1. 0.5 moles of gas $A$ and $x$ moles of gas $B$ exert a pressure of 200 Pa in a container of volume $10 \mathrm{~m}^{3}$ at 1000 K .
Given R is the gas constant in $\mathrm{JK}^{-1} \mathrm{~mol}^{-1}, \mathrm{x}$ is:
( A . $\frac{2 R}{4+12}$
(x) B. $\frac{2 R}{4-R}$
( $)$ C. $\frac{4-R}{2 R}$
(D. $\frac{4+R}{2 R}$

Total mole, $n_{T}=(0.5+x)$
Ideal gas equation, $P V=n R T$
$200 \times 10=(0.5+x) \times R \times 1000$
$2=(0.5+x) R$
$\frac{2}{R}=\frac{1}{2}+x$
$\frac{4}{R}-1=2 x$
$\frac{4-R}{2 R}=x$
or, $x=\frac{4-R}{2 R}$
2. 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. $2 P_{A}=3 P_{B}$
B. $2 P_{A}=3 P_{B}$
$\times$
C. $P_{A}=2 P_{B}$
x
D. $3 P_{A}=2 P_{B}$

Given, $V_{A}=2 V_{B}$
$Z_{A}=3 Z_{B}$
Compressibility factor, $Z=\frac{P V}{n R T}$
$\frac{P_{A} V_{A}}{n_{A} R T_{A}}=\frac{3 \cdot P_{B} \cdot V_{B}}{n_{B} \cdot R T_{B}}$
$2 P_{A}=3 P_{B}$

## Gaseous State \& Thermodynamics \& Equilibrium

3. An open vessel at $27^{\circ} \mathrm{C}$ 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:
x A. $750^{\circ} \mathrm{C}$
$\times$
B. $500^{\circ} \mathrm{C}$
( 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, $n_{1} T_{1}=n_{2} T_{2}$

$$
\begin{aligned}
& n_{1}(300)=\left(\frac{3}{5} n_{1}\right) T_{2} \\
& \Rightarrow T_{2}=500 \mathrm{~K}
\end{aligned}
$$

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

Gas $\quad \mathrm{Ar} \quad \mathrm{Ne} \quad \mathrm{Kr} \quad \mathrm{Xe}$
a ( $\mathrm{atm} d m^{6} \mathrm{~mol}^{-2}$ ) $1.3 \begin{array}{lllll} & 0.2 & 5.1 & 4.1\end{array}$
$b\left(10^{-2} \mathrm{dm}^{3} \mathrm{~mol}^{-1}\right) \quad 3.2 \quad 1.7 \quad 1.0 \quad 5.0$
Which gas is expected to have the highest critical temperature?
x A. Xe
$x$
B. Ne
(v)
C. Kr
$\times$
D. Ar

We know the expression of critical temperature which is given by,
$T_{c}=\frac{8 a}{27 R b}$
$T_{c} \propto \frac{a}{b}$
Among the given gases, $K r$ has highest ratio of $\frac{a}{b}=5.1$. Therefore, it is expected to have the highest critical temperature.

## Gaseous State \& Thermodynamics \& Equilibrium

5. At a given temperature T , gases $\mathrm{Ne}, \mathrm{Ar}, \mathrm{Xe}$ and Kr are found to deviate from ideal gas behaviour. Their equation of state is given as $P=\frac{R T}{V-b}$ at T .
Here, b is the van der Waals constant. Which gas will exhibit steepest increase in the plot of $Z$ (compression factor) vs $P$ ?
x A. Kr
x B. Ar
(v) C. Xe
x D. Ne
$P=\frac{R T}{(V-b)}$
$P(V-b)=R T$
$\left(P+\frac{a}{V^{2}}\right)(V-b)=R T$
At high pressure,
$P(V-b)=R T$
$P V-P b=R T$
$\frac{P V}{R T}-\frac{P b}{R T}=1$
$Z=1+\frac{P b}{R T}$
$Z>1, Z \propto b$
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.

## Gaseous State \& Thermodynamics \& Equilibrium

6. Consider the following table:

| Gas | $a\left(\mathrm{kPa} \mathrm{dm}^{6} \mathrm{~mol}^{-2}\right)$ | $b\left(\mathrm{dm}^{3} \mathrm{~mol}^{-1}\right)$ |
| :--- | :--- | :--- |
| 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:
x A. Gas $C$ will ocupy lesser volume than gas $A$; gas $B$ will be lesser compressible than gas D
$\times$
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.

## Gaseous State \& Thermodynamics \& Equilibrium

7. Points I, II and III in the following plot respectively correspond to $u_{m p}$ (most probable velocity).
令


Speed, v $\rightarrow$
Choose the correct order in increasing order of their most probable velocity.
X A. $u_{m p}$ of $N_{2}(300 K) ; u_{m p}$ of $H_{2}(300 K) ; u_{m p}$ of $O_{2}(400 K)$
$x$
B. $u_{m p}$ of $H_{2}(300 K) ; u_{m p}$ of $N_{2}(300 K) ; u_{m p}$ of $O_{2}(400 K)$
$\times$
C. $u_{m p}$ of $O_{2}(300 K) ; u_{m p}$ of $N_{2}(300 K) ; u_{m p}$ of $H_{2}(400 K)$
D. $u_{m p}$ of $N_{2}(300 K) ; u_{m p}$ of $O_{2}(400 K) ; u_{m p}$ of $H_{2}(300 K)$
$u_{m p}=\sqrt{\frac{2 R T}{M}} \Rightarrow u_{m p} \propto \sqrt{\frac{T}{M}}$
For $N_{2}, O_{2}, H_{2}$
$\sqrt{\frac{300}{28}}<\sqrt{\frac{400}{32}}<\sqrt{\frac{300}{2}}$
$u_{m p}$ of $N_{2}(300 K)<u_{m p}$ of $O_{2}(400 K)<u_{m p}$ of $H_{2}(300 K)$
Hence, option (d) is correct.

## Gaseous State \& Thermodynamics \& Equilibrium

8. Which one of the following statements is incorrect?
x A. Bond dissociation enthalpy of $H_{2}$ is highest among diatomic gaseous molecules which contain a single bond
x B. Atomic hydrogen is produced when $H_{2}$ molecules at a high temperature are irradiated with UV radiation
C. At around $2000 K$, the dissociation of dihydrogen into its atoms is nearly $8.1 \%$
$\times$ D. Dihydrogen is produced on reacting zinc with HCl as well as NaOH (aq)
The $H-H$ bond dissociation enthalpy is the highest for a single bond between two atoms of any element.

It is because of this factor that the dissociation of dihydrogen into its atoms is only $-0.081 \%$ around 2000 K . The atomic hydrogen is produced at a high temperature in an electric arc or under ultraviolet radiations.
$\mathrm{Zn}+2 \mathrm{HCl} \rightarrow \mathrm{ZnCl}_{2}+\mathrm{H}_{2}$
$\mathrm{Zn}+2 \mathrm{NaOH} \rightarrow \mathrm{Na}_{2} \mathrm{ZnO}_{2}+\mathrm{H}_{2}$
9. The incorrect expression among the following is:
(A. For isothermal process $w_{\text {reversible }}=-n R T \ln \frac{V_{f}}{V_{i}}$
$x$
B. $\frac{\Delta G_{\text {system }}}{\Delta S_{\text {Total }}}=-T_{(\text {at constant } P)}$C. $\ln K=\frac{\Delta H^{o}-T \Delta S^{o}}{R T}$
( D. $K=e^{-\Delta G^{o} / R T}$
$W_{\text {rev }}=-n R T \ln \left(\frac{V_{f}}{V_{i}}\right)$
So, option (a) is the correct expression
$\Delta G_{\text {sys }}=-T \Delta S_{\text {Total }}($ at constant $P)$
So, option (b) is the correct expression

$$
\begin{aligned}
& \Delta G^{o}=\Delta H^{o}-T \Delta S^{o} \\
& -R T \ln K=\Delta H^{o}-T \Delta S^{o} \\
& \ln K=\frac{\Delta H^{o}-T \Delta S^{o}}{-R T}
\end{aligned}
$$

So, option (c) is the incorrect expression
$\ln K=\frac{T \Delta S^{o}-\Delta H^{o}}{R T}$
$\Delta G^{o}=-R T \ln K$
$\frac{\Delta G^{o}}{-R T}=\ln K$
$\Rightarrow K=e^{-\frac{\Delta G^{o}}{R T}}$
So, option (d) is the correct expression
10. Enthalpy of sublimation of iodine is $24 \mathrm{cal} \mathrm{g} g^{-1}$ at $200^{0} \mathrm{C}$. If specific heat $I_{2}(s)$ and $I_{2}(v a p)$ are 0.055 and $0.031 \mathrm{cal} \mathrm{g}^{-1} \mathrm{~K}^{-1}$ respectively, then enthalpy of sublimation of iodine $250^{0} \mathrm{C}$ in cal $\mathrm{g}^{-1}$ is :
(x) A. 2.85
x B. 5.7

C. 22.8
( D. 11.4
$I_{2}(s) \rightarrow I_{2}(g)$

Heat of reaction depend upon temperature i.e., it varies with temperature, as given by Kirchoff's equation,
$\Delta H_{T_{2}}=\Delta H_{T_{1}}+\int_{T_{1}}^{T_{2}} \Delta C_{p} d T$
where $\Delta C_{p}=C_{p}$ of product $-C_{p}$ of reactant
$\therefore \Delta C_{p}=0.031-0.055=-0.024 \mathrm{cal} / g$
Now, $\Delta H_{T_{2}}-\Delta H_{T_{1}}=\Delta C_{p}\left(T_{2}-T_{1}\right)$
$\Delta H_{(250)}-\Delta H_{(200)}=-0.024(523-473)$
$\Delta H_{(250)}=24-50 \times 0.024=22.8 \mathrm{cal} / \mathrm{g}$

## Gaseous State \& Thermodynamics \& Equilibrium

11. For silver, $C_{p}\left(J K^{-1} \mathrm{~mol}^{-1}\right)=23+0.01 T$. If the temperature $(\mathrm{T})$ of moles of silver is raised from 300 K to 1000 K at 1 atm pressure, the value of $\Delta H$ will be close to:A. 62 kJ
$\times$
B. 16 kJ
$x$
C. 21 kJ
$x$
D. 13 kJ

Given: $\mathrm{n}=3$
$T_{1}=300 ; T_{2}=1000$
$C_{p}=23+0.01 T$
$\Delta H$ and $C_{p}$
$\Delta H=\int_{T_{1}}^{T_{2}} n C_{p} d T$

$$
\begin{aligned}
& \Delta H=n \int_{300}^{1000}(23.0 .01 T) d T \\
& =3\left[23(1000-300)\left[+\frac{0.01}{2}\left(1000^{2}-300^{2}\right)\right]\right] \\
& =3[16100+4550] \\
& =61.95 \mathrm{~kJ} \\
& =3 \times 20650=61950 \mathrm{~J} \\
& \approx 62 \mathrm{~kJ}
\end{aligned}
$$

## Gaseous State \& Thermodynamics \& Equilibrium

12. The enthalpy change on freezing of 1 mol of water at $5^{0} \mathrm{C}$ is ice at $-5^{0} \mathrm{C}$ is :
(Given $\Delta_{f u s} H=6 \mathrm{~kJ} \mathrm{~mol}^{-1}$ at $0^{0} \mathrm{C}$,
$\mathrm{C}_{p}\left(\mathrm{H}_{2} \mathrm{O}, 1\right)=75.3 \mathrm{Jmol}^{-1} \mathrm{~K}^{-1}$
$\left.\left.C_{p}\left(H_{2} \mathrm{O}, s\right)=36.8 \mathrm{Jmol}^{-1} \mathrm{~K}^{-1}\right)\right)$
× A. $5.44 \mathrm{~kJ} \mathrm{~mol}^{-1}$
( B. $5.81 \mathrm{~kJ} \mathrm{~mol}^{-1}$
C. $6.56 \mathrm{~kJ} \mathrm{~mol}^{-1}$
$x$
D. $6.00 \mathrm{~kJ} \mathrm{~mol}^{-1}$

In order to calculate the enthalpy change for $\mathrm{H}_{2} \mathrm{O}$ at $5^{0} \mathrm{C}$, we need to calculate the enthalpy change of all the transformation involved in the process.
(a) Energy change of $1 \mathrm{~mol}, \mathrm{H}_{2} \mathrm{O}(l)$ at $5^{0} \mathrm{C} \rightarrow 1 \mathrm{molH}_{2} \mathrm{O}(\mathrm{l}), 0^{0} \mathrm{C}$
(b) Energy change of $1 \mathrm{~mol}, \mathrm{H}_{2} \mathrm{O}(\mathrm{l})$ at $0^{0} \mathrm{C} \rightarrow 1 \mathrm{~mol} \mathrm{H}_{2} \mathrm{O}(\mathrm{s})($ ice $), 0^{0} \mathrm{C}$
(c) Energy change of 1 mol , ice (s), at $0^{0} \mathrm{C} \rightarrow 1 \mathrm{~mol}$, ice $(\mathrm{s}),-5^{0} \mathrm{C}$

Total $\Delta H=C_{p}\left[H_{2} O(l)\right] \Delta T+\Delta H$ freezing $+C_{p}\left[H_{2} O(s)\right] \Delta T$
$=\left(75.3 \mathrm{~J} \mathrm{~mol}^{-1} \mathrm{~K}^{-1}\right)(0-5) K+\left(-6 \times 10^{3} \mathrm{~J} \mathrm{~mol}^{-1}\right)+\left(36.8 \mathrm{Jmol}^{-1} \mathrm{~K}^{-1}\right)(-5-0) K$
$\Delta H=-6.56 \mathrm{kJmol}^{-1}$
$\Delta H=6.56 \mathrm{kJmol}^{-1}$

## Gaseous State \& Thermodynamics \& Equilibrium

13. A gas undergoes change from state $A$ to state $B$. In this process, the heat absorbed and work done by the gas is 5 J and 8 J , respectively. Now gas is brought back at A by another process during which 3 J of heat is evolved. In this reverse process of $B$ to $A$ :
(A. 10 J of the work will be done by the gas.
$\times$
B. 6 J of the work will be done by the gas.

X C. 10 J of the work will be done by the surrounding on gas.
D. 6 J of the work will be done by the surrounding on gas

$q=-3, \Delta U_{B A}=+3$
$\Delta U_{B A}=q+w$
$\Rightarrow 3=-3+w$
$\Rightarrow w=+6$
$\Delta U_{B C}=-5 k J \mathrm{~mol}^{-1}, q_{A B}=2 \mathrm{~kJ} \mathrm{~mol}^{-1}$
$W_{A B}=-5 \mathrm{~kJ} \mathrm{~mol}^{-1}, \quad W_{C A}=3 \mathrm{~kJ} \mathrm{~mol}^{-1}$ (work done on the system).
14.
$q_{A B}=2 k J / m o l$
$\Delta U_{B C}=-5 \mathrm{~kJ} / \mathrm{mol}$
$W_{A B}=-5 \mathrm{~kJ} / \mathrm{mol}$
$W_{C A}=3 \mathrm{~kJ} / \mathrm{mol}$
Heat absorbed by the system during process CA is:
( A. $-5 k J m o l ~ l i$
( $)$ B. $+5 \mathrm{~kJ} \mathrm{~mol}^{-1}$
× C. $18 \mathrm{~kJ} \mathrm{~mol}^{-1}$
( D. $-18 k J \mathrm{~mol}^{-1}$
$\Delta U_{A B}=q_{A B}+W_{A B}=2+(-5)=-3 k J / m o l$
$\Delta U_{B C}=-5 k J / m o l$
For cyclic process, $\Delta U=0$
$\Delta U_{A B}+\Delta U_{B C}+\Delta U_{C A}=0$
$\Delta U_{C A}=-\Delta U_{A B}-\Delta U_{B C}$
$\Delta U_{C A}=-(-3)-(-5)=8 \mathrm{~kJ} / \mathrm{mol}$
$\Delta U_{C A}=q_{C A}+W_{C A}$
$8=q_{C A}+3$
$q_{C A}=+5 \mathrm{~kJ} / \mathrm{mol}$

## Gaseous State \& Thermodynamics \& Equilibrium

15. The equilibrium constant at 298 K for a reaction $A+B \rightleftharpoons C+D$ is 100 . If the initial concentration of all the four species were 1 M each, then equilibrium concentration of D (in $\mathrm{mol} L^{-1}$ ) will be.
x A. 0.818B. 1.818
x C. 1.182
(x) D. 0.182
$A+B \rightarrow C+D$
$\begin{array}{llll}1 & 1 & 1 & 1\end{array}$ : initially
$(1-x)(1-x)(1+x)(1+x):$ at equilibrium
$K c=\left(\frac{1+x}{1-x}\right)^{2}$
$K c=\left(\frac{1+x}{1-x}\right)^{2}=100$
$\frac{1+x}{1-x}=10$
$x=\frac{9}{11}$
Moles of $D=1+x=1+\frac{9}{11}=\frac{20}{11}=1.818$

## Gaseous State \& Thermodynamics \& Equilibrium

16. Two solids dissociated as follows

$$
\begin{aligned}
& A(s) \rightleftharpoons B(g)+C(g) ; K_{P 1}=x \mathrm{~atm}^{2} \\
& D(s) \rightleftharpoons C(g)+E(g) ; K_{P 2}=x \mathrm{~atm}^{2}
\end{aligned}
$$

The total pressure when both the solids dissociate simultaneously is:
x A. $x^{2}+y^{2}$
( B. $\sqrt{x^{2}+y^{2}}$
( $)$ C. $2(\sqrt{x+y})$
© D. $\sqrt{x+y}$
$A(s) \rightleftharpoons \underset{P 1}{B(g)}+\underset{P 1}{C(g)}$
$D(s) \rightleftharpoons \underset{P 2}{C(g)}+\underset{P 2}{E(g)}$
$C, P_{C}=P_{1}+P_{2}$
$K_{P 1}=x=P_{B} \cdot P_{C}$
$x=P_{1}\left(P_{1}+P_{2}\right)$
$K_{P 2}=y=P_{C} \cdot P_{E} \ldots \ldots$
$y=\left(P_{1}+P_{2}\right)\left(P_{2}\right)$
$x+y=\left(P_{1}+P_{2}\right)^{2}$
$P_{T}=P_{C}+P_{B}+P_{E}$
$=\left(P_{1}+P_{2}\right)+P_{1}+P_{2}=2\left(P_{1}+P_{2}\right)$
$P_{T}=2(\sqrt{x+y})$

## Gaseous State \& Thermodynamics \& Equilibrium

17. For the following reactions, equilibrium constants are given:
$S(s)+O_{2}(g) \rightleftharpoons S O_{2}(g) ; K_{1}=10^{52}$
$2 S(s)+3 O_{2}(g) \rightleftharpoons 2 S_{3}(g) ; K_{2}=10^{129}$
Find the equilibrium constant for $2 \mathrm{SO}_{2}+\mathrm{O}_{2}(\mathrm{~g}) \rightleftharpoons 2 \mathrm{SO}_{3}(\mathrm{~g}) ; \mathrm{K}_{3}$
x A. $10^{181}$
(X) B. $10^{154}$
( $)$ C. $10^{25}$
(x) D. $10^{77}$
$S(s)+O_{2}(g) \rightleftharpoons S O_{2}(g) ; K_{1}=10^{52}$
$2 S(s)+3 O_{2}(g) \rightleftharpoons 2 S_{3}(g) ; K_{2}=10^{129}$.
$2 \mathrm{SO}_{2}+\mathrm{O}_{2}(\mathrm{~g}) \rightleftharpoons 2 \mathrm{SO}_{3}(g) ; K_{3}=x$

Multiplying equation (1) by 2 ;
$2 S(s)+2 O_{2}(g) \rightleftharpoons 2 S_{2}(g) ; K^{\prime}{ }_{1}=K_{1}^{2}==10^{104}$.
$\Rightarrow$ Substracting (3) from (2); we get
$2 \mathrm{SO}_{2}(\mathrm{~g})+\mathrm{O}_{2}(\mathrm{~g}) \rightleftharpoons 2 \mathrm{SO}_{3}(\mathrm{~g})$
$K_{\text {eq }}=\frac{K_{2}}{K_{1}^{\prime}}=10^{(129-104)}=10^{25}$

## Gaseous State \& Thermodynamics \& Equilibrium

18. An acid buffer is obtained on mixing :
x A. 100 mL of $0.1 \mathrm{M} \mathrm{CH}_{3} \mathrm{COOH}$ and 200 mL of 0.1 M NaOH
x B. 100 mL of $0.1 \mathrm{MCH}_{3} \mathrm{COOH}$ and 100 mL of 0.1 M NaOHC. 100 mL of 0.1 M HCl and 200 mL of 0.1 MCH COONa
$x$
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, finaly we get mixture of
$\mathrm{CH}_{3} \mathrm{COOH}+\mathrm{CH}_{3} \mathrm{COONa}$ that will work like acidic buffer solution.
Hence, option (c) only act as acid buffer.

## Gaseous State \& Thermodynamics \& Equilibrium

19. Arrange the following solutions in the decreasing order of pOH
(A) 0.01 M HCl
(B) 0.01 M NaOH
(C) $0.01 \mathrm{M} \mathrm{CH}_{3} \mathrm{COONa}$
(D) 0.01 M NaCl
x A. $(A)>(C)>(D)>(B)$
$x$
B. $(B)>(D)>(C)>(A)$
x C. $(B)>(C)>(D)>(A)$
(1) D. $(A)>(D)>(C)>(B)$
(A) $10^{-2} \mathrm{MHCl} \Rightarrow\left[H^{+}\right]=10^{-2} M \rightarrow p H=2 \Rightarrow p O H=12$
(B) $10^{-2} \mathrm{M} \mathrm{NaOH} \Rightarrow\left[\mathrm{OH}^{-}\right]=10^{-2} \mathrm{M} \rightarrow \mathrm{pOH}=2$
(C) $10^{-2} \mathrm{MCH}_{3} \mathrm{COO}^{-} \mathrm{Na}^{+} \Rightarrow\left[\mathrm{OH}^{-}\right]>10^{-7} \Rightarrow \mathrm{pOH}<7$
(D) $10^{-2} \mathrm{M} \mathrm{NaCl} \Rightarrow$ Neutral $\mathrm{pOH}=7$

Decreasing order of pOH ,
$(\mathrm{A})>(\mathrm{D})>(\mathrm{C})>(\mathrm{B})$
Hence, option (d) is correct.

## Gaseous State \& Thermodynamics \& Equilibrium

20. Th solubilty of $\mathrm{Ca}(\mathrm{OH})_{2}$ in water is :
[Given : The solubility product of $\mathrm{Ca}(\mathrm{OH})_{2}$ in water $5.5 \times 10^{-6}$ ]
( A. $1.77 \times 10^{-6}$
(x) B. $1.11 \times 10^{-6}$
(v) C. $1.11 \times 10^{-2}$
( D. $1.77 \times 10^{-2}$
$\mathrm{Ca}(\mathrm{OH})_{2} \rightleftharpoons \mathrm{Ca}^{2+}(a q)+2 \mathrm{OH}^{-}(a q)$
$K_{s p}=S(2 S)^{2} \Rightarrow 5.5 \times 10^{-6}=4 S^{3}$
$\Rightarrow S=\left(\frac{5.5}{4}\right)^{\frac{1}{3}} \times 10^{-2}=1.11 \times 10^{-2}$

Hence, option (c) is correct.
21. A home owner uses $4.00 \times 10^{3} \mathrm{~m}^{3}$ of methane $\left(\mathrm{CH}_{4}\right)$ gas, (assume $\left(\mathrm{CH}_{4}\right)$ 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 $x \times 10^{5} g$. The value of $x$ is $\qquad$ .(Nearest integer)
(Given $R=0.083 \mathrm{Latm} \mathrm{K} \mathrm{K}^{-1} \mathrm{~mol}^{-1}$ )
Accepted Answers
$26 \quad 26.0 \quad 26.00$
Solution:
Pressure $=1 \mathrm{~atm}$
Volume $=4.00 \times 10^{3} \mathrm{~m}^{3}=4 \times 10^{6} \mathrm{~L}$
Using $P V=n R T$
Moles $=\frac{1 \times 4 \times 10^{6}}{0.083 \times 300}$
Moles, $n=0.1606 \times 10^{6} \mathrm{~mol}$
Mass $=$ Moles $\times$ Molar mass
Mass $=0.1606 \times 10^{6} \times 16$
$\approx 26 \times 10^{5} g$
22. 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 $27^{\circ} \mathrm{C}$ is $\qquad$ $k P a$
(Round off to the Nearest Integer).
[Assume gases are ideal, $R=8.314 \mathrm{~J} \mathrm{~mol}^{-1} \mathrm{~K}^{-1}$
Atomic masses : $C=12.0 u, H: 1.0 u, O: 16.0 u$ ]
Accepted Answers
150150.00150 .0

Solution:
Number of moles of $\mathrm{CH}_{4}=\frac{6.4}{16}=0.4 \mathrm{~mol}$
Number of moles $\mathrm{CO}_{2}=\frac{8.8}{44}=0.2 \mathrm{~mol}$
Total number of moles of the mixture $=0.6 \mathrm{~mol}$
Pressure of the mixture of gases in $10 L\left(0.01 \mathrm{~m}^{3}\right)$ vessel at 300 K is given as:
$P=\frac{n R T}{V}=\frac{0.6 \times 8.314 \times 300}{0.01}=149652 \mathrm{~Pa} \approx 150 \mathrm{kPa}$
23. An $L P G$ cylinder contains gas at a pressure of $300 k P a$ at $27^{\circ} \mathrm{C}$. The cylinder can withstand the pressure of $1.2 \times 10^{6} \mathrm{~Pa}$. The room in which the cylinder is kept catches fire. The minimum temperature at which the bursting of cylinder will take place is $\qquad$ $\circ$
C. (Nearest Integer)

Accepted Answers
927927.00927 .0

Solution:
At constant volume and number of moles of a gas, pressure is directly proportional to temperature change.
$\frac{P_{1}}{T_{1}}=\frac{P_{2}}{T_{2}}$
$T_{2}=\frac{1.2 \times 10^{6}}{300 \times 10^{3}} \times 300=1200 \mathrm{~K}=927^{\circ} \mathrm{C}$

## Gaseous State \& Thermodynamics \& Equilibrium

24. For water at $100^{\circ} \mathrm{C}$ and 1 bar ,
$\Delta H_{\text {vap }}-\Delta U_{\text {vap }}$ is $x \times 10^{2} \mathrm{~J} \mathrm{~mol}^{-1}$
The value of x (Round off to the Nearest Integer) is
[Use : $R=8.31 \mathrm{~mol}^{-1} \mathrm{~K}^{-1}$ ]
[Assume volume of $\mathrm{H}_{2} \mathrm{O}(\mathrm{l})$ is much smaller than volume of $\mathrm{H}_{2} \mathrm{O}(\mathrm{g})$. Assume $\mathrm{H}_{2} \mathrm{O}(\mathrm{g})$ can be treated as an ideal gas]

Accepted Answers
$31 \quad 31.0 \quad 31.00$
Solution:
$\Delta H-\Delta U=\Delta n_{g} R T$
$\Delta n_{g}=1-0=1$
$\Delta H-\Delta U=1 \times 8.31 \times 373$
$\Delta H-\Delta U=30.99 \times 10^{2} \mathrm{~J} \mathrm{~mol}^{-1}$
$\Delta H-\Delta U \approx 31 \times 10^{2} \mathrm{~J} \mathrm{~mol}^{-1}$
$x=31$
25. For water $\Delta_{\text {vap }} H=41 \mathrm{~kJ} \mathrm{~mol}^{-1}$ at 373 K and 1 bar pressure. Assuming that water vapour is an ideal gas the that occupies a much larger volume than liquid water, the internal energy change during evaporation of water is $\qquad$ $k J \mathrm{~mol}^{-1}$.
[Use : $R=8.3 \mathrm{~J} \mathrm{~mol}{ }^{-1} K^{-1}$ ]
Accepted Answers

$$
\begin{array}{lll}
38 & 38.0 & 38.00
\end{array}
$$

Solution:
$\mathrm{H}_{2} \mathrm{O}(\mathrm{l}) \rightleftharpoons \mathrm{H}_{2} \mathrm{O}(\mathrm{g}) \quad \Delta H_{\text {vap }}=41 \mathrm{~kJ} \mathrm{~mol}^{-1}$
$\Delta H=\Delta E+\Delta n_{g} R T$
$\Delta E$ is internal energy change
$\Delta n_{g}$ is change in gaseous moles $=1-0=1$
$41=\Delta E+1 \times 8.3 \times 10^{-3} \times 373$
$\Delta E \approx(41-3)=38 \mathrm{~kJ} \mathrm{~mol}^{-1}$

## Gaseous State \& Thermodynamics \& Equilibrium

26. 200 mL of 0.2 M HCl is mixed with 300 mL of 0.1 M NaOH . The molar heat of neutralization of this reaction is -57.1 kJ . The increase in temperature in ${ }^{\circ} \mathrm{C}$ of the system on mixing is $x \times 10^{-2}$. The value of x is (Nearest integer)
[Given: Specific heat of water $=4.18 \mathrm{~J} \mathrm{~g}^{-1} K^{-1}$ Density of water $=1.00 \mathrm{~g} \mathrm{~cm}^{-3}$ ]
[Assume no volume change on mixing]

Accepted Answers

## $82 \quad 82.0 \quad 82.00$

Solution:
$\mathrm{HCl}+\mathrm{NaOH} \rightarrow \mathrm{NaCl}+\mathrm{H}_{2} \mathrm{O}$
Moles $0.04 \quad 0.0$.
0.01 -- $0.03 \quad 0.03$
$Q$, Heat released $=0.03 \times 57.1 \mathrm{~kJ}=1.713 \mathrm{~kJ}$
$Q=m \times s \times \Delta T$
$s$ is specific heat
$\Delta T=\frac{1.713 \times 1000}{500 \times 4.18}=81.96 \times 10^{-2} \approx 82 \times 10^{-2}$
$x=82$
27. Assuming that $\mathrm{Ba}(\mathrm{OH})_{2}$ is completely ionised in aqueous solution under the given conditions the concentration of $\mathrm{H}_{3} \mathrm{O}^{+}$ions in 0.005 M acqueous solution of $\mathrm{Ba}(\mathrm{OH})_{2}$ at 298 K is $\qquad$ $\times 10^{-12} \mathrm{~mol} L^{-1}$. (Nearest integer)

Accepted Answers
$1 \quad 1.0 \quad 1.00$
Solution:
Assuming $\mathrm{Ba}(\mathrm{OH})_{2}$ is completely ionised,
$\mathrm{Ba}(\mathrm{OH})_{2} \rightarrow \mathrm{Ba}^{+2}+2 \mathrm{OH}$

$$
2 \times 0.005=0.01=10^{-2}
$$

We know
$\left[\mathrm{H}^{+}\right]\left[\mathrm{OH}^{-}\right]=10^{-14}$
$\left[\mathrm{H}_{3} \mathrm{O}^{+}\right]\left[\mathrm{OH}^{-}\right]=10^{-14}$
$\left[H_{3} \mathrm{O}^{+}\right]=\frac{10^{-14}}{10^{-2}}=10^{-12}$

Hence, answer is 1 .

## Gaseous State \& Thermodynamics \& Equilibrium

28. Sulphurous acid $\left(\mathrm{H}_{2} \mathrm{SO}_{3}\right)$ has $K_{a 1}=1.7 \times 10^{-2}$ and $\mathrm{Ka} 2=6.4 \times 10^{-8}$. The pH of $0.588 \mathrm{M} \mathrm{H}_{2} \mathrm{SO}_{3}$ is $\qquad$ (Round off to the Nearest Integer).

Accepted Answers
$1 \quad 1.0 \quad 1.00$
Solution:
$\mathrm{H}_{2} \mathrm{SO}_{3}$ is a dibasic acid.

Concentration, $\mathrm{c}=0.588 \mathrm{M}$
$\Rightarrow \mathrm{pH}$ of solution is due to first dissociation only dissociation only, since $K_{a 1} \gg K_{a 2}$
$\Rightarrow$ First dissociation of $\left(\mathrm{H}_{2} \mathrm{SO}_{3}\right)$

$$
\mathrm{H}_{2} \mathrm{SO}_{3}(a q) \rightleftharpoons H^{+}(a q)+\mathrm{HSO}_{3}^{-}(a q): K_{a 1}=1.7 \times 10^{-2}
$$

$t=0 \quad C$
At 't' C-x x x
$\Rightarrow K_{a 1}=\frac{1.7}{100}=\frac{\left[H^{+}\right]\left[\mathrm{HSO}_{3}^{-}\right]}{\left[\mathrm{H}_{2} \mathrm{SO}_{3}\right]}$
$\Rightarrow \frac{1.7}{100}=\frac{x^{2}}{(0.58-x)}$
$\Rightarrow 1.7 \times 0.588-1.7 x=100 x^{2}$
$\Rightarrow 100 x^{2}+1.7 x-1=0$
$\Rightarrow\left[H^{+}\right]=x=\frac{-1.7+\sqrt{(1.7)^{2}+4 \times 100 \times 1}}{2 \times 100}=0.09186$
Therefore pH of sol is : $p H=-\log \left[H^{+}\right]$
$\Rightarrow p H=-\log (0.09186)=1.036 \approx 1$

## Gaseous State \& Thermodynamics \& Equilibrium

29. Value of $\mathrm{f} K_{p}$ for the equilibrium reaction
$\mathrm{N}_{2} \mathrm{O}_{4(g)} \rightleftharpoons 2 \mathrm{NO}_{2(g)}$ at 288 K is 47.9 . The $K_{C}$ for this reaction at same temperature is ........(Nearest integer)
$\left(R=0.083 L b a r K^{-1} \mathrm{~mol}^{-1}\right)$

Accepted Answers
2
Solution:
$\mathrm{N}_{2} \mathrm{O}_{4(g)} \rightleftharpoons 2 \mathrm{NO}_{2(g)}$
$\Delta n_{g}=2-1=1$
$K_{p}=K_{c}(R T)^{\Delta n_{g}}$
$K_{p}=K_{c}(R T)^{1}$
$K_{c}=\frac{K_{p}}{R T}=\frac{47.9}{0.083 \times 288}=2$
30. For the reaction $A(g) \rightleftharpoons B(g)$ at $495 K, \Delta r G^{o}=-9.478 \mathrm{kJmol}^{-1}$. If we start reaction in a closed container at 495 K with 22 millimoles of A , the amount of B is the equilibrium mixture is $\qquad$ millimoles. (Round off to the Nearest integer). [R8.314J mol ${ }^{-1} \mathrm{~K}^{-1}$; ]~1n10=2.303]

Accepted Answers
20
Solution:
$\Delta G^{o}=-R T \ln K_{e q}$
$\Delta G^{o}=-9.478 \mathrm{~kJ} /$ mole
$T=495 K \quad R=8.314 \mathrm{~J} \mathrm{~mol}^{-1}$
$-9.478 \times 10^{3}=-495 \times 8.314 \times \ln K_{e q}$
$\ln K_{e q}=2.303$
$\ln K_{\text {eq }}=\ln 10$
So $K_{\text {eq }}=10$
Now $A(g) \rightleftharpoons B(g)$
$t=0 \quad 22 \quad 0$
$t=t \quad 22-x \quad x$
$K_{e q}=\frac{[B]}{[C]}=\frac{x}{22-x}=10$
or $x=20$
So millmoles of $B=20$

