Chemistry · Chemical Equilibrium

Ionic Equilibrium

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Multiple choice questions — 63 questions

1 All of the following are correct, except .....

(A) Molten potassium chloride is a strong electrolyte.

(B) Hydrogen chloride in benzene is a strong electrolyte.

(C) A solution of acetic acid in water is a weak electrolyte.

(D) A solution of ammonia in water is a weak electrolyte.

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2 In which of the following compound solutions does ionic equilibrium not occur?

(A) CH_3COOH (B) NH_4OH (C) H_2CO_3 (D) KCl

---

3 Strong electrolyte solutions include .....

(A) HCl , NH_3 , NaCl

(B) HCl , $NaNO_3$, KOH

(C) HCl , NaCl , CH_3COOH

(D) HCl , NH_3 , CH_3COOH

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4 Which of the following aqueous solutions (of equal concentration) is the poorest conductor of electricity?

(A) H_2SO_4 (B) H_2S (C) NaOH (D) $NaNO_3$

---

5 Which equation represents the ionization of HSO_3^- in water?

(A) $HSO_3^- + H_2O \rightleftharpoons H_2SO_4 + H^+$

(B) $HSO_3^- + H_2O \rightleftharpoons SO_3^{2-} + H_3O^+$

(C) $HSO_3^- + H_2O \rightleftharpoons H_2SO_3 + OH^-$

(D) $HSO_3^- + H_2O \rightleftharpoons H_2SO_4 + ½H_2$

---

6 Which of the following represents the dissolving of acetic acid in water?

(A) $CH_3COOH + H_2O \rightarrow CH_3COO^- + OH^-$

(B) $CH_3COOH + H_2O \rightarrow CH_3COO^- + H_3O^+$

(C) $CH_3COOH + H_2O \rightleftharpoons CH_3COO^- + H_3O^+$

(D) $CH_3COOH + H_2O \rightleftharpoons CH_3COO^- + OH^-$

---

7 Which of the following aqueous solutions (of equal concentration) has the highest electrical conductivity?

(A) HCl (B) H_3BO_3 (C) NH_3 (D) CH_3COOH

---

8 Which of these acids has the lowest ionization constant?

(A) HCl (B) HBr (C) HNO_2 (D) HNO_3

9 $[H^+]$ is the greatest in the solution made by dissolving .....

(A) 0.3 mol of CO_2 in 200 mL of water.

(B) 0.8 mol of CH_3COOH in 200 mL of water.

(C) 1 mol of CH_3COOH in 200 mL of water.

(D) 0.2 mol of HCl in 50 mL of water.

10 Which of the following contains the greatest number of moles of ions?

(A) $H^+(aq)$ ions in 0.1 L of 0.5 M acetic acid

(B) $OH^-(aq)$ ions in 0.5 L of 0.1 M sodium hydroxide solution

(C) $H^+(aq)$ ions in 0.2 L of 0.2 M hydrochloric acid

(D) $OH^-(aq)$ ions in 0.4 L of 1 M ammonium hydroxide solution

11 All of the following describe the cation formed when hydrogen chloride gas dissolves in water, except that it .....

(A) turns litmus red.

(B) contains a coordinate bond.

(C) has a concentration different from that of the chloride ions.

(D) is a hydrated proton.

12 The 0.1 M solution that contains the highest concentration of hydronium ions is .....

(A) CH_3COOH (B) NaCl (C) $Ba(OH)_2$ (D) Na_2CO_3

13 The opposite table shows the time needed to obtain 30 mL of hydrogen gas from the reaction of zinc with a mineral acid in two different experiments.

Experiment (1): 25 mL of 1 M H_2SO_4 , time 28 s

Experiment (2): 25 mL of 1 M HCl , time 56 s

The time of experiment (1) is less than that of experiment (2), because .....

(A) the acid is more stable in experiment (1).

(B) the number of moles of acid is greater in experiment (1).

(C) the number of moles of (H^+) is greater in experiment (1).

(D) the number of moles of anions is greater in experiment (1).

---

14 In deriving Ostwald's law, the relation $\alpha = \sqrt{(Ka\ V)}$ expresses the degree of ionization of .....

(A) a weak acid of volume V containing a known mass of solute.

(B) a weak base of volume V containing a known mass of solute.

(C) a weak base of volume V containing 1 mol of solute.

(D) a weak acid of volume V containing 1 mol of solute.

---

15 What happens to a weak acid when it is diluted with water?

(A) Its Ka decreases and its degree of ionization increases.

(B) Its Ka decreases and its degree of ionization decreases.

(C) Its Ka does not change and its degree of ionization increases.

(D) Its Ka does not change and its degree of ionization decreases.

---

16 From the table: Ka (at 25°C) for $CH_3COOH = 1.8 \times 10^{-5}$, and for $HCN = 0.2 \times 10^{-10}$

In which of the following solutions is the degree of ionization of the solute the lowest?

(A) 0.1 M HCN solution

(B) 0.01 M HCN solution

(C) 0.01 M CH_3COOH solution

(D) 0.001 M CH_3COOH solution

---

17 An organic acid has an ionization constant of 1×10^{-5}. What is its degree of ionization when its concentration is 0.1 M?

(A) 10^{-2}

(B) 10^{-3}

(C) 10^{-4}

(D) 10^{-5}

---

18 A weak monoprotic organic acid has a degree of ionization of 3.72% (at 25°C) and an ionization constant of 6.88×10^{-5}

What is the molar concentration of the acid?

(A) 5×10^{-2} M (B) 1×10^{-1} M (C) 2×10^{-2} M (D) 5×10^{-1} M

19 A basic solution has a degree of ionization of 3.873×10^{-6} when its concentration is 0.001 M

What is its ionization constant?

(A) 4.4×10^{-4} (B) 1.1×10^{-8} (C) 1.4×10^{-9} (D) 1.5×10^{-14}

20 What is the degree of ionization of a 250 mL solution containing 0.5 g of hydrofluoric acid, given that the ionization constant of the acid is 6.7×10^{-4}? [F = 19 , H = 1]

(A) 0.82 (B) 0.41 (C) 0.041 (D) 0.082

21 What is the non-ionized percentage of nitrous acid of concentration 0.5 M, volume 1 L and ionization constant 7.1×10^{-4}?

(A) 1.9% (B) 3.8% (C) 96.2% (D) 98.1%

22 If the ionization constant of benzoic acid C_6H_5COOH is 6.5×10^{-5}

what is $[H_3O^+]$ in a solution of this acid whose concentration is 0.55 M?

(A) 3.575×10^{-4} M (B) 3.575×10^{-3} M (C) 6×10^{-4} M (D) 6×10^{-3} M

23 The concentration of acetate ions in a 0.18 M acetic acid solution (Ka = 1.76×10^{-5}) equals .....

(A) 0.18 M (B) 1.8×10^{-3} M (C) 3.17×10^{-6} M (D) 4.2×10^{-3} M

24 The opposite table shows the Ka values of formic acid HCOOH and acetic acid CH_3COOH, each of concentration 0.1 M

Ka of HCOOH = 1.8×10^{-4} , Ka of CH_3COOH = 1.8×10^{-5}

Which of the following is present at the highest concentration?

(A) CH_3COOH in the acetic acid solution. (B) CH_3COO^- in the acetic acid solution.

(C) HCOOH in the formic acid solution. (D) $HCOO^-$ in the formic acid solution.

25 A weak base solution has a concentration of 0.35 M and a hydroxide ion concentration of 1.5×10^{-5} M

What is the value of (Kb)?

(A) 6.16×10^{-3} (B) 6.43×10^{-10} (C) 1.5×10^{-6} (D) 4.28×10^{-4}

26 25 mL of acid (X) of concentration 0.75 M reacts completely with 15 mL of 2.5 M NaOH solution.

Which of the following represents acid (X) and its ionization constant?

(A) Acetic acid , $(Ka = 1.8 \times 10^{-5})$.
(B) Sulphuric acid , $(Ka = 1.8 \times 10^{-4})$.
(C) Nitrous acid , $(Ka = 4.5 \times 10^{-4})$.
(D) Sulphurous acid , $(Ka = 1.7 \times 10^{-2})$.

27 If the ionization constant of a weak monoprotic acid is 7.2×10^{-10} and its degree of dissociation is 8.5×10^{-5}

what is $[H_3O^+]$ in a solution of this acid?

(A) 8.47×10^{-6} M (B) 84.7×10^{-6} M (C) 9.9×10^{-3} M (D) 0.099×10^{-3} M

28 What is the concentration of OH^- ions in a known volume of 0.015 M H_2SO_4?

(A) 5×10^{-12} M (B) 3.3×10^{-13} M (C) 6.7×10^{-13} M (D) 2×10^{-9} M

29 What is the concentration of H_3O^+ ions in the solution formed by adding 60 mL of water to 40 mL of 0.04 M KOH solution?

(A) 6.25×10^{-5} M (B) 6.25×10^{-8} M (C) 6.25×10^{-11} M (D) 6.25×10^{-13} M

30 Kw of pure water (at 100°C) equals 51.3×10^{-14}

Which of the following describes water at this temperature?

(A) Neutral , $[H_3O^+] = 7.16 \times 10^{-7}$ M
(B) Acidic , $[H_3O^+] = 7.16 \times 10^{-7}$ M
(C) Basic , $[OH^-] = 10^{-7}$ M
(D) Neutral , $[OH^-] = 10^{-7}$ M

31 Which of the following substances is the most acidic?

(A) Grapefruit , its pH is 3
(B) Synthetic detergent , its pH is 10.5
(C) Gastric juice , its pH is 1
(D) Sea water , its pH is 8.5

32 What is the pH of a 0.4 M H_3BO_3 solution whose ionization constant is 7.3×10^{-10}?

(A) 1.7 (B) 4.77 (C) 6.12 (D) 8.22

33 If you have a 0.2 M weak alkaline solution whose equilibrium constant Kb is 3.6×10^{-4} then the pOH of the solution equals .....

(A) 1.70 (B) 4.07 (C) 3.02 (D) 2.07

34 If the ionization constant of an HCN solution equals 4.9×10^{-10} then the Kb of the solution equals .....

(A) 2×10^{-6} (B) 2×10^{-5} (C) 2×10^{5} (D) 2×10^{6}

35 The pH of 0.1 M H_2SO_4 (at 25°C) is .....

(A) less than 1 (B) equal to 1 (C) equal to 2 (D) equal to 3

36 4 g of sodium hydroxide were dissolved to form a 500 mL solution. [Na = 23 , O = 16 , H = 1]

What is the (pH) of the solution?

(A) 0.7 (B) 0.2 (C) 13.3 (D) 13.8

37 What is the pOH of a 0.05 M HCl solution?

(A) 0.3 (B) 1.3 (C) 12.7 (D) 13.7

38 What is the pH of a 0.1 M ammonia solution whose ionization constant is 4×10^{-5}?

(A) 9 (B) 11.3 (C) 5 (D) 2.7

39 Every 100 mL of vinegar contains 5 g of acetic acid. If the molar mass of this acid is 60 g/mol and its ionization constant is 1.8×10^{-5}, what is the pH of the solution?

(A) 2.41 (B) 2.92 (C) 5.85 (D) 6.73

40 A 0.01 M H_2CO_3 solution has a hydronium ion concentration of 6.557×10^{-5} M

What are the values of Ka and Kb for this solution?

(A) Ka : 4.3×10^{-7} , Kb : 2.3×10^{-8} (B) Ka : 4.3×10^{-7} , Kb : 0.23×10^{-5}

(C) Ka : 0.23×10^{-5} , Kb : 4.3×10^{-9} (D) Ka : 2.3×10^{-8} , Kb : 4.3×10^{-7}

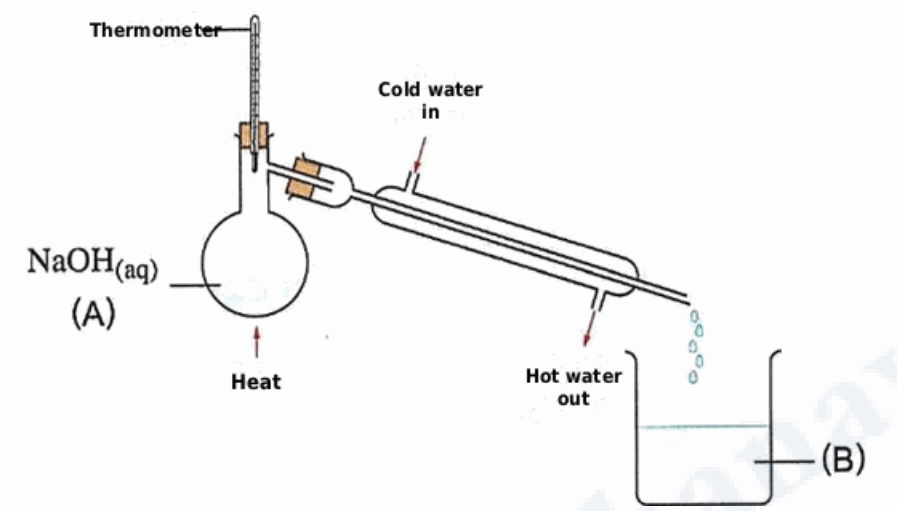
41 Adding 0.01 mol of HCl to 1 L of pure water changes the pH of the pure water by .....

(A) 0.01 (B) 2 (C) 5 (D) 7

42 How many H^+ ions are there in 1 mL of a solution whose pOH is 10 (at 25°C)?

(A) 6.02×10^{10} ion (B) 6.02×10^{16} ion (C) 6.02×10^{13} ion (D) 10^{13} ion

43 The opposite figure shows the distillation of a sodium hydroxide solution (A).
Which of the following gives the pH of liquid (B) produced by distillation compared with the pH of solution (A), and the concentration of solution (A) a few minutes after distillation starts, respectively?



(A) Greater , increases. (B) Greater , decreases.
(C) Less , increases. (D) Less , decreases.

44 If the solubility of the salt MnS (at 25°C) is 4.8×10^{-7} M
what is the solubility product of this salt?

(A) 2.3×10^{-13} (B) 4.8×10^{-7} (C) 9.6×10^{-7} (D) 6.9×10^{-14}

45 What is the solubility product of the salt Ag_2SO_4, given that its solubility in water at a certain temperature is 1.4×10^{-2}?

(A) 1.0976×10^{-5} (B) 10.976×10^{-5} (C) 1.96×10^{-4} (D) 19.6×10^{-4}

46 A saturated solution of calcium phosphate has $[PO_4^{3-}] = 3.3 \times 10^{-7}$ M
What is the Ksp of calcium phosphate?

(A) 1.32×10^{-31} (B) 1.32×10^{-32} (C) 1.32×10^{-33} (D) 1.32×10^{-35}

47 Which of the following expresses the solubility product of zinc phosphate?

(A) Ksp = $[Zn^{2+}]\ [PO_4^{3-}]$ (B) Ksp = $[Zn^{2+}]^3\ [PO_4^{3-}]^2$

(C) Ksp = $[Zn^{2+}]\ [2PO_4^{3-}]$ (D) Ksp = $[3Zn^{2+}]^3\ [2PO_4^{3-}]^2$

48 If the solubility of copper(II) iodate $Cu(IO_3)_2$ is 3.3×10^{-3} M at a certain temperature what is its Ksp?

(A) 1.4×10^{-7} (B) 1.1×10^{-5} (C) 3.3×10^{-3} (D) 5.1×10^{-1}

49 The solubility of barium oxalate in water is 4.8×10^{-4} M

What is the Ksp of this salt?

(A) 2.3×10^{-7} (B) 3.9×10^{-6} (C) 2.4×10^{-4} (D) 2.2×10^{-2}

50 If $[Ba^{2+}]$ in a saturated solution of BaF_2 is 3.6×10^{-3} M

what is the Ksp of this salt?

(A) 12.96×10^{-6} (B) 1.86×10^{-7} (C) 12.96×10^{-7} (D) 1.86×10^{-6}

51 What is $[X^+]$ in a saturated solution of the salt (XY) if Ksp = 1.8×10^{-10}?

(A) 13.4×10^{-6} M (B) 13.4×10^{-3} M (C) 26.8×10^{-7} M (D) 18×10^{-5} M

52 The salt $AgBrO_3$ has a solubility product of 5.5×10^{-5}

What is the solubility of this salt?

(A) 2.8×10^{-9} M (B) 5.3×10^{-5} M (C) 1.1×10^{-4} M (D) 7.4×10^{-3} M

53 The solubility product of SrF_2 is 4.3×10^{-9}, so its solubility is .....

(A) 3.2×10^{-25} M (B) 1.8×10^{-17} M (C) 4.3×10^{-9} M (D) 1×10^{-3} M

54 If the solubility product of A_2B_3 is 1.08×10^{-23}, then its solubility equals .....

(A) 1×10^{-3} M (B) 1×10^{-4} M (C) 1×10^{-5} M (D) 1×10^{-6} M

55 From the opposite table: Ksp of the solutions: ZnS = 2×10^{-25} , CuS = 6×10^{-37} , PbS = 2.5×10^{-27} , CoS = 4×10^{-21}

Which of the following saturated solutions contains the lowest concentration of S^{2-} ions?

(A) ZnS (B) CuS (C) PbS (D) CoS

56 What is the concentration of OH^- ions in a saturated solution of $Mg(OH)_2$? [Ksp $(Mg(OH)_2)$ = 5.6×10^{-12}]

(A) 1.1×10^{-4} M (B) 2.2×10^{-4} M (C) 1.4×10^{-12} M (D) 2.8×10^{-6} M

57 If the solubility of $Pb(OH)_2$ is 0.0155 g/100 g H_2O [Pb = 207 , O = 16 , H = 1]
what are the concentrations of the two ions of this compound in its saturated solution?

(A) $[Pb^{2+}]$: 0.155 g/L , $[OH^-]$: 0.155 g/L

(B) $[Pb^{2+}]$: 0.052 g/L , $[OH^-]$: 0.103 g/L

(C) $[Pb^{2+}]$: 6.43×10^{-4} M , $[OH^-]$: 1.29×10^{-3} M

(D) $[Pb^{2+}]$: 6.43×10^{-4} M , $[OH^-]$: 6.43×10^{-3} M

58 A magnesium hydroxide solution has a pH of 10.45, so its solubility product is .....

(A) 2.24×10^{-4} (B) 1.12×10^{-11} (C) 3.36×10^{-11} (D) 5.6×10^{-12}

59 25 mL of 0.15 M $AgNO_3$ solution was added to 15 mL of 0.2 M NaCl solution. [Ksp (AgCl) = 1.8×10^{-10}]
Which of the following is correct?

(A) A precipitate forms, because $[Ag^+]\,[Cl^-] > Ksp$

(B) No precipitate forms, because $[Ag^+]\,[Cl^-] < Ksp$

(C) A precipitate forms, because $[Ag^+]\,[Cl^-] < Ksp$

(D) No precipitate forms, because $[Ag^+]\,[Cl^-] > Ksp$

60 On evaporating 200 mL of a saturated solution of the salt $SrCrO_4$, 1.2×10^{-3} mol of the dry salt was obtained.
What is the solubility of this salt?

(A) 1.4×10^{-6} M (B) 3.6×10^{-5} M (C) 2.4×10^{-4} M (D) 6×10^{-3} M

61 What is the lowest $[CO_3^{2-}]$ that must be added to a 1.3×10^{-4} M $AgNO_3$ solution for a precipitate to form? [Ksp (Ag_2CO_3) = 8.5×10^{-12}]

(A) 5×10^{-4} M (B) 6.5×10^{-10} M (C) 5×10^{-10} M (D) 6.5×10^{-4} M

62 From the opposite table: Ksp of the salts AgBr = 5.4×10^{-13} , $Bi_2S_3 = 2 \times 10^{-78}$, CuS = 6×10^{-37}

Which of the following gives the correct order of the solubility of the salts in water (at 25°C)?

(A) CuS < Bi_2S_3 < AgBr

(B) AgBr < CuS < Bi_2S_3

(C) Bi_2S_3 < CuS < AgBr

(D) AgBr < Bi_2S_3 < CuS

---

63 The following equation represents the equilibrium in a saturated solution of barium sulphate:

$BaSO_4(s) \rightleftharpoons Ba^{2+}(aq) + SO_4^{2-}(aq)$

When the salt Na_2SO_4 is added to the saturated solution, the system shifts in the .....

(A) backward direction and $[Ba^{2+}]$ decreases.

(B) backward direction and $[Ba^{2+}]$ increases.

(C) forward direction and $[Ba^{2+}]$ decreases.

(D) forward direction and $[Ba^{2+}]$ increases.

Essay questions — 17 questions

1 A mixture is made of three solutions of equal volume and concentration of:
• sulphuric acid. • sodium hydroxide. • potassium hydroxide.
Predict the pH of the resulting mixture, with explanation.

2 Phosphoric acid ionizes in three successive steps:
(1) Write the expression of the ionization constant Ka for the first step.
(2) Do you expect Ka to be (6.9×10^{-3}) or (1.7×10^{5})? Explain.

3 What is the effect of adding drops of NaOH to distilled water on:
(1) the concentration of hydronium ions?
(2) the pH value?

4 The opposite table shows the Kb values of three weak bases: (A) : 1.4×10^{-9} , (B) : 4.7×10^{-4} , (C) : 1.1×10^{-8}
Arrange the solutions of these bases (of equal concentration) in ascending order of their pH.

5 What type of solution is solution (X), whose H_3O^+ concentration is 2×10^{-3} M? Explain.

6 Hydrochloric acid reacts with substance (X) to form a solution that gives a green colour with bromothymol blue indicator:
(1) Suggest the name of substance (X), with explanation.
(2) What is the pOH of the resulting solution?

7 Arrange the following solutions of equal concentration (0.1 M) in ascending order of pH, with explanation:
(HCl , NaOH , H_3BO_3 , NH_4OH)

8 The pH of an aqueous solution is affected when its temperature rises above 25°C
State two other factors that affect the pH of acids.

9 The following table shows the pH values of several solutions of equal concentration:

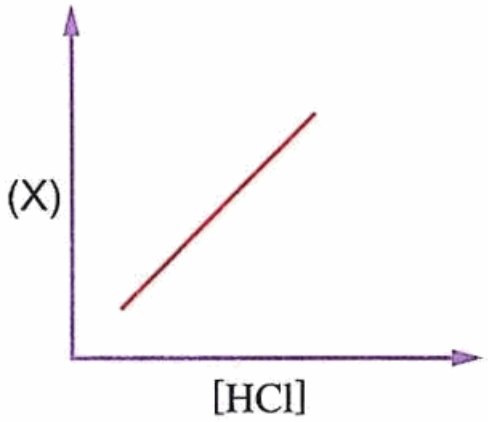
pH of solution (A) = 11 , (B) = 3 , (C) = 7 , (D) = 5 , (E) = 13 , (F) = 9 , (G) = 1

Give the symbol of:

(1) the weakest acid, with explanation.

(2) the best conductor of electricity among solutions (B), (F) and (G), with explanation.

10 Does axis (X) in the opposite graph represent pOH or pH? Explain.



11 100 mL of distilled water was added to 100 mL of hydrochloric acid whose pH is 3

Calculate the pH of the acid after dilution.

12 Calculate $[OH^-]$ and pOH for benzoic acid, given that its concentration is 0.2 M and its ionization constant Ka equals 6.5×10^{-5}

13 The following table shows the pH values of several solutions of equal concentration:

pH of solution (A) = 11 , (B) = 3 , (C) = 7 , (D) = 5 , (E) = 13 , (F) = 9 , (G) = 1

Give the symbol of the solution that:

(1) has the highest OH^- concentration, with explanation.

(2) may be a sodium chloride solution.

14 Potassium sulphide solution reacts with cobalt(II) acetate solution, forming two salts, one of which is sparingly soluble in water.

Write the chemical formula of the salt produced that:

(1) has the greater solubility in water.

(2) has a Ksp value.

15 Two saturated solutions of Ag_2CO_3 and AgCl at 25°C

Show by chemical calculations which of these two solutions contains the higher $[Ag^+]$, given that:

- the solubility product of silver chloride is 1.8×10^{-10}
- the solubility product of silver carbonate is 8.5×10^{-12}

16 The following figures show three solutions (A , B , C) of hydrofluoric acid at room temperature: solution (A): M = 0.4 M , Ka = 6.7×10^{-4} , solution (B): M = 0.28 M , solution (C): M = 0.02 M

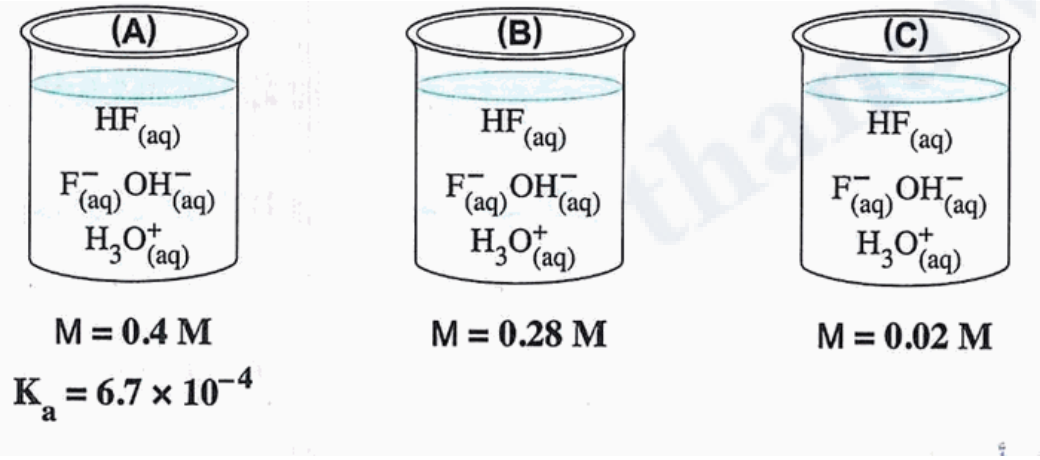
Study the figures, then answer:

(1) Which solution has the highest pH?

(2) Which solution has the highest concentration of negative fluoride ions?

(3) What is the Ka value of solution (B)?

(4) In which solution is the percentage dissociation of the acid 4.9 %?



17 A basic dihydroxide compound is sparingly soluble in water. If the pH of this compound is 8, deduce its Ksp.

Past exam questions — 71 questions

1 50 mL of 0.2 M ammonium hydroxide (NH_4OH) solution was diluted by adding 450 mL of distilled water.

What is the degree of dissociation (α) of the solution after dilution? (Ionization constant of ammonia solution: $Kb = 1.8 \times 10^{-5}$)

(A) 0.03 (B) 0.0095 (C) 0.2 (D) 0.0009

---

2 Two test tubes (A) and (B) each contain a saturated solution of calcium carbonate: $CaCO_3(s) \rightleftharpoons Ca^{2+}(aq) + CO_3^{2-}(aq)$

• In tube (A): a few drops of hydrochloric acid were added.

• In tube (B): a few drops of calcium chloride solution were added.

Which of the following is correct?

(A) The amount of precipitate gradually increases in (A), and gradually decreases in (B).

(B) The amount of precipitate gradually decreases in (A), and gradually increases in (B).

(C) The amount of precipitate gradually increases in both tubes.

(D) The amount of precipitate gradually decreases in both tubes.

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3 Drops of solution (X) were added to some distilled water, and the pOH of the water was observed to decrease.

Which of the following represents solution (X)?

(A) A base , its pOH is 8 (B) An acid , its pOH is 5

(C) A base , its pH is 8 (D) An acid , its pH is 5

---

4 A 5 L saturated solution of zinc sulphide (ZnS) was cooled from 60°C to 25°C, and a mass of 1.53×10^{-5} g of the salt precipitated.

Given that the solubility product Ksp of the salt at 25°C equals 1×10^{-21} [ZnS = 97 g/mol] which of the following represents the solubility product (Ksp) of ZnS at 60°C?

(A) 1×10^{-15} (B) 1×10^{-21} (C) 3.16×10^{-8} (D) 3.16×10^{-11}

---

5 A hydrocyanic acid solution is in equilibrium according to the following equation: $HCN + H_2O(l) \rightleftharpoons H_3O^+(aq) + CN^-(aq)$

Which of the following happens when a few drops of HCl are added to this solution?

(A) The degree of dissociation of the acid increases.

(B) The concentration of the CN^- ion increases.

(C) The degree of dissociation of the acid decreases.

(D) The equilibrium is not affected.

---

6 Solution (X) has a hydrogen ion concentration $[H^+]$ of 1.0×10^{-9} M at 25°C

Which of the following represents solution (X)?

(A) A solution of a base whose pOH is 9

(B) A solution of an acid whose pOH is 5

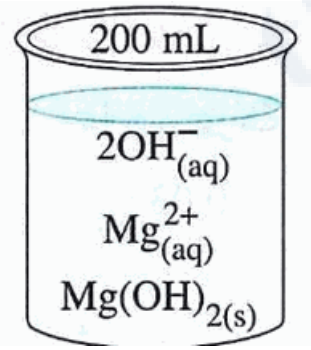
(C) A solution of a base whose pH is 9

(D) A solution of an acid whose pH is 5

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7 From the figure in front of you, every 50 mL of the solution was found to contain 2×10^{-4} mol of solute.

Which of the following represents the Ksp of the salt $Mg(OH)_2$?



(A) 4×10^{-6}

(B) 2.5×10^{-7}

(C) 1.6×10^{-8}

(D) 8×10^{-5}

---

8 All of the following solutions have a degree of dissociation $(\alpha \simeq 1)$, except .....

(A) hydrochloric acid (1 M).

(B) sodium hydroxide (1 M).

(C) nitric acid (1 M).

(D) boric acid (1 M).

---

9 An acetic acid solution ionizes according to the following equation: $CH_3COOH \rightleftharpoons H^+ + CH_3COO^-$

Which of the following happens when drops of sodium hydroxide are added to this solution?

(A) The dissociation of the acid increases and the pH of the solution decreases.

(B) The dissociation of the acid increases and the pH of the solution increases.

(C) The rate of forming the acid increases and the pH of the solution decreases.

(D) The rate of forming the acid increases and the pH of the solution increases.

---

10 An ammonium hydroxide (NH_4OH) solution of concentration 0.1 M at 25°C has an equilibrium constant Kb = 1.8×10^{-5}

Which of the following is correct?

(A) $\alpha = 0.0134$, pOH = 11.13 , pH = 2.87

(B) $\alpha = 0.0134$, pOH = 2.87 , pH = 11.13

(C) $\alpha = 1$, pOH = 1 , pH = 13

(D) $\alpha = 1.8 \times 10^{-5}$, pOH = 4.74 , pH = 9.26

---

11 Which of the following choices does not represent an equilibrium system?

(A) Dissolving ammonia gas in water.

(B) A reversible reaction with constant concentrations.

(C) Strong heating of hydrated barium chloride.

(D) A saturated solution of a sparingly soluble salt.

---

12 Two solutions (A , B) have the same volume and concentration:

- (A): a weak acid solution (such as CH_3COOH).
- (B): a weak base solution (such as NH_4OH).

On diluting each solution by adding 100 mL of distilled water, which of the following describes what happens after dilution?

(A) The pH decreases in both solutions (A) and (B).

(B) The pH of solution (A) increases and the pH of solution (B) decreases.

(C) The pH increases in both solutions (A) and (B).

(D) The pH of solution (A) decreases and the pH of solution (B) increases.

---

13 A 500 mL sodium hydroxide NaOH solution has a pH of 12.0 [Na = 23 , O = 16 , H = 1] so the mass of sodium hydroxide (NaOH) dissolved in this solution equals .....

(A) 2.0 g (B) 0.2 g (C) 0.4 g (D) 4.0 g

14 Four saturated solutions of sparingly soluble salts at 25°C:

(1) AgCl , Ksp = 1.0×10^{-10} , (2) PbI_2 , Ksp = 4.0×10^{-12}

(3) AgBr , Ksp = 1.0×10^{-8} , (4) BiI_3 , Ksp = 2.7×10^{-15}

Which of the following gives the order of these solutions according to their electrical conductivity?

(A) 4 > 3 > 2 > 1 (B) 4 > 2 > 3 > 1 (C) 3 > 1 > 2 > 4 (D) 1 > 3 > 2 > 4

15 Two solutions of two different acids, both weak, (HA) and (HB), each with pH = 3.

- The acid HA has a concentration of 0.1 M
- The acid HB has a concentration of 0.01 M

Which of the following is correct for the two acids HA and HB?

(A) They differ in the concentration of the OH^- ion

(B) They have the same Ka

(C) The Ka of HB is greater.

(D) The Ka of HA is greater.

16 Four solutions of the same concentration: (1) HCl solution , (2) NaOH solution , (3) CH_3COOH solution , (4) NH_4OH solution

Which of the following gives the correct order of these solutions according to the concentration of the hydronium ion?

(A) 2 < 4 < 3 < 1 (B) 1 < 3 < 4 < 2 (C) 4 < 3 < 2 < 1 (D) 4 < 2 < 3 < 1

17 Given that the solubility product of lead(II) chloride, which is sparingly soluble in water, is (Ksp = 1.2×10^{-5}) at 25°C [$PbCl_2$ = 278 g/mol]

which of the following represents the volume of saturated solution that contains 0.1 g of the salt at the same temperature?

(A) 25 mL (B) 50 mL (C) 100 mL (D) 150 mL

18 A saturated solution of lead(II) chloride ($PbCl_2$) is in equilibrium according to the following equation: $PbCl_2(s) \rightleftharpoons Pb^{2+}(aq) + 2Cl^-(aq)$

Which of the following is correct for the solubility of $PbCl_2$ when a little of each of the following salts is added separately?

(A) The solubility decreases on adding sodium sulphate solution.

(B) The solubility increases on adding sodium nitrate solution.

(C) The solubility decreases on adding lead(II) acetate solution.

(D) The solubility increases on adding potassium nitrate solution.

---

19 Each of the following can represent an equilibrium system, except .....

(A) A saturated solution of a sparingly soluble salt in water.

(B) Dissolving carbon dioxide in water in a closed container.

(C) Dissolving acetic acid in water in an open container.

(D) Obtaining oxygen gas by decomposing H_2O_2

---

20 The following table shows the pH of three solutions of different acids that have the same concentration:

Solution A : pH = 1 , solution B : pH = 6 , solution C : pH = 3

The correct order of these solutions according to their acid ionization constant Ka is .....

(A) B > A > C (B) A > B > C (C) C > B > A (D) A > C > B

---

21 A 0.1 M acetic acid solution (X) was diluted by adding water to obtain solution (Y) of concentration 0.01 M

Which of the following does not describe the two solutions (X , Y)?

(A) The electrical conductivity of solution (Y) is higher than that of (X).

(B) The concentration of hydronium ions in solution (X) is higher than in (Y).

(C) The pH of solution (Y) is higher than that of solution (X).

(D) The ionization constant of the acid in solution (X) is higher than in (Y).

---

22 If the solubility of magnesium carbonate $MgCO_3$ in water at 25°C is [4.4×10^{-5} mol/100 mL H_2O]
then the solubility product (Ksp) of this salt equals .....

(A) 4.16×10^{-11} (B) 1.9×10^{-7} (C) 19.36×10^{-10} (D) 6.44×10^{-4}

23 A hydrocyanic acid (HCN) solution has a pH of 4.7 and an acid ionization constant (Ka = 6.2×10^{-10})
so the number of moles of acid dissolved in 300 mL of its solution equals .....

(A) 0.19 (B) 0.47 (C) 0.64 (D) 0.14

24 The ionic product of water (Kw) increases as the temperature increases.
Which of the following happens when the temperature of water is raised?

(A) The concentration of hydrogen ions increases, the pH of water increases and it becomes acidic to litmus solution.

(B) The concentration of hydroxide ions increases, the pOH of water decreases and it becomes alkaline to litmus solution.

(C) The concentration of hydroxide ions increases, the pOH of water decreases and it stays neutral to litmus solution.

(D) The concentration of hydrogen ions increases, the pH of water increases and it stays neutral to litmus solution.

25 A saturated solution of a sparingly soluble salt (A) has a concentration of 1×10^{-4} mol/L.
Given that the solubility product of this salt equals 1.08×10^{-18}
which of the following represents the chemical formula of salt (A)?

(A) X_2Y_3 (B) XY_3 (C) X_2Y (D) XY_2

26 Two solutions of two different acids (X) and (Y), each monoprotic:

- (X): concentration 0.1 M and ionization constant Ka = 1.8×10^{-5}
- (Y): concentration 0.1 M and ionization constant Ka = 5.1×10^{-4}

Which of the following describes the properties of acids (X) and (Y)?

(A) The solution of acid (X) conducts electricity better and its pH is lower than that of acid (Y).

(B) The solution of acid (Y) conducts electricity better and its pH is higher than that of acid (X).

(C) The solution of acid (X) conducts electricity less and its pH is lower than that of acid (Y).

(D) The solution of acid (Y) conducts electricity better and its pH is lower than that of acid (X).

---

27 If the Ksp of the salt AgCl equals 1.6×10^{-10}

then the concentration of dissolved ions in its saturated solution equals .....

(A) 1.26×10^{-5} M (B) 2.53×10^{-5} M (C) 6.32×10^{-6} M (D) 1.6×10^{-10} M

---

28 Which of the following represents the mass of $Ba(OH)_2$ dissolved in 1.5 L of pure water needed to form a solution of pH 12.3? [$Ba(OH)_2$ = 171 g/mol]

(A) 2.56 g (B) 5.12 g (C) 43.605 g (D) 0.513 g

---

29 0.2 mol of hydrocyanic acid was dissolved in a litre of water, and the concentration of the non-ionized acid in the water was 0.167 M,

so the ionization constant of the acid at the same temperature equals .....

(A) 4.18×10^{-3} (B) 5.45×10^{-3} (C) 3.03×10^{-3} (D) 6.06×10^{-3}

---

30 A weak monoprotic acid solution is diluted by adding water so that its volume doubles.

Which of the following happens to the values of pH and α?

(A) Its value decreases and becomes $(\alpha / 1.414)$, and the pH of the solution decreases.

(B) Its value increases and becomes $(1.414\ \alpha)$, and the pH of the solution increases.

(C) α doubles, and the pH of the solution increases.

(D) α is halved, and the pH of the solution decreases.

---

31 If the Ksp of the salt AgCl equals 1.6×10^{-10}, then the mass of salt dissolved in 50 mL of water equals ..... [AgCl = 143.5 g/mol]

(A) 1.6×10^{-10} g (B) 0.905×10^{-4} g (C) 1.26×10^{-5} g (D) 1.81×10^{-4} g

32 A weak acid whose degree of ionization is 0.03 % and concentration is 0.2 M has a pOH of .....

(A) 2.22 (B) 11.78 (C) 9.78 (D) 4.22

33 A litre of 0.1 M nitrous acid in which the number of non-ionized moles is 0.0933 mol
Which of the following represents the ionization constant of the acid?

(A) 4.5×10^{-5} (B) 4.5×10^{-4} (C) 6.7×10^{-3} (D) 8.7×10^{-2}

34 When drops of sodium hydroxide solution are added to the following equilibrium reaction:
$H_2SO_3(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + HSO_3^-(aq)$
which of the following choices is correct?

(A) The dissociation of the acid increases and the pH of the solution increases.
(B) The dissociation of the acid decreases and the pH of the solution increases.
(C) The dissociation of the acid increases and the pH of the solution decreases.
(D) The dissociation of the acid decreases and the pH of the solution decreases.

35 If ($Ksp = 8.75 \times 10^{-11}$) for the salt X_2Y at 25°C [X_2Y = 248 g/mol]
which of the following represents the mass of salt dissolved in 100 mL of its saturated solution at the same temperature?

(A) 0.003 g (B) 0.007 g (C) 0.005 g (D) 0.009 g

36 From the following equations:
(1) $CH_3COOH(aq) \rightleftharpoons CH_3COO^-(aq) + H^+(aq)$ (2) $HNO_3(aq) \rightarrow H^+(aq) + NO_3^-(aq)$
(3) $HCl(aq) \rightarrow H^+(aq) + Cl^-(aq)$ (4) $H_2CO_3(aq) \rightleftharpoons 2H^+(aq) + CO_3^{2-}(aq)$
Which of the following choices gives the numbers of the equations that involve an ionic equilibrium?

(A) (1) , (4) (B) (1) , (2) (C) (1) , (2) , (3) (D) (2) , (3) , (4)

37 Which of the following choices represents the result of dividing the pH of a sodium carbonate solution by the pH of a potassium chloride solution?

(A) Greater than one.
(B) Equal to 7
(C) Equal to one.
(D) Less than one.

38 When drops of an acid are added to pure water,
which of the following choices is correct?

(A) The concentration of the positive hydrogen ion increases and Kw increases
(B) The pOH increases and Kw stays constant.
(C) The concentration of the negative hydroxide ion decreases and Kw increases
(D) The pH increases and Kw stays constant.

39 A saturated solution of the substance $X(OH)_2$ has a pOH of 4, so its solubility product equals .....

(A) 5×10^{-5} (B) 5×10^{-13} (C) 1×10^{-4} (D) 4×10^{-12}

40 When drops of HCl are added to the following equilibrium reaction: $HCN(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + CN^-(aq)$
which of the following is correct?

(A) The ionization constant of HCN increases and the concentration of the cyanide ion in the solution decreases.
(B) The ionization constant of HCN does not change and the concentration of the cyanide ion in the solution decreases.
(C) The degree of dissociation of HCN increases and the pOH of the solution increases.
(D) The degree of dissociation of HCN does not change and the pH of the solution increases.

41 The aqueous solution of sulphurous acid contains .....

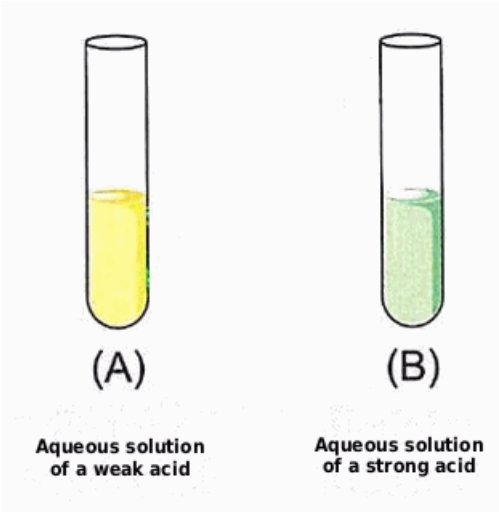
(A) OH^-, HSO_3^-, SO_3^{2-}, H_3O^+, H_2SO_3
(B) OH^-, H_3O^+, H_2SO_3
(C) OH^-, HSO_3^-, H_3O^+
(D) OH^-, HSO_3^-, SO_3, H_3O^+, H_2SO_3

42 The law of mass action can be applied to each of the following, except .....

(A) $H_2SO_3(aq)$ (B) HCl(aq) (C) HF(aq) (D) $H_2CO_3(aq)$

43 In the opposite figure: tube (A) contains an aqueous solution of a weak acid, and tube (B) contains an aqueous solution of a strong acid.

Which of the following represents the change in the degree of ionization (α) after adding an equal amount of water to each tube?



(A) Tube (A): increases / tube (B): not affected

(B) Tube (A): not affected / tube (B): decreases

(C) Tube (A): decreases / tube (B): increases

(D) Tube (A): increases / tube (B): decreases

---

44 When a weak electrolyte is diluted at constant temperature, ...

(A) the degree of ionization decreases, and the concentration of the solution increases.

(B) the degree of ionization increases, and the concentration of the solution increases.

(C) the degree of ionization increases, and the concentration of the solution decreases.

(D) the degree of ionization decreases, and the concentration of the solution decreases.

---

45 The following table shows the ionization constants of some acids:

(A) : 1.7×10^{-3} (B) : 1.8×10^{-5} (C) : 4.4×10^{-7} (D) : 1.2×10^{-2}

Which of the following is correct?

(A) (B) is weaker than (C), and stronger than (A).

(B) (C) is weaker than (B), and stronger than (D).

(C) (D) is stronger than (C) and (B).

(D) (A) is stronger than (B) and (D).

---

46 7.258 g of HCN was dissolved in water and the volume of the solution became 100 mL.
Given that [H = 1 , C = 12 , N = 14] , ($Ka = 7.2 \times 10^{-10}$)
the degree of ionization of the acid equals .....

(A) 2.56×10^{-4} (B) 1.63×10^{-3} (C) 2.56×10^{-6} (D) 1.63×10^{-5}

47 Given that the ionization constant (Ka) of a weak monoprotic acid equals (5.1×10^{-4}) and its concentration is (0.2 M) in a solution of volume (200 mL), the number of dissociated moles equals .....

(A) 0.04×10^{-2} mol (B) 1.01×10^{-3} mol (C) 5.05×10^{-2} mol (D) 2.02×10^{-3} mol

48 In the following equilibrium system: $CH_3COOH(l) + H_2O(l) \rightleftharpoons CH_3COO^-(aq) + H_3O^+(aq)$, ($Ka = 1.8 \times 10^{-5}$)
when drops of HCl(aq) are added to the reaction, the Ka of acetic acid equals .....

(A) 1.8×10^{-5} (B) 0.9×10^{-5} (C) 3.6×10^{-6} (D) 3.6×10^{-4}

49 Given that the ionic product of water changes with temperature, and under certain temperature conditions Kw was found to be 0.49×10^{-13}
the pOH of water in this case is .....

(A) 5.65 (B) 7 (C) 7.13 (D) 6.65

50 Two solutions (A) and (B) have pH values of [A = 8.2 , B = 13.6]
Which of the following statements is correct when each of them is diluted separately?

(A) The degree of ionization of solution (A) increases and its pH decreases.
(B) The degree of ionization of solution (A) decreases and $[H^+]$ decreases
(C) The degree of ionization of solution (B) decreases and its pH does not change.
(D) The degree of ionization of solution (B) increases and its pH increases.

51 A solution whose pOH equals 11 was added to two indicators (X) and (Y), each separately, and the following was observed:

• (X): colourless.

• (Y): red.

The two indicators (X) and (Y) are .....

(A) (X): phenolphthalein , (Y): methyl orange.

(B) (X): phenolphthalein , (Y): bromothymol blue.

(C) (X): methyl orange , (Y): litmus.

(D) (X): litmus , (Y): bromothymol blue.

---

52 An aqueous solution of potassium chloride differs from an aqueous solution of sodium carbonate of the same concentration and volume in that .....

(A) $[OH^-]$ in the potassium chloride solution is greater.

(B) the pH of the sodium carbonate solution is lower.

(C) the pH of the potassium chloride solution is lower.

(D) $[H_3O^+]$ in the sodium carbonate solution is greater.

---

53 The pH of a salt solution is greater than 7, so the anion and cation of this salt are .....

(A) Anion: NO_3^- , cation: Na^+

(B) Anion: SO_4^{2-} , cation: Na^+

(C) Anion: Cl^- , cation: K^+

(D) Anion: CO_3^{2-} , cation: K^+

---

54 A monoprotic acid solution contains 0.2 mol in a volume (V) L. If Ka = 3.5×10^{-8} and the number of dissociated moles in it is 0.002 mol

then the pH of the acid equals .....

(A) 3.5×10^{-6} (B) 5.455 (C) 8.544 (D) 6.5×10^{-7}

---

55 11 g of the acid $C_5H_{11}COOH$ was dissolved in some water until the volume of the solution became 1 L. Given that the pH of this solution at 25°C is 2.94 [H = 1 , C = 12 , O = 16] the ionization constant of this acid equals .....

(A) 1.39×10^{-5} (B) 1.148×10^{-3} (C) 1.318×10^{-6} (D) 1.39×10^{-4}

---

56 Given that the concentration of a methylamine CH_3NH_2 solution is (0.4 M) and its pH = 9, its Kb at 25°C equals .....

(A) 2.5×10^{-18} (B) 2×10^{-9} (C) 4.47×10^{-5} (D) 2.5×10^{-10}

57 If the pOH of a weak acid equals 10 and its ionization constant equals 5.1×10^{-4}, then the degree of ionization of this acid equals .....

(A) 6.3 (B) 4.8 (C) 7.2 (D) 5.1

58 If the pH of an aqueous solution equals 3.7, then the hydroxide ion concentration $[OH^-]$ of this solution is .....

(A) 1.99×10^{-4} M (B) 10.3 M (C) 5.01×10^{-11} M (D) 7.3 M

59 When 300 mL of water is added to 200 mL of NaOH solution whose pH = 12, which of the following is correct?

(A) $[H^+]$ increases and its pH becomes 11.6

(B) $[H^+]$ increases and its pH becomes 10.6

(C) $[OH^-]$ decreases and its pOH becomes 3.4

(D) $[OH^-]$ decreases and its pOH becomes 4.4

60 Which of the following systems is irreversible?

(A) $CH_3COOH(aq) + H_2O(l) = CH_3COO^-(aq) + H_3O^+(aq)$

(B) $AgCl(s) = Ag^+(aq) + Cl^-(aq)$ (saturated solution)

(C) $N_2O_4(g) = 2NO_2(g)$ (closed container)

(D) $Zn(s) + 2HCl(aq) = ZnCl_2(aq) + H_2(g)$

61 When HCl is added to the equilibrium system represented by the equation: $AgCl(s) \rightleftharpoons Ag^+(aq) + Cl^-(aq)$

the change that happens is .....

(A) The concentration of Ag^+ increases and the amount of AgCl(s) decreases

(B) Kc increases

(C) Kc decreases

(D) The concentration of Ag^+ decreases and the amount of AgCl(s) increases

62 In the opposite saturated solution: $AgCl(s) \rightleftharpoons Ag^{+}(aq) + Cl^{-}(aq)$

Each of the following lowers the solubility of AgCl when added to it, except .....

(A) $NH_4OH(aq)$ (B) $AgNO_3(aq)$ (C) NaCl(aq) (D) HCl(aq)

63 The opposite equation represents a system in equilibrium: $AgCl(s) \rightleftharpoons Ag^{+}(aq) + Cl^{-}(aq)$

Which of the following changes happens when drops of lead acetate are added to this system?

(A) The rate of the backward reaction increases and the concentration of the silver ion increases.

(B) The rate of the backward reaction decreases and the concentration of the silver ion decreases.

(C) The rate of the forward reaction increases and the concentration of the chloride ion decreases.

(D) The rate of the forward reaction decreases and the concentration of the chloride ion increases.

64 In the opposite equilibrium: $PbBr_2(s) \rightleftharpoons Pb^{2+}(aq) + 2Br^{-}(aq)$

Which of the following choices gives the two compounds whose addition lowers the solubility of $PbBr_2$?

(A) NaBr, $Pb(NO_3)_2$ (B) $Pb(NO_3)_2$, $NaNO_3$

(C) NaBr, K_2SO_4 (D) $Pb(NO_3)_2$, K_2SO_4

65 Given that the solubility of silver chromate (Ag_2CrO_4) equals 6.62×10^{-5} M, its solubility product equals .....

(A) 0.58×10^{-12} (B) 1.16×10^{-12} (C) 2.32×10^{-12} (D) 3.48×10^{-12}

66 Given that the solubility product of lead hydroxide $Pb(OH)_2$ is 2.5×10^{-6}, its solubility equals .....

(A) 0.27 M (B) 0.0135 M (C) 4.27×10^{-3} M (D) 8.54×10^{-3} M

67 If the solubility product of the salt XY_2 equals 1.6×10^{-10}, then $[Y^{-}]$ equals .....

(A) 3.41×10^{-4} M (B) 6.84×10^{-4} M (C) 2.36×10^{-5} M (D) 2.14×10^{-5} M

68 Given that the Ksp of the salt XY_2 is 1.6×10^{-10}, the number of moles of salt that must be dissolved in water to make 2 L of saturated solution at 25°C equals .....

(A) 5.2×10^{-5} mol (B) 6.84×10^{-4} mol (C) 2.5×10^{-5} mol (D) 3.42×10^{-4} mol

69 Given that the solubility product of zinc sulphide is Ksp = 1×10^{-21} and its molar mass is 97 g/mol at 25°C, the mass of zinc sulphide that dissolves in 100 g of pure water is .....

(A) 6.034×10^{-10} g (B) 31.6×10^{-12} g (C) 2×10^{-21} g (D) 3.067×10^{-10} g

70 Given that the solubility product of silver chloride in a 0.1 L saturated solution at a certain temperature equals 2.56×10^{-6}, the mass of silver chloride dissolved in the solution equals ..... [Ag = 108 , Cl = 35.5]

(A) 0.023 g (B) 0.0115 g (C) 2.3×10^{-6} g (D) 1.15×10^{-6} g

71 A 5 L solution of zinc sulphide ZnS, which is sparingly soluble in water, has a solubility product of 1×10^{-15} at 60°C. On cooling to 25°C its solubility product became 1×10^{-21} [Given: ZnS = 97 g/mol]

The mass of zinc sulphide that precipitates equals .....

(A) 1.53×10^{-5} g (B) 3.16×10^{-11} g (C) 1.53×10^{-8} g (D) 3.16×10^{-8} g

Answer key and solutions

Multiple choice questions

1 B	2 D	3 B	4 B	5 B	6 C	7 A	8 C	9 D	10 B
11 C	12 A	13 C	14 D	15 C	16 A	17 A	18 A	19 D	20 D
21 C	22 D	23 B	24 A	25 B	26 D	27 A	28 B	29 D	30 A
31 C	32 B	33 D	34 B	35 A	36 C	37 C	38 B	39 A	40 A
41 C	42 B	43 C	44 A	45 A	46 B	47 B	48 A	49 A	50 B
51 A	52 D	53 D	54 C	55 B	56 B	57 C	58 B	59 A	60 D
61 A	62 A	63 A							

1 **Answer (B)**

Hydrogen chloride is a covalent compound that does not ionize in benzene.

So it is not a strong electrolyte in it.

2 **Answer (D)**

KCl is a salt that dissociates completely in water.

So no ionic equilibrium occurs in it.

3 **Answer (B)**

HCl, $NaNO_3$ and KOH all ionize completely in water.

4 **Answer (B)**

H_2S is a weak acid, so it ionizes partially.

So it is the poorest conductor of electricity.

5 **Answer (B)**

HSO_3^- loses a proton to water.

SO_3^{2-} and H_3O^+ are produced.

6 **Answer (C)**

Acetic acid is weak, so it ionizes partially.

So the equation is written with two arrows $(\rightleftharpoons)$ and H_3O^+ is produced.

7 **Answer (A)**

HCl is a strong electrolyte that ionizes completely.

So its solution has the highest conductivity.

8 **Answer (C)**

HNO_2 is a weak acid with a small ionization constant.

HCl, HBr and HNO_3 are strong acids with large ionization constants.

9 **Answer (D)**

0.2 mol of HCl in 50 mL gives a concentration of 4 M.

HCl is a strong acid that ionizes completely, so its $[H^+]$ is the greatest.

10 **Answer (B)**

NaOH is strong: $0.1 \times 0.5 = 0.05$ mol of OH^-

HCl: $0.2 \times 0.2 = 0.04$ mol of H^+

The weak acid and the weak base give fewer ions.

11 **Answer (C)**

HCl ionizes completely in a 1 : 1 ratio.

So the concentration of H_3O^+ equals that of Cl^-

12 **Answer (A)**

Acetic acid gives H_3O^+ at a concentration of about 1.3×10^{-3} M

NaCl is neutral ($[H_3O^+] = 10^{-7}$ M).

$Ba(OH)_2$ and Na_2CO_3 are basic, so $[H_3O^+]$ is lower in them.

13 **Answer (C)**

H_2SO_4 is diprotic and HCl is monoprotic.

The number of moles of H^+ in experiment (1) is double that of experiment (2), so the rate increases.

14 **Answer (D)**

The relation is $\alpha = \sqrt{(Ka / C)}$

When there is 1 mol in a volume V, $C = 1 / V$

So $\alpha = \sqrt{(Ka\ V)}$

15 **Answer (C)**

Ka is constant; it changes only when the temperature changes.

On dilution, the degree of ionization increases.

16 **Answer (A)**

$\alpha = \sqrt{(Ka / C)}$

The lowest degree of ionization is for the weakest acid (HCN) at the highest concentration (0.1 M).

17 **Answer (A)**

$\alpha = \sqrt{(Ka / C)} = \sqrt{(10^{-5} / 0.1)} = 10^{-2}$

18 **Answer (A)**

$C = Ka / \alpha^2$

$C = 6.88 \times 10^{-5} / (0.0372)^2 = 0.05\ M$

19 **Answer (D)**

$Kb = C\ \alpha^2$

$Kb = 0.001 \times (3.873 \times 10^{-6})^2 = 1.5 \times 10^{-14}$

20 **Answer (D)**

$mol = 0.5 / 20 = 0.025\ mol$

$C = 0.025 / 0.25 = 0.1\ M$

$\alpha = \sqrt{(6.7 \times 10^{-4} / 0.1)} = 0.082$

21 **Answer (C)**

$\alpha = \sqrt{(Ka / C)} = \sqrt{(7.1 \times 10^{-4} / 0.5)} = 0.0377$

Ionized percentage = 3.77 %

Non-ionized = 100 − 3.77 = 96.2 %

22 **Answer (D)**

$[H_3O^+] = \sqrt{(Ka \times C)}$

$= \sqrt{(6.5 \times 10^{-5} \times 0.55)} = 6 \times 10^{-3}\ M$

23 **Answer (B)**

$[CH_3COO^-] = [H^+] = \sqrt{(Ka \times C)}$

$= \sqrt{(1.76 \times 10^{-5} \times 0.18)} = 1.8 \times 10^{-3}$ M

24 **Answer (A)**

The Ka of acetic acid is small, so it ionizes weakly.

So most of it stays non-ionized, and it has the highest concentration.

25 **Answer (B)**

$Kb = [OH^-]^2 / C$

$= (1.5 \times 10^{-5})^2 / 0.35 = 6.43 \times 10^{-10}$

26 **Answer (D)**

mol NaOH = $0.015 \times 2.5 = 0.0375$ mol

mol of acid = $0.025 \times 0.75 = 0.01875$ mol

The ratio is 2 : 1, so the acid is diprotic.

27 **Answer (A)**

$C = Ka / \alpha^2 = 7.2 \times 10^{-10} / (8.5 \times 10^{-5})^2 = 0.1$ M

$[H_3O^+] = C\,\alpha = 0.1 \times 8.5 \times 10^{-5} = 8.47 \times 10^{-6}$ M

28 **Answer (B)**

$[H^+] = 2 \times 0.015 = 0.03$ M

$[OH^-] = 10^{-14} / 0.03 = 3.3 \times 10^{-13}$ M

29 **Answer (D)**

mol OH^- = $0.04 \times 0.04 = 1.6 \times 10^{-3}$ mol

Total volume = 0.1 L

$[OH^-] = 0.016$ M

$[H_3O^+] = 10^{-14} / 0.016 = 6.25 \times 10^{-13}$ M

30 **Answer (A)**

Pure water is neutral at any temperature.

$[H^+] = [OH^-] = \sqrt{(51.3 \times 10^{-14})} = 7.16 \times 10^{-7}$ M

31 **Answer (C)**

Most acidic = lowest pH

The lowest value is pH = 1

32 **Answer (B)**

$[H^+] = \sqrt{(Ka \times C)}$

$= \sqrt{(7.3 \times 10^{-10} \times 0.4)} = 1.7 \times 10^{-5}$ M

pH = 4.77

33 **Answer (D)**

$[OH^-] = \sqrt{(Kb \times C)} = \sqrt{(3.6 \times 10^{-4} \times 0.2)} = 8.5 \times 10^{-3}$ M

pOH = 2.07

34 **Answer (B)**

Ka × Kb = Kw

$Kb = 10^{-14} / 4.9 \times 10^{-10} = 2 \times 10^{-5}$

35 **Answer (A)**

H_2SO_4 is diprotic and ionizes completely.

$[H^+]$ = 0.2 M

pH = 0.7, which is less than 1

36 **Answer (C)**

mol = 4 / 40 = 0.1 mol

C = 0.1 / 0.5 = 0.2 M

pOH = 0.7, so pH = 13.3

37 **Answer (C)**

$[H^+]$ = 0.05 M

pH = 1.3

pOH = 14 − 1.3 = 12.7

38 **Answer (B)**

$[OH^-] = \sqrt{(Kb \times C)} = \sqrt{(4 \times 10^{-5} \times 0.1)} = 2 \times 10^{-3}$ M

pOH = 2.7

pH = 11.3

39 **Answer (A)**

mol = 5 / 60 = 0.083 mol

C = 0.083 / 0.1 = 0.83 M

$[H^+] = \sqrt{(1.8 \times 10^{-5} \times 0.83)} = 3.9 \times 10^{-3}$ M

pH = 2.41

40 **Answer (A)**

$Ka = [H^+]^2 / C = (6.557 \times 10^{-5})^2 / 0.01 = 4.3 \times 10^{-7}$

$Kb = Kw / Ka = 2.3 \times 10^{-8}$

41 **Answer (C)**

The pH of pure water = 7

$[H^+]$ = 0.01 M, so the pH becomes 2

The change = 7 − 2 = 5

42 **Answer (B)**

pH = 14 − 10 = 4

$[H^+] = 10^{-4}$ M

Number of moles in 1 mL = $10^{-4} \times 10^{-3} = 10^{-7}$ mol

Number of ions = $10^{-7} \times 6.02 \times 10^{23} = 6.02 \times 10^{16}$ ion

43 **Answer (C)**

Distillation separates pure water (B) from the solution.

The pH of pure water is less than the pH of the NaOH solution.

As water is lost from (A), its concentration increases.

44 **Answer (A)**

MnS : $Ksp = s^2 = (4.8 \times 10^{-7})^2 = 2.3 \times 10^{-13}$

45 **Answer (A)**

Ag_2SO_4 : $Ksp = 4\ s^3$

$= 4 \times (1.4 \times 10^{-2})^3 = 1.0976 \times 10^{-5}$

46 **Answer (B)**

$[PO_4^{3-}] = 2s$, so $s = 1.65 \times 10^{-7}$ M

$Ca_3(PO_4)_2$: $Ksp = 108\ s^5 = 1.32 \times 10^{-32}$

47 **Answer (B)**

$Zn_3(PO_4)_2 \rightleftharpoons 3Zn^{2+} + 2PO_4^{3-}$

$Ksp = [Zn^{2+}]^3 [PO_4^{3-}]^2$

48 **Answer (A)**

$Cu(IO_3)_2$: $Ksp = 4\ s^3$

$= 4 \times (3.3 \times 10^{-3})^3 = 1.4 \times 10^{-7}$

49 **Answer (A)**

BaC_2O_4 : $Ksp = s^2$

$= (4.8 \times 10^{-4})^2 = 2.3 \times 10^{-7}$

50 **Answer (B)**

$[F^-] = 2 \times 3.6 \times 10^{-3} = 7.2 \times 10^{-3}$ M

$Ksp = [Ba^{2+}][F^-]^2 = 3.6 \times 10^{-3} \times (7.2 \times 10^{-3})^2 = 1.86 \times 10^{-7}$

51 **Answer (A)**

XY : $Ksp = s^2$

$s = \sqrt{(1.8 \times 10^{-10})} = 13.4 \times 10^{-6}$ M

52 **Answer (D)**

$AgBrO_3$: $s = \sqrt{Ksp}$

$= \sqrt{(5.5 \times 10^{-5})} = 7.4 \times 10^{-3}$ M

53 **Answer (D)**

SrF_2 : $Ksp = 4\ s^3$

$s = \sqrt[3]{(4.3 \times 10^{-9} / 4)} = 1 \times 10^{-3}$ M

54 **Answer (C)**

A_2B_3 : $Ksp = 108\ s^5$

$s = \sqrt[5]{(1.08 \times 10^{-23} / 108)} = 1 \times 10^{-5}$ M

55 **Answer (B)**

The lowest Ksp gives the lowest concentration of S^{2-}

The lowest value is CuS

56 **Answer (B)**

$Mg(OH)_2$: $Ksp = 4\ s^3$

$s = \sqrt[3]{(5.6 \times 10^{-12} / 4)} = 1.1 \times 10^{-4}$ M

$[OH^-] = 2\ s = 2.2 \times 10^{-4}$ M

57 **Answer (C)**

mol in 100 mL = $0.0155 / 241 = 6.43 \times 10^{-5}$ mol

$[Pb^{2+}] = 6.43 \times 10^{-4}$ M

$[OH^-] = 2 \times 6.43 \times 10^{-4} = 1.29 \times 10^{-3}$ M

58 **Answer (B)**

$[H^+] = 10^{-10.45} = 3.548 \times 10^{-11}$ M

$[OH^-] = 2.82 \times 10^{-4}$ M

$[Mg^{2+}] = 1.41 \times 10^{-4}$ M

$Ksp = 1.41 \times 10^{-4} \times (2.82 \times 10^{-4})^2 = 1.12 \times 10^{-11}$

59 **Answer (A)**

mol $Ag^+ = 0.025 \times 0.15 = 3.75 \times 10^{-3}$, so $[Ag^+] = 0.094$ M

mol $Cl^- = 0.015 \times 0.2 = 3 \times 10^{-3}$, so $[Cl^-] = 0.075$ M

The ionic product = 7×10^{-3}, which is greater than Ksp, so a precipitate forms.

60 **Answer (D)**

$S = mol / V = 1.2 \times 10^{-3} / 0.2 = 6 \times 10^{-3}$ M

61 **Answer (A)**

$Ksp = [Ag^+]^2 [CO_3^{2-}]$

$[CO_3^{2-}] = 8.5 \times 10^{-12} / (1.3 \times 10^{-4})^2 = 5 \times 10^{-4}$ M

62 **Answer (A)**

$S(CuS) = \sqrt{(6 \times 10^{-37})} = 7.7 \times 10^{-19}$

$S(Bi_2S_3) = 1.13 \times 10^{-16}$

$S(AgBr) = 7.3 \times 10^{-7}$

63 **Answer (A)**

Adding Na_2SO_4 increases $[SO_4^{2-}]$ (common ion).

The backward direction is favoured, so $[Ba^{2+}]$ decreases.

Essay questions

1 **Model answer**

pH = 7

Explanation: the mixture is neutral because the number of moles of H^+ from sulphuric acid equals the number of moles of OH^- from the sodium hydroxide and potassium hydroxide solutions.

2 **Model answer**

(1) $H_3PO_4(aq) \rightleftharpoons H^+(aq) + H_2PO_4^-(aq)$

$Ka = [H^+][H_2PO_4^-] / [H_3PO_4]$

(2) $Ka = 6.9 \times 10^{-3}$, because phosphoric acid is a weak acid that does not ionize completely, so the product of the concentrations of the ions formed is less than the concentration of the non-ionized acid molecules.

3 **Model answer**

$H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$

$NaOH(aq) \rightarrow Na^+(aq) + OH^-(aq)$

(1) The concentration of H_3O^+ ions decreases because the concentration of OH^- ions increases.

(2) The pH increases because the concentration of OH^- ions increases.

4 **Model answer**

The greater the Kb, the stronger the base and the higher the pH of its solution.

Ascending order of pH: A < C < B

5 **Model answer**

Type of solution (X): acidic

Because the pH of the solution = $-\log (2 \times 10^{-3}) = 2.69$ (less than 7).

6 **Model answer**

(1) NaOH solution (or any strong base), because bromothymol blue gives a green colour with the neutral solution formed by titrating the strong acid HCl with any strong base.

(2) pOH = 7

7 **Model answer**

HCl: strong acid , H_3BO_3: weak acid , NH_4OH: weak base , NaOH: strong base.

Ascending order of pH: $HCl < H_3BO_3 < NH_4OH < NaOH$

8 **Model answer**

The concentration of the acid.

The strength of the acid.

The number of moles of H^+ in one mole of the acid.

(Any two of these factors.)

9 **Model answer**

(1) Acid (D), because its pH is greater than 0 and a little below 7, so the $[H^+]$ in its aqueous solution is low.

(2) Solution (G), because it is a stronger acid than (B), and solution (F) is a weak base.

10 **Model answer**

Axis (X) represents pOH, because an increase in $[H^+]$ is followed by a decrease in pH, and therefore an increase in pOH of the same solution.

11 **Model answer**

$[H^+] = 10^{-pH} = 10^{-3}$ M

Number of moles of H^+ in 100 mL of the acid = $(100 / 1000) \times 10^{-3} = 1 \times 10^{-4}$ mol

Volume of the acid after adding water = 100 + 100 = 200 mL

$[H^+]$ after dilution = $10^{-4} / 0.2 = 5 \times 10^{-4}$ M

pH = $-\log (5 \times 10^{-4}) = 3.3$

12 **Model answer**

$[H_3O^+] = \sqrt{(Ca \times Ka)} = \sqrt{(0.2 \times 6.5 \times 10^{-5})} = 0.0036$ M

$[H^+][OH^-] = 1 \times 10^{-14}$

$[OH^-] = (1 \times 10^{-14}) / 0.0036 = 2.78 \times 10^{-12}$ M

pOH = $-\log (2.78 \times 10^{-12}) = 11.56$

13 **Model answer**

(1) Solution (E), because its pH is the highest.

(2) Solution (C), because it is a neutral solution with a pH of 7

14 **Model answer**

(1) CH_3COOK

(2) CoS

15 **Model answer**

$AgCl(s) \rightleftharpoons Ag^+(aq) + Cl^-(aq)$

$Ksp = [Ag^+][Cl^-] = [Ag^+]^2$

$[Ag^+] = \sqrt{Ksp} = \sqrt{(1.8 \times 10^{-10})} = 1.3 \times 10^{-5}$ M

$Ag_2CO_3(s) \rightleftharpoons 2Ag^+(aq) + CO_3^{2-}(aq)$

$Ksp = [Ag^+]^2 [CO_3^{2-}]$

$8.5 \times 10^{-12} = (2x)^2 (x) = 4x^3$

$x = \sqrt[3]{(8.5 \times 10^{-12} / 4)} = 1.3 \times 10^{-4}$ M

$[Ag^+] = 2 \times 1.3 \times 10^{-4} = 2.6 \times 10^{-4}$ M

So $[Ag^+]$ in the saturated solution of Ag_2CO_3 is greater than in the saturated solution of AgCl

16 **Model answer**

(1) Solution (C)

(2) Solution (A)

(3) $Ka = 6.7 \times 10^{-4}$ (because Ka is constant for the same acid at the same temperature)

(4) Solution (B)

17 **Model answer**

$pOH = 14 - pH = 14 - 8 = 6$

$[OH^-] = 10^{-pOH} = 1 \times 10^{-6}$ M

$Y(OH)_2(s) \rightleftharpoons Y^{2+}(aq) + 2OH^-(aq)$

$[OH^-] = 2x = 1 \times 10^{-6}$, so $x = 5 \times 10^{-7}$ M

$Ksp = [Y^{2+}][OH^-]^2 = (x)(2x)^2 = 4x^3 = 4 \times (5 \times 10^{-7})^3 = 5 \times 10^{-19}$

Past exam questions

1	2	3	4	5	6	7	8	9	10
A	B	C	A	C	C	B	B	B	B
11	12	13	14	15	16	17	18	19	20
C	B	B	B	C	A	A	C	D	D
21	22	23	24	25	26	27	28	29	30
D	B	A	C	A	D	B	A	B	B
31	32	33	34	35	36	37	38	39	40
B	C	B	A	B	A	A	B	B	B
41	42	43	44	45	46	47	48	49	50
A	B	A	C	C	D	D	A	D	A

51	52	53	54	55	56	57	58	59	60
A	C	D	B	A	D	D	C	A	D
61	62	63	64	65	66	67	68	69	70
D	A	C	A	B	D	B	B	D	A
71									
A									

1 **Answer (A)**

$C = 0.2 \times 50 / 500 = 0.02$ M

$\alpha = \sqrt{(Kb / C)} = \sqrt{(1.8 \times 10^{-5} / 0.02)} = 0.03$

2 **Answer (B)**

HCl consumes CO_3^{2-}, so more of the precipitate dissolves in (A).

$CaCl_2$ increases Ca^{2+} (common ion), so the precipitate increases in (B).

3 **Answer (C)**

A decrease in pOH means an increase in $[OH^-]$.

So solution (X) is a base, and a base whose pH is 8 lowers the pOH of water.

4 **Answer (A)**

s at 25°C $= \sqrt{(10^{-21})} = 3.16 \times 10^{-11}$ M

Precipitate $= 1.53 \times 10^{-5} / 97 / 5 = 3.16 \times 10^{-8}$ M

s at 60°C $\approx 3.16 \times 10^{-8}$ M

Ksp $= s^2 = 1 \times 10^{-15}$

5 **Answer (C)**

HCl increases $[H_3O^+]$, so the backward direction is favoured.

So the degree of dissociation of the acid decreases.

6 **Answer (C)**

pH = 9, which is greater than 7

So it is a solution of a base.

7 **Answer (B)**

$S = 2 \times 10^{-4} / 0.05 = 4 \times 10^{-3}$ M

$Mg(OH)_2$: Ksp $= 4\ s^3 = 2.56 \times 10^{-7} \approx 2.5 \times 10^{-7}$

8 **Answer (B)**

9 **Answer (B)**

NaOH consumes H^+, so the forward direction is favoured.

The dissociation of the acid increases and the pH increases.

10 **Answer (B)**

$\alpha = \sqrt{(Kb / C)} = \sqrt{(1.8 \times 10^{-5} / 0.1)} = 0.0134$

$[OH^-] = 0.1 \times 0.0134 = 1.34 \times 10^{-3}$ M

pOH = 2.87

pH = 14 − 2.87 = 11.13

11 **Answer (C)**

Strongly heating the hydrate drives the water vapour out of the open container.

So the system does not reach equilibrium.

12 **Answer (B)**

Diluting the weak acid lowers $[H^+]$, so the pH increases.

Diluting the weak base lowers $[OH^-]$, so the pH decreases.

13 **Answer (B)**

pOH = 14 − 12 = 2

$[OH^-] = 0.01$ M

mol = 0.01 × 0.5 = 0.005 mol

Mass = 0.005 × 40 = 0.2 g

14 **Answer (B)**

PbI_2 : s = 10^{-4} and the total ions = 3×10^{-4}

AgBr : s = 10^{-4} and the total ions = 2×10^{-4}

BiI_3 : s = 10^{-4} and the total ions = 4×10^{-4}

AgCl : s = 10^{-5} and the total ions = 2×10^{-5}

Conductivity increases as the concentration of ions increases: 4 > 2 > 3 > 1

15 **Answer (C)**

HA : Ka = $(10^{-3})^2 / 0.1 = 10^{-5}$

HB : Ka = $(10^{-3})^2 / 0.01 = 10^{-4}$

So the Ka of HB is greater.

16 **Answer (A)**

NaOH has the lowest $[H_3O^+]$, then NH_4OH.

Then CH_3COOH, and the highest is HCl.

17 **Answer (A)**

Ksp = $4\ s^3$, so s = $\sqrt[3]{(1.2 \times 10^{-5} / 4)} = 0.0144$ M

Solubility = $0.0144 \times 278 = 4$ g/L

Volume = $0.1 / 4 = 0.025$ L = 25 mL

18 **Answer (C)**

$PbCl_2 \rightleftharpoons Pb^{2+} + 2Cl^-$

Lead(II) acetate adds Pb^{2+} (common ion).

So the solubility of $PbCl_2$ decreases

19 **Answer (D)**

The decomposition of H_2O_2 is irreversible because O_2 gas escapes.

So it does not represent an equilibrium system.

20 **Answer (D)**

The lower the pH, the stronger the acid and the greater its Ka.

pH : A = 1 , C = 3 , B = 6, so the order is A > C > B

21 **Answer (D)**

Ka is constant and does not change on dilution.

So it is not correct that the Ka of solution (X) is higher than that of (Y).

22 **Answer (B)**

S = 4.4×10^{-5} mol / 0.1 L = 4.4×10^{-4} M

Ksp = $s^2 = 1.9 \times 10^{-7}$

23 **Answer (A)**

$[H^+] = 10^{-4.7} = 2 \times 10^{-5}$ M

C = $[H^+]^2 / Ka = (2 \times 10^{-5})^2 / 6.2 \times 10^{-10} = 0.645$ M

mol = $0.645 \times 0.3 = 0.19$ mol

24 **Answer (C)**

On heating, Kw increases, so $[H^+]$ and $[OH^-]$ increase equally.

pH and pOH decrease and the water stays neutral.

25 **Answer (A)**

Ksp = 108 s^5 for a salt X_2Y_3

$108 \times (10^{-4})^5 = 1.08 \times 10^{-18}$

26 **Answer (D)**

The Ka of acid (Y) is greater, so it is stronger.

It conducts electricity better and its pH is lower.

27 **Answer (B)**

$s = \sqrt{(1.6 \times 10^{-10})} = 1.26 \times 10^{-5}$ M

Total ions = $2 \times 1.26 \times 10^{-5} = 2.53 \times 10^{-5}$ M

28 **Answer (A)**

pOH = 14 − 12.3 = 1.7, so $[OH^-] = 0.02$ M

$[Ba(OH)_2] = 0.01$ M

mol = 0.01 × 1.5 = 0.015 mol

Mass = 0.015 × 171 = 2.56 g

29 **Answer (B)**

30 **Answer (B)**

$\alpha = \sqrt{(Ka / C)}$

When the volume doubles, C is halved, so α becomes 1.414 α

And the pH increases because $[H^+]$ decreases.

31 **Answer (B)**

$s = \sqrt{(1.6 \times 10^{-10})} = 1.26 \times 10^{-5}$ M

Mass = $1.26 \times 10^{-5} \times 143.5 \times 0.05 = 0.905 \times 10^{-4}$ g

32 **Answer (C)**

$[H^+] = C\,\alpha = 0.2 \times 0.0003 = 6 \times 10^{-5}$ M

pH = 4.22

pOH = 14 − 4.22 = 9.78

33 **Answer (B)**

Ionized = 0.1 − 0.0933 = 0.0067 mol

α = 0.0067 / 0.1 = 0.067

$Ka = C\,\alpha^2 = 0.1 \times (0.067)^2 = 4.5 \times 10^{-4}$

34 **Answer (A)**

NaOH consumes H_3O^+, so the forward direction is favoured.

The dissociation of the acid increases and the pH increases.

35 **Answer (B)**

X_2Y : Ksp = $4\ s^3$

$s = \sqrt[3]{(8.75 \times 10^{-11} / 4)} = 2.8 \times 10^{-4}$ M

Mass = $2.8 \times 10^{-4} \times 248 \times 0.1 = 0.007$ g

36 **Answer (A)**

Ionic equilibrium is specific to weak electrolytes.

CH_3COOH and H_2CO_3 are weak, while HNO_3 and HCl are strong.

37 **Answer (A)**

Na_2CO_3 is a basic salt, so its pH is greater than 7

KCl is neutral and its pH is 7

So the result is greater than one.

38 **Answer (B)**

Adding an acid increases $[H^+]$, so the pH decreases and the pOH increases

Kw is constant; it changes only with temperature.

39 **Answer (B)**

pOH = 4, so $[OH^-] = 10^{-4}$ M

$s = 5 \times 10^{-5}$ M

Ksp = $4\ s^3 = 5 \times 10^{-13}$

40 **Answer (B)**

Ka is constant at constant temperature.

HCl increases $[H_3O^+]$, so the backward direction is favoured and $[CN^-]$ decreases

41 **Answer (A)**

Sulphurous acid is a weak diprotic acid.

Its solution contains H_2SO_3, HSO_3^-, SO_3^{2-}, H_3O^+ and OH^-

42 **Answer (B)**

HCl is a strong acid that ionizes completely.

So the law of mass action is not applied to it.

43 **Answer (A)**

Diluting the weak acid increases its degree of ionization.

The strong acid is completely ionized, so α is not affected.

44 **Answer (C)**

Diluting a weak electrolyte lowers the concentration.

And the degree of ionization increases.

45 **Answer (C)**

A greater Ka means a stronger acid: D > A > B > C

So acid (D) is stronger than (C) and (B)

46 **Answer (D)**

mol = 7.258 / 27 = 0.2688 mol

C = 2.688 M

$\alpha = \sqrt{(Ka / C)} = \sqrt{(7.2 \times 10^{-10} / 2.688)} = 1.63 \times 10^{-5}$

47 **Answer (D)**

$[H^+] = \sqrt{(Ka \times C)} = \sqrt{(5.1 \times 10^{-4} \times 0.2)} = 0.0101$ M

Number of dissociated moles = $0.0101 \times 0.2 = 2.02 \times 10^{-3}$ mol

48 **Answer (A)**

Ka changes only with temperature.

Adding HCl does not change it.

49 **Answer (D)**

$[H^+] = [OH^-] = \sqrt{(0.49 \times 10^{-13})} = 2.2 \times 10^{-7}$ M

pOH = 6.65

50 **Answer (A)**

Solution (A) is a weak base (pH = 8.2)

On dilution its degree of ionization increases and $[OH^-]$ decreases, so the pH decreases

51 **Answer (A)**

pOH = 11, so pH = 3 (an acidic solution).

Phenolphthalein is colourless in acid.

Methyl orange is red in acid.

52 **Answer (C)**

Sodium carbonate is a basic salt and its solution has a pH greater than 7

KCl is neutral with a pH of 7

So the pH of the KCl solution is lower.

53 **Answer (D)**

Hydrolysis gives a basic product: the cation of a strong base with the anion of a weak acid.

That is K^+ with CO_3^{2-}

54 **Answer (B)**

$\alpha = 0.002 / 0.2 = 0.01$

$[H^+] = Ka / \alpha = 3.5 \times 10^{-8} / 0.01 = 3.5 \times 10^{-6}$ M

pH = 5.455

55 **Answer (A)**

mol = 11 / 116 = 0.0948 mol

C = 0.0948 M

$[H^+] = 10^{-2.94} = 1.148 \times 10^{-3}$ M

$Ka = (1.148 \times 10^{-3})^2 / 0.0948 = 1.39 \times 10^{-5}$

56 **Answer (D)**

$[OH^-] = 10^{-5}$ M because pH = 9

$Kb = [OH^-]^2 / C = 10^{-10} / 0.4 = 2.5 \times 10^{-10}$

57 **Answer (D)**

58 **Answer (C)**

pOH = 14 – 3.7 = 10.3

$[OH^-] = 10^{-10.3} = 5.01 \times 10^{-11}$ M

59 **Answer (A)**

Adding the water increases the volume 2.5 times.

$[OH^-] = 0.01 / 2.5 = 0.004$ M

pOH = 2.4 and pH = 11.6

60 **Answer (D)**

Zn replaces the hydrogen of the acid and the gas escapes.

So the reaction is irreversible.

61 **Answer (D)**

HCl increases $[Cl^-]$ (common ion).

The backward direction is favoured, so $[Ag^+]$ decreases and the amount of AgCl increases

62 **Answer (A)**

$AgNO_3$, NaCl and HCl add a common ion, so the solubility decreases.

NH_4OH forms a complex ion with Ag^+, so the solubility increases.

63 **Answer (C)**

Lead acetate gives Pb^{2+}, which precipitates Cl^- as $PbCl_2$

So $[Cl^-]$ decreases and the rate of the forward reaction increases.

64 **Answer (A)**

The two ions of $PbBr_2$ are Pb^{2+} and Br^-

$Pb(NO_3)_2$ adds Pb^{2+} and NaBr adds Br^-, so the solubility decreases.

65 **Answer (B)**

Ag_2CrO_4 : $Ksp = 4\ s^3$

$= 4 \times (6.62 \times 10^{-5})^3 = 1.16 \times 10^{-12}$

66 **Answer (D)**

$Pb(OH)_2$: $Ksp = 4\ s^3$

$s = \sqrt[3]{(2.5 \times 10^{-6} / 4)} = 8.54 \times 10^{-3}$ M

67 **Answer (B)**

XY_2 : $Ksp = 4\ s^3$

$s = \sqrt[3]{(1.6 \times 10^{-10} / 4)} = 3.42 \times 10^{-4}$ M

$[Y^-] = 2\ s = 6.84 \times 10^{-4}$ M

68 **Answer (B)**

$s = 3.42 \times 10^{-4}$ M

$mol = 3.42 \times 10^{-4} \times 2 = 6.84 \times 10^{-4}$ mol

69 **Answer (D)**

$s = \sqrt{(10^{-21})} = 3.16 \times 10^{-11}$ M

Mass dissolved in 0.1 L $= 3.16 \times 10^{-11} \times 0.1 \times 97 = 3.07 \times 10^{-10}$ g

70 **Answer (A)**

$s = \sqrt{(2.56 \times 10^{-6})} = 1.6 \times 10^{-3}$ M

Mass $= 1.6 \times 10^{-3} \times 143.5 \times 0.1 = 0.023$ g

71 **Answer (A)**

s at 60°C $= \sqrt{(10^{-15})} = 3.16 \times 10^{-8}$ M

s at 25°C $= 3.16 \times 10^{-11}$ M (negligible)

Mass precipitated $= 3.16 \times 10^{-8} \times 5 \times 97 = 1.53 \times 10^{-5}$ g