Equilibrium

Question1

For the reaction $N_2O_4(g) \rightleftharpoons 2NO_2(g)$, Kp = 0.492atm at 300K. K_c for the reaction at same temperature is $\times 10^{-2}$.

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

[29-Jan-2024 Shift 1]

Answer: 2

Solution:

$$K_p = K_C \cdot (RT)^{\Delta n_g}$$

$$\Delta n_g = 1$$

$$\Rightarrow K_c = \frac{K_P}{RT} = \frac{0.492}{0.082 \times 300} = 2 \times 10^{-2}$$

Question2

The following concentrations were observed at 500K for the formation of NH_3 from N_2 and H_2. At equilibrium :

$[N_2] = 2 \times 10^{-2}$M, $[H_2] = 3 \times 10^{-2}$M and $[NH_3] = 1.5 \times 10^{-2}$M. Equilibrium constant for the reaction is___

[29-Jan-2024 Shift 2]

Answer: 417

Solution:

$$K_C = \frac{[NH_3]^2}{[N_2][H_2]^3}$$

$$K_C = \frac{(1.5 \times 10^{-2})^2}{(2 \times 10^{-2}) \times (3 \times 10^{-2})^3}$$

$$K_C = 417$$

Question3

For the given reaction, choose the correct expression of K_C from the following :-

$$Fe_{(aq)}^{3+} + SCN_{(aq)}^{-} \rightleftharpoons (FeSCN)_{(aq)}^{2+}$$

[31-Jan-2024 Shift 1]

Options:

A.

$$K_C = \frac{[FeSCN^{2+}]}{[Fe^{3+}][SCN^-]}$$

B.

$$K_C = \frac{[Fe^{3+}][SCN^-]}{[FeSCN^{2+}]}$$

C.

$$K_C = \frac{[FeSCN^{2+}]}{[Fe^{3+}]^2[SCN^-]^2}$$

D.

$$K_C = \frac{[FeSCN^{2+}]^2}{[Fe^{3+}][SCN^-]}$$

Answer: A

Solution:

$$K_C = \frac{\text{Products ion conc.}}{\text{Reactants ion conc.}}$$

$$K_C = \frac{[FeSCN^{2+}]}{[Fe^{3+}][SCN^-]}$$

Question4

Given below are two statements :

Statement (I) : Aqueous solution of ammonium carbonate is basic.
Statement (II) : Acidic/basic nature of salt solution of a salt of weak acid and weak base depends on Ka and Kb value of acid and the base forming it.

In the light of the above statements, choose the most appropriate answer from the options given below :

[27-Jan-2024 Shift 1]

Options:

A.

Both Statement I and Statement II are correct

B.

Statement I is correct but Statement II is incorrect

C.

Both Statement I and Statement II are incorrect

D.

Statement I is incorrect but Statement II is correct

Answer: A

Solution:

Aqueous solution of $(NH_4)_2CO_3$ is Basic

pH of salt of weak acid and weak base depends on Ka and Kb value of acid and the base forming it

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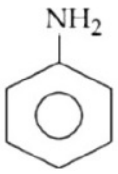
Question5

Which of the following is strongest Bronsted base?

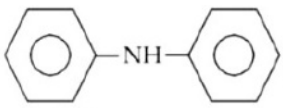
[27-Jan-2024 Shift 1]

Options:

A.



B.

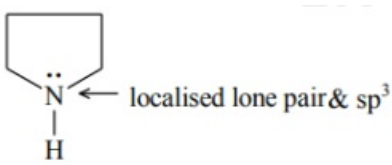


C.

D.

Answer: D

Solution:



Question6

The pH at which $Mg(OH)_2$[K sp = 1×10^{-11}] begins to precipitate from a solution containing 0.10M Mg^{2+} ions is___

[30-Jan-2024 Shift 1]

Answer: 9

Solution:

Precipitation when $Q_{sp} = K_{sp}$

$[Mg^{2+}][OH^-]^2 = 10^{-11}$

$0.1 \times [OH^-]^2 = 10^{-11} \Rightarrow [OH^-] = 10^{-5}$

$\Rightarrow pOH = 5 \quad \Rightarrow pH = 9$

Question7

The pH of an aqueous solution containing 1M benzoic acid (pKa = 4.20) and 1M sodium benzoate is 4.5. The volume of benzoic acid solution in 300 mL of this buffer solution is_____ mL.

[30-Jan-2024 Shift 2]

Answer: 100

Solution:

	1M Benzoic acid (V_a ml)	+	1M Sodium Benzoate (V_s ml)
Millimole	$V_a \times 1$		$V_s \times 1$

$pH = 4.5$

$$pH = pka + \log \frac{[salt\ ]}{[\ acid\ ]}$$

$$4.5 = 4.2 + \log\left(\frac{V_s}{V_a}\right)$$

$$\frac{V_s}{V_a} = 2 \ldots\ldots(1)$$

$V_s + V_a = 300 \ldots\ldots(2)$

$V_a = 100\ ml$

Question8

Ka for CH_3COOH is 1.8×10^{-5} and Kb for NH_4OH is 1.8×10^{-5}. The pH of ammonium acetate solution will be

[1-Feb-2024 Shift 1]

Answer: 7

Solution:

$$pH = \frac{pK_w + pK_a - pK_b}{2}$$

$pK_a = pK_b$

$$\Rightarrow pH = \frac{pK_w}{2} = 7$$

Question9

Solubility of calcium phosphate (molecular mass, M) in water is W_g per 100mL at 25°C. Its solubility product at 25°C will be approximately.

[1-Feb-2024 Shift 2]

Options:

A.

$10^7\left(\frac{W}{M}\right)^3$

B.

$10^7\left(\frac{W}{M}\right)^5$

C.

$10^3\left(\frac{W}{M}\right)^5$

D.

$10^5\left(\frac{W}{M}\right)^5$

Answer: B

Solution:

$$S = \frac{W \times 10}{M}$$

$$Ca_3(PO_4)_2(s) \rightleftharpoons \underset{3s}{3Ca^{2+}(aq.)} + \underset{2s}{2PO_4^{3-}(aq.)}$$

$$S = \frac{W \times 1000}{M \times 100} = \frac{W \times 10}{M}$$

$$K_{sp} = (3s)^3(2s)^2$$

$$= 108\, s^5$$

$$= 108 \times 10^5 \times \left(\frac{W}{M}\right)^5$$

$$= 1.08 \times 10^7\left(\frac{W}{M}\right)^5$$

Question10

The dissociation constant of acetic is $x \times 10^{-5}$. When 25 mL of 0.2M CH_3COONa solution is mixed with 25 mL of 0.02 M CH_3COOH solution, the pH of the resultant solution is found to be equal to 5 . The value of x is___
[24-Jan-2023 Shift 1]

Answer: 10

Solution:

Solution:
Buffer of HOAc and NaOAc

$$pH = pKa + \log\frac{0.1}{0.01}$$

$$5 = pKa + 1$$

$$pKa = 4$$

$$Ka = 10^{-4}$$

$x = 10$

Question11

If the pKa of lactic acid is 5 , then the pH of 0.005M calcium lactate solution at 25°C is _____$\times 10^{-1}$ (Nearest integer)

Lactic acid

[24-Jan-2023 Shift 2]

Answer: 85

Solution:

Concentration of calcium lactate $= 0.005$M,: concentration of lactate ion $= (2 \times 0.005)$M. Calcium lactate is a salt of weak acid + strong base ∴ Salt hydrolysis will take place.

$$pH = 7 + \frac{1}{2}(pKa + \log C)$$

$$= 7 + \frac{1}{2}(5 + \log(2 \times 0.005))$$

$$= 7 + \frac{1}{2}[5 - 2\log 10] = 7 + \frac{1}{2} \times 3 = 8.5 = 85 \times 10^{-1}$$

Question12

A litre of buffer solution contains 0.1 mole of each of NH_3 and NH_4Cl. On the addition of 0.02 mole of HCl by dissolving gaseous HCl, the pH of the solution is found to be _____ $\times 10^{-3}$(Nearest integer)

[. Given : $pK_b(NH_3) = 4.745$

$\log 2 = 0.301$

$\log 3 = 0.477$

T = 298K]

[25-Jan-2023 Shift 1]

Answer: 9079

Solution:

In resultant solution

$$n_{NH_3} = 0.1 - 0.02 = 0.08$$

$$n_{NH_4Cl} = n_{NH_4^+} = 0.1 + 0.02 = 0.12$$

$$pOH = pKb_b + \log \frac{[NH_4^+]}{[NH_3]}$$

$$= 4.745 + \log \frac{0.12}{0.08}$$

$$= 4.745 + \log \frac{3}{2}$$

$$= 4.745 + 0.477 - 0.301$$

$$pOH = 4.921$$

$$pH = 14 - pH$$

$$= 9.079$$

Question13

When the hydrogen ion concentration $[H^+]$changes by a factor of 1000 , the value of pH of the solution _____.
[25-Jan-2023 Shift 2]

Options:

A. increases by 1000 units

B. decreases by 3 units

C. decreases by 2 units

D. increases by 2 units

Answer: B

Solution:

$\Delta [H^+] = 1000$
$\Delta pH = -\log \Delta [H^+] = -\log 10^3$
$= -3$

Question14

Match List I with List II

List I (Amines)	List II (pK_b)
A. Aniline	I. 3.25
B. Ethanamine	II. 3.00
C. N-Ethylethanamine	III. 9.38
D. N, N-Diethylethanamine	IV. 3.29

Choose the correct answer from the options given below :-
[25-Jan-2023 Shift 2]

Options:

A. A-I, B-IV, C-II, D-III

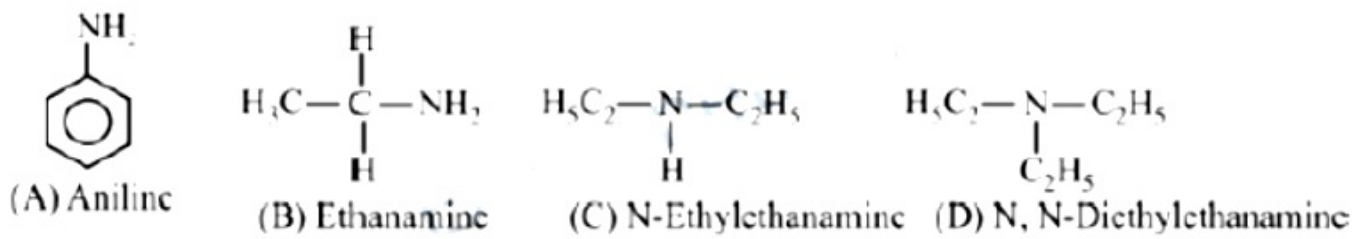
B. A-III, B-II, C-I, D-IV

C. A-III, B-II, C-IV, D-I

D. A-III, B-IV, C-II, D-I

Answer: D

Solution:



(A) Aniline (B) Ethanamine (C) N-Ethylethanamine (D) N, N-Diethylethanamine

Basic Strength $\alpha \frac{1}{pK_b}$

Order for pK_b : A > B > D > C

Question15

Millimoles of calcium hydroxyide required to produce 100 mL of the aqueous solution of pH 12 is $x \times 10^{-1}$. The value of x is _____(Nearest integer).
Assume complete dissociation.
[29-Jan-2023 Shift 1]

Answer: 5

Solution:

$\because$ pH = 12
$\therefore [H^+] = 10^{-12}M$
$\therefore [OH^-] = 10^{-2}M$
$\therefore [Ca(OH)_2] = 5 \times 10^{-3}M$

$$5 \times 10^{-3} = \frac{\text{milli moles of Ca (OH)}_2}{100\,\text{mL}}$$

$$\text{milli moles of } Ca(OH)_2 = 5 \times 10^{-1}$$

Question16

600 mL of 0.01M HCl is mixed with 400 mL of 0.01M H_2SO_4. The pH of the mixture is _____ $\times 10^{-2}$. (Nearest integer)
[Given log 2 = 0.30, log 3 = 0.48
log 5 = 0.69 log 7 = 0.84
log 11 = 1.04]
[30-Jan-2023 Shift 1]

Answer: 186

Solution:

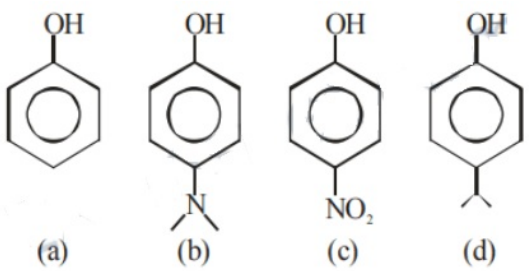
Total milimoles of $H^+ = (600 \times 0.01) + (400 \times 0.01 \times 2)$
$= 14$

$$[H^+] = \frac{14}{1000} = 14 \times 10^{-3}$$

$$pH = 3 - \log 14$$
$$= 1.86$$
$$= 186 \times 10^{-2}$$

Question17

The correct order of pK_a values for the following compounds is:



(a) (b) (c) (d)

[30-Jan-2023 Shift 2]

Options:

A. c > a > d > b

B. b > d > a > c

C. b > a > d > c

D. a > b> c > d

Answer: B

Solution:

Solution:
Due to $-M$ effect of $-NO_2$ group, it increases acidity $+M$ effect of $N(CH_3)_2$ decreases acidity.
Hyperconjugation of isopropyl decrease acidity
$\therefore$ order of acidic strength
(c) > (a) > (d) > (b)

Question18

The logarithm of equilibrium constant for the reaction $Pd^{2+} + 4Cl^- \rightleftharpoons PdCl_4^{2-}$ is _____ (Nearest integer)

Given : $\frac{2.303\,RT}{F} = 0.06V$

$Pd_{(aq)}^{2+} + 2e^- \rightleftharpoons Pd(s)$ $E^\circ = 0.83V$

$PdCl_4^{2-}(aq) + 2e^- \rightleftharpoons Pd(s) + 4Cl^-(aq)$

$E^\circ = 0.65V$

[31-Jan-2023 Shift 1]

Answer: 6

Solution:

Sol. $\Delta G^\circ = -RT\ell n\,K$

$-nFE_{cell}^{0} = -RT \times 2.303(\log_{10}K)$

$\frac{E_{Cell}^{0}}{0.06} \times n = \log K \ldots (1)$

Pd^{+2} (aq.) + not mathcal $Le^- \rightleftharpoons Pd(s)$, $E_{cat,red}^{\circ} = 0.83$

$Pd(s) + 4Cl^-$ (aq.) $\rightleftharpoons PdCl_4^{2-}$, (aq) + $2e^-$, $E_{mat.ouir}^{0} = 0.65$

Net Reaction $\rightarrow Pd^{2+}$ (aq.) $+ 4Cl^-$ (aq.) $\rightleftharpoons PdCl_4^{2-}$ (aq.)

$E_{cell}^{\circ} = E_{cat,red}^{\circ} - E_{Alode\ ,\ 0cd^a}^{\circ}$

$E_{cell}^{\circ} = 0.83 - 0.65$

$E_{cell}^{\circ} = 0.18 \ldots (2)$

Also $n = 2 \ldots (3)$

Using equation (1), (2) & (3)

$\log K = 6$

Question19

Incorrect statement for the use of indicators in acid-base titration is :
[31-Jan-2023 Shift 2]

Options:

A. Methyl orange may be used for a weak acid vs weak base titration.

B. Methyl orange is a suitable indicator for a strong acid vs weak base titration

C. Phenolphthalein is a suitable indicator for a weak acid vs strong base titration

D. Phenolphthalein may be used for a strong acid vs strong base titration.

Answer: A

Solution:

Methyl orange may be used for a strong acid vs strong base and strong acid vs weak base titration. Phenolpthalein may be used for a strong acid vs strong base and weak acid vs strong base titration.

Question20

At 298K, the solubility of silver chloride in water is $1.434 \times 10^{-3} gL^{-1}$. The value of $-\log K_{sp}$ for silver chloride is

(Given mass of Ag is $107.9 gmol^{-1}$ and mass of Cl is _____ $35.5 gmol^{-1}$)
[31-Jan-2023 Shift 2]

Answer: 10

Solution:

$$AgCl(s) \rightarrow \underset{S}{Ag^{+}}(aq.) + \underset{Cl}{Cl^{-}}(aq.)$$

$$K_{sp} = S^2 = \left(\frac{1.43}{143.4} \times 10^{-3}\right)^2 = 10^{-10}$$

$$-\log K_{sp} = 10$$

Question21

Consider the following reaction approaching equilibrium at 27°C and 1 atm pressure

$$A + B \underset{K_r = 10^2}{\overset{K_f = 10^3}{\rightleftharpoons}} C + D$$

The standard Gibb's energy change ($\Delta_r G^\circ$) at 27°C is (-) _____ $kJ\,mol^{-1}$
(Nearest integer).
(Given : $R = 8.3 JK^{-1}mol^{-1}$ and $\ln 10 = 2.3$)
[29-Jan-2023 Shift 1]

Answer: 6

Solution:

Solution:

$$\because \Delta G^\circ = -RT \ln K_{eq}$$

$$\text{and } K_{eq} = \frac{K_f}{K_b}$$

$$\therefore K_{eq} = \frac{10^3}{10^2} = 10$$

$$\therefore \Delta G = -RT \ln 10$$

$$\Rightarrow -(8.3 \times 300 \times 2.3) = -5.7\,kJ\,mole = 6\,kJ\,mole^{-1}(\text{nearest integer})$$

Ans = 6

Question22

At 298K

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$, $K_1 = 4 \times 10^5$

$N_2(g) + O_2(g) \rightleftharpoons 2\,NO(g)$, $K_2 = 1.6 \times 10^{12}$

$H_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons H_2O(g)$, $K_3 = 1.0 \times 10^{-13}$

Based on above equilibria, the equilibrium constant of the reaction, $2NH_3(g) + \frac{5}{2}O_2(g) \rightleftharpoons 2NO(g) + 3H_2O(g)$ is _____ $\times 10^{-33}$ (Nearest integer)
[29-Jan-2023 Shift 2]

Answer: 4

Solution:

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$, $K_1 = 4 \times 10^5$ . . . (i)

$N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$, $K_2 = 1.6 \times 10^{12}$... (ii)

$H_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons H_2O(g)$, $K_3 = 1.0 \times 10^{-13}$... (iii)

(ii) + 3 × (iii) − (i)

$2NH_3(g) + \frac{5}{2}O_2(g) \rightleftharpoons 2NO(g) + 3H_2O(g)$

$k_{eq} = \frac{k_2 \times k_3^3}{k_1} = \frac{1.6 \times 10^{12} \times (10^{-13})^3}{4 \times 10^5}$

$= \frac{1.6}{4} \times 10^{-32} = 4 \times 10^{-33}$

Question23

Consider the following equation:
$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$, $\Delta H = -190\,kJ$
The number of factors which will increase the yield of SO_3 at equilibrium from the following is _____
A. Increasing temperature
B. Increasing pressure
C. Adding more SO_2
D. Adding more O_2
E. Addition of catalyst
[30-Jan-2023 Shift 2]

Answer: 3

Solution:

The yield of SO_3 at equilibrium will be due to:
B. Increasing pressure
C. Adding more SO_2
D. Adding more O_2

Question24

For reaction: $SO_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons SO_3(g)$ $K_P = 2 \times 10^{12}$ at 27°C and 1 atm pressure. The K_c for the same reaction is _____ $\times 10^{13}$. (Nearest integer)
(Given R = $0.082\,L\,atm\,K^{-1}\,mol^{-1}$)
[31-Jan-2023 Shift 1]

Answer: 1

Solution:

$SO_{2(g)} + \frac{1}{2}O_{2(g)} \rightleftharpoons SO_{3(g)}$

$K_p = 2 \times 10^{12}$ at 300K

$K_P = K_C \times (RT)^{\Delta n_g}$

$2 \times 10^{12} = K_c \times (0.082 \times 300)^{-1/2}$

$K_C = 9.92 \times 10^{12}$

$K_C = 0.992 \times 10^{13}$

Ans. 1

Question25

For independent process at 300 K.

Process	$\Delta H / kJ\,mol^{-1}$	$\Delta S / JK^{-1}$
A	−25	−80
B	−22	40
C	25	−50
D	22	20

The number of non-spontaneous process from the following is___
[24-Jan-2023 Shift 1]

Answer: 2

Solution:

$\Delta G = \Delta H - T\Delta S$

$A : \Delta G(Jmol^{-1}) = -25 \times 10^3 + 80 \times 300 : -ve$

$B : \Delta G(Jmol^{-1}) = -22 \times 10^3 - 40 \times 300 : -ve$

$C : \Delta G(Jmol^{-1}) = 25 \times 10^3 + 300 \times 50 : +ve$

$D : \Delta G(Jmol^{-1}) = 22 \times 10^3 - 20 \times 300 : +ve$

Processes C and D are non-spontaneous.

Question26

Water decomposes at 2300K
$H_2O(g) \rightarrow H_2(g) + \frac{1}{2}O_2(g)$
The percent of water decomposing at 2300K and 1 bar is _____ (Nearest integer).
Equilibrium constant for the reaction is 2×10^{-3} at 2300K
[29-Jan-2023 Shift 1]

Answer: 2

Solution:

$H_2O(g) \rightleftharpoons H_2(g) + \frac{1}{2}O_2(g)$

$P_0[1-\alpha]$ $P_0\alpha$ $\frac{P_0\alpha}{2}$ partial pr. at eq.

$P_0\left[1 + \frac{\alpha}{2}\right] = 1 \ldots (i)$

$$K_p = \frac{(P_{H_2})(P_{O_2})^{1/2}}{P_{H_2O}}$$

$$\frac{(P_0\alpha)\left(\frac{P_0\alpha}{2}\right)^{1/2}}{P_0[1-\alpha]} = 2 \times 10^{-3}$$

since α is negligible w.r.t 1 so $P_0 = 1$ and $1 - \alpha \approx 1$

$$\frac{\alpha\sqrt{\alpha}}{\sqrt{2}} = 2 \times 10^{-3}$$

$$\alpha^{3/2} = 2^{3/2} \times 10^{-3}$$

$$\alpha = 2^{3/2 \times 2/3} \times 10^{-3 \times 2/3}$$

$$\alpha = 2 \times 10^{-2} \quad \%\alpha = 2\%$$

Question27

At 25˚C, the enthalpy of the following processes are given:

$H_2(g) + O_2(g) \rightarrow 2\,OH(g)\ \Delta H^0 = 78\,kJ\,mol^{-1}$

$H_2(g) + 1/2O_2(g) \rightarrow H_2O(g)\ \Delta H^0 = -242\,kJ\,mol^{-1}$

$H_2(g) \rightarrow 2H(g)\ \Delta H^0 = 436\,kJ\,mol^{-1}$

$1/2O_2(g) \rightarrow O(g)\ \Delta H^0 = 249\,kJ\,mol^{-1}$

What would be the value of X for the following reaction? _____ (Nearest integer)

$H_2O(g) \rightarrow H(g) + OH(g)\ \Delta H^o = X\,kJ\,mol^{-1}$

[1-Feb-2023 Shift 1]

Answer: 499

Solution:

$$2H_2O(g) \rightarrow 2H_2(g) + O_2(g) + (242 \times 2)\,kJ\,mol^{-1}$$

$$H_2(g) + O_2(g) \rightarrow 2\,OH + 78\,kJ\,mol^{-1}$$

$$H_2(g) \rightarrow 2H + 436\,kJ\,mol^{-1}$$

$$2H_2O \rightarrow 2H + 2\,OH + 998\,kJ\,mol^{-1}$$

$$H_2O \rightarrow H + OH \quad 998 \times \frac{1}{2} = +499\,kJ\,mol^{-1}$$

Question28

(i) $X(g) \rightleftharpoons Y(g) + Z(g) K_{p1} = 3$

(ii) $A(g) \rightleftharpoons 2B(g)\ K_{p2} = 1$

If the degree of dissociation and initial concentration of both the reactants X (g) and A(g) are equal, then the ratio of the total pressure at equilibrium $\left(\frac{p_1}{p_2}\right)$ is equal to x : 1. The value of x is _____ (Nearest integer)

[1-Feb-2023 Shift 1]

Answer: 12

Solution:

$x(g) \rightleftharpoons y(g) + z(g)\ k_{p_1} = 3$

Initial moles	n	–	–
at equilibrium	n − αn	αn	αn

$$k_{p_1} = \frac{\left(\frac{\alpha}{1+\alpha} \times p_1\right)^2}{\frac{1-\alpha}{1+\alpha} p_1}$$

$$3 = \frac{\alpha^2 \times p_1}{1-\alpha^2}$$

$A(g) \rightleftharpoons 2B(g)\ k_{p_2} = 1$

Initial mole $n\ -$

at equilibrium $x - \alpha n\ 2\alpha n\ p_{total} = p_2$

$$k_{p_2} = \frac{\left(\frac{2\alpha}{1+\alpha} \times p_2\right)^2}{\frac{1-\alpha}{1+\alpha} \times p_2}$$

$$1 = \frac{4\alpha^2 \times p_2}{1-\alpha^2}$$

$$\frac{k_{p_1}}{k_{p_2}} = \frac{p_1}{4p_2}$$

$$\frac{3}{1} = \frac{p_1}{4p_2} \quad \therefore p_1 : p_2 = 12 : 1$$

$x = 12$

Question29

The effect of addition of helium gas to the following reaction in equilibrium state, is : $PCI_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$

[1-Feb-2023 Shift 2]

Options:

A. the equilibrium will shift in the forward direction and more of Cl_2 and PCl_3 gases will be produced.

B. the equilibrium will go backward due to suppression of dissociation of PCl_5.

C. helium will deactivate PCl_5 and reaction will stop.

D. addition of helium will not affect the equilibrium.

Answer: 0

Solution:

Solution:

$PCI_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$

(Case 1 : At constant P - volume will increase so reaction will shift in forward direction then answer will be A

Case 2 : At constant volume no change in active mass so reaction will not shift in any direction then answer will be D.

Question30

For a concentrated solution of a weak electrolyte (K_{eq} = equilibrium constant) A_2B_3 of concentration ' c ', the degree of dissociation " α ' is

[6-Apr-2023 shift 1]

Options:

A. $\left(\frac{K_{eq}}{108c^4}\right)^{\frac{1}{5}}$

B. $\left(\frac{K_{eq}}{6c^5}\right)^{\frac{1}{5}}$

C. $\left(\frac{K_{eq}}{5c^4}\right)^{\frac{1}{5}}$

D. $\left(\frac{K_{eq}}{25c^2}\right)^{\frac{1}{5}}$

Answer: A

Solution:

$A_2B_3\ (aq.) \rightleftharpoons 2A_{(aq.)}^{3+} + 3B_{(aq)}^{2-}$
$c(1-\alpha)\ \ 2c\alpha\ \ 3c\alpha$
$K_{eq} = \frac{[A^{3+}]^2[B^{2-}]^3}{[A_2B_3]} = \frac{4c^2\alpha^2 \times 27c^3\alpha^3}{c(1-\alpha)}$

$K_{eq} = = \frac{108c^5\alpha^5}{c}\alpha = \left(\frac{K_{eq}}{108c^4}\right)\frac{1}{5}$

Question31

The number of correct statement/s involving equilibria in physical from the following is _____

[10-Apr-2023 shift 1]

Options:

A. Equilibrium is possible only in a closed system at a given temperature.

B. Both the opposing processes occur at the same rate.

C. When equilibrium is attained at a given temperature, the value of all its parameters

D. For dissolution of solids in liquids, the solubility is constant at a given temperature.

Answer: C

Solution:

Solution:
(A) is correct
(B) for equilibrium $r_f = r_b \Rightarrow$(B) is correct
(C) at equilibrium the value of parameters become constant of a given temperature and not equal $\Rightarrow$(C) is incorrect
(D) for a given solid solute and a liquid solvent solubility depends upon temperature only $\Rightarrow$(D) is correct

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Question32

The equilibrium composition for the reaction $PCl_3 + Cl_2 \rightleftharpoons PCl_5$ at 298K is given below.
$[PCl_3]_{eq} = 0.2\,mol\,L^{-1}$ $[Cl_2]_{eq} = 0.1\,mol\,L^{-1}$,
$[PCl_5]_{eq} = 0.40\,mol\,L^{-1}$
If $0.2\,mol$ of Cl_2 is added at the same temperature, the equilibrium concentrations of PCl_5 is _____ $\times 10^{-2}\,mol\,L^{-1}$.
Given : K_c for the reaction at 298K is 20
[6-Apr-2023 shift 2]

Answer: 48

Solution:

$PCl_3 + Cl_2 \rightleftharpoons PCl_5$
$0.2M\ \ (0.1+0.2)M\ \ 0.4M$
$Eq^m \cdot 0.2-x\ \ 0.3-x\ \ 0.4+x$
$\frac{(0.4+x)}{(0.2-x)(0.3-x)} = 20$
$\Rightarrow x \simeq 0.086$
$[PCl_5]_{eq} = 0.486M = 48.6 \times 10^{-2}M$

Question33

A mixture of 1 mole of H_2O and 1 mole of CO is taken in a 10 litre container and heated to 725K. At equilibrium 40% of water by mass reacts with carbon monoxide according to the equation : $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$. The equilibrium constant $K_e \times 10^2$ for the reaction is _____ (Nearest integer)
[11-Apr-2023 shift 1]

Answer: 44

Solution:

$$\underset{1\text{ mole}}{CO(g)} + \underset{1\text{ mole}}{H_2O(g)} \rightleftharpoons CO_2(g) + H_2(g)$$

$$K_c = \frac{0.4 \times 0.4}{0.6 \times 0.6} = \frac{4}{9}$$

$$K_c \times 10^2 = \frac{4}{9} \times 100 = \frac{400}{9} = 44.44 \approx 44$$

Question34

4.5 moles each of hydrogen and iodine is heated in a sealed ten litre vessel. At equilibrium, 3 moles of HI were found. The equilibrium constant for $H_2(g) + I_2(g) \rightleftharpoons 2\,HI(g)$ is _____
[11-Apr-2023 shift 2]

Answer: 1

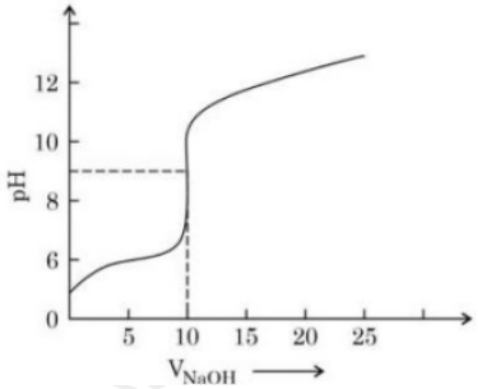
Solution:

	$H_{2(g)}$	$+ I_{2(g)}$	$\rightleftharpoons$	$2HI_{(g)}$
$t = 0$	4.5	4.5		–
t_{eq}	3	3		3

$$K_c = \frac{[HI]^2}{[H_2][I_2]} = \frac{(3)^2}{3 \times 3} = \frac{9}{9} = 1$$

Question35

The titration curve of weak acid vs. strong base with phenolphthalein as indictor) is shown below. The $K_{phenolphthalein} = 4 \times 10^{-10}$
Given : $\log 2 = 0.3$



The number of following statements/s which is/are correct about phenolphthalein is

_____

[8-Apr-2023 shift 1]

Options:

A. It can be used as an indicator for the titration of weak acid with weak base.

B. It begins to change colour at pH = 8.4

C. It is a weak organic base

D. It is colourless in acidic medium

Answer: B

Solution:

(B) $pk_n = -\log(4 \times 10^{-10}) = 9.4$
Indicator range
$\Rightarrow pk_{In} \pm 1$
i.e. 8.4 to 10.4
(D) In acidic medium, phenolphthalein is in unionized form and is colourless.

Question36

Given below are two statements :
Statement I : Methyl orange is a weak acid.
Statement II : The benzenoid form of methyl orange is more intense/deeply coloured than the quinonoid form.
In the light of the above statement, choose the most appropriate answer from the options given below:
[8-Apr-2023 shift 2]

Options:

A. Both statement I and statement II are incorrect

B. Both statement I and Statement II are correct

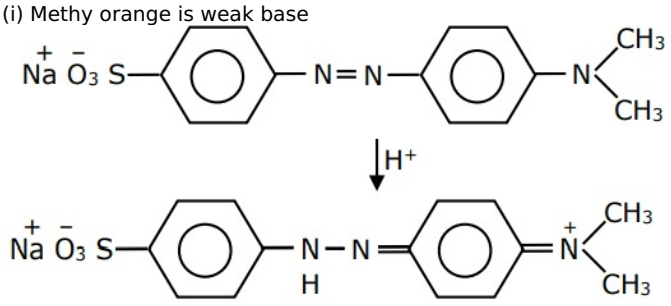
C. Statement I is correct but statement II is incorrect

D. Statement I is incorrect but statement II is correct

Answer: A

Solution:

(i) Methy orange is weak base



(ii) So both statement are false

Question37

The solubility product of $BaSO_4$ is _____ 1×10^{-10} at 298K. The solubility of $BaSO_4$ in $0.1M K_2SO_4$ (aq) solut is $\times 10^{-9} gL^{-1}$ (Nearest integer)
Given: Molar mass of $BaSO_4$ is $233 gmol^{-1}$
[8-Apr-2023 shift 2]

Answer: 233

Solution:

$K_{sp} = x(x + 0.1) = 10^{-10}$
$0.1x = 10^{-10}$
$x = 10^{-9}M$
$x(\text{ in } g/l) = 233 \times 10^{-9}$

Question38

An analyst wants to convert 1L HCl of pH = 1 to a solution of HCl of pH 2. The volume of water needed to do this dilution is _____ mL. (Nearest integer)
[12-Apr-2023 shift 1]

Answer: 9000

Solution:

$(M_1 \times V_1)\ (M_2 \times V_2)$
$-1 \quad = \quad -2$
$10 \times 1\ 10 \times V_2$
$V_2 = 10L$
Water added $= 10 - 1$
$= 9$ Litre
$= 9000$ mL

Question39

25.0 mL of 0.050 M $Ba(NO_3)_2$ is mixed with 25.0 mL of 0.020M NaF . K_{sp} of BaF_2 is 0.5×10^{-6} at 298K. The ratio of $[Ba^{2+}][F^-]^2$ and K_{sp} is _____ . (Nearest integer)
[13-Apr-2023 shift 1]

Answer: 5

Solution:

$[Ba^{+2}] = \frac{25 \times 0.05}{50} = 0.025M$
$[F^-] = \frac{25 \times 0.02}{50} = 0.01M$
$[Ba^{+2}][F^-]^2 = 25 \times 10^{-7}$
$K_{sp} = 5 \times 10^{-7}$ (given)
Ratio $= \frac{[Ba^{+2}][F^-]^2}{K_{sp}} = 5$

Question40

20 mL of 0.1M NaOH is added to 50 mL of 0.1M acetic acid solution. The pH of the resulting solution is _____ $\times 10^{-2}$ (Nearest integer)
Given : $pKa(CH_3COOH) = 4.76$

log 2 = 0.30
log 3 = 0.48
[13-Apr-2023 shift 2]

Answer: 458

Solution:

	$CH_3COOH + NaOH \rightarrow$		CH_3COONa	$+ H_2O$
Initially	5mmol	2mmol	0	0
after Rxn	3mmol	0	2 mmole	2 mmole

$$pH = pKa + \log_{10}\frac{[\text{ salt }]}{[\text{ acid }]}$$
$$pH = 4.76 + \log_{10}\frac{2}{3}$$
$$pH = 4.58 = 458 \times 10^{-2}$$

Question41

Which of the following statement(s) is/are correct?
(A) The pH of 1×10^{-8}M HCl solution is 8
(B) The conjugate hase of $H_2PH_4^-$is HPO_4^{2-}
(C) K_w increases with increase in temperature.
(D) When a solution of a weak monoprotic acid is titrated against a strong base at half neutralisation point.
pH = $\frac{1}{2}pK_a$
Choose the correct answer from the options given below
[15-Apr-2023 shift 1]

Options:

A. (A), (B). (C)

B. (A), (D)

C. (B), (C)

D. (B), (C). (D)

Answer: D

Solution:

Solution:
(A) pH of 10^{-8}M HCl in acidic range (6.98).
(B) Conjugate Base of $H_2PO_4^-$is HPO_4^{2-}
(C) K_w increases with increasing Temperature, as the temperature increases, the dissociation of water increases.
(D) At half neutralization point, half of the acid is present in the from salt.
$pH = Pk_a + \log\frac{1}{1} = Pk_a$

Question42

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:
[24-Jun-2022-Shift-1]

Options:

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

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

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

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

Answer: B

Solution:

	$A(g)$	$\rightleftharpoons$	$B(g)$	$+$	$\frac{1}{2}C(g)$	Total Moles
Att = 0:	1		0		0	1
Att = t_{req}:	$1-\alpha$		α		$\frac{\alpha}{2}$	1
Mole Fraction:	$\frac{\alpha}{1+\frac{\alpha}{2}}$		$\left(\frac{1-a}{1+\frac{a}{2}}\right)$		$P\left(\frac{2}{2}\right)P$	

Now,

$$K_P \text{ or } K = \frac{P_B \times (P_C)^{\frac{1}{2}}}{P_A}$$

$$= \frac{\left(\frac{\alpha}{1+\frac{\alpha}{2}}\right)P \times \left[\left(\frac{\frac{\alpha}{2}}{1+\frac{\alpha}{2}}\right)P\right]^{\frac{1}{2}}}{\left(\frac{1-\alpha}{1+\frac{\alpha}{2}}\right)P}$$

$$= \frac{\left(\frac{2\alpha}{2+\alpha}\right)P \times \left[\left(\frac{\alpha}{2+\alpha}\right)P\right]^{\frac{1}{2}}}{\left(\frac{2(1-\alpha)}{2+\alpha}\right)P}$$

$$= \frac{\alpha}{1-\alpha} \times \left(\frac{\alpha P}{2+\alpha}\right)^{\frac{1}{2}}$$

$$= \frac{\alpha^{\frac{3}{2}} \cdot P^{\frac{1}{2}}}{(1-\alpha)(2+\alpha)^{\frac{1}{2}}}$$

Question43

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 prẽššure is 2.46 atm. The equilibrium constant K_p for the dissociation of PCl_5 is ____$\times 10^{-3}$. (nearest integer)
(Given : R = 0.082Latm^{-1}mol^{-1}; Assume ideal gas behaviour)
[24-Jun-2022-Shift-2]

Answer: 1107

Solution:

	$PCl_5(g)$	$\rightleftharpoons$	$PCl_3(g)$ +	$Cl_2(g)$	Total Moles
At t = 0 :	5		0	0	5 + 2 (For N_2 gas) = 7
At $t = t_{eq}$:	5 − x		x	x	5 − x + x + x + 2 (For N_2 gas) = 7 + x
Mole Fraction :	$\frac{5-x}{7+x}$		$\frac{5-x}{7+x}$	$\frac{5-x}{7+x}$	
Partial pressure :	$\left(\frac{5-x}{7+x}\right)P$		$\left(\frac{x}{7+x}\right)P$	$\left(\frac{x}{7+x}\right)P$	

Here 2 moles of N_2 also present that is why 2 moles always have to add in total mole calculation.
At equilibrium,
Pressure (P) = 2.46 atm
Volume (V) = 200L
Temperature (T) = 600K
∴ Applying ideal gas equation,
PV = nRT
⇒2.46 × 200 = (7 + x) × 0.082 × 600
⇒x = 3
Now,

$$K_P = \frac{P_{PCl_3} \times P_{Cl_2}}{P_{PCl_5}}$$

$$= \frac{\left[\frac{3}{7+3} \times 2.46\right]\left[\frac{3}{7+3} \times 2.46\right]}{\left[\frac{5-3}{7+3} \times 2.46\right]}$$

$$= \frac{\frac{3}{10} \times \frac{3}{10} \times (2.46)^2}{\frac{2}{10} \times 2.46}$$

$$= \frac{9}{20} \times 2.46$$

$$= 1107 \times 10^{-3}\,\text{atm}$$

Question44

The standard free energy change (ΔG°) for 50% dissociation of N_2O_4 into NO_2 at 27°C and 1 atm pressure is $-x\,J\,mol^{-1}$. The value of x is_____ (Nearest Integer)
[Given : .R = $8.31\,JK^{-1}mol^{-1}$, log 1.33 = 0.1239 ln 10 = 2.3]
[25-Jun-2022-Shift-1]

Answer: 710

Solution:

	N_2O_4	$\rightleftharpoons$	$2NO_2$
t = 0	1 mol		
t = t	(1-0.5) mol		0.5×2 mol
	= 0.5 mol		1 mol

$$k_P = \frac{\left(\frac{1}{1.5} \times 1\right)^2}{\left(\frac{0.5}{1.5} \times 1\right)} = \frac{1}{0.75} = \frac{100}{75}$$

$$= 1.33$$

$$\Delta G^0 = -RT\ell nk_P$$

$$= -8.31 \times 300 \times \ln(1.33) = -710.45\,J/mol$$

$$= -710\,J/mol$$

Question45

$2\,NOCl(g) \rightleftharpoons 2\,NO(g) + Cl_2(g)$

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_____ $\times 10^{-4}$

[27-Jun-2022-Shift-1]

Answer: 125

Solution:

$$2\,NOCl(g) \rightleftharpoons 2\,NO(g) + Cl_2(g)$$

At $t = 0$: 2 0 0

At $t = t_{eq}$: $2 - 2x$ $2x$ 0

Given that at equilibrium, concentration of $NO = 0.4\,mol\,/\,L$

$\therefore 2x = 0.4$

$\Rightarrow x = 0.2$

$\therefore$ Concentration of NOCl at equilibrium,

$[NOCl]_{eq} = 2 - 2 \times 0.2 = 1.6$

and $[NO]_{eq} = 0.4$

and $[Cl_2]_{eq} = 0.2$

We know,

$$K_C = \frac{[NO]^2[Cl_2]}{[NOCl]^2}$$

$$= \frac{[0.4]^2[0.2]}{[1.6]^2}$$

$\Rightarrow K_C = 12.5 \times 10^{-3}$

$\Rightarrow K_C = 125 \times 10^{-4}$

Question46

4.0 moles of argon and 5.0 moles of PCl_5 are introduced into an evacuated flask of 100 litre capacity at 610K. 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 = $0.082\,L\,atm\,K^{-1}\,mol^{-1}$]

[29-Jun-2022-Shift-2]

Options:

A. 2.25

B. 6.24

C. 12.13

D. 15.24

Answer: A

Solution:

	$PCl_5(g) \rightleftharpoons$	$PCl_3(g) +$	$Cl_2(g)$	Total Moles:
At $t = 0$:	5	0	0	$5 + 4(\text{For Ne gas}) = 9$
At $t = t_{eq}$:	$5 - x$	x	x	$5 - x + x + x + 4(\text{For Ne gas}) = 9 + x$
Mole Fraction:	$\frac{5-x}{9+x}$	$\frac{x}{9+x}$	$\frac{x}{9+x}$	
Partial Pressure:	$\left(\frac{5-x}{9+x}\right)P$	$\left(\frac{x}{9+x}\right)^p$	$\left(\frac{x}{9+x}\right)^P$	

Here 4 moles of inert gas argon also present.

∴ Total moles of mixture present at equilibrium,
$n_T = 5 + x + 4$
$= 9 + x$
At equilibrium, total pressure (p_T) = 6 atm
Volume (v) = 100L
Temperature = 610K
∴ using ideal gas equation,
$P_T V = n_T RT$
$\Rightarrow 6 \times 100 = (9 + x) \times 0.082 \times 610$
$\Rightarrow x = 3$
Now,

$$K_P = \frac{P_{PCl_3} \times P_{Cl_2}}{P_{PCl_5}}$$

$$= \frac{\left[\frac{3}{9+3} \times 6\right] \times \left[\frac{3}{9+3} \times 6\right]}{\left[\frac{5}{9+3} \times 6\right]}$$

$$= \frac{27}{12}$$

$$= \frac{9}{4}$$

$= 2.25$ atm
Note :
Inert gas always contribute to total mole and pressure calculation.

Question47

A box contains 0.90g 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 = 0.082L atm K^{-1} mol^{-1})
(Ignore the volume of the liquid water and assume water vapours behave as an ideal gas.)
[29-Jun-2022-Shift-2]

Answer: 29

Solution:

We know, 760 Torr = 1 atm

$$\therefore 32 \text{ Torr} = \frac{32}{760} \text{atm}$$

As all the liquid water evaporates so entire water is in gaseous state.
∴ Weight of water vapour = 0.9g

$$\therefore \text{Moles of water vapour (n)} = \frac{0.9}{18}$$

$$\text{Pressure (P)} = \frac{32}{760} \text{atm}$$

Temperature (T) = (27 + 273)K = 300K
R = 0.082L atm $K^{-1}mol^{-1}$
Given water vapour act as an ideal gas, so we can apply ideal gas equation.
From ideal gas equation,
PV = nRT

$$\Rightarrow \frac{32}{760} \times v = \frac{0.9}{18} \times 0.082 \times 300$$

$\Rightarrow v = 29L$

Question48

Solute A associates in water. When 0.7g of solute A is dissolved in 42.0g of water, it depresses the freezing point by 0.2˚C. The percentage association of solute A in water, is :
[Given : Molar mass of A = 93gmol^{-1}. Molal depression constant of water is 1.86K kg mol^{-1}.]

[25-Jun-2022-Shift-2]

Options:

A. 50%

B. 60%

C. 70%

D. 80%

Answer: D

Solution:

$\Delta T = ik_f \times m$

$0.2 = i \times 1.86 \times \frac{0.7}{93} \times \frac{1000}{42}$

$i = \frac{0.2 \times 93 \times 6}{1.86 \times 100}$

$i = 0.60$

$2A \rightleftharpoons A_2$

$1 - \alpha \quad \frac{\alpha}{2}$

$i = 1 - \alpha + \frac{\alpha}{2}$

$i = 1 - \frac{\alpha}{2}$

$1 - \frac{\alpha}{2} = 0.60$

$1 - 0.60 = \frac{\alpha}{2}$

$\alpha = 0.80$

Question49

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 NH_3 and as a base with H_2S.
In the light of the above statements choose the correct answer from the options given below :
[25-Jun-2022-Shift-2]

Options:

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

B. Both A and R are true but R is NOT the correct explanation of A.

C. A is true but R is false.

D. A is false but R is true.

Answer: D

Solution:

The amphoteric nature of water is explained by using Bronsted-Lowry acid base concept

$\underset{\text{(acid)}}{H_2O} + NH_3 - OH^- + NH_4^+$

$\underset{\text{(base)}}{H_2O} + H_2S \quad H_3O^+ + HS^-$

Hence, A is false but R is true

Question50

50 mL of 0.1M CH_3COOH is being titrated against 0.1M NaOH. When 25 mL of NaOH has been added, the pH of the solution will be ____$\times 10^{-2}$. (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
[26-Jun-2022-Shift-1]

Answer: 476

Solution:

$CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$
After adding 25 ml of NaOH volume of mixture $= 50 + 25 = 75$ ml
Initially,
Number of millimole of NaOH $= 25 \times 0.1 = 2.5$ mm
Number of millimole of $CH_3COOH = 50 \times 0.1 = 5$ mm
After nutrilisation,
Millimole of NaOH = 0
Millimole of $CH_3COOH = 5 - 2.5 = 2.5$ mm
Millimole of $CH_3COONa = 2.5$
After nutrilisation,
Concentration of $CH_3COOH = [CH_3COOH] = \frac{5-2.5}{75} = \frac{1}{30}$
Concentration of $CH_3COONa = [CH_3COONa] = \frac{2.5}{75} = \frac{1}{30}$

$$P^H = P^{Ka} + \log \frac{[CH_3COONa]}{[CH_3COOH]}$$

$$= 4.76 + \log \frac{\frac{1}{30}}{\frac{1}{30}}$$

$= 4.76 + \log(1)$
$= 4.76 + 0$
$= 4.76$
$= 4.76 \times 10^{-2}$

Question51

pH value of 0.001M NaOH solution is___
[27-Jun-2022-Shift-2]

Answer: 11

Solution:

$[OH^-] = 0.001 = 10^{-3}M$
$[H^+][OH^-] = 10^{-14}$
$[H^+] = 10^{-11}$
$pH = -\log[H^+]$
$= -\log(10^{-11})$
$pH = 11$

Question52

A student needs to prepare a buffer solution of propanoic acid and its sodium salt with pH 4. The ratio of $\frac{[CH_3CH_2COO^-]}{[CH_3CH_2COOH].}$ required to make buffer is

Given : $K_a(CH_3CH_2COOH) = 1.3 \times 10^{-5}$
[28-Jun-2022-Shift-2]

Options:

A. 0.03

B. 0.13

C. 0.23

D. 0.33

Answer: B

Solution:

$CH_3CH_2COOH \rightleftharpoons CH_3CH_2COO^- + H^+$
From Henderson equation

$$pH = pK_a + \log \frac{[CH_3CH_2COO^-]}{[CH_3CH_2COOH]}$$

$$4 = -\log 1.3 \times 10^{-5} + \log \frac{[CH_3CH_2COO^-]}{[CH_3CH_2COOH^2]}$$

$$-\log 10^{-4} = -\log 1.3 \times 10^{-5} + \log \frac{[CH_3CH_2COO^-]}{[CH_3CH_2COOH^-]}$$

$$-\log 10^{-4} = -\log 1.3 \times 10^{-5} \frac{[CH_3CH_2COOH]}{[CH_3CH_2COO^-]}$$

$$10^{-4} = 1.3 \times 10^{-5} \frac{[CH_3CH_2COOH^3]}{[CH_3CH_2COO^-]}$$

$$\frac{[CH_3CH_2COO^-]}{[CH_3CH_2COOH]} = 0.13$$

Question53

The solubility of AgCl will be maximum in which of the following?
[29-Jun-2022-Shift-1]

Options:

A. 0.01M KCl

B. 0.01M HCl

C. 0.01M$AgNO_3$

D. Deionised water

Answer: D

Solution:

In deionized water no common ion effect will take place so maximum solubility.

Question54

K_{a_1}, K_{a_2} and K_{a_3} are the respective ionization constants for the following reactions (a), (b) and (c).
(a) $H_2C_2O_4 \rightleftarrows H^+ + HC_2O_4^-$
(b) $HC_2O_4^- \rightleftarrows H^+ + HC_2O_4^{2-}$
(c) $H_2C_2O_4 \rightleftarrows 2H^+ + C_2O_4^{2-}$
The relationship between K_{a_1}, K_{a_2} and K_{a_3} is given as
[25-Jul-2022-Shift-2]

Options:

A. $K_{a_3} = K_{a_1} + K_{a_2}$

B. $K_{a_3} = K_{a_1} - K_{a_2}$

C. $K_{a_3} = K_{a_1} / K_{a_2}$

D. $K_{a_3} = K_{a_1} \times K_{a_2}$

Answer: D

Solution:

$H_2C_2O_4 \rightleftharpoons 2H^+ + C_2O_4^{2-}$ K_{a3}

$H_2C_2O_4 \rightleftharpoons H^+ + HC_2O_4^-$ K_{a1}

$HC_2O_4^- \rightleftharpoons H^+ + C_2O_4^{2-}$ K_{a2}

$$K_{a3} = \frac{[H^+]^2[C_2O_4^{2-}]}{[H_2C_2O_4]}$$

$$K_{a1} = \frac{[H^+][HC_2O_4^-]}{[H_2C_2O_4]}, K_{a2} = \frac{[H^+][C_2O_4^-]}{[HC_2O_4^-]}$$

$K_{a3} = K_{a1} \times K_{a2}$

Question55

At 298K, the equilibrium constant is 2×10^{15} for the reaction :
$Cu(s) + 2Ag^+(aq) \rightleftharpoons Cu^{2+}(aq) + 2\,Ag(s)$
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)
[26-Jul-2022-Shift-1]

Answer: 2

Solution:

$$K_{eq}' = \frac{1}{\sqrt{K_{eq}}} = \frac{1}{\sqrt{2 \times 10^{15}}} = X \times 10^{-8}$$

$$\Rightarrow \frac{1}{\sqrt{20}} \times \frac{1}{10^7} = x \times 10^{-8}$$

$$\Rightarrow \frac{1}{\sqrt{20}} \times 10^{-7} = x \times 10^{-8}$$

$$\Rightarrow x = \frac{\sqrt{10}}{\sqrt{2}} = \sqrt{5} = 2.236$$

$\simeq 2.24$

Question56

At 600K, 2 mol of NO are mixed with 1 mol of O_2.
$2NO_{(g)} + O_2(g) \rightleftarrows 2NO_2(g)$
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)
[28-Jul-2022-Shift-2]

Answer: 2

Solution:

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

at intial 2 1 0

at equilibrium $2 - 0.8$ 0.6 0.8

Partial pressure of $NO(g) = 1.2 / 2.6 \times 1$

Partial pressure of $O_2(g) = 0.6 / 2.6$

Partial pressure of $NO_2(g) = 0.8 / 2.6$

$K_p = (P_{NO_2})^2 / (P_{NO})^2 (P_{O_2}) = 0.8 \times 0.8 \times 2.6 / 1.2 \times 1.2 \times 0.6$

$= 1.925$

≈ 2

Question57

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:
$K_b(NH_4OH) = 1 \times 10^{-5}$, $\log 2 = 0.30$, $\log 3 = 0.48$, $\log 5 = 0.69$, $\log 7 = 0.84$, $\log 11 = 1.04$)
[25-Jul-2022-Shift-1]

Options:

A. 3.2

B. 4.2

C. 5.2

D. 6.2

Answer: C

Solution:

$NH_4OH + HCl \rightarrow NH_4Cl + H_2O$

mmole 22

$$[NH_4^+] = \frac{2\,\text{mmole}}{60\,\text{ml}} = \frac{1}{30}\text{M}$$

$$pH = \frac{pK_w - pK_b - \log C}{2} = \frac{14 - 5 + 1.48}{2} = 5.24$$

Question58

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 0.2M 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 $NH_4Cl = 53.5 g mol^{-1}$)
[26-Jul-2022-Shift-2]

Options:

A. 53.5g

B. 72.3g

C. 107.0g

D. 126.0g

Answer: C

Solution:

For basic Buffer, $pOH = pK_b + \log \frac{[\text{ salt }]}{[\text{ Base }]}$ $pOH = 14 - 8.26 = 5.74$

$5.74 = 4.74 + \log \frac{[NH_4Cl]}{0.2}$

$[NH_4Cl] = 2M$

Moles of $NH_4Cl = 2 \times 1 = 2$ moles

Weight of $NH_4Cl = 2 \times 53.5 = 107g$

Question59

At 310K, the solubility of CaF_2 in water is 2.34×10^{-3}g / 100 mL. The solubility product of CaF_2 is _____ $\times 10^{-8}(mol / L)^3$. (Give molar mass : $CaF_2 = 78 gmol^{-1}$) [27-Jul-2022-Shift-1]

Answer: 0

Solution:

$CaF_2 \overset{s}{\rightleftharpoons} \underset{s}{Ca^{2+}} + 2 \underset{2s}{F^-}$

$K_{sp} = s(2s)^2$

$= 4s^3$

Solubility (s) $= 2.34 \times 10^{-3}$g / 100 mL

$= \frac{2 \cdot 34 \times 10^{-3} \times 10}{78}$ mole / lit

$= 3 \times 10^{-4}$ mole/ lit

$\therefore K_{sp} = 4 \times (3 \times 10^{-4})^3$

$= 108 \times 10^{-12}$

$= 0.0108 \times 10^{-8}(\text{mole / lit})^3$

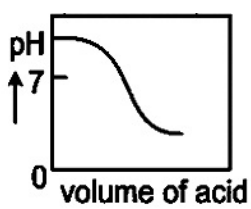
$\therefore x \approx 0$

Question60

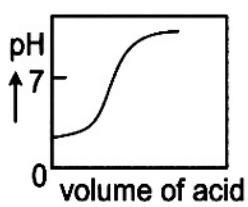
The plot of pH-metric titration of weak base NH_4OH vs strong acid HCl looks like : [27-Jul-2022-Shift-2]

Options:

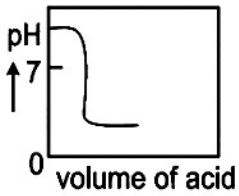
A.



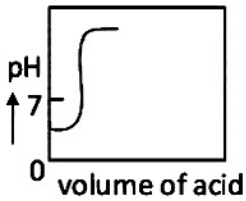
B.



C.



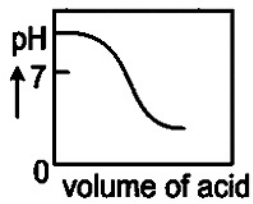
D.



Answer: A

Solution:

NH_4OH is a weak base and HCl is a strong acid.
With the addition of HCl to NH_4OH, pH of solution will decrease gradually.
So, the correct graph should be



Question61

K_a for butyric acid (C_3H_7COOH) is 2×10^{-5}. The pH of 0.2M solution of butyric acid is _____ $\times 10^{-1}$. (Nearest integer)
[Given $\log 2 = 0.30$]
[28-Jul-2022-Shift-1]

Answer: 27

Solution:

K_a of Butyric acid $\Rightarrow 2 \times 10^{-5}$ PKa = 4.7
pH of 0.2M solution

$$pH = \frac{1}{2}pK_a - \frac{1}{2}\log C$$

$$= \frac{1}{2}(4 \cdot 7)\frac{1}{2}\log(0.2)$$

$$= 2.35 + 0.35 = 2.7$$

$pH = 27 \times 10^{-1}$

Question62

If the solubility product of PbS is 8×10^{-28}, then the solubility of PbS in pure water at 298K is $\times \times 10 - 16\,mol\,L^{-1}$. The value of x is _____. (Nearest Integer)
[Given : $\sqrt{2} = 1.41$]
[29-Jul-2022-Shift-1]

Answer: 282

Solution:

$K_{sp} = S^2$

$S = \sqrt{K_{sp}} = \sqrt{8 \times 10^{-28}} = 2\sqrt{2} \times 10^{-14}$

$= 2.82 \times 10^{-14}$

$= 282 \times 10^{-16}$

$\therefore$ Ans. 282

Question63

200 mL of 0.01 MHCl is mixed with 400 mL of 0.01MH_2SO_4. The pH of the mixture is _____.
Given: log 2 = 0.30, log 3 = 0.48, log 5 = 0.70, log 7 = 0.84, log 11 = 1.04
[29-Jul-2022-Shift-2]

Options:

A. 1.14

B. 1.78

C. 2.34

D. 3.02

Answer: B

Solution:

$$[H^+] = \frac{0.01 \times 200 + 2 \times 0.01 \times 400}{600}$$

$$= \frac{0.01 + 2 \times 0.01 \times 2}{3}$$

$$= \frac{0.01 + 0.04}{3}$$

$$= \frac{5}{3} \times 10^{-2}$$

$$pH = -\log[H^+]$$

$$= -\log\left(\frac{5}{3} \times 10^{-2}\right)$$

$$= -\left[\log\frac{5}{3} + \log 10^{-2}\right]$$

$$= -[\log 5 - \log 3 - 2]$$

$$= -0.7 + 0.48 + 2$$

$$= 2.48 - 0.7$$

$$= 1.78$$

Question64

The solubility of $Ca(OH)_2$ in water is [Given: The solubility product of $Ca(OH)_2$ in water $= 5.5 \times 10^{-6}$]
[25 Feb 2021 Shift 2]

Options:

A. 1.11×10^{-2}

B. 1.11×10^{-6}

C. 1.77×10^{-2}

D. 1.77×10^{-6}

Answer: A

Solution:

Let, solubility of $Ca(OH)_2$ in pure water $= S mol\ /\ L$

$Ca(OH)_2 \rightleftharpoons Ca^{2+} + 2OH^-$

$S mol\ /\ L \quad 2 \times S (mol\ /\ L)$

$= [Ca^{2+}][OH^-]^2 = S \times (2S)^2 = 4S^3 (mol\ /\ L)$

The expression of K_{sp} can also be written as,

$K_{sp} = x^x \cdot y^y \cdot S^{x+y}$

$= 1^1 \cdot 2^2 \cdot S^{1+2}$

$= 4S^3$

$K_{sp} = x^x \cdot y^y \cdot S^{x+y}$

$= 1^1 \cdot 2^2 \cdot S^{1+2}$

$= 4S^3$ [$\because$ For $Ca(OH)_2 : x = 1, y = 2$]

x and y are the coefficients of cations and anions respectively

$$S = \left(\frac{K_{sp}}{4}\right)^{1/3} = \left(\frac{5.5 \times 10^{-6}}{4}\right)^{1/3}$$

$= 1.11 \times 10^{-2} mol\ /\ L$

Question65

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 $x \times 10^{-6} mol\ /\ L$. The value of x is ..... (Rounded off to the nearest integer).
[Given, : $\sqrt{2} = 1.41$]
[24 Feb 2021 Shift 2]

Answer: 141

Solution:

Given, $[K_{sp}]_{PbI_2} = 8 \times 10^{-9}$

To calculate solubility of PbI_2 in 0.1M solution of $Pb(NO_3)_2$.

(I) $\underset{0.1M}{Pb(NO_3)_2} \longrightarrow \underset{0.1M}{Pb^{2+}}(aq) + 2\underset{0.2M}{NO_3^-}(aq)$

(II) $PbI_2(s) \rightleftharpoons Pb^{2+}(aq) + 2I^-(aq)$

S 2S

$\therefore [Pb^{2+}] = S + 0.1 \approx 0.1$

$\because S << 0.1$

Now, $K_{sp} = 8 \times 10^{-9}$

$[Pb^2][I^-]^2 = 8 \times 10^{-9}$

$0.1 \times (2S)^2 = 8 \times 10^{-9}$

$4S^2 = 8 \times 10^{-8} \Rightarrow S = 141 \times 10^{-6} M$

$x = 141$

Question66

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 ..... .
[26 Feb 2021 Shift 2]

Answer: 7

Solution:

Phosphoric acid is a weak tribasic acid (H_3PO_4) and NH_4OH is a weak monoacidic base. So, hydrolysis of ammonium phosphate $(NH_4)_3PO_4$ can be shown as,

$(NH_4)_3PO_4 + 3H_2O \rightleftharpoons H_3PO_4 + 3NH_4OH$ [3 : 1 type salt]

So, $[H^+] - K_a \times \left(\frac{K_w}{K_a \times K_b}\right)^{12}$

$pH = pK_a + \frac{1}{2}[pK_w - pK_a - pK_b]$

$= 5.23 + \frac{1}{2}(14 - 5.23 - 4.75)$

[$\because pK_w = 14 H_2O$

$pK_a = 5.23 (H_3PO_4)$

$pK_b = 4.75 (NH_4OH)$]

$= 7.24 \sim eq7$

Question67

The solubility of AgCN in a buffer solution of pH = 3 is x. The value of x is..... .
[Assume : No cyano complex is formed; $K_{sp}(AgCN) = 2.2 \times 10^{-16}$ and $K_a(HCN) = 6.2 \times 10^{-10}$]
[25 Feb 2021 Shift 1]

Options:

A. 0.625×10^{-6}

B. 1.6×10^{-6}

C. 2.2×10^{-16}

D. 1.9×10^{-5}

Answer: D

Solution:

pH of AgCN buffer solution = 3

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

$K_{sp}(AgCN) = 2.2 \times 10^{-16}$

$K_a[HCN] = 6.2 \times 10^{-10}$

$AgCN \rightleftharpoons Ag^+ + CN^- ..... K_{sp}$

$CN^- + H^+ \rightleftharpoons HCN ..... \frac{1}{K_a}$

$AgCN + H^+ \rightleftharpoons HCN + Ag^+$

$K_{sp} \times \frac{1}{K_a} = \frac{[Ag^+][CN^-][HCN]}{[H^+][CN^-]}$

$[S] = \sqrt{\frac{K_{sp}[H^+]}{K_a}} \Rightarrow \frac{2.2 \times 10^{-16}}{6.2 \times 10^{-10}} = \frac{[S][S]}{10^{-3}}$

$[S]^2 = \frac{2.2 \times 10^{-16}}{6.2 \times 10^{-10}} \times 10^{-3}$

$S = 1.9 \times 10^{-5}$

Question68

A homogeneous ideal gaseous reaction $AB_2(g) \rightleftharpoons A(g) + 2B(g)$ is carried out in a 25L flask at 27°C. The initial amount of AB_2 was 1 mole and the equilibrium pressure was 1.9atm. The value of K_p is $x \times 10^{-2}$. The value of x is ..... .
[26 Feb 2021 Shift 1]

Answer: 73

Solution:

$(\Sigma \text{ mole})_{t_{eq}} = 1 - x + x + 2x = (1 + 2x)$ Partial pressure $\frac{1 - x}{1 + 2x}p$

(atm) $\frac{x}{1 + 2x}p$ $\frac{2x}{1 + 2x}p$

[p = Total pressure at equilibrium = 1.9atm]

Now, at equilibrium $pV = (1 + 2x)RT$

$\Rightarrow 1 + 2x = \frac{pV}{RT} = \frac{1.9 \times 25}{0.082 \times 300} = 1.93$ [$V = 25L$, $R = 0.082 L\,atm\,mol^{-1}\,K^{-1} T = 300K$]

$\Rightarrow x = \frac{1.93 - 1}{2} = 0.465$

$\Rightarrow K_p = \frac{p_A \times p_B{}^2}{p_{AB_2}} \Rightarrow \frac{\left(\frac{x}{1+2x}p\right) \times \left(\frac{2x}{1+2x}p\right)^2}{\left(\frac{1-x}{1+2x}p\right)}$

$= \frac{4x^3 \times p^3}{(1+2x)^3} \times \frac{(1+2x)}{(1-x) \times p} = \frac{4x^3 \times p^2}{(1+2x)^2 \times (1-x)}$

$= \frac{4 \times (0.465)^3 \times (1.9)^2}{(1 + 2 \times 0.465)^2 \times (1 - 0.465)} = 0.7285 atm$

$= 72.85 \times 10^{-2} atm \sim eq 73 \times 10^{-2} = x \times 10^{-2}$

$\therefore x = 73$

Question69

At 1990K and 1atm 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 $x \times 10^{-1}$. The value of x is___ (Rounded off to the nearest integer) [24feb2021shift1]

Answer: 5

Solution:

$Cl_2(g) \rightleftharpoons 2Cl(g)$

Let mol of both of Cl_2 and Cl be x.

$P_{Cl} = \frac{x}{2x} \times 1 = \frac{1}{2}$

$P_{Cl_2} = \frac{x}{2x} \times 1 = \frac{1}{2}$

$\therefore K_p = \frac{\left(\frac{1}{2}\right)^2}{\frac{1}{2}} = \frac{1}{2} = 0.5 = 5 \times 10^{-1}.$

Question70

For the reaction A(g) → (B)(g), the value of the equilibrium constant at 300K and 1atm is equal to 100.0. The value of $\Delta_r G$ for the reaction at 300K and 1atm in $J\,mol^{-1}$ is $-xR$, where x is_____ (Rounded off to the nearest integer) ($R = 8.31\,J\,mol^{-1}K^{-1}$ and $\ln 10 = 2.3$) [24feb2021shift1]

Answer: 1380

Solution:

$\Delta G^\circ = RT \ln K_p$

$= -R(300)(2)\ln(10)$

$= -R(300 \times 2 \times 2.3)$

$\Delta G^\circ = -1380R$

Question71

The solubility of $CdSO_4$ in water is $8.0 \times 10^{-4} mol\, L^{-1}$. Its solubility in 0.01M H_2SO_4 solution is ..... $\times 10^{-6} mol\, L^{-1}$. (Round off to the nearest integer) (Assume that, solubility is much less than 0.01M)
[18 Mar 2021 Shift 2]

Answer: 64

Solution:

Given, solubility in water (S) = $8.0 \times 10^{-4} mol\, L^{-1}$
In pure water
$K_{sp} = S^2 = (8 \times 10^{-4})^2 = 64 \times 10^{-8}$
In 0.01 M H_2SO_4
$H_2SO_4(aq) \longrightarrow \underset{0.02}{2H^+(aq)} + \underset{0.02}{SO_4^{2-}(aq)}$
$CdSO_4(s) \rightleftharpoons \underset{x}{Cd^{2+}(aq)} + \underset{(x+0.01)}{SO_4^{2-}(aq)}$
$K_{sp} = x(x + 0.01) = 64 \times 10^{-8}$
$x + 0.01 \cong 0.01M$
So, $x(0.01) = 64 \times 10^{-8}$
$x = 64 \times 10^{-6} M$

Question72

The oxygen dissolved in water exerts a partial pressure of 20kPa in the vapour above water. The molar solubility of oxygen in water is ..... $\times 10^{-5} mol\, d\, m^{-3}$. (Round off to the nearest integer).
[Given, Henry's law constant (K_H) = 8.0×10^4kPa for O_2, density of water with dissolved oxygen = $1.0 kgd\, m^{-3}$].
[17 Mar 2021 Shift 1]

Answer: 25

Solution:

Given, partial pressure of O_2 = 20kPa
K_H (Henry's constant) = 8×10^4kPa
From Henry's law,
$p(g) = [K_H]\chi_{O_2}$
where, χ_{O_2} = solubility of oxygen
$20 \times 10^3 = (8 \times 10^4 \times 10^3)\chi_{o_2}$
$\Rightarrow \chi_{O_2} = \dfrac{20}{8 \times 10^4}$
Solubility = $2.5 \times 10^{-4} = 25 \times 10^{-5}$

Question73

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)
[16 Mar 2021 Shift 1]

Answer: 50

Solution:

Let the solubility of A_2X be ' 'S'.

$A_2X(s) \rightleftharpoons \underset{2s}{2A^+(aq)} + X_s^{2-}(aq)$; $K_{sp1} = 4 \times 10^{-12}$

$K_{sp_1} = [A^+]^2[X^{2-}]$

$4 \times 10^{-12} = (2S)^2(S)$

$4 \times 10^{-12} = 4S^3$

$\Rightarrow S = 10^{-3}M$

Let the solubility of MY be ' S_1 '.

$MY(s) \rightleftharpoons \underset{s_1}{M^+(aq)} + \underset{s_1}{Y^-(aq)}$, $K_{sp_2} = 4 \times 10^{-12}$

$K_{sp_2} = [M^+][Y^-]$

$K_{sp_2} = (S_1)^2$

$4 \times 10^{-12} = (S_1)^2$

$\Rightarrow S_1 = 2 \times 10^{-6}M$

$$\frac{[A_2Y]}{[MY]} = \frac{S}{S_1} = \frac{10^{-4}}{2 \times 10^{-6}} = 50$$

Question74

0.01 moles of a weak acid $HA(K_a = 2.0 \times 10^{-6})$ is dissolved in 1.0L of 0.1M 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 $\ll < 1$]
[17 Mar 2021 Shift 1]

Answer: 2

Solution:

Given, $[HA] = 0.01$

$[HCl] = 0.1M$

When strong acid (HCl) is completely dissociated,

$\underset{0.1}{HCl} \longrightarrow \underset{0.1}{H^+(aq)} + \underset{0.1}{Cl^-(aq)}$

For weak acid, dissociation is very less,

	HA	$\rightleftharpoons$	$H^+(aq)$	$+$	$A^-(aq)$
$t = 0$	0.01		0.1		0
$t = t_{eq}$	$0.01 - 0.01 - \alpha$		$0.1 + 0.01\alpha$		0.01α

$$K_a = \frac{[H^+][A^-]}{[HA]} = 2 \times 10^{-6} \Rightarrow \frac{(0.1 + 0.01\alpha)(0.01\alpha)}{(0.01 - 0.01\alpha)} = 2 \times 10^{-6}$$

As $0.01\alpha << 0.1$ $[H^+] = 0.1$

and $0.01\alpha << 0.01$ $[HA] = 0.01$

$$\therefore 2 \times 10^{-6} = \frac{(0.1)(0.01\alpha)}{0.01} \Rightarrow \alpha = 2 \times 10^{-5}$$

$\Rightarrow x = 2$

Question75

Given below are two statements: One is labelled as Assertion A and the other labelled as Reason R.
Assertion A During the boiling of water having temporary hardness, $Mg(HCO_3)_2$ is converted to $MgCO_3$.
Reason R The solubility product of $Mg(OH)_2$ is greater than that of $MgCO_3$.
In the light of the above statements, choose the most appropriate answer from the options given below
[18 Mar 2021 Shift 1]

Options:

A. Both A and R are true but R is not the correct explanation of A.

B. A is true but R is fals

C. Both A and R are true and R is the correct explanation of A.

D. A is false but R is true.

Answer: D

Solution:

During boiling, soluble $Mg(HCO_3)_2$ is converted into insoluble
$Mg(OH)_2$ and $Ca(HCO_3)_2$ is converted into insoluble $CaCO_3$. This is because of high solubility product of $Mg(OH)_2$ as compared to $MgCO_3$ hence, $Mg(OH)_2$ is precipitated. These precipitates can be removed by filtration. Thus, filtrate will be obtained in soft water.
$Mg(HCO_3)_2 \longrightarrow Mg(OH)_2 \downarrow + 2CO_2$
Temporary hardness
$Ca(HCO_3)_2 \longrightarrow CaCO_3 \downarrow + CO_2 + 2H_2O$
K_{sp} of $Mg(OH)_2 > K_{sp}$ of $MgCO_3$
and hence, $Mg(OH)_2$ precipitation first.

Question76

The gas phase reaction
$2A(g) \rightleftharpoons A_2(g)$
at 400K has $\Delta G^\circ = +25.2 kJ\,mol^{-1}$. The equilibrium constant K_C for this reaction is ..... $\times 10^{-2}$. (Round off to the nearest integer).
[Use : $R = 8.3 J\,mol^{-1}K^{-1}$, $\ln 10 = 2.3$] $\log_{10^2} 2 = 0.30$, 1atm = 1bar] [antilog $(-0.3) = 0.501$]
[18 Mar 2021 Shift 2]

Answer: 1.66

Solution:

Given, $\Delta G = 25.2 kJ\,mol^{-1}$
$= 25200 J\,mol^{-1}$
$T = 400K$
According to standard free Gibb's equation,
$\Delta G^0 = -RT \ln K_p$
$25200 = -2.3 \times 8.3 \times 400 \log(K_p)$
$\log K_p = \dfrac{-25200}{2.3 \times 8.3 \times 400} = -3.3$
$K_p = 10^{-3.3} = 10^{-3} \times 0.501$
$K_p = 5.01 \times 10^{-4} bar^{-1}$
$K_p = 5.01 \times 10^{-5} Pa^{-1}$
We know that,
$K_p = K_c(RT)^{\Delta r_k}$
$K_p = K_c(RT)^{-1} \quad [\because \Delta n_g = 1 - 2 = -1]$
$K_p = \dfrac{K_C}{8.3 \times 400}$
$K_c = 5.01 \times 10^{-5} \times 8.3 \times 400$
$\Rightarrow K_c = 166 \times 10^{-5} m^3/mol$
$= 1.66 \times 10^{-2} L/mol$

Question77

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 $R = 0.0831 L\,bar, K^{-1}mol^{-1}$].

[17 Mar 2021 Shift 2]

Answer: 354

Solution:

The temperature at which $K_C = 20.4$ and $K_\rho = 600.1$, is $354K$.
Given reaction is, $N_2O_4(g) \rightleftharpoons 2NO_2(g)$
Given values are : $K_\rho = 600.1$
$K_C = 20.4$
$\Delta n_g =$ number of moles of product - number of moles of reactant Using relation between K_p and $K_C = 2 - 1 = 1$
where R is the gas constant $= 0.083 Latm/K\,mol$
$\Delta n_g = 1$ (for given reaction)
On putting given values, we will get
$600.1 = 20.4(RT)^1 \Rightarrow T \approx 354K$

Question78

For the reaction, $A(g) \rightleftharpoons B(g)$ at $495K$, $\Delta, G^\circ = -9.478 kJ\,mol^{-1}$. If we start the reaction in a closed container at $495K$ with 22 millimoles of A, the amount of B is the equilibrium mixture is ..... millimoles (Round off to the nearest integer).
[$R = 8.314 J\,mol^{-1}K^{-1}$, $\ln 10 = 2.303$]
[16 Mar 2021 Shift 1]

Answer: 20

Solution:

$A(g) \rightleftharpoons B(g)$
Given, $T = 495K$, $\Delta_r C^\circ = -9.478 kJ / mol$
We know,
$\Delta G^\circ = -2.303 RT \log K$
$\because K = \frac{[B]}{[A]}$
where, $K =$ equilibrium constant
Now, $\log K = \frac{-\Delta G^\circ}{2.303RT}$
$\log K = \frac{9.478 \times 1000}{2.303 \times 8.314 \times 495}$
$\therefore \log K = 1$
$\Rightarrow K = 10$
$\Rightarrow \frac{[B]}{[A]} = \frac{n_B}{n_A} = 10$

	A(g)	$\rightleftharpoons$	B(g)
Now, t = 0	22		0
t = t	22 − x		x

$K = \frac{[B]}{[A]} = \frac{x}{22 - x} = 10$
So, $x = 20$ Milimoles of $B = 20$

Question79

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 1.0M, the concentration of sodium acetate in the buffer is ..... M. (Round off to the nearest integer). [Given : pK_a (acetic acid =4.74]
[18 Mar 2021 Shift 1]

Answer: 10

Solution:

Given : pH $= 5.74$
Concentration of acetic acid in buffer $= 1.0M$
Acetic acid and its conjugate base sodium acetate makes acidic buffer.
$CH_3COOH + CH_3COONa \longrightarrow$ (Acidic buffer)
Using formula,

$$pH = pK_a + \log \frac{[\text{Salt}]}{[\text{Acid}]}$$

$$pH = pK + agg \frac{[CH_3COONa]}{[CH_3COOH]}$$

$$5.74 = 4.74 + \log \frac{[CH_3COONa]}{[CH_3COOH]}$$

$$5.74 - 4.74 = \log \frac{[CH_3COONa]}{[CH_3COOH]}$$

$$1 = \log \frac{[CH_3COONa]}{[CH_3COOH]}$$

$$\Rightarrow \frac{[CH_3COONa]}{[CH_3COOH]} = 10 \quad [\because [CH_3COOH] = 1]$$

$[CH_3COONa] = [10 \times 1] = 10$
Thus, the concentration of sodium acetate in buffer is $10M$.

Question80

Sulphurous acid (H_2SO_3) has $K_{a_1} = 1.7 \times 10^{-2}$ and $K_{a_2} = 6.4 \times 10^{-8}$. The pH of 0.588M is (Round off to the nearest integer)
[16 Mar 2021 Shift 2]

Answer: 1

Solution:

For H_2SO_3, $K_{a_1} > > K_{a_2}$
So, we mainly consider 1st ionisation

$$H_2SO_3 \rightleftharpoons H^+ + HSO_3^-; \; K_{a_1} = 1.7 \times 10^{-2}$$

$t = 0$	0.558	0	0
$t = t_{eq}$	$0.558 - 0.558\alpha$	0.558α	0.558α

$$K_{a_1} = \frac{[H^+][HSO_3^-]}{[H_2SO_3]} = \frac{(0.558\alpha)(0.558\alpha)}{0.558(1-\alpha)} = \frac{0.558\alpha^2}{1-\alpha}$$

$\alpha << 1$ for weak acid
$(1 - \alpha) \approx 1$

$$\alpha = \sqrt{\frac{K_{a_1}}{0.558}} = \sqrt{\frac{1.7 \times 10^{-2}}{0.558}}$$

$\alpha = 1.7 \times 10^{-1} = 0.17$
$[H]^+ = 0.558\alpha = 9.9 \times 10^{-2}$
$pH = -\log[H^+] = -\log(9.9 \times 10^{-2}) \quad [\because \log 9.9 \approx 1]$
$= 2 - \log 9.9 = 2 - 1$
$pH = 1$

Question81

Assuming that $Ba(OH)_2$ is completely ionised in aqueous solution under the given conditions the concentration of H_3O^+ions in 0.005M aqueous solution of $Ba(OH)_2$ at 298K is _____ $\times 10^{-12} mol\, L^{-1}$. (Nearest integer)
[25 Jul 2021 Shift 2]

Answer: 1

Solution:

$Ba(OH)_2 \rightarrow Ba^{+2} + 2OH^-$
$\downarrow$
$2 \times 0.005 = 0.01 = 10^{-2}$
At 298K : in aq. solution $[H_3O^+][OH^-] = 10^{-14}$
$[H_3O^+] = \frac{10^{-14}}{10^{-2}} = 10^{-12}$

Question82

A solution is 0.1M in Cl^- and 0.001M 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 $K_{sp}(Ag_2CrO_4) = 1.9 \times 10^{-12} M^3$
Select correct statement from the following:
[20 Jul 2021 Shift 2]

Options:

A. AgCl precipitates first because its K_{sp} is high.

B. Ag_2CrO_4 precipitates first as its K_{sp} is low.

C. Ag_2CrO_4 precipitates first because the amount of Ag^+ needed is low.

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

Answer: D

Solution:

(i) $[Ag^+]$ required to ppt AgCl (s)
$K_{sp} = IP = [Ag^+][Cl^-] = 1.7 \times 10^{-10}$
$[Ag^+] = 1.7 \times 10^{-9}$
(ii) $[Ag^+]$ required to ppt Ag_2CrO_4(s)
$K_{sp} = IP = [Ag+]^2[CrO_4^{-2}] = 1.9 \times 10^{-12}$
$[Ag^+] = 4.3 \times 10^{-5}$
$[Ag^+]$ required to ppt AgCl is low so AgCl will ppt 1^{st}

Question83

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)
[27 Jul 2021 Shift 2]

Answer: 16

Solution:

$k_p = Po_2^{1/2} = 4$
$\therefore Po_2 = 16bar = 16atm$

Question84

$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$
The above reaction is carried out in a vessel starting with partial pressure P_{SO_2} = 250m barP$_{O_2}$ = 750m bar and P_{SO_3} = 0 bar . When the reaction is complete, the total pressure in the reaction vessel is _____ m bar. (Round off of the nearest integer).
[27 Jul 2021 Shift 2]

Answer: 875

Solution:

	$2SO_2(g)$	+	$O_2(g)$	→	$2SO_3(g)$
Initial	250mbar (L . R.)		750mbar		O
Final	–250mbar		–125mbar		250mbar
	0		625mbar		250mba

∴ Final total pressure = 625 + 250 = 875mbar

Question85

$PCl_5 \rightleftharpoons PCl_3 + Cl_3$ $K_c = 1.844$
3.0 moles of PCl_5 is introduced in a 1L closed reaction vessel at 380K . The number of moles ofPCl_5 at equilibrium is _____ $\times 10^{-3}$
(Round off to the Nearest Integer)
[27 Jul 2021 Shift 1]

Answer: 1400

Solution:

$PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}$ $K_c = 1.844$

$$\Rightarrow \frac{[PCl_3][Cl_2]}{[PCl_5]} = \frac{x^2}{3-x} = 1.844$$

$$\Rightarrow x^2 + 1.844 - 5.532 = 0$$

$$\Rightarrow x = \frac{-1.844 + \sqrt{(1.844)^2 + 4 \times 5.532}}{2}$$

$\cong 1.604$
$\Rightarrow$ Moles of $PCl_5 = 3 - 1.604 \cong 1.396$

Question86

Value of K_p for the equilibrium reaction
$N_2O_4 \rightleftharpoons 2NO_{2(g)}$ at 288K is 47.9. The K_C for this reaction at same temperature is _____. (Nearest integer)
(R = 0.083L. bar $K^{-1}mol^{-1}$)
[22 Jul 2021 Shift 2]

Answer: 2

Solution:

$$K_C = \frac{K_P}{RT} = \frac{47.9}{0.083 \times 288} = 2$$

Question87

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$
In an equilibrium mixture, the partial pressures are P_{SO_3} = 43kPa; P_{O_2} = 530Pa andP_{SO_2} = 45kPa. The equilibrium constant K_P = _____$\times 10^{-2}$. (Nearest integer)
[20 Jul 2021 Shift 1]

Answer: 172

Solution:

$$2SO_2(g) + O_2(g) = 2SO_3(g)$$
$$K_P = \frac{(pSO_{3(g)})^2}{pSO2(g)} \times pO_{2(g)}$$
$$= \frac{43 \times 43}{45 \times 45} \times 530Pa^{-1}$$
$$= 172.28 \times 10^{-5}Pa^{-1}$$
$$= 172.28atm$$
$$= 17228 \times 10^{-2}atm$$

Question88

A_3B_2 is a sparingly soluble salt of molar mass M($gmol^{-1}$) and solubility xgL^{-1}. The solubility product satisfies $K_{sp} = a\left(\frac{x}{M}\right)^5$.
The value of a is ..... (Integer answer)
[31 Aug 2021 Shift 1]

Answer: 108

Solution:

$$A_3B_2 \rightleftharpoons \underset{3S}{3A^{2+}}(aq) + \underset{2S}{2B^{3-}}(aq)$$
$$K_{sp} = [A^{2+}]^3[B^{3-}]^2$$
$$K_{sp} = (3S)^3(2S)^2 = 108S^5$$
$$AlsOS = \frac{x}{m}$$
$$K_{sp} = 108\left(\frac{x}{m}\right)^5$$
$$\text{Given that, } K_{sp} = a\left(\frac{x}{m}\right)^5$$
$$\therefore a = 108$$

Question89

The pH of a solution obtained by mixing 50 mL of 1M HCl and 30 mL of 1M NaOH is $x \times 10^{-4}$. The value of x is ..... (Nearest integer)
[log 2.5 = 0.3979]
[31 Aug 2021 Shift 2]

Answer: 6021

Solution:

Milliequivalents of HCl(N_aV_a) = $50 \times 1 = 50$
Milliequivalents of NaOH(N_bV_b) = $30 \times 1 = 30$
Since, $N_aV_a > N_bN_b$
and they neutralise each other

$$[H^+] = \frac{N_aV_a - N_bV_b}{V_a + V_b}$$

$$= \frac{50 - 30}{80} = 0.25 = 2.5 \times 10^{-1}$$

$$pH = -\log[H^+] = -\log(2.5 \times 10^{-1})$$
$$= 1 - 0.3979 = 0.6021$$
$$pH \times 10^4 = 0.6021 \times 10^4 = 6021$$
$\therefore x = 6021$

Question90

The number of moles of NH_3, that must be added to 2L of 0.80M$AgNO_3$ 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..... (Nearestinteger)
[Assume no volume change on adding NH_3]
[27 Aug 2021 Shift 1]

Answer: 4

Solution:

Let moles added = a

$$Ag^+ + 2NH_3 \rightleftharpoons Ag(NH_3)_2^+$$

t = 0

$$0.8 \quad \left(\frac{a}{2}\right)$$

t = ∞

$$5 \times 10^{-8} \left[\frac{a}{2} - 1.6\right] \quad 0.8$$

$$\frac{0.8}{5 \times 10^{-8}\left(\frac{a}{2} - 1.6\right)^2} = 10^8$$

$$\frac{a}{2} - 1.6 = 0.4$$

$\Rightarrow a = 4.$

Question91

The number of moles of NH_3, that must be added to 2L of 0.80M$AgNO_3$ 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..... (Nearestinteger)

[Assume no volume change on adding NH_3]
[27 Aug 2021 Shift 1]

Answer: 4

Solution:

Let moles added = a

$Ag^+ + 2NH_3 \rightleftharpoons Ag(NH_3)_2^+$

t = 0

$0.8 \quad \left(\frac{a}{2}\right)$

t = ∞

$5 \times 10^{-8}\left[\frac{a}{2} - 1.6\right] \quad 0.8$

$$\frac{0.8}{5 \times 10^{-8}\left(\frac{a}{2} - 1.6\right)^2} = 10^8$$

$$\frac{a}{2} - 1.6 = 0.4$$

$\Rightarrow a = 4.$

Question92

The equilibrium constant K_c at 298K for the reaction A + B ⇌ C + D is 100 . Starting with an equimolar solution with concentrations of A, B, C and D all equal to 1M, the equilibrium concentration of D is .....$\times 10^{-2}$M. (Nearestinteger)
[26 Aug 2021 Shift 2]

Answer: 182

Solution:

$A + B \rightleftharpoons C + D$

Initially,

At equilibrium, 1− x, 1− x, 1+ x, 1+ x

$$\therefore K_C = \left(\frac{1+x}{1-x}\right)^2$$

$$100 = \left(\frac{1+x}{1-x}\right)^2$$

$$\frac{1+x}{1-x} = 10$$

$$x = \frac{9}{11}$$

Moles of D = 1 + x

$$= 1 + \frac{9}{11} = \frac{20}{11}$$

$= 1.818 = 181.8 \times 10^{-2} = 181.8 \times 10^{-2}$

$\cong 182 \times 10^{-2}$M

Question93

When 5.1g 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 × 10^{-2}. The value of x is ..... (Integer answer)
[Given, R = 0.082L atm K^{-1} mol^{-1}]
[27 Aug 2021 Shift 2]

Answer: 6

Solution:

51g of $NH_4HS = 1\,mol$

5.1g of $NH_4HS = \frac{1}{51} \times 5.1 = 0.1\,mol$

$NH_4HS(s) \rightleftharpoons NH_3(g) + H_2S(g)$

At t = 0, 0.1

At t = t, $0.1(1-\alpha)$ 0.1α 0.1α

It is given that dissociation is 20% from 100 moles.
∴ 20 moles get dissociated.
20% dissociation from 1 mol $\frac{20}{100} = 0.2$ moles get dissociated.
$\alpha = 0.2$
$\because K_C = \frac{[NH_3][H_2S]}{[NH_4HS]} = \frac{[NH_3][H_2S]}{1}$ (Concentration of solid is assumed as 1)

$[NH_3] = \frac{\text{Number of moles of } NH_3(g)}{\text{Volume(in L)}} = \frac{0.1\alpha}{2}$

$[H_2S] = \frac{\text{Number of moles of } H_2S}{\text{Volume(in L)}} = \frac{0.1\alpha}{2}$

$K_C = 0.1\alpha 2 \times \frac{0.1\alpha}{2} = \frac{0.1 \times 0.2}{2} \times \frac{0.1 \times 0.2}{2} = 10^{-4}$

$\therefore K_p = K_C(RT)^{\Delta n}$
[Δn =change in the number of gaseous moles = 2]
$K_p = 10^{-4} \times (0.08 \times 300)^2$
$K_p = 10^{-4} \times (24)^2 = 0.06$
$x \times 10^{-2} = 0.06$
$\Rightarrow x = \frac{0.06}{10^{-2}} = 0.06 \times 10^2 = 6$
x = 6 is the answer.

Question94

The molar solubility of $Zn(OH)_2$ in 0.1M 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}).
[1 Sep 2021 Shift 2]

Answer: 2

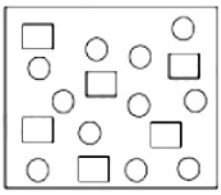
Solution:

$Zn(OH)_2 \rightleftharpoons \underset{S}{Zn^{2+}} + \underset{2S}{2OH^-}$

Due to common-ion effect (presence of NaOH) the concentration of OH^- will be (2S + 0.1) ≈ 0.1
(∵ 0.1> > 2 S)
∴ Solubility of product,
$K_{sp} = (0.1)^2 \times S$
$2 \times 10^{-20} = 0.01 \times S$
$\Rightarrow S = \frac{2 \times 10^{-20}}{0.01} = 2 \times 10^{-18}$
∴ x = 2
Hence, answer is 2.

Question95

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



[Jan. 09, 2020 (II)]

Options:

A. 4

B. 8

C. 1

D. 2

Answer: D

Solution:

Equilibrium constant

$K_c = \frac{[B]}{[A]} = \frac{11}{6} \approx 2$

Question96

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.
[Jan.08,2020(II)]

Options:

A. Both assertion and reason are true, and the reason is the correct explanation for the assertion.

B. Both assertion and reason are false.

C. Both assertion and reason are true, but the reason is not the correct explanation for the assertion.

D. Assertion is not true, but reason is true.

Answer: B

Solution:

.

Temperature plays a significant role on pH measurements. As the temperature rises, molecular vibrations increase which results in greater ability of water to ionise and form more hydrogen ions.
As a result, the pH will drop. So assertion is incorrect. The dissociation of water molecules into ions is bond breaking and is therefore an endothermic process (energy must be absorbed to break the bonds). So reason is also incorrect.

Question97

Two solutions, A and B, each of 100L was made by dissolving 4g of NaOH and 9.8g of H_2SO_4 in water, respectively. The pH of the resultant solution obtained from mixing 40L of solution A and 10L of solution. B is _____.
[NV, Jan. 07, 2020 (I)]

Answer: 10.60

Solution:

$M_{H_2SO_4} = \frac{9.8}{98 \times 100} = 10^{-3}M$

$M_{NaOH} = \frac{4}{40 \times 100} = 10^{-3}M$

After neutralisation $[OH^-]$ can be calculated as

$[OH] = \frac{(40 \times 10^{-3}) - (2 \times 10^{-3} \times 10)}{50}$

$= \frac{20}{50} \times 10^{-3}$

$[OH^-] = \frac{2}{5} \times 10^{-3}$

pOH = 3.397

pH = 14 − pOH

= 14 − 3.397 = 10.603

Question98

3g of acetic acid is added to 250mL of 0.1M HCl and the solution made up to 500mL. To 20mL of this solution $\frac{1}{2}$ mL of 5M NaOH is added. The pH of the solution is _____.
[Given: pKa of acetic acid = 4.75, molar mass of acetic acid = 60g / mol, log 3 = 0.4771]
Neglect any changes in volume.
[NV, Jan. 07, 2020 (II)]

Answer: 5.22

Solution:

No. of moles $= \frac{\text{Mass}}{\text{Molar mass}}$

$3gCH_3COOH = \frac{3}{60}0.5mol = 50mmol$

No. of millimoles = Molarity × Volume in mL

250mL of 0.1M HCl $= 250 \times 0.1 = 25mmol$

500mL solution $= 50mmol\ CH_3COOH$

20mL solution $= \frac{50}{500} \times 20 = 2mmol\ CH_3COOH$

500mL solution contains $= 25mmol$ HCl

20mL solution contains $= \frac{25}{500} \times 20 = 1mmol$ HCl

$\frac{1}{2}$mL of 5M NaOH $= \frac{1}{2} \times 5 = 2.5mmol$ NaOH

$\underset{1}{HCl} + \underset{2.5}{NaOH} \longrightarrow \underset{1}{NaCl} + H_2O$

Remaining NaOH $= 2.5 - 1 = 1.5mmol$

CH_3COOH	+ NaOH (remaining)	→ CH_3COONa	+ Water
2	1.5	0	0
0.5	0	1.5	–

$pH = pK_a + \log \frac{1.5}{0.5} = 4.74 + \log 3$

$= 4.74 + 0.48 = 5.22$

Question99

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?
[Jan. 09, 2020 (I)]

Options:

A. Not enough data provided

B. $Q < K_s$

C. $Q > K_{sp}$

D. $Q = K_{sp}$

Answer: C

Solution:

$PbCl_2 \rightleftharpoons Pb^{2+}(aq) + 2Cl^-(aq)$
Given; $K_{sp} = 1.6 \times 10^{-5}$
$[Pb^{2+}] = \frac{300 \times 0.134}{400} = 0.1005$
$[Cl^-] = \frac{100 \times 0.4}{400} = 0.1$
$Q = [Pb^{2+}][Cl^-]^2 = 0.1005 \times (0.1)^2$
$= 1.005 \times 10^{-3}$
$Q > K_{sp}$

Question100

The solubility product of $Cr(OH)_3$ at 298K is 6.0×10^{-31}.
The concentration of hydroxide ions in a saturated solution of $Cr(OH)_3$ will be:
[Jan. 09,2020 (II)]

Options:

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

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

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

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

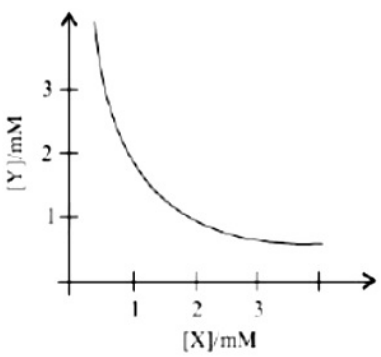
Answer: B

Solution:

$Cr(OH)_3 \rightarrow \underset{s}{Cr^{3+}} + 3OH^-$
$K_{sp} = s \cdot (3s)^3$
$\Rightarrow 6 \times 10^{-31} = 27 \cdot s^4$; $s = \left(\frac{6}{27} \times 10^{-31}\right)^{1/4}$
$[OH^-] = 3s = 3 \times \left(\frac{6}{27} \times 10^{-31}\right)^{1/4}$
$= (18 \times 10^{-31})^{1/4} M$

Question101

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



[Jan. 08,2020 (I)]

Options:

A. X_2Y , $2 \times 10^{-9} M^3$

B. XY_2, $4 \times 10^{-9} M^3$

C. XY_2, $1 \times 10^{-9} M^3$

D. XY , $2 \times 10^{-6} M^3$

Answer: B

Solution:

From the given curve,
if $[X] = 1mM$ then $[Y] = 2mM$
$\therefore$ Salt is XY_2
$K_{sp} = [X][Y]^2 = (10^{-3})(2 \times 10^{-3})^2 = 4 \times 10^{-9} M^3$

Question102

For the reaction
$Fe_2N(s) + \frac{3}{2}H_2(g) \rightleftharpoons 2Fe(s) + NH_3(g)$
[Sep. 06,2020(I)]

Options:

A. $K_c = K_p(RT)$

B. $K_c = K_p(RT)^{\frac{-1}{2}}$

C. $K_c = K_p(RT)^{\frac{1}{2}}$

D. $K_c = K_p(RT)^{\frac{3}{2}}$

Answer: C

Solution:

$K_p = K_c(RT)^{\Delta n_g} = K_c(RT)^{1-3/2} = K_c(RT)^{-1/2}$
$\Rightarrow K_c = K_p(RT)^{1/2}$

Question103

The value of Kc is 64 at 800K for the reaction $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$.
The value of K_c for the following reaction is:
$NH_3(g) \rightleftharpoons \frac{1}{2}N_2(g) + \frac{3}{2}H_2(g)$
[Sep. 06, 2020 (II)]

Options:

A. 1 / 64

B. 8

C. 1 / 4

D. 1 / 8

Answer: D

Solution:

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

$2NH_3(g) \rightleftharpoons N_2(g) + 3H_2(g)$; $\frac{1}{K_c}$

For

$NH_3(g) \rightleftharpoons \frac{1}{2}N_2(g) + \frac{3}{2}H_2(g)$; $\frac{1}{K_c^{1/2}}$

$\frac{1}{K_c^{1/2}} = \frac{1}{(64)^{1/2}} = \frac{1}{8}$

Question104

For a reaction $X + Y \rightleftharpoons 2Z$, 1.0mol of X, 1.5mol 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 1.0mol L^{-1}. The equilibrium constant of the reaction is $\frac{x}{15}$. The value of x is _____.
[NV, Sep. 05, 2020 (II)]

Answer: 16

Solution:

Solution:

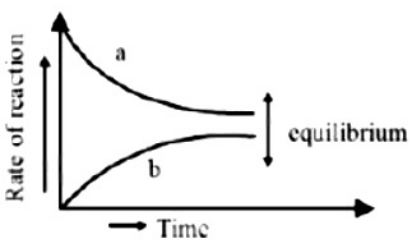
Question105

For the equilibrium A ⇌ B, the variation of the rate of the forward (a) and reverse (b) reaction with time is given by:
[Sep. 04,2020(I)]

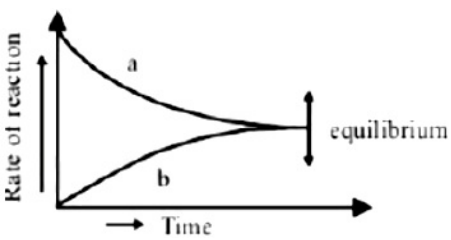
For the equilibrium A ⇌ B, the variation of the rate of the forward (a) and reverse (b) reaction with time is given by:
[Sep. 04,2020(I)]

Options:

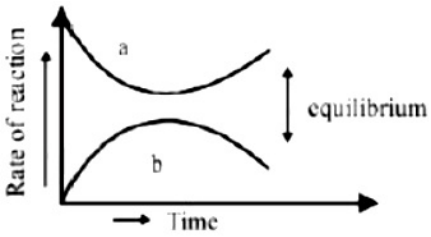
A.



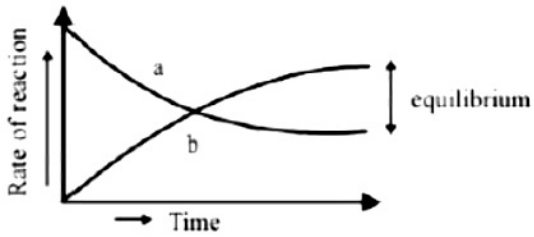
B.



C.



D.



Answer: B

Solution:

Solution:
At equilibrium, rate of forward reaction = Rate of backward reaction.

Question106

If the equilibrium constant for A ⇌ B + C is $K_{eq}^{(1)}$ and that of B + C ⇌ P is $K_{eq}^{(2)}$, the equilibrium constant for A ⇌ P is:
[Sep. 04,2020(II)]

Options:

A. $K_{eq}^{(1)} / K_{eq}^{(2)}$

B. $K_{eq}^{(2)} - K_{eq}^{(t)}$

C. $K_{eq}^{(1)} + K_{eq}^{(2)}$

D. $K_{eq}^{(1)} K_{eq}^{(2)}$

Answer: D

Solution:

$A \rightleftharpoons B + C$; $K_{eq}^{(1)}$ . . . (i)
$B + C \rightleftharpoons P$; $K_{eq}^{(2)}$ . . . (ii)
On adding equations (i) and (ii), we get
$A \rightleftharpoons P$
$K_{eq}(\text{ overall }) = K_{eq}^{(1)} \cdot K_{eq}^{(2)}$

Question107

The variation of equilibrium constant with temperature is given below:
Temperature Equilibrium Constant
$T_1 = 25^{\circ}C$ $K_1 = 10$
$T_2 = 100^{\circ}C$ $K_2 = 100$
The values of ΔH°, ΔG° at T_1 and ΔG° at T_2 (in kj mol^{-1}) respectively, are close to
[use $R = 8.314 J K^{-1} mol^{-1}$]
[Sep. 06, 2020 (I)]

Options:

A. 28.4, −7.14 and −5.71

B. 0.64, −7.14 and −5.71

C. 28.4, −5.71 and −14.29

D. 0.64, −5.71 and −14.29

Answer: C

Solution:

$\Delta G^{\circ} = -RT \ln K$, $T_1 = 25^{\circ}C$, $K_1 = 10$
ΔG° at $T_1 = -8.314 \times 298 \times 2.303 \times \log 10 = -5.71 kJ / mol$
ΔG° at $T_2 = -8.314 \times 298 \times 373 \times 2.303 \times \log(100)$
$= -14.29 kJ / mol$
$\Delta G^{\circ} = \Delta H^{\circ} - T \Delta S^{\circ}$
$\Rightarrow -5.71 = \Delta H^{\circ} - 298(\Delta S^{\circ})$
$\Rightarrow -14.29 = \Delta H^{\circ} - 373(\Delta S^{\circ})$
$\Delta H^{\circ} = 28.4 kJ / mol$

Question108

Consider the following reaction:
$N_2O_4(g) \rightleftharpoons 2NO_2(g); \Delta H^0 = +58 kJ$
For each of the following cases ((i), (ii)), the direction in which the equilibrium shifts is:
(i) Temperature is decreases
(ii) Pressure is increased by adding N_2 at constant T.
[Sep .05,2020(I)]

Options:

A. (i) towards product, (ii) towards product

B. (i) towards reactant, (ii) towards product

C. (i) towards reactant, (ii) no change

D. (i) towards product, (ii) no change

Answer: C

Solution:

Solution:
(i) As reaction is endothermic (ΔH z = + ve) so on decrease in temperature equilibrium will shift towards reactant side.
(ii) On increase in pressure by adding inert gas (N_2) at same temperature, no shifting will take place. The equilibrium changes only if the added gas is a reactant or product involved in the reaction.

Question109

Arrange the following solutions in the decreasing order of pOH:
(A) 0.01M HCl
(B) 0.01M NaOH
(C) 0.01M CH_3COONa
(D) 0.01M NaCl
[Sep. 06, 2020 (I)]

Options:

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

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

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

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

Answer: B

Solution:

0.01M HCl
$[H^+] = 10^{-2}$, $pH = -\log 10^{-2} = 2$
$pOH = 14 - 2 = 12$
(B) 0.01M NaOH
$[OH^-] = 10^{-2}$, $pOH = -\log[OH] = 2$
(C) 0.01M CH_3COONa

$pH = 7 + \frac{1}{2}[pK_a + \log 0.01]$

$pH > 7 \Rightarrow pOH < 7$
(D) 0.01M NaCl, $pH = 7$, $pOH = 7$
Decreasing order of pOH value is,
(A) > (D) > (C) > (B)

Question110

A soft drink was bottled with a partial pressure of CO_2 of 3 bar over the liquid at room temperature. The partial pressure of CO_2 over the solution approaches a value of 30 bar when 44g of CO_2 is dissolved in 1kg of water at room temperature. The approximate pH of the soft drink is _____ $\times 10^{-1}$.
(First dissociation constant of H_2CO_3 = 4.0×10^{-7}; $\log 2 = 0.3$; density of the soft drink = $1 gmL^{-1}$)
[NV, Sep. 05, 2020(I)]

Answer: 7

Solution:

$$CO_2 + H_2O \longrightarrow H_2CO_3$$
30 bar ..... 1 mol/L
3 bar ..... 0.1 mol/L

$$H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$$

	H_2CO_3	H^+	HCO_3^-
$t=0$	0.1	0	0
at Equb.	$0.1(1-\alpha)$	0.1α	0.1α

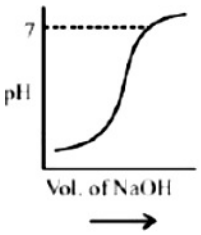
$4.0 \times 10^{-7} = \frac{0.1\alpha^2}{1-\alpha}$
$\Rightarrow (1-\alpha) = 1$
$\alpha^2 = 4 \times 10^{-6} \Rightarrow \alpha = 2 \times 10^{-3}$
$= [H^+] = 2 \times 10^{-4} M$
$pH = 4 \times \log 2 = 3.7 = 37 \times 10^{-1}$

Question111

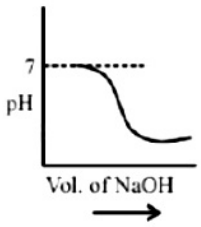
100mL of 0.1M HCl is taken in a beaker and to it 100mL of 0.1M NaOH is added in steps of 2mL and the pH is continuously measured. Which of the following graphs correctly depicts the change in pH?
[Sep. 03, 2020 (II)]

Options:

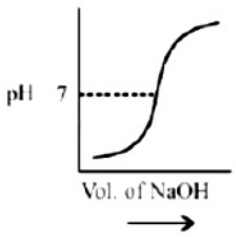
A.



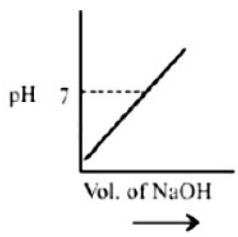
B.



C.



D.



Answer: C

Solution:

Solution:
At equivalence point pH is 7 and pH increases with addition of N aOH so correct graph is (c).

Question112

If the solubility product of AB_2 is $3.20 \times 10^{-11} M^3$, 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]
[NV, Sep.06, 2020 (II)]

Answer: 2

Solution:

$$AB_2 \rightleftharpoons \underset{s}{A^{2+}}(aq) + \underset{2s}{2B^-}(aq)$$

$$K_{sp} = 4s^3 = 3.2 \times 10^{-11}$$

$$\Rightarrow s^3 = 8 \times 10^{-12}$$

$$\Rightarrow s = 2 \times 10^{-4}$$

Question113

An acidic buffer is obtained on mixing :
[Sep. 03,2020 (I)]

Options:

A. 100mL of 0.1M CH_3COOH and 100mL of 0.1M N aOH

B. 100mL of 0.1M H Cl and 200mL of 0.1M N aCl

C. 100mL of 0.1M CH_3COOH and 200mL of 0.1M N aOH

D. 100mL of 0.1M H Cl and 200mL of 0.1M CH_3COON a

Answer: D

Solution:

$$HCl + CH_3COONa \longrightarrow CH_3COOH + NaCl$$

Millimoles at start	10	20	0	0
Millimoles after reaction	0	10	10	10

Buffer solution contains CH_3COON a(10 millimole) and CH_3COOH (10 millimole) which is a acidic buffer.

Question114

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.
[Sep. 02,2020(I)]

Options:

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

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

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

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

Answer: C

Solution:

Cu^{2+} ions get precipitated every quickely due to low K_{sp} value even at very low concentration of S^{2-} ion.

$CuS(s) \rightleftharpoons Cu^{2+} + S^{2-}$

$K_{sp} = [Cu^{2+}][S^{2-}]$

$Cu^{2+} + S^{2-} \rightleftharpoons CuS(s)$

$$K_{eq} = \frac{1}{[Cu^{2+}][S^{2-}]} = \frac{1}{K_{sp}}$$

Due to high value of K_{eq}, CuS precipitated easily.

Question115

For the equilibrium
$2H_2O \rightleftharpoons H_3O^+ + OH^-$; the value of ΔG° at 298K is approximately:
[Jan. 11, 2019 (II)]

Options:

A. 100kJ mol^{-1}

B. -80kJ mol^{-1}

C. 80kJ mol^{-1}

D. -100kJ mol^{-1}

Answer: C

Solution:

$\Delta G = \Delta G^{\circ} + RT \ln Q$
At equilibrium; $\Delta G = 0$ and $Q = K_{eq}$
$\Rightarrow \Delta G^{\circ} = -2.303RT \log K_w$
$= -2.303 \times 8.314 \times 298 \times \log 10^{-14}$
$= 79.9\text{kJ / mol} \approx 80\text{kJ / mol}$

Question116

Which amongst the following is the strongest acid? [Jan. 9,2019 (I)]

Options:

A. $CH Br_3$

B. $CH I_3$

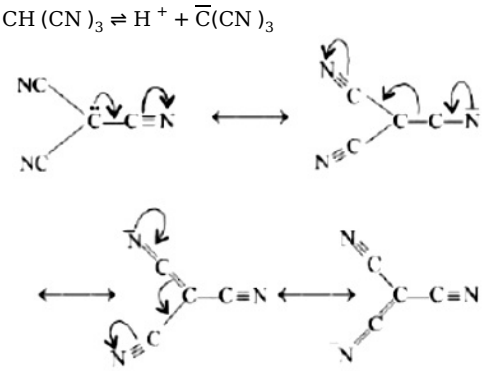
C. $CH (CN)_3$

D. $CH Cl_3$

Answer: C

Solution:

Due to the resonance stabilisation of the conjugate base, $CH (CN)_3$ is the strongest acid amongst the given compounds.
$CH (CN)_3 \rightleftharpoons H^+ + \overline{C}(CN)_3$



The conjugate bases of $CH Br_3$ and $CH I_3$ are stabilised by inductive effect of halogens. This is why, they are less stable. Also, the conjugate base of $CH Cl_3$ involves backbonding between 2p and 3p orbitals.

Question117

If K_{50} of Ag_2CO_3 is 8×10^{-12}, the molar solubility of Ag_2CO_3 in $0.1M\ AgNO_3$ is: [Jan. 12,2019(II)]

Options:

A. $8 \times 10^{-12}M$

B. $8 \times 10^{-11}M$

C. 8×10^{-10}M

D. 8×10^{-13}M

Answer: C

Solution:

Solution:
As $AgNO_3$ dissociates completely,
therefore in 0.1M $AgNO_3$ solution, $[Ag^+] = 0.1M$

$$AgNO_3 \longrightarrow \underset{0.1^+}{Ag} + NO_{0.1}^-$$

$$Ag_2CO_3 \rightleftharpoons {}_{0.1+2ss}Ag^+ + CO_3^{2-}$$

$K_{sp} = [Ag^+]^2[CO_3^{2-}]$
$8 \times 10^{-12} = (0.1 + 2s)^2 \times s$
$0.01s = 8 \times 10^{-12}$; $(0.1 + 2s \times 0.1)$
$s = 8 \times 10^{-10}$M

Question118

20mL of 0.1M H_2SO_4 solution is added to 30mL of 0.2 M NH_4OH solution. The pH of the resultant mixture is:
[pK_b of NH_4OH = 4.7]
[Jan. 9,2019 (I)]

Options:

A. 5.2

B. 9.0

C. 5.0

D. 9.4

Answer: B

Solution:

m · mol of $H_2SO_4 = 20 \times 0.1 = 2$
m . mol of $NH_4OH = 30 \times 0.2 = 6$

$$H_2SO_4 + 2NH_4OH \rightarrow (NH_4)_2SO_4 + 2H_2O$$

Initial	2 m mol	6 m mol	0
Final	(2-2)	$(6 - 2 \times 2)$	2 m mol

$[NH_4OH]_{left} = 2m\,mol$
$[(NH_4)_2SO_4] = 2m\,mol$
$[NH_4] = 2 \times 2 = 4m\,mol$
Total Volume $= 30 + 20 = 50\,mL$

$$pOH = pK_b + \log\left[\frac{Salt}{Base}\right]$$

$$= 4.7 + \log\frac{4/50}{2/50}$$

$= 4.7 + \log 2 = 5$
$pH = 14 - pOH$
$pH = 14 - 5 = 9$

Question119

A mixture of 100m mol of $Ca(OH)_2$ and 2g of sodium sulphate was dissolved in water and the volume was made up to 100mL. 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 136gmol^{-1}, respectively; K_{sp} of $Ca(OH)_2$ is 5.5×10^{-6})

[Jan. 10,2019(I)]

Options:

A. 1.9g, 0.28mol L^{-1}

B. 13.6g, 0.28mol L^{-1}

C. 1.9g, 0.14mol L^{-1}

D. 13.6g, 0.14mol L^{-1}

Answer: A

Solution:

$\text{N a}_2\text{SO}_4 + \text{Ca(OH)}_2 \rightarrow \text{CaSO}_4 + 2\text{N aOH}$

$\text{m mol of N a}_2\text{SO}_4 = \frac{2 \times 1000}{143} = 13.98 \text{m mol}$

$\text{m mol of CaSO}_4 \text{ formed } = 13.98 \text{m mol}$

$\text{Mass of CaSO}_4 \text{ formed } = 13.98 \times 10^{-3} \times 136 = 1.90 \text{g}$

$\text{m mol of N aOH } = 28 \text{m mol} \approx 0.028 \text{ mol}$

$\text{Ca(OH)}_2 \rightleftharpoons \underset{\text{S}}{\text{Ca}^{2+}} + \underset{2\text{s} + 0.028}{2\text{OH}^-}$

Value of ' S ' will be negligible so

$[\text{OH}] = \frac{0.028 \text{ mol}}{0.1 \text{L}} = 0.28 \text{ mol L}^{-1}$

Question120

Two solids dissociate as follows
$\text{A(s)} \rightarrow \text{B(g)} + \text{C(g)}; K_{P_1} = x\text{atm}^2$

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

The total pressure when both the solids dissociate simultaneously is:
[Jan. 12, 2019 (I)]

Options:

A. $\sqrt{x + y}$ atm

B. $2(\sqrt{x + y})$ atm

C. $(x + y)$atm

D. $x^2 + y^2$ atm

Answer: B

Solution:

$\text{A(s)} \longrightarrow \text{B(g)} + \text{C(g)}$

$P_1 \quad P_1 + P_2$

$K_{P_1} = P_B \times P_C$

$P_1(P_1 + P_2) = x$

$K_{P_2} = P_C \times P_E$

$(P_1 + P_2)P_2 = y \quad ...(ii)$

Adding (i) and (ii)

$\therefore P_1(P_1 + P_2) + P_2(P_1 + P_2) = x + y$

$P_1^2 + P_1P_2 + P_2P_1 + P_2^2 = x + y$

$P_1^2 + P_2^2 + 2P_1P_2 = x + y$

$\Rightarrow \&(P_1 + P_2)^2 = x + y$

$\Rightarrow P_1 + P_2 = \sqrt{x + y}$

$\therefore \text{ Total pressure } (P_T) = P_C + P_B + P_E$

$(P_1 + P_2) + P_1 + P_2 = 2(P_1 + P_2)$

$P_T = 2(\sqrt{x + y})$

Question121

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:
[Jan. 12, 2019 (I)]

Options:

A. 4

B. 16

C. $\frac{1}{4}$

D. 1

Answer: A

Solution:

	A	+	2B	⟺	2C	+	D
$t=0$	2		3		0		0
t_{eq}	$2-x$		$3-2x$		$2x$		x

Given, $3 - 2x = 2 - x$
$\Rightarrow x = 1$
$\therefore [C] = 2, [D] = 1, [A] = 1, [B] = 1$

$K_c = \left\{ \frac{2^2 \times 1}{1^2 \times 1} \right\} = 4$

Question122

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)
[Jan. 11, 2019 (I)]

Options:

A. $\frac{3^{3/2} K_P^{1/2} P^2}{16}$

B. $\frac{K_P^{1/2} P^2}{16}$

C. $\frac{K_P^{1/2} P^2}{4}$

D. $\frac{3^{3/2} K_P^{1/2} P^2}{4}$

Answer: A

Solution:

$2NH_3(g) \rightleftharpoons \underset{P_{N_2}}{N_2(g)} + \underset{P_{H_2}}{3H_2(g)}, K = \frac{1}{K_P}$

$K = \frac{1}{K_p} = \frac{P_{N_2}(P_{H_2})^3}{(P_{NH_3})^2} \ldots$ (i)

$\Rightarrow P_{Total}(P) = P_{N_2} + P_{H_2} + P_{NH_3}$
$= P_{N_2} + P_{H_2} (\because P_{NH_3} < P_T)$

Now, Partial $f_2 = \frac{1}{4}P$; Partial pressure of $H_2 = \frac{3}{4}P$

From eq (i), $\frac{1}{K_P} = \frac{\left(\frac{1}{4}P\right)\left(\frac{3}{4}P\right)^3}{\left(P_{NH_3}\right)^2}$

$\frac{\left(P_{NH_3}\right)^2}{K_P} = \frac{P}{4}\cdot\frac{P^3}{4^3}\cdot 3^3;\ \frac{\left(P_{NH_3}\right)^2}{K_P} = \frac{P^4}{4^4}\cdot 3^3$

$\left(P_{NH_3}\right)^2 = K_P\cdot\frac{P^4}{4^4}\cdot 3^3;\ P_{NH_3} = \left[K_P\cdot\frac{P^4}{4^4}\cdot 3^3\right]^{1/2}$

$P_{NH_3} = \frac{3^{3/2}\cdot P^2\cdot K_P{}^{1/2}}{16}$

Question123

The values of K_p / K_c for the following reactions at 300K are, respectively: (At 300K, RT = $24.62 dm^3 atm\, mol^{-1}$)
$N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$
$N_2O_4(g) \rightleftharpoons 2NO_2(g)$
$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
[Jan. 10, 2019 (I)]

Options:

A. 1, $24.62 dm^3 atm\, mol^{-1}$,
$606.0 dm^6 atm^2 mol^{-2}$

B. 1, $24.62 d\, m^3 atm\, mol^{-1}$,
$1.65 \times 10^{-3} dm^{-6} atm^{-2} mol^2$

C. 1, $4.1 \times 10^{-2} dm^{-3} atm^{-1}$ mol,
$606 dm^6 atm^2 mol^2$

D. $24.62 dm^3 atm\, mol^{-1}$,
$606.0 dm^6 atm^2 mol^{-2}$
$1.65 \times 10^{-3} dm^{-6} atm^{-2} mol^2$

Answer: B

Solution:

Solution:
$K_p = K_c(RT)^{\Delta^n g}$

Δn_g = No. of gaseous moles of products - No. of gaseous moles of reactants $\frac{K_p}{K_c} = (RT)^{\Delta^n g}$

$N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$, $\Delta n_g = 0$

$\frac{K_p}{K_c} = (24.62 d\, m^3 atm mol^{-1})^0 = 1$

$N_2O_4(g) \rightleftharpoons 2NO_2(g)$, $\Delta n_g = 1$

$\frac{K_p}{K_c} = 24.62 d\, m^3 atm mol^{-1}$

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$, $\Delta n_g = -2$

$\frac{K_p}{K_c} = (24.62 d\, m^3 atm mol^{-1})^{-2}$

$= \frac{1}{(24.62 d\, m^3 atm mol^{-1})^2}$

$= 1.65 \times 10^{-3} d\, m^{-6} atm^{-2} mol^2$

Question124

5.1 g NH_4SH is introduced in 3.0L evacuated flask at 327°C, 30% of the solid NH_4SH decomposed to NH_3 and H_2S as gases. The K_p of the reaction at 327°C is (R = 0.082L atm $mol^{-1} K^{-1}$, molar mass of S = $32 g mol^{-1}$, molar mass of N = $14 g mol^{-1}$)
[Jan. 10, 2019 (II)]

Options:

A. $0.242 \times 10^{-4} atm^2$

B. $1 \times 10^{-4} atm^2$

C. $4.9 \times 10^{-3} atm^2$

D. $0.242 atm^2$

Answer: D

Solution:

Concerned reaction:

$NH_4SH \longrightarrow NH_3(g) + H_2S(g)$

Initial moles $= \frac{5.1}{51} = 0.1 mol$

Moles at equillibrium

$NH_4SH \longrightarrow NH_3(g) + H_2S(g)$

$0.1(1-0.3) \quad 0.1 \times 0.3 \quad 0.1 \times 0.3$

$\therefore K_c = [NH_3][H_2S] = \left(\frac{0.03}{3}\right)^2 = 10^{-4}$

$K_p = K_c(RT)^{\Delta n} g$

$= 10^{-4} \times (0.082 \times 600)^2 = 0.242 atm^2$

Question125

Consider the following reversible chemical reactions:

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

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

The relation between K_1 and K_2 is:

[Jan. 9,2019(II)]

Options:

A. $K_1 K_2 = \frac{1}{3}$

B. $K_2 = K_1^3$

C. $K_2 = K_1^{-3}$

D. $K_1 K_2 = 3$

Answer: C

Solution:

Given:

$A_2 + B_2 \overset{K_1}{\rightleftharpoons} 2AB$

$\Rightarrow 2AB \rightleftharpoons A_2 + B_2; K = \frac{1}{K_1}$

$6AB \overset{K_1}{\longleftarrow} 3A_2 + 3B_2; K_2 = \left(\frac{1}{K_1}\right)^3$

The relation between K_1 and K_2 is $K_2 = K_1^{-3}$

Question126

The INCORRECT match in the following is:
[April 12, 2019 (II)]

Options:

A. $\Delta G^0 < 0, K > 1$

B. $\Delta G^0 = 0, K = 1$

C. $\Delta G^0 > 0, K < 1$

D. $\Delta G^0 < 0, K < 1$

Answer: D

Solution:

$\Delta G^\circ = -RT \ln K$
$\therefore$ If $K > 1$ then $\Delta G^\circ < 0$
If $K < 1$ then $\Delta G^\circ > 0$
If $K = 1$ then $\Delta G^\circ = 0$

Question127

In which one of the following equilibria, $K_p \neq K_c$? [April 12, 2019 (II)]

Options:

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

B. $2HI(g) \rightleftharpoons H_2(g) + I_2(g)$

C. $NO_2(g) + SO_2(g) \rightleftharpoons NO(g) + SO_3(g)$

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

Answer: A

Solution:

We know that, $K_p = K_c . (RT)^{\Delta n_g}$
$\therefore$ If $\Delta n_g \neq 0$ then $K_p \neq K_c$
Now, $2C(s) + O_2(g) \rightleftharpoons 2CO(g)$
$\Delta n_g = +1$
$\Rightarrow K_p = K_c(RT)^1$
Hence, $K_p \neq K_c$

Question128

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: [April 8, 2019 (II)]

Options:

A. 10^{154}

B. 10^{181}

C. 10^{25}

D. 10^{77}

Answer: C

Solution:

Given, $S + O_2 \rightleftharpoons SO_2 \ldots$ (i); $K_1 = 10^{52}$
$2S + 3O_2 \rightleftharpoons 2SO_3$ ... (ii); $K_2 = 10^{129}$
$2SO_2 + O_2 \rightleftharpoons 2SO_3$ ... (iii) ; K = ?
To get equation (iii) follow (ii) -2 (i),
$2S + 3O_2 \rightarrow 2SO_3$ $K = 10^{129}$
$-(2S + 2O_2 \rightarrow 2SO_2$ $K = 10^{104})$
$O_2 \rightarrow 2SO_3 - 2SO_2$ $K = 10^{25}$
or $2SO_2 + O_2 \rightarrow 2SO_3 K = 10^{25}$

Question129

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?
[April 10, 2019 (II)]

Options:

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

B. The equilibrium will shift in forward direction as the pressure increases.

C. The equilibrium constant decreases as the temperature increases.

D. The addition of inert gas at constant volume will not affect the equilibrium constant.

Answer: A

Solution:

Equilibrium constant has no relation with catalyst. Catalyst only affects the rate of the reaction. Catalyst, V_2O_5 in the given reaction, is used to speed up the reaction.

Question130

Consider the following statements
(a) The pH of a mixture containing 400mL of 0.1M H_2SO_4 and 400mL of 0.1M 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 :
[April 10, 2019 (I)]

Options:

A. (a), (b), and (d)

B. (a), (b) and (c)

C. (b) and (c)

D. (a) and (b)

Answer: B

Solution:

$$H_2SO_4 + NaOH \rightarrow NaHSO_4 + H_2O$$

Initial mol	0.04	0.04	0	0
mol at eqm.	0	0	0.04	0.04

$NaHSO_4 \rightarrow Na^+ + H^+ + SO_4^{2-}$

$[H^+] = \frac{0.04}{0.80} = 0.05M$; pH = 1.3

(b) Ionic product of water increases with increase in temperature because ionisation of water is endothermic.

(c)

	HA	$\rightleftharpoons$	H^+	A^-
Initial	C		0	0
At eqm.	$C(1-\alpha)$		$C\alpha$	$C\alpha$

Given pH $= 5 \Rightarrow -\log(H^+) = 5$

$\therefore [H^+] = 10^{-5}$

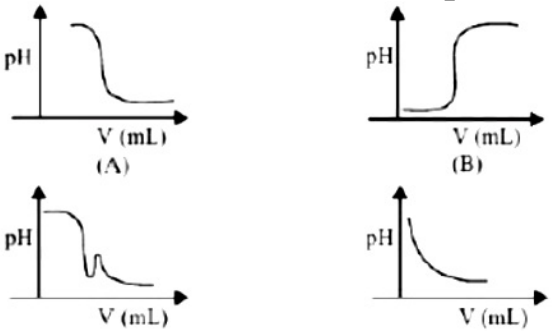
As we know,

$K_a = \frac{C\alpha^2}{1-\alpha}$; $10^{-5} = \frac{C\alpha^2}{1-\alpha} = \frac{C\alpha \cdot \alpha}{(1-\alpha)}$

$10^{-5} = 10^{-5}\frac{\alpha}{1-\alpha}$; $\alpha = \frac{1}{2}$ i.e., 50%

Question131

In an acid base titration, 0.1M 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?



[April 9,2019 (II)]

Options:

A. (B)

B. (A)

C. (C)

D. (D)

Answer: B

Solution:

Solution:
Graph A and B, both represents the titration curve between strong acid and strong base, i.e., HCl and NaOH but, the pH of NaOH is more than 7 and during the titration it decreases, so graph (A) is correct.

Question132

What is the molar solubility of $Al(OH)_3$ in 0.2M NaOH solution ?
Given that, solubility product of $Al(OH)_3$ $= 2.4 \times 10^{-24}$:
[April 12, 2019 (I)]

Options:

A. 3×10^{-19}

B. 12×10^{-21}

C. 3×10^{-22}

D. 12×10^{-23}

Answer: C

Solution:

Solution:
Let the solubility of $Al(OH)_3$ in 0.2M NaOH solution be s.
Then,
$Al(OH)_3 \rightleftharpoons \underset{s}{Al^{3+}} + \underset{3s}{3OH^-}$
and $\underset{0.2M}{NaOH} \rightleftharpoons \underset{0.2M}{Na^+} + \underset{0.2M}{OH^-}$
$[Al^{3+}] = s$ and $[OH^-] = 3s + 0.2 \approx 0.2$
$K_{sp} = 2.4 \times 10^{-24} = [Al^{3+}][OH]^3$
$2.4 \times 10^{-24} = s(0.2)^3$
$s = \frac{2.4 \times 10^{-24}}{8 \times 10^3} = 3 \times 10^{-22} mol / L$

Question133

The molar solubility of $Cd(OH)_2$ is $1.84 \times 10^{-5}M$ in water. The expected solubility of $Cd(OH)_2$ in a buffer solution pH = 12 is: [April 12, 2019 (II)]

Options:

A. $1.84 \times 10^{-9}M$

B. $\frac{2.49}{1.84} \times 10^{-9}M$

C. $6.23 \times 10^{-11}M$

D. $2.49 \times 10^{-10}M$

Answer: D

Solution:

Solution:
$Cd(OH)_2 \rightleftharpoons \underset{s}{Cd^{2+}} + \underset{2s}{2OH^-}$
At equilibrium, $K_{sp} = s(2s)^2 = 4s^3$
$\Rightarrow K_{sp} = 4 \times (1.84 \times 10^{-5})^{-3}$
Solubility in buffer solution having pH = 12
$[OH^-] = 10^{-2}$
$Cd(OH)_2 \rightleftharpoons Cd^{2+} + 2OH^-$
$2s' + 10^{-2} \approx 10^{-2}$
$\therefore K_{sp} = 4 \times (1.84 \times 10^{-5})^3 = s'(10^{-2})^2$
$\Rightarrow s' = \frac{24.9 \times 10^{-15}}{10^{-4}} = 2.49 \times 10^{-10}M$

Question134

The pH of a 0.02M NH_4Cl solution will be [given $K_b(NH_4OH) = 10^{-5}$ and $\log 2 = 0.301$] [April 10, 2019 (II)]

Options:

A. 2.65

B. 4.35

C. 4.65

D. 5.35

Answer: D

Solution:

$$pH = 7 - \frac{1}{2}pK_b - \frac{1}{2}\log C$$
$$= 7 - \frac{5}{2} - \frac{1}{2}(\log 2 \times 10^{-2}) = 5.35$$
$$pH = 5.35$$

Question135

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?
[April 8, 2019 (I)]

Options:

A. $S = \left(\frac{K_{gp}}{144}\right)^{1/6}$

B. $S = \left(\frac{K_{sp}}{6912}\right)^{1/7}$

C. $S = \left(\frac{K_{\phi}}{929}\right)^{1/9}$

D. $S = \left(\frac{K_{sp}}{216}\right)^{1/7}$

Answer: B

Solution:

$$Zr_3(PO_4)_4 \rightleftharpoons \underset{3S}{3Zr^{4+}} + \underset{4S}{3SO_4^{3-}}$$
$$K_{sp} = [Zr^{4+}]^3[PO_4^{3-}]^4 = (3S)^3(4S)^4$$
$$K_{sp} = 6912S^7$$
$$S = \left(\frac{K_{sp}}{6912}\right)^{1/7}$$

Question136

At a certain temperature in a 5L vessel, 2 moles of carbon monoxide and 3 moles of chlorine were allowed to reach equilibrium according to the reaction, $CO + Cl_2 \rightleftharpoons COCl_2$ At equilibrium, if one mole of CO is present then equilibrium constant (K_c) for the reaction is:
[Online April 15, 2018 (II)]

Options:

A. 2.5

B. 4

C. 2

D. 3

Answer: A

Solution:

Initially 2 moles of CO are present.
At equilibrium, 1 mole of CO is present
Hence, $2 - 1 = 1$ moles of CO has reacted.
l. mole of CO will react with 1 mole of Cl_2 to form 1 mole of $COCl_2$

$3 - 1 = 2$ moles of Cl_2 remains at equilibrium The equilibrium constant

$$K_c = \frac{[COCl_2]}{[CO][Cl_2]} = \frac{\frac{1mol}{5L}}{\frac{1mol}{5L} \times \frac{2mol}{5L}} = 2.5$$

Question137

In which of the following reactions, an increase in the volume of the container will favour the formation of products? [Online April 15,2018(I)]

Options:

A. $4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(l)$

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

C. $3O_2 \rightleftharpoons 2O_3(g)$

D. $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

Answer: B

Solution:

Solution:
Volume $\uparrow P \downarrow$, reaction proceeds in which direction where the number of moles of gases increases.
$2NO_2(g) \rightleftharpoons 2NO(g) + O_2(g) \quad \Delta n_g = (2 + 1) - 2 = 1$

Question138

The gas phase reaction $2NO_2(g) \longrightarrow N_2O_4(g)$ is an exothermic reaction. The decomposition of N_2O_4, in equilibrium mixutre of $NO_2(g)$ and $N_2O_4(g)$, can be increased by: [Online April 16, 2018]

Options:

A. addition of an inert gas at constant pressure

B. lowering the temperature

C. increasing the pressure

D. addition of an inert gas at constant volume

Answer: C

Solution:

Solution:
Reaction at equilibirium
$N_2O_4 \rightleftharpoons 2NO_2$
According to Le chatelier's principle-
(a) addition of an inert gas at constant pressure will increase volume and equilibirium shifts towards more number of molecules.
(b) Decomposition of N_2O_4 will be endothermic, so reaction will move in forward reaction when temperature is increased.So, It is incorrect. It will not effect reaction (volume is constant)
(c) Increasing the pressure on a gas reaction shifts theposition of equilibirium towards thesidewith fewer molecules. So, it will move in backward direction which leads to formation of N_2O_4 from NO_2.

Question139

Following four solutions are prepared by mixing different volumes of NaOH and HCl of different concentrations, pH of which one of them will be equal to 1 ? [Online April 15, 2018 (II)]

Options:

A. 55mL $\frac{M}{10}$H Cl + 45mL $\frac{M}{10}$N aOH

B. 75mL $\frac{M}{5}$H Cl + 25mL $\frac{M}{5}$N aOH

C. 100mL $\frac{M}{10}$H Cl + 100mL $\frac{M}{10}$N aOH

D. 60mL $\frac{M}{10}$H Cl + 40mL $\frac{M}{10}$N aOH

Answer: B

Solution:

Solution:

75mL $\frac{M}{5}$H Cl + 25mL $\frac{M}{5}$N aOH

25mL $\frac{M}{5}$N aOH will neutralise 25mL $\frac{M}{5}$H Cl

$75 - 25 = 50$mL $\frac{M}{5}$H Cl will remain.

Total volume will be $75 + 25 = 100$mL

50mL $\frac{M}{5}$H Cl is diluted to 100mL

$[H^+] = [HCl] = \frac{M}{5} \times \frac{50}{100} = \frac{M}{10}$

$pH = -\log_{10}[H^+] = -\log_{10}\frac{M}{10} = 1$

Question140

Which of the following is a Lewis acid? [Online April 15, 2018 (I)]

Options:

A. PH_3

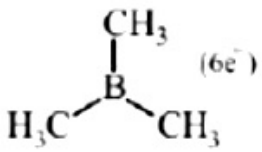
B. NF_3

C. NaH

D. $B(CH_3)_3$

Answer: D

Solution:



Question141

Which of the following salts is the most basic in aqueous solution? [2018]

Options:

A. $Al(CN)_3$

B. CH_3COOK

C. $FeCl_3$

D. $Pb(CH_3COO)_2$

Answer: B

Solution:

CH_3COOK is a salt of weak acid (CH_3COOH) and strong base (KOH).
$FeCl_3$ is a salt of weak base [$Fe(OH)_3$] and strong acid (HCl).
$Pb(CH_3COO)_2$, is a salt of weak base $Pb(OH)_2$ and weak acid (CH_3COOH)
$Al(CN)_3$ is a salt of weak base [$Al(OH)_3$] and weak acid (HCN).

Question142

An aqueous solution contains 0.10M H_2S and 0.20M HCl. If the equilibrium constants 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 :
[2018]

Options:

A. 5×10^{8}

B. 3×10^{-20}

C. 6×10^{-21}

D. 5×10^{-19}

Answer: B

Solution:

$$\underset{\text{Atequb. } 0.10}{H_2S} \rightleftharpoons \underset{0.20}{2H^+} + \underset{?}{S^{2-}},\ K_{a_1} \cdot K_{a_2} = K_{eq}$$

$$\therefore \frac{[H^+]^2[s^{2-}]}{[H_2S]} = 1 \times 10^{-7} \times 1.2 \times 10^{-13}$$

$$\frac{[0.2]^2[s^{2-}]}{[0.1]} = 1.2 \times 10^{-20}$$

$$[S^2] = 3 \times 10^{-20}$$

Question143

An aqueous solution contains an unknown concentration of Ba^{2+}. When 50mL of a 1M 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 the original concentration of Ba^{2+}?
[2018]

Options:

A. 5×10^{-9}M

B. 2×10^{-9}M

C. 1.1×10^{-9}M

D. 1.0×10^{-10}M

Answer: C

Solution:

Concentration of SO_4^{2-} in $BaSO_4$ solution
$M_1V_1 = M_2V_2$
$1 \times 50 = M_2 \times 500$

$M_2 = \frac{1}{10}$
For just precipitation
Ionic product $= K_{sp}$
$[Ba^{2+}][SO_4^{2}] = K_{sp}(BaSO_4)$
$[Ba^{2+}] \times \frac{1}{10} = 10^{-10}$
$[Ba^{2+}] = 10^{-9}M$ in 500mL solution
Thus $[Ba^{2+}]$ in original solution
$(500 - 50 = 450mL)$
$\Rightarrow M_1 \times 450 = 10^{-9} \times 500$
[where M_1 = Molarity of original solution]
$M_1 = \frac{500}{450} \times 10^{-9} = 1.11 \times 10^{-9}M$

Question144

The minimum volume of water required to dissolve 0.1g lead (II) chloride to get a saturated solution (K_{sP} of $PbCl_2 = 3.2 \times 10^{-8}$; atomic mass of Pb = 207u) is: [Online April 15, 2018 (I)]

Options:

A. 1.798L

B. 0.36L

C. 17.95L

D. 0.18L

Answer: D

Solution:

$(K_{sp})_{PbCl_2} = 3.2 \times 10^{-8} = 32 \times 10^{-9}$
$PbCl_2 \rightleftharpoons Pb^{2+} + 2Cl^{-}$
$K_{sp} = [Pb^{2+}][Cl^{-}]^2$
$K_{sp} = 4s^3 = 32 \times 10^{-9}$
$s^3 = 8 \times 10^{-9}$
$s = 2 \times 10^{-3}M$
$\frac{W}{M \cdot W} \times \frac{1}{V_L} = 2 \times 10^{-3}$
$\frac{0.1}{278} \times \frac{1}{V_L} = 2 \times 10^{-3}$
$V_L = \frac{0.1 \times 1000}{278 \times 2} = 0.18L$

Question145

The following reaction occurs in the Blast Furnace where iron ore is reduced to iron metal :
$Fe_2O_3(s) + 3CO(g) \rightleftharpoons 2Fe(l) + 3CO_2(g)$
Using the Le Chatelier's principle, predict which one of the following will not disturb the equilibrium?
[Online April 9, 2017]

Options:

A. Removal of CO

B. Removal of CO_2

C. Addition of CO_2

D. Addition of Fe_2O_3

Answer: D

Solution:

Perturbation	Shifts reaction towards
Removal of CO	Left
Removal of CO_2	Right
Addition of CO_2	Left
Addition of Fe_2O_3	No change (This is a solid compound. Its concentration has noeffect on the equilibrium.)

Question146

50mL of 0.2M ammonia solution is treated with 25mL of 0.2M HCl. If pK_b of ammonia solution is 4.75, the pH of the mixture will be:
[Online April 9, 2017]

Options:

A. 3.75

B. 4.75

C. 8.25

D. 9.25

Answer: D

Solution:

$NH_3 + HCl \longrightarrow NH_4Cl$
moles of $HCl = 0.2M \times 25 \times 10^{-3}L = 0.005$ moles HCl (total consumed)
moles of $NH_3 = 0.2M \times 50 \times 10^{-3}L = 0.01$mol esHCl
excess $NH_3 = 0.01 - 0.005 = 0.005$mol es
1 mole ammonia = 1mol eNH_4Cl
$0.005NH_3 = 0.005NH_4Cl$
Total volume $= V_{HCl} + V_{NH_3} = 25 + 50 = 75mL$ $[NH_3] = [NH_4Cl] = \frac{0.005\text{mol e}}{75 \times 10^{-3}L} = 0.066M$

$$pOH = pK_b + \log \frac{[NH_4Cl]}{[NH_3]}$$

$$pOH = 4.75 + \log \frac{[0.066]}{[0.066]}$$

$pOH = 4.75$
$pH = 14 - pOH \Rightarrow pH = 9.25$

Question147

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
[2017]

Options:

A. 7.2

B. 6.9

C. 7.0

D. 1.0

Answer: B

Solution:

The salt (AB) given is a salt of weak acid and weak base. Hence the pH can be calculated by the following formula

$\therefore pH = 7 + \frac{1}{2}pK_a - \frac{1}{2}pK_b$

$= 7 + \frac{1}{2}(3.2) - \frac{1}{2}(3.4) = 6.9$

Question148

Addition of sodium hydroxide solution to a weak acid (HA) results in a buffer of pH . . If ionisation constant of H A is 10^{-5}, the ratio of salt to acid concentration in the buffer solution will be:
[Online April 8, 2017]

Options:

A. 4 : 5

B. 1 : 10

C. 10 : 1

D. 5 : 4

Answer: C

Solution:

$HA \rightleftharpoons H^+ + A^-$
(Unionized, weak acid and common ion effect)
$HA + NaOH \longrightarrow NaA + H_2O$
$NaA \longrightarrow Na^+ + A^-$ (ionized)
$K_a = \frac{[H^+][A^-]}{[HA]}$
Given, $pH = 6$, $[H^+] = 1 \times 10^{-6}$
$[H^+] = \frac{K_a[\text{ Acid }]}{[\text{ Salt }]}$
$\frac{[\text{ Salt }]}{[\text{ Acid }]} = \frac{K_a}{[H^+]} = \frac{10^{-5}}{10^{-6}} = 10 : 1$

Question149

The equilibrium constant at 298K for a reaction A + B ⇌ 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:
[2016]

Options:

A. 1.818

B. 1.182

C. 0.182

D. 0.818

Answer: A

Solution:

Given,	$A + B \rightleftharpoons C + D$			
No. of moles initially	1	1	1	1
At eqm.	$1-x$	$1-x$	$1+x$	$1+x$

Given, $A + B \rightleftharpoons C + D$

$K_c = \left(\frac{1+a}{1-a}\right)^2 = 100;\ \frac{1+a}{1-a} = 10$

On solving; $a = 0.81$

$[D]_{At_{Oq}} = 1 + a = 1 + 0.81 = 1.81$

Question150

A solid XY kept in an evacuated sealed container undergoes decomposition to form a mixture of gases X and Y at temperature T. The equilibrium pressure is 10 bar in the vessel. K_p for this reaction is:
[Online April 10,2016]

Options:

A. 25

B. 100

C. 10

D. 5

Answer: A

Solution:

$XY(s) \rightleftharpoons \underset{p}{X}(g) + \underset{p}{Y}(g)$

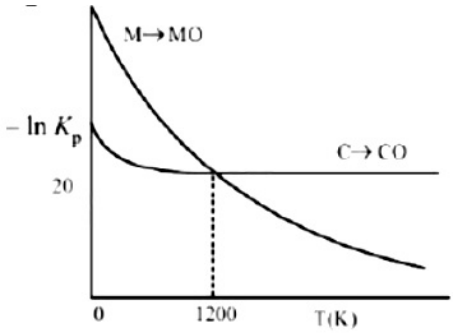
At eqm.

Total pressure $= 2p = 10$ bar $\therefore p = 5;$

Now $K_p = (p_x)(p_y) = p^2 = 25.$

Question151

The plot shows the variation of $-\ln K_p$ versus temperature for the two reactions.
$M(s) + \frac{1}{2}O_2(g) \rightarrow MO(s)$ and
$C(s) + \frac{1}{2}O_2(g) \rightarrow CO(s)$



Identify the correct statement:
[Online April 9,2016]

Options:

A. At $T < 1200K$, oxidation of carbon is unfavourable.

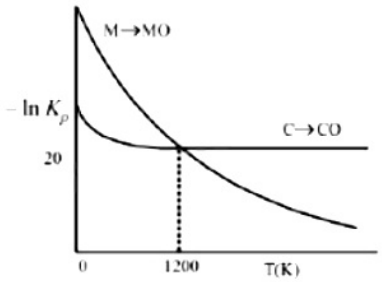
B. Oxidation of carbon is favourable at all temperatures.

C. At $T < 1200K$, the reaction $MO(s) + C(s) \rightarrow M(s) + CO(g)$ is spontaneous.

D. At $T > 1200K$, carbon will reduce M O(s) to M (s).

Answer: C

Solution:



At $T < 1200K$, carbon will reduce M O(s) to M (s) hence, chemical reaction M O(s) + C(s) ⟶ M (s) + CO(g) is spontaneous.

Question152

For the reaction,
A(g) + B(g) → C(g) + D(g), ΔH° and ΔS° are, respectively, $-29.8 kJ\ mol^{-1}$ and $-0.100 kJ\ K^{-1} mol^{-1}$ at 298K.
The equilibrium constant for the reaction at 298K is :
[Online April 9, 2016]

Options:

A. 1.0×10^{-10}

B. 10

C. 1

D. 1.0×10^{10}

Answer: C

Solution:

Given $\Delta H^\circ = -29.8 kJ\ mol^{-1}$
$\Delta S^\circ = -1.00 kJ\ K^{-1}$
From the equation
$\Delta G^\circ = \Delta H^\circ - T\ \Delta S^\circ = -29.8 - (298 \times -0.100)$
$= -29.8 + 29.8 = 0$
Now, $\Delta G^\circ = -2.303 RT\ \log K_{eq}$
$0 = -2.303 RT\ \log K_{eq}$
$\therefore K_{eq} = 1.$

Question153

Gaseous N_2O_4 dissociates into gaseous NO_2 according to the reaction
[$N_2O_4(g) \rightleftharpoons 2NO_2(g)$]
At 300K and 1 atm pressure, the degree of dissociation of N_2O_4 is 0.2. If one mole of N_2O_4 gas is contained in a vessel, then the density of the equilibrium mixture is :
[Online April 10, 2015]

Options:

A. 1.56g / L

B. 6.22g / L

C. 3.11gL

D. 4.56g / L

Answer: C

Solution:

	$N_2O_4(g) \rightleftharpoons 2NO_2(g)$	
t = 0	1	0
t = eqm	1 − α	2α

$N_2O_4(g) \rightleftharpoons 2NO_2(g)$
Where α = degree of dissociation.
∴ Mol. wt. of mixture
$= \frac{(1-\alpha) \times M_{N_2O_4} + 2\alpha \times M_{NO_2}}{(1-\alpha+2\alpha)}$
$= \frac{(1-0.2)92 + 2 \times 0.2 \times 46}{(1+0.2)} = 76.66$
Now, as per ideal gas equation,
$PV = nRT$
$PM_{mix} = dRT$
$\therefore d = \frac{PM_{mix}}{RT} = \frac{1 \times 76.66}{0.0821 \times 300} = 3.11 g / L$

Question154

The standard Gibbs energy change at 300K for the reaction 2A ⇌ B + C is 2494.2J . 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 = 8.314J / K / mol , e = 2.718]
[2015]

Options:

A. forward direction because $Q < K_c$

B. reverse direction because $Q < K_c$

C. forward direction because $Q > K_c$

D. reverse direction because $Q > K_c$

Answer: D

Solution:

$\Delta G^\circ = 2494.2J$
$2A \rightleftharpoons B + C.$
$[A] = \frac{1}{2}, [B] = 2, [C] = \frac{1}{2}$
$Q = \frac{[B][C]}{[A]^2} = \frac{2 \times 1/2}{\left(\frac{1}{2}\right)^2} = 4$
$\Delta G^\circ = -2.303RT \log K_c$
$2494.2J = -2.303 \times (8.314J / K / mol) \times (300K) \log K_c$
$\Rightarrow \log K_c = -\frac{2494.2J}{2.303 \times 8.314J / K / mol \times 300K}$
$\Rightarrow \log K_c = -0.4341; K_c = 0.37; Q > K_c$

Question155

The following reaction is performed at 298K .
$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$
The standard free energy of formation of NO(g) is 86.6 KJ / mol at 298K .
What is the standard free energy of formation of $NO_2(g)$ at 298K ?($K_p = 1.6 \times 10^{12}$)
[2015]

Options:

A. $86600 - \frac{\ln(1.6 \times 10^{12})}{R(298)}$

B. $0.5[2 \times 86,600 - R(298)\ln(1.6 \times 10^{12})]$

C. $R(298)\ln(1.6 \times 10^{12}) - 86600$

D. $86600 + R(298)\ln(1.6 \times 10^{12})$

Answer: B

Solution:

$\Delta G_{rex^n}^{\circ} = 2\Delta G_f^{o}(NO_2) - 2\Delta G_f^{\circ}(NO) - \Delta G_f^{\circ}(O_2)$
$2\Delta G_f^{\circ}(NO_2) = \Delta G_{rex^n}^{\circ} + 2\Delta G_f^{\circ}(NO) + \Delta G_f^{\circ}(O_2)$
$\because \quad \Delta G = \Delta G^{\circ} + RT\ln K_p$
At equilibrium,
$\Delta G = 0, Q = K_p; \Delta G^{\circ} = -R\ln K_p$
$\Delta G_j^{\circ}(O_2) = 0$
$\therefore \Delta G_f^{\circ}(NO_2) = \frac{1}{2}[2 \times 86600 - R(298)\ln(1.6 \times 10^{12})]$

Question156

The increase of pressure on ice ⇌ water system at constant temperature will lead to [Online April 11, 2015]

Options:

A. a decrease in the entropy of the system

B. an increase in the Gibb's energy of the system

C. no effect on the equilibrium

D. a shift of the equilibrium in the forward direction

Answer: D

Solution:

Solution:
Volume of ice is greater than that of water. The direction in which the reaction will proceed can be predicted by applying Le-Chatelier's principle
Pressure $\propto \frac{1}{\text{Volume}}$
So equilibrium, will shift forward.

Question157

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): [2014]

Options:

A. -1

B. $-\frac{1}{2}$

C. $\frac{1}{2}$

D. 1

Answer: B

Solution:

$SO_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons SO_3(g)$

$K_p = K_c(RT)^x$

where $x = \Delta n_g =$ number of gaseous moles in product − number of gaseous moles in reactants

$= 1 - \left(1 + \frac{1}{2}\right) = 1 - \frac{3}{2} = -\frac{1}{2}$

Question158

At a certain temperature, only 50%HI is dissociated into H_2 and I_2 at equilibrium. The equilibrium constant is:
[Online April 9, 2014]

Options:

A. 1.0

B. 3.0

C. 0.5

D. 0.25

Answer: D

Solution:

$$2HI \rightleftharpoons H_2 + I_2$$

At t = 0	c	0	0
At eqm.	c−cα	$\frac{c\alpha}{2}$	$\frac{c\alpha}{2}$

$2HI \rightleftharpoons H_2 + I_2$

At eqm. c-cα $\frac{c\alpha}{2}$ $\frac{c\alpha}{2}$

Now, $K_c = \frac{\left(\frac{c\alpha}{2}\right)\left(\frac{c\alpha}{2}\right)}{(c - c\alpha)^2}$

$K_C = \frac{\alpha}{4(1-\alpha)^2}$; $K_c = \frac{0.5}{4(1-0.5)^2}$

$K_0 = 0.25$

Question159

For the decomposition of the compound, represented as
$NH_2COONH_4(s) \rightleftharpoons 2NH_3(g) + CO_2(g)$ the $K_p = 2.9 \times 10^{-5} atm^3$.
If the reaction is started with 1mol of the compound, the total pressure at equilibrium would be:
[Online April 19, 2014]

Options:

A. 1.94×10^{-2} atm

B. 5.82×10^{-2}atm

C. 7.66×10^{-2}atm

D. 38.8×10^{-2}atm

Answer: B

Solution:

$NH_2COONH_4(s) \rightleftharpoons 2NH_3(g) + CO_2(g)$

$K_p = \frac{(p_{NH_3})^2 \times (p_{Co_2})}{P_{NH_2COONH_4}(s)} = (p_{NH_3})^2 \times (p_{CO_2})$

As evident by the reaction, NH_3 and CO_2 are formed in molar ratio of 2 : 1.

Thus if P is the total pressure of the system at equilibrium, then

$p_{NH_3} = \frac{2}{3} \times p \;\; p_{CO_2} = \frac{1}{3} \times P$

$K_p = \left(\frac{2P}{3}\right)^2 \times \frac{P}{3} = \frac{4P^3}{27}$

Given, $K_p = 2.9 \times 10^{-5}$

$\therefore 2.9 \times 10^{-5} = \frac{4P^3}{27}$

$P^3 = \frac{2.9 \times 10^{-5} \times 27}{4}$

$P = \left(\frac{2.9 \times 10^{-5} \times 27}{4}\right)^{1/3} = 5.82 \times 10^{-2} atm$

Question160

What happens when an inert gas is added to an equilibrium keeping volume unchanged?
[Online April 12, 2014]

Options:

A. More product will form

B. Less product will form

C. More reactant will form

D. Equilibrium will remain unchanged

Answer: D

Solution:

Solution:
On adding inert gas at constant volume the total pressure of the system is increased, but the partial pressure of each reactant and product remains the same. Hence no effect on the state of equilibrium.

Question161

The conjugate base of hydrazoic acid is:
[Online April 12, 2014]

Options:

A. N^{-3}

B. N_3^-

C. N_2^-

D. HN_3^-

Answer: B

Solution:

$\underset{\text{Hydrazoic acid}}{N_3H} \rightleftharpoons N_3^- + H^+$

i.e, conjugate base of hydrazoic acid is N_3.

Question162

Assuming that the degree of hydrolysis is small, the pH of 0.1M solution of sodium

acetate ($K_a = 1.0 \times 10^{-5}$) will be:
[Online April 11, 2014]

Options:

A. 5.0

B. 6.0

C. 8.0

D. 9.0

Answer: D

Solution:

Sodium acetate is a salt of strong base and weak acid.

$\therefore pH = 7 + \frac{1}{2}pK_a + \frac{1}{2}\log c$ where $pK_a = -\log K_a$

$= 7 + \frac{5}{2} - \frac{1}{2}$

$= 9.0$

$= -\log 10^{-5} = 5$

$\log c = \log 10^{-1} = -1$

Question163

In some solutions, the concentration of H_3O^+ remains constant even when small amounts of strong acid or strong base are added to them. These solutions are known as:
[Online April 11, 2014]

Options:

A. Ideal solutions

B. Colloidal solutions

C. True solutions

D. Buffer solutions

Answer: D

Solution:

Solution:
Solutions which resist the change in the value of pH when small amount of acid or base is added to them are known as buffers.

Question164

Consider the following equilibrium
$AgCl \downarrow + 2NH_3 \rightleftharpoons [Ag(NH_3)_2]^+ + Cl^-$
White precipitate of AgCl appears on adding which of the following?
[Online April 11,2014]

Options:

A. NH_3

B. aqueous NaCl

C. aqueous HNO_3

D. aqueous NH_4Cl

Answer: C

Solution:

$2HNO_3(aq) + [Ag(NH_3)_2]^+ + Cl^- \longrightarrow AgCl(s) \downarrow + 2NH_4 + 2NO_3^-$
When nitric acid is added to amine solution, solution is made acidic and the complex ion dissociates and liberate silver ion to recombine with chloride ion. This is the conformatory test for silver in group 1.

Question165

Zirconium phosphate $[Zr_3(PO_4)_4]$ dissociates into three zirconium cations of charge +4 and four phosphate anions of charge −3. If molar solubility of zirconium phosphate is denoted by S and its solubility product by K_{sp} then which of the following relationship between S and K_{sp} is correct?
[Online April 19,2014]

Options:

A. $S = \{K_{sp} / (6912)^{1/7}\}$

B. $S = \{K_{sp} / 144\}^{1/7}$

C. $S = \{K_{sp} / 6912\}^{1/7}$

D. $S = \{K_{sp} / 6912\}^7$

Answer: C

Solution:

$$[Zr_3(PO_4)_4] \rightleftharpoons \underset{3s}{3Zr^{4+}} + \underset{4s}{4PO_4^{3-}}$$

$K_{sp} = (3s)^3(4s)^4$
$= 27s^3 \times 256s^4$
$= 6912s^7$
$\therefore s = \left(\frac{K_{sp}}{6912}\right)^{1/7}$

Question166

In reaction A + 2B ⇌ 2C + D, initial concentration of B was 1.5 times of [A], but at equilibrium the concentrations of A and B became equal. The equilibrium constant for the reaction is :
[Online April 9, 2013]

Options:

A. 8

B. 4

C. 12

D. 6

Answer: B

Solution:

	A	+	2B	⇌	2C	+	D
At t = 0	a		$1.5a$		0		0
At eqns.	$(a-x)$		$(1.5a-2x)$		$2x$		x

Hence, $K_c = \frac{(2x)^2 \times x}{(a-x)(1.5a-2x)^2}$
Given, at equilibrium
$\therefore\ (a-x) = (1.5a-2x)$
$\therefore\ a = 2x$
On solving $K_c = 4$

Question167

(1) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$, K_1
(2) $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$, K_2
(3) $H_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons H_2O(g)$, K_3
The equation for the equilibrium constant of the reaction $2NH_3(g) + \frac{5}{2}O_2(g) \rightleftharpoons 2NO(g) + 3H_2O(g)$, ($K_4$) in ter of K_1, K_2 and K_3 is :
[Online April 23, 2013]

Options:

A. $\frac{K_1 \cdot K_2}{K_3}$

B. $\frac{K_1 \cdot K_3^2}{K_2}$

C. $K_1K_2K_3$

D. $\frac{K_2 \cdot K_3^3}{K_1}$

Answer: D

Solution:

Solution:
To calculate the value of K_4 in the given equation we should apply:
eqn. (2) +cqn . (3) × 3 -eqn. (1)
hence $K_4 = \frac{K_2K_3^3}{K_1}$

Question168

The ratio $\frac{K_p}{K_c}$ for the reaction is:
[Online April 25, 2013]

Options:

A. $\frac{1}{\sqrt{RT}}$

B. $(RT)^{1/2}$

C. RT

D. 1

Answer: A

Solution:

$K_p = K_c(RT)^{\Delta n_g}$
For the reaction
$CO(g) + \frac{1}{2}O_2(g) \rightleftharpoons CO_2(g)$
$\Delta n_g = 1 - \left(1 + \frac{1}{2}\right) = -\frac{1}{2}$

$\therefore K_p = \frac{K_c}{\sqrt{RT}}; \quad \frac{K_p}{K_c} = \frac{I}{\sqrt{RT}}$

Question169

How many litres of water must be added to 1 litre an aqueous solution of HCl with a pH of 1 to create an aqueous solution with pH of 2 ?
[2013]

Options:

A. 0.1L

B. 0.9L

C. 2.0L

D. 9.0L

Answer: D

Solution:

$\because$pH $= 1; H^+ = 10^{-1} = 0.1M$
$pH = 2; H^+ = 10^{-2} = 0.01M$
$\therefore M_1 = 0.1 \ V_1 = 1$
$M_2 = 0.01, V_2 = ?$
From
$M_1V_1 = M_2V_2$
$0.1 \times 1 = 0.01 \times V_2$
$V_2 = 10L$
$\therefore$ Volume of water added $= 10 - 1 = 9L$

Question170

NaOH is a strong base. What will be pH of 5.0×10^{-2}M NaOH solution ? (log 2 = 0.3)
[Online April 22, 2013]

Options:

A. 14.00

B. 13.70

C. 13.00

D. 12.70

Answer: D

Solution:

Given $[OH^-] = 5 \times 10^{-2}$
$\therefore$pOH $= -\log 5 \times 10^{-2}$
$= -\log 5 + 2\log 10 = 1.30$
$\because$pH + pOH $= 14$
$\because$pH $= 14 - pOH$
$= 14 - 1.30 = 12.70$

Question171

Equimolar solutions of the following compounds are prepared separately in water. Which will have the lowest pH value?
[Online April 23, 2013]

Options:

A. $BeCl_2$

B. $SrCl_2$

C. $CaCl_2$

D. $MgCl_2$

Answer: A

Solution:

Metal halide on hydrolysis with water form corresponding hydroxides.
The basic strength of hydroxide increases as we move down in a group. This is because of the increase in size which results in decrease of ionization energy which weakens the strength of $M-O$ bonds in MOH and thus increases the basic strength.
$\underset{\text{Amphoteric}}{Be(OH)_2}$ $\underset{\text{Weak base}}{Mg(OH)_2}$
$Ca(OH)_2$ $\underset{\text{Strong base}}{Sr(OH)_2}$ $Ba(OH)_2$
Hence, $Be(OH)_2$ will have lowest pH.

Question172

What is the pH of a $10^{-4}M\,OH^-$ solution at 330K, if K_w at 330K is $10^{-13.6}$? [Online April 23, 2013]

Options:

A. 4

B. 9.0

C. 10

D. 9.6

Answer: D

Solution:

Given at 330K
$K_w = 10^{-13.6}$
i.e. $pK_w = pH + pOH$
$\because pOH = -\log[OH^-]$
$13.6 = pH + pOH$
$pOH = -\log 10^{-4}$
$pOH = 4$
$\therefore\ pH = 13.6 - 4$
$= 9.6$

Question173

Which one of the following arrangements represents the correct order of the proton affinity of the given species: [Online April 25, 2013]

Options:

A. $I^- < F^- < HS^- < NH_2^-$

B. $HS^- < NH_2^- < F^- < I^-$

C. $F^- < I^- < NH_2^- < HS$

D. $NH_2^- < HS^- < I^- < F^-$

Answer: A

Solution:

The species with the greatest proton affinity will be the strongest base, and its conjugate acid will be the weakest acid. The weakest acid will have the smallest value of $K_{a^{\circ}}$ Since HI is a stronger acid than HF which is a stronger acid than H_2S, a partial order of proton affinity is
$I^- < F^- < HS^-$
Since NH_3 is a very weak acid, NH_2^- must be a very strong base. Therefore the correct order of proton affinity is
$I^- < F^- < HS^- < NH_2$

Question174

Values of dissociation constant, K_0 are given as follows:

Acid	K_a
HCN	6.2×10^{-10}
HF	7.2×10^{-4}
HNO_2	4.0×10^{-4}

Correct order of increasing base strength of the base CN^- F^- and NO_2^- will be:
[Online April 22, 2013]

Options:

A. $F < CN^- < NO_2^-$

B. $NO_2^- < CN^- < F^-$

C. $F < NO_2^- < CN^-$

D. $NO_2^- < F^- < CN^-$

Answer: C

Solution:

Higher the value of K_a lower will be the value of pK_a i.e. higher will be the acidic nature. Further since CN^-, F^- and NO_2^- are conjugate base of the acids HCN, HF and HNO_2 respectively hence the correct order of base strength will be
$F^- < NO_2^- < CN$
($\because$ stronger the acid weaker will be its conjugate base)

Question175

What would be the pH of a solution obtained by mixing 5g of acetic acid and 7.5g of sodium acetate and making the volume equal to 500mL ?
($K_a = 1.75 \times 10^{-5}$, $pK_a = 4.76$)
[Online April 25, 2013]

Options:

A. pH = 4.70

B. pH < 4.70

C. pH of solution will be equal to pH of acetic acid

D. 4.76 < pH < 5.0

Answer: D

Solution:

Concentration of CH_3COOH is computed as under.
conc. = 5g in 500mL
= 10g / L [Mol. wt. of CH_3COOH = 60
$[CH_3COOH] = \frac{10}{60}M ; \frac{1}{6}M$
concentration of CH_3COONa is computed as under.
conc. = 7.5g in 500mL
= 15g / L
$[CH_3COOH] = \frac{15}{18}M$
$pK_a = -\log K_a$
$= \log(1.8 \times 10 - 5) = 4.7447$
$pH = pK_a + \log \frac{[salt]}{[acid]}$
$= 4.744 \log \frac{15 / 82}{1 / 6}$
$= 4.7447 + \log 1.097$
$= 4.7447 + 0.0402$
$= 4.78$

Question176

Solid $Ba(NO_3)_2$ is gradually dissolved in a $1.0 \times 10^{-4}M$ Na_2CO_3 solution. At which concentration of Ba^{2+}, precipitate of $BaCO_3$ begins to form ?(K_{sp} for $BaCO_3$ $= 5.1 \times 10^{-9}$)
[Online April 9, 2013]

Options:

A. $5.1 \times 10^{-5}M$

B. $7.1 \times 10^{-8}M$

C. $4.1 \times 10^{-5}M$

D. $8.1 \times 10^{-7}M$

Answer: A

Solution:

Conc. of $Na_2CO_3 = 1.0 \times 10^{-4}M$
$\therefore [CO_3^{2}] = 1.0 \times 10^{-4}M$ i.e. $s = 1.0 \times 10^{-4}M$
At equilibrium
$[Ba^{2+}][CO_3^{2-}] = K_{sp}$ of $BaCO_3$
$[Ba^{2+}] = \frac{K_{sp}}{[CO_3^{2-}]} = \frac{5.1 \times 10^{-9}}{1.0 \times 10^{-4}}$
$= 5.1 \times 10^{-5}M$

Question177

Which one of the following arrangements represents the correct order of solubilities of sparingly soluble salts $HgCl_2$, $Cr_2(SO_4)_3$, $BaSO_4$ and $CrCl_3$ respectively?
[Online April 22, 2013]

Options:

A. $BaSO_4 > HgCl_2 > Cr_2(SO_4)_3 > CrCl_3$

B. $BaSO_4 > HgCl_2 > CrCl_3 > Cr_2(SO_4)_3$

C. $BaSO_4 > CrCl_3 > HgCl_2 > Cr_2(SO_4)_3$

D. $HgCl_2 > BaSO_4 > CrCl_3 > Cr_2(SO_4)_3$

Answer: B

Solution:

$Cr_2(SO_4)_3 \Longrightarrow 2Cr^{3+} + 3SO_4^{2-}$

$K_{sp} = (2s)^2(3s)^3 = 4s^2 \times 27s^3 = 108s^5$

$s = \left(\frac{K_{sp}}{108}\right)^{1/5}$

$Hg_2Cl_2 \rightleftharpoons 2Hg^{2+} + \underset{2s}{2Cl^-}$

$K_{sp} = (2s)^2 \times (2s)^2 = 16s^4$

$s = \left(\frac{K_{sp}}{16}\right)^{1/4}$

$BaSO_4 \rightleftharpoons \underset{s}{Ba^{2+}} + \underset{s}{SO_4^{2-}}$

$K_{sp} = s^2$

$s = \sqrt{K_{sp}}$

$CrCl_3 \Longrightarrow \underset{s}{Cr^{3+}} + \underset{3s}{3Cl^-}$

$K_{sp} = s \times (3s)^3 = 27s^4$

$s = \left(\frac{K_{sp}}{27}\right)^{1/4}$

Hence the correct order of solubilities of salts is

$\sqrt{K_{sp}} > \left(\frac{K_{sp}}{16}\right)^{1/4} > \left(\frac{K_{sp}}{27}\right)^{1/4} > \left(\frac{K_{sp}}{108}\right)^{1/5}$

Question178

K_1, K_2 and K_3 are the equilibrium constants of the following reactions (I), (II) and (III) respectively:

(I) $N_2 + 2O_2 \rightleftharpoons 2NO_2$

(II) $2NO_2 \rightleftharpoons N_2 + 2O_2$

(III) $NO_2 \rightleftharpoons \frac{1}{2}N_2 + O_2$

The correct relation from the following is

[Online May 7, 2012]

Options:

A. $K_1 = \frac{1}{K_2} = \frac{1}{K_3}$

B. $K_1 = \frac{1}{K_2} = \frac{1}{(K_3)^2}$

C. $K_1 = \sqrt{K_2} = K_3$

D. $K_1 = \frac{1}{K_2} = K_3$

Answer: B

Solution:

(I) $N_2 + 2O_2 \overset{K_1}{\rightleftharpoons} 2NO_2$

$K_1 = \frac{[NO_2]^2}{[N_2][O_2]^2}$ . . . (i)

(II) $2NO_2 \overset{K_2}{\rightleftharpoons} N_2 + 2O_2$

$K_2 = \frac{[N_2][O_2]^2}{[NO_2]^2}$ . . . (ii)

(III) $NO_2 \overset{K_3}{\text{ef tarrows}} \frac{1}{2}N_2 + O_2$

$K_3 = \frac{[N_2]^{1/2}[O_2]}{[NO_2]}$

$\therefore (K_3)^2 = \frac{[N_2][O_2]^2}{[NO_2]^2}$ . . . (iii)

$\therefore$ From equation (i), (ii) and (iii)

$K_1 = \frac{1}{K_2} = \frac{1}{(K_3)^2}$

Question179

8 mol of $AB_3(g)$ are introduced into a 1.0d m^3 vessel. If it dissociates as $2AB_3(g) \rightleftharpoons A_2(g) + 3B_2(g)$. At equilibrium, 2 mol of A_2 are found to be present. The equilibrium constant of this reaction is
[Online May 12, 2012]

Options:

A. 2

B. 3

C. 27

D. 36

Answer: C

Solution:

$$2AB_3(g) \rightleftharpoons A_2(g) + 3B_2(g)$$

at $t = 0$	8	0	0
at eqm.	$(8 - 2 \times 2)$	2	3×2
	$= 4$	2	6
molar cones.	4/V	2/V	6/V

$2AB_3(g) \leftrightarrows A_2(g) + 3B_2(g)$

now $K_c = \frac{[A_2][B_2]^3}{[AB_3]^2} = \frac{2/1 \times [6/1]^3}{[4/1]^2} = 27$

Question180

The value of K_p for the equilibrium reaction $N_2O_4(g) \rightleftharpoons 2NO_2(g)$ is 2 .
The percentage dissociation of $N_2O_4(g)$ at a pressure of 0.5 atm is
[Online May 19, 2012]

Options:

A. 25

B. 88

C. 50

D. 71

Answer: D

Solution:

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

Initial moles	1	0
Moles at eqm.	$(1 - \alpha)$	2α

(α = degree of dissociation)

Total number of moles at eqm.
$= (1 - \alpha) + 2\alpha$
$= (1 + \alpha)$

$p_{N_2O_4} = \frac{(1 - \alpha)}{a(1 + \alpha)} \times P$

$p_{NO_2} = \frac{2\alpha}{a(1 + \alpha)} \times P$

$K_p = \frac{(p_{NO_2})^2}{P_{N_2O_4}} = \frac{\left(\frac{2\alpha}{(1+\alpha)} \times P\right)^2}{\left(\frac{1-\alpha}{1+\alpha}\right) \times P}$

$K_p = \frac{4\alpha^2 P}{\frac{(1+\alpha)^2(1-\alpha)}{1+\alpha}}$; $K_p = \frac{4\alpha^2 P}{(1+\alpha)(1-\alpha)}$; $= \frac{4\alpha^2 P}{1-\alpha^2}$

Given, $K_p = 2$, $P = 0.5$atm

$\therefore K_p = \frac{4\alpha^2 P}{1-\alpha^2}$; $2 = \frac{4\alpha^2 \times 0.5}{1-\alpha^2}$

$\alpha = 0.707 \approx 0.71$

$\therefore$ Percentage dissociation

$= 0.71 \times 100 = 71$

Question181

One mole of $O_2(g)$ and two moles of $SO_2(g)$ were heated in a closed vessel of one-litre capacity at 1098K. At equilibrium 1.6 moles of $SO_3(g)$ were found. The equilibrium constant K_c of the reaction would be
[Online May 26, 2012]

Options:

A. 30

B. 40

C. 80

D. 60

Answer: C

Solution:

	O_2 +	$2SO_2$ $\rightleftharpoons$	$2SO_3$
At t = 0	1	2	0
At eqm.	$(1-\alpha)$	$2(1-\alpha)$	2α

Given at equilibrium,

$2\alpha = 1.6$

$\alpha = 0.8$

$K_c = \frac{(2\alpha)^2}{(1-\alpha)(2-2\alpha)^2} = \frac{(0.8)^2}{(1-0.8)(1-0.8)^2} = \frac{0.64}{0.002}$

$K_c = 80$

Question182

The pH of a 0.1 molar solution of the acid H Q is 3. The value of the ionization constant, K_a of the acid is :
[2012]

Options:

A. 3×10^{-1}

B. 1×10^{-3}

C. 1×10^{-5}

D. 1×10^{-7}

Answer: C

Solution:

$H^+ = C\alpha$; $\alpha = \frac{[H^+]}{C}$

or $\alpha = \frac{10^{-3}}{0.1} = 10^{-2}$

$K_a = C\alpha^2 = 0.1 \times 10^{-2} \times 10^{-2} = 10^{-5}$

Question183

Given

(i) $HCN(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + CN^-(aq)$

$K_a = 6.2 \times 10^{-10}$

(ii) $CN^-(aq) + H_2O(l) \rightleftharpoons HCN(aq) + OH^-(aq)$

$K_b = 1.6 \times 10^{-5}$

These equilibria show the following order of the relative base strength, [Online May 12, 2012]

Options:

A. $OH^- > H_2O > CN^-$

B. $OH^- > CN^- > H_2O$

C. $H_2O > CN^- > OH^-$

D. $CN^- > H_2O > OH^-$

Answer: B

Solution:

Solution:
The more is the value of equilibrium constant, the more is the completion of reaction or more is the concentration of products i.e. the order of relative strength would be
$OH^- > CN^- > H_2O$

Question184

The solubility (in $mol\,L^{-1}$) of AgCl ($K_{sp} = 1.0 \times 10^{-10}$) in a 0.1 M KCl solution will be [Online May 7, 2012]

Options:

A. 1.0×10^{-9}

B. 1.0×10^{-10}

C. 1.0×10^{-5}

D. 1.0×10^{-11}

Answer: A

Solution:

Let solubility of AgCl = smol / L
$AgCl \rightleftharpoons Ag^+ + Cl^-$
i.e., $K_{sp(AgCl)} = s \times s$
$KCl \longrightarrow \underset{0.1}{K^+} + Cl^-$
$[Cl^-]$ from KCl = 0.1M
Total $[Cl^-]$ in solution = s + 0.1
$K_{cp}(AgCl) = [Ag^+][Cl^-] = s(s + 0.1)$
$1.0 \times 10^{-10} = s(s + 0.1)$
$1.0 \times 10^{-10} = s^2 + 0.1s$
$1.0 \times 10^{-10} = 0.1s$ (as $s^2 \ll < 1$)
$s = 1.0 \times 10^{-9} mol / L$

Question185

If K_{sp} of CaF_2 at 25°C is 1.7×10^{-10}, the combination amongst the following which gives a precipitate of CaF_2 is
[Online May 19, 2012]

Options:

A. 1×10^{-2}M Ca^{2+} and 1×10^{-3}M F^-

B. 1×10^{-4}M Ca^{2+} and 1×10^{-4}M F^-

C. 1×10^{-2}M Ca^{2+} and 1×10^{-5}M F

D. 1×10^{-3}M Ca^{2+} and 1×10^{-5}M F^-

Answer: A

Solution:

When ionic product i.e. the product of the concentration of ions in the solution exceeds the value of solubility product, formation of precitpiate occurs.
$CaF_2 \rightleftharpoons Ca^{2+} + 2F^-$
Ionic product $= [Ca^{2+}][F^-]^2$
when, $[Ca^{2+}] = 1 \times 10^{-2}$M
$[F^-]^2 = (1 \times 10^{-3})^2$M
$= 1 \times 10^{-6}$M
$\therefore [Ca^{2+}][F^-]^2 = (1 \times 10^{-2})(1 \times 10^{-6}) = 1 \times 10^{-8}$
In this case,
Ionic product $(1 \times 10^{-8})>$
solubility product (1.7×10^{-10})

Question186

The solubility of PbI_2 at 25°C is $0.7gL^{-1}$. The solubility product of PbI_2 at this temperature is (molar mass of $PbI_2 = 461.2gmol^{-1}$)
[Online May 26, 2012]

Options:

A. 1.40×10^{-9}

B. 0.14×10^{-9}

C. 140×10^{-9}

D. 14.0×10^{-9}

Answer: D

Solution:

$PbI_2 \rightleftharpoons \underset{s}{Pb^{2+}} + \underset{2s}{2I^-}$
$K_{cp} = s \times (2s)^2 = 4s^3$
$= 4 \times \left(\frac{0.7}{461.2}\right)^3 = 14.0 \times 10^{-9}$

Question187

An acid HA ionises as
$HA \rightleftharpoons H^+ + A^-$
The pH of 1.0M solution is 5. Its dissociation constant would be :

[2011RS]

Options:

A. 5

B. 5×10^{-8}

C. 1×10^{-5}

D. 1×10^{-10}

Answer: D

Solution:

pH = 5 means
$[H^+] = 10^{-5}$

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

$t = 0$	c	0	0
t_{eq}	$c(1-\alpha)$	$c\alpha$	$c\alpha$

$$K_a = \frac{[H^+][A^-]}{[HA]} = \frac{(c\alpha)^2}{c(1-\alpha)} = \frac{[H^+]^2}{c - [H^+]}$$

But, $[H^+] << c$
$\therefore K_a = [H^+]^2 = (10^{-5})^2 = 10^{-10}$

Question188

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

Options:

A. $4\sqrt{1.6 \times 10^{-30}}$

B. $4\sqrt{1.6 \times 10^{-30}/27}$

C. $1.6 \times 10^{-30/27}$

D. $2\sqrt{1.6 \times 10^{-30}}$

Answer: B

Solution:

$Cr(OH)_3(s) \Longrightarrow Cr^{3+}(aq) + 3OH^-(aq.)$
$27s^4 = K_{sp}$

$$s = \left(\frac{K_{sp}}{27}\right)^{1/4} = \left(\frac{1.6 \times 10^{-30}}{27}\right)^{1/4}$$

Question189

In aqueous solution the ionization constants for carbonic acid are $K_L = 4.2 \times 10^{-7}$ and $K_2 = 4.8 \times 10^{-11}$
Select the correct statement for a saturated 0.034M solution of the carbonic acid. [2010]

Options:

A. The concentration of CO_3^{2-} is 0.034M .

B. The concentration of CO_3^{2-} is greater than that of HCO_3^-

C. The concentrations of H^+ and HCO_3^- are approximately equal.

D. The concentration of H^+ is double that of CO_3^{2-}.

Answer: C

Solution:

$H_2CO_3 \rightleftharpoons H^+ + HCO_3^- K_1 = 4.2 \times 10^{-7}$
$HCO_3^- \rightleftharpoons H^+ + CO_3^{2-}$ $K_2 = 4.8 \times 10^{-11}$
Second dissociation constant (K_2) is much smaller than the first one (K_1). Just a small fraction of total HCO_3^- formed will undergo second stage of ionization. Hence in saturated solution
$[H^+] \gg > [CO_3^{2-}]$; $[CO_3^{2-}] \neq 0.034M$
$[HCO_3^{2-}] > > [CO_3^{2-}]$ and $[H^+] \approx [HCO_3^-]$

Question190

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

Options:

A. 1.2×10^{-10}g

B. 1.2×10^{-9}g

C. 6.2×10^{-5}g

D. 5.0×10^{8}g

Answer: B

Solution:

$AgBr \rightleftharpoons Ag^+ + Br^-$
$K_{sp} = [Ag^+][Br^-]$
For precipitation to occur
Ionic product > Solubility product

$$[Br^-] = \frac{K_{sp}}{[Ag^+]} = \frac{5 \times 10^{-13}}{0.05} = 10^{-11}$$

i.e., precipitation just starts when 10^{-11} moles of KBr is added to 1 L $AgNO_3$ solution
$\therefore$ Number of moles of Br^- needed from KBr = 10^{-11}
$\therefore$ Mass of KBr = $10^{-11} \times 120 = 1.2 \times 10^{-9}$g

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Question191

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 0.001M Mg^{2+} ions? [2010]

Options:

A. 9

B. 10

C. 11

D. 8

Answer: B

Solution:

$M g(OH)_2 \rightleftharpoons M g^{2+} + 2OH^-$
$K_{sp} = [M g^{2+}][OH^-]^2$
$1.0 \times 10^{-11} = 10^{-3} \times [OH^-]^2$
$[OH^-] = \sqrt{\frac{10^{-11}}{10^{-3}}} = 10^{-4}$
$\therefore$ pOH = 4
$\therefore$ pH + pOH = 14
$\therefore$ pH = 10

Question192

Three reactions involving $H_2PO_4^-$ are given below:
(i) $H_3PO_4 + H_2O \rightarrow H_3O^+ + H_2PO_4^-$ [2010]
(ii) $H_2PO_4^- + H_2O \rightarrow HPO_4^{2-} + H_3O^+$
(iii) $H_2^2PO_4^- + OH^- \rightarrow H_3PO_4 + O^2$
In which of the above does $H_2PO_4^-$ act as an acid ? [2010]

Options:

A. (ii) only

B. (i) and (ii)

C. (iii) only

D. (i) only

Answer: A

Solution:

(i) $\underset{acid_1}{H_3PO_4} + \underset{base_2}{H_2O} \longrightarrow \underset{acid_2}{H_3O^+} + \underset{base_1}{H_2PO_4^-}$
(ii) $\underset{acid_1}{H_2PO_4^-} + \underset{base_2}{H_2O} \longrightarrow \underset{base_1}{HPO_4^{2-}} + \underset{acid_2}{H_3O^+}$
(iii) $\underset{base_1}{H_2PO_4^-} + \underset{acid_2}{OH^-} \longrightarrow \underset{acid_1}{H_3PO_4} + \underset{base_2}{O^{2-}}$
Hence only in (ii) reaction, $H_2PO_4^-$ is acting as an acid.

Question193

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

Options:

A. $5.1 \times 10^{-5}M$

B. $8.1 \times 10^{-8}M$

C. $8.1 \times 10^{-7}M$

D. $4.1 \times 10^{-5}M$

Answer: A

Solution:

$\underset{1 \times 10^{-4}M}{Na_2CO_3} \longrightarrow \underset{1 \times 10^{-4}M}{2Na^+} + \underset{1 \times 10^{-4}M}{CO_3^{2-}}$
$K_{sp(BaCO_3)} = [Ba^{2+}][CO_3^{2-}]$

$[Ba^{2+}] = \frac{5.1 \times 10^{-9}}{1 \times 10^{-4}} = 5.1 \times 10^{-5} M$

Question194

The equilibrium constants K_{p_1} and K_{p_2} for the reactions $X \rightleftharpoons 2Y$ and $Z \rightleftharpoons P + Q$, respectively are in the ratio of 1 : 9. If the degree of dissociation of X and Z be equal, then the ratio of total pressures at these equilibria is
[2008]

Options:

A. 1 : 36

B. 1 : 1

C. 1 : 3

D. 1 : 9

Answer: A

Solution:

Let the initial moles of X be 'a' and that of Z be ' b ' then for the given reactions.

$$X \rightleftharpoons 2Y$$

Initial	a moles	0
At eqm. (moles)	$a(1-\alpha)$	$2a\alpha$

Total no. of moles $= a(1-\alpha) + 2a\alpha$
$= a - a\alpha + 2a\alpha$
$= a(1+\alpha)$

$$K_{p_1} = \frac{(n_Y)^2}{n_x} \times \left(\frac{P_{T_1}}{\sum n}\right)^{\Delta n}$$

Now $K_{p_2} = \frac{n_Q \times n_P}{n_z} \times \left[\frac{P_{T_2}}{\sum n}\right]^{dn}$

or $K_{p_2} = \frac{(b\alpha)(b\alpha) \cdot P_{T_2}}{[b(1-\alpha)][b(1+\alpha)]}$

or $\frac{K_{p_1}}{K_{p_2}} = \frac{4\alpha^2 \cdot P_{T_1}}{(1-\alpha^2)} \times \frac{(1-\alpha)^2}{P_{T_2} \cdot \alpha^2} = \frac{4P_{T_1}}{P_{T_2}}$

or $\frac{4P_{T_1}}{P_{T_2}} = \frac{1}{9}$ $\left[\because \frac{K_{p_1}}{K_{p_2}} = \frac{1}{9} \text{ given }\right]$

or $\frac{P_{T_1}}{P_{T_2}} = \frac{1}{36}$ or 1 : 36

Question195

For the following threereactions (i), (ii) and (iii), equilibrium constants are given:
(i) $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$; K_1
(ii) $CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$; K_2
(iii) $CH_4(g) + 2H_2O(g) \rightleftharpoons CO_2(g) + 4H_2(g)$; K_3
Which of the following is correct?
[2008]

Options:

A. $K_1\sqrt{K_2} = K_3$

B. $K_2K_3 = K_1$

C. $K_3 = K_1K_2$

D. $K_3 \cdot K_2^3 = K_1^2$

Answer: C

Solution:

Reaction (iii) can be obtained by adding reactions (i) and (ii) therefore $K_3 = K_1 . K_2$

Question196

Four species are listed below:
i. HCO_3^-
ii. H_3O^+
iii. HSO_4^-
iv. HSO_3F
Which one of the following is the correct sequence of their acid strength?
[2008]

Options:

A. iv < ii < iii < i

B. ii < iii < i < iv

C. i < iii < ii < iv

D. iii < 1 < iv < ii

Answer: C

Solution:

The correct order of acidic strength of the given species is
$\underset{(iv)}{HSO_3F} > \underset{(ii)}{H_3O^+} > \underset{(iii)}{HSO_4^-} > \underset{(i)}{HCO_3^-}$
or (i) < (iii) < (ii) < (iv)

Question197

The pK_a of a weak acid, HA, is 4.80. The pK_b of a weak base, BOH, is 4.78. The pH of an aqueous solution of the corresponding salt, BA, will be
[2008]

Options:

A. 9.58

B. 4.79

C. 7.01

D. 9.22

Answer: C

Solution:

In aqueous solution, BA(salt) hydrolyses to give
$BA + H_2O \rightleftharpoons \underset{\text{base}}{BOH} + \underset{\text{acid}}{HA}$
Now pH is given by
$$pH = \frac{1}{2}pK_W + \frac{1}{2}pK_a - \frac{1}{2}pK_b$$
Substituting given values, we get
$$pH = \frac{1}{2}(14 + 4.80 - 4.78) = 7.01$$

Question198

The first and second dissociation constants of an acid H_2A are 1.0×10^{-5} and 5.0×10^{-10} respectively. The overall dissociation constant of the acid will be [2007]

Options:

A. 0.2×10^{5}

B. 5.0×10^{-5}

C. 5.0×10^{15}

D. 5.0×10^{-15}.

Answer: D

Solution:

$H_2A \rightleftharpoons H^+ + HA^-$

$\therefore K_1 = 1.0 \times 10^{-5} = \frac{[H^+][HA^-]}{[H_2A]}$

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

$\therefore\ K_2 = 5.0 \times 10^{-10} = \frac{[H^+][A^-]}{[HA^-]}$

For the reaction,

$H_2A \rightleftharpoons 2H^+ + A^{2-}$

$K = \frac{[H^+]^2[A^{2-}]}{[H_2A]} = K_1 \times K_2$

$= (1.0 \times 10^{-5}) \times (5 \times 10^{-10}) = 5 \times 10^{-15}$

Question199

The pK_a of a weak acid (HA) is 4.5. The pOH of an aqueous buffer solution of HA in which 50% of the acid is ionized is [2007]

Options:

A. 7.0

B. 4.5

C. 2.5

D. 9.5

Answer: D

Solution:

For acidic buffer, $pH = pK_a + \log\left[\frac{salt}{acid}\right]$ $pH = 4.5 + \log\frac{[\ salt\ ]}{[acid]}$

As HA is 50% ionized so [salt] = [acid]

$\therefore pH = 4.5$

$\because pH + pOH = 14$

$pOH = 14 - pH = 14 - 4.5 = 9.5$

Question200

In a saturated solution of the sparingly soluble strong electrolyte $AgIO_3$ (molecular mass = 283) the equilibrium which sets in is $AgIO_3(s) \rightleftharpoons Ag^+(aq) + IO_3^-(aq)$. If the

solubility product constant K_{sp} of $AgIO_3$ at a given temperature is 1.0×10^{-8}, what is the mass of $AgIO_3$ contained in 100mL of its saturated solution?
[2007]

Options:

A. 1.0×10^{-4}g

B. 28.3×10^{-2}g

C. 2.83×10^{-3}g

D. 1.0×10^{-7}g.

Answer: C

Solution:

Let s = solubility $AgIO_3 \rightleftharpoons Ag^+ + IO_3^-$

$K_{sp} = [Ag^+][IO_3^s] = s \times s = s^2$

Given $K_{5p} = 1 \times 10^{-8}$

$\therefore\ s = \sqrt{K_{sp}} = \sqrt{1 \times 10^{-8}}$

$= 1.0 \times 10^{-4}$mol / L $= 1.0 \times 10^{-4} \times 283$g / L

($\because$ Molecular mass of $AgIO_3 = 283$)

$= \frac{1.0 \times 10^{-4} \times 283 \times 100}{1000}$g / 100mL

$= 2.83 \times 10^{-3}$g / 100mL

Question201

Phosphorus pentachloride dissociates as follows, in a closed reaction vessel
$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$
If total pressure at equilibrium of the reaction mixture is P and degree of dissociation of PCl_5 is x, the partial pressure of PCl_3 will be
[2006]

Options:

A. $\left(\frac{x}{x-1}\right)P$

B. $\left(\frac{x}{1-x}\right)P$

C. $\left(\frac{x}{x+1}\right)P$

D. $\left(\frac{2x}{1-x}\right)P$

Answer: C

Solution:

$$\underset{1-x}{PCl_5(g)} \rightleftharpoons \underset{x}{PCl_3(g)} + \underset{x}{Cl_2(g)}$$

Total moles after dissociation $1 - x + x + x = 1 + x$

p_{PCl_3} = Mole fraction of PCl_3 × Total pressure

$= \left(\frac{x}{1+x}\right)P$

Question202

The equilibrium constant for the reaction
$SO_3(g) \rightleftharpoons SO_2(g) + \frac{1}{2}O_2(g)$

is $K_c = 4.9 \times 10^{-2}$.
The value of K_c for the reaction $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ will be
[2006]

Options:

A. 9.8×10^{-2}

B. 4.9×10^{-2}

C. 416

D. 2.40×10^{-3}

Answer: C

Solution:

$SO_3(g) \rightleftharpoons SO_2(g) + \frac{1}{2}O_2(g)$

$K_c = \frac{[SO_2][O_2]^{1/2}}{[SO_3]} = 4.9 \times 10^{-2}$

On taking the square of the above reaction

$\frac{[SO_2]^2[O_2]}{[SO_3]^2} = 24.01 \times 10^{-4}$

Now for $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3$

$K_c' = \frac{[SO_3]^2}{[SO_2]^2[O_2]} = \frac{1}{24.01 \times 10^{-4}} = 416$

Question203

For the reaction :
$2N O_2(g) \rightleftharpoons 2N O(g) + O_2(g)$
($K_c = 1.8 \times 10^{-6}$ at $184^\circ C$)($R = 0.0831 kJ / (mol . K)$)
When K_p and K_c are compared at $184^\circ C$, it is found that
[2005]

Options:

A. Whether K_p is greater than, less than or equal to K_c depends upon the total gas pressure

B. $K_p = K_c$

C. K_p is less than K_c

D. K_p is greater than K_c

Answer: D

Solution:

For the reaction:-
$2N O_2(g) \rightleftharpoons 2N O(g) + O_2(g)$
Given $K_c = 1.8 \times 10^{-6}$ at $184^\circ C$
$R = 0.0831 kJ / mol . K$
$K_p = K_c(RT)^{\Delta n}$
$K_p = 1.8 \times 10^{-6} \times 0.0831 \times 457$
$= 6.836 \times 10^{-6}$
Hence it is clear that $K_p > K_c$

Question204

An amount of solid NH_4HS is placed in a flask already containing ammonia gas at a certain temperature and 0.50 atm pressure. Ammonium hydrogen sulphide decomposes to yield NH_3 and N_2S gases in the flask. When the decomposition reaction reaches equilibrium, the total pressure in the flask rises to 0.84 atm? The equilibrium constant for NH_4HS decomposition at this temperature is
[2005]

Options:

A. 0.11

B. 0.17

C. 0.18

D. 0.30

Answer: A

Solution:

$$NH_4HS(s) \rightleftharpoons NH_3(s) + H_2S(g)$$

At	t = 0	0.5 atm	0 atm
At eqm.		0.5 + x atm	x atm.

Then $0.5 + x + x = 2x + 0.5 = 0.84$ (given)
$x = 0.17$ atm.
$p_{NH_3} = 0.5 + 0.17 = 0.67$atm
$p_{H_2S} = 0.17$atm
$K = p_{NH_3} \times p_{H_2S} = 0.67 \times 0.17 atm^2$
$= 0.1139 = 0.11$

Question205

The exothermic formation of ClF_3 is represented by the equation:
$Cl_2(g) + 3F_2(g) \rightleftharpoons 2ClF_3(g); \quad \Delta H = -329kJ$
Which of the following will increase the quantity of ClF_3 in an equilibrium mixture of Cl_2, F_2 and ClF_3 ?
[2005]

Options:

A. Adding F_2

B. Increasing the volume of the container

C. Removing Cl_2

D. Increasing the temperature

Answer: A

Solution:

The reaction given is an exothermic reaction thus accordingly to Le-Chatalier's principle lowering of temperature, addition of F_2 and or Cl_2 favour the forward direction and in hence the production of ClF_3.

Question206

Hydrogen ion concentration in mol / L in a solution of pH = 5.4 will be:
[2005]

Options:

A. 3.98×10^{-6}

B. 3.68×10^{-6}

C. 3.88×10^{6}

D. 3.98×10^{8}

Answer: A

Solution:

$pH = -\log[H^+] = \log \frac{1}{[H^+]}$

$5.4 = \log \frac{1}{[H^+]}$

On solving, $[H^+] = 3.98 \times 10^{-6}$

Question207

What is the conjugate base of OH^- ? [2005]

Options:

A. O^{2-}

B. O^-

C. H_2O

D. O_2

Answer: A

Solution:

Conjugate acid-base pair differ by only one proton.

$OH^- \longrightarrow H^+ + O^{2-}$

Conjugate base of OH is O^2

Question208

The solubility product of a salt having general formula MX_2, in water, is :4×10^{-12}. The concentration of M^{2+} ions in the aqueous solution of the salt is [2005]

Options:

A. 4.0×10^{-10}M

B. 1.6×10^{-4}M

C. 1.0×10^{-4}M

D. 2.0×10^{-6}M

Answer: C

Solution:

$MX_2 \rightleftharpoons \underset{s}{M^{2+}} + \underset{2s}{2s^{2+}}$

Where s is the solubility of MX_2

then $K_{sp} = 4s^3$

$4 \times 10^{-12} = 4s^3$

or $s = 1 \times 10^{-4}$

Question209

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:
[2004, 2012]

Options:

A. 0.02

B. 2.5×10^2

C. 4×10^{-4}

D. 50.0

Answer: D

Solution:

For the reaction
$N_2 + O_2 \longrightarrow 2NO \quad K_c = 4 \times 10^{-4}$
Hence for the reaction
$NO \longrightarrow \frac{1}{2}N_2 + \frac{1}{2}O_2 \quad K_c' = \frac{1}{\sqrt{K_c}} = \frac{1}{\sqrt{4 \times 10^{-4}}} = 50$

Question210

What is the equilibrium expression for the reaction $P_4(s) + 5O_2(g) \rightleftharpoons P_4O_{10}(s)$?
[2004]

Options:

A. $K_c = [O_2]^5$

B. $K_c = [P_4O_{10}] / 5[P_4][O_2]$

C. $K_c = [P_4O_{10}] / [P_4][O_2]^5$

D. $K_c = 1 / [O_2]^5$

Answer: D

Solution:

For $P_4(s) + 5O_2(g) \rightleftharpoons P_4O_{10}(s)$

$$K_c = \frac{1}{(O_2)^5}$$

Solids have concentration unity.

Question211

For the reaction, $CO(g) + Cl_2(g) \rightleftharpoons COCl_2(g)$ the K_p/K_c is equal to
[2004]

Options:

A. $\sqrt{RT}$

B. RT

C. 1 / RT

D. 1.0

Answer: C

Solution:

$K_p = K_c(RT)^{\Delta n}$;
Here $\Delta n = 1 - 2 = -1$
$\therefore \frac{K_p}{K_c} = \frac{1}{RT}$

Question212

The conjugate base of $H_2PO_4^-$ is
[2004]

Options:

A. H_3PO_4

B. P_2O_5

C. PO_4^{3-}

D. HPO_4^{2-}

Answer: D

Solution:

$$\underset{\text{Acid}}{H_2PO_4^-} \xrightarrow{-H^+} \underset{\text{Conjugate base}}{HPO_4^{2-}}$$

Conjugate acid-base differs by H^+.

Question213

The molar solubility (in mol L^{-1}) of a sparingly soluble salt MX_4 is 's'. The corresponding solubility product is K_{sp}. 's' is given in term of K_{sp} by the relation:
[2004]

Options:

A. $s = (256K_{sp})^{1/5}$

B. $s = (128K_{sp})^{1/4}$

C. $s = (K_{sp}/128)^{1/4}$

D. $s = (K_{sp}/256)^{1/5}$

Answer: D

Solution:

$MX_4 \rightleftharpoons \underset{s}{M^{4+}} + \underset{4s^-}{4X}$
$K_{sp} = [s][4s]^4 = 256s^5$
$\therefore s = \left(\frac{K_{sp}}{256}\right)^{1/5}$

Question214

For the reaction equilibrium
$N_2O_4(g) \rightleftharpoons 2NO_2(g)$
the concentrations of N_2O_4 and NO_2 at equilibrium are 4.8×10^{-2} and $1.2 \times 10^{-2} mol\, L^{-1}$ respectively. The value of K_c for the reaction is
[2003]

Options:

A. $3 \times 10^{-1} mol\, L^{-1}$

B. $3 \times 10^{-3} mol\, L^{-1}$

C. $3 \times 10^{3} mol\, L^{-1}$

D. $3.3 \times 10^{2} mol\, L^{-1}$

Answer: B

Solution:

$$K_c = \frac{[NO_2]^2}{[N_2O_4]} = \frac{[1.2 \times 10^{-2}]^2}{[4.8 \times 10^{-2}]}$$
$$= 3 \times 10^{-3} mol\ /\ L$$

Question215

Consider the reaction equilibrium
$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g);\ \Delta H^\circ = -198 kJ$
On the basis of Le Chatelier's principle, the condition favourable for the forward reaction is
[2003]

Options:

A. increasing temperature as well as pressure

B. lowering the temperature and increasing the pressure

C. any value of temperature and pressure

D. lowering of temperature as well as pressure

Answer: B

Solution:

Due to exothermic nature of reaction low or optimum temperature will be required. Since 3 moles are changing to 2 moles, therefore high pressure will be required.

Question216

Which one of the following statements is not true?
[2003]

Options:

A. pH + pOH = 14 for all aqueous solutions

B. The pH of $1 \times 10^{8} M$ HCl is 8

C. 96,500 coulombs of electricity when passed through a $CuSO_4$ solution deposits 1 gram equivalent of copper at the cathode

D. The conjugate base of $H_2PO_4^-$ is HPO_4^{2-}

Answer: B

Solution:

pH of an acidic solution should be less than 7 . The reason is that from H_2O, $[H^+] = 10^{-7}M$ which cannot be neglected in comparison to $10^{-8}M$. The pH can be calculated as.
From acid, $[H^+] = 10^{-8}M$
From H_2O, $[H^+] = 10^{-7}M$
$\therefore$ Total $[H^+] = 10^{-8} + 10^{-7}$
$= 10^{-8}(1 + 10) = 11 \times 10^{-8}$
$\therefore pH = -\log[H^+] = -\log 11 \times 10^{-8}$
$= -[\log 11 + 8 \log 10]$
$= -[1.0414 - 8] = 6.9586$

Question217

When rain is accompanied by a thunderstorm, the collected rain water will have a pH value
[2003]

Options:

A. slightly higher than that when the thunderstorm is not there

B. uninfluenced by occurrence of thunderstorm

C. that depends on the amount of dust in air

D. slightly lower than that of rain water without thunderstorm.

Answer: D

Solution:

Solution:
The rain water after thunderstorm contains dissolved acid and therefore the pH is less than rain water without thunderstorm.

Question218

The solubility in water of a sparingly soluble salt AB_2 is $1.0 \times 10^{-5} mol\ L^{-1}$. Its solubility product will be
[2003]

Options:

A. 4×10^{-10}

B. 1×10^{-15}

C. 1×10^{-10}

D. 4×10^{-15}

Answer: D

Solution:

$AB_2 \rightleftharpoons A^{2+} + 2B^-$
$[A] = 1.0 \times 10^{-5}$, $[B] = [2.0 \times 10^{-5}]$
$K_{gp} = [B][A] = [2 \times 10^{-5}]^2[1.0 \times 10^{-5}] = 4 \times 10^{-15}$

Question219

For the reaction $CO(g) + (1 / 2)O_2(g) \rightleftharpoons CO_2(g)$, K_p / K_c is [2002]

Options:

A. RT

B. $(RT)^{-1}$

C. $(RT)^{-1/2}$

D. $(RT)^{1/2}$

Answer: C

Solution:

$K_p = K_c(RT)^{\Delta n}$;

$\Delta n = 1 - \left(1 + \frac{1}{2}\right) = 1 - \frac{3}{2} = -\frac{1}{2}$

$\therefore \frac{K_p}{K_c} = (RT)^{-1/2}$

Question220

Change in volume of the system does not alter which of the following equilibria? [2002]

Options:

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

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

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

D. $SO_2Cl_2(g) \rightleftharpoons SO_2(g) + Cl_2(g)$

Answer: A

Solution:

In reaction (a) the ratio of number of moles of reactants to products is same i.e. 2 : 2, hence change in volume will not alter the number of moles.

Question221

Species acting as both Bronsted acid and base is [2002]

Options:

A. HSO_4^-

B. Na_2CO_3

C. NH_3

D. OH

Answer: A

Solution:

$(H\,SO_4)^-$ can accept and donate a proton
$(H\,SO_4)^- + H^+ \rightarrow H_2SO_4$ (acting as base)
$(H\,SO_4) - H^+ \rightarrow SO_4^{2-}$. (acting as acid)

Question222

Let the solubility of an aqueous solution of $M\,g(OH)_2$, be x, then its K_{sp} is [2002]

Options:

A. $4x^3$

B. $108x^5$

C. $27x^4$

D. 9x.

Answer: A

Solution:

$M\,g(OH)_2 \rightarrow [M\,g^{2+}] + 2[OH^-]$
$\underset{x}{} \quad \underset{2x}{}$
$K_{sp} = [M\,g][OH]^2 = [x][2x]^2 = x.4x^2 = 4x^3$

Question223

1M NaCl and 1M HCl are present in an aqueous solution. The solution is [2002]

Options:

A. not a buffer solution with pH < 7

B. not a buffer solution with pH > 7

C. a buffer solution with pH < 7

D. a buffer solution with pH > 7.

Answer: A

Solution:

A buffer is a solution of weak acid and its salt with strong base and vice versa. $H\,Cl$ is strong acid and $N\,aCl$ is its salt with strong base. pH is less than 7 due to $H\,Cl$.
