Q1. A system is said to be in equilibrium when:

A. Forward reaction stops completely
B. Backward reaction becomes irreversible
C. Rate of forward reaction equals rate of backward reaction
D. Concentration of reactants becomes zero

Answer: C. Rate of forward reaction equals rate of backward reaction

Explanation:
At equilibrium, dynamic balance is achieved — both reactions continue, but their rates are equal, so concentrations remain constant.

Q2. The equilibrium constant Kp for a reaction is 1.5×10^4 at 298 K. What can be concluded about the reaction?

A. Reactants are favored
B. Products are favored
C. System is at equilibrium
D. Rate of forward reaction is slow

Answer: B. Products are favored

Explanation:
A large Kp ($> 10^3$) means the equilibrium lies far to the right, i.e., products dominate.

Q3. For the reaction:

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
If pressure is increased at constant temperature, the equilibrium will:

A. Shift to left
B. Shift to right
C. Remain unaffected
D. Cannot be predicted

Answer: B. Shift to right

Explanation:

According to Le Chatelier's Principle, increasing pressure shifts equilibrium to the side with fewer moles of gas (from 4 mol to 2 mol here).

Q4. Assertion (A): Equilibrium constant changes with temperature.

Reason (R): Kp = Kc(RT)^Δn

A. Both A and R are true, and R is the correct explanation
B. Both A and R are true, but R is not the correct explanation
C. A is true, R is false
D. A is false, R is true

Answer: B. Both A and R are true, but R is not the correct explanation

Explanation:
Kp = Kc(RT)^Δn relates pressure and concentration equilibrium constants. Temperature dependence of K comes from Van't Hoff equation.

Q5. Which of the following statements is incorrect?

A. A catalyst affects the equilibrium constant
B. Kc is constant at constant temperature
C. Equilibrium is dynamic in nature
D. Kp = Kc when Δn = 0

Answer: A. A catalyst affects the equilibrium constant

Explanation:
Catalysts only speed up the approach to equilibrium but do not alter the equilibrium constant.

Q6. If Kc for a reaction is 10, what will be the value of K for the reverse reaction?

A. 10
B. 0.1
C. 1
D. 0.01

Answer: B. 0.1

Explanation:
For reverse reaction, K_reverse = 1/K_forward = 1/10 = 0.1

Q7. Which of the following will increase the degree of dissociation of a weak electrolyte?

A. Adding common ion
B. Increasing concentration
C. Adding inert solvent (dilution)
D. Increasing temperature

Answer: C. Adding inert solvent (dilution)

Explanation:
According to Ostwald's dilution law, degree of dissociation increases with dilution.

Q8. Match the following:

Column I
A. Kp = Kc
B. Le Chatelier's Principle
C. Ionic Product > Solubility Product
D. Buffer Solution

Column II

1. Δn = 0
2. Common ion effect
3. Precipitation occurs
4. Opposes change

Answer: A. 1 – 4 – 3 – 2

Q9. Which of the following solutions acts as a buffer?

A. HCl + NaOH
B. $CH_3COOH + CH_3COONa$
C. $NH_4Cl + NaCl$

D. NaOH + NaCl

Answer: B. $CH_3COOH + CH_3COONa$

Explanation:
This is a classic acidic buffer of weak acid + its salt with strong base.

Q10. At equilibrium, which of the following remains constant?

A. Concentration of reactants and products
B. Rate of forward reaction
C. Rate of backward reaction
D. All of the above

Answer: D. All of the above

Explanation:
At dynamic equilibrium, concentrations and rates remain constant though reactions are still occurring.

Q11. In the reaction:

$A \rightleftharpoons B + C$,
If concentration of A is increased, the equilibrium will:

A. Shift to left
B. Shift to right
C. Remain unchanged
D. Stop the reaction

Answer: B. Shift to right

Explanation:
Increasing reactant shifts equilibrium toward product side.

Q12. The dissociation constant of acetic acid is 1.8×10^{-5}. What will be its pKa?

A. 4.74
B. 5.2

C. 6.0
D. 3.2

Answer: A. 4.74

Explanation:
pKa = -log Ka = -log(1.8×10^{-5}) ≈ 4.74

Q13. A saturated solution of AgCl has a solubility of 1.3×10^{-5} mol/L. What is the Ksp?

A. 1.3×10^{-5}
B. 1.69×10^{-10}
C. 2.6×10^{-5}
D. 1.69×10^{-5}

Answer: B. 1.69×10^{-10}

Explanation:
$AgCl \rightleftharpoons Ag^+ + Cl^-$
$Ksp = [Ag^+][Cl^-] = (1.3 \times 10^{-5})^2 = 1.69 \times 10^{-10}$

Q14. In the reaction:

$H_2 + I_2 \rightleftharpoons 2HI$,
Initial pressure of all gases = 1 atm. At equilibrium, HI = 1.8 atm. Find equilibrium constant Kp.

A. 1.5
B. 6.5
C. 9
D. 3.24

Answer: C. 9

Explanation:
Let x = pressure of HI formed = 1.8 atm
Then decrease in H_2 and I_2 = x/2 = 0.9 atm
$Kp = (PHI)^2 / (PH_2 \times PI_2) = (1.8)^2 / (0.1 \times 0.1) = 3.24 / 0.01 = 9$

Q15. Which of the following statements is true regarding equilibrium constant?

A. Depends on pressure
B. Depends on temperature
C. Depends on volume
D. Depends on catalyst

Answer: B. Depends on temperature

Explanation:
Only temperature affects the value of equilibrium constant. Catalyst only speeds up equilibrium attainment.

Q16. The pH of 0.01 M HCl solution is:

A. 1
B. 2
C. 12
D. 14

Answer: B. 2

Explanation:
HCl is a strong acid, so it dissociates completely:
$[H^+] = 0.01$ M → pH = –log(0.01) = 2

Q17. Which of the following salts will not undergo hydrolysis in water?

A. CH_3COONa
B. NH_4Cl
C. NaCl
D. $FeCl_3$

Answer: C. NaCl

Explanation:
NaCl is a neutral salt (from strong acid + strong base), so no hydrolysis occurs.

Q18. What is the $[H^+]$ in a buffer solution containing 0.2 M CH_3COOH and 0.1 M CH_3COONa? ($K_a = 1.8 \times 10^{-5}$)

A. 1.8×10^{-5}
B. 3.6×10^{-5}
C. 0.9×10^{-5}
D. 2.4×10^{-5}

Answer: B. 3.6×10^{-5}

Explanation:
Use Henderson–Hasselbalch equation:
$[H^+] = Ka \times [acid]/[salt] = 1.8 \times 10^{-5} \times 0.2 / 0.1 = 3.6 \times 10^{-5}$

Q19. What is the pH of a 0.1 M NH_4OH solution? ($Kb = 1.8 \times 10^{-5}$)

A. 11.13
B. 9.13
C. 3.13
D. 8.87

Answer: A. 11.13

Explanation:
$[OH^-] = \sqrt{(Kb \times C)} = \sqrt{(1.8 \times 10^{-5} \times 0.1)} = \sqrt{1.8 \times 10^{-6}} \approx 1.34 \times 10^{-3}$
$pOH \approx 2.87 \rightarrow pH = 14 - 2.87 = 11.13$

Q20. In which of the following will increase in temperature shift the equilibrium to the right?

A. $N_2 + 3H_2 \rightleftharpoons 2NH_3$ (ΔH = –ve)
B. $2SO_2 + O_2 \rightleftharpoons 2SO_3$ (ΔH = –ve)
C. $CaCO_3 \rightleftharpoons CaO + CO_2$ (ΔH = +ve)
D. $H_2 + I_2 \rightleftharpoons 2HI$ (ΔH = –ve)

Answer: C. $CaCO_3 \rightleftharpoons CaO + CO_2$ (ΔH = +ve)

Explanation:
For endothermic reactions (ΔH positive), increasing temperature favors forward reaction.

Q21. For the weak base NH_4OH, which of the following equilibrium exists?

A. $NH_4OH \rightleftharpoons NH_4^+ + OH^-$
B. $NH_4OH \rightleftharpoons NH_3 + H^+$
C. $NH_4OH \rightleftharpoons NH_3 + OH^-$
D. $NH_4OH \rightleftharpoons NH_4^+ + H^+$

Answer: C. $NH_4OH \rightleftharpoons NH_3 + OH^-$

Explanation:
NH_4OH dissociates into NH_3 and OH^- in aqueous solution.

Q22. The solubility of a salt MX_2 is S mol/L. What is its Ksp?

A. S^3
B. $4S^3$
C. $27S^2$
D. S^2

Answer: B. $4S^3$

Explanation:
$MX_2 \rightleftharpoons M^{2+} + 2X^-$
$Ksp = [M^{2+}][X^-]^2 = (S)(2S)^2 = 4S^3$

Q23. The solubility of Ag_2CrO_4 is 1.3×10^{-4} mol/L. Calculate Ksp.

A. 1.3×10^{-4}
B. 2.2×10^{-12}
C. 8.8×10^{-12}
D. 2.2×10^{-7}

Answer: C. 8.8×10^{-12}

Explanation:
$Ag_2CrO_4 \rightleftharpoons 2Ag^+ + CrO_4^{2-}$
$Ksp = (2S)^2 \times S = 4S^3 = 4 \times (1.3 \times 10^{-4})^3 = 8.8 \times 10^{-12}$

Q24. Which of the following has highest degree of dissociation?

A. 0.01 M CH_3COOH
B. 0.1 M CH_3COOH
C. 1.0 M CH_3COOH
D. All have same

Answer: A. 0.01 M CH_3COOH

Explanation:
According to Ostwald's dilution law, $\alpha \propto 1/\sqrt{C}$ — so lower the concentration, higher the dissociation.

Q25. At 25°C, the ionization constant of water (Kw) is:

A. 1.0×10^{-14}
B. 1.0×10^{-7}
C. 1.0×10^{-12}
D. 1.0×10^{-6}

Answer: A. 1.0×10^{-14}

Explanation:
$Kw = [H^+][OH^-] = 1.0 \times 10^{-7} \times 1.0 \times 10^{-7} = 1.0 \times 10^{-14}$

Q26. The hydrolysis constant (Kh) of a salt from weak base and strong acid is given by:

A. Kw/Ka
B. Kw/Kb
C. Kw/(Ka×Kb)
D. Ka/Kw

Answer: B. Kw/Kb

Explanation:
For weak base + strong acid:
Kh = Kw / Kb

Q27. For the reaction:

$2SO_2 + O_2 \rightleftharpoons 2SO_3$,
If O_2 is removed from the system at equilibrium, what happens?

A. Reaction shifts to right
B. Reaction shifts to left
C. Reaction stops
D. Equilibrium constant increases

Answer: B. Reaction shifts to left

Explanation:
Removing O_2 disturbs the equilibrium → system tries to replace it → shifts to left.

Q28. The pH of a solution is 5. What is the concentration of H^+ ions?

A. 1×10^5 M
B. 5×10^{-5} M
C. 1×10^{-5} M
D. 1×10^{-9} M

Answer: C. 1×10^{-5} M

Explanation:
$pH = -\log[H^+] \Rightarrow [H^+] = 10^{-5}$ M

Q29. Which of the following expressions is correct for Kp and Kc relation?

A. Kp = Kc
B. Kp = Kc × (RT)^Δn
C. Kp = Kc / (RT)^Δn
D. Kp = Kc × log(RT)

Answer: B. Kp = Kc × (RT)^Δn

Explanation:
Standard thermodynamic relation: Kp = Kc(RT)^Δn

Q30. Which condition will increase the rate of attainment of equilibrium?

A. Increasing temperature
B. Adding catalyst
C. Removing products
D. All of the above

Answer: B. Adding catalyst

Explanation:
Only catalyst increases rate of attainment, without changing equilibrium position or Kc.

Q31. The equilibrium constant for the reaction

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
is $K_p = 6.0 \times 10^5$ at 400°C. What will happen if the pressure is increased?

A. Reaction will shift to right
B. Reaction will shift to left
C. No change
D. Kp will increase

Answer: A. Reaction will shift to right

Explanation:
There are fewer moles of gas on the right (2) than left (4). Increasing pressure shifts equilibrium toward fewer gas moles.

Q32. What is the conjugate acid of NH_3?

A. NH_4^+
B. NH_2^-
C. NH_4OH
D. H_3O^+

Answer: A. NH_4^+

Explanation:
$NH_3 + H^+ \rightleftharpoons NH_4^+ \rightarrow$ conjugate acid of NH_3 is NH_4^+.

Q33. Which of the following is not a buffer solution?

A. $CH_3COOH + CH_3COONa$
B. $NH_4OH + NH_4Cl$
C. HCl + NaCl
D. HCOOH + HCOONa

Answer: C. HCl + NaCl

Explanation:
Buffer = weak acid/base + its salt. HCl is a strong acid → no buffer action.

Q34. The addition of NaOH to CH_3COOH will:

A. Increase pH slowly
B. Decrease pH
C. Increase pH sharply
D. Keep pH constant

Answer: A. Increase pH slowly

Explanation:
NaOH reacts with CH_3COOH forming CH_3COONa → creates a buffer → slow rise in pH.

Q35. The solubility of a salt AB is S mol/L. What is the expression for its solubility product (Ksp)?

A. S
B. $2S^2$
C. S^2
D. $4S^3$

Answer: C. S^2

Explanation:
$AB \rightleftharpoons A^+ + B^-$ → $Ksp = [A^+][B^-] = S \times S = S^2$

Q36. Which of the following will decrease the degree of dissociation of acetic acid?

A. Dilution
B. Addition of NaCl
C. Addition of CH_3COONa
D. Heating

Answer: C. Addition of CH_3COONa

Explanation:
Common ion (CH_3COO^-) suppresses dissociation due to common ion effect.

Q37. Which change does not affect the equilibrium constant (K)?

A. Pressure
B. Temperature
C. Catalyst
D. Concentration

Answer: A. Pressure
Correction: C. Catalyst

Explanation:
Only temperature affects K. Catalyst affects rate, not position or value of K.

Q38. Which is correct about the pH of blood?

A. Always acidic
B. Always basic
C. Slightly alkaline and buffered
D. Neutral

Answer: C. Slightly alkaline and buffered

Explanation:
Blood has pH ~7.4 and contains buffers like HCO_3^-/H_2CO_3.

Q39. At equilibrium, which of the following is true?

A. Concentrations of reactants = products
B. Rate of forward reaction = rate of backward reaction
C. Reactions stop
D. All concentrations become zero

Answer: B. Rate of forward = rate of backward

Explanation:
Equilibrium is dynamic: reactions continue at equal rate, concentrations stay constant.

Q40. If pH of a solution is 3, then the pOH is:

A. 3
B. 11
C. 7
D. 1

Answer: B. 11

Explanation:
pH + pOH = 14 ⇒ pOH = 14 – 3 = 11

Q41. Which of the following is a correct buffer pair?

A. HCl and NaCl
B. NH_4OH and NaOH
C. HCOOH and HCOONa
D. NaOH and NaCl

Answer: C. HCOOH and HCOONa

Explanation:
Weak acid + its salt = buffer system.

Q42. A solution of KCN is:

A. Acidic
B. Basic

C. Neutral
D. Amphoteric

Answer: B. Basic

Explanation:
CN^- undergoes hydrolysis → forms OH^- → basic solution.

Q43. Which of the following represents Bronsted-Lowry base?

A. HCl
B. H_2O
C. NH_3
D. NH_4^+

Answer: C. NH_3

Explanation:
A Bronsted base accepts H^+. NH_3 accepts H^+ to form NH_4^+.

Q44. Which statement is correct for solubility product (Ksp)?

A. Depends on temperature
B. Independent of salt type
C. Changes with pressure
D. Same for all salts

Answer: A. Depends on temperature

Explanation:
Ksp is constant at a given temperature only.

Q45. A solution has $[OH^-] = 1 \times 10^{-3}$ M. What is its pH?

A. 3
B. 11
C. 7
D. 9

Answer: B. 11

Explanation:
pOH = $-\log(1\times10^{-3}) = 3 \rightarrow$ pH = 14 – 3 = 11