Chemistry

Higher level

Paper 1A

Practice paper

Topic: Acid/Base Chemistry

Chemistry

Higher level

Paper 1A

Specimen paper

1 hour

Instructions to candidates

- Do not open this examination paper until instructed to do so.
- Answer all questions.
- For each question, choose the best answer.
- A clean copy of the chemistry data booklet is required.
- The maximum mark for this paper is [30 marks].

Section A

1. Which species acts as a Lewis acid but not a Brønsted-Lowry acid?
   A. BF_3
   B. H_3O^+
   C. NH_3
   D. CH_3COOH

2. The K_a of ethanoic acid is 1.8×10^{-5}. What is the pK_a of ethanoic acid?
   A. 5.18
   B. 4.74
   C. 9.26
   D. -4.74

3. Which equimolar mixture forms a buffer solution at 298 K?
   A. HCl(aq) and NaCl(aq)
   B. CH_3COOH(aq) and CH_3COONa(aq)
   C. HNO_3(aq) and NH_4NO_3(aq)
   D. H_2SO_4(aq) and Na_2SO_4(aq)

4. Which structural features characterize a Lewis base?
   I. Presence of a lone pair of electrons
   II. Ability to accept a proton
   III. Possession of an empty valence orbital
   A. I and II only
   B. I only
   C. II and III only
   D. I, II and III

5. The indicator phenol red has a pK_{in} of 7.9. Over what approximate pH range will it change color?
   A. 6.9 - 8.9
   B. 7.9 - 9.9
   C. 5.9 - 7.9
   D. 8.9 - 10.9

6. A 0.10 mol dm^{-3} solution of a weak monoprotic acid has a pH of 3.0. What is the value of its acid dissociation constant, K_a?
   A. 1.0×10^{-3}
   B. 1.0×10^{-4}
   C. 1.0×10^{-5}

D. 1.0×10^{-6}

7. In an aqueous solution at 298 K, if pOH = 4.5, what is the $[H^+]$?
A. 3.2×10^{-5}
B. $1.0 \times 10^{-4.5}$
C. 3.2×10^{-10}
D. 1.0×10^{-14}

8. Which of the following statements about buffer solutions are correct?
I. They maintain a nearly constant pH when small amounts of strong acid or base are added.
II. Blood represents a naturally occurring buffer system.
III. A buffer is fully exhausted when the pH reaches 7.0.
A. I and II only
B. I and III only
C. II and III only
D. I, II and III

9. Which salt dissolves in water to form a solution with a pH less than 7?
A. NaCl
B. K_2CO_3
C. CH_3COONa
D. NH_4Cl

10. Which is a nucleophile?
A. $AlCl_3$
B. OH^-
C. H^+
D. BF_3

11. What is the pH of a 0.20 mol dm^{-3} solution of NaOH at 298 K? ($K_w = 1.0 \times 10^{-14}$)
A. 0.70
B. 13.3
C. 13.7
D. 14.0

12. Which processes contribute to acid deposition?
I. Combustion of sulfur-containing coal
II. Reactions of nitrogen and oxygen at high temperatures in car engines
III. Photosynthesis in marine algae

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

13. An acid-base indicator, HIn, dissociates according to: $HIn(aq) \rightleftharpoons H^+(aq) + In^-(aq)$. If the indicator is red in acidic solution and blue in basic solution, what is the color of the In^- ion?
A. Red
B. Blue
C. Colorless
D. Purple

14. A volume of 50.0 cm^3 of 0.10 mol dm^{-3} HCl is mixed with 50.0 cm^3 of 0.10 mol dm^{-3} NH_3. What is the approximate pH of the resulting solution at 298 K?
A. 2.0
B. 5.1
C. 7.0
D. 8.9

15. What is the correct expression for K_b of ammonia?
A. $K_b = [NH_3] / ([NH_4^+][OH^-])$
B. $K_b = ([NH_4^+][OH^-]) / [NH_3]$
C. $K_b = [NH_4^+] / [NH_3]$
D. $K_b = ([NH_3][H^+]) / [NH_4^+]$

16. Which factors determine the strength of an acid?
I. The electronegativity of the central atom
II. The strength of the bond to the acidic hydrogen
III. The concentration of the acid in solution
A. I and II only
B. I and III only
C. II and III only
D. I, II and III

17. For a conjugate acid-base pair at 298 K, which relationship is correct?
A. $K_a / K_b = K_w$
B. $K_a \times K_b = K_w$
C. $pK_a \times pK_b = pK_w$
D. $K_w / K_b = pK_a$

18. Which titration curve would have a vertical region passing through pH = 7.0?
A. Weak acid and strong base
B. Strong acid and weak base
C. Strong acid and strong base
D. Weak acid and weak base

19. A student prepares a buffer by mixing 100 cm^3 of 0.1 mol dm^{-3} CH_3COOH with 50 cm^3 of 0.1 mol dm^{-3} NaOH. What relates the pH to the pK_a in this specific mixture?
A. $pH = pK_a + 1$
B. $pH = pK_a - 1$
C. $pH = pK_a$
D. pH = 7.0

20. Which approximations are commonly assumed when calculating the pH of a weak monoprotic acid?
I. The initial concentration of the acid equals its equilibrium concentration.
II. The contribution of H^+ from the autoionization of water is negligible.
III. The value of K_w is exactly 10^{-14} at all temperatures.
A. I and II only
B. I and III only
C. II and III only
D. I, II and III

21. The pK_w of water at 323 K (50 °C) is 13.3. What is the pH of pure water at this temperature?
A. 7.00
B. 6.65
C. 7.35
D. 13.3

22. Which action would increase the pH of a 0.10 mol dm^{-3} solution of ethanoic acid?
A. Adding a few drops of 1.0 mol dm^{-3} HCl
B. Adding solid sodium ethanoate
C. Adding 10 cm^3 of water
D. Adding 50 cm^3 of 0.10 mol dm^{-3} ethanoic acid

23. A titration curve for a weak acid titrated with a strong base shows an equivalence point at pH = 8.8. Which indicator would be best suited for this titration?
A. Methyl orange (pK_{in} 3.7)
B. Bromothymol blue (pK_{in} 7.0)
C. Phenolphthalein (pK_{in} 9.3)

D. Alizarin yellow (pK_{in} 11.0)

24. Which characteristics are typical of an amphiprotic species?
I. It contains a hydrogen atom.
II. It possesses a lone pair of electrons.
III. It must be an anion.
A. I and II only
B. I and III only
C. II and III only
D. I, II and III

25. If the pK_b of methylamine is 3.36, what is the K_a of the methylammonium ion, $CH_3NH_3^+$, at 298 K?
A. $10^{-3.36}$
B. $10^{-10.64}$
C. 10^{-14}
D. $10^{-7.36}$

26. An acid HX has a K_a of 4.0×10^{-6}. What is the $[H^+]$ in a 0.25 mol dm^{-3} solution of HX?
A. 1.0×10^{-3} mol dm^{-3}
B. 1.0×10^{-6} mol dm^{-3}
C. 1.6×10^{-5} mol dm^{-3}
D. 2.0×10^{-3} mol dm^{-3}

27. Which solution has the lowest pH?
A. 0.1 mol dm^{-3} HCl(aq)
B. 0.1 mol dm^{-3} H_2SO_4(aq)
C. 0.1 mol dm^{-3} CH_3COOH(aq)
D. 0.1 mol dm^{-3} NaCl(aq)

28. In the generic reaction: $Y^- + HX \rightleftharpoons HY + X^-$, if the equilibrium lies strongly to the right, which deduction is valid?
I. HX is a stronger acid than HY.
II. Y^- is a stronger base than X^-.
III. The pK_a of HX is greater than the pK_a of HY.
A. I and II only
B. I and III only
C. II and III only
D. I, II and III

29. A student determines through conductivity measurements that Acid HA is a weak acid and Acid HB is a strong acid. If both are 0.1 mol dm^{-3}, which graph of conductivity versus added strong base would distinguish them?

A. They cannot be distinguished by conductivity
B. HA starts at a lower initial conductivity than HB
C. Both start at high conductivity and drop equally
D. HB has zero conductivity initially

What is the pH of a 0.05 mol dm^{-3} solution of $Ba(OH)_2$?

A. 1.0
B. 1.3
C. 12.7
D. 13.0

Which of the following is an amphiprotic species?

A. H_3O^+
B. $H_2PO_4^-$
C. PO_4^{3-}
D. SO_4^{2-}

32. During the titration of a weak base with a strong acid, the region where the pH changes least upon addition of the acid is known as the buffer region. Which point on the titration curve lies precisely in the center of the buffer region?

I. The start of the titration
II. The half-equivalence point
III. The point where pOH = pK_b

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

What is the conjugate base of NH_3?

A. NH_4^+
B. NH_2^-
C. H_2O
D. OH^-

Which statement is true for the equivalence point of a weak acid-strong base titration?

A. pH = 7
B. pH < 7
C. pH > 7

D. $[H^+] = [OH^-]$

Which indicator is most suitable for the titration of ethanoic acid with sodium hydroxide?

A. Methyl orange ($pK_a = 3.7$)
B. Bromothymol blue ($pK_a = 7.0$)
C. Phenolphthalein ($pK_a = 9.3$)
D. Universal indicator

Which combinations can form a buffer solution?

I. 0.1M CH_3COOH and 0.1M CH_3COONa
II. 0.1M CH_3COOH and 0.05M NaOH
III. 0.1M HCl and 0.1M NaCl

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

How is the acid dissociation constant, K_a, related to the strength of an acid?

A. Smaller K_a means stronger acid.
B. Larger K_a means stronger acid.
C. K_a is inversely proportional to $[H^+]$.
D. K_a depends on the concentration of the acid.

Which species can act as a Lewis acid but not a Brønsted-Lowry acid?

A. BF_3
B. H_2O
C. NH_3
D. CH_3COOH

What is the relationship between K_a, K_b, and K_w for a conjugate acid-base pair?

A. $K_a + K_b = K_w$
B. K_a imes $K_b = K_w$
C. $K_a / K_b = K_w$
D. pK_a imes $pK_b = pK_w$

Which statements about indicators are correct?

I. They are weak acids or weak bases.
II. The color change depends on the pK_a of the indicator.
III. The end point occurs when $[HIn] = [In^-]$.

A. I and II only

B. I and III only
C. II and III only
D. I, II and III