WEEKLY TEST RANKER'S BATCH-01 TEST - 01 Balliwala SOLUTION Date 08-09-2019

[PHYSICS]

1. According to Kepler's first law, every planet moves in an elliptical orbit with the sun situated at one of the foci of the ellipse.

   In options (a) and (b) sun is not at a focus while in (c) the planet is not in orbit around the sun. Only (d) represents the possible orbit for a planet.

2. Kepler's law $T^2 \propto R^3$

3. In arrangement 1, both forces act in the same direction. In arrangement 3, both the forces act in opposite direction. This alone decides in favour of option (a),

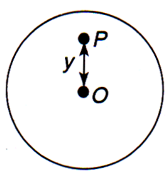
4. Time period of a revolution of a planet,

$$T = \frac{2\pi r}{v} = \frac{2\pi r}{\sqrt{\frac{GM_S}{r}}} = \frac{2\pi r^{3/2}}{\sqrt{GM_S}}$$

5. Gravitational force is independent of the medium. Thus, gravitational force will be same i.e., F.

6. If a point mass is placed inside a uniform spherical shell, the gravitational force on the point mass is zero. Hence, the gravitational force exerted by the shell on the point mass is zero.

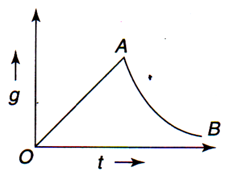
7. $g_d = g\left(1 - \frac{d}{g}\right)$



or $\quad g_d = g\frac{R-d}{R}$

or $\quad g_d = \frac{gy}{R}$ or $g_d \propto y$

So, within the Earth, the acceleration due to gravity varies linearly, with the distance from the centre of the Earth. This explains the linear portion OA of the graphs.



8. The value of g at the height h from the surface of earth

$$g' = g\left(1 - \frac{2h}{R}\right)$$

The value of g at depth x below the surface of earth

$$g' = g\left(1 - \frac{x}{R}\right)$$

These two are given equal, hence $\left(1 - \frac{2h}{R}\right) = \left(1 - \frac{x}{R}\right)$

On solving, we get $x = 2h$

9. Acceleration due to gravity $g = \frac{4}{3}\pi\rho GR \ \therefore\ g \propto \rho R$

or $\frac{g_m}{g_e} = \frac{\rho_m}{\rho_e} \cdot \frac{R_m}{R_e}$

$$\left[\text{As } \frac{g_m}{g_e} = \frac{1}{6} \text{ and } \frac{\rho_e}{\rho_m} = \frac{5}{3} \text{(given)}\right]$$

$$\therefore \quad \frac{R_m}{R_e} = \left(\frac{g_m}{g_e}\right)\left(\frac{\rho_e}{\rho_m}\right) = \frac{1}{6} \times \frac{5}{3} \therefore R_m = \frac{5}{18}R_e$$

10. Acceleration due to gravity $g = \frac{GM}{R^2}$

$$\therefore \quad \frac{g_{\text{moon}}}{g_{\text{earth}}} = \frac{M_{\text{moon}}}{M_{\text{earth}}} \cdot \frac{R_{\text{earth}}^2}{R_{\text{moon}}^2} = \left(\frac{1}{80}\right)\left(\frac{4}{1}\right)^2$$

$$g_{\text{moon}} = g_{\text{earth}} \times \frac{16}{80} = \frac{g}{5}$$

11. Acceleration due to gravity $g = \frac{4}{3}\pi\rho GR$

$$\therefore \quad g_1 : g_2 = R_1\rho_1 : R_2\rho_2$$

12. We know $g = \frac{GM}{R^2} = \frac{GM}{(D/2)^2} = \frac{4GM}{D^2}$

If mass of the planet $= M_0$ and diameter of the planet $= D_0$. Then $g = \frac{4GM_0}{D_0^2}$.

13. $\frac{g'}{g} = \left(\frac{R}{R+h}\right)^2 = \left(\frac{R}{R+2R}\right)^2 = \frac{1}{9} \quad \therefore g' = \frac{g}{9}$.

14. Acceleration due to gravity on earth is

$$g = \frac{GM_E}{R_E^2} \qquad \text{(i)}$$

As $\quad \rho = \frac{M_E}{\frac{4}{3}\pi R_E^3} \Rightarrow M_E = \rho\frac{4}{3}\pi R_E^3$

Substituting this value in Eq. (i), we get

$$g = \frac{G\left(\rho\frac{4}{3}\pi R_E^3\right)}{R_E^2} = \frac{4}{3}\pi\rho GR_E \text{ or } \rho = \frac{3g}{4\pi GR_E}$$

15. $$\Delta U = U_2 - U_1 = \frac{mgh}{1+\frac{h}{R_e}} = \frac{mgR_e}{1+\frac{R_e}{R_e}} = \frac{mgR_e}{2}$$

$$\Rightarrow \quad U_2 - (-mgR_e) = \frac{mgR_e}{2} \Rightarrow U_2 = -\frac{1}{2}mgR_e$$

16. Potential energy $U = \frac{-GMm}{r} = -\frac{GMm}{R+h}$

$$U_{\text{initial}} = -\frac{GMm}{3R} \text{ and } U_{\text{final}} = -\frac{-GMm}{2R}$$

Loss in PE = gain in $KE = \frac{GMm}{2R} - \frac{GMm}{3R} = \frac{GMm}{6R}$

17. $$\Delta u = -\left(\frac{GMm}{R+h}\right) - \left(-\frac{GMm}{R}\right)$$

$H = 3R$

$$\Delta u = -\frac{GMm}{4R} + \frac{GMm}{R} = \frac{3GMm}{4R^2} \times R$$

$$\Delta u = \frac{3}{4}mgR$$

18. $U = \frac{-GMm}{r}$, $K = \frac{GMm}{2r}$ and $E = \frac{-GMm}{2r}$

For a satellite U, K and E vary with r and also U and E remain negative whereas K remains always positive.

19. $$v = \sqrt{\frac{GM}{R+h}}$$

For first satellite $h = 0$, $v_1 = \sqrt{\frac{GM}{R}}$

For second satellite $h = \frac{R}{2}$, $v_2 = \sqrt{\frac{2GM}{3R}}$

$$v_2 = \sqrt{\frac{2}{3}}v_1 = \sqrt{\frac{2}{3}}v$$

20. Orbital velocity of the satellite is

$v = \sqrt{\frac{GM_E}{r}}$ where M_E is the mass of the earth

Kinetic energy, $K = \frac{1}{2}mv^2 = \frac{GM_E m}{2r}$

where m is the mass of the satellite.

$$K \propto \frac{1}{r}$$

Hence, option (b) in incorrect.

Linear momentum, $p = mv = m\sqrt{\frac{GM_E}{r}}$

$$p \propto \frac{1}{\sqrt{r}}$$

Hence, option (c) is incorrect.

Frequency of revolution, $\nu = \frac{1}{T} = \frac{1}{2\pi}\sqrt{\frac{GM_E}{r^3}}$

$$\nu \propto \frac{1}{r^{3/2}}$$

Hence, option (d) is correct.

21. Time period, $T = \frac{2\pi R}{\sqrt{\frac{GM_m}{R}}} = \frac{2\pi R^{3/2}}{\sqrt{GMm}}$

where the symbols have their meanings as given. Squaring both sides, we get

$$T^2 = \frac{4\pi^2 R^3}{GMm}$$

22. Total energy of the orbiting satellite of mass m having orbital radius r is

$E = -\frac{GMm}{2r}$ where M is the mass of the planet.

Additional kinetic energy required to transfer the satellite from a circular orbit of radius R_1 to another radius R_2 is

$$= E_2 - E_1$$

$$= -\frac{GMm}{2R_E} - \left(-\frac{GMm}{2R_1}\right) = -\frac{GMm}{2R_2} + \frac{GMm}{2R_1}$$

$$= \frac{GMm}{2}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

23. $$\frac{1}{2}mv_{min}^2 = \left[-\frac{GMm}{r} - \frac{GMm}{r}\right]$$
$$-\left[-\frac{GMm}{(2r-a)} - \frac{GMm}{a}\right]$$
$$= \frac{2GMm(a^2 - 2ar + r^2)}{ar(2r-a)}$$

or $$v_{min} = \sqrt{\frac{GM}{a}} \times \frac{2(r-a)}{[r(2r-a)]^{1/2}}$$

So, $$K = \frac{2(r-a)}{[r(2r-a)]^{1/2}}$$

24. $v = \sqrt{\frac{GM}{r}}$ if $r_1 > r_2$ then $v_1 < v_2$

Orbital speed of satellite does not depend upon the mass of the satellite.

25.

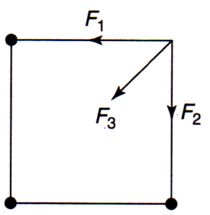
If two particles of mass m are placed x distance apart

then force of attraction $\frac{Gmm}{x^2} = F$ (Let)

26.

$F_1 = F_2 = \frac{GM}{a^2}$

Resultant of F_1 and F_2 is $\sqrt{2}\frac{GM}{a^2}$



Now, $F_3 = \frac{GM}{(\sqrt{2}a)^2} \frac{GM}{2a^2}$

Now, $\frac{\sqrt{2}GM}{a^2}$ and $\frac{GM}{2a^2}$ act in the same direction.

Their resultant is $\frac{\sqrt{2}GM}{a^2} + \frac{GM}{2a^2}$ or $\frac{GM}{a^2}\left[\sqrt{2} + \frac{1}{2}\right]$

$$G\left[M - \frac{10}{100}M\right]$$

27.

Time period does not depend upon the mass of satellite, it only depends upon the orbital radius.

According to Kepler's law

$$\frac{T_1}{T_2}=\left(\frac{r_1}{r_2}\right)^{3/2}=\left(\frac{r}{2r}\right)^{3/2}=\frac{1}{2\sqrt{2}}$$

28. Since the planet is at the centre, the focus and centre of the elliptical path coincide and the elliptical path becomes circular and the major axis is nothing but the diameter. For a circular path:

$$\frac{mv^2}{r}=\sqrt{\frac{GM}{r^2}}m$$

Also $T=\frac{2\pi r}{v}=\frac{2\pi r^{3/2}}{\sqrt{GM}} \Rightarrow T^2=\frac{4\pi^2 r^3}{GM}$

$\Rightarrow \quad r=\left(\frac{GMT^2}{4\pi^2}\right)^{1/3}=$ Radius

$\Rightarrow \quad$ Diameter (major axis) $=2\left(\frac{GMT^2}{4\pi^2}\right)^{1/3}$

29.

Acceleration due to gravity $g=\frac{GM}{R^2}$

$$\therefore \quad \frac{g_{moon}}{g_{earth}}=\frac{M_{moon}}{M_{earth}}\cdot\frac{R^2_{earth}}{R^2_{moon}}=\left(\frac{1}{80}\right)\left(\frac{4}{1}\right)^2$$

$$g_{moon}=g_{earth}\times\frac{16}{80}=\frac{g}{5}$$

30.

Radius of earth $R=6400$ km $\therefore\ h=\frac{R}{4}$

Acceleration due to gravity at a height h

$$g_h=g\left(\frac{R}{R+h}\right)^2=g\left(\frac{R}{R+\frac{R}{4}}\right)^2=\frac{16}{25}g$$

At depth 'd' value of acceleration due to gravity

$$g_d=\frac{1}{2}g_h \text{ (According to problem)}$$

$$\Rightarrow \quad g_d=\frac{1}{2}\left(\frac{16}{25}\right)g \Rightarrow g\left(1-\frac{d}{R}\right)=\frac{1}{2}\left(\frac{16}{25}\right)g$$

By solving we get $d=4.3\times10^6$ m

31.

Acceleration due to gravity $g = \frac{GM}{R^2}$

$$\therefore \quad \frac{g_{\text{planet}}}{g_{\text{earth}}} = \frac{M_{\text{planet}}}{M_{\text{earth}}}\left(\frac{R_{\text{earth}}}{R_{\text{planet}}}\right)^2 = \frac{1}{10}\times\left(\frac{3}{1}\right)^2 = \frac{9}{10}$$

If a stone is thrown with velocity u from the surface of the planet then maximum height

$$H = \frac{u^2}{2g} \Rightarrow \frac{H_{\text{planet}}}{H_{\text{earth}}} = \frac{g_{\text{earth}}}{g_{\text{planet}}}$$

$$\Rightarrow \quad H_{\text{planet}} = \frac{10}{9}\times H_{\text{earth}} = \frac{10}{9}\times 90 = 100 \text{ metre}$$

32.

Let m be mass of a body.

$\therefore$ Weight of the body on the surface of the earth is

$$W = mg = 250 \text{ N}$$

Acceleration due to gravity at a depth d below the surface of the earth is

$$g' = g\left(1 - \frac{d}{R_E}\right)$$

Weight of the body at depth d is

$$W' = mg' = mg\left(1 - \frac{d}{R_E}\right)$$

Here, $d = \frac{R_E}{2}$

$$\therefore \ W' = mg\left(1 - \frac{R_E/2}{R_E}\right) = \frac{mg}{2} = \frac{W}{2} = \frac{250 \text{ N}}{2} = 125 \text{ N}$$

33.

Acceleration due to gravity at a place of latitude λ due to the rotation of earth is

$$g' = g - R_E\omega^2 \cos^2\lambda$$

At equator, $\lambda = 0°$, $\cos 0° = 1$

$$\therefore \quad g' = g_e = g - R_g\omega^2$$

At poles, $\lambda = 90°$, $\cos 90° = 0$

$$\therefore \quad g' = g_P = g$$

$$\therefore \quad g_P - g_e = g - (g - R_E\omega^2) = R_E\omega^2$$

34.

$$g' = g\left(1 - \frac{d}{R}\right) \Rightarrow \frac{g}{4} = g\left(1 - \frac{d}{R}\right) \Rightarrow d = \frac{3R}{4}$$

35.

Potential energy of the body at a distance $4R_e$ from the surface of earth

$$U=-\frac{mgR_e}{1+h/R_e}=-\frac{mgR_e}{1+4}=-\frac{mgR_e}{5}$$

[As $h=4R_e$ (given)]

So minimum energy required to escape the body will be

$$\frac{mgR_e}{5}.$$

36. Total energy of orbiting satellite at a height h is

$$E=-\frac{GM_Em}{2(R_E+h)}$$

The total energy of the satellite at infinity is zero.

$\therefore$ Energy expended to rocket the satellite out of the earth's gravitational field is

$$\Delta E=E_\infty-E$$

$$=0-\left(-\frac{GM_Em}{2(R_E+h)}\right)=\frac{GM_Em}{2(R_E+h)}$$

37.

$$\Delta K.E.=\Delta U$$

$$\frac{1}{2}MV^2=GM_eM\left(\frac{1}{R}-\frac{1}{R+h}\right) \quad \text{(i)}$$

Also $g=\frac{GM_e}{R^2}$ (ii)

On solving (i) and (ii) $h=\frac{R}{\left(\frac{2gR}{V^2}-1\right)}$

38.

$$\Delta u=-\left(\frac{GMm}{R+h}\right)-\left(-\frac{GMm}{R}\right)$$

$$H=3R$$

$$\Delta u=-\frac{GMm}{4R}+\frac{GMm}{R}=\frac{3GMm}{4R^2}\times R$$

$$\Delta u=\frac{3}{4}mgR$$

39.

40.

$$v\propto\frac{1}{\sqrt{r}}.$$

% increase in speed $=\frac{1}{2}$ (% decrease in radius)

$$=\frac{1}{2}(1\%)=0.5\%$$

i.e., speed will increase by 0.5%

41. **Potential energy = 2 (total energy) = $2E_0$**

42.

Interstellar velocity $v' = \sqrt{\frac{GM}{r}} = R\sqrt{\frac{g}{(R+h)}}$

$= \sqrt{v^2 - v_e^2}$

where v = projection velocity

$$\frac{R^2 g}{(r+h)} = v^2 - 2gR \text{ Solving } v^2 = \frac{23gR}{11}$$

43.

Angular speed of earth = angular speed of geostationary satellite

$$T \propto \frac{1}{\omega}$$

$$\Rightarrow \quad \frac{T_2}{T_1} = \frac{\omega_1}{\omega_2} = \frac{1}{2} \Rightarrow T_2 = \frac{T_1}{2}$$

$$\therefore \quad \left(\frac{r_2}{r_1}\right)^{3/2} = \frac{T_2}{T_1} = \frac{1}{2}$$

$$\frac{r_2}{r_1} = \left(\frac{1}{2}\right)^{2/3} = \frac{1}{4^{1/3}}$$

$$r_2 = \frac{r_1}{4^{1/3}}$$

44.

$$g = \frac{GM}{R^2} = G\frac{4}{3}\pi R^3 \cdot \rho$$

$$g = \frac{4}{3}G\pi R\rho \Rightarrow g \times R\rho$$

$$g' \times R'\rho' \Rightarrow \rho' = 2\rho$$

Given, $\frac{g}{g'} = 1$

$$\frac{R}{R_1} = 2 \Rightarrow R' = \frac{R}{2}$$

45.

According to the question, the gravitational force between the planet and the star is $F \propto \frac{1}{R^{5/2}}$

$$\therefore \quad F = \frac{GMm}{R^{5/2}}$$

where M and m be mass of star and planet respectively.

For motion of a planet in a circular orbit,

$$mR\omega^2 = \frac{GMm}{R^{5/2}}$$

$mR\left(\frac{2\pi}{T}\right)^2 = \frac{GMm}{R^{5/2}}$ $\left(\because \omega = \frac{2\pi}{T}\right)$

$\frac{4\pi^2}{T^2} = \frac{GM}{R^{7/2}} \Rightarrow T^2 = \frac{4\pi^2}{GM}R^{7/2}$

$T^2 \propto R^{7/2}$ or $T \propto R^{7/4}$

[CHEMISTRY]

46.

$$N_2O_4 \rightleftharpoons 2NO_2$$

At Eqm. 4.8×10^{-2} mol L^{-1} $\quad$ 1.2×10^{-2} mol L^{-1}

$$K_c = \frac{[NO_2]^2}{[N_2O_4]} = \frac{[1.2\times10^{-2}]^2}{[4.8\times10^{-2}]} = \frac{1.2\times1.2\times10^{-4}}{4.8\times10^{-2}} = \mathbf{3\times10^{-3}\,mol\,L^{-1}}$$

47.

$$COCl_2(g) \rightleftharpoons CO(g) + Cl_2(g)$$

At t=0 $\quad$ 450 mm Hg $\quad$ – $\quad$ –

At Eqm. $\quad$ 450–P $\quad$ P $\quad$ P

$\Rightarrow \quad 450 + P = 600$

$\Rightarrow \quad P = 150$

$$K_p = \frac{150\times150}{300} = \mathbf{75}$$

48.

$N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$; $\quad K_1 = 4\times10^{-4}$

$2NO(g) \rightleftharpoons N_2(g) + O_2(g)$; $\quad K_2 = \frac{1}{K_1} = \frac{1}{4\times10^{-4}}$

$NO(g) \rightleftharpoons \frac{1}{2}N_2(g) + \frac{1}{2}O_2(g)$; $\quad K_c = (K_2)^{\frac{1}{2}} = \frac{1}{2\times10^{-2}} = \mathbf{50}$

49.

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

At $t = 0$ $\quad$ a moles $\quad$ 0.5 atm $\quad$ —

At Eqm. $\quad$ $(a - x)$ mole $\quad$ $(0.5 + P)$ atm $\quad$ P atm

When x moles of solid NH_4HS decompose, total pressure = $0.5 + P + P$

$= (0.5 + 2P)$ atm

$\Rightarrow \quad 0.5 + 2P = 0.84$ (given value)

$\Rightarrow \quad P = 0.17$ atm

$\Rightarrow \quad P_{NH_3} = 0.5 + 0.17 = 0.67$ atm

Eqm. constt. $K_p = P_{NH_3} \times P_{H_2S}$

$= 0.67 \times 0.17$

$= \mathbf{0.1139\ atm}$

50.

$SO_3(g) \rightleftharpoons SO_2(g) + \frac{1}{2}O_2(g)$; $\quad K_c = 4.9\times10^{-2}$

$2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g)$; $\quad K = K_c^2 = (4.9\times10^{-2})^2$

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$; $\quad K' = \frac{1}{K} = \frac{1}{(4.9\times10^{-2})^2} = \frac{10000}{(4.9)^2} = \mathbf{416.5}$

The closest choice is **(d).**

51.

	$H_2(g)$	+	$I_2(g)$	$\rightleftharpoons$	$2HI(g)$
At $t = 0$	40 mL		50 mL		—
At Eqm.	30 mL		30 mL		60 mL

	consumed				produced
Ratio of volumes	(40 – 30)	:	(50 – 30)	:	60
Ratio of moles	1	:	2	:	6
(Avogadro's law)					

$$K_c = \frac{C_{HI}^2}{C_{H_2} \times C_{I_2}} = \frac{6\times 6}{1\times 2} = \mathbf{18}$$

52.

$$H_2 + I_2 \rightleftharpoons 2HI,\ K = 49$$

$$2HI \rightleftharpoons H_2 + I_2,\ K' = \frac{1}{K} = \frac{1}{49}$$

$$HI \rightleftharpoons \frac{1}{2}H_2 + \frac{1}{2}I_2,$$

$$K'' = (K')^{1/2} = \frac{1}{\sqrt{49}} = \frac{1}{7} = \mathbf{0.143}$$

53.

$$CO(g) + Cl_2(g) \rightleftharpoons COCl_2(g)$$

$$K_p = K_c(RT)^{\Delta n} = K_c(RT)^{1-(1+1)} = \frac{K_c}{RT}$$

$$\frac{K_p}{K_c} = \frac{\mathbf{1}}{\boldsymbol{RT}}$$

54.

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

Since, Δn is [2 + 1 – 2] = 1, $\boldsymbol{K_p > K_c}$

55.

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

	PCl_5	PCl_3	Cl_2
At $t = 0$	1 mole	—	—
At Eqm.	$(1 - x)$ moles	x moles	x moles

(x is degree of dissociation of PCl_5)

$$P_{PCl_3} = \frac{n_{PCl_3}}{n_{total}} \times P_{total} = \left(\frac{\boldsymbol{x}}{\mathbf{1}+\boldsymbol{x}}\right)\boldsymbol{P}$$

56.

Δn (gaseous substances) for this equation is zero.

Hence, $K_p = K_c(RT)^{\Delta n} = \boldsymbol{K_c}$.

57.

$$\Delta n = (c+d) - (a+b)$$

$$K_p = K_c(RT)^{\Delta n} = \boldsymbol{K_c(RT)^{(c+d)-(a+b)}}$$

58.

$$SO_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons SO_3(g)$$

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

Here, $\Delta n_g = x = 1 - \left(1 + \frac{1}{2}\right) = -\frac{\mathbf{1}}{\mathbf{2}}$

59.

$$K_c = \frac{K_p}{(RT)^{\Delta n}} = \frac{0.41}{(0.082 \times 300)^{-1}} = 0.41 \times 0.082 \times 300 = \mathbf{10.08\ L\ mol^{-1}}$$

60.

$$\begin{array}{lccc} & X & \rightleftharpoons & 2Y \\ \text{At } t=0 & 1\text{ mole} & & - \\ \text{At Eqm.} & 1-\alpha & & 2\alpha \end{array}$$

Total moles $= 1-\alpha+2\alpha = 1+\alpha$

Total pressure $= P_1$

$$K_{p_1} = \frac{P_Y^2}{P_X} = \frac{\left(\frac{2\alpha}{1+\alpha}P_1\right)^2}{\left(\frac{1-\alpha}{1+\alpha}\cdot P_1\right)} = \frac{4\alpha^2 P_1^2 (1+\alpha)}{P_1 (1+\alpha)(1+\alpha)(1-\alpha)} = \frac{4\alpha^2 P_1}{1-\alpha^2} \quad \text{...(i)}$$

$$\begin{array}{lccccc} & Z & \rightleftharpoons & P & + & Q \\ \text{At } t=0 & 1\text{ mole} & & - & & - \\ \text{At Eqm.} & 1-\alpha & & \alpha & & \alpha \end{array}$$

Total moles $= 1-\alpha+\alpha+\alpha = 1+\alpha$

Total pressure $= P_2$

$$K_{p_2} = \frac{P_P P_Q}{P_Z} = \frac{\left(\frac{\alpha}{1+\alpha}P_2\right)\cdot\left(\frac{\alpha}{1+\alpha}P_2\right)}{\left(\frac{1-\alpha}{1+\alpha}\right)P_2} = \frac{\frac{\alpha^2}{(1+\alpha)^2}\cdot P_2^2}{\left(\frac{1-\alpha}{1+\alpha}\right)P_2} = \frac{\alpha^2 P_2}{1-\alpha^2} \quad \text{...(ii)}$$

From eqns. (i) and (ii)

$$\frac{K_{p_1}}{K_{p_2}} = \frac{4\alpha^2 P_1}{1-\alpha^2} \times \frac{1-\alpha^2}{\alpha^2 P_2} = \frac{4P_1}{P_2} \quad \text{...(iii)}$$

Given, $\frac{K_{p_1}}{K_{p_2}} = \frac{1}{9}$ ...(iv)

From eqns. (iii) and (iv)

So, $\frac{4P_1}{P_2} = \frac{1}{9} \Rightarrow \frac{P_1}{P_2} = \mathbf{\frac{1}{36}}$

61.

$$\begin{array}{lccccccc} & RCOOH & + & R'OH & \rightleftharpoons & RCOOR' & + & H_2O \\ \text{At } t=0 & 100\text{ moles} & & 100\text{ moles} & & \text{Nil} & & \text{Nil} \\ \text{At Eqm.} & 100-67 & & 100-67 & & 67 & & 67 \end{array}$$

$$K = \frac{67 \times 67}{33 \times 33} = \mathbf{4.12}$$

62.

$$2AB_2(g) \rightleftharpoons 2AB(g) + B_2(g)$$

At $t=0$	2 moles (let)	—	—
At Eqm.	$(2-2x)$ moles	$2x$ moles	x mole

(x is degree of dissociation)

Total $= 2-2x+2x+x = (2+x)$ moles;
Total pressure $= P$

$$K_p = \frac{P_{AB}^2 \cdot P_{B_2}}{P_{AB_2}^2} = \frac{\left(\frac{2x}{2+x}\cdot P\right)^2 \left(\frac{x}{2+x}\cdot P\right)}{\left(\frac{2-2x}{2+x}\cdot P\right)^2} = \frac{x^3}{2}\cdot P$$

$$\Rightarrow \quad x = \left[\frac{\mathbf{2K_p}}{\mathbf{P}}\right]^{1/3} \qquad \text{(given is } x << 1)$$

63.

On adding the first two equations,

$$K = K_1 \cdot K_2 = \mathbf{5 \times 10^{-23}}$$

64.

The value of equilibrium constant will not change by addition of reactant 'A', since the value of equilibrium constant changes with temperature only.

65.

3rd equation is the sum of first and second equation. Hence, its Eqm. Constt. $= \boldsymbol{K_1 \times K_2}$.

66.
67.

$$N_2 + 3H_2 \overset{K_1}{\rightleftharpoons} 2NH_3$$

$$\Rightarrow \quad 2NH_3 \overset{K'}{\rightleftharpoons} N_2 + 3H_2; \; K' = \frac{1}{K_1}$$

$$N_2 + O_2 \overset{K_2}{\rightleftharpoons} 2NO; \; K_2$$

$$H_2 + \frac{1}{2}O_2 \overset{K_3}{\rightleftharpoons} H_2O$$

$$\Rightarrow \quad 3H_2 + \frac{3}{2}O_2 \overset{K''}{\rightleftharpoons} 3H_2O; \; K'' = K_3^3$$

Adding of eqns. (i), (ii) and (iii)

$$2NH_3 + \frac{5}{2}O_2 \longrightarrow 2NO + 3H_2O; \; K = ?$$

$$K = K' \times K_2 \times K'' = \frac{\mathbf{K_2 \cdot K_3^3}}{\mathbf{K_1}}$$

* For $4NH_3 + 5O_2 \longrightarrow 4NO + 6H_2O; \; K = \dfrac{K_2^2 \cdot K_3^6}{K_1^2}$

68.

$$k_f = 3k_b \quad \Rightarrow \quad K = \frac{k_f}{k_b} = \mathbf{3}$$

69.

$$NH_2COONH_4(s) \rightleftharpoons 2NH_3(g) + CO_2(g)$$

At $t=0$	solid	–	–	
At Eqm.	–	2 moles	1 mole	; $n_{total}=3$

$$K_p = (P_{NH_3})^2 (P_{CO_2})$$

For $P = 3\,\text{atm}$

$$K_p = \left(\frac{2}{3}\times 3\right)^2 \times \left(\frac{1}{3}\times 3\right) = \mathbf{4}$$

70.

The third equation is obtained by adding the first and second. So, $\boldsymbol{K_3 = K_1 \cdot K_2}$

71.

$$A + 2B \rightleftharpoons 2C + D$$

	A	$2B$	$2C$	D
At $t=0$	1.1 moles	2.2 moles	Nil	Nil
At Eqm.	(1.1 – 0.1) = 1.0 mole	(2.2 – 0.2) = 2.0 moles	0.2 mole	0.1 mole (given)
	left		produced	

$$K = \frac{(0.2)^2 \times (0.1)}{(1)\times(2)^2} = 1\times 10^{-3} = \mathbf{0.001}$$

72.

$H_2A \rightleftharpoons H^+ + HA^-$, $\quad K_a = 1\times 10^{-5}$

$HA \rightleftharpoons H^+ + A^{2-}$, $\quad K'_a = 5.0\times 10^{-10}$

Overall, $H_2A \rightleftharpoons 2H^+ + A^{2-}$,

$K = K_a \cdot K'_a = 1\times 10^{-5} \times 5\times 10^{-10} = \mathbf{5\times 10^{-15}}$

73.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

	N_2	$3H_2$	$2NH_3$
At $t=0$	10 moles	10 moles	Nil
At Eqm.	$1\times\frac{6}{3}$ mol consumed *i.e.*, 8 moles left	4 mol left 6 moles consumed	$2\times\frac{6}{3}$ moles *i.e.*, 4 moles produced

40% of 10 moles of H_2 = 4 moles left

Moles of H_2 consumed = 10 – 4 = 6

Total moles in the chamber at equilibrium = 8 + 4 + 4 = **16 mol**

74.

$$CO_2(g) + C(s) \rightleftharpoons 2CO$$

	$CO_2(g)$	$C(s)$	$2CO$
At $t=0$	0.5 atm	–	–
At Eqm.	$0.5 - P$	–	$2P$

Total pressure $0.8 = 0.5 - P + 2P \quad \Rightarrow \quad P = 0.3$

$$K_p = \frac{P_{CO}^2}{P_{CO_2}} = \frac{(0.6)^2}{0.2} = \mathbf{1.8\ atm}$$

75.

$$K = \frac{k_f}{k_b} = \frac{3.25\times 10^{-3}}{1.62\times 10^{-4}} = \mathbf{20}$$

76.

The reaction is endothermic. It will be favoured by **increase in temperature.**

77.

First eqn. is obtained by adding the 2nd and 3rd equations. So,

$$K_1 = K_2 \cdot K$$

$$\boldsymbol{K = K_1 \div K_2}$$

78.

Add the two equations

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

$$K = K_1 \cdot K_2 = 6.8\times 10^{-3} \times 1.6\times 10^{-3} \doteq \mathbf{1.088\times 10^{-5}}$$

79.

1000 mL water at 4°C = 1000 g

$$= \frac{1000}{18} \text{ mol} = 55.55 \text{ mol}$$

So, one litre water has 55.55 mol of water. Active mass of water

$$= \mathbf{55.55\ mol\ L^{-1}}.$$

80.

$$\% \text{ dissociation} = \frac{D-d}{(n-1)\,d} \times 100 = \frac{(30-15)}{(3-1)\times 15} \times 100 = \mathbf{50\,\%}$$

81.

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

At equilibrium, $Q = K$ and $\Delta G = 0$

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

$$RT \log_e K = -\Delta G^0$$

$$\log_e K = -\frac{\Delta G^0}{RT}$$

$$K = e^{-\frac{\Delta G^0}{RT}}$$

82.

$$\frac{1}{2}X_2 + \frac{3}{2}Y_2 \rightleftharpoons XY_3;\ \Delta H = -30\times 1000\text{J}$$

$$\Delta S = 50 - \frac{3}{2}\times 40 - \frac{1}{2}\times 60 = -40\text{JK}^{-1}\text{ mol}^{-1}$$

$$T = \frac{\Delta H}{\Delta S} = \frac{-30\times 1000}{-40}\text{K} = \mathbf{750\ K}$$

83.

$$K_c = \frac{[AB]^2}{[A_2][B_2]} = \frac{(2.8\times 10^{-3})^2}{(3.0\times 10^{-3})(4.2\times 10^{-3})}$$

$$= \frac{2.8\times 2.8}{3.0\times 4.2} = \mathbf{0.62}$$

84.C

85.

86.

B

88. (c) Assertion is true but reason is false. This is based on common ion effect.

$NaCl \rightleftharpoons Na^+ + Cl^-$; $HCl \rightleftharpoons H^+ + Cl^-$

Concentration of Cl^- ions increases due to ionisation of HCl which increases the ionic product $[Na^+][Cl^-]$. This result in the precipitation of pure $NaCl$.

89. (b) Both assertion and reason are true and reason is not the correct explanation of assertion, solid+heat $\rightleftharpoons$ liquid,

so on heating forward reactions is favoured and amount of solid will decrease.

90. (a) $aA + bB \rightleftharpoons cC + dD$

$$K_C = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

For $2aA + 2bB \rightleftharpoons 2cC + 2dD$

$$K_C = \frac{[C]^{2c}[D]^{2d}}{[A]^{2a}[B]^{2b}}.$$