IIT – JEE: 2023 **TW TEST (ADV)** **DATE: 17/10/21**

TOPIC: LAWS OF MOTION & FRICTION

Answer Key & Solution

1. (B)
   Angle of repose.

2. (A)

3. (A)
   Applied force F is less than maximum value of friction force.

4. (B)
   Weight is less than maximum value of frictional force

5. (A)
   acceleration is zero. Velocity is constant

6. (B)

7. (D)
   $a = -5$, then use kinematics equation

8. (A)
   Applying newtons along x and y direction

9. (C)

10. (B)

11. (B)
    Contact force = normal force
    Therefore friction=0, also possible that bodies do not slip on each other.

12. (CD)
    Initially till the motion begins applied force is equal to friction.
    So graph is straight line with slope = 1, after that due to kinetic friction , there is a kink down

13. (AB)
    By applying 2^{nd} law on vehicle.

14. (AC)
    For painter;

$R + T - mg = ma$

$R + T = m(g + a)$ .....(1)

For the system;

$2T - (m + M)g = (m + M)a$

$2T = (m + M)(g + a)$ .....(2)

Where; $m = 100$ kg

M = 50 kg

a = 5 m/sec^2

$\therefore \quad T = \frac{150 \times 15}{2} = 1125\,\text{N}$ and $R = 375\,\text{N}$

15. (BD)

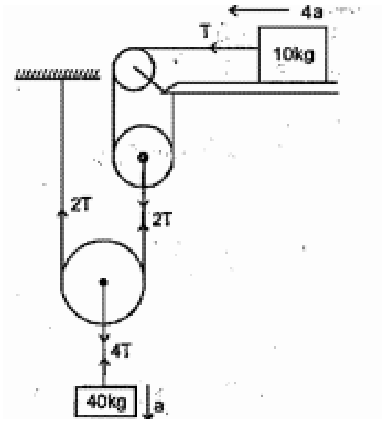
Applying NLM on 40 kg block

$400 - 4T = 40a$

For 10 kg block $T = 10.4a$

Solving $a = 2$ m/s^2

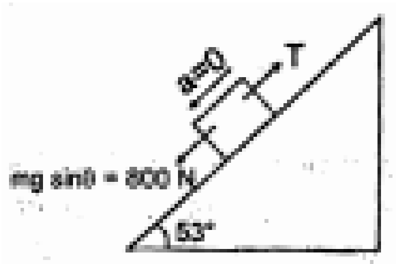
Ti= 80 N



16. (6)

For block to be stationary T = 800 N

If man moves uo by acceleration 'a'.



$T - mg = ma \Rightarrow 800 - 500 = 50a$

17. (2)

$a = \frac{Mg\sin\theta}{2M}$ and $T = Ma$

18. (8)

$f = \mu(m_1 + m_2 + m_3)g = 0.4(3 + 2 + 1) \times 10 = 24\,\text{N}$

To move the blocks $F \geq f$, $3t \geq 24, t \geq 8\,\text{s}$

19. (1)

For the sliding not to occur when

$\tan\theta \leq \mu$

$$\tan\theta = \frac{dy}{dx} = \frac{2x}{a} = \frac{2\sqrt{4y}}{a} = 2\sqrt{\frac{y}{a}}$$

$$\therefore \quad 2\sqrt{\frac{y}{a}} \le \mu \text{ or } y \le \frac{a\mu^2}{4}$$

20. (5)

Maximum friction $= \mu mg = 0.6\times10\times1 = 6\,\text{N}$

Psuedo force = ma = 5 N

Applied the Pseudo force $= \frac{1\times5}{1} = 5\ \text{m/s}^2$

So required friction force is only 5 N although maximum friction force available is 6 N.

Answer Key & Solution

21. (A)

Bond order is defined as one half of the difference between the number of electrons present in the bonding and the antibonding molecular orbital's. B.O. = $n_b - n_a/2$

Molecular orbital configuration for CN^- and NO^+ are :

CN^- (total no. of e^- = 14 [7(N) + 6(C) + 1(–ve charge)]

$(\sigma 1s)^2(\sigma^* 1s)^2(\sigma 2s)^2(\sigma^* 2s)^2(\pi 2p_x^2 = \pi 2p_y^2)(\sigma 2p_z)^2$

Or $kk(\sigma 2s)^2(\sigma^* 2s)^2(\pi 2p_x^2 = \pi 2p_y^2)(\sigma 2p_z)^2$

B.O. = $n_b - n_a/2 = 8 - 2/2 = 3.0$

NO^+ (total no. of e^- = 14 [7(N) + 8(0) – 1(+ve charge)]

$Kk\ (\sigma 2s)^2(\sigma^* 2s)^2(\sigma 2p_z)^2(\pi 2p_x^2 = \pi 2p_y^2)$

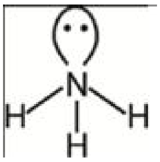
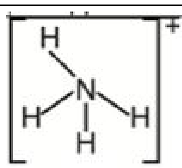
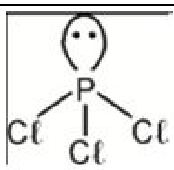
B.O. = 8 – 2/2 = 3.0

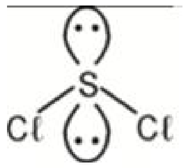
22. (D)

In SOF_2 the central atom is S (at No. 16)

According to VSEPR theory, there are total number of 5 electron pairs around S [4 bond pairs (3σ and 1π) for two S–F single bonds and one S=O double bond) + 1 lone pair]. Thus lone pair-bond pair repulsion result in pyramidal shape of the molecule. (AB_3E type of molecule where B are σ bond pairs ad E is lone pair)

23. (B)

Molecules	Hybridization	Shape	bp	Lp
NH_3	sp^3		3	1
NH_4^+	sp^3		4	0
PCl_3	sp^3		3	1

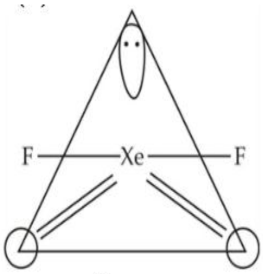
SCl_2	sp^3		2	2

Based on VSEPR, the electronic repulsions follow the order

lp – lp > lp – bp > bp – bp – bp

In NH_4^+ there is no lone pair present and hence electron repulsion are minimum. Thus bond angles are maximum.

24. (C)



Sea-saw

25. (A)

$N(SiH_3)_3$ has $p\pi$-$p\pi$ back bonding from lone pair of N-atom atom empty d-orbital of Si.

Similarly $(SiH_3)P$ also has $p\pi$-$d\pi$ back bonding from ℓp of P/atom to empty d-orbital of Si.

π-bonding makes them planar.

26. (C)

PF_5 and BrF_5

Hybridisation of central atom P in PF_5 is sp^3d (5σ bond pairs around P) and the structure is trigonal bipyramidal.

Hybridisation of central atom Br in BrF_5 is sp^3d^2 (5σ bond pairs and one lone pair around Br). The geometry is thus octahedral and the actual shape appears to be square pyramidal.

27. (B)

N, C and oxygen do not have d-orbital’s whereas sulphur has d-orbital.

So it undergoes $p\pi$–$d\pi$ overlap.

28. (B)

Hybridisation of central atom, geometry and shapes of NO_2 and O_3 are

NO_2 Hybridisaton – sp^2 Geometry – triangular planar shape – bent

O_3 Hybridisation – sp^2 Geometry – triangular planar shape – bent

In both the molecules, individual bond moments do not cancel out each other’s effects giving rise to a net permanent dipole moment in the molecule.

29. (C)

30. (D)

31. (A, B, D)

In NH_2^-, N has 2 bond pairs, 2 pone pairs.

So, it is sp^3 hybridised and bent or V-shaped.

32. (ABC)

NO (15 electrons) : $\sigma 1s^2\ \sigma^*1s^2\ \sigma 2s^2\ \sigma^*2s^2\ \sigma 2p^2, \pi 2p_x^2 = \pi 2p_y^2\ \pi^*2px_x^1 = \pi^*2p_y^0$

NO^+ (14 electrons) : $\sigma 1s^2\ \sigma^*1s^2\ \sigma 2s^2\ \sigma^*2s^2\ \sigma 2p_z^2\ \pi 2p_x^2 = \pi 2p_y^2$

$\therefore$ B.O. = 3

O_2^+ (15 electrons) : configuration same as NO

$\therefore$ B.O. = 2.5

OF^+ ($16e^-$) : $\sigma 1s^2\ \sigma^*1s^2\ \sigma 2s^2\ \sigma^*2s^2\ \pi 2p_z^2\ \pi 2p_x^2 = \pi 2p_y^2\ \pi^*2px_x^1 = \pi^*2p_y^1$

(2 unpaired electron)

$Ne_2^+(19e^-) : \sigma 1s^2\ \sigma^*1s^2\ \sigma 2s^2\ \sigma^*2s^2\ \sigma 2p_z^2\ \sigma 2p_x^2 = \pi 2p_y^2\ \pi^*2p_x^2 = \pi^*2p_y^2\ \sigma 2p_z^1$

(1 paired electron)

33. (AB)

HF is an associated liquid due to strong intermolecular.

$F^- + H^{\delta+} - F^{\delta-} \rightarrow [F..........H - F]^-$

34. (BD)

Both are also linear, like CO_2.

35. (BC)

36. (7)

$$\text{Partial charge} = \frac{\text{Dipole moment}}{\text{Bond distance}} = \frac{1.2\times10^{-18}\text{ esu}}{4.8\times\times10^{-18}\text{ esu}}\times100$$

$$= 1.2\times10^{-10}\text{ esu}$$

$$\therefore \text{ percentage of partial charge} = \frac{1.2\times10^{-10}\text{ esu}}{4.8\times10^{-10}\text{ esu}}\times100 =$$

$$= 25\%$$

Ans. 2 + 5 = 7

37. (4)

$$\%\text{ ionic character} = \frac{\text{Observed dipole moment}}{\text{Theoretical dipole moment}}\times100$$

$$= \frac{1.945\times10^{-29}\text{C.m.}}{\left(1.6\times10^{-19}\text{C}\right)\times\left(1.6\times10^{-10}\text{m}\right)}\times100$$

So, answer = 7 + 6 = 13, further 1 + 3 = 4

38. (6)

$I_3^+, SO_2 \rightarrow$ V-shape (sp^2)

$ClO_3^-, AsH_3 \rightarrow$ Pyramidal (sp^3)

XeF_3, $ICl_2^- \rightarrow$ Linear (sp^3d)

ICl_3, $XeOF_2 \rightarrow$ Bent T-shape (sp^3d^2)

$TeCl_4 \rightarrow$ square planar (sp^3d)

$ICl_4^- \rightarrow$ square planar (sp^3d^2)

$XeF_6 \rightarrow$ distorted Octahedral (sp^3d^3)

39. (3)

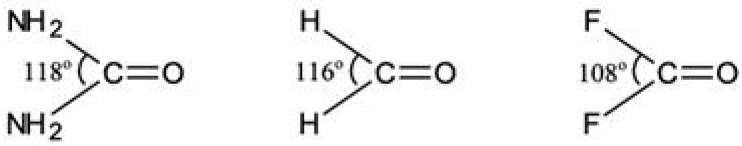
CH_4 >	NH_3 >	H_2O	(all sp^3)
109°28'	106°51'	104°31'	

PF_3 < PCl_3	< PBr_3	< PI_3	
(97°) (100°)	(101.5°)	(102°)	

As electronegativity of the terminal atom increases, the flow of electrons away from the central atom, and hence decrease the bp-bp repulsions. This leads to decrease in bond angles between the bond pair of electrons.

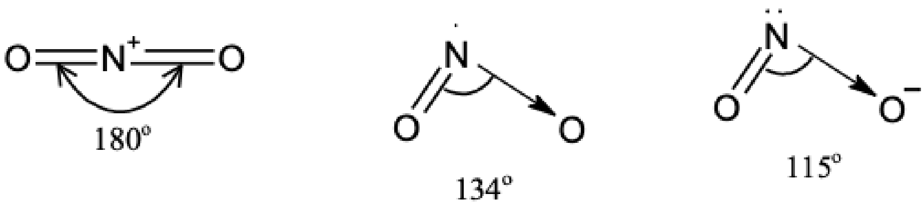
NH_3 >	PH_3 >	AsH_3 <	BiH_3
106°51'	93.5°	91.5°	90.2°

As the electronegativity of central atom increase, the bond pair electrons flow towards the central atom, and so the bp-bp repulsions increase, causing an increase in bond angle.

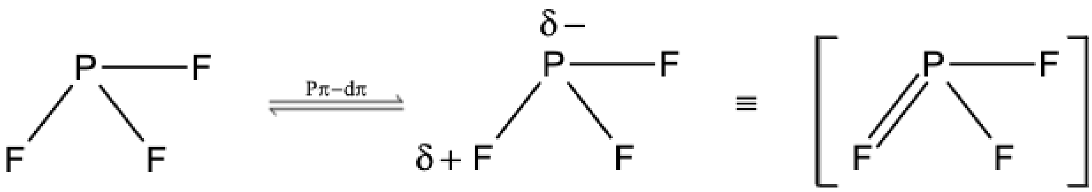


$\alpha > \beta > \gamma$

There is repulsion created by the π-bond orbitals. Hence none of the bond angels are equal to 120°, as expected.



A lone pair and double bond repulsion is much greater than a lone electron and double bond repulsion.



The small size of F-atom leads to $p\pi$-$d\pi$ bonding in PF_3. Similarly AsF_3 also has $p\pi$-$d\pi$ bonding which leads to greater bond angle compared to $AsCl_3$.

There is $p\pi$-$d\pi$ bonding in $(SiH_3)_3N$. Hence bond angle is more than $(CH_3)_3N$.

40. (6)

TOPIC: TRIGONOMETRIC EQUATIONS INEQUATIONS & EQUATIONS

Answer Key & Solution

41. (D)

$7x^3 - 25x + 42 = 0 \Rightarrow a + b + c = 0$

$$ab + bc + ca = -\frac{25}{7}$$

$$abc = -6$$

$\therefore (a+b)^3 + (b+c)^3 + (c+a)^3 = -a^3 - b^3 - c^3 = -7abc = 18$

42. (A)

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

$\Rightarrow (x-2)^2 + \left(x + \frac{1}{x}\right)^2 = 4$

LHS $\geq 4 \; \forall \; x \in R$

$\therefore$ for solution LHS = 4

Which is not possible for any value of x.

43. (C)

$x^2 + 2x + 3 = 0$ has complex conjugate root.

$\Rightarrow$ Both roots must be common.

Hence, $\frac{a}{1} = \frac{b}{2} = \frac{c}{3}$

$\therefore$ least $a + b + c = 6$

44. (A)

Let $x^2 - px + q = 0$ has roots $I_1 = I_2$ ($I_1, I_2 \in N$)

$\therefore I_1 + I_2 = p$

$I_1 I_2 = q$

Since q prime $\Rightarrow I_1 = 1, I_2 = 2$

So, $1+q=p$

$\therefore$ for p & q to be prime $q=2,\ p=3$ is only possibility.

45. (A)

Since, sum of coefficient any way $O \Rightarrow$ 1 is a part.

$\Rightarrow$ atleast 2 real rest.

46. (D)

No such polynomial possible.

47. (D)

$x^3+2x^2+2x+1=0 \Rightarrow \left(x^3+1\right)+2x\left(x+1\right)=0$

$\Rightarrow \left(x+1\right)\left(x^2+x+1\right)=0$

Roots $-1, \alpha, \beta$ when $\alpha+\beta=-1$

$\alpha\beta=1$

$\therefore\ 1^2+\alpha^2+\beta^2=0$

48. (C)

Conceptual

49. (A)

$P\left(x\right)=ax^3+bx^2-12x-5$

Given $P\left(1\right)=0, P\left(-1\right)=6$

$a+b=17 \qquad -a+b=-1$

$\therefore\ a=8,\ b=9$

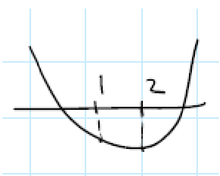
50. (A)

$f\left(x\right)=x^2+2ax+a<0\ \ \forall\ x\in[1, 2]$

$\Rightarrow\ f\left(1\right)<0\ \ \&\ \ f\left(2\right)<0$

$3a+1<0\ \ \&\ \ 5a+4<0$

$a\in\left(-\infty, -\dfrac{4}{5}\right)$



51. (AC)

$3\cos 2x-10\cos x+7=0$

$3\left(2c^2-1\right)-10c+7=0$

$\Rightarrow\ 3c^2-5c+2=0$

$(3c-2)(c-1)=0$

$c=\frac{2}{3}$ or $c=1$

52. (ABC)

$\sec^2 x=\sqrt{2}\left(1-\tan^2 x\right)$

$\Rightarrow \frac{1-\tan^2 x}{1+\tan^2 x}=\frac{1}{\sqrt{2}} \Rightarrow \cos 2x=\frac{1}{\sqrt{2}}$

$2x=2n\pi\pm\frac{\pi}{4}$

$x=n\pi\pm\frac{\pi}{8}$

53. (CD)

Conceptual

54. (AC)

Only possible when $\sin x=\sin y=1$

Or $x=\frac{\pi}{2},\frac{5\pi}{2}$

$y=\frac{\pi}{2},\frac{5\pi}{2}$

55. (AD)

Conceptual

56. (2)

$\sqrt{x+2\sqrt{x-1}}-\sqrt{x-2\sqrt{x+1}}=2$

$\left|\sqrt{x-1}+1\right|-\left|\sqrt{x-1}-1\right|=2$

$\left(\sqrt{x-1}+1\right)-\left|\sqrt{x-1}-1\right|=2$

$\Rightarrow \left|\sqrt{x-1}-1\right|=\sqrt{x-1}-1$ only when $x\geq 2$

57. (0)

If α satisfied then $-\alpha$ also satisfied

$\therefore$ sum = 0

58. (2)

$\sin x + \cos x = 1 \Rightarrow x = -2n\pi$ or $2n\pi + \frac{\pi}{2}$

$\therefore$ $x = 0$ or $\frac{\pi}{2}$ only solution in $[0, 2\pi)$

59. (4)

$6\sin^2 x + \sin x - 1 = 0$

$(3\sin x + 1)(2\sin x - 1) = 0$

$\sin x = -\frac{1}{3}, \ \sin x = \frac{1}{2}$

$x = \pi + \sin^{-1}\left(\frac{1}{3}\right), \sin x = \frac{1}{2}$

$x = \pi + \sin^{-1}\left(\frac{1}{3}\right), 2\pi - \sin^{-1}\left(\frac{1}{3}\right)$ or $x = \frac{\pi}{6}, \pi - \frac{\pi}{6}$

$\therefore$ Sum of solution 4π.

60. (1)

$x = 0$ only solution