PACE-IIT & MEDICAL

MUMBAI / DELHI-NCR / PUNE / NASHIK / AKOLA / GOA / JALGOAN / BOKARO / AMRAVATI / DHULE

IIT – JEE: 2025 ADVANCED | **MAJOR TEST - 3** | **DATE: 28/01/24**

ANSWER KEY

PAPER – 1 (Code – 11)

PHYSICS		CHEMISTRY		MATHEMATICS	
1.	A, B, C	**18.**	A, C, D	**35.**	A, C, D
2.	A, C, D	**19.**	C, D	**36.**	A, B
3.	A	**20.**	A, B, D	**37.**	A, C, D
4.	D	**21.**	C	**38.**	C
5.	B	**22.**	C	**39.**	A
6.	C	**23.**	B	**40.**	C
7.	B	**24.**	C	**41.**	B
8.	4	**25.**	8	**42.**	6
9.	5	**26.**	5	**43.**	5
10.	8	**27.**	6	**44.**	12
11.	3	**28.**	5	**45.**	4
12.	5	**29.**	4	**46.**	0
13.	7	**30.**	6	**47.**	4
14.	C	**31.**	A	**48.**	B
15.	A	**32.**	B	**49.**	B
16.	D	**33.**	B	**50.**	D
17.	B	**34.**	D	**51.**	B

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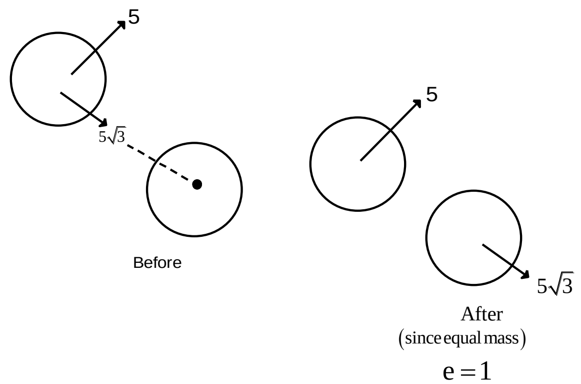
PAPER – 2 (Code – 21)

PHYSICS		CHEMISTRY		MATHEMATICS	
1.	B	**18.**	A	**35.**	A
2.	D	**19.**	B	**36.**	D
3.	B	**20.**	C	**37.**	B
4.	D	**21.**	B	**38.**	A
5.	A, B, C	**22.**	B, C	**39.**	C, D
6.	A, C, D	**23.**	A, D	**40.**	A, B, C
7.	C	**24.**	B, C, D	**41.**	A, B, D
8.	4	**25.**	3	**42.**	1
9.	2 or 3	**26.**	5	**43.**	6
10.	7	**27.**	4	**44.**	4
11.	35	**28.**	5	**45.**	2
12.	1	**29.**	6	**46.**	7.00
13.	5	**30.**	2	**47.**	2.00
14.	2.9 to 3	**31.**	16	**48.**	243
15.	3.8 to 3.9	**32.**	2.4	**49.**	405
16.	5	**33.**	1.78	**50.**	1
17.	15.70	**34.**	76.66 – 76.67	**51.**	0.67

PART (A) : PHYSICS

1. (A, B, C)



2. (A, C, D)

Volume is doubled $\Rightarrow$ Density is half

$pv^{-1} = \text{constant}$ $[\because pv = nRT]$

$\Rightarrow TV^{-2} = \text{constant}$. Hence parabola

$\therefore$ Volume is doubled so temp becomes 4 times

3. (A)

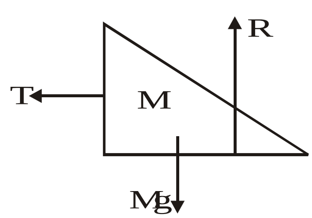
$M'g - T = M'a$ … (i)

T = Ma … (ii)

$M'g = a(M + M')$

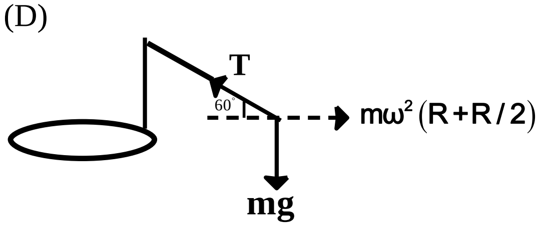
$a = \frac{M'g}{(M + M')}$

$ma\sin\theta = mg\cos\theta$



$a = g\cot\theta$

4. (D)



$\Rightarrow T\cos 60^\circ = m\omega^2\, 3R/2$

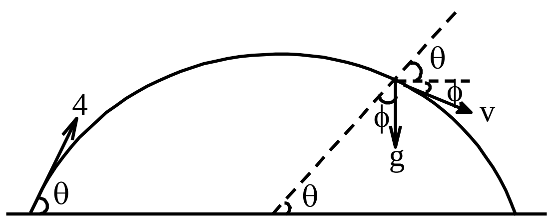
$T\sin 60^\circ = mg$

$$\cot 60^\circ = \frac{3\omega^2 R}{2g}$$

$$\Rightarrow \omega^2 = \frac{2g}{3\sqrt{3}R}$$

$$\therefore \omega = \sqrt{\frac{2g}{3\sqrt{3}R}}$$

5. (B)

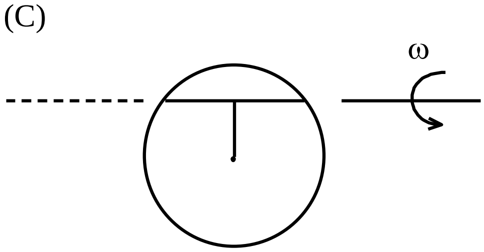


$v\cos\phi = u\cos\theta$ $\qquad$ $v = u\cot\theta$

$$\phi = \frac{\pi}{2} - \theta$$

$$\text{Radius of curvature}\,(R) = \frac{v^2}{g\cos\phi} = \frac{u^2\cot^2\theta}{g\sin\theta}$$

6. (C)



$$F \times x = \left(\frac{mr^2}{4} + mx^2\right)\alpha$$

$$\alpha = \frac{4Fx}{m\left(r^2 + 4x^2\right)}$$

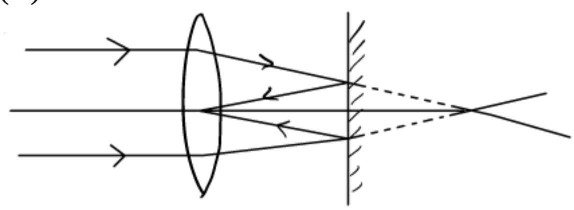
$$\alpha = \frac{4F}{m\left(\frac{r^2}{x} + 4x\right)}$$

$$y = \frac{r^2}{x} + 4x$$

$$\frac{dy}{dx} = -\frac{r^2}{x^2} + 4 = 0$$

$\Rightarrow \quad x = \frac{r}{2}$

7. (B)

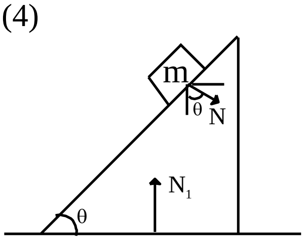


For lens : $v = 20\text{ cm}$

$u = -\infty$

$\Rightarrow \quad f = 20\text{ cm}$

8. (4)



$N = mg\cos\theta$

$N_1 = mg\cos^2\theta + Mg$

To prevent slipping

$N\sin\theta = \mu N_1$

$\Rightarrow mg\cos\theta\sin\theta = \mu\left(mg\cos^2\theta + Mg\right)$

$\Rightarrow \frac{mg}{2} = 0.1\left(\frac{mg}{2} + Mg\right)$

$\Rightarrow 9m\not{g} = 2M\not{g}$

$\Rightarrow m = \frac{2M}{g} = \frac{2\times 18}{9} = 4\text{ kg}$

9. (5)

$\because$ All friction forces are internal. Hence by constant of linear momentum

$\Rightarrow (3+2+1)v = 3\times 10$

$\Rightarrow v = 5\text{ m/s}$

$\therefore$ Total loss in KE of system

$= \frac{1}{2}\times 3\times (10)^2 - \frac{1}{2}\times 6\times (5)^2$

$= 150 - 75 = 75\text{ J}$

$\therefore$ Work done by friction $= -75\text{ J}$.

10. (8)

$$N = \frac{3Mgx}{L}$$

$$\Rightarrow 5x = \frac{3 \times 40 \times \frac{5}{3}}{5}$$

$$\Rightarrow x = 8$$

11. (3)

$$I = I_{cm} + md^2$$

I is minimum about an axis passing through COM.

$$I = 2x^2 - 12x + 27$$

$$\frac{dI}{dx} = 0 \qquad \Rightarrow \qquad 4x - 12 = 0$$

$x = 3$

12. (5)

$$\int_{300K}^{500K} m(A + BT)\,dT = 100 \times 80 + 100 \times 27 = 10700\,\text{cal}$$

$$m\left[AT + \frac{BT^2}{2}\right]_{300}^{500} = 10700$$

$$m\left[10.5 \times 200 + 5 \times 10^{-4} \times \frac{(500^2 - 300^2)}{2}\right] = 10700$$

$$m = \frac{10700}{2100 + 40} = \frac{10700}{2140} = 5\,\text{kg}$$

13. (7)

$$7m\omega^2 l \ge 5\mu mg$$

$$\omega \ge \sqrt{\frac{5\mu g}{7l}}$$

14. (C)

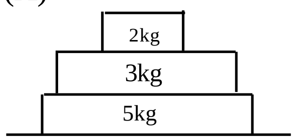
(P) Since relative acceleration zero- relative velocity constant. Hence motion is straight line.

(Q) Stationary particle as seen from a projectile will exactly be the reverse motion

(R) The particle will have a uniform acceleration as seen from projectile but if its velocity w.r.t. to projectile is along the same line as the relative acceleration then the apparent motion will be straight line

(S) same as previous part

15. (A)



f_{L_1} : limiting friction between 2 kg and 3kg =4N ; f_{L_2} = Limitup friction between 3 kg and 5kg $= 5N$

f_{L_3} = limiting friction between 5 kg and ground $= 10\,N$

$f_{L_2} < f_{L_3}$ so relative motion does not occur at the bottom surface, $f_3 = f_2$. But 3kg will slip over 5 kg assume if 2 kg and 3 kg move with same acceleration

$\Rightarrow$ acceleration of two blocks $= \dfrac{100-5}{5} = 19 m/s^2$ $\quad f_1 = 2a = 38 > f_{\ell_1}$

So relative motion between 2kg and 3kg block $\quad \therefore\ f_1 = f_{\ell_1} = 4N$

As relative motion between 3 and 5kg block

$f_2 = f_{\ell_2} = 5N$

As 5 kg does not slip $f_3 = f_2 = 5N$ on 5kg

Block F_2 and F_3 are equal but opposite hence zero resultant friction will act on 5 kg

16. (D)

(P) for $u > f$ image is real $u < f$ image is virtual. For $u = \dfrac{f}{2}$ image distance = f .

Hence 1, 2,4.

(Q) Object is virtual hence a concave mirror always forms a real image, and image distance is always $< f$. Hence only 1 is correct

(R) for real objects convex mirror forms only virtual images and image distance is always $< f$.

(S) for virtual objects convex mirror can form both real and virtual objects, for u = focal length image is formed at infinity. Hence 1, 2, 4

17. (B)

(P) $\therefore F_{net} = 0 \Rightarrow$ No translation

$\therefore \tau_{net} \neq 0 \Rightarrow$ Rotation

(Q) $\because F_{net} \neq 0 \Rightarrow$ Translation

$\because \tau_{net}$ may or may not be zero.

$\therefore$ Object may or may not rotate.

(R) $\because F_{net} \neq 0 \Rightarrow$ Translation

$\because \tau_{net}$ may or may not be zero.

$\therefore$ Object may or may not rotate.

(S) $\because F_{net} \neq 0 \Rightarrow$ Translation

$\because$ τ_{net} may or may not be zero

$\therefore$ Object may or may not rotate.

PART (B) : CHEMISTRY

18. **(ACD)**

19. **(CD)**

(A) $\rightarrow$ –ve charge is more stable on more electronegative element.

(B) $\rightarrow$ Charge separation

(C) $\rightarrow$ $CH_3-C\equiv\overset{+}{\underset{\cdot\cdot}{O}}$ octet rule

(D) +ve charge is more stable on more electropositive element.

20. **(ABD)**

21. **(C)**

$$2FeO+\frac{1}{2}O_2 \rightarrow Fe_2O_3$$

$$\text{i} \quad \frac{2}{3} \qquad\qquad \frac{1}{3}$$

$$\text{f} \quad \frac{2}{3}-2x \qquad\qquad \frac{1}{3}+x$$

$$\frac{\frac{1}{3}+x}{\frac{2}{3}-2x}=\frac{2}{1}$$

$$\frac{1}{3}+x=\frac{4}{3}-4x$$

$$5x=1$$

$$x=\frac{1}{5}$$

$$\Delta H^{o}_{Rxn}=(-200)-2(-60)$$

$$=-80kJ/mole \text{ of } Fe_2O_3$$

$$\text{Heat}=-80\times\frac{1}{5}=-16kJ$$

22. **(C)**

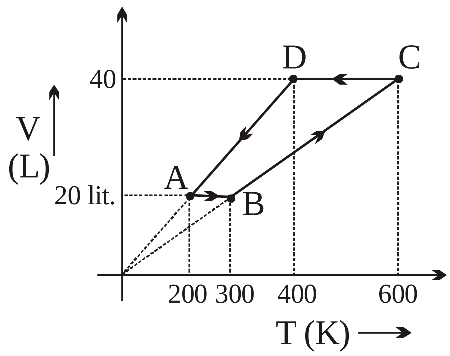
$$\frac{d(\Delta H)}{dT}=\Delta C_p \ ; \qquad \Delta C_p=-C_{P\,(reactant)}+C_{P\,(products)}$$

$$\therefore \int_{\Delta H_1}^{\Delta H_2} d(\Delta H)=\Delta C_P\int_{T_1}^{T_2} dT.$$

23. (B)

24. (C)

25. **(8)**



$W_{AB} = W_{CD} = 0$

$W_{BC} = -nR\Delta T = -1 \times R \times 300 = 300\ R$

$W_{DA} = -nR\Delta T = -1 \times R \times -200 = 200\ R$

$W_{total} = -100\ R$

$\Rightarrow |W| = 8$ atm. lit.

26. **(5)**

$\Delta U_{tot} = 0$

$Q_{tot} = 45 - 60$

$= -15J$

$\Rightarrow W_{tot} = 15J = -10 + W_2$

$W_2 = 25J$

$\Rightarrow x = 5$

27. **(6)**

	A_2	+	B_2	$\rightleftharpoons$	2AB
i	0.2		0.2		0
e	0.05		0.05		0.3

$$K_1 = \frac{0.3 \times 0.3}{0.05 \times 0.05} = 36$$

$A_2 + B_2 \rightleftharpoons 2AB$

$0.08 - y \quad 0.08 \quad 0.24$

$$\frac{0.24 \times 0.24}{0.08 \times (0.08 - y)} = 36$$

$A_2 + C_2 \rightleftharpoons 2AC$

$$\Rightarrow 0.08 - y = \frac{3 \times 0.24}{36}$$

$0.08 - y \quad 0.1 - y \quad 2y$

$y = 0.06$

$$K_2 = \frac{0.12 \times 0.12}{0.02 \times 0.04} = 18$$

$x = 6$

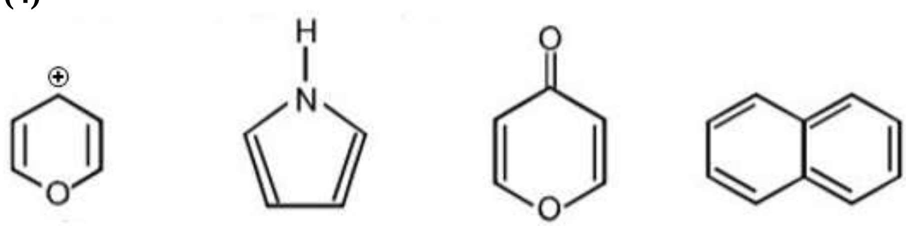
28. **(5)**

$$K_{neutralisation} = \frac{1}{K_{hydro}} = \frac{K_a}{K_w} = 10^{+9}$$

$$\frac{k_f}{k_b} = 10^{+9} \Rightarrow \frac{10^{-11}}{k_b} = 10^{+9} \Rightarrow k_b = 10^{-20}$$

$\therefore x = 5$

29. **(4)**



30. (6)

31. (A)

32. (B)

(1) $\left[OH^-\right] = \sqrt{\frac{2\times10^{-6}}{2\times10^{-3}}} = 10^{-1.5}$

$pOH = 1.5 \quad \Rightarrow \quad pH = 12.5$

(2) $1\times10^{-28} = 0.1\times\left[OH^-\right]^3$

$\left[OH^-\right] = 10^{-9}$

$pOH = 9 \quad \Rightarrow \quad pH = 5$

(3) $10^{-5} = \left[H^+\right]\times\frac{\frac{10}{11}}{\frac{1}{11}}$

$\left[H^+\right] = 10^{-6} \quad \Rightarrow \quad pH = 6$

(4) $pH = \frac{7--3}{2} = 5$

(5) $pH = 7 + \frac{1}{2}\log\left(6\times10^{-5}\right) + \frac{8.22}{2}$

$= 7 + 4.11 - 2.11 = 9$

33. (B)

34. (D)

PART (C) : MATHEMATICS

35. (A, C, D)

36. (A, B)

$a_2 = a_1 k\,;\; a_3 = ka_2 = k^2 a_1$

$\therefore \quad a_1(k-1)(k-3) > 0$

as $\quad a_1 < 0$

$(k-1)(k-3) < 0$

$\Rightarrow \quad k \in (1, 3)$

37. (ACD)

$f^{-1}(5) = 2$

$f^{-1}(x+4) = 2f^{-1}(x) + 1$

Put $x = 1 \quad \Rightarrow f^{-1}(1) = \dfrac{1}{2}$

Similarly put $x = 5, 9, 13$ to get remaining results.

38. (C)

G.M of roots $= H.M.$ of roots

$\Rightarrow \alpha = \beta = \gamma = \delta = 2(each)$

Where $\alpha, \beta, \gamma, \delta$ are roots of given equation

$\therefore p = -8, q = 24$

39. (A)

Given equation,

$x^2 - |x| - 12 = 0$

$\Rightarrow \quad |x^2| - |x| - 12 = 0$

$\Rightarrow \quad |x^2| - 4|x| + 3|x| - 12 = 0$

$\Rightarrow \quad (|x| - 4)(|x| + 3) = 0$

So $\quad |x| - 4 = 0$ or $|x| + 3 = 0$

$|x| = 4$ or $|x| = -3$ (not possible)

$x = \pm 4$

Hence, the number of real solution = 2

40. (C)

$$T_n = \frac{n}{(n^4 + 4n^2 + 4) - 4n^2} = \frac{n}{(n^2+2)^2 - (2n)^2} = \frac{n}{(n^2+2+2n)(n^2+2-2n)}$$

$$T_n = \frac{1}{4}\left[\frac{(n^2+2+2n)-(n^2-2n+2)}{(n^2+2+2n)(n^2-2n+2)}\right] = \frac{1}{4}\left[\frac{1}{(n-1)^2+1} - \frac{1}{(n+1)^2+1}\right]$$

$$\therefore\ S_n = \sum_{n=1}^{\infty} T_n = \frac{3}{8}$$

41. (B)

$$\text{Limit} = \lim_{n\to\infty}\left(1+\frac{\sin\frac{a}{n}}{\frac{a}{n}}.\frac{a}{n}\right)^n = \lim_{x\to\infty}\left(1+\frac{a}{n}\right)^n = e^a$$

42. (6)

$1+2\cos 2x = 0$

$\Rightarrow 4\cos^2 x - 1 = 0$

$\Rightarrow x = \frac{\pi}{3}, \frac{2\pi}{3}, \frac{4\pi}{3}, \frac{5\pi}{3}$ (i)

Also, $|\sin x| = 1 \quad \Rightarrow x = \frac{\pi}{2}, \frac{3\pi}{2}$ (ii)

43. **(5)**

$f(x) = \cos(5x - [5x]) = \cos\{5x\}$ where $\{.\}$ is a fractional part function

44. (12)

Perfect square >1 $[\sqrt{100}] - 1 = 9$ (where [.] denotes integral part)

Perfect cubes >1 $[\sqrt[3]{100}] - 1 = 3$ (in which 4^3 is already in included)

Perfect 4^{th} power >1 $[\sqrt[4]{100}] - 1 = 2$ (already included in squares)

Perfect 5^{th} power >1 $[\sqrt[5]{100}] - 1 = 1$

Perfect 6^{th} power >1 $[\sqrt[6]{100}] - 1 = 1$ (already included in cubes)

$\Rightarrow$ 9 + 2 + 1 = 12

45. (4)

If a is integer then x must be integer, i.e., [x] = x

$a = x^3 + x$

$1 \le a \le 500 \Rightarrow 1 \le x \le 7,\ x \in I$

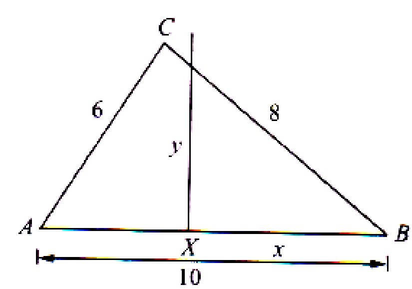
$$\sum a_i = \sum_{x=1}^{7}\left(x^3 + x\right) = \left(\frac{7\cdot 8}{2}\right)^2 + \left(\frac{7\cdot 8}{2}\right) = 812$$

46. (0)
$\because 4+5+3=12$

47. (4)
$x + y + z = 13-6$
$x + y + z = 7$
no. of non-negative integral solutions = ${}^{n+r-1}C_{r-1}$

48. (B)
(P) $6x + 10 - x^2 > 3$
$\therefore$ $x^2 - 6x - 7 < 0$
$(x + 1)(x - 7) < 0$
$\Rightarrow$ 0, 1, 2, 3, 4, 5, 6,

(Q) $f(x) = (x - 1)(x^2 - 7x + 13)$ for f(x) to be prime at least one of the factors must be prime.
Hence $x - 1 = 1 \Rightarrow x = 2$ or $x^2 - 7x + 13 = 1 \Rightarrow x^2 - 7x + 12 = 0 \Rightarrow x = 3$ or 4
$\Rightarrow$ x = 2, 3, 4
(R) $D = a^2 - 4(a + 1) = p^2$, where $p \in I$
$\Rightarrow$ $(a - 2)^2 - p^2 = 8$
$\Rightarrow$ $(a - 2 + p)$ and $(a - 2 - p)$ are even
$\left.\begin{matrix} a-2+p=4 \\ a-2-p=2 \end{matrix}\right\}$ or $\begin{matrix} a-2+p=2 \\ a-2-p=4 \end{matrix}$ etc.
$\Rightarrow$ a = 5, p = –1, or a = –1, p = 1
$\Rightarrow$ number of integral value of 'a' = 2.



(S) $2\frac{x \cdot y}{2} = \frac{8 \times 6}{2} = 24$
$\Rightarrow$ $x \cdot x \tan B = 24$ $\Rightarrow$ $x^2 \times \frac{3}{4} = 24$
$\Rightarrow$ $x^2 = 32 \Rightarrow x = 4\sqrt{2}$

49. (B)

(P) From $\log_3(a+b) + \log_3(c+d) \ge 4$

We get $(a+b)(c+d) \ge 81$

Applying $AM \ge GM$ we get

$$\frac{(a+b)+(c+d)}{2} \ge \left((a+b)(c+d)\right)^{1/2} \ge 9$$

$(a+b+c+d)\geq 18$

(Q) $\frac{(x+y)^{14}(1+xy)^{14}}{(xy)^{14}}$ both factors in numerator have15 independent terms.

Hence total no of terms

$=15\times 15=225$

(R) $(23)^{86}=(529)^{43}=(530-1)^{43}$

$\Rightarrow\left[(530)^{43}-{}^{43}C_1(530)^{42}.........{}^{43}C_{41}(530)^2\right]+(43\times 530)-1.$

Hence last 2 digits are same as last two digits of $(43\times 530)-1$, i.e. 89

(S) $T_3=5C_2\frac{1}{x^3}\left(x^{\log_{10}x}\right)^2=1000$

Taking $\log \text{to the base} 10$ of both sides we get,

$-3\log_{10}x+2(\log_{10}x)^2-2=0$

Put $\log_{10}x=t\Rightarrow 2t^2-3t-2=0$

$t=-\frac{1}{2},2$

As $x>1\Rightarrow \log_{10}x=2\Rightarrow x=100$

50. (D)

(P) $\lim_{x\to 0}\frac{(\sin 2x)^5(\tan 4x)^3}{\log_e^5(1+2x)}=0$

(Q) Put $x=\pi+h$ where $h\to 0$

$$\frac{\sin^{-1}(1-\cos h)}{(1-\cos h)}\times\frac{(1-\cos h)}{h^2}\times\frac{h\times\frac{h}{2}\times 2}{h.\sin\frac{h}{2}}=-1$$

$\Rightarrow |5L|=5$

(R) Make separate cases for three and four digit numbers. So total such numbers = 51

$\Rightarrow\left[\frac{N}{10}\right]=5$

(S) $f(x)=\operatorname{sgn}\left(\cot^{-1}x\right)=1$

51. (B)

(P) $\text{LHS}=\sin^2\theta+1-\left[\cos^2\left(120^\circ+\theta\right)-\sin^2\left(120^\circ-\theta\right)\right]$

$=\sin^2\theta+1-\left[\left(\cos 240^\circ\right)\left(\cos 2\theta\right)\right]=\sin^2\theta+1+\frac{1}{2}\cos 2\theta=\sin^2\theta+1+\frac{1}{2}\left(1-2\sin^2\theta\right)=\frac{3}{2}$

(Q) $2e^{2x}-5e^{x}+4=0$

Let roots be x_1 and x_2, product of the roots be

$e^{x_1}\cdot e^{x_2}=2, e^{x_1+x_2}=2$

$x_1+x_2=\ln 2$

(R) $a,b\in R\ \ p_1+=p_2=4\ \ 3\tan p_1+p_2=8=\tan p_1p_2=b^2=16-\tan 3p_2$

$p_1\ 2\tan 16x^2+25y^2=400, +\tan 3\theta=0\Rightarrow\frac{\tan 3\theta}{\tan\theta}=-2$

Now $\frac{\cot\theta}{\cot\theta-\cot 3\theta}=\frac{1}{1-\tan\theta-\cot 3\theta}=\frac{1}{1-\frac{\tan\theta}{\tan 3\theta}}=\frac{1}{1+\frac{1}{2}}=\frac{2}{3}$

Alternatively: Prove that $\frac{\tan\theta}{\tan\theta-\tan 3\theta}=\frac{1}{1-\frac{\tan\theta}{\tan 3\theta}}=1$ now proceed

(s) $\frac{2\sin\left(\theta-30^\circ\right)}{2\sin\left(\theta+120^\circ\right)}\cdot\frac{\cos\left(\theta+120^\circ\right)}{\cos\left(\theta-30^\circ\right)}=\frac{1}{3}$

$\frac{\sin\left(2\theta-90^\circ\right)-\sin 150^\circ}{\sin\left(2\theta+90^\circ\right)+\sin 150^\circ}=\frac{1}{3}$ or $\frac{\cos 2\theta-\frac{1}{2}}{\cos 2\theta+\frac{1}{2}}=\frac{1}{3}$ or $\frac{\cos 2\theta-\frac{1}{2}}{\cos 2\theta+\frac{1}{2}}=\frac{1}{3}$

$\Rightarrow\ 3\cos 2\theta-\frac{3}{2}=\cos 2\theta+\frac{1}{2}$

$2\cos 2\theta=2\Rightarrow\ \cos 2\theta=1$

PART (A) : PHYSICS

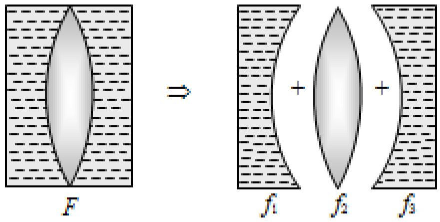
1. (B)

Work done = Area under the graph

$= \frac{\pi(1)(1)}{2} = \pi / 2 \text{ atm-litre}$

2. (D)

$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3}$



$\frac{1}{f_1} = (1.6-1)\left(\frac{1}{\infty} - \frac{1}{20}\right) = -\frac{0.6}{20} = -\frac{3}{100}$ ...(i)

$\frac{1}{f_2} = (1.5-1)\left(\frac{1}{20} - \frac{1}{-20}\right) = \frac{1}{20}$ ...(ii)

$\frac{1}{f_3} = (1.6-1)\left(\frac{1}{-20} - \frac{1}{\infty}\right) = -\frac{3}{100}$ ...(iii)

$\Rightarrow \frac{1}{F} = -\frac{3}{100} + \frac{1}{20} - \frac{3}{100} \Rightarrow F = -100 \text{ cm}$

3. (B)

Distance of image (I_1) seen directly $= \frac{y}{\mu}$.

Distance of image (I_2) seen mirror $= \frac{2h+y}{\mu}$.

$I_1 I_2 = \frac{2h}{\mu}$

4. (D)

Velocity of particle w.r.t platform in x direction = $\frac{v}{2}$

Velocity of platform = v

Velocity of particle in x direction w.r.t ground = $v + \frac{v}{2} = \frac{3v}{2}$

Time of flight will remain the same

So range will become 3R.

5. (ABC)

$v_0 = \sqrt{2gH}$ of A just before collision [For elastic collision]

$mv_0 = mv_1 + 3mv_2$ …..(1) $mv_0 = mv_1 + 3m(v_0 + v_1)$

$v_2 - v_1 = v_0$ …..(2) $4mv_1 = -2mv_0$

$v_1 = -\frac{\sqrt{2gh}}{2}$ $v_2 = +\frac{\sqrt{2gh}}{2}$ $v_1 = -\frac{v_0}{2}$

$\therefore$ both will rise up to height $H/4$

In case of Inelastic collision

$mv_0 = 4mv$

$v = \frac{v_0}{4} = \frac{\sqrt{2gH}}{4}$

$\therefore$ By conservation of energy combined mass will rise upto height $H/16$

6. (A, C, D)

Temperature first increases & then decreases

Temperature is maximum at midpoint $\left(\frac{3P_0}{4}, \frac{3V_0}{2}\right)$

$T_{max} = \frac{9P_0V_0}{8R}$ (At midpoint)

$T_{min} = \frac{P_0V_0}{R}$ (At initial & final state)

7. (C)

$U = 2x + 5y - xy$

$\bar{F} = -\frac{dU}{dx}\hat{i} - \frac{dU}{dy}\hat{j}$

$= (-2+y)\hat{i} + (-5+x)\hat{j}$

$\therefore m = 1kg \therefore$ acceleration at $(2,1)$

$\vec{a} = -\hat{i} - 3\hat{j}$

$\Rightarrow |\vec{a}| = \sqrt{10}$

8. (4)

Minimum force required $= \frac{\mu m\cancel{g}}{\sqrt{1+\mu^2}} = \frac{3}{5}m\cancel{g}$

$\Rightarrow 25\mu^2 = 9(1+\mu^2)$

$\Rightarrow 16\mu^2 = 9$

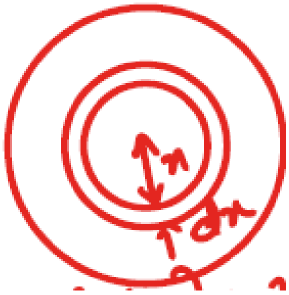
$\Rightarrow \mu = 3/4$

$\therefore x = 4$

9. (2 or 3)

$\tau = I\alpha$

$\mu mg(2R/3) = \left(\frac{MR^2}{2}\right)\alpha$



$\alpha = \frac{4\mu g}{3R}$

$\frac{2\omega_0}{3} = \alpha t \Rightarrow t = \frac{2\omega_0 3R}{3\times 4\mu g} = \frac{\omega_0 R}{2\mu g}$

$\tau = \mu g\left(2\pi x^2\, dx\right)(\sigma) = 2\mu(\sigma) g\pi \frac{R^2}{3} R$

$= \frac{2}{3}\mu mgR$

$\therefore x = 2$

10. (7)

$\frac{2}{m} = \frac{w}{\theta} = \frac{nR\Delta T}{nc_p\Delta T}$

$\Rightarrow \frac{2C_p}{R} = m$

$\Rightarrow 2\left(\frac{f}{2}+1\right) = m$

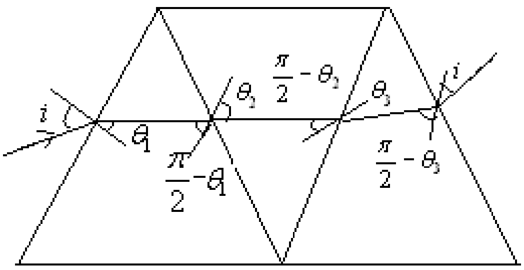
$\Rightarrow 2\left(\frac{5}{2}+1\right) = m$

$\Rightarrow m = 7$

11. (35)

Relative velocity of stone = 5 m/s
Relative acceleration of stone =10+5 = 15 m/s^2
Therefore, v = u +at =5 + 15 x 2 = 35 m/s
Therefore Relative velocity after t = 2 s is 35 m/s.

12. (1)



$1\sin i = \mu_1 \sin\theta_1$

$\mu_1 \cos\theta_1 = \mu_2 \sin\theta_2$

$\mu_2 \cos\theta_2 = \mu_3 \sin\theta_3$

$\mu_3 \cos\theta_3 = i\sin i$

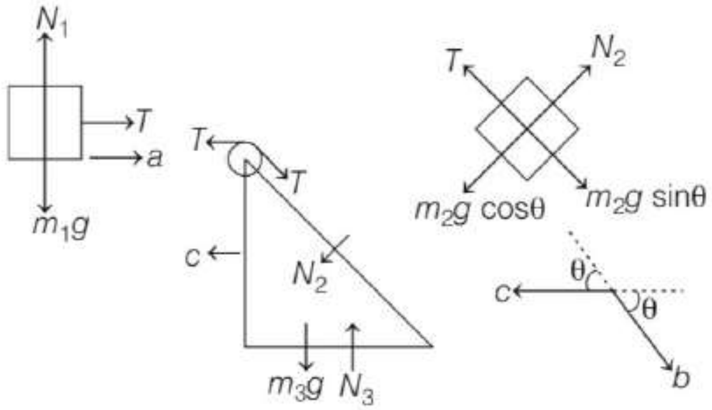
Squaring and rearranging will give

$\mu_1^2 + \mu_3^2 - \mu_2^2 = 1$

13. (5)
At maximum compression, the velocity of the both the blocks will be same.
From conservation of momentum theorem,
4 x 10 = (4+4) x v’ or v’ = 5 m/s

14. (2.9 to 3)

15. (3.8 to 3.9)



For $m_1 \Rightarrow T = m_1 a$ ...(i)

For $(m_2 + m_3)$ in horizontal

$\Rightarrow \quad T = m_3 c + m_2 (c - b\cos\theta)$ ...(ii)

For $m_2 \Rightarrow m_2 g \sin\theta - T = m_2 (b - c\cos\theta)$ ...(iii)

From string constraint,

$\Rightarrow -a - c + b = 0$ ...(iv)

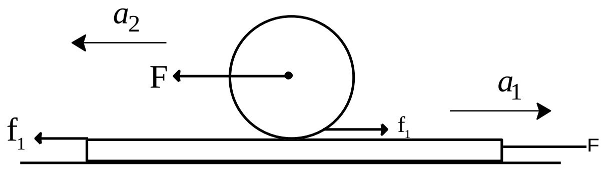
Solving Eqs. (i), (ii), (iii) and (iv), we get

$a = 3\,m/s^2$

$T = 3.9N$

$c = 2\,m/s^2$

16. (5)



$F - f_1 = ma_1$ ….(1) (plank)

$F - f_1 = ma_2$ …..(2) (Disc)

$\therefore a_1 = a_2$

$f_1 R = \dfrac{mR^2}{2}\alpha$ ……(3)

$\alpha R - a_2 = a_1$ ....(4)

$\Rightarrow f_1 = \frac{m(a_1 + a_2)}{2}$ by equation (3) & (4)

$2F - 2f_1 = m(a_1 + a_2)$ by equation (1) & (2)

$\Rightarrow 2F - 2f_1 = 2f_1$

$\Rightarrow f_1 = F/2$

17. (15.70)

In one rotation of disc distance moves by plank $= \pi R$

$\therefore \left|w_{\text{friction on plank}}\right| = \left|w_{\text{friction on disc}}\right| \left[\because w_{\text{static friction}} = 0\right]$

$\Rightarrow$ Work done $= f_1 \pi R$

$= \left(\frac{F}{2}\right)\pi R$

PART (B) : CHEMISTRY

18. **(A)**

19. **(B)**

$$\left[H^+\right] = \frac{12\times10^{-8} + \sqrt{144\times10^{-16} + 256\times10^{-16}}}{2}$$

$$= 1.6\times10^{-7}$$

20. **(C)**

21. **(B)**
$\rightarrow$Senior functional group $-\text{CHO}$ is present.
So, name of given compound is :-
5-phenylpent-4-en-2 ynal.

22. **(B, C)**

$$NH_4OH + HCl \longrightarrow NH_4Cl + H_2O$$

10 mol 5 mol 0 0
5 mol 0 5 mol 5 mol
The solution contains 5 mol of NH_4OH and 5 mol of NH_4Cl which constitutes a basic buffer.
Ammonium acetate being a salt of weak acid and weak base functions as salt buffer.

23. **(AD)**

$$P_{H_2O,air} = 85\times0.8 = 68\,\text{mm of Hg}$$

$$\Delta P = \frac{\frac{2}{1000}\times\frac{1}{12}\times300}{1}\times760$$

$$= 38\,\text{mm of Hg}$$

$$P_{f,H_2O} = 68-38 = 30\text{ mm of Hg}$$

If $RH = 40\%$ $P_{H_2O,air} = 34$ $\Rightarrow$ reaction $\leftarrow$

If $RH = 20\%$ $P_{H_2O,air} = 17$ $\Rightarrow$ reaction $\rightarrow$

24. **(B, C, D)**

25. **(3)**

$$K_{sp}\text{ of }M\left(OH\right)_x = x^x.\left(S\right)^{x+1} = 27\times10^{-12}$$

$$\therefore\ x^x.\left(10^{-3}\right)^{x+1} = 27\times10^{-12}$$

Put the $x = 1, 2, 3......$

$\therefore\ x = 3$

26. **(5)**
For reversible adiabatic process

$$\left(\frac{T_2}{T_1}\right)^{C_P/R} = \frac{P_2}{P_1}$$

$$\Rightarrow \left(\frac{287}{298}\right)^{C_P/2} = \frac{1.0}{1.1}$$

$$\frac{C_P}{2}\log\frac{287}{298} = \log\frac{10}{11}$$

$$\frac{C_P}{2}\times -0.01633 = -0.04139$$

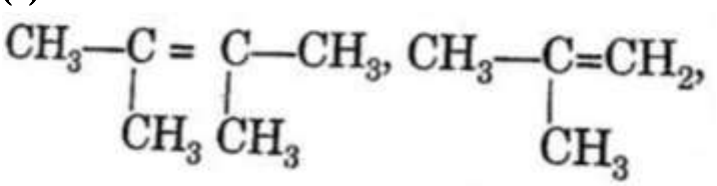
$$\Rightarrow C_P = 5\,\text{cal mol}^{-1}$$

27. (4)
(iii), (iv), (v), (viii)

28. (5)
(iii), (iv), (v), (vi), (viii)

29. **(6)**

30. **(2)**



31. (16)
32. (2.4)

	Ag^+	+ $2S_2O_3^{2-}$	$\rightarrow \left[Ag(S_2O_3)_2\right]^{3-}$	$K = 30\times10^{12}$
i	15 m mol	750 m mol	0	
f	15 – x	750 – 2x	x	

$$\frac{\frac{x}{300}}{\frac{15-x}{300}\times\left(\frac{750-2x}{300}\right)^2} = 30\times10^{12}$$

$$15 - x \approx 0 \quad \Rightarrow \quad x \approx 15$$

$$\Rightarrow \quad \frac{15}{15-x} = 30\times10^{12}\times\left(\frac{720}{300}\right)^2$$

$$\left[Ag^+\right] = \frac{15-x}{300} = \frac{15}{30\times10^{12}\times(2.4)^2\times300}$$

$$= \frac{1}{3.45\times10^{15}}$$

$$= 2.9\times10^{-16}$$

$$\left[S_2O_3^{2-}\right] = \frac{720}{300} = 2.4$$

33. (1.78)

34. (76.66 to 76.67)

PART (C) : MATHEMATICS

35. (A)
f(x) is continuous at x=0 hence
$$\lim_{x\to 0} x^a \sin\frac{1}{x} = f(0) = 0$$
This is only possible when a > 0, thus the required set of values of a is $(0, \infty)$
Hence (A) is the correct answer.

36. (D)
$${}^nC_1 \cdot 1^p - {}^nC_2 \cdot 2^p + {}^nC_3 \cdot 3^p ....+(-1)^{n-1} \cdot {}^nC_n \cdot n^p$$
$$\sum_{r=1}^{n}(-1)^{r-1} \cdot {}^nC_r \cdot r^p$$
Use, $r \cdot {}^nC_r = n \cdot {}^{n-1}C_{r-1}$

37. (B)
Here, $\lim_{x\to\infty}\frac{(x^2+x+1)-ax(x+1)-b(x+1)}{x+1}=4$
$\Rightarrow \lim_{x\to\infty}\frac{x^2(1-a)+x(1-a-b)+1-b}{x+1}=4$
This is possible iff
$1-a=0 \Rightarrow a=1$
and $1-a-b=4 \Rightarrow b=-4$

38. (A)
$(a_1)^{1/x_1}=(a_2)^{1/x_2}=(a_3)^{1/x_3}=\ldots=(a_n)^{1/x_n}=k$, (Let)
$\therefore\ a_1=k^{x_1},\ a_2=k^{x_2},\ a_3=k^{x_3}\ldots\ a_n=k^{x_n}$
Since $a_1, a_2, a_3, \ldots, a_n$ are in G.P.
$k^{x_1},\ k^{x_2},\ k^{x_3}\ldots\ k^{x_n}$ are in G.P.
$\therefore x_1, x_2, x_3, \ldots, x_n$ are in A.P.

39. (C, D)

40. (ABC)
$$\frac{x^2-kx-2}{x^2-x+1}<2$$
$\Rightarrow\ x^2+x(k-2)+4>0\ \forall\ x\in R$
$\Rightarrow\ D<0\ \Rightarrow\ -2<k<6$ ….(1)

$$-3<\frac{x^2-kx-2}{x^2-x+1}$$

$\Rightarrow \quad 4x^2-x(k+3)+1>0 \quad \forall\, x\in R$

$\Rightarrow \quad -7<k<1$ .....(2)

$(1)\cap(2)\Rightarrow -2<k<1$

$$-\frac{\sqrt{3}+1}{\sqrt{2}}=-2\cos(15^o)>-2$$

$$\frac{\sqrt{2+\sqrt{2}}}{2}=\sqrt{\frac{1+\frac{1}{\sqrt{2}}}{2}}=\cos 22.5^o<1$$

$3<4\Rightarrow \log_{\frac{1}{2}} 3>-2$

41. **(ABD)**

$$P\left(\frac{A}{A\cup B}\right)=\frac{P\left(A\cap\left(A\cup B\right)\right)}{P\left(A\cup B\right)}$$

$$=\frac{P\left(A\right)}{P\left(A\right)+P\left(B\right)-P\left(A\cap B\right)}=\frac{\frac{1}{3}}{\frac{1}{3}+\frac{1}{4}-\frac{1}{12}}$$

$$P\left(\frac{\bar{B}}{\bar{A}\cup\bar{B}}\right)=\frac{P\left(\bar{B}\cap\left(\bar{A}\cup\bar{B}\right)\right)}{P\left(\bar{A}\cup\bar{B}\right)}$$

$$=\frac{P\left(\bar{B}\right)}{P\left(\bar{A}\cup\bar{B}\right)}=\frac{\frac{3}{4}}{1-\frac{1}{12}} \qquad P\left(\frac{A}{A\cap B}\right)=1 \qquad P\left(\frac{\bar{A}}{\bar{\bar{B}}}\right)=P\left(\bar{A}\right)=\frac{2}{3}$$

42. (1)

$$f\left(\frac{3x+x^3}{1+3x^2}\right)-f\left(\frac{2x}{1+x^2}\right)=\log\left\{\frac{1+\frac{3x+x^3}{1+3x^2}}{1-\frac{3x+x^3}{1+3x^2}}\right\}-\log\left\{\frac{1+\frac{2x}{1+x^2}}{1-\frac{2x}{1+x^2}}\right\}$$

$$=3\log\left(\frac{1+x}{1-x}\right)-2\log\left(\frac{1+x}{1-x}\right)=f\left(x\right)$$

$\therefore\ M=1$

43. (6)

$0\le\frac{1+4P}{4}\le 1\Rightarrow -\frac{1}{4}\le P\le\frac{3}{4}$ ..... (i)

$0\le\frac{1-P}{3}\le 1\Rightarrow -2\le P\le 1$ ..... (ii)

$0 \le \frac{1-2P}{3} \le 1 \Rightarrow -1 \le P \le \frac{1}{2}$ ..... (iii)

Also, $0 \le P(A \cup B \cup C) \le 1$

$\Rightarrow 0 \le \frac{1+4P}{4} + \frac{1-P}{3} + \frac{1-2P}{2} \le 1$

$\Rightarrow 0 \le \frac{13-4P}{12} \le 1 \Rightarrow \frac{1}{4} \le P \le \frac{13}{4}$ ..... (v)

From (i), (ii), (iii) and (iv)

$\frac{1}{4} \le P \le \frac{1}{2}$

44. (4)

g is symmetrical about

$x = \frac{\pi}{2}, g_{max} = g\left(\frac{\pi}{2}\right) = 2f\left(\frac{\pi}{2}\right) = 4$

45. (2)

A + B + C = π

cosA = cosB.cosC $\quad \therefore \cos(B+C) = -\cos B \cos C$

$\Rightarrow \cos B \cos C - \sin B \sin C = -\cos B \cos C$

$\Rightarrow \sin B \sin C = 2\cos B \cos C$

$\Rightarrow \tan B \tan C = 2$

46. (7.00)

There are Maths-I, Maths-II and 6 other books.

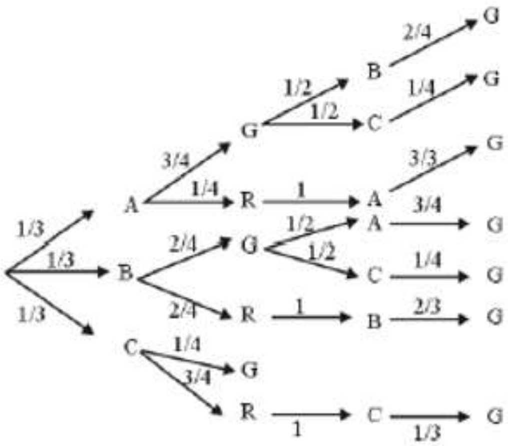
If Maths-II is selected, Maths-I also selected. So number of ways = $^6C_1$

If Maths-II not selected then number of ways = $^7C_3$

$\lambda = {}^6C_1 + {}^7C_3 = 6 + 35 = 41$

Perfect squares less than 41 are 0, 1, 4, 9, 16, 25, 36.

47. (2.00)



Required Probability

$$= \frac{1}{3}\left(\frac{3}{4}\cdot\frac{1}{2}\left(\frac{2}{4}+\frac{1}{4}\right)+\frac{1}{4}.1.1\right)$$

$$+\frac{1}{3}\left(\frac{2}{4}\cdot\frac{1}{2}\left(\frac{3}{4}+\frac{1}{4}\right)+\frac{2}{4}.1.\frac{2}{3}\right)+\frac{1}{3}\left(\frac{1}{4}\cdot\frac{1}{2}\left(\frac{3}{4}+\frac{2}{4}\right)+\frac{3}{4}.1.\frac{1}{3}\right)$$

$$= \frac{1}{3}\left[\frac{9}{32}+\frac{1}{4}+\frac{1}{4}+\frac{1}{3}+\frac{5}{32}+\frac{1}{4}\right] = \frac{1}{3}\left[\frac{7}{16}+\frac{13}{12}\right]$$

$$= \frac{1}{3}\left[\frac{21+52}{48}\right] = \frac{73}{3\times 48} = \frac{m}{n}; \text{ so } \frac{n}{m-1} = \frac{3\times 48}{72} = 2$$

48. **(243)**

If $P \cap Q = \phi$ then each element in A has 3 options

(i) it belongs to P but not Q

(ii) it belongs to Q but not P

(iii) it belongs to neither P not Q

Since set A has 5 elements

$\therefore$ Total number of ways = 3.3.3.3.3 = 3^5

$= 243$

49. **(405)**

One common elements can be chosen in $^5C_1$ ways and for remaining four elements each elements has 3 options. Therefore for number of ways = 5×3^4 = 405.

50. (1)

$$\lim_{x\to1}\frac{x^2-3x+2}{x-1}=\lim_{x\to1}\frac{2x-3}{1}=-1$$

51. (0.67)

$$\lim_{x\to a}\frac{x^2-a^2}{x^3-a^3}=\lim_{x\to a}\frac{2x}{3x^2}=\frac{2}{3a}$$