ANSWER KEY PAPER-1

PART-1 : PHYSICS

SECTION-I (i)	Q.	1	2	3	4		
	A.	C	A	D	C		
SECTION-I (ii)	Q.	5	6	7			
	A.	B,C	B,D	B,D			
SECTION-I (iii)	Q.	8	9	10			
	A.	B	A	A			
SECTION-II	Q.	1	2	3	4	5	6
	A.	4.00	0.14 to 0.15	25.00	3.46	0.50	6.00

PART-2 : CHEMISTRY

SECTION-I (i)	Q.	1	2	3	4		
	A.	A	B	D	B		
SECTION-I (ii)	Q.	5	6	7			
	A.	A,C,D	A,C,D	A,B,C,D			
SECTION-I (iii)	Q.	8	9	10			
	A.	B	A	B			
SECTION-II	Q.	1	2	3	4	5	6
	A.	4.00	3.00	3.00	7.00	5.70	4.00

PART-3 : MATHEMATICS

SECTION-I (i)	Q.	1	2	3	4		
	A.	A	B	B	A		
SECTION-I (ii)	Q.	5	6	7			
	A.	A,B,C	A,B,C,D	A,C			
SECTION-I (iii)	Q.	8	9	10			
	A.	C	D	B			
SECTION-II	Q.	1	2	3	4	5	6
	A.	0.00	4.00	1.00	2.00	5.00	2.00

HINT – SHEET

PART-1 : PHYSICS

SECTION-I (i)

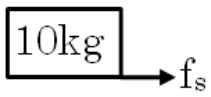
1. Ans (C)

$$\tan 37 = \frac{2H}{R} = 2\left[\frac{u_y^2}{2g}\right]\left[\frac{g}{2u_x u_y}\right]$$

$$2\tan 37 = \frac{u_y}{u_x} = \tan\theta$$

$$2 \times \frac{3}{4} = \tan\theta$$

2. Ans (A)



to not to slide,

$f_s = 10\ a \le \mu_S \times 10\ g$

$a \le 4\ m/s^2$

3. Ans (D)

Total number of revolution = Area of graph

$$= \frac{1}{2} \times 10 \times \frac{1200}{60} + 10 \times \frac{1200}{60} + \frac{1}{2} \times 20 \times \frac{1200}{60}$$

$$= \frac{1}{2} \times 10 \times 20 + 10 \times 20 + \frac{1}{2} \times 20 \times 20$$

$$= 100 + 200 + 200 = 500$$

4. Ans (C)

Maximum speed is at mean position (equilibrium).

$F = kx$

$$x = \frac{F}{k}$$

$W_F + W_{sp} = \Delta KE$

$$F(x) - \frac{1}{2}kx^2 = \frac{1}{2}mv^2 - 0$$

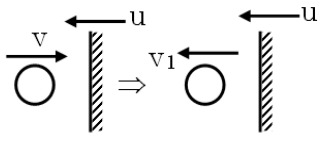
$$F\left(\frac{F}{k}\right) - \frac{1}{2}k\left(\frac{F}{k}\right)^2 = \frac{1}{2}mv^2$$

$$\Rightarrow v_{max} = \frac{F}{\sqrt{mk}}$$

PART-1 : PHYSICS

SECTION-I (ii)

5. Ans (B,C)



$$e = 1 = \frac{v_1 - u}{v + u} \therefore v_1 = v + 2u$$

$\Delta P = m(v_1 + v)$

$= 2m(v + u)$

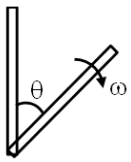
$$F = \frac{\Delta P}{\Delta t}$$

$$\Delta K = \frac{1}{2}m\left(v_1^2 - v^2\right)$$

$$= \frac{1}{2}m(v_1 - v)(v_1 + v)$$

$= 2mu(u + v)$

6. Ans (B,D)



$$mg\frac{\ell}{2}(1 - \cos\theta) = \frac{1}{2}I\omega^2$$

$$mg\frac{\ell}{2}(1 - \cos\theta) = \frac{m\ell^2}{6}\omega^2$$

$$\omega = \sqrt{\frac{3g}{\ell}(1 - \cos\theta)}$$

$$\omega_2 = \sqrt{\frac{3g}{2\ell}}$$

$$\omega_3 = \sqrt{\frac{3g}{\ell}}$$

$$\omega_4 = \sqrt{\frac{6g}{\ell}}$$

7. Ans (B,D)

At maximum compression $\vec{v}_A = \vec{v}_B$ & kinetic

energy of A–B system will be minimum

so $v_A = v_B = \frac{v}{2} \Rightarrow K_{AB} = \frac{1}{4}mv^2$

From energy conservation

$$\frac{1}{2}mv^2 = \frac{1}{2}m\left(\frac{v}{2}\right)^2 + \frac{1}{2}m\left(\frac{v}{2}\right)^2 + \frac{1}{2}kx_m^2$$

$$\Rightarrow x_m = v\sqrt{\frac{m}{2k}}$$

PART-1 : PHYSICS

SECTION-I (iii)

8. Ans (B)

If $\vec{u}||\vec{a}$ straight line

If $\vec{a}$ = constant. straight line or parabola

9. Ans (A)

$\overrightarrow{V_D} = \vec{V}_{D,P} + \vec{V}_{P,G} = 4\left(-\hat{i}\right) - 1\hat{j}$

$\overrightarrow{V_D} = \sqrt{17}$ m/s

10. Ans (A)

For $v \geqslant \sqrt{5g\ell}$, the bob will complete a vertical circular path

For $\sqrt{2g\ell} < v < \sqrt{5g\ell}$, the bob will execute projectile motion For $v < \sqrt{2g\ell}$, the bob oscillates

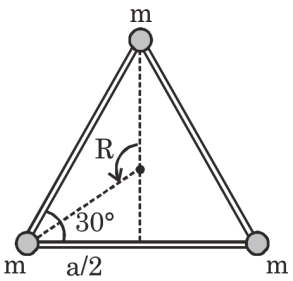
PART-1 : PHYSICS

SECTION-II

1. Ans (4.00)

$F_0 = \frac{1}{4\pi\epsilon_0}\frac{q^2}{r^2} = \frac{1}{4\pi\epsilon_0 K}\frac{(4q)^2}{(2r)^2}$, K = 4

2. Ans (0.14 to 0.15)



$KE_{rot} = \frac{1}{2}I\omega^2 = \frac{1}{2}3m\left(\frac{a}{\sqrt{3}}\right)^2\omega^2 = \frac{1}{2}ma^2\omega^2$

$= \frac{1}{2}\times\frac{1}{5}\times\frac{4}{25}\times 9 = \frac{18}{125} = 0.14$

3. Ans (25.00)

Given a particle of mass = 10 kg

SHM of time period = 25

Amplitude of oscillation = 0.25

Equation of particle will be $x = A\sin\omega t$

$v = \frac{dx}{dt} = A\omega\cos\omega t$

$a = \frac{dv}{dt} = -A\omega^2\sin\omega t$

$a_{max} = A\omega^2$

and $F_{max} = m \times a_{max}$

$= 10 \times A\omega^2$

$= 10(0.25)\left(\frac{2\pi}{T}\right)^2 \quad \left[\omega = \frac{2\pi}{T}\right]$

$= 2.5\left(\frac{4\pi^2}{2\times 2}\right)$

$2.5\ (3.14)^2 = 24.65N$

4. Ans (3.46)

$T = 12$ g & $T = 10(1)\ \omega^2$

5. Ans (0.50)

$e = \frac{v_f}{v_i} = \frac{\sqrt{2gh}}{\sqrt{4gh}} = \frac{1}{\sqrt{2}}$

6. Ans (6.00)

To reach opposite bank with zero drift.

$v_{Br}\sin\theta = v_R$

$2\sin\theta = 1$

$\sin\theta = \frac{1}{2}$

$\theta = \frac{\pi}{6}$

PART-2 : CHEMISTRY

SECTION-I (i)

1. Ans (A)

The correct answer option is (A)

2. **Ans (B)**

From the reaction, we see that for every two N_2O_5 consumed, one O_2 is produced. Thus we can calculate the rate of consumption of N_2O_5 and then use a ratio from the reaction.

$$\frac{0.080 \text{ mol } N_2O_5}{4.0 \text{ L} \times 0.20 \text{ s}} \times \frac{1 \text{ mol } O_2}{2 \text{ mol } N_2O_5} = \boxed{0.050 \text{ M s}^{-1}}$$

Thus, the answer is B.

3. **Ans (D)**

Explain Question :

Boiling of non volatile solute depends on

Concept: Elevation in boiling point ΔT_b

Solution:

When a non-volatile solute A is dissolved in a pure solvent B , its vapour pressure decreases and hence the boiling point increases. The difference ΔT_b of boiling points of the solution and pure solvent is called elevation in boiling point.

If T_b^0 is the boiling point of pure solvent and T_b is the boiling point of the solution then, $T_b > T_b^0$ and the elevation in boiling point $\Delta T_b = T_b - T_b^0$

Experiments have shown that for dilute solutions, the elevation of boiling point (ΔT_b) is directly proportional to the molal concentration of the solute in a solution. Thus

$\Delta T_b \propto m$

or $\Delta T_b = K_b.m$

where K_b = boiling point elevation constant or molal elevation constant or ebulioscopic constant.

Molal elevation constant is characteristic of a particular solvent and can be calculated from the thermodynamical relationship.

$$K_b = \frac{RT_b^2M}{1000\Delta H_{vap}}$$

Where, R is molar gas constant =2cal/mol-K,

M= molar mass of solvent

Final Answer = Option (4)

Boiling point of an ideal liquid solution containing non-volatile solute depends on all the given factors. hence all options are correct.

4. **Ans (B)**

The correct answer is option (B)

PART-2 : CHEMISTRY

SECTION-I (ii)

5. **Ans (A,C,D)**

The correct answer option is (A), (C), (D)

6. **Ans (A,C,D)**

$Al(CH_3)_3$ and B_2H_6 has three centre two electron bond.

$(AlCl_3)_2$ has three centred $4e^-$ bond.

$AlCl_3$ shows less lewis acidic character as compared to BCl_3.

7. **Ans (A,B,C,D)**

The correct answer is option (A),(B),(C),(D)

PART-2 : CHEMISTRY

SECTION-I (iii)

8. **Ans (B)**

(P) is Tautomers, Same molecular formula.

(Q) is Metamers, Same molecular formula.

(R) is Functional isomers, Same molecular formula.

(S) is Homologues

9. **Ans (A)**

P $\longrightarrow$ 1,2,3

Q $\longrightarrow$ 4,5

R $\longrightarrow$ 2,4,5

S $\longrightarrow$ 1,2,3

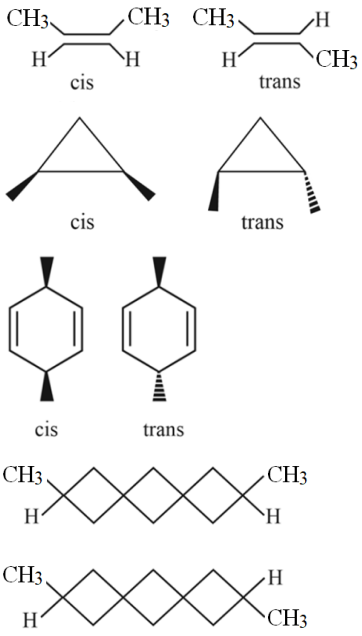
10. **Ans (B)**

The correct answer is option (B)

PART-2 : CHEMISTRY

SECTION-II

1. Ans (4.00)



2. Ans (3.00)

The correct answer is 3.00

3. Ans (3.00)

For first order reaction $t = \frac{2.303}{k}\log\frac{N_0}{N_1}$

At 298 K, $t = \frac{2.303}{k_{298}}\log\frac{100}{90}$

At 308K, $t = \frac{2.303}{k_{308}}\log\frac{100}{25}$

Since time is same

$$\frac{2.303}{k_{298}}\log\frac{100}{90} = \frac{2.303}{k_{308}}\log\left(\frac{100}{75}\right)$$

$$\frac{k_{308}}{k_{298}} = 3$$

4. Ans (7.00)

Molar mass of $Na_2SO_4.nH_2O = 142 + 18n$

number of moles of water $= \frac{12.6}{26.8}$

So, mass of water $= \frac{12.6}{26.8} \times (142 + 18n)$

$18n = \frac{12.6}{26.8} \times (142 + 18n)$

$n = 7$

5. Ans (5.70)

From Raoult's law,

$$\frac{P_0 - P}{P_1} = \frac{W_B \times M_A}{W_A \times M_B}$$

or, $\frac{1}{19} = \frac{0.3 \times W_B}{W_A}$

6. Ans (4.00)

XeF_4, NO_3^- , SiF_4 , H_2S

PART-3 : MATHEMATICS

SECTION-I (i)

1. Ans (A)

$$\lim_{x\to0} \frac{-2\sin x}{x} \times \frac{(1-\cos x)}{x^2} \times \frac{(1+\cos x)}{\frac{\ell n(1+x^3)}{x^3}}$$

$$= -2 \times 1 \times \times \frac{1}{2} \times \frac{2}{1} = -2$$

2. Ans (B)

$$\lim_{x\to0} \frac{(1+\cos 2x) - 2\cos x + a(1-\cos x)}{x^2}$$

$$\lim_{x\to0} \frac{2\cos x(\cos x - 1) + a(1-\cos x)}{x^2}$$

$$\lim_{x\to0} \frac{(1-\cos x)}{x^2}(2\cos x - a) = \frac{1}{2}$$

$a = 3$

3. Ans (B)

$$\lim_{x\to0} \frac{x^2}{\sin(2\pi\sec x - 2\pi)}$$

$$= \lim_{x\to0} \frac{x^2 \times (2\pi(\sec x - 1))}{\sin(2\pi(\sec x - 1))(2\pi(\sec x - 1))}$$

$$= \lim_{x\to0} \frac{x^2\cos x}{2\pi(1-\cos x)} = \frac{2\times1}{2\times\pi} = \frac{1}{\pi}$$

4. Ans (A)

$$e^{\lim\limits_{n\to\infty}\left(1+\frac{1}{n^3+3n^2+n\sin n+1}-1\right)n^3+5}$$

$$= e^{\lim\limits_{n\to\infty}\frac{n^3+5}{n^3+3n^2+n\sin n+1}}$$

$$= e^{\lim\limits_{n\to\infty}\frac{1+\frac{5}{n^3}}{1+\frac{3}{n}+\frac{\sin n}{n^2}+\frac{1}{n^3}}} = e^1$$

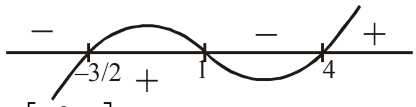
PART-3 : MATHEMATICS

SECTION-I (ii)

5. Ans (A,B,C)

$2x^3 - 7x^2 - 7x + 12 \geq 0$

$= 2(x-1)(x-4)\left(x + \frac{3}{2}\right) \geqslant 0$

$\Rightarrow$ 

$\Rightarrow x \in \left[-\frac{3}{2}, 1\right] \cup [4, \infty)$

6. Ans (A,B,C,D)

Let $f(x) = ax + b$

Either	OR
$f(-1) = 3$	$f(-1) = 5$
$f(1) = 5$	$f(1) = 3$
$f(x) = 4 + x$	$f(x) = 4 - x$

7. Ans (A,C)

$f(x)$ is odd degree polynomial $\Rightarrow$ onto

and $f'(x) > 0 \Rightarrow f$ is one-one

PART-3 : MATHEMATICS

SECTION-I (iii)

8. Ans (C)

(P) $-1 \leq [2x] \leq 1$ and $[x] \neq 0$

$-1 \leq 2x \leq 2$ and $x \notin [0, 1)$

$-\frac{1}{2} \leq x < 1$ and $x \notin [0, 1)$ $\quad \therefore x \in \left[-\frac{1}{2}, 0\right)$

(Q) $-2 \leq 2x + 4 \leq 10 \Rightarrow -6 \leq 2x \leq 6$

$\Rightarrow -3 \leq x \leq 3$

(R) $f(x) = x^4 - x^2 = x^2(x^2 - 1)$

$f(t) = t(t-1),\ 0 \leq t < \infty$

$\therefore f(t) \in \left[\frac{-1}{4}, \infty\right)$

(S) $f(x) = \log_2\left(1 - [\sin^2 x]\right) + \cos^2 x$

$[\sin^2 x] < 1 \Rightarrow [\sin^2 x] = 0 \Rightarrow 0 \leq \sin^2 x < 1$

$\therefore \sin^2 x \neq 1 \Rightarrow 0 < \cos^2 x \leq 1$

$\therefore$ range of f(x) is (0, 1]

9. Ans (D)

(Q) $\lim\limits_{x\to 0}\left[\frac{5\sin 2x}{2x}.2\right] = 9$

(R) $\lim\limits_{x\to 0}[1 + [x]]^{\frac{2}{x}} = 1$

(S) $\lim\limits_{x\to 0}\left(\frac{\tan 2x - 2x}{x^3}\right) = \frac{8}{3}$

10. Ans (B)

For each part, we consider boundary values :

(P) $\sin^{-1}x = \pm\frac{\pi}{2}$; $\sin^{-1}y = \pm\frac{\pi}{2}$

$\Rightarrow x = \pm 1$; $y = \pm 1$

$\therefore x^3 + y^3$ can be 2, 0, −2

(Q) $\cos^{-1}x = \pi$; $\cos^{-1}y = \pi$

$\Rightarrow x = -1$; $y = -1$

$\therefore x^5 + y^5 = -2$

(R) $\sin^{-1}x = \pm\frac{\pi}{2}$; $\cos^{-1}y = \pi$

$\Rightarrow x = \pm 1$; $y = -1$

(S) $\sin^{-1}x = -\frac{\pi}{2}$; $\sin^{-1}y = \frac{\pi}{2}$

or $\sin^{-1}x = \frac{\pi}{2}$; $\sin^{-1}y = -\frac{\pi}{2}$

$\Rightarrow$ (x, y) can be (−1, 1) or (1, −1)

$\therefore |x|^y$ can be 1

PART-3 : MATHEMATICS

SECTION-II

1. Ans (0.00)

$f\left(\frac{\pi^-}{4}\right) = f\left(\frac{\pi^+}{4}\right) = f\left(\frac{\pi}{4}\right)$

$\Rightarrow \frac{\pi}{4} + A = \frac{\pi}{2} + B$ ....(1)

$f\left(\frac{\pi^-}{2}\right) = f\left(\frac{\pi^+}{2}\right) = f\left(\frac{\pi}{2}\right)$

$B = -A - B$ ....(2)

$\Rightarrow A + 2B = 0$

2. Ans (4.00)

$x = \frac{\pi}{4} - \left(\pi - \cos^{-1}\frac{1}{2}\right) + \frac{\pi}{6} + \left(\pi - \cot^{-1}\sqrt{3}\right) + \frac{\pi}{6} = \frac{3\pi}{4}$

& $y = \frac{3}{4}$

$\therefore 4y - \tan x = 4$

3. Ans (1.00)

$T_n = \tan^{-1}\left(\frac{\frac{n+1}{2} - \frac{n}{2}}{1 + \frac{n}{2}.\frac{n+1}{2}}\right) = \tan^{-1}\left(\frac{n+1}{2}\right) - \tan^{-1}\frac{n}{2}$

4. Ans (2.00)

Use multiple, submultiple angle formula.

5. Ans (5.00)

$\sin25°\cos20°(\tan60° + \tan35°)$

$= \sin 25° \sin 70° \frac{\sin 95°}{\cos 60°.\cos 35°}$

$= 4\sin25°\sin35°\sin95°$

$= 4 \times \frac{1}{4}\sin(105°) = \frac{\sqrt{3}+1}{\sqrt{8}}$

$\Rightarrow p = 3, q = 8$

6. Ans (2.00)

$\tan\left(2\left(\tan^{-1}\frac{1}{5} + \tan^{-1}\frac{1}{8}\right) + \tan^{-1}\left(\frac{1}{2}\right)\right)$

$= \tan\left[2\tan^{-1}\left(\frac{1}{3}\right) + \tan^{-1}\left(\frac{1}{2}\right)\right]$

$= 2$