

Equilibrium — NEET Chemistry PYQ (2005-2021)

Class 11 Chemistry · 59 real NEET & AIPMT questions, year-tagged · answers checked by RankUp

NEET 2021

1. The pK_b of dimethylamine and pK_a of acetic acid are 3.27 and 4.77 respectively at T (K). The correct option for the pH of dimethylammonium acetate solution is :

- (A) 8.50
- (B) 5.50
- (C) 7.75
- (D) 6.25

NEET 2021

2. Statement I : Acid strength increases in the order given as $HF \ll HCl \ll HBr \ll HI$.

Statement II : As the size of the elements F, Cl, Br, I increases down the group, the bond strength of HF, HCl, HBr and HI decreases and so the acid strength increases. In the light of the above statements, choose the correct answer from the options given below.

- (A) Both Statement I and Statement II are true.
- (B) Both Statement I and Statement II are false.
- (C) Statement I is correct but Statement II is false.
- (D) Statement I is incorrect but Statement II is true.

NEET 2020 · Q92

3. Find out the solubility of $Ni(OH)_2$ in 0.1 M NaOH. Given that the ionic product of $Ni(OH)_2$ is 2×10^{-15} .

- (A) 2×10^{-13} M
- (B) 2×10^{-8} M
- (C) 1×10^{-13} M
- (D) 1×10^8 M

NEET 2019 · Q62

4. pH of a saturated solution of $Ca(OH)_2$ is 9. The solubility product (K_{sp}) of $Ca(OH)_2$ is:

- (A) 0.5×10^{-15}
- (B) 0.25×10^{-10}
- (C) 0.125×10^{-15}
- (D) 0.5×10^{-10}

NEET 2019 · Q71

5. Conjugate base for Brønsted acids H_2O and HF are:

- (A) OH^- and H_2F^+ , respectively
- (B) H_3O^+ and F^- , respectively
- (C) OH^- and F^- , respectively
- (D) H_3O^+ and H_2F^+ , respectively

NEET 2019 · Q77

6. Which will make basic buffer?

- (A) 50 mL of 0.1 M NaOH + 25 mL of 0.1 M CH_3COOH
- (B) 100 mL of 0.1 M CH_3COOH + 100 mL of 0.1 M NaOH
- (C) 100 mL of 0.1 M HCl + 200 mL of 0.1 M NH_4OH
- (D) 100 mL of 0.1 M HCl + 100 mL of 0.1 M NaOH

NEET 2018 · Q74

7. Following solutions were prepared by mixing different volumes of NaOH and HCl of different concentrations: a. 60 mL M/10 HCl + 40 mL M/10 NaOH b. 55 mL M/10 HCl + 45 mL M/10 NaOH c. 75 mL M/5 HCl + 25 mL M/5 NaOH d. 100 mL M/10 HCl + 100 mL M/10 NaOH. pH of which one of them will be equal to 1?

- (A) d
- (B) a
- (C) b
- (D) c

NEET 2018 · Q77

8. The solubility of BaSO_4 in water is $2.42 \times 10^{-3} \text{ g L}^{-1}$ at 298 K. The value of its solubility product (K_{sp}) will be (Given molar mass of $\text{BaSO}_4 = 233 \text{ g mol}^{-1}$)

- (A) $1.08 \times 10^{-14} \text{ mol}^2 \text{ L}^{-2}$
- (B) $1.08 \times 10^{-12} \text{ mol}^2 \text{ L}^{-2}$
- (C) $1.08 \times 10^{-10} \text{ mol}^2 \text{ L}^{-2}$
- (D) $1.08 \times 10^{-8} \text{ mol}^2 \text{ L}^{-2}$

NEET 2018 · Q83

9. Which one of the following conditions will favour maximum formation of the product in the reaction, $\text{A}_2(\text{g}) + \text{B}_2(\text{g}) \rightleftharpoons \text{X}_2(\text{g})$ $\Delta_r H = -X \text{ kJ}$?

- (A) High temperature and high pressure
- (B) Low temperature and low pressure
- (C) Low temperature and high pressure
- (D) High temperature and low pressure

NEET 2017 · Q27

10. The equilibrium constants of the following are: $\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$ K_1 ; $\text{N}_2 + \text{O}_2 \rightleftharpoons 2\text{NO}$ K_2 ; $\text{H}_2 + \frac{1}{2}\text{O}_2 \rightarrow \text{H}_2\text{O}$ K_3 . The equilibrium constant (K) of the reaction: $2\text{NH}_3 + \frac{5}{2}\text{O}_2 \rightleftharpoons 2\text{NO} + 3\text{H}_2\text{O}$, will be:

- (A) $K_1 K_3^3 / K_2$
- (B) $K_2 K_3^3 / K_1$
- (C) $K_2 K_3 / K_1$
- (D) $K_2^3 K_3 / K_1$

NEET 2017 · Q41

11. Concentration of the Ag^+ ions in a saturated solution of $\text{Ag}_2\text{C}_2\text{O}_4$ is $2.2 \times 10^{-4} \text{ mol L}^{-1}$. Solubility product of $\text{Ag}_2\text{C}_2\text{O}_4$ is:

- (A) 2.42×10^{-8}
- (B) 2.66×10^{-12}
- (C) 4.5×10^{-11}
- (D) 5.3×10^{-12}

NEET 2017 · Q43

12. Which one of the following statements is not correct?

- (A) Catalyst does not initiate any reaction.
- (B) The value of equilibrium constant is changed in the presence of a catalyst in the reaction at equilibrium.
- (C) Enzymes catalyse mainly bio-chemical reactions.
- (D) Coenzymes increase the catalytic activity of enzyme.

NEET 2017 (Gujarati paper) · Q32

13. The standard equilibrium constant, K_p at 298 K for the reaction, $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$ is 5.8×10^5 . The value of standard equilibrium constant, if the concentration of gases is expressed in terms of mol/L, will be: [Given: $R = 0.08314 \text{ L bar K}^{-1} \text{ mol}^{-1}$]

- (A) 3.51×10^6
- (B) 3.84×10^7
- (C) 3.56×10^8
- (D) 3.99×10^9

NEET 2017 (Gujarati paper) · Q38

14. Consider the following reaction for which the change in enthalpy is positive. $2A(g) + B(g) \rightleftharpoons C(g) + D(g)$. Which of the following will not affect the equilibrium?

- (A) Change in concentration of reactants
- (B) Change in pressure
- (C) Change in temperature
- (D) Presence of catalyst

NEET 2017 (Gujarati paper) · Q41

15. For the reaction $CO(g) + Cl_2(g) \rightleftharpoons COCl_2(g)$, K_p/K_c is equal to:

- (A) $1/RT$
- (B) RT
- (C) $\sqrt{RT}$
- (D) $(RT)^2$

NEET 2016 Phase 2 · Q54

16. The percentage of pyridine (C_5H_5N) that forms pyridinium ion ($C_5H_5N^+H$) in a 0.10 M aqueous pyridine solution (K_b for $C_5H_5N = 1.7 \times 10^{-9}$) is

- (A) 0.0060%
- (B) 0.013%
- (C) 0.77%
- (D) 1.6%

NEET 2016 Phase 2 · Q58

17. The solubility of $AgCl(s)$ with solubility product 1.6×10^{-10} in 0.1 M NaCl solution would be

- (A) 1.26×10^{-5} M
- (B) 1.6×10^{-9} M
- (C) 1.6×10^{-11} M
- (D) zero

NEET 2016 Phase 1 · Q55

18. MY and NY_3 , two nearly insoluble salts, have the same K_{sp} values of 6.2×10^{-13} at room temperature. Which statement would be true in regard to MY and NY_3 ?

- (A) The molar solubilities of MY and NY_3 in water are identical.
- (B) The molar solubility of MY in water is less than that of NY_3 .
- (C) The salts MY and NY_3 are more soluble in 0.5 M KY than in pure water.
- (D) The addition of the salt of KY to solution of MY and NY_3 will have no effect on their solubilities.

NEET 2016 Phase 1 · Q72

19. Consider the following liquid - vapour equilibrium.

Liquid $\rightleftharpoons$ Vapour

Which of the following relations is correct?

- (A) $d \ln G/dT^2 = \Delta H_v/RT^2$
- (B) $d \ln P/dT = -\Delta H_v/RT$
- (C) $d \ln P/dT^2 = -\Delta H_v/T^2$
- (D) $d \ln P/dT = \Delta H_v/RT^2$

AIPMT 2015

20. Which of the following statements is correct for a reversible process in a state of equilibrium?

- (A) $\Delta G^\circ = 2.30 RT \log K$
- (B) $\Delta G = -2.30 RT \log K$
- (C) $\Delta G = 2.30 RT \log K$
- (D) $\Delta G^\circ = -2.30 RT \log K$

AIPMT 2015

21. The K_{sp} of Ag_2CrO_4 , $AgCl$, $AgBr$ and AgI are respectively, 1.1×10^{-12} , 1.8×10^{-10} , 5.0×10^{-13} , 8.3×10^{-17} . Which one of the following salts will precipitate last if $AgNO_3$ solution is added to the solution containing equal moles of $NaCl$, $NaBr$, NaI and Na_2CrO_4 ?

- (A) Ag_2CrO_4
- (B) AgI
- (C) $AgCl$
- (D) $AgBr$

AIPMT 2015

22. If the value of an equilibrium constant for a particular reaction is 1.6×10^{12} , then at equilibrium the system will contain:

- (A) similar amounts of reactants and products
- (B) all reactants
- (C) mostly reactants
- (D) mostly products

AIPMT 2014

23. Which of the following salts will give highest pH in water?

- (A) $NaCl$
- (B) Na_2CO_3
- (C) $CuSO_4$
- (D) KCl

AIPMT 2014

24. Using the Gibbs energy change, $\Delta G^\circ = +63.3$ kJ, for the following reaction, $Ag_2CO_3(s) \rightleftharpoons 2Ag^+(aq) + CO_3^{2-}(aq)$, the K_{sp} of $Ag_2CO_3(s)$ in water at $25^\circ C$ is: ($R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$)

- (A) 8.0×10^{-12}
- (B) 2.9×10^{-3}
- (C) 7.9×10^{-2}
- (D) 3.2×10^{-26}

AIPMT 2014

25. For the reversible reaction: $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) + \text{heat}$. The equilibrium shifts in forward direction:

- (A) by decreasing the pressure
- (B) by decreasing the concentrations of $N_2(g)$ and $H_2(g)$
- (C) by increasing pressure and decreasing temperature
- (D) by increasing the concentration of $NH_3(g)$

NEET 2013

26. Identify the correct order of solubility in aqueous medium

- (A) $CuS > ZnS > Na_2S$
- (B) $ZnS > Na_2S > CuS$
- (C) $Na_2S > CuS > ZnS$
- (D) $Na_2S > ZnS > CuS$

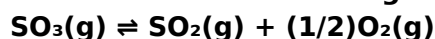
NEET 2013

27. Which of these is least likely to act as a Lewis base ?

- (A) CO
- (B) F^-
- (C) BF_3
- (D) PF_3

AIPMT 2012 Mains

28. Given that the equilibrium constant for the reaction $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$ has a value of 278 at a particular temperature. What is the value of the equilibrium constant for the following reaction at the same temperature?



- (A) 1.8×10^{-3}
- (B) 3.6×10^{-3}
- (C) 6.0×10^{-2}
- (D) 1.3×10^{-5}

AIPMT 2012 Mains

29. Given the reaction between 2 gases represented by A_2 and B_2 to give the compound $\text{AB}(\text{g})$: $\text{A}_2(\text{g}) + \text{B}_2(\text{g}) \rightleftharpoons 2\text{AB}(\text{g})$. At equilibrium, the concentration of $\text{A}_2 = 3.0 \times 10^{-3} \text{ M}$, of $\text{B}_2 = 4.2 \times 10^{-3} \text{ M}$ and of $\text{AB} = 2.8 \times 10^{-3} \text{ M}$. If the reaction takes place in a sealed vessel at 527°C , then the value of K_c will be

- (A) 2.0
- (B) 1.9
- (C) 0.62
- (D) 4.5

AIPMT 2012 Prelims

30. Equimolar solutions of the following substances were prepared separately. Which one of these will record the highest pH value?

- (A) BeCl_2
- (B) BaCl_2
- (C) AlCl_3
- (D) LiCl

AIPMT 2012 Prelims

31. Buffer solutions have constant acidity and alkalinity because:

- (A) they have fixed value of pH
- (B) these give unionised acid or base on reaction with added acid or alkali
- (C) acids and alkalies in these solutions are shielded from attack by other ions
- (D) they have large excess of H^+ or OH^- ions

AIPMT 2012 Prelims

32. pH of a saturated solution of $\text{Ba}(\text{OH})_2$ is 12. The value of solubility product (K_{sp}) of $\text{Ba}(\text{OH})_2$ is

- (A) 5.0×10^{-6}
- (B) 3.3×10^{-7}
- (C) 5.0×10^{-7}
- (D) 4.0×10^{-6}

AIPMT 2011 Mains

33. In qualitative analysis, the metals of group I can be separated from other ions by precipitating them as chloride salts. A solution initially contains Ag^+ and Pb^{2+} at a concentration of 0.10 M. Aqueous HCl is added to this solution until the Cl^- concentration is 0.10 M. What will the concentrations of Ag^+ and Pb^{2+} be at equilibrium? (K_{sp} for $\text{AgCl} = 1.8 \times 10^{-10}$, K_{sp} for $\text{PbCl}_2 = 1.7 \times 10^{-5}$)

- (A) $[\text{Ag}^+] = 1.8 \times 10^{-9} \text{ M}$, $[\text{Pb}^{2+}] = 1.7 \times 10^{-3} \text{ M}$
- (B) $[\text{Ag}^+] = 1.8 \times 10^{-11} \text{ M}$, $[\text{Pb}^{2+}] = 1.7 \times 10^{-4} \text{ M}$
- (C) $[\text{Ag}^+] = 1.8 \times 10^{-7} \text{ M}$, $[\text{Pb}^{2+}] = 1.7 \times 10^{-6} \text{ M}$
- (D) $[\text{Ag}^+] = 1.8 \times 10^{-11} \text{ M}$, $[\text{Pb}^{2+}] = 8.5 \times 10^{-5} \text{ M}$

AIPMT 2011 Prelims

34. A buffer solution is prepared in which the concentration of NH_3 is 0.30 M and the concentration of NH_4^+ is 0.20 M. If the equilibrium constant, K_b for NH_3 equals 1.8×10^{-5} , what is the pH of this solution?

- (A) 8.73
- (B) 9.08
- (C) 9.43
- (D) 11.72

AIPMT 2011 Prelims

35. For the reaction $\text{N}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{NO}(\text{g})$, the equilibrium constant is K_1 . The equilibrium constant is K_2 for the reaction $2\text{NO}(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g})$. What is K for the reaction $\text{NO}_2(\text{g}) \rightleftharpoons (1/2)\text{N}_2(\text{g}) + \text{O}_2(\text{g})$?

- (A) $1/(K_1K_2)$
- (B) $1/(2K_1K_2)$
- (C) $1/(4K_1K_2)$
- (D) $[1/(K_1K_2)]^{(1/2)}$

AIPMT 2011 Prelims

36. The value of ΔH for the reaction $\text{X}_2(\text{g}) + 4\text{Y}_2(\text{g}) \rightleftharpoons 2\text{XY}_4(\text{g})$ is less than zero. Formation of $\text{XY}_4(\text{g})$ will be favoured at

- (A) High pressure and low temperature
- (B) High temperature and high pressure
- (C) Low pressure and low temperature
- (D) High temperature and low pressure

AIPMT 2010 Mains · Q92

37. The reaction $2\text{A}(\text{g}) + \text{B}(\text{g}) \rightleftharpoons 3\text{C}(\text{g}) + \text{D}(\text{g})$ is begun with the concentrations of A and B both at an initial value of 1.00 M. When equilibrium is reached, the concentration of D is measured and found to be 0.25 M. The value for the equilibrium constant for this reaction is given by the expression

- (A) $[(0.75)^3(0.25)] \div [(1.00)^2(1.00)]$
- (B) $[(0.75)^3(0.25)] \div [(0.50)^2(0.75)]$
- (C) $[(0.75)^3(0.25)] \div [(0.50)^2(0.25)]$
- (D) $[(0.75)^3(0.25)] \div [(0.75)^2(0.25)]$

AIPMT 2010 Prelims · Q55

38. In a buffer solution containing equal concentration of B^- and HB , the K_b for B^- is 10^{-10} . The pH of buffer solution is

- (A) 4
- (B) 10
- (C) 7
- (D) 6

AIPMT 2010 Prelims · Q57

39. What is $[\text{H}^+]$ in mol/L of a solution that is 0.20 M in CH_3COONa and 0.10 M in CH_3COOH ? K_a for $\text{CH}_3\text{COOH} = 1.8 \times 10^{-5}$.

- (A) 9.0×10^{-6}
- (B) 3.5×10^{-4}
- (C) 1.1×10^{-5}
- (D) 1.8×10^{-5}

AIPMT 2010 Prelims · Q66

40. In which of the following equilibrium K_c and K_p are not equal?

- (A) $2\text{C}(\text{s}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{CO}(\text{g})$
- (B) $2\text{NO}(\text{g}) \rightleftharpoons \text{N}_2(\text{g}) + \text{O}_2(\text{g})$
- (C) $\text{SO}_2(\text{g}) + \text{NO}_2(\text{g}) \rightleftharpoons \text{SO}_3(\text{g}) + \text{NO}(\text{g})$
- (D) $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2\text{HI}(\text{g})$

41. If pH of a saturated solution of Ba(OH)_2 is 12, the value of its K_{sp} is

- (A) $5.00 \times 10^{-7} \text{ M}^3$
- (B) $4.00 \times 10^{-6} \text{ M}^3$
- (C) $4.00 \times 10^{-7} \text{ M}^3$
- (D) $5.00 \times 10^{-6} \text{ M}^3$

42. Which of the following molecules acts as a Lewis acid?

- (A) $(\text{CH}_3)_2\text{O}$
- (B) $(\text{CH}_3)_3\text{P}$
- (C) $(\text{CH}_3)_3\text{N}$
- (D) $(\text{CH}_3)_3\text{B}$

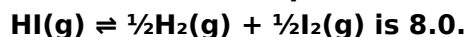
43. The ionization constant of ammonium hydroxide is 1.77×10^{-5} at 298 K. Hydrolysis constant of ammonium chloride is:

- (A) 6.50×10^{-12}
- (B) 5.65×10^{-13}
- (C) 5.65×10^{-12}
- (D) 5.65×10^{-10}

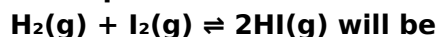
44. What is the $[\text{OH}^-]$ in the final solution prepared by mixing 20.0 mL of 0.050 M HCl with 30.0 mL of 0.10 M Ba(OH)_2 ?

- (A) 0.40 M
- (B) 0.0050 M
- (C) 0.12 M
- (D) 0.10 M

45. The value of equilibrium constant of the reaction



The equilibrium constant of the reaction



- (A) 1/8
- (B) 1/16
- (C) 1/64
- (D) 16

46. Equal volumes of three acid solutions of pH 3, 4 and 5 are mixed in a vessel.

What will be the H^+ ion concentration in the mixture?

- (A) $1.11 \times 10^{-3} \text{ M}$
- (B) $1.11 \times 10^{-4} \text{ M}$
- (C) $3.7 \times 10^{-4} \text{ M}$
- (D) $3.7 \times 10^{-3} \text{ M}$

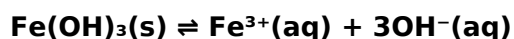
47. The values of K_{p1} and K_{p2} for the reactions



are in ratio of 9 : 1. If degree of dissociation of X and A be equal, then total pressure at equilibrium (1) and (2) are in the ratio

- (A) 1 : 1
- (B) 3 : 1
- (C) 1 : 9
- (D) 36 : 1

48. If the concentration of OH^- ions in the reaction



is decreased by $1/4$ times, then equilibrium concentration of Fe^{3+} will increase by

- (A) 4 times
- (B) 8 times
- (C) 16 times
- (D) 64 times

49. The dissociation equilibrium of a gas AB_2 can be represented as,



The degree of dissociation is 'x' and is small compared to 1. The expression relating the degree of dissociation (x) with equilibrium constant K_p and total pressure P is

- (A) (K_p/P)
- (B) $(2K_p/P)$
- (C) $(2K_p/P)^{1/3}$
- (D) $(2K_p/P)^{1/2}$

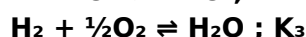
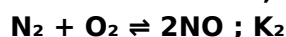
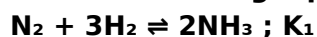
50. A weak acid, HA, has a K_a of 1.00×10^{-5} . If 0.100 mole of this acid dissolved in one litre of water, the percentage of acid dissociated at equilibrium is closest to

- (A) 1.00%
- (B) 99.9%
- (C) 0.100%
- (D) 99.0%

51. Which one of the following ionic species has the greatest proton affinity to form stable compound?

- (A) NH_2^-
- (B) F^-
- (C) I^-
- (D) HS^-

52. The following equilibrium constants are given:



The equilibrium constant for the oxidation of NH_3 by oxygen to give NO is

- (A) $K_2K_3^2/K_1$
- (B) $K_2^2K_3/K_1$
- (C) K_1K_2/K_3
- (D) $K_2K_3^3/K_1$

53. Calculate the pOH of a solution at 25°C that contains 1×10^{-10} M of hydronium ions, i.e. H_3O^+ .

- (A) 4.000
- (B) 9.000
- (C) 1.000
- (D) 7.000

54. For the reaction,



Which of the following statements is not true ?

- (A) At equilibrium, the concentrations of $\text{CO}_2(\text{g})$ and $\text{H}_2\text{O}(\text{l})$ are not equal
- (B) The equilibrium constant for the reaction is given by $K_p = [\text{CO}_2]/[\text{CH}_4][\text{O}_2]$
- (C) Addition of $\text{CH}_4(\text{g})$ or $\text{O}_2(\text{g})$ at equilibrium will cause a shift to the right
- (D) The reaction is exothermic

55. Which of the following pairs constitutes a buffer ?

- (A) HNO_2 and NaNO_2
- (B) NaOH and NaCl
- (C) HNO_3 and NH_4NO_3
- (D) HCl and KCl

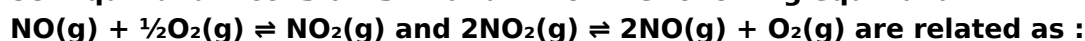
56. The hydrogen ion concentration of a 10^{-8} M HCl aqueous solution at 298 K ($K_w = 10^{-14}$) is :

- (A) 1.0525×10^{-6} M
- (B) 1.0525×10^{-7} M
- (C) 8.525×10^{-8} M
- (D) 1.0525×10^{-8} M

57. What is the correct relationship between the pHs of isomolar solutions of sodium oxide (pH_1), sodium sulphide (pH_2), sodium selenide (pH_3) and sodium telluride (pH_4) ?

- (A) $\text{pH}_1 > \text{pH}_2 \approx \text{pH}_3 > \text{pH}_4$
- (B) $\text{pH}_1 < \text{pH}_2 < \text{pH}_3 < \text{pH}_4$
- (C) $\text{pH}_1 < \text{pH}_2 < \text{pH}_3 \approx \text{pH}_4$
- (D) $\text{pH}_1 > \text{pH}_2 > \text{pH}_3 > \text{pH}_4$

58. Equilibrium constants K_1 and K_2 for the following equilibria :



- (A) $K_2 = 1/K_1$
- (B) $K_2 = K_1^2$
- (C) $K_2 = K_1/2$
- (D) $K_2 = 1/K_1^2$

59. H_2S gas when passed through a solution of cations containing HCl precipitates the cations of second group of qualitative analysis but not those belonging to the fourth group. It is because :

- (A) presence of HCl decreases the sulphide ion concentration
- (B) presence of HCl increases the sulphide ion concentration
- (C) solubility product of group II sulphides is more than that of group IV sulphides
- (D) sulphides of group IV cations are unstable in HCl

Answer key and explanations

1. Answer: (C) 7.75

For a salt of a weak acid and weak base, $\text{pH} = 7 + (\text{pK}_a - \text{pK}_b)/2 = 7 + (4.77 - 3.27)/2 = 7 + 0.75 = 7.75$. The solution is slightly basic because dimethylamine (pK_b 3.27) is a stronger base than acetic acid is an acid.

2. Answer: (A) Both Statement I and Statement II are true.

Acid strength of hydrogen halides increases $\text{HF} < \text{HCl} < \text{HBr} < \text{HI}$. This is because the halogen size increases down the group, the H-X bond becomes longer and weaker, and H^+ is released more easily. Both statements are true.

3. Answer: (A) $2 \times 10^{-13} \text{ M}$

In 0.1 M NaOH , $[\text{OH}^-] \approx 0.1 \text{ M}$ from the common ion, so $s \times (0.1)^2 = 2 \times 10^{-15}$, giving $s = 2 \times 10^{-15}/10^{-2} = 2 \times 10^{-13} \text{ M}$. Forgetting to square $[\text{OH}^-]$ gives 2×10^{-14} , and ignoring the common ion leads to the much larger 10^{-5} – 10^{-8} range.

4. Answer: (A) 0.5×10^{-15}

$\text{pOH} = 5$, so $[\text{OH}^-] = 10^{-5} \text{ M}$ and $[\text{Ca}^{2+}] = 0.5 \times 10^{-5} \text{ M}$. $K_{\text{sp}} = [\text{Ca}^{2+}][\text{OH}^-]^2 = 0.5 \times 10^{-5} \times 10^{-10} = 0.5 \times 10^{-15}$. Taking $s = 10^{-5}$ and computing $4s^3$ wrongly treats $[\text{OH}^-]$ as the solubility.

5. Answer: (C) OH^- and F^- , respectively

A conjugate base is what remains after the acid loses a proton: $\text{H}_2\text{O} \rightarrow \text{OH}^-$ and $\text{HF} \rightarrow \text{F}^-$. H_3O^+ and H_2F^+ are conjugate acids formed by gaining a proton.

6. Answer: (C) 100 mL of 0.1 M HCl + 200 mL of 0.1 M NH_4OH

10 mmol HCl neutralises 10 mmol of the 20 mmol NH_4OH , leaving 10 mmol NH_4OH with 10 mmol NH_4Cl : a weak base with its salt, i.e. a basic buffer. Excess NaOH with acetate is just a strong-base solution, and equal amounts of acid and base give only a salt.

7. Answer: (D) c

For c: $\text{HCl} = 75 \times 0.2 = 15 \text{ mmol}$, $\text{NaOH} = 25 \times 0.2 = 5 \text{ mmol}$; excess $\text{H}^+ = 10 \text{ mmol}$ in $100 \text{ mL} = 0.1 \text{ M}$, so $\text{pH} = 1$. Mixture a leaves 0.02 M H^+ , b leaves 0.01 M H^+ , and d is exactly neutral.

8. Answer: (C) $1.08 \times 10^{-10} \text{ mol}^2 \text{ L}^{-2}$

Molar solubility $s = 2.42 \times 10^{-3}/233 = 1.04 \times 10^{-5} \text{ mol L}^{-1}$. For $\text{BaSO}_4 \rightleftharpoons \text{Ba}^{2+} + \text{SO}_4^{2-}$, $K_{\text{sp}} = s^2 = 1.08 \times 10^{-10} \text{ mol}^2 \text{ L}^{-2}$. Squaring the gram solubility without converting to moles gives a wrong exponent.

9. Answer: (C) Low temperature and high pressure

The forward reaction is exothermic, so low temperature favours the product. It also reduces gas moles from 2 to 1, so high pressure shifts equilibrium forward (Le Chatelier). High temperature would favour the reverse reaction.

10. Answer: (B) $K_2K_3^3/K_1$

The required reaction = (reverse of the NH_3 formation) + (NO formation) + $3 \times (\text{H}_2\text{O formation})$: $2\text{NH}_3 \rightarrow \text{N}_2 + 3\text{H}_2$ ($1/K_1$), $\text{N}_2 + \text{O}_2 \rightarrow 2\text{NO}$ (K_2), $3\text{H}_2 + 3/2 \text{O}_2 \rightarrow 3\text{H}_2\text{O}$ (K_3^3). Adding reactions multiplies constants, so $K = K_2K_3^3/K_1$.

11. Answer: (D) 5.3×10^{-12}

$\text{Ag}_2\text{C}_2\text{O}_4 \rightleftharpoons 2\text{Ag}^+ + \text{C}_2\text{O}_4^{2-}$, so $[\text{C}_2\text{O}_4^{2-}] = \frac{1}{2} \times 2.2 \times 10^{-4} = 1.1 \times 10^{-4} \text{ M}$. $K_{\text{sp}} = [\text{Ag}^+]^2[\text{C}_2\text{O}_4^{2-}] = (2.2 \times 10^{-4})^2 \times 1.1 \times 10^{-4} = 4.84 \times 10^{-8} \times 1.1 \times 10^{-4} \approx 5.3 \times 10^{-12}$. Forgetting to square $[\text{Ag}^+]$ gives a wrong value.

12. Answer: (B) The value of equilibrium constant is changed in the presence of a catalyst in the reaction at equilibrium.

A catalyst speeds up the forward and backward reactions equally, so equilibrium is reached sooner but the equilibrium constant stays the same. The other statements are correct: a catalyst cannot start a reaction that is not feasible, enzymes are biological catalysts, and coenzymes enhance enzyme activity.

13. Answer: (C) 3.56×10^8

$K_{\text{p}} = K_{\text{c}}(\text{RT})^{\Delta n}$ with $\Delta n = 2 - 4 = -2$, so $K_{\text{c}} = K_{\text{p}}(\text{RT})^2$. $\text{RT} = 0.08314 \times 298 = 24.78$, $(\text{RT})^2 = 613.9$, and $K_{\text{c}} = 5.8 \times 10^5 \times 613.9 \approx 3.56 \times 10^8$. Dividing by $(\text{RT})^2$ instead would give a much smaller value.

14. Answer: (D) Presence of catalyst

A catalyst speeds up the forward and backward reactions equally, so equilibrium is reached faster but its position and K do not change. Since $\Delta n = -1$, pressure shifts the equilibrium; changing temperature changes K for this endothermic reaction; and changing reactant concentration shifts the position.

15. Answer: (A) $1/\text{RT}$

$K_{\text{p}} = K_{\text{c}}(\text{RT})^{\Delta n}$, and here $\Delta n = 1 - 2 = -1$. So $K_{\text{p}}/K_{\text{c}} = (\text{RT})^{-1} = 1/\text{RT}$. RT would be the answer if the number of gas moles increased by one.

16. Answer: (B) 0.013%

For a weak base $\alpha = \sqrt{(K_{\text{b}}/C)} = \sqrt{(1.7 \times 10^{-9}/0.10)} = \sqrt{(1.7 \times 10^{-8})} \approx 1.3 \times 10^{-4}$. As a percentage this is 0.013%. Forgetting to convert the fraction to a percentage, or not taking the square root, gives the other values.

17. Answer: (B) 1.6×10^{-9} M

Because of the common ion, $[\text{Cl}^-] \approx 0.1$ M, so $s = K_{\text{sp}}/[\text{Cl}^-] = 1.6 \times 10^{-10}/0.1 = 1.6 \times 10^{-9}$ M. 1.26×10^{-5} M is the solubility in pure water, which ignores the common-ion effect.

18. Answer: (B) The molar solubility of MY in water is less than that of NY_3 .

For MY, $K_{\text{sp}} = s^2$ so $s = \sqrt{6.2 \times 10^{-13}} \approx 7.9 \times 10^{-7}$ M. For NY_3 , $K_{\text{sp}} = 27s^4$, so $s = (6.2 \times 10^{-13}/27)^{1/4} \approx 3.9 \times 10^{-4}$ M, which is larger. Equal K_{sp} does not mean equal solubility when the formulas differ, and adding KY lowers both solubilities by the common ion effect.

19. Answer: (D) $d \ln P/dT = \Delta H_v/RT^2$

For liquid $\rightleftharpoons$ vapour, the vapour pressure P plays the role of the equilibrium constant, and the van't Hoff (Clausius-Clapeyron) equation gives $d \ln P/dT = \Delta H_v/RT^2$. The sign is positive because vapour pressure rises with temperature for an endothermic vaporisation, and the derivative is with respect to T , not T^2 .

20. Answer: (D) $\Delta G^\circ = -2.30 RT \log K$

$\Delta G = \Delta G^\circ + 2.303RT \log Q$, and at equilibrium $\Delta G = 0$ with $Q = K$. So $\Delta G^\circ = -2.303RT \log K$. $\Delta G = -2.303RT \log K$ is wrong because ΔG itself is zero at equilibrium.

21. Answer: (A) Ag_2CrO_4

$[\text{Ag}^+]$ needed to start precipitation (for 1 M anion): AgI 8.3×10^{-17} , AgBr 5.0×10^{-13} , AgCl 1.8×10^{-10} M, but Ag_2CrO_4 needs $\sqrt{1.1 \times 10^{-12}} \approx 1.05 \times 10^{-6}$ M. Ag_2CrO_4 needs the highest Ag^+ , so it precipitates last even though its K_{sp} is not the largest.

22. Answer: (D) mostly products

$K = [\text{products}]/[\text{reactants}] = 1.6 \times 10^{12}$ is very large, so at equilibrium products far exceed reactants. Similar amounts would correspond to K near 1.

23. Answer: (B) Na_2CO_3

Na_2CO_3 is a salt of a strong base and weak acid; CO_3^{2-} hydrolyses to give OH^- , so its solution is basic. NaCl and KCl give neutral solutions and CuSO_4 is acidic by hydrolysis of Cu^{2+} .

24. Answer: (A) 8.0×10^{-12}

$\Delta G^\circ = -2.303RT \log K_{\text{sp}}$, so $\log K_{\text{sp}} = -63\,300/(2.303 \times 8.314 \times 298) = -11.09$. $K_{\text{sp}} = 10^{-11.09} \approx 8.0 \times 10^{-12}$.

25. Answer: (C) by increasing pressure and decreasing temperature

The forward reaction lowers the number of gas moles ($4 \rightarrow 2$) and releases heat. By Le Chatelier's principle, raising pressure and lowering temperature both favour it; adding NH_3 or removing reactants pushes it backward.

26. Answer: (D) $\text{Na}_2\text{S} > \text{ZnS} > \text{CuS}$

Na_2S is an ionic alkali-metal sulphide and is freely soluble. ZnS ($K_{\text{sp}} \approx 10^{-22}$) is sparingly soluble, and CuS ($K_{\text{sp}} \approx 10^{-36}$) is far less soluble. So the order is $\text{Na}_2\text{S} > \text{ZnS} > \text{CuS}$.

27. Answer: (C) BF_3

A Lewis base donates an electron pair. CO , F^- and PF_3 all have lone pairs to donate, but boron in BF_3 has only six valence electrons and accepts a pair, so BF_3 is a Lewis acid.

28. Answer: (C) 6.0×10^{-2}

The required reaction is the given one reversed and halved, so $K' = (1/278)^{1/2} = 1/16.7 \approx 6.0 \times 10^{-2}$. Reversing without taking the square root gives 3.6×10^{-3} .

29. Answer: (C) 0.62

$K_c = [\text{AB}]^2/([\text{A}_2][\text{B}_2]) = (2.8 \times 10^{-3})^2/(3.0 \times 10^{-3} \times 4.2 \times 10^{-3}) = 7.84 \times 10^{-6}/1.26 \times 10^{-5} \approx 0.62$. The temperature is not needed, since K_c is computed directly from concentrations.

30. Answer: (B) BaCl_2

BaCl_2 is a salt of a strong acid and a strong base, so it does not hydrolyse and its solution is neutral ($\text{pH} \approx 7$). BeCl_2 and AlCl_3 hydrolyse strongly to give acidic solutions, and LiCl is very slightly acidic due to the small, polarising Li^+ . So BaCl_2 has the highest pH.

31. Answer: (B) these give unionised acid or base on reaction with added acid or alkali

A buffer contains a weak acid with its conjugate base (or a weak base with its conjugate acid). Added H^+ or OH^- is consumed to form the weakly ionised acid or base, so $[\text{H}^+]$ changes very little. A buffer's pH is not fixed absolutely (it depends on the ratio of components), and it does not hold a large excess of H^+ or OH^- .

32. Answer: (C) 5.0×10^{-7}

pH 12 means $\text{pOH} = 2$ and $[\text{OH}^-] = 10^{-2}$ M, so $[\text{Ba}^{2+}] = 5 \times 10^{-3}$ M. $K_{\text{sp}} = [\text{Ba}^{2+}][\text{OH}^-]^2 = 5 \times 10^{-3} \times (10^{-2})^2 = 5 \times 10^{-7}$. Writing $4s^3$ with $s = 10^{-2}$ wrongly treats $[\text{OH}^-]$ as the solubility, giving 4×10^{-6} .

33. Answer: (A) $[Ag^+] = 1.8 \times 10^{-9} M$, $[Pb^{2+}] = 1.7 \times 10^{-3} M$

At $[Cl^-] = 0.10 M$: $[Ag^+] = K_{sp}/[Cl^-] = 1.8 \times 10^{-10}/0.1 = 1.8 \times 10^{-9} M$ and $[Pb^{2+}] = K_{sp}/[Cl^-]^2 = 1.7 \times 10^{-5}/0.01 = 1.7 \times 10^{-3} M$. Choices that use $[Cl^-]$ instead of $[Cl^-]^2$ for $PbCl_2$ give $1.7 \times 10^{-4} M$, which is wrong.

34. Answer: (C) 9.43

$pK_b = -\log(1.8 \times 10^{-5}) = 4.74$. $pOH = pK_b + \log([NH_4^+]/[NH_3]) = 4.74 + \log(0.20/0.30) = 4.74 - 0.18 = 4.57$, so $pH = 14 - 4.57 = 9.43$. Swapping the ratio gives pOH 4.92 and pH 9.08, the trap.

35. Answer: (D) $[1/(K_1K_2)]^{(1/2)}$

Adding the two given reactions gives $N_2 + 2O_2 \rightleftharpoons 2NO_2$ with $K = K_1K_2$. The required reaction is the reverse of this halved, so $K = (K_1K_2)^{-1/2} = [1/(K_1K_2)]^{(1/2)}$. Halving a reaction takes the square root of K ; it does not divide K by 2.

36. Answer: (A) High pressure and low temperature

The forward reaction reduces gas moles from 5 to 2, so high pressure shifts it forward (Le Chatelier). It is exothermic ($\Delta H < 0$), so low temperature favours products. Hence high pressure and low temperature.

37. Answer: (B) $[(0.75)^3(0.25)] \div [(0.50)^2(0.75)]$

Forming 0.25 M of D consumes 0.25 M B and 0.50 M A and forms 0.75 M C. At equilibrium $[A] = 0.50$, $[B] = 0.75$, $[C] = 0.75$, $[D] = 0.25$, so $K = (0.75)^3(0.25)/[(0.50)^2(0.75)]$. Using the initial 1.00 M values in the denominator ignores the amounts consumed.

38. Answer: (A) 4

For the buffer B^-/HB , $pOH = pK_b + \log([HB]/[B^-])$. With equal concentrations $pOH = pK_b = 10$, so $pH = 14 - 10 = 4$. Answering 10 confuses pOH with pH .

39. Answer: (A) 9.0×10^{-6}

Buffer: $[H^+] = K_a[CH_3COOH]/[CH_3COO^-] = 1.8 \times 10^{-5} \times 0.10/0.20 = 9.0 \times 10^{-6} M$. 1.8×10^{-5} would hold only if the acid and salt concentrations were equal.

40. Answer: (A) $2C(s) + O_2(g) \rightleftharpoons 2CO(g)$

$K_p = K_c(RT)^{\Delta n_g}$. For $2C(s) + O_2(g) \rightleftharpoons 2CO(g)$, only gases count: $\Delta n_g = 2 - 1 = 1$, so $K_p \neq K_c$. In the other three reactions the moles of gas are the same on both sides ($\Delta n_g = 0$).

41. Answer: (A) $5.00 \times 10^{-7} M^3$

$pH\ 12 \rightarrow pOH\ 2 \rightarrow [OH^-] = 10^{-2} M$. $Ba(OH)_2$ gives s and $2s$, so $s = 5 \times 10^{-3} M$. $K_{sp} = s(2s)^2 = 5 \times 10^{-3} \times 10^{-4} = 5.00 \times 10^{-7} M^3$. Using $4s^3$ with $s = 10^{-2}$ gives 4×10^{-6} .

42. Answer: (D) $(CH_3)_3B$

In $(CH_3)_3B$ boron has only six valence electrons and an empty p orbital, so it accepts an electron pair: a Lewis acid. The O, P and N compounds each carry a lone pair and act as Lewis bases.

43. Answer: (D) 5.65×10^{-10}

For the salt of a weak base and strong acid, $K_h = K_w/K_b = 1.0 \times 10^{-14}/1.77 \times 10^{-5} = 5.65 \times 10^{-10}$. Values with 10^{-12} or 10^{-13} come from slips in the exponent.

44. Answer: (D) 0.10 M

HCl gives $20 \times 0.050 = 1.0$ mmol H^+ ; $Ba(OH)_2$ gives $30 \times 0.10 \times 2 = 6.0$ mmol OH^- . After neutralisation 5.0 mmol OH^- remain in 50 mL: $[OH^-] = 0.10 M$. Forgetting that $Ba(OH)_2$ gives two OH^- per formula unit leads to a wrong value.

45. Answer: (C) 1/64

Doubling the given reaction gives $2HI \rightleftharpoons H_2 + I_2$ with $K = 8^2 = 64$. Reversing it gives $H_2 + I_2 \rightleftharpoons 2HI$ with $K = 1/64$. 1/8 only reverses the reaction and forgets that doubling the equation squares K .

46. Answer: (C) $3.7 \times 10^{-4} M$

With equal volumes V , total $H^+ = (10^{-3} + 10^{-4} + 10^{-5})V = 1.11 \times 10^{-3} V$ mol in a total volume $3V$. $[H^+] = 1.11 \times 10^{-3}/3 = 3.7 \times 10^{-4} M$. $1.11 \times 10^{-3} M$ forgets the threefold dilution.

47. Answer: (D) 36 : 1

With degree of dissociation α : for the first reaction, moles $1 - \alpha$, α , α (total $1 + \alpha$) give $K_{p1} = \alpha^2 P_1/(1 - \alpha^2)$. For the second reaction, moles $1 - \alpha$, 2α (total $1 + \alpha$) give $K_{p2} = 4\alpha^2 P_2/(1 - \alpha^2)$. Then $K_{p1}/K_{p2} = P_1/(4P_2) = 9$, so $P_1 : P_2 = 36 : 1$. 9 : 1 would forget the factor 4 from $(2\alpha)^2$.

48. Answer: (D) 64 times

$K = [Fe^{3+}][OH^-]^3$ is constant (the solid does not appear). If $[OH^-]$ becomes one quarter, $[OH^-]^3$ falls by $4^3 = 64$, so $[Fe^{3+}]$ must increase 64 times. 4 times ignores the cube from the coefficient 3.

49. Answer: (C) $(2K_p/P)^{1/3}$

Starting with 1 mol AB_2 : $AB_2 = 1 - x$, $AB = x$, $B_2 = x/2$, total = $1 + x/2 \approx 1$. $K_p = (xP)^2(xP/2)/(P)^2 = x^3P/2$, so $x = (2K_p/P)^{1/3}$. The square-root form would hold for a reaction where x enters only as x^2 , e.g. $AB_2 \rightleftharpoons AB + B$.

50. Answer: (A) 1.00%

$\alpha = \sqrt{(K_a/C)} = \sqrt{(1.00 \times 10^{-5}/0.100)} = 1.00 \times 10^{-2}$, i.e. 1.00%. 0.100% would come from K_a/C without the square root.

51. Answer: (A) NH_2^-

Proton affinity is greatest for the strongest base. NH_2^- is the conjugate base of NH_3 , an extremely weak acid, so it is the strongest base here. F^- , I^- and HS^- are conjugate bases of much stronger acids.

52. Answer: (D) $K_2K_3^3/K_1$

Target: $2NH_3 + (5/2)O_2 \rightleftharpoons 2NO + 3H_2O$ = (reverse of eq. 1) + (eq. 2) + $3 \times$ (eq. 3). So $K = K_2K_3^3/K_1$. Using K_3 only once ignores that three water molecules form.

53. Answer: (A) 4.000

$pH = -\log(1 \times 10^{-10}) = 10$, and at $25^\circ C$ $pOH = 14 - 10 = 4.000$. 10 would be the pH itself, which is not an option.

54. Answer: (B) The equilibrium constant for the reaction is given by $K_p = [CO_2]/[CH_4][O_2]$

The correct expression excludes the pure liquid H_2O and raises O_2 to its coefficient: $K_p = p(CO_2)/[p(CH_4) \cdot p(O_2)^2]$. The given $K_p = [CO_2]/[CH_4][O_2]$ omits the square on O_2 , so it is the false statement. Adding a reactant shifts the equilibrium right, and a negative $\Delta_r H$ means exothermic.

55. Answer: (A) HNO_2 and $NaNO_2$

A buffer needs a weak acid with its conjugate base (or weak base with its conjugate acid). HNO_2 is a weak acid and $NaNO_2$ supplies NO_2^- , so this pair is an acidic buffer. The other pairs contain a strong acid or strong base with a neutral salt and cannot resist pH changes.

56. Answer: (B) $1.0525 \times 10^{-7} M$

At $10^{-8} M$ the acid's H^+ is smaller than that from water, so both must be counted: $x(x - 10^{-8}) = 10^{-14}$. Solving, $x = [10^{-8} + \sqrt{(10^{-16} + 4 \times 10^{-14})}]/2 \approx 1.05 \times 10^{-7} M$ ($pH \approx 6.98$). Taking $[H^+] = 10^{-8} M$ would make an acid solution basic ($pH \approx 8$).

57. Answer: (D) $pH_1 > pH_2 > pH_3 > pH_4$

These salts are basic by anion hydrolysis. Acid strength rises $H_2O < H_2S < H_2Se < H_2Te$, so the conjugate bases weaken $O^{2-} > S^{2-} > Se^{2-} > Te^{2-}$ and $pH_1 > pH_2 > pH_3 > pH_4$.

58. Answer: (D) $K_2 = 1/K_1^2$

The second equilibrium is the first reversed and doubled. Reversing gives $1/K_1$ and doubling squares it, so $K_2 = 1/K_1^2$. $1/K_1$ forgets the factor of 2.

59. Answer: (A) presence of HCl decreases the sulphide ion concentration

HCl suppresses ionisation of H_2S by the common-ion (H^+) effect, lowering $[S^{2-}]$. This low $[S^{2-}]$ still exceeds the very small K_{sp} of group II sulphides but not the larger K_{sp} of group IV sulphides. Group II sulphides have smaller, not larger, K_{sp} .

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