Chapter 7

Equilibrium

1. Solid $Ba(NO_3)_2$ is gradually dissolved in a 1.0×10^{-4} M Na_2CO_3 solution. At what concentration of Ba^{2+} will a precipitate begin to form? (K_{sp} for $BaCO_3 = 5.1 \times 10^{-9}$) **[AIEEE-2009]**

   (1) 5.1×10^{-5} M (2) 8.1×10^{-8} M

   (3) 8.1×10^{-7} M (4) 4.1×10^{-5} M

2. In aqueous solution the ionisation constants for carbonic acid are

   $$K_1 = 4.2 \times 10^{-7} \text{ and } K_2 = 4.8 \times 10^{-11}$$

   Select the correct statement for a saturated 0.034 M solution of the carbonic acid. **[AIEEE-2010]**

   (1) The concentration of H^+ is double that of CO_3^{2-}

   (2) The concentration of CO_3^{2-} is 0.034 M

   (3) The concentration of CO_3^{2-} is greater than that of HCO_3^-

   (4) The concentrations of H^+ and HCO_3^- are approximately equal

3. Solubility product of silver bromide is 5.0×10^{-13}. The quantity of potassium bromide (molar mass taken as 120 g mol^{-1}) to be added to 1 litre of 0.05 M solution of silver nitrate to start the precipitation of AgBr is **[AIEEE-2010]**

   (1) 5.0×10^{-8} g (2) 1.2×10^{-10} g

   (3) 1.2×10^{-9} g (4) 6.2×10^{-5} g

4. Three reactions involving $H_2PO_4^-$ are given below

   (i) $H_3PO_4 + H_2O \rightarrow H_3O^+ + H_2PO_4^-$

   (ii) $H_2PO_4^- + H_2O \rightarrow H_2PO_4^{2-} + H_3O^+$

   (iii) $H_2PO_4^- + OH^- \rightarrow H_3PO_4 + O^{2-}$

   In which of the above does $H_2PO_4^-$ act as an acid? **[AIEEE-2010]**

   (1) (i) only (2) (ii) only

   (3) (i) and (ii) (4) (iii) only

5. At 25°C, the solubility product of $Mg(OH)_2$ is 1.0×10^{-11}. At which pH, will Mg^{2+} ions start precipitating in the form of $Mg(OH)_2$ from a solution of 0.001 M Mg^{2+} ions? **[AIEEE-2010]**

   (1) 8 (2) 9

   (3) 10 (4) 11

6. At 25°C, the solubility product of $Mg(OH)_2$ is 1.0×10^{-11}. At which pH, will Mg^{2+} ions start precipitating in the form of $Mg(OH)_2$ from a solution of 0.001 M Mg^{2+} ions? **[AIEEE-2010]**

   (1) 8 (2) 9

   (3) 10 (4) 11

7. If 10^{-4} dm^3 of water is introduced into a 1.0 dm^3 flask at 300 K, how many moles of water are in the vapour phase when equilibrium is established?

   (Given : Vapour pressure of H_2O at 300 K is 3170 Pa; R = 8.314 J K^{-1} mol^{-1}) **[AIEEE-2010]**

   (1) 1.27×10^{-3} mol (2) 5.56×10^{-3} mol

   (3) 1.53×10^{-2} mol (4) 4.46×10^{-2} mol

8. The K_{sp} for $Cr(OH)_3$ is 1.6×10^{-30}. The molar solubility of this compound in water is **[AIEEE-2011]**

   (1) $1.6 \times 10^{-30}/27$ (2) $\sqrt[2]{1.6 \times 10^{-30}}$

   (3) $\sqrt[4]{1.6 \times 10^{-30}}$ (4) $\sqrt[4]{1.6 \times 10^{-30}/27}$

9. An acid HA ionises as

   $$HA \rightleftharpoons H^+ + A^-$$

   The pH of 1.0 M solution is 5. Its dissociation constant would be **[AIEEE-2011]**

   (1) 1×10^{-5} (2) 1×10^{-10}

   (3) 5 (4) 5×10^{-8}

10. The pH of a 0.1 molar solution of the acid HQ is 3. The value of the ionization constant, Ka of this acid is **[AIEEE-2012]**

    (1) 1×10^{-3} (2) 1×10^{-5}

    (3) 1×10^{-7} (4) 3×10^{-1}

11. The equilibrium constant (K_c) for the reaction $N_2(g)+O_2(g) \rightarrow 2NO(g)$ at temperature T is 4×10^{-4}. The value of K_c for the reaction,

$NO(g) \rightarrow \frac{1}{2}N_2(g) + \frac{1}{2}O_2(g)$ at the same temperature is **[AIEEE-2012]**

(1) 2.5×10^2 (2) 4×10^{-4}

(3) 50.0 (4) 0.02

12. How many litres of water must be added to 1 litre of an aqueous solution of HCl with a pH of 1 to create an aqueous solution with pH of 2? **[JEE (Main)-2013]**

(1) 0.1 L (2) 0.9 L

(3) 2.0 L (4) 9.0 L

13. For the reaction $SO_{2(g)} + \frac{1}{2}O_{2(g)} \rightleftharpoons SO_{3(g)}$, if $K_P = K_C(RT)^x$ where the symbols have usual meaning then the value of x is (assuming ideality) **[JEE (Main)-2014]**

(1) –1 (2) $-\frac{1}{2}$

(3) $\frac{1}{2}$ (4) 1

14. The standard Gibbs energy change at 300 K for the reaction $2A \rightleftharpoons B + C$ is 2494.2 J. At a given time, the composition of the reaction mixture is $[A]=\frac{1}{2}, [B]=2$ and $[C]=\frac{1}{2}$. The reaction proceeds in the : [R = 8.314 J/K/mol, e = 2.718] **[JEE (Main)-2015]**

(1) Forward direction because $Q > K_C$

(2) Reverse direction because $Q > K_C$

(3) Forward direction because $Q < K_C$

(4) Reverse direction because $Q < K_C$

15. The equilibrium constant at 298 K for a reaction $A + B \rightleftharpoons C + D$ is 100. If the initial concentration of all the four species were 1 M each, then equilibrium concentration of D (in mol L^{-1}) will be **[JEE (Main)-2016]**

(1) 0.818

(2) 1.818

(3) 1.182

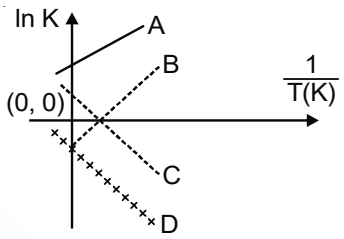
(4) 0.182

16. pK_a of a weak acid (HA) and pK_b of a weak base (BOH) are 3.2 and 3.4, respectively, The pH of their salt (AB) solution is **[JEE (Main)-2017]**

(1) 7.0 (2) 1.0

(3) 7.2 (4) 6.9

17. Which of the following lines correctly show the temperature dependence of equilibrium constant K, for an exothermic reaction? **[JEE (Main)-2018]**



(1) A and B (2) B and C

(3) C and D (4) A and D

18. An aqueous solution contains 0.10 M H_2S and 0.20 M HCl. If the equilibrium constant for the formation of HS^- from H_2S is 1.0×10^{-7} and that of S^{2-} from HS^- ions is 1.2×10^{-13} then the concentration of S^{2-} ions in aqueous solution is **[JEE (Main)-2018]**

(1) 5×10^{-8} (2) 3×10^{-20}

(3) 6×10^{-21} (4) 5×10^{-19}

19. An aqueous solution contains an unknown concentration of Ba^{2+}. When 50 mL of a 1 M solution of Na_2SO_4 is added, $BaSO_4$ just begins to precipitate. The final volume is 500 mL. The solubility product of $BaSO_4$ is 1×10^{-10}. What is original concentration of Ba^{2+}? **[JEE (Main)-2018]**

(1) 5×10^{-9} M (2) 2×10^{-9} M

(3) 1.1×10^{-9} M (4) 1.0×10^{-10} M

20. Which of the following salts is the most basic in aqueous solution? **[JEE (Main)-2018]**

(1) $Al(CN)_3$ (2) CH_3COOK

(3) $FeCl_3$ (4) $Pb(CH_3COO)_2$

21. An alkali is titrated against an acid with methyl orange as indicator, which of the following is a correct combination? **[JEE (Main)-2018]**

	Base	Acid	End point
(1)	Weak	Strong	Colourless to pink
(2)	Strong	Strong	Pinkish red to yellow
(3)	Weak	Strong	Yellow to pinkish red
(4)	Strong	Strong	Pink to colourless

22. 20 ml of 0.1 M H_2SO_4 solution is added to 30 mL of 0.2 M NH_4OH solution. The pH of the resultant mixture is : [pK_b of NH_4OH = 4.7]

[JEE (Main)-2019]

(1) 9.0 (2) 5.2

(3) 5.0 (4) 9.4

23. Consider the following reversible chemical reactions

$$A_2(g) + B_2(g) \overset{K_1}{\rightleftharpoons} 2AB(g) \quad \ldots(1)$$

$$6AB(g) \overset{K_2}{\rightleftharpoons} 3A_2(g) + 3B_2(g) \quad \ldots(2)$$

The relation between K_1 and K_2 is

[JEE (Main)-2019]

(1) $K_2 = K_1^3$ (2) $K_1K_2 = \frac{1}{3}$

(3) $K_2 = K_1^{-3}$ (4) $K_1K_2 = 3$

24. The values of $\frac{K_p}{K_c}$ for the following reactions at 300 K are, respectively (At 300 K, RT = 24.62 dm^3 atm mol^{-1})

$N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$

$N_2O_4(g) \rightleftharpoons 2NO_2(g)$

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ **[JEE (Main)-2019]**

(1) 24.62 dm^3 atm mol^{-1}, 606.0 dm^6 atm^2 mol^{-2}, 1.65×10^{-3} dm^{-6} atm^{-2} mol^2

(2) 1, 24.62 dm^3 atm mol^{-1}, 1.65×10^{-3} dm^{-6} atm^{-2} mol^2

(3) 1, 24.62 dm^3 atm mol^{-1}, 606.0 dm^6 atm^2 mol^{-2}

(4) 1, 4.1×10^{-2} dm^{-3} atm^{-1} mol, 606 dm^6 atm^2 mol^{-2}

25. A mixture of 100 m mol of $Ca(OH)_2$ and 2 g of sodium sulphate was dissolved in water and the volume was made up to 100 mL. The mass of calcium sulphate formed and the concentration of OH^- in resulting solution, respectively, are (Molar mass of $Ca(OH)_2$, Na_2SO_4 and $CaSO_4$ are 74, 143 and 136 g mol^{-1}, respectively; K_{sp} of $Ca(OH)_2$ is 5.5×10^{-6}) **[JEE (Main)-2019]**

(1) 1.9 g, 0.14 mol L^{-1}

(2) 13.6 g, 0.28 mol L^{-1}

(3) 13.6 g, 0.14 mol L^{-1}

(4) 1.9 g, 0.28 mol L^{-1}

26. 5.1 g NH_4SH is introduced in 3.0 L evacuated flask at 327ºC. 30% of the solid NH_4SH decomposed to NH_3 and H_2S as gases. The K_p of the reaction at 327ºC is (R = 0.082 L atm $mol^{-1}K^{-1}$, Molar mass of S = 32 g mol^{-1}, molar mass of N = 14 g mol^{-1})

[JEE (Main)-2019]

(1) 4.9×10^{-3} atm^2 (2) 0.242 atm^2

(3) 1×10^{-4} atm^2 (4) 0.242×10^{-4} atm^2

27. Consider the reaction

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

The equilibrium constant of the above reaction is K_P. If pure ammonia is left to dissociate, the partial pressure of ammonia at equilibrium is given by (Assume that $P_{NH_3} << P_{total}$ at equilibrium)

[JEE (Main)-2019]

(1) $\frac{K_P^{1/2} P^2}{4}$ (2) $\frac{3^{3/2} K_P^{1/2} P^2}{4}$

(3) $\frac{K_P^{1/2} P^2}{16}$ (4) $\frac{3^{3/2} K_P^{1/2} P^2}{16}$

28. For the equilibrium

$2H_2O \rightleftharpoons H_3O^+ + OH^-$, the value of ΔG° at 298 K is approximately **[JEE (Main)-2019]**

(1) –80 kJ mol^{-1} (2) –100 kJ mol^{-1}

(3) 80 kJ mol^{-1} (4) 100 kJ mol^{-1}

29. Two solids dissociate as follows

$$A(s) \rightleftharpoons B(g) + C(g); K_{P_1} = x\,atm^2$$

$$D(s) \rightleftharpoons C(g) + E(g); K_{P_2} = y\,atm^2$$

The total pressure when both the solids dissociate simultaneously is **[JEE (Main)-2019]**

(1) $x^2 + y^2$ atm

(2) (x + y) atm

(3) $\sqrt{x + y}$ atm

(4) $2\left(\sqrt{x + y}\right)$ atm

30. In a chemical reaction, $A + 2B \overset{K}{\rightleftharpoons} 2C + D$, the initial concentration of B was 1.5 times of the concentration of A, but the equilibrium concentrations of A and B were found to be equal. The equilibrium constant (K) for the aforesaid chemical reaction is **[JEE (Main)-2019]**

(1) 1 (2) 16

(3) 4 (4) $\frac{1}{4}$

31. If K_{sp} of Ag_2CO_3 is 8×10^{-12}, the molar solubility of Ag_2CO_3 in 0.1 M $AgNO_3$ is **[JEE (Main)-2019]**

(1) 8×10^{-11} M (2) 8×10^{-12} M

(3) 8×10^{-13} M (4) 8×10^{-10} M

32. If solubility product of $Zr_3(PO_4)_4$ is denoted by K_{sp} and its molar solubility is denoted by S, then which of the following relation between S and K_{sp} is correct? **[JEE (Main)-2019]**

(1) $S = \left(\frac{K_{sp}}{929}\right)^{\frac{1}{9}}$ (2) $S = \left(\frac{K_{sp}}{216}\right)^{\frac{1}{7}}$

(3) $S = \left(\frac{K_{sp}}{144}\right)^{\frac{1}{6}}$ (4) $S = \left(\frac{K_{sp}}{6912}\right)^{\frac{1}{7}}$

33. For the following reactions, equilibrium constants are given :

$S(s) + O_2(g) \rightleftharpoons SO_2(g); K_1 = 10^{52}$

$2S(s) + 3O_2(g) \rightleftharpoons 2SO_3(g); K_2 = 10^{129}$

The equilibrium constant for the reaction,

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ is

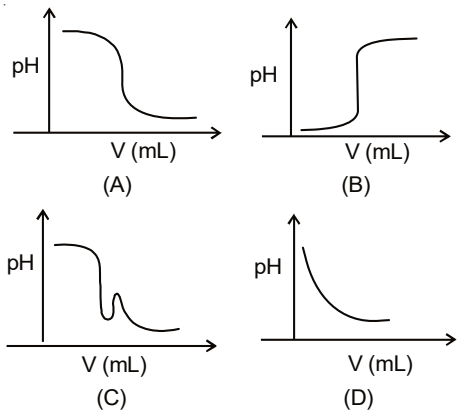
[JEE (Main)-2019]

(1) 10^{154} (2) 10^{25}

(3) 10^{77} (4) 10^{181}

34. In an acid-base titration, 0.1 M HCl solution was added to the NaOH solution of unknown strength. Which of the following correctly shows the change of pH of the titration mixture in this experiment?

[JEE (Main)-2019]



(1) (A) (2) (C)

(3) (B) (4) (D)

35. Consider the following statements

(a) The pH of a mixture containing 400 mL of 0.1 M H_2SO_4 and 400 mL of 0.1 M NaOH will be approximately 1.3.

(b) Ionic product of water is temperature dependent.

(c) A monobasic acid with $K_a = 10^{-5}$ has a pH = 5. The degree of dissociation of this acid is 50%.

(d) The Le Chatelier's principle is not applicable to common-ion effect.

The correct statements are **[JEE (Main)-2019]**

(1) (a), (b) and (d)

(2) (b) and (c)

(3) (a) and (b)

(4) (a), (b) and (c)

36. The pH of a 0.02 M NH_4Cl solution will be [given $K_b(NH_4OH) = 10^{-5}$ and log2 = 0.301]

[JEE (Main)-2019]

(1) 2.65 (2) 5.35

(3) 4.35 (4) 4.65

37. For the reaction,

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$,

$\Delta H = -57.2$ kJ mol^{-1} and $K_c = 1.7 \times 10^{16}$.

Which of the following statement is INCORRECT?

[JEE (Main)-2019]

(1) The equilibrium constant is large suggestive of reaction going to completion and so no catalyst is required.

(2) The addition of inert gas at constant volume will not affect the equilibrium constant.

(3) The equilibrium will shift in forward direction as the pressure increases.

(4) The equilibrium constant decreases as the temperature increases.

38. What is the molar solubility of $Al(OH)_3$ in 0.2 M NaOH solution? Given that, solubility product of $Al(OH)_3 = 2.4 \times 10^{-24}$ **[JEE (Main)-2019]**

(1) 3×10^{-19} (2) 12×10^{-21}

(3) 12×10^{-23} (4) 3×10^{-22}

39. In which one of the following equilibria, $K_P \neq K_C$? **[JEE (Main)-2019]**

(1) $2HI(g) \rightleftharpoons H_2(g) + I_2(g)$

(2) $2NO(g) \rightleftharpoons N_2(g) + O_2(g)$

(3) $NO_2(g) + SO_2(g) \rightleftharpoons NO(g) + SO_3(g)$

(4) $2C(s) + O_2(g) \rightleftharpoons 2CO(g)$

40. The INCORRECT match in the following is **[JEE (Main)-2019]**

(1) $\Delta G° = 0, K = 1$ (2) $\Delta G° < 0, K < 1$

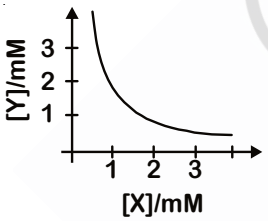
(3) $\Delta G° > 0, K < 1$ (4) $\Delta G° < 0, K > 1$

41. The molar solubility of $Cd(OH)_2$ is 1.84×10^{-5} M in water. The expected solubility of $Cd(OH)_2$ in a buffer solution of pH = 12 is **[JEE (Main)-2019]**

(1) 1.84×10^{-9} M (2) 6.23×10^{-11} M

(3) $\frac{2.49}{1.84} \times 10^{-9}$ M (4) 2.49×10^{-10} M

42. The stoichiometry and solubility product of a salt with the solubility curve given below is, respectively



[JEE (Main)-2020]

(1) X_2Y, 2×10^{-9} M^3 (2) XY_2, 4×10^{-9} M^3

(3) XY_2, 1×10^{-9} M^3 (4) XY, 2×10^{-6} M^3

43. For the following Assertion and Reason, the correct option is

Assertion : The pH of water increases with increase in temperature.

Reason : The dissociation of water into H^+ and OH^- is an exothermic reaction.

[JEE (Main)-2020]

(1) Both assertion and reason are false

(2) Assertion is not true, but reason is true

(3) Both assertion and reason are true, and the reason is the correct explanation for the assertion

(4) Both assertion and reason are true, but the reason is not the correct explanation for the assertion

44. The K_{sp} for the following dissociation is 1.6×10^{-5}

$$PbCl_{2(s)} \rightleftharpoons Pb^{2+}_{(aq)} + 2Cl^-_{(aq)}$$

Which of the following choices is correct for a mixture of 300 mL 0.134 M $Pb(NO_3)_2$ and 100 mL 0.4 M NaCl? **[JEE (Main)-2020]**

(1) $Q < K_{sp}$

(2) $Q = K_{sp}$

(3) Not enough data provided

(4) $Q > K_{sp}$

45. The solubility product of $Cr(OH)_3$ at 298 K is 6.0×10^{-31}. The concentration of hydroxide ions in a saturated solution of $Cr(OH)_3$ will be **[JEE (Main)-2020]**

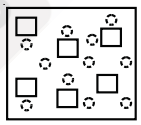
(1) $(2.22 \times 10^{-31})^{1/4}$

(2) $(18 \times 10^{-31})^{1/2}$

(3) $(18 \times 10^{-31})^{1/4}$

(4) $(4.86 \times 10^{-29})^{1/4}$

46. In the figure shown below reactant A (represented by square) is in equilibrium with product B (represented by circle). The equilibrium constant is



[JEE (Main)-2020]

(1) 4 (2) 2

(3) 8 (4) 1

47. For the following Assertion and Reason, the correct option is

Assertion (A): When Cu (II) and sulphide ions are mixed, they react together extremely quickly to give a solid.

Reason (R): The equilibrium constant of $Cu^{2+}(aq) + S^{2-}(aq) \rightleftharpoons CuS(s)$ is high because the solubility product is low. **[JEE (Main)-2020]**

(1) (A) is false and (R) is true.

(2) Both (A) and (R) are true but (R) is not the explanation for (A).

(3) Both (A) and (R) are true and (R) is the explanation for (A).

(4) Both (A) and (R) are false.

48. An acidic buffer is obtained on mixing

[JEE (Main)-2020]

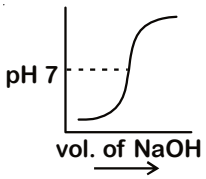
(1) 100 mL of 0.1 M HCl and 200 mL of 0.1 M NaCl

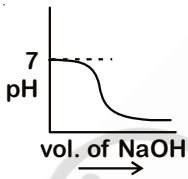
(2) 100 mL of 0.1 M HCl and 200 mL of 0.1 M CH_3COONa

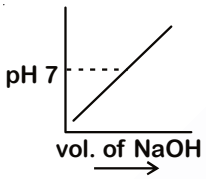
(3) 100 mL of 0.1 M CH_3COOH and 100 mL of 0.1 M NaOH

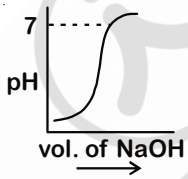
(4) 100 mL of 0.1 M CH_3COOH and 200 mL of 0.1 M NaOH

49. 100 mL of 0.1 M HCl is taken in a beaker and to it 100 mL of 0.1 M NaOH is added in steps of 2 mL and the pH is continuously measured. Which of the following graphs correctly depicts the change in pH? **[JEE (Main)-2020]**

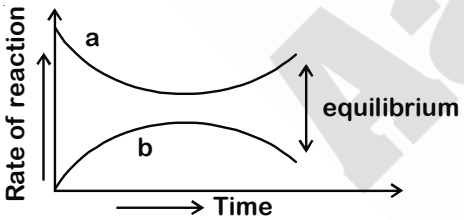
(1) 

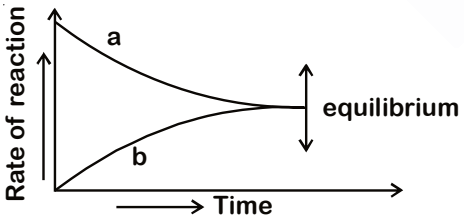
(2) 

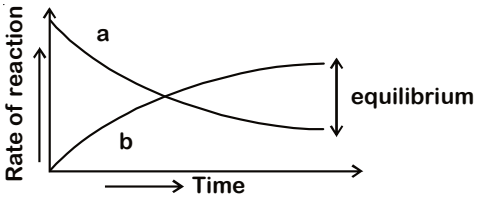
(3) 

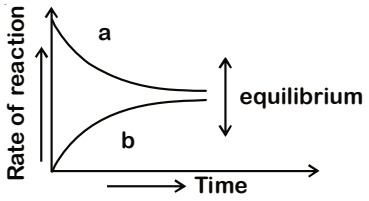
(4) 

50. For the equilibrium $A \rightleftharpoons B$, the variation of the rate of the forward (a) and reverse (b) reaction with time is given by **[JEE (Main)-2020]**

(1) 

(2) 

(3) 

(4) 

51. If the equilibrium constant for $A \rightleftharpoons B + C$ is $K_{eq}^{(1)}$ and that of $B + C \rightleftharpoons P$ is $K_{eq}^{(2)}$, the equilibrium constant for $A \rightleftharpoons P$ is **[JEE (Main)-2020]**

(1) $K_{eq}^{(1)} / K_{eq}^{(2)}$ (2) $K_{eq}^{(1)} + K_{eq}^{(2)}$

(3) $K_{eq}^{(2)} - K_{eq}^{(1)}$ (4) $K_{eq}^{(1)} K_{eq}^{(2)}$

52. Consider the following reaction :

$N_2O_4(g) \rightleftharpoons 2NO_2(g)$; $\Delta H^0 = +58$ kJ

For each of the following cases (a, b), the direction in which the equilibrium shifts is

[JEE (Main)-2020]

(a) Temperature is decreased

(b) Pressure is increased by adding N_2 at constant T.

(1) (a) Towards product, (b) towards reactant

(2) (a) Towards reactant, (b) no change

(3) (a) Towards reactant, (b) towards product

(4) (a) Towards product, (b) no change

53. Arrange the following solutions in the decreasing order of pOH

(A) 0.01 M HCl

(B) 0.01 M NaOH

(C) 0.01 M CH_3COONa

(D) 0.01 M NaCl **[JEE (Main)-2020]**

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

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

54. For the reaction

$$Fe_2N(s) + \frac{3}{2}H_2(g) \rightleftharpoons 2Fe(s) + NH_3(g)$$

[JEE (Main)-2020]

(1) $K_C = K_p(RT)^{1/2}$

(2) $K_C = K_p(RT)$

(3) $K_C = K_p(RT)^{3/2}$

(4) $K_C = K_p(RT)^{-1/2}$

55. The variation of equilibrium constant with temperature is given below

Temperature	Equilibrium Constant
$T_1 = 25°C$	$K_1 = 10$
$T_2 = 100°C$	$K_2 = 100$

The values of $\Delta H°$, $\Delta G°$ at T_1 and $\Delta G°$ at T_2 (in kJ mol^{-1}) respectively, are close to [Use R = 8.314 J K^{-1} mol^{-1}] **[JEE (Main)-2020]**

(1) 28.4, –5.71 and –14.29

(2) 0.64, –7.14 and –5.71

(3) 28.4, –7.14 and –5.71

(4) 0.64, –5.71 and –14.29

56. The value of K_C is 64 at 800 K for the reaction

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

The value of K_C for the following reaction is

$NH_3(g) \rightleftharpoons \frac{1}{2}N_2(g) + \frac{3}{2}H_2(g)$ **[JEE (Main)-2020]**

(1) 1/8 (2) 1/64

(3) 8 (4) 1/4

57. Two solutions, A and B, each of 100 L was made by dissolving 4 g of NaOH and 9.8 g of H_2SO_4 in water, respectively. The pH of the resultant solution obtained from mixing 40 L of solution A and 10 L of solution B is_____. **[JEE (Main)-2020]**

58. 3 g of acetic acid is added to 250 mL of 0.1 M HCl and the solution made up to 500 mL. To 20 mL of this solution $\frac{1}{2}$mL of 5 M NaOH is added. The pH of the solution is_____.

[Given : pK_a of acetic acid = 4.75, molar mass of acetic acid = 60 g/mol, log3 = 0.4771]

Neglect any changes in volume.

[JEE (Main)-2020]

59. For a reaction $X + Y \rightleftharpoons 2Z$, 1.0 mol of X, 1.5 mol of Y and 0.5 mol of Z were taken in a 1 L vessel and allowed to react. At equilibrium, the concentration of Z was 1.0 mol L^{-1}. The equilibrium constant of the reaction is _____ $\frac{x}{15}$. The value of x is _____. **[JEE (Main)-2020]**

60. If the solubility product of AB_2 is 3.20×10^{-11} M^3, then the solubility of AB_2 in pure water is _____ $\times 10^{-4}$ mol L^{-1}. [Assuming that neither kind of ion reacts with water] **[JEE (Main)-2020]**

61. The strength of an aqueous NaOH solution is *most accurately* determined by titrating

(Note : consider that an appropriate indicator is used) **[JEE (Main)-2020]**

(1) Aq. NaOH in a pipette and aqueous oxalic acid in a burette

(2) Aq. NaOH in a burette and aqueous oxalic acid in a conical flask

(3) Aq. NaOH in a burette and concentrated H_2SO_4 in a conical flask

(4) Aq. NaOH in a volumetric flask and concentrated H_2SO_4 in a conical flask

62. At 1990 K and 1 atm pressure, there are equal number of Cl_2 molecules and Cl atoms in the reaction mixture. The value of K_p for the reaction $Cl_{2(g)} \rightleftharpoons 2Cl_{(g)}$ under the above conditions is x × 10^{-1}. The value of x is____. (Rounded off to the nearest integer) **[JEE (Main)-2021]**

63. The solubility product of PbI_2 is 8.0×10^{-9}. The solubility of lead iodide in 0.1 molar solution of lead nitrate is x × 10^{-6} mol/L. The value of x is _____ (Rounded off to the nearest integer)

$[\text{Given } \sqrt{2} = 1.41]$ **[JEE (Main)-2021]**

64. The solubility of AgCN in a buffer solution of pH = 3 is x. The value of x is : **[JEE (Main)-2021]**

[Assume : No cyano complex is formed; $K_{sp}(AgCN) = 2.2 \times 10^{-16}$ and $K_a(HCN) = 6.2 \times 10^{-10}$]

(1) 1.9×10^{-5} (2) 1.6×10^{-6}

(3) 2.2×10^{-16} (4) 0.625×10^{-6}

65. The solubility of $Ca(OH)_2$ in water is :

[Given : The solubility product of $Ca(OH)_2$ in water = 5.5×10^{-6}] **[JEE (Main)-2021]**

(1) 1.77×10^{-2} (2) 1.11×10^{-2}

(3) 1.77×10^{-6} (4) 1.11×10^{-6}

66. A homogeneous ideal gaseous reaction $AB_{2(g)} \rightleftharpoons A_{(g)} + 2B_{(g)}$ is carried out in a 25 litre flask at 27°C. The initial amount of AB_2 was 1 mole and the equilibrium pressure was 1.9 atm. The value of K_p is x × 10^{-2}. The value of x is _____. (Integer answer)

[R = 0.08206 dm^3atm K^{-1} mol^{-1}]

[JEE (Main)-2021]

67. The pH of ammonium phosphate solution, if pk_a of phosphoric acid and pk_b of ammonium hydroxide are 5.23 and 4.75 respectively, is _____.

[JEE (Main)-2021]

68. For the reaction $A(g) \rightleftharpoons B(g)$ at 495 K, $\Delta_r G° = -9.478$ kJ mol^{-1}.

If we start the reaction in a closed container at 495 K with 22 millimoles of A, the amount of B in the equilibrium mixture is _____ millimoles. (Round off to the Nearest Integer).

[R = 8.314 J mol^{-1} K^{-1}; ln 10 = 2.303]

[JEE (Main)-2021]

69. Two salts A_2X and MX have the same value of solubility product of 4.0×10^{-12}. The ratio of their molar solubilities i.e. $\frac{S(A_2X)}{S(MX)}$ = _____. (Round off to the Nearest Integer) **[JEE (Main)-2021]**

70. Sulphurous acid (H_2SO_3) has $Ka_1 = 1.7 \times 10^{-2}$ and $Ka_2 = 6.4 \times 10^{-8}$. The pH of 0.588 M H_2SO_3 is _____. **[JEE (Main)-2021]**

(Round off to the Nearest Integer).

71. 0.01 moles of a weak acid HA ($K_a = 2.0 \times 10^{-6}$) is dissolved in 1.0 L of 0.1 M HCl solution. The degree of dissociation of HA is _____ $\times 10^{-5}$ (Round off to the Nearest Integer).

[Neglect volume change on adding HA.

Assume degree of dissociation <<1]

[JEE (Main)-2021]

72. Consider the reaction $N_2O_4(g) \rightleftharpoons 2NO_2(g)$.

The temperature at which $K_C = 20.4$ and $K_P = 600.1$, is _____ K. (Round off to the Nearest Integer). [Assume all gases are ideal and R = 0.0831 L bar K^{-1} mol^{-1}] **[JEE (Main)-2021]**

73. In order to prepare a buffer solution of pH 5.74, sodium acetate is added to acetic acid. If the concentration of acetic acid in the buffer is 1.0 M, the concentration of sodium acetate in the buffer is _____ M.

(Round off to the Nearest Integer).

[Given : pK_a (acetic acid) = 4.74]

[JEE (Main)-2021]

74. The solubility of $CdSO_4$ in water is 80×10^{-4} mol L^{-1}. Its solubility in 0.01 M H_2SO_4 solution is ____ $\times 10^{-6}$ mol L^{-1}. (Round off to the Nearest Integer). (Assume that solubility is much less than 0.01 M)

[JEE (Main)-2021]

75. $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

In an equilibrium mixture, the partial pressures are $P_{SO_3} = 43$ kPa; $P_{O_2} = 530$ Pa and $P_{SO_2} = 45$ kPa. The equilibrium constant K_P = _____ $\times 10^{-2}$. (Nearest integer)

[JEE (Main)-2021]

76. A solution is 0.1 M in Cl^- and 0.001 M in CrO_4^{2-}. Solid $AgNO_3$ is gradually added to it. Assuming that the addition does not change in volume and $K_{sp}(AgCl) = 1.7 \times 10^{-10}$ M^2 and $K_{sp}(Ag_2CrO_4) = 1.9 \times 10^{-12}$ M^3. **[JEE (Main)-2021]**

Select **correct** statement from the following

(1) AgCl precipitates first because its K_{sp} is high.

(2) Ag_2CrO_4 precipitates first as its K_{sp} is low.

(3) Ag_2CrO_4 precipitates first because the amount of Ag^+ needed is low.

(4) AgCl will precipitate first as the amount of Ag^+ needed to precipitate is low.

77. Value of K_p for the equilibrium reaction $N_2O_{4(g)} \rightleftharpoons 2NO_{2(g)}$ at 288 K is 47.9. The K_C for this reaction at same temperature is _____. (Nearest integer) (R = 0.083 L bar K^{-1} mol^{-1})

[JEE (Main)-2021]

78. For the reaction

$A + B \rightleftharpoons 2C$

The value of equilibrium constant is 100 at 298 K. If the initial concentration of all the three species is 1 M each, then the equilibrium concentration of C is $x \times 10^{-1}$ M. The value of x is _____. (Nearest integer) **[JEE (Main)-2021]**

79. Assuming that $Ba(OH)_2$ is completely ionised in aqueous solution under the given conditions the concentration of H_3O^+ ions in 0.005 M aqueous solution of $Ba(OH)_2$ at 298 K is _____ $\times 10^{-12}$ mol L^{-1}. (Nearest integer) **[JEE (Main)-2021]**

80. $PCl_5 \rightleftharpoons PCl_3 + Cl_2 \quad K_c = 1.844$

3.0 moles of PCl_5 is introduced in a 1 L closed reaction vessel at 380 K. The number of moles of PCl_5 at equilibrium is _____ $\times 10^{-3}$. (Round off to the Nearest Integer) **[JEE (Main)-2021]**

81. The equilibrium constant for the reaction

$$A(s) \rightleftharpoons M(s) + \frac{1}{2}O_2(g)$$

is $K_P = 4$. At equilibrium, the partial pressure of O_2 is _____ atm. (Round off to the Nearest Integer).

[JEE (Main)-2021]

82. $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$

The above reaction is carried out in a vessel starting with partial pressures $P_{SO_2} = 250$ m bar, $P_{O_2} = 750$ m bar and $P_{SO_3} = 0$ bar. When the reaction is complete, the total pressure in the reaction vessel is _____ m bar. (Round off to the nearest Integer). **[JEE (Main)-2021]**

83. Given below are two statements :

Statement I : In the titration between strong acid and weak base methyl orange is suitable as an indicator.

Statement II : For titration of acetic acid with NaOH phenolphthalein is not a suitable indicator.

In the light of the above statements, choose the most appropriate answer from the options given below : **[JEE (Main)-2021]**

(1) **Statement I** is false but **Statement II** is true

(2) **Statement I** is true but **Statement II** is false

(3) Both **Statement I** and **Statement II** are false

(4) Both **Statement I** and **Statement II** are true

84. The OH^- concentration in a mixture of 5.0 mL of 0.0504 M NH_4Cl and 2 mL of 0.0210 M NH_3 solution is $x \times 10^{-6}$ M. The value of x is _____. (Nearest integer)

[Given $K_w = 1 \times 10^{-14}$ and $K_b = 1.8 \times 10^{-5}$]

[JEE (Main)-2021]

85. The equilibrium constant K_c at 298 K for the reaction

$A + B \rightleftharpoons C + D$

is 100. Starting with an equimolar solution with concentrations of A, B, C and D all equal to 1 M, the equilibrium concentration of D is ____ $\times 10^{-2}$ M. (Nearest integer) **[JEE (Main)-2021]**

86. The number of moles of NH_3, that must be added to 2 L of 0.80 M $AgNO_3$ in order to reduce the concentration of Ag^+ ions to 5.0×10^{-8} M ($K_{formation}$ for $[Ag(NH_3)_2]^+ = 1.0 \times 10^8$) is _____. (Nearest integer)

[Assume no volume change on adding NH_3]

[JEE (Main)-2021]

87. When 5.1 g of solid NH_4HS is introduced into a two litre evacuated flask at 27°C, 20% of the solid decomposes into gaseous ammonia and hydrogen sulphide. The K_p for the reaction at 27°C is $x \times 10^{-2}$. The value of x is _____. (Integer answer)

[Given R = 0.082 L atm K^{-1} mol^{-1}]

[JEE (Main)-2021]

88. A_3B_2 is a sparingly soluble salt of molar mass M (g mol^{-1}) and solubility x g L^{-1}. The solubility product satisfies $K_{sp} = a\left(\frac{x}{M}\right)^5$. The value of a is _____. (Integer answer) **[JEE (Main)-2021]**

89. The pH of a solution obtained by mixing 50 mL of 1 M HCl and 30 mL of 1 M NaOH is $x \times 10^{-4}$. The value of x is _____. (Nearest integer)

[log 2.5 = 0.3979] **[JEE (Main)-2021]**

90. The molar solubility of $Zn(OH)_2$ in 0.1 M NaOH solution is $x \times 10^{-18}$ M. The value of x is _____. (Nearest integer)

(Given : The solubility product of $Zn(OH)_2$ is 2×10^{-20}) **[JEE (Main)-2021]**

91. For a reaction at equilibrium

$$A(g) \rightleftharpoons B(g) + \frac{1}{2}C(g)$$

the relation between dissociation constant (K), degree of dissociation (α) and equilibrium pressure (p) is given by : **[JEE (Main)-2022]**

(1) $K = \dfrac{\alpha^{\frac{1}{2}} p^{\frac{3}{2}}}{\left(1+\frac{3}{2}\alpha\right)^{\frac{1}{2}}(1-\alpha)}$

(2) $K = \dfrac{\alpha^{\frac{3}{2}} p^{\frac{1}{2}}}{(2+\alpha)^{\frac{1}{2}}(1-\alpha)}$

(3) $K = \dfrac{(\alpha p)^{\frac{3}{2}}}{\left(1+\frac{3}{2}\alpha\right)^{\frac{1}{2}}(1-\alpha)}$

(4) $K = \dfrac{(\alpha p)^{\frac{3}{2}}}{(1+\alpha)(1-\alpha)^{\frac{1}{2}}}$

92. PCl_5 dissociates as

$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$

5 moles of PCl_5 are placed in a 200 litre vessel which contains 2 moles of N_2 and is maintained at 600 K. The equilibrium pressure is 2.46 atm. The equilibrium constant K_p for the dissociation of PCl_5 is _____ × 10^{-3}. (nearest integer)

(Given: R = 0.082 L atm K^{-1} mol^{-1}; Assume ideal gas behaviour) **[JEE (Main)-2022]**

93. The Ksp for bismuth sulphide (Bi_2S_3) is 1.08 × 10^{-73}. The solubility of Bi_2S_3 in mol L^{-1} at 298 K is

[JEE (Main)-2022]

(1) 1.0×10^{-15} (2) 2.7×10^{-12}

(3) 3.2×10^{-10} (4) 4.2×10^{-8}

94. Given below are two statements one is labelled as Assertion A and the other is labelled as Reason R:

Assertion A: The amphoteric nature of water is explained by using Lewis acid/base concept

Reason R: Water acts as an acid with NH3 and as a base with H_2S.

In the light of the above statements choose the *correct* answer from the options given below:

[JEE (Main)-2022]

(1) Both A and R are true and R is the correct explanation of A.

(2) Both A and R are true but R is NOT the correct explanation of A.

(3) A is true but R is false.

(4) A is false but R is true.

95. 50 mL of 0.1 M CH_3COOH is being titrated against 0.1 M NaOH. When 25 mL of NaOH has been added, the pH of the solution will be _____ × 10^{-2}. (Nearest integer)

(Given : pK_a (CH_3COOH) = 4.76)

log 2 = 0.30

log 3 = 0.48

log 5 = 0.69

log 7 = 0.84

log 11 = 1.04

[JEE (Main)-2022]

96. $2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g)$

In an experiment, 2.0 moles of NOCl was placed in a one-litre flask and the concentration of NO after equilibrium established, was found to be 0.4 mol/ L. The equilibrium constant at 30°C is _____ × 10^{-4}.

[JEE (Main)-2022]

97. pH value of 0.001 M NaOH solution is_____.

[JEE (Main)-2022]

98. A student needs to prepare a buffer solution of propanoic acid and its sodium salt with pH 4.

The ratio of $\dfrac{[CH_3CH_2COO^-]}{[CH_3CH_2COOH]}$ required to make buffer is _____.

Given : $K_a(CH_3CH_2COOH) = 1.3 \times 10^{-5}$

[JEE (Main)-2022]

(1) 0.03 (2) 0.13

(3) 0.23 (4) 0.33

99. The solubility of AgCl will be maximum in which of the following? **[JEE (Main)-2022]**

(1) 0.01 M KCl (2) 0.01 M HCl

(3) 0.01 M $AgNO_3$ (4) Deionised water

100. 4.0 moles of argon and 5.0 moles of PCl_5 are introduced into an evacuated flask of 100 litre capacity at 610 K. The system is allowed to equilibrate. At equilibrium, the total pressure of mixture was found to be 6.0 atm. The K_p for the reaction is [Given : R = 0.082 L atm K^{-1} mol^{-1}]

[JEE (Main)-2022]

(1) 2.25 (2) 6.24

(3) 12.13 (4) 15.24

101. A box contains 0.90 g of liquid water in equilibrium with water vapour at 27°C. The equilibrium vapour pressure of water at 27°C is 32.0 Torr. When the volume of the box is increased, some of the liquid water evaporates to maintain the equilibrium pressure. If all the liquid water evaporates, then the volume of the box must be _____ litre. [nearest integer]

(Given : R = 0.082 L atm K^{-1} mol^{-1}]

(Ignore the volume of the liquid water and assume water vapours behave as an ideal gas.

[JEE (Main)-2022]

102. 20 mL of 0.1 M NH_4OH is mixed with 40 mL of 0.05 M HCl. The pH of the mixture is nearest to

(Given : $K_b(NH_4OH) = 1 \times 10^{-5}$, log2 = 0.30, log3 = 0.48, log5 = 0.69, log7 = 0.84, log11 = 1.04)

[JEE (Main)-2022]

(1) 3.2 (2) 4.2

(3) 5.2 (4) 6.2

103. K_{a_1}, K_{a_2} and K_{a_3} are the respective ionization constants for the following reactions (a), (b) and (c).

(a) $H_2C_2O_4 \rightleftharpoons H^+ + HC_2O_4^-$

(b) $HC_2O_4^- \rightleftharpoons H^+ + C_2O_4^{2-}$

(c) $H_2C_2O_4 \rightleftharpoons 2H^+ + C_2O_4^{2-}$

The relationship between K_{a_1}, K_{a_2} and K_{a_3} is given as **[JEE (Main)-2022]**

(1) $K_{a_3} = K_{a_1} + K_{a_2}$ (2) $K_{a_3} = K_{a_1} - K_{a_2}$

(3) $K_{a_3} = K_{a_1} / K_{a_2}$ (4) $K_{a_3} = K_{a_1} \times K_{a_2}$

104. In base vs. acid titration, at the end point methyl orange is present as **[JEE (Main)-2022]**

(1) quinonoid form (2) heterocyclic form

(3) phenolic form (4) benzenoid form

105. At 298 K, the equilibrium constant is 2×10^{15} for the reaction:

$Cu(s) + 2Ag^+(aq) \rightleftharpoons Cu^{2+}(aq) + 2Ag(s)$

The equilibrium constant for the reaction

$$\frac{1}{2}Cu^{2+}(aq) + Ag(s) \rightleftharpoons \frac{1}{2}Cu(s) + Ag^+(aq)$$

is $x \times 10^{-8}$. The value of x is _____ (Nearest integer) **[JEE (Main)-2022]**

106. Class XII students were asked to prepare one litre of buffer solution of pH 8.26 by their Chemistry teacher. The amount of ammonium chloride to be dissolved by the student in 0.2 M ammonia solution to make one litre of the buffer is

(Given : $pK_b(NH_3) = 4.74$, Molar mass of NH_3 = 17 g mol^{-1}, Molar mass of NH_4Cl = 53.5 g mol^{-1})

[JEE (Main)-2022]

(1) 53.5 g (2) 72.3 g

(3) 107.0 g (4) 126.0 g

107. Given below are two statements: One is labelled as **Assertion A** and the other is labelled as **Reason R**.

Assertion A: Phenolphthalein is a pH dependent indicator, remains colourless in acidic solution and gives pink colour in basic medium.

Reason R: Phenolphthalein is a weak acid. It doesn't dissociate in basic medium. In the light of the above statements, choose the ***most appropriate*** answer from the options given below.

[JEE (Main)-2022]

(1) Both **A** and **R** are true and **R** is the correct explanation of **A**

(2) Both **A** and **R** are true but **R** is NOT the correct explanation of **A**

(3) **A** is true but **R** is false

(4) **A** is false but **R** is true

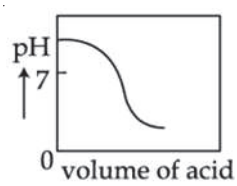
108. At 310 K, the solubility of CaF_2 in water is 2.34×10^{-3} g/100 mL. The solubility product of CaF_2 is _____ $\times 10^{-8}$ $(mol/L)^3$.

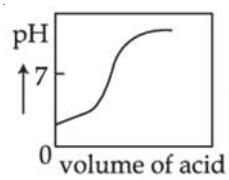
(Given molar mass : $CaF_2 = 78\ g\ mol^{-1}$)

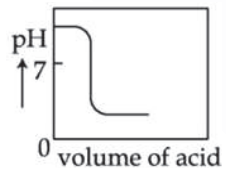
[JEE (Main)-2022]

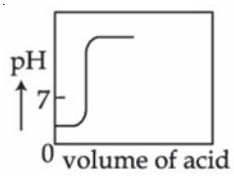
109. The plot of pH-metric titration of weak base NH_4OH vs strong acid HCl looks like :

[JEE (Main)-2022]

(1)


(2)


(3)


(4)


110. K_a for butyric acid (C_3H_7COOH) is 2×10^{-5}. The pH of 0.2 M solution of butyric acid is ____$\times 10^{-1}$. (Nearest integer) (Given log2 = 0.30)

[JEE (Main)-2022]

111. At 600 K, 2 mol of NO are mixed with 1 mol of O_2.

$$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$$

The reaction occurring as above comes to equilibrium under a total pressure of 1 atm. Analysis of the system shows that 0.6 mol of oxygen are present at equilibrium. The equilibrium constant for the reaction is _____. (Nearest integer) **[JEE (Main)-2022]**

112. If the solubility product of PbS is 8×10^{-28}, then the solubility of PbS in pure water at 298 K is $x \times 10^{-16}$ mol L^{-1}. The value of x is _____. (Nearest integer)

[Given : $\sqrt{2}$ = 1.41] **[JEE (Main)-2022]**

113. 200 mL of 0.01 M HCl is mixed with 400 mL of 0.01 M H_2SO_4. The pH of the mixture is ___.

[Given log 2 = 0.30, log 3 = 0. 48, log 5 = 0.70, log7 = 0.84, log 11 = 1.04.] **[JEE (Main)-2022]**

(1) 1.14 (2) 1.78

(3) 2.34 (4) 3.02

114. A compound 'X' is a weak acid and it exhibits colour change at pH close to the equivalence point during neutralization of NaOH with CH_3COOH. Compound 'X' exists in ionized form in basic medium. The compound 'X' is **[JEE (Main)-2022]**

(1) Methyl orange (2) Methyl red

(3) Phenolphthalein (4) Eriochrome Black T

❑ ❑ ❑