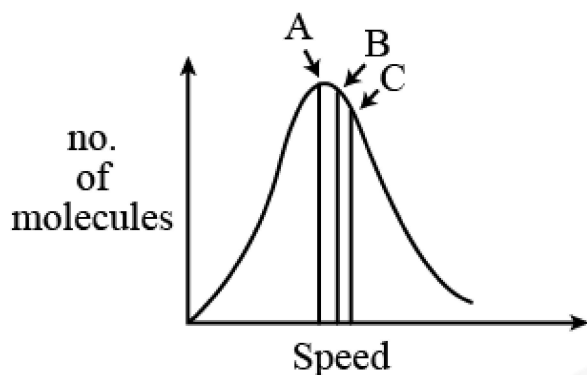


1. Identify the correct labels of A , B and C in the following graph from the options given below:

Root mean square speed (u_{rms}); most probable speed (u_{mp}); Average speed (u_{av})



- ☒ A. $A - u_{mp}; B - u_{av}; C - u_{rms}$
☐ B. $A - u_{mp}; B - u_{rms}; C - u_{av}$
☐ C. $A - u_{av}; B - u_{rms}; C - u_{mp}$
☐ D. $A - u_{rms}; B - u_{mp}; C - u_{av}$

$$u_{av} = \sqrt{\frac{8RT}{\pi M}}, \quad u_{rms} = \sqrt{\frac{3RT}{M}}$$

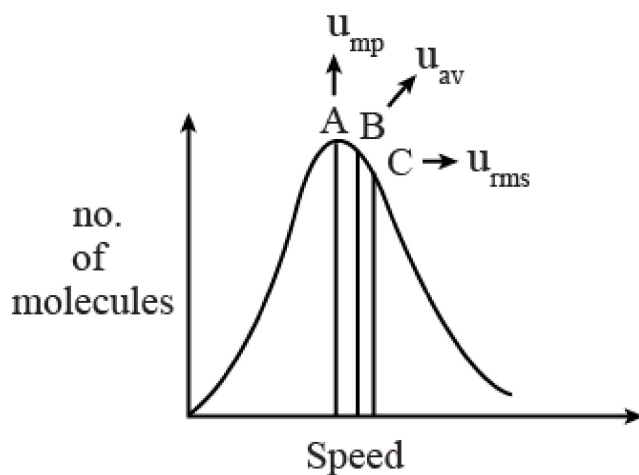
$$u_{mp} = \sqrt{\frac{2RT}{M}}$$

Ratio of the speeds are:

$$u_{rms}; u_{av}; u_{mp} = 1.22 : 1.12 : 1$$

u_{rms} is greater magnitude than u_{av} and u_{mp} is smallest in magnitude.

Therefore correct option is (a) i.e. $A - u_{mp}; B - u_{av}; C - u_{rms}$

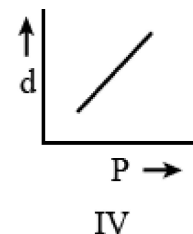
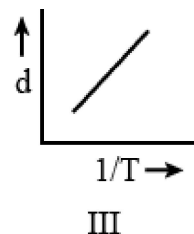
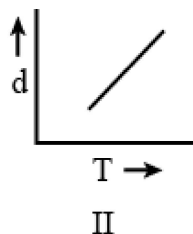
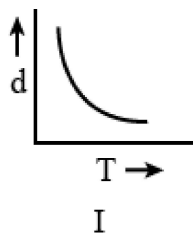


2. The predominant intermolecular forces present in ethyl acetate, a liquid, are:

- ☐ A. London dispersion, dipole - dipole and hydrogen bonding
- ☐ B. Hydrogen bonding and London dispersion
- ☐ C. Dipole-dipole and hydrogen bonding
- ☒ D. London dispersion and dipole-dipole

The predominant intermolecular forces present in ethyl acetate liquid is London dispersion and dipole-dipole interaction. Ethyl acetate is a polar molecule, therefore, dipole-dipole interaction will be present there. Hence, option (d) is correct.

3. Which one of the following graph is not correct for an ideal gas?

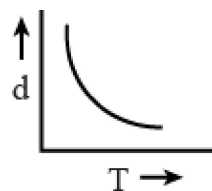


- ☒ A. (I)
- ☒ B. (IV)
- ☒ C. (III)
- ☒ D. (II)

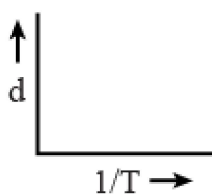
We know the relation, $d = [P \times M]/RT$

$$d \propto P \propto \frac{1}{T}$$

d vs T (at constant P) \rightarrow Hyperbolic

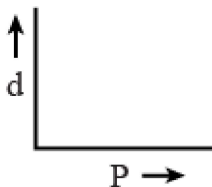


d vs $1/T$ \rightarrow Straight line



\therefore II Graph is incorrect.

d vs P (at constant T) \rightarrow Straight line



4. A graph of vapour pressure and temperature for the three different liquids X , Y and Z is shown:

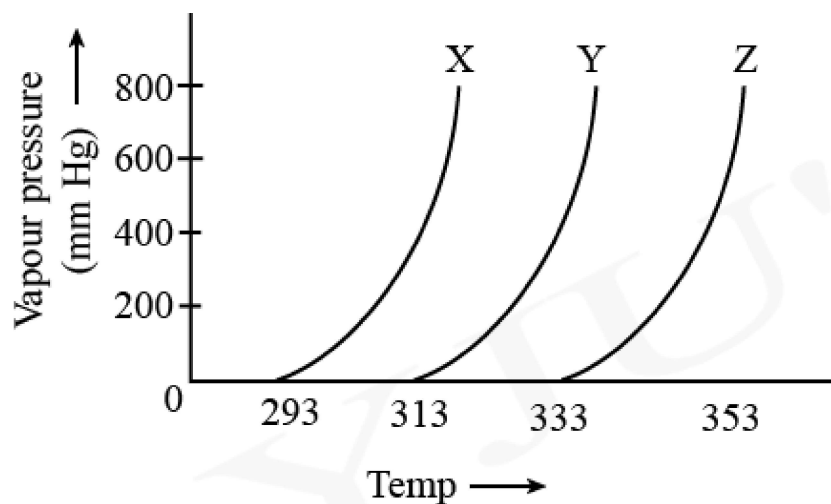
The following interference are made:

(A) X has higher intermolecular interaction compared to Y .

(B) X has lower intermolecular interaction compared to Y .

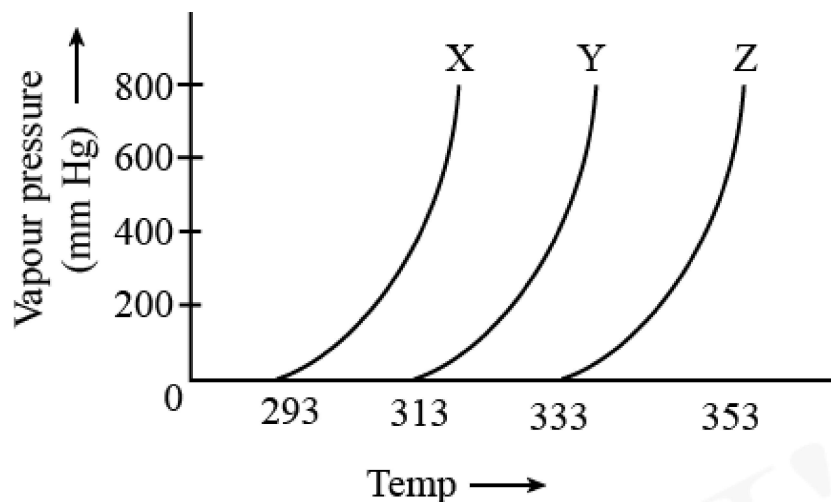
(C) Z has lower intermolecular interaction compared to Y .

The correct interference(s) is/are:



- ☒ A. (A) and (C)
- ☒ B. (A)
- ☒ C. (C)
- ☒ D. (B)

Only statement (B) i.e. (X) has lower intermolecular interactions as compared to (Y) is correct because at a particular temperature the vapour pressure decreases intermolecular interaction increases.



Hence, the correct option is (d).

5. 0.5 moles of gas A and x moles of gas B exert a pressure of 200 Pa in a container of volume 10 m^3 at 1000 K .

Given R is the gas constant in $\text{JK}^{-1}\text{ mol}^{-1}$, x is:

- ☒ A. $\frac{2R}{4 + 12}$
- ☒ B. $\frac{2R}{4 - R}$
- ☒ C. $\frac{4 - R}{2R}$
- ☒ D. $\frac{4 + R}{2R}$

Total mole, $n_T = (0.5 + x)$

Ideal gas equation, $PV = nRT$

$$200 \times 10 = (0.5 + x) \times R \times 1000$$

$$2 = (0.5 + x)R$$

$$\frac{2}{R} = \frac{1}{2} + x$$

$$\frac{4}{R} - 1 = 2x$$

$$\frac{4 - R}{2R} = x$$

$$\text{or, } x = \frac{4 - R}{2R}$$

6. The volume of gas A is twice than that of gas B. The compressibility factor of gas A is thrice than that of gas B at same temperature. The pressures of the gases for equal number of moles are:

- ☒ A. $2P_A = 3P_B$
- ☐ B. $2P_A = 3P_B$
- ☐ C. $P_A = 2P_B$
- ☐ D. $3P_A = 2P_B$

Given, $V_A = 2V_B$

$Z_A = 3Z_B$

Compressibility factor, $Z = \frac{PV}{nRT}$

$$\frac{P_A V_A}{n_A R T_A} = \frac{3 \cdot P_B \cdot V_B}{n_B \cdot R T_B}$$

$$2P_A = 3P_B$$

7. An open vessel at 27°C is heated until two fifth of the air (assumed as an ideal gas) in it has escaped from the vessel. Assuming that the volume of the vessel remains constant, the temperature at which the vessel has been heated is:

- ☐ A. 750°C
- ☐ B. 500°C
- ☐ C. 750 K
- ☒ D. 500 K

$\frac{2}{5}$ air escaped from vessel,

$\therefore \frac{3}{5}$ air remain in vessel.

P and V are constant

So, $n_1 T_1 = n_2 T_2$

$$n_1(300) = \left(\frac{3}{5}n_1\right) T_2$$

$$\Rightarrow T_2 = 500\text{ K}$$

8. Consider the van der Waals constants, a and b , for the following gases.

Gas	Ar	Ne	Kr	Xe
$a \text{ (atm dm}^6 \text{ mol}^{-2}\text{)}$	1.3	0.2	5.1	4.1
$b \text{ (10}^{-2} \text{ dm}^3 \text{ mol}^{-1}\text{)}$	3.2	1.7	1.0	5.0

Which gas is expected to have the highest critical temperature?

☒ A. Xe

☒ B. Ne

☒ C. Kr

☒ D. Ar

We know the expression of critical temperature which is given by,

$$T_c = \frac{8a}{27Rb}$$

$$T_c \propto \frac{a}{b}$$

Among the given gases, Kr has highest ratio of $\frac{a}{b} = 5.1$. Therefore, it is expected to have the highest critical temperature.

9. At a given temperature T , gases Ne, Ar, Xe and Kr are found to deviate from ideal gas behaviour. Their equation of state is given as $P = \frac{RT}{V - b}$ at T .

Here, b is the van der Waals constant. Which gas will exhibit steepest increase in the plot of Z (compression factor) vs P ?

- ☐ A. Kr
- ☐ B. Ar
- ☒ C. Xe
- ☐ D. Ne

$$P = \frac{RT}{(V - b)}$$

$$P(V - b) = RT$$

$$\left(P + \frac{a}{V^2}\right)(V - b) = RT$$

At high pressure,

$$P(V - b) = RT$$

$$PV - Pb = RT$$

$$\frac{PV}{RT} - \frac{Pb}{RT} = 1$$

$$Z = 1 + \frac{Pb}{RT}$$

$$Z > 1, Z \propto b$$

We know that the ' b ' is the volume occupied by the particles of the gas.

Xe has the highest size so it occupies the highest volume for a certain amount of gases.

Hence, Xe will have the highest slope.

10. Consider the following table:

Gas	a ($kPa\ dm^6\ mol^{-2}$)	b ($dm^3\ mol^{-1}$)
A	642.32	0.05196
B	155.21	0.04136
C	431.91	0.05196
D	155.21	0.4382

a and b are vander waals constant. The correct statement about the gases is:

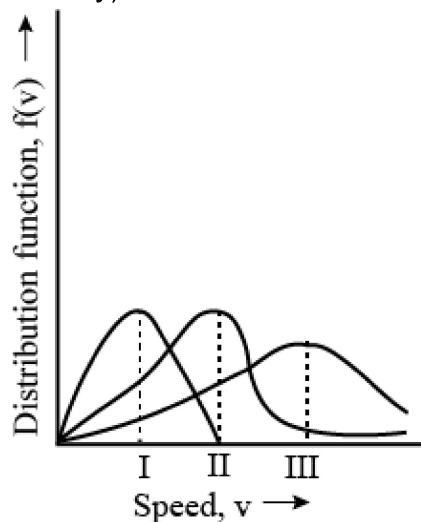
- ☒ A. Gas C will occupy lesser volume than gas A; gas B will be lesser compressible than gas D
- ☒ B. Gas C will occupy more volume than gas A; gas B will be lesser compressible than gas D
- ☒ C. Gas C will occupy more volume than gas A; gas B will be more compressible than gas D
- ☒ D. Gas C will occupy lesser volume than gas A; gas B will be more compressible than gas D

Gas C will occupy more volume than gas A; gas B will be more compressible than gas D.

Gas A and C have same value of ' b ' but different value of ' a ' so gas having higher value of ' a ' have more force of attraction so molecules will be more closer hence occupy less volume.

Gas B and D have same value of ' a ' but different value of ' b ' so gas having lesser value of ' b ' will be more compressible.

11. Points I, II and III in the following plot respectively correspond to u_{mp} (most probable velocity).



Choose the correct order in increasing order of their most probable velocity.

- ☒ A. u_{mp} of $N_2(300K)$; u_{mp} of $H_2(300K)$; u_{mp} of $O_2(400K)$
- ☒ B. u_{mp} of $H_2(300K)$; u_{mp} of $N_2(300K)$; u_{mp} of $O_2(400K)$
- ☒ C. u_{mp} of $O_2(300K)$; u_{mp} of $N_2(300K)$; u_{mp} of $H_2(400K)$
- ☒ D. u_{mp} of $N_2(300K)$; u_{mp} of $O_2(400K)$; u_{mp} of $H_2(300K)$

$$u_{mp} = \sqrt{\frac{2RT}{M}} \Rightarrow u_{mp} \propto \sqrt{\frac{T}{M}}$$

For N_2, O_2, H_2

$$\sqrt{\frac{300}{28}} < \sqrt{\frac{400}{32}} < \sqrt{\frac{300}{2}}$$

$$u_{mp} \text{ of } N_2(300K) < u_{mp} \text{ of } O_2(400K) < u_{mp} \text{ of } H_2(300K)$$

Hence, option (d) is correct.

12. Assuming ideal gas behaviour, the ratio of density of ammonia to that of hydrogen chloride at same temperature and pressure is: (Atomic wt. of Cl 35.5 u)

- ☒ A. 1.46
☒ B. 1.64
☒ C. 0.46
☒ D. 0.64

We know the relation for ideal gas, $d = \frac{PM}{RT}$

Where, M is molar mass of gas

d is density of gas

P is pressure of the gas

R is universal gas constant

T is temperature

$$(M)_{NH_3} = 17 \text{ u}$$

$$(M)_{HCl} = 36.5 \text{ u}$$

$$\frac{d_{NH_3}}{d_{HCl}} = \frac{(M)_{NH_3}}{(M)_{HCl}} = \frac{17}{36.5} = 0.46$$

13. When does a gas deviate the most from its ideal behaviour?

- ☒ A. At low pressure and low temperature
☒ B. At low pressure and high temperature
☒ C. At high pressure and low temperature
☒ D. At high pressure and high temperature

At high pressure and low temperature, gaseous atoms or molecules get closer to each other and van der Waal forces operates. So molecules or atoms start attracting each other. Hence a gas deviate the most from its ideal behaviour. While in ideal behaviour we can consider that gases do not attract each, i.e., there is no intermolecular forces of attraction.

14. The initial volume of a gas cylinder is 750.0 mL. If the pressure of gas inside the cylinder changes from 840.0 mm Hg to 360.0 mm Hg, the final volume the gas will be :

- ☒ A. 1.750 L
- ☐ B. 3.60 L
- ☐ C. 4.032 L
- ☐ D. 7.50 L

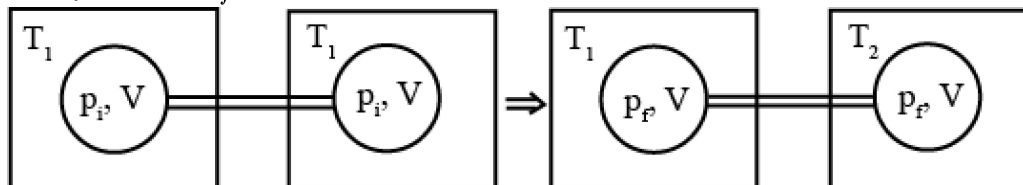
According to Boyle's law

$$\frac{V_1}{V_2} = \frac{P_2}{P_1}$$

$$\Rightarrow \frac{750}{V_2} = \frac{360}{840}$$

$$V_2 = 1750 \text{ mL} = 1.750 \text{ L}$$

15. Two closed bulbs of equal volume (V) containing an ideal gas initially at pressure P_i and temperature T_1 are connected through a narrow tube of negligible volume as shown in the figure below. The temperature of one of the bulbs is then raised to T_2 . The final pressure P_f is:



- ☒ A. $2P_i \left(\frac{T_1 T_2}{T_1 + T_2} \right)$
- ☒ B. $P_i \left(\frac{T_1 T_2}{T_1 + T_2} \right)$
- ☒ C. $2P_i \left(\frac{T_1}{T_1 + T_2} \right)$
- ☒ D. $2P_i \left(\frac{T_2}{T_1 + T_2} \right)$

Initial moles and final moles are equal

$$(n_T)_i = (n_T)_f$$

$$\frac{P_i V}{RT_1} + \frac{P_i V}{RT_1} = \frac{P_f V}{RT_1} + \frac{P_f V}{RT_2}$$

$$2 \frac{P_i}{T_1} = \frac{P_f}{T_1} + \frac{P_f}{T_2}$$

$$2 \frac{P_i}{T_1} = P_f \left(\frac{1}{T_1} + \frac{1}{T_2} \right)$$

$$P_f = \frac{2P_i T_2}{T_1 + T_2}$$

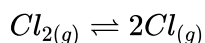
$$P_f = 2P_i \left(\frac{T_2}{T_1 + T_2} \right)$$

16. At 1990 K and 1 atm pressure, there are equal number of Cl_2 molecules and Cl atoms in the reaction mixture. The value of K_p for the reaction $Cl_{2(g)} \rightleftharpoons 2Cl_{(g)}$ under the above condition is $x \times 10^{-1}$. The value of x is _____.
(rounded off to the nearest integer)

Accepted Answers

5 5.0 5.00

Solution:



\therefore No. of atoms of Cl = No. of molecules of Cl_2

i.e. $n_{Cl(g)} = n_{Cl_2(g)}$

'n' represent number of moles

$$P_T = 1 \text{ atm}$$

Using Dalton's law of partial pressure:

$$P_{Cl(g)} = 0.5 \text{ atm} = P_{Cl_2(g)}$$

$$\therefore K_P = \frac{(0.5)^2}{0.5} = 5 \times 10^{-1}$$

Hence, $x = 5$

17. The volume occupied by 4.75 g of acetylene gas at $50^\circ C$ and 740 mm Hg pressure is ____L.

(Rounded off to the nearest integer)]

[Given $R = 0.0826 \text{ L atm K}^{-1} \text{ mol}^{-1}$]

Accepted Answers

5 5.0 5.00

Solution:

Molar mass of acetylene = 26 g mol^{-1}

$$\text{No. of moles, } n = \frac{4.75}{26} \text{ mol}$$

$$P = \frac{740}{760} \text{ atm}$$

$$T = 323 \text{ K}$$

From ideal gas law,

$$PV = nRT$$

$$V = \frac{4.75 \times 0.0826 \times 323 \times 760}{26 \times 740} = 5.00 \text{ L}$$

Hence, volume occupied by the gas is 5 L.

18. 3.12 g of oxygen is adsorbed on 1.2 g of platinum metal. The volume of oxygen adsorbed per gram of the adsorbent at 1 atm and 300 K in L is _____.

$$[R = 0.0821 \text{ L atm K}^{-1} \text{ mol}^{-1}]$$

Accepted Answers

2 2.0 2.00

Solution:

$$P = 1 \text{ atm}$$

$$T = 300 \text{ K}$$

$$\text{Mass of oxygen adsorbed on 1 g of platinum} = \frac{3.12}{1.2} = 2.6$$

$$\text{No. of moles of oxygen adsorbed on 1 g of platinum} = \frac{2.6}{32} = 0.0812$$

Using ideal gas equation,

$$PV = nRT$$

$$V = \frac{0.0812 \times 0.0821 \times 300}{1} = 1.99 \text{ L} \approx 2 \text{ L}$$

19. A home owner uses $4.00 \times 10^3 \text{ m}^3$ of methane (CH_4) gas, (assume (CH_4) is an ideal gas) in a year to heat his home. Under the pressure of 1.0 atm and 300 K, mass of gas used is $x \times 10^5 \text{ g}$. The value of x is_____.(Nearest integer)
(Given $R = 0.083 \text{ L atm K}^{-1} \text{ mol}^{-1}$)

Accepted Answers

26 26.0 26.00

Solution:

$$\text{Pressure} = 1 \text{ atm}$$

$$\text{Volume} = 4.00 \times 10^3 \text{ m}^3 = 4 \times 10^6 \text{ L}$$

$$\text{Using } PV = nRT$$

$$\text{Moles} = \frac{1 \times 4 \times 10^6}{0.083 \times 300}$$

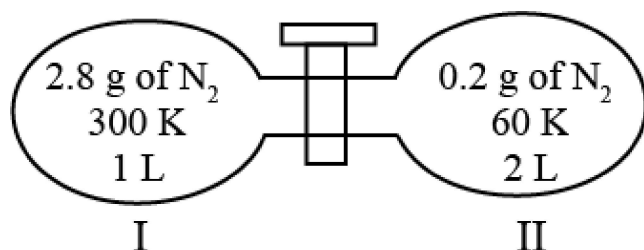
$$\text{Moles, } n = 0.1606 \times 10^6 \text{ mol}$$

$$\text{Mass} = \text{Moles} \times \text{Molar mass}$$

$$\text{Mass} = 0.1606 \times 10^6 \times 16$$

$$\approx 26 \times 10^5 \text{ g}$$

20. Two flasks *I* and *II* shown below are connected by a valve of negligible volume.



When the valve is opened, the final pressure of the system in bar is $x \times 10^{-2}$. The value of x is ____.

(Integer answer)

[Assume - ideal gas: $1 \text{ bar} = 10^5 \text{ Pa}$.

Molar mass of $N_2 = 28.0 \text{ g mol}^{-1}$ $R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$

Accepted Answers

84 84.0 84.00

Solution:

$$\text{Number of moles of flask I} = \frac{2.8}{28} = 0.1$$

$$\text{Number of moles of flask II} = \frac{0.2}{28} = \frac{1}{140}$$

Assuming the system attains a final temperature of T
Heat lost by N_2 of flask I = Heat gained by N_2 of flask II

$$n_I C_m (300 - T) = n_{II} C_m (T - 60)$$

$$0.1(300 - T) = \frac{1}{140}(T - 60)$$

$$\text{Final temperature } T = 284 \text{ K}$$

$$P_T = \frac{n_1 R T}{V_1} = \frac{\left(\frac{1}{10} + \frac{1}{140}\right) \text{ mol} \times 8.31 \text{ J mol}^{-1} \text{ K}^{-1} \times 284 \text{ K}}{3 \times 10^{-3} \text{ m}^3} \times 10^{-5} \frac{\text{bar}}{\text{Pa}} = 84.2$$

$$P_T = 84.28 \times 10^{-2} \text{ bar}$$

$$x = 84 \text{ (nearest integer)}$$

21. An empty *LPG* cylinder weighs 14.8 kg . When full, it weighs 29.0 kg and shows a pressure of 3.47 atm . In the course use at ambient temperature, the mass of the cylinder is reduced to 23.0 kg . The final pressure inside the cylinder is _____ atm .

(Nearest Integer)

(Assume *LPG* to be an ideal gas)

Accepted Answers

2

Solution:

Initial amount of gas present in the cylinder
 $(29.0 - 14.8)$
 $= 14.2\text{ kg}$

Final amount of gas present in the cylinder
 $(23.0 - 14.8)$
 $= 8.2\text{ kg}$

$$\frac{P_1}{n_1} = \frac{P_2}{n_2}$$

$$P_2 = n_2 \times \frac{P_1}{n_1} = \frac{8200}{14200} \times \frac{3.47 \times MM}{MM}$$

$$P_2 = 2\text{ atm}$$

22. A car tyre is filled with nitrogen gas at 35 psi at 27°C . It will burst if pressure exceeds 40 psi . The temperature in $^\circ\text{C}$ at which the car tyre will burst is _____. (Rounded off to the nearest integer)

Accepted Answers

70 70.0 70.00

Solution:

Assuming that no. of moles of N_2 and volume of tyre remains constant and pressure is changed by changing temperature.

Using : $\frac{P}{T} = \text{constant}$

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

$$\Rightarrow T_2 = \frac{40 \times 300}{35}$$

$$\approx 343\text{ K}$$

$$T_2 - 273 = 70^\circ\text{C}$$

23. The pressure exerted by a non- reactive gaseous mixture of 6.4 g of methane and 8.8 g of carbon dioxide in a 10 L vessel at 27°C is ____ kPa
(Round off to the Nearest Integer).

[Assume gases are ideal, $R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$

Atomic masses : C = 12.0 u, H : 1.0 u, O : 16.0 u]

Accepted Answers

150 150.00 150.0

Solution:

$$\text{Number of moles of } CH_4 = \frac{6.4}{16} = 0.4 \text{ mol}$$

$$\text{Number of moles } CO_2 = \frac{8.8}{44} = 0.2 \text{ mol}$$

Total number of moles of the mixture = 0.6 mol

Pressure of the mixture of gases in 10 L (0.01 m³) vessel at 300 K is given as:

$$P = \frac{nRT}{V} = \frac{0.6 \times 8.314 \times 300}{0.01} = 149652 \text{ Pa} \approx 150 \text{ kPa}$$

24. An LPG cylinder contains gas at a pressure of 300 kPa at 27°C. The cylinder can withstand the pressure of $1.2 \times 10^6 \text{ Pa}$. The room in which the cylinder is kept catches fire. The minimum temperature at which the bursting of cylinder will take place is ____ °C. (Nearest Integer)

Accepted Answers

927 927.00 927.0

Solution:

At constant volume and number of moles of a gas, pressure is directly proportional to temperature change.

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

$$T_2 = \frac{1.2 \times 10^6}{300 \times 10^3} \times 300 = 1200 \text{ K} = 927^\circ \text{C}$$

25. A certain gas obeys $P(V_m - b) = RT$. The value of $\left(\frac{\delta Z}{\delta P}\right)_T$ is $\frac{xb}{RT}$. The value of x is _____.
(Z: compressibility factor)

Accepted Answers

1 1.0 1.00

Solution:

$$P(V_m - b) = RT$$

$$\Rightarrow PV_m - Pb = RT$$

$$\Rightarrow \frac{PV_m}{RT} = 1 + \frac{Pb}{RT}$$

$$\text{Compressibility factor, } Z = \frac{PV_m}{RT}$$

$$\Rightarrow Z = 1 + \frac{Pb}{RT}$$

$$\left(\frac{\delta Z}{\delta P}\right)_T = \frac{b}{RT}$$

$$\therefore \boxed{x = 1}$$

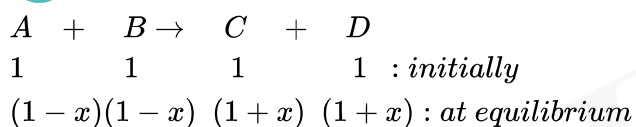
1. The equilibrium constant at 298K for a reaction $A + B \rightleftharpoons C + D$ is 100. If the initial concentration of all the four species were 1 M each, then equilibrium concentration of D (in molL^{-1}) will be.

☐ A. 0.818

☒ B. 1.818

☐ C. 1.182

☐ D. 0.182



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

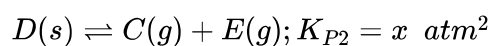
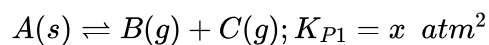
$$K_c = \left(\frac{1+x}{1-x} \right)^2 = 100$$

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

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

$$\text{Moles of } D = 1 + x = 1 + \frac{9}{11} = \frac{20}{11} = 1.818$$

2. Two solids dissociate as follows



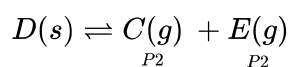
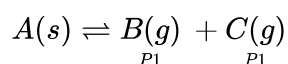
The total pressure when both the solids dissociate simultaneously is:

☒ A. $x^2 + y^2$

☒ B. $\sqrt{x^2 + y^2}$

☒ C. $2(\sqrt{x + y})$

☒ D. $\sqrt{x + y}$



$$C, P_C = P_1 + P_2$$

$$K_{P1} = x = P_B \cdot P_C \dots \dots (1)$$

$$x = P_1(P_1 + P_2)$$

$$K_{P2} = y = P_C \cdot P_E \dots \dots (2)$$

$$y = (P_1 + P_2)(P_2)$$

$$x + y = (P_1 + P_2)^2$$

$$P_T = P_C + P_B + P_E$$

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

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

3. The INCORRECT match in the following is :

☒ A. $\Delta G^0 < 0, K < 1$

☐ B. $\Delta G^0 < 0, K = 1$

☐ C. $\Delta G^0 > 0, K < 1$

☐ D. $\Delta G^0 < 0, K > 1$

$$\Delta G = \Delta G^0 + RT \ln K$$

At equilibrium,

$$\Rightarrow \Delta G^0 = -RT \ln K = 0$$

$$-RT \ln K < 0$$

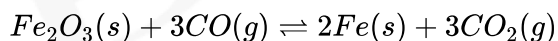
$$RT \ln K > 0$$

$$\ln K > 0$$

$$\Rightarrow K > 1$$

Hence, correct option is (a).

4. The following reaction occurs in the Blast Furnace where iron ore is reduced to iron metal:



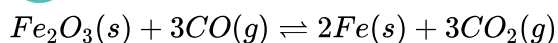
Using Le Chatelier's principle, predict which one of the following will not disturb the equilibrium?

☐ A. Removal of CO_2

☐ B. Removal of CO

☐ C. Addition of CO_2

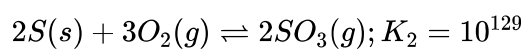
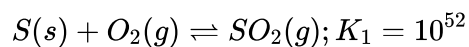
☒ D. Addition of Fe_2O_3



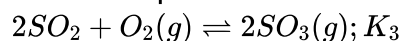
Addition of Fe_2O_3 will not disturb the equilibrium Fe_2O_3 is in solid state and its concentration remains unchanged when more Fe_2O_3 is added.

Hence, correct option is (d).

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



Find the equilibrium constant for

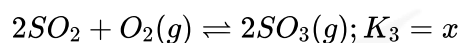
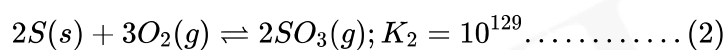
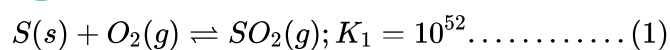


☒ A. 10^{181}

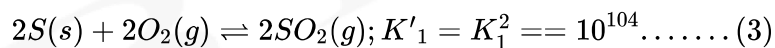
☒ B. 10^{154}

☒ C. 10^{25}

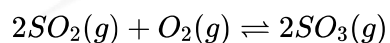
☒ D. 10^{77}



Multiplying equation (1) by 2;



\Rightarrow Subtracting (3) from (2); we get



$$K_{eq} = \frac{K_2}{K'_1} = 10^{(129-104)} = 10^{25}$$

6. 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, $CO + Cl_2 \rightleftharpoons COCl_2$

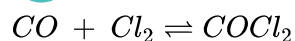
At equilibrium, if one mole of CO is present then equilibrium constant (K_c) for the reaction is:

☒ A. 2.5

☐ B. 4

☐ C. 2

☐ D. 3



$$2 \quad 3 \quad 0$$

$$(2 - 1) \quad (3 - 1) \quad 1$$

Initially, 2 moles of CO are present.

At equilibrium, 1 mole of CO is present.

Hence, $2 - 1 = 1$ mole CO has reacted.

1 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.

Volume of vessel = 5L (Given)

The equilibrium constant

$$K_c = \frac{[COCl_2]}{[CO][Cl_2]}$$

$$K_c = \frac{\frac{1mol}{5L}}{\frac{1mol}{5L} \times \frac{2mol}{5L}}$$

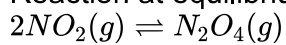
$$K_c = 2.5$$

Option (a) is correct.

7. The gas phase reaction $2NO_2(g) \rightleftharpoons N_2O_4(g)$ is an exothermic reaction. The decomposition of N_2O_4 in equilibrium mixture of $NO_2(g)$ and $N_2O_4(g)$ can be increased by:

- ☐ A. increasing the pressure
- ☒ B. addition of an inert gas at constant pressure
- ☐ C. lowering the temperature
- ☐ D. addition of an inert gas at constant volume

Reaction at equilibrium



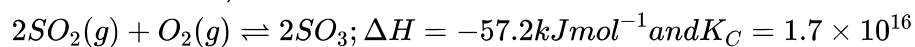
(1) According to Le chatelier's principle: Increasing the pressure on a gas reaction shifts the position of equilibrium toward the side with fewer molecules.

So, it will move in backward direction which leads to formation of $N_2O_4(g)$

(2) Addition of an inert gas to constant pressure will increase volume and equilibrium shifts towards more number of molecules i.e. there will be decomposition.

(3) Decomposition of N_2O_4 is endothermic. So, the reaction will move in forward reaction when the temperature is increased.

8. For the reaction,



Which of the following statement is INCORRECT?

- ☒ 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

In option (B): Δn_g is -ve, therefore, the increase in pressure will bring reaction in the forward direction.

In option (C): as the reaction is exothermic therefore increase in temperature will decrease the equilibrium constant.

In option (D): Equilibrium constant changes only with temperature.

Hence, option (B), (C) and (D) are correct therefore option (A) is the incorrect choice.

9. The equilibrium constant for the reaction at $298K$ is:

Given that: $\Delta H^\circ = -29.8 kJ mol^{-1}$

$$\Delta S^\circ = -0.100 kJK^{-1} mol^{-1}$$

☐ A. 1.0×10^{10}

☐ B. 1.0×10^{-10}

☐ C. 10

☒ D. 1

Given that: $\Delta H^\circ = -29.8 kJ mol^{-1}$

$$\Delta S^\circ = -0.100 kJK^{-1} mol^{-1}$$

$$T = 298 K$$

Now, $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$

$$= -29.8 - \{298 \times (-0.1)\}$$

Also, $\Delta G = -RT \ln K_p$

$$\Delta G = -RT \ln K_p = 0$$

$$\ln K_p = 0$$

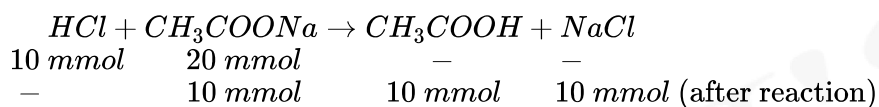
$$K_p = e^0 = 1$$

The equilibrium constant for the reaction at $298K$ is : 1

10. An acid buffer is obtained on mixing :

- ☒ A. 100 mL of 0.1 M CH_3COOH and 200 mL of 0.1 M $NaOH$
- ☒ B. 100 mL of 0.1 M CH_3COOH and 100 mL of 0.1 M $NaOH$
- ☒ C. 100 mL of 0.1 M HCl and 200 mL of 0.1 M CH_3COONa
- ☒ D. 100 mL of 0.1 M HCl and 200 mL of 0.1 M $NaCl$

A buffer solution is an aqueous solution consisting of a mixture of a weak acid and its conjugate base, or vice versa.



So, finally we get mixture of $CH_3COOH + CH_3COONa$ that will work like acidic buffer solution.

Hence, option (c) only act as acid buffer.

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

- (A) 0.01 M HCl
- (B) 0.01 M NaOH
- (C) $0.01\text{ M CH}_3\text{COONa}$
- (D) 0.01 M NaCl

☒ A. $(A) > (C) > (D) > (B)$

☒ B. $(B) > (D) > (C) > (A)$

☒ C. $(B) > (C) > (D) > (A)$

☒ D. $(A) > (D) > (C) > (B)$

(A) $10^{-2}\text{ M HCl} \Rightarrow [H^+] = 10^{-2}\text{ M} \rightarrow pH = 2 \Rightarrow pOH = 12$

(B) $10^{-2}\text{ M NaOH} \Rightarrow [OH^-] = 10^{-2}\text{ M} \rightarrow pOH = 2$

(C) $10^{-2}\text{ M CH}_3\text{COO}^- \text{Na}^+ \Rightarrow [OH^-] > 10^{-7} \Rightarrow pOH < 7$

(D) $10^{-2}\text{ M NaCl} \Rightarrow \text{Neutral } pOH = 7$

Decreasing order of pOH ,
 $(A) > (D) > (C) > (B)$

Hence, option (d) is correct.

12. The pH of a $0.02\text{ M } NH_4Cl$ solution will be:
[Given $K_b(NH_4OH) = 10^{-5}$ and $\log 2 = 0.301$].

☐ A. 4.65

☒ B. 5.35

☐ C. 4.35

☐ D. 2.65

NH_4Cl is a salt of strong acid and weak base. Hence the formula for calculating its pH can be written as

$$pH = \frac{1}{2}[pK_w - pK_b - \log C]$$

$$K_b = 10^{-5}$$

$$pK_b = -\log K_b$$

$$pK_b = 5$$

$$pH = \frac{1}{2}[14 - pK_b - \log C]$$

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

$$pH = 7 - \frac{5}{2} - \frac{1}{2} \times 0.301 + 1$$

$$pH = 7 - \frac{5}{2} - 0.1505 + 1$$

$$pH = 5.35$$

Hence, option (b) is correct.

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

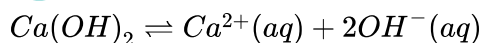
[Given : The solubility product of $Ca(OH)_2$ in water 5.5×10^{-6}]

☐ A. 1.77×10^{-6}

☐ B. 1.11×10^{-6}

☒ C. 1.11×10^{-2}

☐ D. 1.77×10^{-2}



$$K_{sp} = S(2S)^2 \Rightarrow 5.5 \times 10^{-6} = 4S^3$$

$$\Rightarrow S = \left(\frac{5.5}{4}\right)^{\frac{1}{3}} \times 10^{-2} = 1.11 \times 10^{-2}$$

Hence, option (c) is correct.

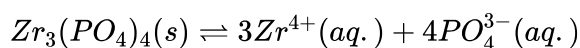
14. If solubility product of $Zr_3(PO_4)_4$ is denoted by K_{sp} and its molar solubility is denoted by S , then which of the following relation between S and K_{sp} is correct?

☐ A. $S = \left(\frac{K_{sp}}{929}\right)^{1/9}$

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

☐ C. $S = \left(\frac{K_{sp}}{144}\right)^{1/6}$

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



$$K_{sp} = [Zr^{4+}]^3 [PO_4^{3-}]^4 = (3S)^3 \cdot (4S)^4 = 6912 S^7$$

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

Hence, option (d) is correct.

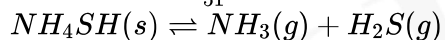
15. 5.1 g NH_4SH is introduced in 3.0 L evacuated flask at $327^\circ C$. 30% of the solid NH_4SH decomposed to NH_3 and H_2S as gases. The K_P of the reaction at $327^\circ C$ is

($R = 0.082 \text{ L atm mol}^{-1}$,
molar mass of $S = 32 \text{ g mol}^{-1}$,
molar mass $N = 14 \text{ g mol}^{-1}$.)

- ☒ A. $1 \times 10^{-4} \text{ atm}^2$
- ☒ B. $4.9 \times 10^{-4} \text{ atm}^2$
- ☒ C. 0.242 atm^2
- ☒ D. $0.242 \times 10^{-4} \text{ atm}^2$

Correction option is C)

$$\text{Moles of } NH_4SH = \frac{5.1}{51} = 0.1 \text{ mol}$$



$$\text{Initially} \quad 0.1 \quad \quad 0 \quad \quad 0$$

$$\text{At equil} \quad 0.1(1 - \alpha) \quad 0.1\alpha \quad 0.1\alpha$$

$$\alpha = 30\% = 0.3$$

So, number of moles equilibrium due to gaseous product

$$= 0.1 \times 0.3 + 0.1 \times 0.3$$

$$= 0.03 + 0.03$$

Now use $PV = nRT$

At equilibrium,

$$P_{total} \times 3 \text{ lit} = (0.03 + 0.03) \times 0.082 \times 600$$

$$P_{total} = 0.984 \text{ atm}$$

At equilibrium,

$$P_{NH_3} = P_{H_2S} = \frac{P_{total}}{2} = 0.492$$

$$K_p = P_{NH_3} \times P_{H_2S} = 0.492 \times 0.492$$

$$K_p = 0.242 \text{ atm}^2$$

16. For a reaction $X + Y \rightleftharpoons 2Z$ 1.0 mol of X, 1.5 mol of Y and 0.5 mol of Z were taken in a 1 L vessel and allowed to react.

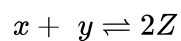
At equilibrium, the concentration of Z was 1.0 mol L^{-1}

The equilibrium constant of the reaction is $\frac{x}{15}$. The value of x is

Accepted Answers

16

Solution:



$$t = 0 \quad 1 \quad \frac{3}{2} \quad \frac{1}{2} \quad \text{initial moles}$$

$$t_{eq} \quad - \quad - \quad 1 \text{ mol} \quad (2x = \frac{1}{2})$$

$$t_{eq} \quad (1-x) \quad (\frac{3}{2}-x) \quad \frac{1}{2} \quad 2x \quad (x = \frac{1}{4})$$

$$t_{eq} \quad \frac{3}{4} \quad \frac{5}{4} \quad 1$$

$$K_{eq} = \frac{(1)^2}{\frac{5}{4} \times \frac{3}{4}} = \frac{16}{15}$$

$$K_{eq} = 16$$

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

The value of x is(Nearest integer)

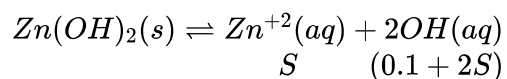
(Given: The solubility product of $Zn(OH)_2$ is 2×10^{-20})

Accepted Answers

2 2.0 2.00

Solution:

$Zn(OH)_2$ is dissolved in 0.1 M of NaOH



$Zn(OH)_2$ is less soluble, so 2S is negligible compared to 0.1.

$$\therefore (0.1 + 2S) \simeq 0.1$$

$$K_{sp} = S(0.1)^2$$

$$2 \times 10^{-20} = S \times 10^{-2}$$

$$\Rightarrow S = 2 \times 10^{-18}$$

$$\Rightarrow x \times 10^{-18} = 2 \times 10^{-18}$$

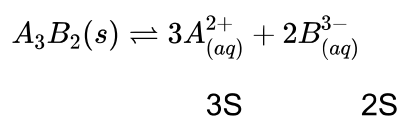
Thus, x=2.

18. A_3B_2 is a sparingly soluble salt of molar mass M ($g\ mol^{-1}$) and solubility $x\ g\ L^{-1}$. The solubility product satisfies $K_{SP} = a\left(\frac{x}{M}\right)^5$. The value of a is _____ (Integer answer).

Accepted Answers

108 108.0 108.00

Solution:



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

$$K_{sp} = 108 S^5$$

$$S = \left(\frac{\text{Solubility in g/L}}{\text{Molar mass of } A_3B_2} \right)$$

$$K_{sp} = 108 \left(\frac{x}{M} \right)^5 \dots (1)$$

$$K_{sp} = a \left(\frac{x}{M} \right)^5 \dots (2)$$

Comparing (1) and (2), we get,
 $a = 108$.

19. The pH of a solution obtained by mixing 50 mL of 1 M HCl and 30 mL of 1 M NaOH is $x \times 10^{-4}$. The value of x is _____(Nearest integer).
[log2.5=0.3979]

Accepted Answers

60216021.06021.00

Solution:

No of moles of H^+ from HCl is,

$$50 \times 1 = 50 \text{ mmol}$$

No of moles of OH^- from NaOH is,

$$30 \times 1 = 30 \text{ mmol}$$

30 mmol of OH^- will neutralise 30 mmol of H^+ and the solution left with 20 mmol of H^+

∴

Concentration of H^+ is,

$$[HCl] = \frac{20}{80} = \frac{1}{4}M = 2.5 \times 10^{-1}M$$

$$pH = -\log 2.5 \times 10^{-1} = 1 - 0.3979 = 0.6021$$

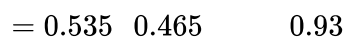
$$pH = 6021 \times 10^{-4}$$

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

Accepted Answers

73 73.0 73.00

Solution:



$$1.9 \times 25 = n_T \times 0.08206 \times 300$$

$$n_T = 1.93 = 1 + 2\alpha$$

$$\alpha = 0.465$$

$$K_p = \frac{\left(\frac{0.465}{1.93} \times 1.9\right) \left(\frac{0.93}{1.93} \times 1.9\right)^2}{\left(\frac{0.535}{1.93} \times 1.9\right)}$$

$$K_p = 73 \times 10^{-2} atm^2$$

$$x = 73$$

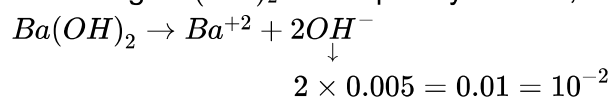
21. Assuming that $Ba(OH)_2$ is completely ionised in aqueous solution under the given conditions the concentration of H_3O^+ ions in 0.005 M aqueous solution of $Ba(OH)_2$ at 298K is _____ $\times 10^{-12} mol L^{-1}$. (Nearest integer)

Accepted Answers

1 1.0 1.00

Solution:

Assuming $Ba(OH)_2$ is completely ionised,



We know

$$[H^+][OH^-] = 10^{-14}$$

$$[H_3O^+][OH^-] = 10^{-14}$$

$$[H_3O^+] = \frac{10^{-14}}{10^{-2}} = 10^{-12}$$

Hence, answer is 1.

22. Sulphurous acid (H_2SO_3) has $K_{a1} = 1.7 \times 10^{-2}$ and $K_{a2} = 6.4 \times 10^{-8}$. The pH of 0.588 M H_2SO_3 is _____ (Round off to the Nearest Integer).

Accepted Answers

1 1.0 1.00

Solution:

H_2SO_3 is a dibasic acid.

Concentration, $c = 0.588$ M

\Rightarrow pH of solution is due to first dissociation only dissociation only, since

$K_{a1} \gg K_{a2}$

\Rightarrow First dissociation of (H_2SO_3)



t = 0 C

At 't' C - x x x

$$\Rightarrow K_{a1} = \frac{1.7}{100} = \frac{[H^+][HSO_3^-]}{[H_2SO_3]}$$

$$\Rightarrow \frac{1.7}{100} = \frac{x^2}{(0.588-x)}$$

$$\Rightarrow 1.7 \times 0.588 - 1.7x = 100x^2$$

$$\Rightarrow 100x^2 + 1.7x - 1 = 0$$

$$\Rightarrow [H^+] = x = \frac{-1.7 + \sqrt{(1.7)^2 + 4 \times 100 \times 1}}{2 \times 100} = 0.09186$$

Therefore pH of sol is : $pH = -\log[H^+]$

$$\Rightarrow pH = -\log(0.09186) = 1.036 \approx 1$$

23. Two solution, *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_____.

Accepted Answers

10.6 10.60

Solution:

$$\text{moles of NaOH} = \frac{4}{40} = 0.1$$

$$\text{molarity of solution A} = \frac{\text{moles}}{\text{volume}} = \frac{0.1}{100} = 10^{-3} \text{ M}$$

$$\text{moles of H}_2\text{SO}_4 = \frac{9.8}{98} = 0.1$$

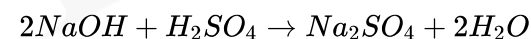
$$\text{molarity of solution B} = \frac{\text{moles}}{\text{volume}} = \frac{0.1}{100} = 10^{-3} \text{ M}$$

40 litre of solution *A* contains,

$$\text{moles of NaOH} = 40 \times 10^{-3} = 4 \times 10^{-2} = 0.04$$

10 litre of solution *B* contains,

$$\text{moles of H}_2\text{SO}_4 = 10 \times 10^{-3} = 10^{-2} = 0.01$$



One mole of H_2SO_4 reacts with 2 mole of NaOH

Thus, 0.01 mole of H_2SO_4 reacts with 0.02 mole of NaOH

Moles of OH^- left is 0.02

Total volume finally = 40 litre + 10 litre
= 50 litre

$$\text{moles of OH}^- = \text{moles of NaOH} = 2 \times 10^{-2}$$

$$[\text{OH}^-] = \frac{\text{moles of OH}^-}{\text{Total volume}} = \frac{2 \times 10^{-2}}{50} = 4 \times 10^{-4}$$

$$[\text{H}^+] = \frac{10^{-14}}{4 \times 10^{-4}} = 2.5 \times 10^{-11}$$

$$\text{pH} = -\log[\text{H}^+] = -\log(2.5 \times 10^{-11}) = 10.6$$

24. Value of $f K_p$ for the equilibrium reaction

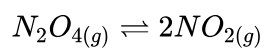
$N_2O_{4(g)} \rightleftharpoons 2NO_{2(g)}$ at 288 K is 47.9. The K_C for this reaction at same temperature is(Nearest integer)

$$(R = 0.083 \text{ LbarK}^{-1} \text{ mol}^{-1})$$

Accepted Answers

2

Solution:



$$\Delta n_g = 2 - 1 = 1$$

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

$$K_p = K_c(RT)^1$$

$$K_c = \frac{K_p}{RT} = \frac{47.9}{0.083 \times 288} = 2$$

25. For the reaction $A(g) \rightleftharpoons B(g)$ at $495K$, $\Delta_r G^\circ = -9.478 \text{ kJ mol}^{-1}$. If we start reaction in a closed container at 495 K with 22 millimoles of A , the amount of B in the equilibrium mixture ismillimoles. (Round off to the Nearest integer). [$8.314 \text{ J mol}^{-1} \text{ K}^{-1}$; $\ln 10 = 2.303$]

Accepted Answers

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Solution:

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

$$\Delta G^\circ = -9.478 \text{ kJ/mole}$$

$$T = 495K \quad R = 8.314 \text{ J mol}^{-1}$$

$$-9.478 \times 10^3 = -495 \times 8.314 \times \ln K_{eq}$$

$$\ln K_{eq} = 2.303$$

$$\ln K_{eq} = \ln 10$$

$$\text{So } K_{eq} = 10$$

$$\text{Now } A(g) \rightleftharpoons B(g)$$

$$t = 0 \quad 22 \quad 0$$

$$t = t \quad 22 - x \quad x$$

$$K_{eq} = \frac{[B]}{[A]} = \frac{x}{22-x} = 10$$

$$\text{or } x = 20$$

$$\text{So millimoles of } B = 20$$