

JEE (Main)-2026

Session-1

22 January 2026 Shift-2

Memory-Based Answers & Solutions (Physics, Chemistry, and Mathematics)

IMPORTANT INSTRUCTIONS:

- (1) The test is of **3 hours** duration.
- (2) This test paper consists of 75 questions. Each subject (PCM) has 25 questions. The maximum marks are 300.
- (3) This question paper contains Three Parts. Part-A is Physics, Part-B is Chemistry and Part-C is Mathematics. Each part has only two sections: Section-A and Section-B.
- (4) Section - A : Attempt all questions.
- (5) Section - B : Attempt all questions.
- (6) Section - A (01 – 20) contains 20 multiple choice questions which have only one correct answer. Each question carries +4 marks for correct answer and –1 mark for wrong answer.
- (7) Section - B (21 – 25) contains 5 Numerical value based questions. The answer to each question should be rounded off to the nearest integer. Each question carries +4 marks for correct answer and –1 mark for wrong answer.

PHYSICS

SECTION - A

Multiple Choice Questions: This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.

Choose the correct answer:

1. Find the dimensions of the expression $\frac{\epsilon_0 E}{T}$, where ϵ_0 , E and T are permittivity, electric field and time.

- (1) AL (2) AL^{-2}
(3) $MA^{-1}L$ (4) MLA^2

Answer (2)

Sol. $EA = \frac{q}{\epsilon_0}; \epsilon_0 = \frac{q}{EA}$

$$\Rightarrow \epsilon_0 E = \frac{q}{A}$$

$$\frac{q}{AT} = \frac{AT}{L^2 T}$$

2. In an open organ pipe 3rd and 6th harmonic frequency differ by 3200 Hz. Find the length of organ pipe (speed of sound = 320 m/s)

- (1) 5 cm (2) 10 cm
(3) 15 cm (4) 20 cm

Answer (3)

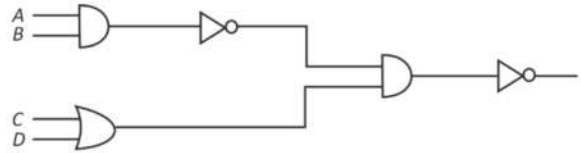
Sol. $\frac{6C}{2l} - \frac{3C}{2l} = 2200$

$$\Rightarrow \frac{3C}{2l} = 3200$$

$$\Rightarrow \frac{3 \times 320}{2l} = 3200 = 10$$

$$\frac{3}{20} = 0.15 \text{ m or } 15 \text{ cm}$$

3. For the given logic gate find output functions.



- (1) $\bar{A} \cdot \bar{B} + C + D$
(2) $\bar{A} + \bar{B} + \bar{C} \cdot \bar{D}$
(3) $AB + CD$
(4) $AB + \bar{C} \cdot \bar{D}$

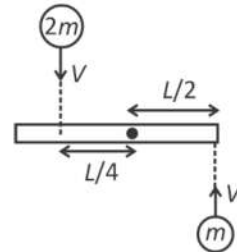
Answer (4)

Sol. $\overline{AB \cdot (C + D)}$

$$= \overline{AB} + \overline{C + D}$$

$$= AB + \bar{C} \cdot \bar{D}$$

4. Two balls of mass $2m$ and m collides with rod of mass m and length L as shown, balls stick to the rod after collision. Find $\frac{V}{\omega}$ if rod is hinged at centre. ($L = 8m$)



- (1) $\frac{11}{2}$ (2) $\frac{11}{3}$
(3) $\frac{11}{4}$ (4) $\frac{9}{4}$

Answer (2)

Sol. $2mV\frac{L}{4} + \frac{mVL}{2} = \left(\frac{mL^2}{12} + \frac{mL^2}{4} + \frac{2mL^2}{16} \right) \omega$

$$mVL = \frac{11}{24} mL^2 \omega$$

$$\frac{V}{\omega} = \frac{11}{24} L$$

$$= \frac{11}{3}$$

5. A gas undergoes a process in which state variable changes from (1 atm, 60ml, 27°C) to (P atm, 30 ml, 77°C) then P is

(1) 3 atm (2) $\frac{5}{4}$ atm

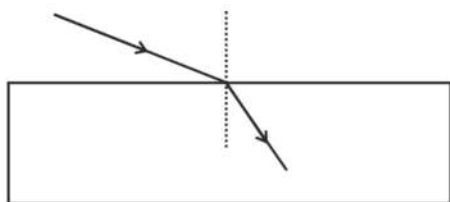
(3) $\frac{7}{3}$ atm (4) $\frac{4}{3}$ atm

Answer (3)

Sol. $\frac{1 \times 60}{300} = \frac{P \times 30}{350}$

$$\Rightarrow P = 2 \times \frac{7}{6} = \frac{7}{3} \text{ atm}$$

6. A light ray incident on a slab of refractive index $\frac{3}{2}$. If wavelength of refracted ray is 520 nm. Find wavelength of incident ray.



(1) 460 nm (2) 780 nm

(3) 360 nm (4) 560 nm

Answer (2)

Sol. $V = f\lambda$

$$\lambda_{\text{slab}} = \frac{\lambda}{\mu}$$

$$\lambda = 520 \times \frac{3}{2} = 780 \text{ nm}$$

7. Which of the following is/are true for YDSE experiment?

- Fringe width increases if slit distance is constant & wavelength increased
- Fringe width increases if slit distance is constant & wavelength decreased
- Fringe width increases if slit distance is increased & wavelength constant
- Fringe width increases if slit distance is decreased & wavelength constant.

(1) i, iii

(2) i, iv

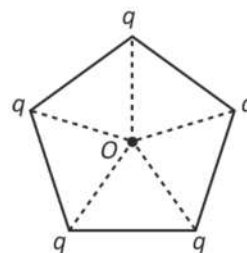
(3) ii, iii

(4) ii, iv

Answer (2)

Sol. $\beta = \frac{\lambda D}{d}$

8. For the given arrangement of charges find the strength of electric field E and potential V at geometrical center O .



(1) $E = 0$; $V = 0$

(2) $E = 0$; $V = \text{Non-zero}$

(3) $E = \text{Non-zero}$; $V = \text{Non-zero}$

(4) $E = \text{Non-zero}$; $V = 0$

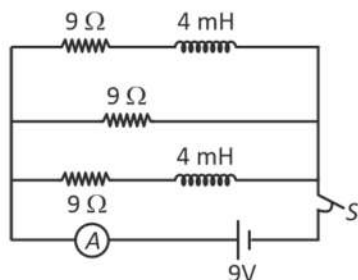
Answer (2)

Sol. $E = 0$

$$V = 5 \cdot \frac{kq}{r}$$

So $E = 0$; $V \neq 0$

9. For the given circuit, find reading of ammeter just after key(s) is closed.



- (1) 1 A (2) 3 A
(3) $\frac{3}{2}$ A (4) $\frac{1}{2}$ A

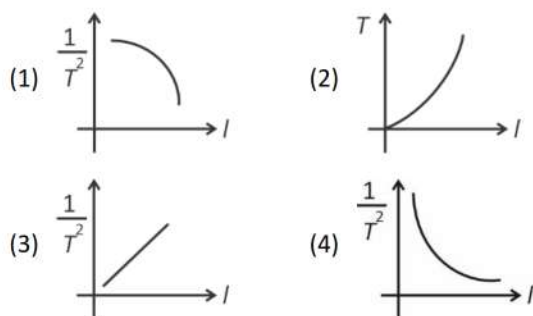
Answer (1)

Sol. At $t = 0$, inductor will behave like open circuit.

So,

$$I = \frac{9}{9} = 1 \text{ A}$$

10. Choose the correct graph between time period T and length of pendulum l .



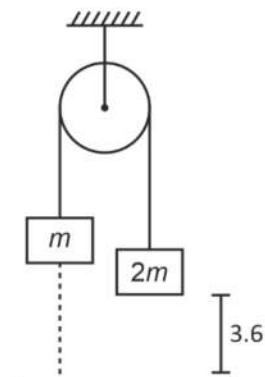
Answer (4)

Sol. $T = 2\pi\sqrt{\frac{l}{g}}$

$$l \cdot \frac{1}{T^2} = k$$

$$T^2 = kl$$

11. If the string connecting m and ground is cut find the speed with which $2m$ block hits the ground as shown. ($g = 10 \text{ m/s}^2$)



- (1) 3 m/s (2) 4 m/s
(3) $2\sqrt{6}$ m/s (4) $6\sqrt{2}$ m/s

Answer (3)

Sol. $a = \frac{2m - m}{2m + m}g = \frac{g}{3} \text{ m/s}^2$

$$v = \sqrt{2as} = \sqrt{7.2 \times \frac{g}{3}} = \sqrt{24} \text{ m/s}$$

12. In hydrogen type atom, shortest wavelength in Lyman series is given as 91 nm. Then longest wavelength in Paschen series of this atom shall be

- (1) 31.82 nm (2) 113.3 nm
(3) $1.87 \mu\text{m}$ (4) $2.31 \mu\text{m}$

Answer (3)

Sol. Lowest Lyman $\frac{1}{\lambda_1} = RZ^2 \left\{1\right\}$

Highest Paschen $\frac{1}{\lambda_2} = RZ^2 \left(\frac{1}{9} - \frac{1}{16}\right)$

$$\frac{\lambda_2}{\lambda_1} = \frac{144}{7}$$

$$\lambda_2 = \frac{144}{7} \times 9 = 1872$$

13. **Statement-1:** Kinetic energy of system = $\frac{1}{2}m_1v_1^2 +$

$$\frac{1}{2}m_2v_2^2 \dots \frac{1}{2}m_nv_n^2$$

Statement-2: Kinetic energy of system = Kinetic energy of center of mass + kinetic energy with respect to center of mass

(1) Statement I is true

Statement II is true

(2) Statement I is true

Statement II is false

(3) Statement I is false

Statement II is true

(4) Statement I is false

Statement II is false

Answer (1)

Sol. $KE = KE_0 + KE$

14. Find the percentage change in height risen by liquid if density of fluid, radius of capillary and surface tension of liquid are decreased by 1%. Assume contact angle doesn't change and capillary is of sufficient length.

(1) +1% (2) -1%

(3) +3% (4) -3%

Answer (1)

Sol. $\frac{2S \cos \theta}{r} = h \rho g$

$$h = \frac{2S \cos \theta}{\rho g r}$$

$$\frac{\Delta h}{h} = \frac{\Delta S}{S} = \frac{\Delta \rho}{\rho} - \frac{\Delta r}{r}$$

$$= -1\% + 1\% + 1\%$$

$$= 1\%$$

15. A capacitor of capacitance $10 \mu\text{F}$ is connected with a battery of emf 6V . Now battery is disconnected and another uncharged capacitor of capacitance $20 \mu\text{F}$ is connected to the capacitor. Find charge on $20 \mu\text{F}$ capacitor.

(1) $\frac{30}{4} \mu\text{C}$

(2) $10 \mu\text{C}$

(3) $\frac{20}{3} \mu\text{C}$

(4) $40 \mu\text{C}$

Answer (4)

Sol. $V = \frac{c_1 V}{c_1 + c_2} = \frac{60}{30} = 2 \text{ Volt}$

$$q_2 = 20 \times 2 = 40 \mu\text{C}$$

16. **Statement-1:** Time period of simple pendulum is increased if density of material of pendulum is increased.

Statement-2: Time a period of simple pendulum is

$$T = 2\pi \sqrt{\frac{l}{g}}$$

(1) Statement I is true

Statement II is true

(2) Statement I is true

Statement II is false

(3) Statement I is false

Statement II is true

(4) Statement I is false

Statement II is false

Answer (3)

Sol. Conceptual

17. For the given statements below mark the correct option.

Statement-I: Work done by a conservative force f , from

$$\vec{r}_1 \text{ to } \vec{r}_2 \text{ is given by } W = - \int_{r_1}^{r_2} f \cdot dr.$$

Statement-II: Work done by conservative force is path dependent.

- (1) Statement-I and statement-II is true
- (2) Statement-I is true and statement-II is false
- (3) Statement-I is false and statement-II is true
- (4) Statement-I and statement-II is false

Answer (4)

Sol. $W = \int_{r_1}^{r_2} f \cdot dr$, is path independent.

18. Electromagnetic wave with intensity $I = 4 \times 10^{14}$ watt/m² is propagating in free space. Find the amplitude of magnetic field B_0 .

(Use $c = 3 \times 10^8$ m/s, $\epsilon_0 = 8.85 \times 10^{-12}$ C²/N.m²)

- (1) 1.83 Tesla
- (2) 0.5 Tesla
- (3) 4.5 Tesla
- (4) 1 Tesla

Answer (1)

Sol. $E_0 = CB_0$

$$\text{And } I = \frac{1}{2} \epsilon_0 E_0^2 \times c$$

$$\Rightarrow I = \frac{1}{2} \epsilon_0 c^3 \cdot B_0^2$$

$$\Rightarrow \frac{2I}{\epsilon_0 c^3} = B_0^2 = 3.35$$

$$\Rightarrow B_0 = 1.83 \text{ Tesla}$$

19.

20.

SECTION - B

Numerical Value Type Questions: This section contains 5 Numerical based questions. The answer to each question should be rounded-off to the nearest integer.

21. Three identical liquid drops each carrying same charges coalesce to form single drop. Ratio of potential of large drop and single smaller drop is $3^{N/3}$ then N is

Answer (2)

$$\text{Sol. } \frac{4}{3} \pi r^3 \cdot 3 = \frac{4}{3} \pi R^3 \Rightarrow R = 3^{1/3} r$$

$$V = \frac{q}{4\pi\epsilon_0 r} \quad V = \frac{3q}{4\pi\epsilon_0 R} \quad V = \frac{3}{3^{1/3}} = 3^{2/3}$$

22. A circular coil is rotating in magnetic field of magnitude $0.25T$ with angular speed 6 rpm about its diameter. At $t = 0$ coil's configuration is given as shown. If induced emf after coil rotated by angle 30° is 1.6 mV. Find radius of the coil (in cm). ($\pi^2 = 10$)



Answer (8)

$$\text{Sol. } \Sigma = BA\omega \sin(\cos t)$$

$$B\pi R^2 \cdot \frac{6 \times 2\pi}{60} \cdot \frac{1}{2} = 16 \times 10^{-4}$$

$$R^2 = \frac{16 \times 10^{-4}}{0.25}$$

$$R = 8 \text{ cm}$$

23. A metallic conductor of length $2m$ and cross-sectional area 0.2 mm^2 carries steady current of $1.2A$ when a potential difference of $2V$ is applied across it. ($e = 1.6 \times 10^{-19}$, charge density $= 7.5 \times 10^{28} \text{ m}^{-3}$)

Then the mobility of charge carrier is $x \times 10^{-4}$ SI units. Find x

Answer (5)

$$\text{Sol. } \mu = \frac{v_d}{E} = \frac{Il}{neA(EI)} = \frac{Il}{neAV}$$

$$= 5 \times 10^{-4} \text{ m}^2 \text{V}^{-1} \text{S}^{-1}$$

24.

25.

CHEMISTRY

SECTION - A

Multiple Choice Questions: This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.

Choose the correct answer:

- The correct order of electron gain enthalpy (magnitude only) for group 16 elements is
 (1) $\text{Te} > \text{Se} > \text{S} > \text{O}$
 (2) $\text{S} > \text{Se} > \text{Te} > \text{O}$
 (3) $\text{O} > \text{S} > \text{Se} > \text{Te}$
 (4) $\text{S} > \text{O} > \text{Se} > \text{Te}$

Answer (2)

Sol.	O	S	Se	Te
ΔH_{eg} (kJ/mol)	-141	-200	-195	-190

- 100 g 98% by weight H_2SO_4 is mixed with 100 g 49% by weight H_2SO_4 . Mole fraction of H_2SO_4 in the solution is
 (1) 0.9 (2) 0.1
 (3) 0.67 (4) 0.33

Answer (4)

Sol. (I) Mass of $\text{H}_2\text{SO}_4 = 98 \text{ g}$
 Mass of $\text{H}_2\text{O} = 2 \text{ g}$
 (II) Mass of $\text{H}_2\text{SO}_4 = 49 \text{ g}$
 Mass of $\text{H}_2\text{O} = 51 \text{ g}$
 Total mass of $\text{H}_2\text{SO}_4 = 98 + 49 = 147 \text{ g}$

$$n_{\text{H}_2\text{SO}_4} = 1.5 \text{ mol}$$

$$\text{Mass of H}_2\text{O} = 53 \text{ g}$$

$$n_{\text{H}_2\text{O}} \approx 3 \text{ mol}$$

$$X_{\text{H}_2\text{SO}_4} = \frac{1.5}{4.5} = \frac{1}{3}$$

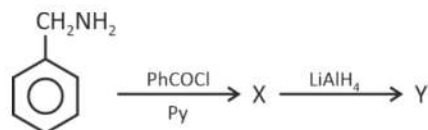
- Correct order of ionisation enthalpy is
 (1) $\text{F} > \text{Cl} > \text{Cl}^- > \text{F}^-$ (2) $\text{F}^- > \text{Cl}^- > \text{F} > \text{Cl}$
 (3) $\text{Cl} > \text{F} > \text{Cl}^- > \text{F}^-$ (4) $\text{F} > \text{Cl} > \text{F}^- > \text{Cl}^-$

Answer (1)

Sol.

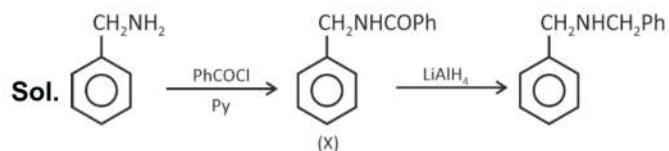
			kJ/mol
$\text{Cl}(17)$	$\rightarrow$	2, 8, 7	$\rightarrow$ 1256
$\text{F}(9)$	$\rightarrow$	2, 7	$\rightarrow$ 1680
$\text{F}^-(9+1)$	$\rightarrow$	2, 8	$\rightarrow$ +328
$\text{Cl}^-(17+1)$	$\rightarrow$	2, 8, 8	$\rightarrow$ +349

- Consider the following reaction.



The correct structure of Y is

- $\text{PhCH}_2\text{NHCOPh}$
- $\text{Ph}-\text{CH}_2\text{NHCH}_2\text{Ph}$
- $\text{PhNH}_2\text{CH}_2\text{Ph}$
- PhCH_3

Answer (2)

5. Which of the following is a mixed oxide?

- (1) Fe_2O_3 (2) PbO_2
 (3) Pb_3O_4 (4) BaO_2

Answer (3)

Sol. Pb_3O_4 is a mixed oxide of PbO and PbO_2

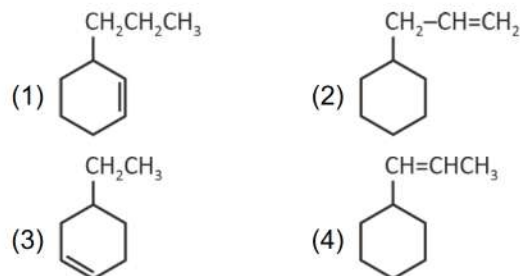
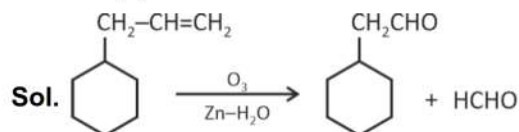
6. Which of following is basic buffer?

- (1) $\text{NaOH} + \text{CH}_3\text{COONa}$
 (2) $\text{NaOH} + \text{Na}_2\text{SO}_4$
 (3) $\text{K}_2\text{SO}_4 + \text{H}_2\text{SO}_4$
 (4) $\text{NH}_4\text{OH} + \text{NH}_4\text{Cl}$

Answer (4)

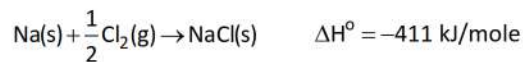
Sol. NH_4OH is weak base and NH_4Cl is its salt with strong base

7. An alkene on reductive ozonolysis gives methanal as one of the products. Its structure is

**Answer (2)**

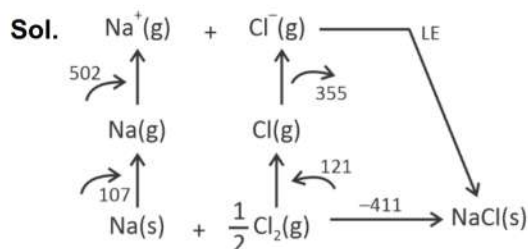
To get HCHO as one of the product, alkene should contain $=\text{CH}_2$ as group.

8. Consider the following data :



Find out lattice energy of NaCl(s) .

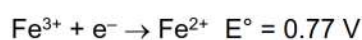
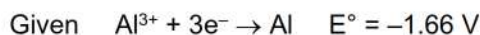
- (1) $-786 \text{ kJ mole}^{-1}$
 (2) $-628 \text{ kJ mole}^{-1}$
 (3) $-428 \text{ kJ mole}^{-1}$
 (4) $-393 \text{ kJ mole}^{-1}$

Answer (1)

$$-411 = 107 + 502 + 121 - 355 + \text{LE}$$

$$\text{LE} = -786 \text{ kJ mole}^{-1}$$

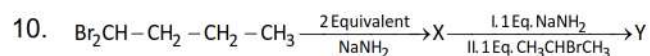
9. Which of the following will behave as best reducing agent?



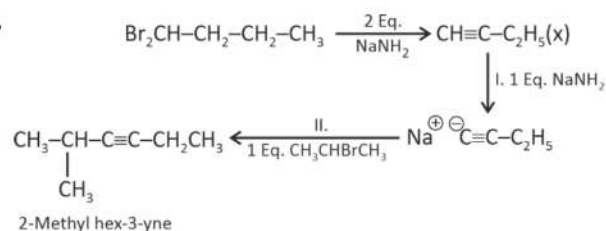
- (1) Al (2) Co^{2+}
 (3) Fe^{2+} (4) Cd

Answer (1)

Sol. Smaller the value of E° , lesser will be the tendency to reduce $\text{Al}^{3+} + e^- \rightarrow \text{Al}$ have smallest E° , so Al will have high tendency to oxidise.



- (1) 2-Methylhex-3-yne
- (2) 2-Methylhex-2-ene
- (3) 2-Pentyne
- (4) 3-Methylhex-2-yne

Answer (1)**Sol.**

11. Given below are two statements.

Statement I : First ionisation enthalpy of Cr is greater than that of Mn.

Statement II : Second and third ionisation enthalpies of Cr are less than that of Mn.

In the light of above statements, choose the correct option.

- (1) Both statement I and statement II are correct
- (2) Both statement I and statement II are incorrect
- (3) Statement I is correct but statement II is incorrect
- (4) Statement I is incorrect but statement II is correct

Answer (2)

Sol.	Cr	Mn
IE_1 (kJ/mol)	653	717
IE_2 (kJ/mol)	1592	1509
IE_3 (kJ/mol)	2990	3260

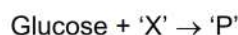
12. Which of the following is the correct IUPAC name of complex $[\text{Ni}(\text{PPh}_3)_3(\text{H}_2\text{O})_3]\text{Cl}_2$?

- (1) Triaquatris(triphenylphosphine)nickel(II) chloride
- (2) Tris(triphenylphosphine)triaquanickel(II) chloride
- (3) Triaquatris(triphenylphosphine)nickelate(II) chloride
- (4) Triaquatris(triphenylphosphine)nickel(III) chloride

Answer (1)

Sol. Correct IUPAC name is triaquatris(triphenyl phosphine) nickel(II) chloride

13. Match the two columns : based on the reaction



	List-I (Reagent-X)		List-II (Product-P)
A.	Br_2/water	(i)	Glucose oxime
B.	Acetic anhydride (excess)	(ii)	Saccharic acid

C.	Conc. HNO ₃	(iii)	Glucose pentaacetate
D.	NH ₂ OH	(iv)	Gluconic acid

(1) A – iv, B – ii, C – iii, D – i

(2) A – ii, B – iv, C – iii, D – i

(3) A – ii, B – iii, C – iv, D – i

(4) A – iv, B – iii, C – ii, D – i

Answer (4)

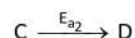
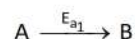
Sol. (1) Glucose + Br₂-water → Gluconic acid

(2) Glucose + Acetic anhydride → Glucose pentaacetate

(3) Glucose + Conc. HNO₃ → Saccharic acid

(4) Glucose + NH₂OH → Glucose oxime

14. Consider two reactions having same pre-exponential factor (A) occurring at same temperature (T).



$$E_{a1} = 5E_{a2}$$

Find out the correct expression?

$$(1) \frac{k_1}{k_2} = e^{-\frac{E_{a2}}{RT}} \quad (2) \frac{k_1}{k_2} = e^{-\frac{4E_{a1}}{RT}}$$

$$(3) \frac{k_1}{k_2} = e^{-\frac{4E_{a1}}{5RT}} \quad (4) \frac{k_1}{k_2} = e^{-\frac{4E_{a2}}{5RT}}$$

Answer (3)

Sol. $k_1 = Ae^{-\frac{E_{a1}}{RT}}$

$$k_2 = Ae^{-\frac{E_{a2}}{RT}}$$

$$\frac{k_1}{k_2} = e^{-\left(\frac{E_{a1} - E_{a2}}{RT}\right)}$$

$$= e^{-\frac{(5E_{a2} - E_{a2})}{RT}}$$

$$= e^{-\frac{4E_{a2}}{RT}}$$

$$= e^{-\frac{4E_{a1}}{5RT}}$$

Option (3) is correct

15. Consider the given species



The number of lone pair on central atom which has lowest dipole moment.

(1) 0

(2) 1

(3) 2

(4) 3

Answer (2)

Sol.

Molecules		Dipole Moment (D)
NH ₃	→	1.47
NF ₃	→	0.23
H ₂ O	→	1.85
H ₂ S	→	0.95
CHCl ₃	→	1.04

16. Consider the statements below

Statement I: BCl_3 is covalent in nature

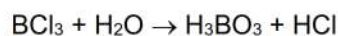
Statement II: BCl_3 undergoes hydrolysis to form $[\text{B}(\text{OH})_4]^-$ and BH_2^+

In the light of above statements choose the correct option.

- (1) Statement I and statement II both are correct
- (2) Statement I and statement II both are incorrect
- (3) Statement I correct statement II incorrect
- (4) Statement I incorrect statement II correct

Answer (3)

Sol. BCl_3 is covalent in nature



17. Energy of first Balmer line of H-atom is x kJ

The energy of second Balmer line of H-atom is ____

- (1) x
- (2) 1.35 x
- (3) 2x
- (4) x/1.35

Answer (2)

Sol. $E_{\text{Balmer } 1^{\text{st}}} \propto 13.6 \times \left(\frac{1}{2^2} - \frac{1}{3^2} \right) \propto 13.6 \times \frac{5}{36} \propto x \dots (i)$

$$(n_1 = 2, n_2 = 3)$$

$E_{\text{Balmer } 2^{\text{nd}}} \propto 13.6 \times \left(\frac{1}{2^2} - \frac{1}{4^2} \right) \propto 13.6 \times \frac{3}{16} \dots (ii)$

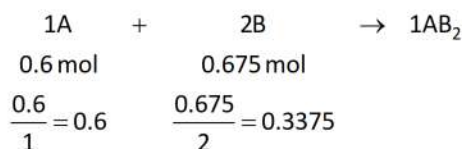
$$(ii)/(i) \Rightarrow E_{\text{Balmer } 2^{\text{nd}}} = \frac{13.6 \times \frac{3}{16}}{13.6 \times \frac{5}{36}} \times x = x \times 1.35$$

18. 36 g of A reacts with 54 g of B to form AB_2 , if molar mass of A and B is respectively 60 and 80, then choose correct option from following.

- (1) Limiting Reagent is A
- (2) 90 g of AB_2 formed
- (3) Limiting Reagent is B
- (4) 50 g of AB_2 formed

Answer (3)

Sol. $n_A = \frac{36}{60} = 0.6$, $n_B = \frac{54}{80} = 0.675$

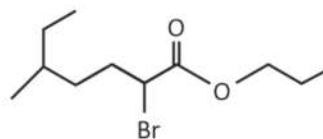


So, limiting reagent is B

Mole of AB_2 formed = 0.3375

W of $\text{AB}_2 = 0.3375 \times 220 = 74.25 \text{ g}$

19. The correct IUPAC nomenclature of the following compound is



- (1) Propyl-2-bromo-6-methyl heptanoate
- (2) 2-Bromo-5-methyl-1-propyl heptanoate
- (3) Propyl-2-bromo-5-ethyl hexanoate
- (4) Propyl-2-bromo-5-methyl heptanoate

Answer (4)

Sol. Ester is the principal functional group in this molecule.



20.

SECTION - B

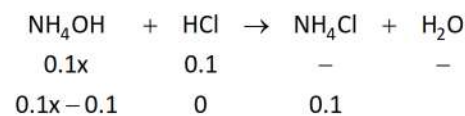
Numerical Value Type Questions: This section contains 5 Numerical based questions. The answer to each question should be rounded-off to the nearest integer.

21. Volume ratio of decimolar NH_4OH and decimolar HCl to give a solution of $\text{pH} = 9.26$ at 25°C is $x : 1$. Find x .

$$\text{pK}_b \text{ of } \text{NH}_4\text{OH} = 4.74$$

Answer (2)

Sol. Assume $V_{\text{NH}_4\text{OH}} = x\text{L}$ and $V_{\text{HCl}} = 1\text{L}$



$$\text{pOH} = \text{pK}_b + \log \frac{[\text{salt}]}{[\text{base}]}$$

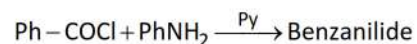
$$4.74 = 4.74 + \log \frac{(0.1x - 0.1) / V}{0.1 / V}$$

$$0.1x - 0.1 = 0.1$$

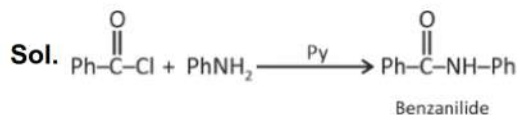
$$x = 2$$

22. 5.8 g Aniline is converted into benzanilide with some reaction sequences.

Calculate mass of benzanilide formed, if percentage yield of reaction is 82%.



Answer (10)



Mole of aniline

$$= \frac{5.8}{93} \text{ mol}$$

Mole of $\text{Ph}-\overset{\text{O}}{\parallel}{\text{C}}-\text{NH}-\text{Ph}$ will be formed of yield is 100%

$$= \frac{5.8}{93} \text{ mol}$$

$$\text{mole of } \text{Ph}-\overset{\text{O}}{\parallel}{\text{C}}-\text{NHPh} = \frac{5.8}{93} \times 0.82 = 0.0511 \text{ mol}$$

$$\text{mass} = 10.07 \approx 10 \text{ g}$$

23. A cycloalkene (X) is treated with Br_2 and compound (Y) is formed with C : Br ratio 3 : 1. One mole of X required 1 mol of Br_2 . Find composition of 'Br' in Y compound (percentage).

Answer (66)

Sol. Cycloalkene (X) $\Rightarrow \text{C}_n\text{H}_{2n-2}$

After reaction with Br_2 compound Y is formed



If ration of C : Br = 3 : 1

MF of Y should be $\text{C}_6\text{H}_{10}\text{Br}_2$

$$\% \text{ of Br} = \frac{2 \times 80}{242} \times 100 = 66.11\% \approx 66$$

24.

25.

MATHEMATICS

SECTION - A

Multiple Choice Questions: This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.

Choose the correct answer:

1. If complex numbers $Z_1, Z_2, \dots, Z_n$ satisfy the equation $4Z^2 + \bar{Z} = 0$, then $\sum_{i=1}^n |Z_i|^2$ is equal to

- (1) $\frac{3}{16}$ (2) $\frac{3}{64}$
(3) $\frac{9}{64}$ (4) $\frac{1}{16}$

Answer (1)

Sol. $4z^2 + \bar{z} = 0$

If $z = 0$ then it is a solution

$$\Rightarrow |z| = 0$$

Now, $z \neq 0$

Multiplying by z we get

$$4z^3 + |z|^2 = 0$$

$$\Rightarrow 4z^3 = -|z|^2$$

Taking modulus both sides

$$4|z|^3 = |z|^2 \Rightarrow |z|^2(4|z| - 1) = 0$$

$$\Rightarrow |z| = \frac{1}{4}$$

$$\Rightarrow 4z^3 = \frac{-1}{16} \Rightarrow z^3 = \frac{-1}{64}$$

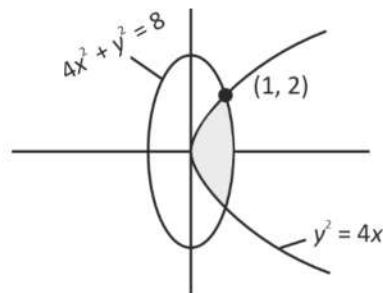
$$\Rightarrow z = \frac{-1}{4}, \frac{-1}{4}\omega, \frac{-1}{4}\omega^2$$

2. Area enclosed by $4x^2 + y^2 \leq 8$ and $y^2 \leq 4x$ is (in square unit) is

- (1) $\left(\pi + \frac{4}{3}\right)$ sq. unit (2) $\left(\pi - \frac{4}{3}\right)$ sq. unit
(3) $\left(\pi + \frac{2}{3}\right)$ sq. unit (4) $\left(\pi - \frac{2}{3}\right)$ sq. unit

Answer (3)

Sol.



$$\begin{aligned} \text{Area} &= 2 \int_0^1 \sqrt{\frac{8-y^2}{4}} - \frac{y^2}{4} dx \\ &= \int_0^2 \left(\sqrt{8-y^2} - \frac{y^2}{2} \right) dy \\ &= 4 \sin^{-1} \left(\frac{y}{2^{3/2}} \right) + \frac{y\sqrt{8-y^2}}{2} - \frac{y^3}{6} \Bigg|_0^2 \\ &= 4 \sin^{-1} \left(\frac{1}{\sqrt{2}} \right) + \frac{2 \times 2}{2} - \frac{8}{6} \\ &= \frac{4\pi}{4} + 2 - \frac{4}{3} \\ &= \left(\pi + \frac{2}{3} \right) \text{ sq. unit} \end{aligned}$$

3. Mean deviation about median for $k, 2k, 3k, \dots, 1000k$ is 500, then the value of k^2 is

- (1) 4
(2) 9
(3) 16
(4) 1

Answer (1)

Sol. data set

$$k, 2k, 3k, \dots, 1000k.$$

$$\text{Median} = \frac{500k + 501k}{2} = 500.5k$$

Mean-deviation about median

$$500 = \frac{|500.5k - k| + |500.5k - 2k| + \dots + |1000k - 500.5k|}{1000}$$

$$= \frac{2[499.5k + 498.5k + \dots + 0.5k]}{1000}$$

$$250000 = \frac{500}{2}[0.5 + 499.5]k$$

$$\Rightarrow \boxed{k=2}$$

$$\boxed{k^2=4}$$

4. If $4x^2 + y^2 < 52$, $x, y \in I$ then number of ordered pairs

(x, y) is

(1) 67

(2) 87

(3) 77

(4) 38

Answer (3)

Sol. $4x^2 + y^2 < 52$, $x, y \in I$

$$\Rightarrow 4x^2 < 52 \Rightarrow x^2 < 13 \Rightarrow x^2 \in \{0, 1, 4, 9\}$$

$$\text{If } x^2 = 0 \Rightarrow y^2 < 52 \Rightarrow y^2 \in \{0, 1, 4, 9, 16, 25, 36, 49\}$$

$$1 \times (1 + 2 \times 7) = 15$$

$$\text{If } x^2 = 1 \Rightarrow y^2 < 48 \Rightarrow y^2 \in \{0, 1, 4, 9, 16, 25, 36\}$$

$$2 \times (1 + 2 \times 6) = 26$$

$$\text{If } x^2 = 4 \Rightarrow y^2 < 36 \Rightarrow y^2 \in \{0, 1, 4, 9, 16, 25\}$$

$$2 \times (1 + 2 \times 5) = 22$$

$$\text{If } x^2 = 9 \Rightarrow y^2 < 16 \Rightarrow y^2 \in \{0, 1, 4, 9\}$$

$$2 \times (1 + 2 \times 3) = 14 \Rightarrow 77 \text{ pairs}$$

5. $x - ny + z = 6$

$$x - (n-2)y + (n+1)z = 8$$

$$(n-1)y + z = 1$$

Let n = number on the dies when rolled randomly then P (that system equation has unique solution)

$= \frac{k}{6}$, then sum of value of k and all possible value

of n is

(1) 22

(2) 21

(3) 20

(4) 24

Answer (4)

Sol. For system of equation to have unique solution

$$\Delta \neq 0$$

$$\begin{vmatrix} 1 & -n & 1 \\ 1 & 2-n & n+1 \\ 0 & n-1 & 1 \end{vmatrix} \neq 0$$

$$\Rightarrow n^2 - n - 2 \neq 0$$

$$(n-2)(n+1) \neq 0$$

$$\Rightarrow n \neq 2$$

$\therefore$ possible values of n is $\{1, 3, 4, 5, 6\}$

$$P(\text{unique solution}) = \frac{5}{6} = \frac{k}{6}$$

$$\Rightarrow k = 5$$

$\therefore$ sum of all possible value of n and k is

$$1 + 3 + 4 + 5 + 6 + 5 = 24$$

$$6. \text{ If } \lim_{x \rightarrow 0} \frac{e^{(a-1)x} + 2\cos(bx) + e^{-x}(c-1)}{x \cos x - \ln(1+x)} = 2$$

Then the value of $a^2 + b^2 + c^2$ is

(1) 8

(2) 9

(3) 10

(4) 11

Answer (3)

$$\begin{aligned} \text{Sol. } \lim_{x \rightarrow 0} & \left(1 + x(a-1) + \frac{(x(a-1))^2}{2!} + \dots \right) + 2 \left(1 - \frac{b^2 x^2}{2!} + \frac{b^4 x^4}{4!} \right) \\ & + \frac{\left(1 - x + \frac{x^2}{2!} - \frac{x^3}{3!} + \dots \right) (c-1)}{x \left(1 - \frac{x^2}{2!} + \frac{x^4}{4!} - \dots \right) - \left(x - \frac{x^2}{2} + \frac{x^3}{3} - \dots \right)} \\ & \Rightarrow \frac{(1+2+(c-1)) + x(a-1-c+1) + x^2 \left(\frac{(a-1)^2}{2!} - b^2 + (c-1)\frac{1}{2} \right) + \dots}{\frac{x^2}{2} - \frac{5}{6}x^3 + \dots} \end{aligned}$$

$$3 + c - 1 = 0$$

$$\boxed{c=-2}$$

$$a - c = 0$$

$$\Rightarrow a = c = -2$$

$$\frac{\frac{9}{2} - b^2 - \frac{3}{2}}{\frac{1}{2}} = 2$$

$$\Rightarrow \frac{9}{2} - \frac{3}{2} - b^2 = 1$$

$$\Rightarrow \boxed{b^2 = 2}$$

$$a^2 + b^2 + c^2 = 4 + 4 + 2 = 10$$

7. If $P(10, 2\sqrt{15})$ lies on hyperbola $\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$ and

length of latus rectum = 8, then the square of area of $\triangle PS_1S_2$ is [where S_1 & S_2 are the foci of the hyperbola]

- (1) 2700 (2) 2400
(3) 1750 (4) 3600

Answer (1)

Sol. $\frac{100}{a^2} - \frac{60}{b^2} = 1$

Also $\frac{2b^2}{a} = 8$

$$\Rightarrow b^2 = 4a$$

$$\frac{100}{a^2} - \frac{60}{4a} = 1$$

$$100 - 15a = a^2$$

$$a^2 + 15a - 100 = 0$$

$$(a + 20)(a - 5) = 0$$

$$a = -20, 5$$

$$\therefore b^2 = 4a \Rightarrow a \text{ cannot be negative}$$

$$\Rightarrow \boxed{a = 5}$$

$$\boxed{b^2 = 20}$$

Now $H: \frac{x^2}{25} - \frac{y^2}{20} = 1$

$$e^2 = 1 + \frac{20}{25} \Rightarrow e = \frac{3}{\sqrt{5}}$$

$$F: (\pm 3\sqrt{5}, 0) \text{ i.e. } S_1 \text{ \& } S_2$$

$$\begin{aligned} \text{Area } PS_1S_2 &= \frac{1}{2} \begin{vmatrix} 10 & 2\sqrt{15} \\ 3\sqrt{5} & 0 \\ -3\sqrt{5} & 0 \end{vmatrix} = \frac{1}{2} [-6\sqrt{75} - 6\sqrt{75}] \\ &= 6\sqrt{75} \end{aligned}$$

$$\text{Area}^2 = 2700$$

8. If a, b, c are in A.P where $a + b + c = 1$ and $a, 2b, c$ are in G.P., then the value of $9(a^2 + b^2 + c^2)$ is equal to

- (1) 3 (2) -3
(3) 4 (4) -4

Answer (2)

Sol. $a, b, c \rightarrow AP \vdash$

$$a, 2b, c \rightarrow GP \Rightarrow 4b^2 = ac$$

$$a + b + c = 1$$

$$2b = a + c$$

$$\Rightarrow b = \frac{1}{3}$$

$$a + c = \frac{2}{3}$$

$$4b^2 = ac$$

$$\frac{4}{9} = ac$$

$$a^2 + b^2 + c^2$$

$$\Rightarrow \frac{1}{9} + (a + c)^2 - 2ac$$

$$\Rightarrow \frac{1}{9} + \frac{4}{9} - 2\left(\frac{4}{9}\right) = \frac{-1}{3}$$

Here $a = \frac{1}{3} + \frac{i}{\sqrt{3}} \quad b = \frac{1}{3} \quad c = \frac{1}{3} - \frac{i}{\sqrt{3}}$

$$\therefore a^2 + b^2 + c^2 \text{ is negative}$$

9. Let the domain of function

$$f(x) = \log_3 \log_5 (7 - \log_2 (x^2 - 10x + 15)) + \sin^{-1} \left(\left| \frac{3x-7}{17-x} \right| \right)$$

be $(\alpha, \beta]$, then $\alpha + \beta$ is equal to

- (1) 6 (2) 7
(3) 8 (4) 9

Answer (4)

Sol. $\log_5 (7 - \log_2 (x^2 - 10x + 85)) > 0$

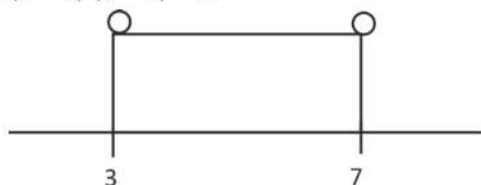
$$\Rightarrow 7 - \log_2 (x^2 - 10x + 85) > 1$$

$$\Rightarrow \log_2 (x^2 - 10x + 85) < 6$$

$$\Rightarrow x^2 - 10x + 85 < 64$$

$$\Rightarrow x^2 - 10x + 21 < 0$$

$$(x-7)(x-3) < 0$$



$$\Rightarrow x \in (3, 7)$$

$$\left| \frac{3x-7}{17-x} \right| \leq 1$$

$$\Rightarrow |3x-7| \leq |17-x|$$

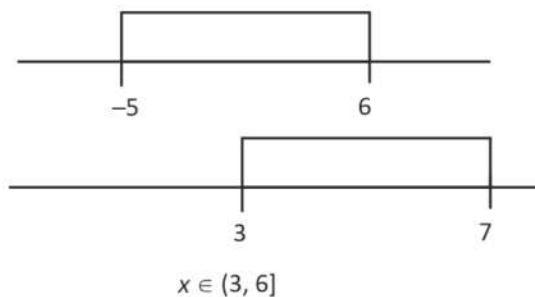
$$\Rightarrow 9x^2 + 49 - 42x \leq 289 + x^2 - 34x$$

$$\Rightarrow 8x^2 - 8x - 240 \leq 0$$

$$\Rightarrow x^2 - x - 30 \leq 0$$

$$(x-6)(x+5) \leq 0$$

$$x \in [-5, 6]$$



10. Let $\vec{a} = \sqrt{2}\hat{i}$ and $\vec{b} = 5\hat{j} + \hat{k}$. If $\vec{c} = \vec{a} \times \vec{b}$ and $\vec{d}$ which lie on y - z plane such that $|\vec{d}| = 2$. Then the

maximum value of $|\vec{c} \cdot \vec{d}|^2$ is equal to

- (1) 104 (2) 52
(3) 208 (4) 120

Answer (3)

Sol. $|\vec{a} \times \vec{b}| = \sqrt{52} = |\vec{c}|$

The maximum value of $|\vec{c} \cdot \vec{d}|^2$

$$= (\sqrt{52} \cdot (2) \cos \theta)^2 = 208 \cos^2 \theta$$

The maximum value of $|\vec{c} \cdot \vec{d}|^2 = 208$

11. If $\int_0^{64} \left(x^{\frac{1}{3}} + \text{floor} \left(x^{\frac{1}{3}} \right) \right) dx = \alpha$ and

$\int_0^{\frac{\pi}{2}} \frac{\sin^2 x}{\sin^6 x + \cos^6 x} dx = \pi\beta$, then the value of $\alpha\beta^2$ is equal to

- (1) 87 (2) 77
(3) 67 (4) 57

Answer (1)

Sol. $I_1 = \int_0^{64} \left(x^{\frac{1}{3}} + \text{floor} \left(x^{\frac{1}{3}} \right) \right) dx$

$$= \left[\frac{x^{\frac{4}{3}}}{\frac{4}{3}} \right]_0^{64} + \int_0^1 0 dx + \int_1^8 (1) dx + \int_8^{27} 2 dx + \int_{27}^{64} (3) dx$$

$$= 192 + 0 + (8-1) + 2 + 2(27-8) + 3(64-27) = 348$$

$$I_2 = \int_0^{\frac{\pi}{2}} \frac{\sin^2 x}{\sin^6 x + \cos^6 x} dx$$

$$\Rightarrow I_2 = \int_0^{\frac{\pi}{2}} \frac{\cos^2 x}{\sin^6 x + \cos^6 x} dx$$

$$\Rightarrow 2I_2 = \int_0^{\frac{\pi}{2}} \frac{1}{\sin^6 x + \cos^6 x} dx = \int_0^{\frac{\pi}{2}} \frac{\sec^2 x}{1 + \tan^6 x} dx$$

$$\Rightarrow I_2 = \frac{\pi}{2} \Rightarrow \beta = \frac{1}{2}, \alpha = 348$$

$$\alpha\beta^2 = 348 \times \frac{1}{4} = 87$$

12.

13.

14.

15.

16.

17.

18.

19.

20.

SECTION - B

Numerical Value Type Questions: This section contains 5 Numerical based questions. The answer to each question should be rounded-off to the nearest integer.

21. If α, β are roots of equation $12x^2 - 20x + 3\lambda = 0$,

$\lambda \in I$. If $\frac{1}{2} \leq |\beta - \alpha| \leq \frac{3}{2}$, then the sum of all possible values of λ is

Answer (03.00)

Sol. $|\beta - \alpha|^2 \in \left[\frac{1}{4}, \frac{9}{4} \right]$

$$(\alpha^2 + \beta^2 - 2\alpha\beta) = (\alpha + \beta)^2 - 4\alpha\beta \in \left[\frac{1}{4}, \frac{9}{4} \right]$$

$$= \left(\frac{20}{12} \right)^2 - 4 \left(\frac{3\lambda}{12} \right) \in \left[\frac{1}{4}, \frac{9}{4} \right]$$

$$\Rightarrow \frac{25}{9} - \lambda \in \left[\frac{1}{4}, \frac{9}{4} \right]$$

$$\Rightarrow 100 - 36\lambda \in [9, 81]$$

$$36\lambda - 100 \in [-81, -9]$$

$$36\lambda \in [19, 91]$$

$$\lambda \in \left[\frac{19}{36}, \frac{91}{36} \right]$$

then integral values of λ is 1, 2

$\Rightarrow$ Sum of integral values of λ is $1 + 2 = 3$

22. If $\cos(\alpha + \beta) = -\frac{1}{10}$ and $\sin(\alpha - \beta) = \frac{3}{8}$, where

$$0 < \alpha < \frac{\pi}{3} \text{ and } 0 < \beta < \frac{\pi}{4}, \text{ if } \tan 2\alpha = \frac{3(1 - r\sqrt{55})}{\sqrt{11}(s + \sqrt{5})}$$

and $r, s \in N$, then $r^2 + s$ is

Answer (20)

Sol. $0 < \alpha < \beta < \frac{7\pi}{12}$

$$\because \cos(\alpha + \beta) = -\frac{1}{10} \Rightarrow \alpha + \beta \in \text{II}^{\text{nd}} \text{ quadrant}$$

$$\sin(\alpha + \beta) = \frac{\sqrt{99}}{10}$$

$$\sin(\alpha - \beta) = \frac{3}{8} \quad \alpha + \beta \in \text{I quadrant}$$

$$\cos(\alpha - \beta) = \frac{\sqrt{55}}{8}$$

$$\tan((\alpha + \beta) + (\alpha - \beta)) = \frac{\tan(\alpha + \beta) + \tan(\alpha - \beta)}{1 - \tan(\alpha + \beta)\tan(\alpha - \beta)}$$

$$\tan 2\alpha = \frac{-\sqrt{99} + \frac{3}{\sqrt{55}}}{1 + 3\sqrt{\frac{99}{55}}} = \left[\frac{-3\sqrt{11 \cdot 55} + 3}{\sqrt{55} + 9\sqrt{11}} \right]$$

$$= \frac{3 - 3\sqrt{11} \cdot \sqrt{55}}{\sqrt{55} + 9\sqrt{11}} = \frac{3(1 - \sqrt{11}\sqrt{55})}{\sqrt{11}(\sqrt{5} + 9)}$$

$$r^2 = 11$$

$$s = 9$$

$$r^2 + s = 20$$

23.

24.

25.

