b) One of the acids in acid deposition is HNO_2. This dissociates to form the nitrate(III) ion, NO_2^-. Draw a Lewis structure for NO_2^-. [1]



(c) Explain whether NO_2^- can act as a Lewis acid or a Lewis base. [2]

Lewis Base;

Has a lone pair of electrons (that can be donated);