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Class: XI
Subject: Chemistry
Topic: Equilibrium
No. of Questions: 27

Q1. Species acting as both bronsted acid and bronsted base are

A. HSO_4^{-1}
B. Na_2CO_3
C. NH_3
D. None of these

Right Answer Explanation: A
HSO_4^- can act as both a bronsted acid as well as a bronsted base. To act as bronsted acid, it will donate one proton and becomes sulphate ion, on the other hand to act as a bronsted base, it will accept one proton to become sulphuric acid.

Q2. The solubility of $Mg(OH)_2$ is S moles/ litre. The solubility product under the same condition is

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

Right Answer Explanation: A
For different salts such as AB, AB_2, AB_3 etc. $K_{sp} = s^2$, $4s^3$. $27s^4$ etc.

Q3. What is the pH of a solution, whose hydronium ion concentration is 6.2×10^{-9} mol L^{-1}

A. 8.31
B. 8.41
C. 8.34
D. 8.21

Right Answer Explanation: D
Use pH = - log $[H^+]$

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Q4. NH_4OH is a weak base because

A. it has low vapour pressure
B. it is only slightly ionized
C. it has low density
D. none of these

Right Answer Explanation:
NH_4OH is a weak base because it is only slightly ionized

Q5. Reaction between silver nitrate and sodium chloride goes to completion because

A. the reaction is instantaneous
B. silver nitrate is insoluble in water
C. silver chloride is sparingly soluble in water
D. solubility of silver nitrate increases with sodium chloride

Ans: silver chloride is sparingly soluble in water

6. For the following equilibrium, $K_c = 6.3 \times 10^{14}$at1000K
$NO(g) + O_3(g) \leftrightarrow NO_2(g) + O_2(g)$
Both the forward and reverse reactions in the equilibrium are elementary bimolecular reacions.
What is K_c for the reverse reaction?

Ans: It is givne that K_c for the forward reacion is 6.3×10^{14}.
Then, K_c for the reverse reaction will be,
$K'_c = \frac{1}{K_C}$

7. Write the equilibrium equation for each of the following reactions:
(a) $CO_2(g) + C(s) \rightleftharpoons 2\,CO(g)$
(b) $Hg(l) + Hg^{2+}(aq) \rightleftharpoons Hg_2^{2+}(aq)$

Ans: (a) $K_c = \frac{[CO]^2}{[CO_2]}$

Alternatively, because CO and CO_2 are gases, the equilibrium equation can be writ-ten using partial pressures:

$K_p = \frac{(P_{CO})^2}{P_{CO_2}}$

The relationship between K_p and K_c is $K_P = K_C (RT)^{\Delta n} = K_c (RT)$, because $\Delta n = 2 - 1 = 1$.

B $K_C = \frac{[Hg_2^{2+}]}{[Hg^{2+}]}$

In this case, it's not appropriate to write an expression for K_P because none of the reactants and products is a gas.

8. In a reversible reaction, two substances are in equilibrium. If the concentration of each one is doubled, the equilibrium constant will be

A. Reduced to half its original value

B. Reduced to one fourth of its original value

C. Doubled

D. Constant.

Ans (d) Constant

9. Explain why pure liquids and solids can be ignored while writing the equilibrium constant expression?

Ans: For a pure substance (both solids and liquids),

[Pure substance] = $\frac{Number\ of\ moles}{Volume}$

$= \frac{Mass/molecular\ mass}{Volume}$

$= \frac{Mass}{Volume \times Molecular\ mass}$

$= \frac{Density}{Molecular\ mass}$

Now, the molecular mass and density (at a particular temperature) of a pure substance is always fixed and is accounted for in the equilibrium constant. Therefore, the values of pure substance are not mentioned are not mentioned in the equilibrium constant expression.

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10. Does the number of moles of reaction products increase, decrease, or remain the same when each of the following equilibria is subjected to a decrease in pressure by increase- ing the volume?

(a) PCl_5 (g) ⇋ PCl_3 (g) + Cl_2(g)
(b) CaO(s) + CO_2 (g) ⇋ $CaCO_3$ (s)
(c) 3 Fe (s) + 4 H_2O (g) ⇋ Fe_3O_4 (s) + 4 H_2 (g)

Ans: (a) Because the forward reaction converts 1 mol of gas to 2 mol of gas, net reaction will go from reactants to products, thus increasing the number of moles of PCl_3 and Cl_2.

(b) Because there is 1 mol of gas on the reactant side of the balanced equation and none on the product side, the stress of a decrease in pressure is relieved by net reaction from products to reactants. The number of moles of $CaCO_3$ therefore decreases.

(c) Because there are 4 mol of gas on both sides of the balanced equation, the composi- ion of the equilibrium mixture is unaffected by a change in pressure. The number of moles of Fe_3O_4 and H_2 remains the same.

11. Which of the following statements is correct about the equilibrium constant?

A. Its value increases by increase in temperature

B. Its value decreases by decrease in temperature

C. Its value may increase or decrease with increase in temperature

D. Its value is constant at all temperature.

Ans : : Its value may increase or decrease with increase in temperature

12. Sulphanilic acid is a/an

A. Arrhenius acid

B. Lewis base

C. Neither (a) nor (b)

D. Both (a) and (b).

Ans Both (a) and (b).

13. A sample of $HI_{(g)}$ is placed in flask at a pressure of 0.2 atm. At equilibrium the partial pressure of $HI_{(g)}$ is 0.04 atm. What is K_p for the given equilibrium?

$2HI\ (g) \leftrightarrow H_2\ (g) + I_2\ (g)$

Ans: The initial concentration of HI is 0.2 atm. At equilibrium, it has a partial pressure of 0.04 atm. Therefore, a decrease in the pressure of HI is 0.2 – 0.04 = 0.16 . The given reaction is:

	$2HI_{(g)}$	$\longleftrightarrow$	$H_{2(g)}$	+	$I_{2(g)}$
Initial conc.	0.2 atm		0		0
At equilibrium	0.04 atm		$\frac{0.16}{2}$ $= 0.08$ atm		$\frac{2.15}{2}$ $= 0.08$ atm

Therefore,

$$K_p = \frac{p_{H_2} \times p_{I_2}}{p_{HI}^2}$$
$$= \frac{0.08 \times 0.08}{(0.04)^2}$$
$$= \frac{0.0064}{0.0016}$$
$$= 4.0$$

Hence, the value of K_p for the given equilibrium is 4.0.

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14. In the first step of the Ostwald process for the synthesis of nitric acid, ammonia is oxi- dized to nitric oxide by the reaction
$4\ NH_3(g) + 5\ O_2\ (g) \leftrightharpoons 4\ NO\ (g) + 6\ H_2O\ (g)\ \Delta H^0 = -\ 901.2\ KJ$ How does the equilibrium amount of NO vary with an increase in temperature?

Ans: Because the oxidation of ammonia is exothermic, we include the heat (901.2 kJ) on the product side :

$4\ NH_3(g) + 5\ O_2\ (g) \leftrightharpoons 4\ NO\ (g) + 6\ H_2O\ (g) + 901.2\ KJ$

The stress of added heat when the temperature is increased will be relieved by net reac- tion from products to reactants, which absorbs the added heat.The equilibrium will therefore shift to the reactant side (K_c will decrease) with an increase in temperature. Consequently, the equilibrium mixture will contain less NO at higher temperatures.

15. To a solution equimolar mixture of sodium acetate solution is added. The pH of mixture solution

A. increase

B. decreases

C. remains unchanged

D. unpredictable.

Ans (a) increase

16. The equlibrium constant expression for a gas reaction is, $K_c = \frac{[NH_3]^4[O_2]^3}{[NO]^4[H_2O]^6}$
Write the balanced chemical equation corresponding to this expression.

Ans: The balanced chmical equation corresponding to the given expression can be written as :
$4NO_{(g)} + 6H_2O(g) \leftrightarrow 4NH_{3(g)} + 5O_{2(g)}$

17. Equilibrium constant changes with

A. time

B. temperature

C. pressure

D. both temperature and concentration

Ans: (b) temperature

18. One mole of H_2O and one mole of CO are taken in 10 L vessel and heated to 725 K. At equilibrium
40% of water (by mass) reacts with CO according to the equation,
$H_2O(g) + CO(g) \leftrightarrow H_2(g) + CO_2(g)$

Calculate the equilibrium constant for the reaction.

Ans:

The given reaction is:

	$H_2O_{(g)}$	+	$CO_{(g)}$	$\longleftrightarrow$	$H_{2(g)}$	+	$CO_{2(g)}$
Initial conc.	$\frac{1}{10}$ M		$\frac{1}{10}$ M		0		0
At equilibrium	$\frac{1-0.4}{10}$ M $= 0.06$ M		$\frac{1-0.4}{10}$ M $= 0.06$ M		$\frac{0.4}{10}$ M $= 0.04$ M		$\frac{0.4}{10}$ M $= 0.04$ M

Therefore, the equilibrium constant for the reaction,

$$K_c = \frac{[H_2][CO_2]}{[H_2O][CO]}$$
$$= \frac{0.04 \times 0.04}{0.06 \times 0.06}$$
$$= 0.444 \text{ (approximately)}$$

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19. Under what conditions of temperature and pressure the formation of atomic hydrogen from molecular hydrogen will be favoured most.

A. High temperature and high pressure

B. High temperature and low pressure

C. Low temperature and low pressure
D. Low temperature and high pressure

Ans: (b) High temperature and low pressure
Explanation: High temperature and low pressure

20. The chemical system in equilibrium is not affected by

A. change in the concentration of products

B. increase in the concentration of reactants

C. addition of a catalyst

D. changing the temperature

Ans: (c) addition of a catalyst

21. Does the number of moles of reaction products increase, decrease or remain same when each of the following equilibria is subjected to a decrease in pressure by increasing the volume?

(a) PCl_5 (g) $\leftrightarrow$ PCl_3 (g) + Cl_2 (g)
(b) CaO (s) + CO_2 (g) $\leftrightarrow$ $CaCO_3$ (s)
(c) 3Fe (s) + $4H_2O$ (g) $\leftrightarrow$ Fe_3O_3 (s) + $4H_2$ (g)

Ans: (a) The number of moles of reaction products will increase. According to Le Chatelier's principle, if pressure is decreased, then the equilibrium shifts in the direction in which the number of moles of gases is more. In the given reaction, the number of moles of gaseous products is more than that of gaseous reactants. Thus, the reaction will proceed in the forward direction. As a result, the number of moles of reaction products will increase.

(b) The number of moles of reaction products will decrease.

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(c) The number of moles of reaction products remains the same.

22. Following gaseous reaction is undergoing in a vessel $C_2H_4 + H_2 \rightleftharpoons C_2H_6$ ΔH = -32.7 Kcal ; Which will increase the equilibrium concentration of C_2H_6

A. Increase of temperature
B. By removing some hydrogen
C. By reducing temperature
D. By adding some C_2H_6

Ans: (c) By reducing temperature
Explanation: Exothermic reaction, favoured by low temperature.

23. A substance X dissolves in water with a decrease in volume and absorption of heat solubility of X will be favoured by

A. low pressure high temp.

B. low temp. high pressure

C. low temp. low pressure

D. high temperature, high pressure

Ans (d) high temperature, high pressure

24. Write the conjugate acids for the following bronsted bases: NH_2^- NH_3 and $HCOO^-$,

Ans: The table below lists the conjugate acids for the given bronsted bases.

Bronsted base	Conjugate acid
NH_2^-	NH_3
NH_3	NH_4^+
$HCOO^-$	HCOOH

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25. 3.2 moles of hydrogen iodide were heated in a sealed bulb at 444 ^{0}C till the equilibrium state was reached. Its degree of dissociation at this temperature was found to be 22%. The number of moles of hydrogen iodide present at equilibrium are . [BHU 1982]
A. 2.496
B. 2
C. 1.87
D. 4

Answer: 2.496
Explanation: (22/100) * 3.2 = 0.704 (∴ at equil. moles of HI =3.2–0.704 = 2.496)

26. Which of the following aqueous solutions will have highest pH?

A. Sodium acetate

B. Sodium chloride

C. Ammonium phosphate

D. Calcium chloride.

Ans (a) Sodium acetate

27. The pH of a sample of vinegar is 3.76. Calculate the concentration of hydrogen ion in it.

Ans: Given, pH = 3.76
it is known that,
pH = - log[H^+]
⇒ log [H^+] = -pH
⇒ [H^+] = antilog (-pH)
= antilog (-3.76)
= 1.74 ×10^{-4} M
Hence, the concentratin of hydrogen ion in the given sample of vinegar is 1.74 × 10^{-4} M.