# WEEKLY TEST TYM TEST - 29 Balliwala
# SOLUTION Date 01 -12-2019

## [PHYSICS]

1. $$\frac{C_{H_2}}{C_{O_2}} = \sqrt{\frac{32}{2}} = 4$$

or $C_{H_2} = 4 \times C_{O_2} = 4 \times 400\ \mathrm{m\,s^{-1}} = 1600\ \mathrm{m\,s^{-1}}$

2. The kinetic energy of gas w.r.t. centre of mass of the system $\text{K.E.} = \frac{5}{2}nRT$

Kinetic energy of gas w.r.t. ground = Kinetic energy of centre of mass w.r.t. ground + Kinetic energy of gas w.r.t. centre of mass.

$$\text{K.E.} = \frac{1}{2}MV^2 + \frac{5}{2}nRT$$

3. Ideal gas equation $PV = \mu RT = \left(\frac{N}{N_A}\right)RT$ where $N$ = Number of molecule, $N_A$ = Avogadro number

$$\therefore \frac{N_1}{N_2} = \left(\frac{P_1}{P_2}\right)\left(\frac{V_1}{V_2}\right)\left(\frac{T_2}{T_1}\right) = \left(\frac{P}{2P}\right)\left(\frac{V}{V/4}\right)\left(\frac{2T}{T}\right) = \frac{4}{1}.$$

4. $C = \sqrt{\frac{3RT}{M}}$ or $T \propto M$

$\therefore \frac{T'}{T} = \frac{4}{2} = 2$ or $T' = 2T$

or $T = 2 \times 273\ \mathrm{K} = 546\ \mathrm{K}$

5. or $m \propto (1/P)$ or, $m_2 > m_1 \ \therefore P_2 < P_1$

6. Since the graph is a straight line,

so, $V = mT$ where $m$ is the slope.

$= (nRT)/P$ [From equation of state]

7. Given:

Initial volume $V_1 = 3V$

Initial pressure $P_1 = 2$ atmosphere.

Final pressure

$$P_2 = 2P_1 = 2 \times 2 = 4 \text{ atmosphere}$$

According to the Boyle's law we have

$P_1V_1 = P_2V_2$ (where $V_2$ is the final volume of gas)

or $2 \times 3V = 4 \times V_2$ or $V_2 = 1.5\ V$

8. For a given pressure, $V$ is small for $T_1$. Since $V \propto T$, therefore, $T_1 < T_2$.

9. When, the container stops, its total kinetic energy is transferred to gas molecules in the form of translational kinetic energy, thereby increasing the absolute temperature.

Assuming $n$ = number of moles.

Given, $m$ = molar mass of the gas.

If $\Delta T$ = change in absolute temperature.

Then, kinetic energy of molecules due to velocity $v_0$,

$$\Delta K_{\text{motion}} = \frac{1}{2}(mn)v_0^2 \qquad \text{(i)}$$

Increase in translational kinetic energy

$$\Delta K_{\text{translation}} = n\frac{3}{2}\text{R}(\Delta T) \qquad \text{(ii)}$$

According to kinetic theory Eqs. (i) and (ii) are equal

$$\Rightarrow \quad \frac{1}{2}(mn)v_0^2 = n\frac{3}{2}R(\Delta T)$$

$$(mn)v_0^2 = n3R(\Delta T)$$

$$\Rightarrow \quad \Delta T = \frac{(mn)v_0^2}{3nR} = \frac{mv_0^2}{3R}$$

10. $\dfrac{C_t}{C_0} = \sqrt{\dfrac{273+t}{273}}$

or $4 \times 273 - 273 = t$

or $t = 3 \times 273 = 819°\text{C}$

11. 3 moles of $H_2$ are given.

12. $PV = \mu RT,\ PV = \dfrac{n}{N} \times hNT$ or $n = \dfrac{PV}{kT}$

13. For a constant value of density, pressure is more at $T_1$.

$\therefore \quad T_1 > T_2 \qquad [\because P \propto T]$

14.

15. Initial volume of gas = $V_1$

Final volume of gas = $V_2$

Initial temperature of gas $T_1 = 27°C = 300$ K

Final temperature of gas $T_2 = 54°C = 327$ K

Now from the Charles's law at constant pressure

$$\frac{V_1}{V_2} = \frac{T_1}{T_2} = \frac{300}{327} = \frac{100}{109}$$

16.

17. The given statement is zeroth law of thermodynamics. It was formulated by R. H. Fowler in 1931

18. The internal energy of ideal gas depends only upon temperature of gas not on other factors.

19. For monoatomic gas, $\frac{\Delta U}{Q} = \frac{1}{3}$ or, $\Delta U = \frac{Q}{3}$

From the first law of thermodynamics,

$$Q = \Delta U + W \quad \therefore \quad W = (2/3)Q$$

20. $\Delta U = nC_V\Delta T = n(5/2)R\Delta T$

$\Delta Q = nC_P\Delta T = n(7/2)R\Delta T$

$W = \Delta Q - \Delta U = \frac{n7}{2}R\Delta T - \frac{n5}{2}R\Delta T = nR\Delta T$

$\frac{W}{\Delta U} = \frac{2}{7}$

## [CHEMISTRY]

21.

$NH_3$ donates pair of electrons while $BF_3$, $Cu^{2+}$ and $AlCl_3$ accept lone pair of electrons.

22.

Acid $\xrightarrow{-H^+}$ Conjugate base, Base $\xrightarrow{+H^+}$ Conjugate acid

23.

$H_3O^+$ (acid), $H_2O$ (conjugate base) and not $OH^-$.

24.

$$
\begin{aligned}
\text{pH [HCl]} &= 2.0\\
\therefore\quad [H^+] &= 10^{-2}\ \text{M}\\
[HCl] &= 10^{-2}\ \text{M}
\end{aligned}
$$

Volume = 200 mL

$$
\begin{aligned}
\text{pH [NaOH]} &= 12.0\\
\text{pOH} &= 2.0\\
[OH^-] &= 10^{-2}\ \text{M}\\
[NaOH] &= 10^{-2}\ \text{M}\\
\text{Volume} &= 300\ \text{mL}\\
N_1V_1\ (\text{acid}) &= 200 \times 10^{-2} = 2\\
N_1V_2\ (\text{base}) &= 300 \times 10^{-2} = 3\\
N_2V_2 &> N_1V_1
\end{aligned}
$$

Thus, resultant mixture basic.

$$
\begin{aligned}
N(OH^-) &= \frac{N_2V_2 - N_1V_1}{V_1 + V_2} = \frac{3-2}{500} = 2\times 10^{-3}\ \text{M}\\
\text{pOH} &= -\log (2 \times 10^{-3}) = 2.7\\
\therefore\quad \text{pH} &= 14 - \text{pOH } 14 - 2.7 = 11.3
\end{aligned}
$$

25.

$K_w$ changes with temperature. As temperature increases, $[OH^-]$ and $[H^+]$ decrease.

26.

Meq. of HCl = $10 \times 10^{-1} = 1$

Meq. of NaOH = $10 \times 10^{-1} = 1$

Thus both are neutralised and 1 Meq. of NaCl (a salt of strong acid and strong base) which does not hydrolyse and thus pH = 7.

27.

$$
\begin{aligned}
pK_w &= -\log K_w = -\log 1 \times 10^{-12} = 12.\\
K_w &= [H^+][OH^-] = 10^{-12}\\
[H^+] &= [OH^-]
\end{aligned}
$$

$\Rightarrow\quad [H^+]^2 = 10^{-12}$; $[H^+] = 10^{-6}$; pH $= -\log [H^+] = -\log 10^{-6} = 6$.

$H_2O$ is neutral because $[H^+] = [OH^-]$ at 373 K even when pH = 6.

(d) is not correct at 373 K. Water cannot become acidic.

28.

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

$$
\begin{aligned}
K_{sp} &= [A^{2+}][B^-]^2 = (s)(2s)^2 = 4s^3\\
&= 4(1.0 \times 10^{-5})^3 = 4 \times 10^{-15}
\end{aligned}
$$

In the presence of 0.1 M $A^{2+}$, solubility is decreased due to common ion effect.

Let, solubility be = $x$ mol $L^{-1}$

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

$A^{2+}$ $(aq)$ added = 0.1 M

Total $[A^{2+}] = (x + 0.1\ \text{M}) \approx 0.1$ M

$$
\begin{aligned}
\because\quad x &<< 1.0 \times 10^{-5}\ \text{M}\\
[B^-] &= 2 \times \text{M}\\
\therefore\quad [A^{2+}][B^-]^2 &= 4 \times 10^{-15}\\
(0.1)(2x)^2 &= 4 \times 10^{-15}\\
4x^2 &= 4 \times 10^{-14}\\
x &= 1 \times 10^{-7}\ \text{M}
\end{aligned}
$$

29.

$$\text{pH} = 4 \Rightarrow [H^+] = 10^{-4}\,\text{M} \Rightarrow [OH^-] = 10^{-10}\,\text{M}$$

$$Al(OH)_3 \rightleftharpoons Al^{+3} + 3\,OH^-$$

$$K_{sp}\,(Al(OH)_3) = [Al^{+3}]\,[OH^-]^3$$

$$[Al^{3+}]\,[OH^-]_3 = 1 \times 10^{-33}$$

$$[Al^{3+}]\,(10^{-10})^3 = 1 \times 10^{-33} \Rightarrow [Al^{+3}] = 10^{-3}\,\text{M}$$

30.

$$K = 2 = \sqrt{k_1},\ K_2 = \frac{1}{K_4},\ K_1 = \frac{1}{K_3}$$

$$\therefore \quad K_1K_3 = 1,\ \sqrt{K_1}\ K_4 = 1\ \sqrt{K_3} = 1$$

31.

32.

33.

34.

35. The equilibrium constant of second reaction is very large and hence the equilibrium concentrations may be determined by adding the reactions. On adding,

| | $A$ | + | $B$ | $\rightleftharpoons$ | $D$ | + | E | $K = K_1 \times K_2 = 1$ |
|---|---|---|---|---|---|---|---|---|
| Initial moles | 2 | | 5 | | 0 | | 0 | |
| Moles at equ. | $2 - x$ | | $5 - x$ | | $x$ | | $x$ | |
| Equ. conc. | $\frac{2-x}{2}$M | | $\frac{5-x}{2}$M | | $\frac{x}{2}$M | | $\frac{x}{2}$M | |

Now, $$K = \frac{[D][E]}{[A][B]} = \frac{\left(\frac{x}{2}\right)\cdot\left(\frac{x}{3}\right)}{\left(\frac{2-x}{2}\right)\cdot\left(\frac{5-x}{2}\right)}$$

or, $$1 = \frac{x^2}{(2-x)(5-x)}$$

or $$x = 1.428$$

Now, for first reaction, $K_1 = \frac{[C][D]}{[A]}$

or, $$5 \times 10^{-6} = \frac{[C]\left(\frac{x}{2}\right)}{\left(\frac{2-x}{2}\right)}$$

∴ $[C] = \mathbf{2 \times 10^{-6}\ M}$

36. **Example 39** *Some solid* $NH_4HS$ *is introduced in a vessel containing* $NH_3$ *gas at* 0.5 atm. *Calculate the equilibrium partial pressures of gases. For the reaction:*

$$NH_4HS(s) \rightleftharpoons NH_3(g) + H_2S(g),\ K_p = 0.12\ \text{atm}^2.$$

**Solution**

| | $NH_4HS(g)$ | $\rightleftharpoons$ | $NH_3(g)$ | + | $H_2S\ (g)$ |
|---|---|---|---|---|---|
| Initial partial pressure | | | 0.5 atm | | 0 |
| Equ. par. pressure of gases | | | $(0.5 + x)$ atm | | $x$ atm |

Now, $$K_p = P_{NH_3} \cdot P_{H_2S}$$

or, $$0.12 = (0.5 + x) \times x$$

or, $$x = 0.177$$

Hence, equilibrium pressure of $NH_3 = 0.5 + x = \mathbf{0.677\ atm}$

$H_2S = x = \mathbf{0.177\ atm}$

Now, $K = \frac{[D][E]}{[A][B]} = \frac{\left(\frac{x}{2}\right)\cdot\left(\frac{x}{3}\right)}{\left(\frac{2-x}{2}\right)\cdot\left(\frac{5-x}{2}\right)}$

or, $1 = \frac{x^2}{(2-x)(5-x)}$

or $x = 1.428$

Now, for first reaction, $K_1 = \frac{[C][D]}{[A]}$

or, $5 \times 10^{-6} = \frac{[C]\left(\frac{x}{2}\right)}{\left(\frac{2-x}{2}\right)}$

∴ $[C] = \mathbf{2 \times 10^{-6}\ M}$

37.

| | $PCl_5(g)$ | $\rightleftharpoons$ | $PCl_3(g)$ | + | $Cl_2(g)$ |
|---|---|---|---|---|---|
| Initial moles | 1 (say) | | 0 | | 0 |
| Moles at equ. | $1-\alpha$ | | $\alpha$ | | $\alpha$ |
| Total moles at equ. | $= (1-\alpha) + \alpha + \alpha = 1 + \alpha$ | | | | |
| Equ. par pressure | $\frac{1-\alpha}{1+\alpha}\cdot P$ | | $\frac{\alpha}{1+\alpha}\cdot P$ | | $\frac{\alpha}{1+\alpha}\cdot P$ |

Now, $K_p = \frac{P_{PCl_3}\cdot P_{Cl_2}}{P_{PCl_5}} = \frac{\left(\frac{\alpha}{1+\alpha}\cdot P\right)\left(\frac{\alpha}{1+\alpha}\cdot P\right)}{\left(\frac{1-\alpha}{1+\alpha}\cdot P\right)} = \frac{\alpha^2 P}{1-\alpha^2}$

or, $0.2 = \frac{\alpha^2 \times 4}{1-\alpha^2}$

∴ $\alpha = \mathbf{0.218}$