WEEKLY TEST TYM TEST - 27 Balliwala
SOLUTION Date 17 -11-2019

[PHYSICS]

1. $t = \frac{A}{a}\sqrt{\frac{2}{g}}[\sqrt{H_1} - \sqrt{H_2}]$

Now, $T_1 = \frac{A}{a}\sqrt{\frac{2}{g}}\left[\sqrt{H} - \sqrt{\frac{H}{\eta}}\right]$

and $T_2 = \frac{A}{a}\sqrt{\frac{2}{g}}\left[\sqrt{\frac{H}{\eta}} - \sqrt{0}\right]$

According to problem $T_1 = T_2$

$\therefore \quad \sqrt{H} - \sqrt{\frac{H}{\eta}} = \sqrt{\frac{H}{\eta}} - 0 \Rightarrow \sqrt{H} = 2\sqrt{\frac{H}{\eta}} \Rightarrow \eta = 4$

2. Pressure at the bottom of tank $P = h\rho g = 3 \times 10^5 \frac{N}{m^2}$.

Pressure due to liquid column $P_l = 3 \times 10^5 - 1 \times 10^5 =$ 2×10^5 and velocity of water $v = \sqrt{2gh}$

$\therefore \quad v = \sqrt{\frac{2P_l}{\rho}} = \sqrt{\frac{2 \times 2 \times 10^5}{10^3}} = \sqrt{400}$ m/s

3. Effective value of acceleration due to gravity becomes $(g + a_0)$.

4. $x = \sqrt{2gh_1} \times \sqrt{\frac{2h_2}{g}}$ or $x = 2\sqrt{h_1 h_2}$

Now, imagine a hole at a depth h_2 below the free surface of the liquid. The height of this hole will be h_1. Clearly, x remains the same.

5. $v = \sqrt{2gh}$

But $\quad p = h\rho g$ or $\frac{p}{\rho} = gh$

$\therefore \quad v\sqrt{\frac{2p}{\rho}} = \sqrt{\frac{2 \times 2 \times 10^5}{10^3}}$ ms^{-1} = 20 ms^{-1}

$R^2 v =$ constant

6. From Torricelli's theorem

$$v = \sqrt{2gd} \quad \text{(i)}$$

where v is horizontal velocity and d is the depth of water in barrel.

Time t to hit the ground is given by

$$h = \frac{1}{2}gt^2 \quad \text{or} \quad t = \sqrt{\frac{2h}{g}}$$

$$\therefore \quad R = vt = \sqrt{(2gd)}\sqrt{\frac{2h}{g}} = 2\sqrt{dh} \quad \text{(Using (i))}$$

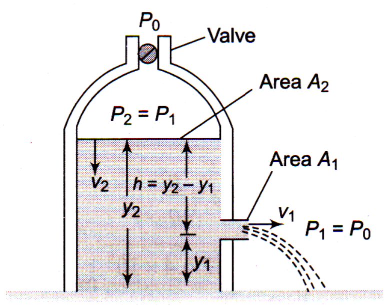
$$\therefore \quad R^2 = 4dh \text{ or } d = \frac{R^2}{4h}$$

7. $4(H-4) = 6(H-6)$

or $\quad 2H = 36 - 16 - 20$ or $H = 10$ cm

8. From equation of continuity, $v_2 = \frac{A_1}{A_2}v_1$

Since $A_1 << A_2$, v_2 must be very small compared to velocity of efflux at the hole, therefore we can take $v_2 = 0$.



Fluid emerging from the hole is open to atmospheric pressure P_0, We take two points A and B at the top of the fluid and at the hole respectively. From Bernoulli's principle,

$$P_0 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_1 + \rho g y_2$$

Solving for v_1, we obtain $v_1 = \sqrt{\frac{2(p_t - p_0)}{\rho} + 2gh}$

9. Velocity of water coming out from hole A

$$= v_1 = \sqrt{2gh}$$

Velocity of water coming out from hole B

$$= v_2 = \sqrt{2g(H-h)}$$

Time taken by water to reach the ground from hole A

$$= t_1 = \sqrt{2(H-h)/g}$$

Time taken by water to reach the ground from hole B

$$= t_2 = \sqrt{2h/g}$$

Obviously, range on the ground for both is the same

$\therefore \quad R = v_1 t_1 = v_2 t_2 = 2g\sqrt{h(H-h)}$

10. Let A and a be the cross-sectional areas of the vessel and hole respectively. Let h be the height of water in the vessel at time. Let $\left(-\frac{dh}{dt}\right)$ represent the rate of fall of level.

Then, $A\left(-\frac{dh}{dt}\right) = \alpha v = a\sqrt{2gh}$

or $\quad -\frac{dh}{\sqrt{h}} = \frac{\alpha\sqrt{2g}}{A}dt$

$$-\int_A^0 \frac{1}{\sqrt{h}}dh = \frac{a\sqrt{2g}}{A}\int_0^g dt$$

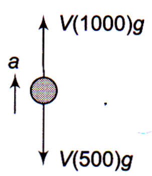
$$-(-2\sqrt{h}) = \frac{\alpha\sqrt{2g}}{A}t$$

or $\quad t = \frac{A}{\alpha}\frac{1}{\sqrt{2g}} \times 2\sqrt{h}$ or $t = \frac{A}{\alpha}\sqrt{\frac{2h}{g}}$

Now, $\quad t \propto \sqrt{h}$

When h is quadrupled, t is doubled.

11. Velocity of ball when it reaches to surface of liquid



$a = \frac{1000\text{ gV} - 500\text{ gV}}{500\text{ V}}$; where V is the volume of the ball.

$$a = 10\text{ m/sec}^2$$

Apply $v = u + at \Rightarrow 0 = \sqrt{2gh} - 10t$

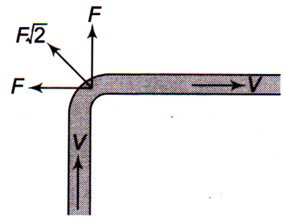
$\Rightarrow \quad \sqrt{2gh} = 10 \times (2)$

$\Rightarrow \quad 2 \times 10 \times h = 400 \Rightarrow = 20\text{ m}$

12. Force exerted in vertical direction and horizontal direction are

$$F_1 = F_2 = v_{rel} \times \frac{dm}{dt} = V\rho \cdot L$$

$\Rightarrow \quad F_{net} = \rho VL\sqrt{2}$



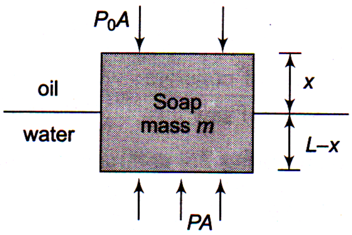
13. The velocity of system will not change in horizontal direction as water is leaking out vertically down. Because leaking water does not exchange any momentum with trolley in horizontal direction.

14. Tension in spring T = upthrust – weight of sphere

$= V\sigma g - V\rho g = V\eta\rho g - V\rho g \qquad (\text{As } \sigma = \eta\rho)$

$= (\eta - 1)V\rho g = (\eta - 1)mg$

15. Let A be area of soap bar.



$PA - P_0A = mg \Rightarrow (P - P_0)A = mg$

$\Rightarrow \quad [300gx + 1000g(L - x)A = AL\ 800g$

$\Rightarrow \quad \frac{x}{L} = \frac{2}{7}$

16. Let specific gravities of concrete and saw dust are ρ_1 and ρ_2 respectively.

According to principle of floatation weight of whole sphere = upthrust on the sphere

$$\frac{4}{3}\pi(R^3 - r^3)\rho_1 g + \frac{4}{3}\pi r^3 \rho_2 g = \frac{4}{3}\pi R^3 \times 1 \times g$$

$$\Rightarrow \quad R^3\rho_1 - r^3\rho_1 + r^3\rho_2 = R^3$$

$$\Rightarrow \quad R^3(\rho_1 - 1) = r^3(\rho_1 - \rho_2) \Rightarrow \frac{R^3}{r^3} = \frac{\rho_1 - \rho_2}{\rho_1 - 1}$$

$$\Rightarrow \quad \frac{R^3 - r^3}{r^3} = \frac{\rho_1 - \rho_2 - \rho_1 + 1}{\rho_1 - 1}$$

$$\Rightarrow \quad \frac{(R^3 - r^3)\rho_1}{r^3\rho_2} = \left(\frac{1 - \rho_2}{\rho_1 - 1}\right)\frac{\rho_1}{\rho_2}$$

$$\Rightarrow \quad \frac{\text{Mass of concrete}}{\text{Mass of saw dust}} = \left(\frac{1 - 0.3}{2.4 - 1}\right) \times \frac{2.4}{0.3} = 4$$

17. Maas of liquid in horizontal portion of U-tube $= A\,d\rho$

Pseudo force on this mass $= Ad\rho a$

Force due to pressure difference in the two limbs

$$= (h_1\rho g - h_2\rho g)A$$

Equating, $(h_1 - h_2)\rho g A = Ad\rho a$

or $\quad h_1 - h_2 = \dfrac{Ad\rho a}{\rho g A} = \dfrac{ad}{g}$

18. Let m gwt be the weight of object in vacuum.

Volume of object $= \dfrac{m}{3.4}$

Weight of air displaced by object $= \dfrac{m}{3.4} \times 0.0012$

Volume of brass weight $= \dfrac{m}{8}$

Weight of air displaced by brass weights

$$= \frac{m}{8} \times 0.0012$$

Error = difference in buoyancy

$$= 0.0012\left[\frac{1}{3.4} - \frac{1}{8}\right]$$

Fractional error $= \dfrac{0.0012 \times 4.6}{3.4 \times 8} = 2 \times 10^{-4}$

19. Suppose volume and density of the body be V and ρ respectively, The, according to law of flatiron in water.

Weight = upthrust

$$V\rho g = \frac{2}{3}V\rho_w g \qquad (1)$$

In liquid, $V\rho g = \frac{1}{4}V\rho_L g$ (2)

From (1) and (2), $\frac{2}{3}V\rho_w g = \frac{1}{4}V\rho_L g$

or $\quad \frac{\rho_L}{\rho_w} = \frac{2/3}{1/4} = \frac{8}{3}$

or $\quad \rho_L = \frac{8}{3}\rho_w = \frac{8}{3}\times 1\ \text{g/cc}$

20. Velocity u of the body when it enters the liquid is given by $mgh = \frac{1}{2}mu^2$ or $u = \sqrt{2gh}$

Let Volume of the body = V

Mass of the body = Vd

Weight of the body = Vdg

Mass of liquid displaced = VD

Weight of liquid displaced = VDg

Net upward force = $VDg - VDg$

$= V_g(D - d)$

$$\text{Retardation} = \frac{\text{net weight}}{\text{mass}}$$

$$= \frac{V(D-d)g}{Vd} = \left(\frac{D-d}{d}\right)g$$

Acceleration $a = -\left(\frac{D-d}{d}\right)g$

Final velocity, v in the liquid when the body is instantaneously at rest is zero. Let the time taken be t.

$$v = u + at$$

$$0 = \sqrt{2gh} - \left(\frac{D-d}{d}\right)gt \cdot \left(\frac{D-d}{d}\right)gt = \sqrt{2gh}$$

$$\therefore \quad t = \left[\frac{d}{D-d}\right]\sqrt{\frac{2h}{g}}$$

[CHEMISTRY]

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

22. $$\frac{1}{2}X_2 + \frac{3}{2}Y_2 \rightleftharpoons XY_3;\ \Delta H = -30\times 1000 J$$
$$\Delta S = 50 - \frac{3}{2}\times 40 - \frac{1}{2}\times 60 = -40 \text{J K}^{-1}\text{ mol}^{-1}$$
$$T = \frac{\Delta H}{\Delta S} = \frac{-30\times 1000}{-40}\text{K} = \mathbf{750\ K}$$

23. In $PCl_5 \rightleftharpoons PCl_3 + Cl_2$, number of moles are increasing, it will be favoured by low pressure.

24. $$K_1 = \frac{[NO]^2}{[N_2][O_2]};\quad K_2 = \frac{[NO_2]^2}{[NO]^2[O_2]^2}$$
$$K = \frac{[N_2]^{1/2}[O_2]}{[NO_2]}$$
$$K_1K_2 = \frac{[NO_2]^2}{[N_2][O_2]^2} \Rightarrow \sqrt{K_1K_2} = \frac{[NO_2]}{[N_2]^{1/2}[O_2]} = \frac{1}{K}$$
$$K = \left[\frac{\mathbf{1}}{\boldsymbol{K_1K_2}}\right]^{\mathbf{1/2}}$$

25. $$K_c = \frac{[AB]^2}{[A_2][B_2]} = \frac{(2.8\times 10^{-3})^2}{(3.0\times 10^{-3})(4.2\times 10^{-3})}$$
$$= \frac{2.8\times 2.8}{3.0\times 4.2} = \mathbf{0.62}$$

26. The reaction is facing the decrease in number of moles and release of heat. According to Le-Chatelier's principle, forward reaction will be favoured by increase in pressure and decrease in temperature.

27. 3rd equation is the sum of first and second equations. Hence, its Eqm. Constt. $= \boldsymbol{K_1 \times K_2}$.

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

29. Since, the number of moles of gaseous substances on product side is less, increase in pressure will increase the yield. Equilibrium constant will not change because it depends only on temperature (for a specific reaction).

30.

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

	$COCl_2(g)$	$CO(g)$	$Cl_2(g)$
At $t=0$	450 mm Hg	–	–
At Eqm.	$450-P$	P	P

$\Rightarrow\ 450 + P = 600$

$\Rightarrow\ P = 150$

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

32. $N_2(g) + O_2(g) \rightleftharpoons 2NO(g);\quad K_1 = 4\times 10^{-4}$

$2NO(g) \rightleftharpoons N_2(g) + O_2(g);\quad K_2 = \frac{1}{K_1} = \frac{1}{4\times 10^{-4}}$

$NO(g) \rightleftharpoons \frac{1}{2}N_2(g) + \frac{1}{2}O_2(g);\quad K_c = (K_2)^{\frac{1}{2}} = \frac{1}{2\times 10^{-2}} = \mathbf{50}$

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

At $t = 0$	a moles	0.5 atm	—
At Eqm.	$(a - x)$ mole	$(0.5 + P)$ atm	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. $K_p = P_{NH_3} \times P_{H_2S}$

$= 0.67 \times 0.17$

$= \mathbf{0.1139\ atm}$

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

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

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

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

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

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

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

(x is degree of dissociation of PCl_5)

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

37. Δn (gaseous substances) for this equation is zero.

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

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

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

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

39.

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

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

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

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

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

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