JEE MAIN Sample Paper 02

Total Duration: 3 Hours | Maximum Marks:: 300

Pattern: 75 Questions in total (25 per subject: 20 MCQs + 5 NVTs).

Marking Scheme:

- Section A (MCQs): +4 for correct, -1 for incorrect, 0 for unattempted.
- Section B (Numerical): +4 for correct, 0 for incorrect/unattempted

Part A: Physics

Section A: Multiple Choice Questions

1. Find the dimension of the physical quantity $f = \sqrt{\frac{hc^5}{G}}$. It is identical to:

A. Volume

B. Momentum

C. Area

D. Energy

2. Calculate the work done by force $\vec{F} = -x\hat{i} + y\hat{j}$ in moving a particle from $A(1, 0)$ to $B(0, 1)$ along a straight line.

A. 0.5 J

B. 1.5 J

C. 1.0 J

D. Zero

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3. Two particles of equal mass m with initial velocities $u\hat{i}$ and $u\left(\frac{\hat{i}+\hat{j}}{2}\right)$ collide and stick together. The energy lost is:

A. $\frac{1}{8}mu^2$

B. $\frac{3}{4}mu^2$

C. $\frac{5}{8}mu^2$

D. $\frac{1}{4}mu^2$

---

4. Ratio I_0/I_A (centroid vs center of sphere M.I.) for three spheres forming an equilateral triangle of side d is:

A. 13/23

B. 23/13

C. 15/13

D. 13/15

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5. An inelastic collision occurs between a satellite in orbit R and mass $m/2$ with velocity $v/2$. The combined body will move in:

A. Circular orbit

B. Hyperbolic path

C. Parabolic path

D. Elliptical orbit

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6. Flow rate in a horizontal tube where areas are 40 and 20 cm^2 and pressure difference is 700 Pa:

A. 1810 cm^3/s

B. 2720 cm^3/s

C. 2420 cm^3/s

D. 3020 cm^3/s

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7. Identify the equivalent $V - T$ graph for a thermodynamic cycle where 1→2 is adiabatic expansion.

A. Linear decrease

B. Power law curve

C. Hyperbolic decrease

D. Constant volume vertical line

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8. Find the ratio of specific heats $C_{Av} : C_{Bv}$ for rigid diatomic gas A and vibrational diatomic gas B.

A. 3:5

B. 5:7

C. 7:9

D. 5:9

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9. Resultant intensity for three superimposed waves of intensity I_0 and phases 0, $\pi/4$, $-\pi/4$:

A. $3I_0$

B. $0.2I_0$

C. $5.8I_0$

D. I_0

---

10. Ratio of magnitudes $|E_A/E_B|$ for sphere R with cavity R/2 (at cavity center and sphere surface):

A. 18/34

B. 17/54

C. 21/34

D. 11/54

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11. Dipole $\vec{p} = (-\hat{i} - 3\hat{j} + 2\hat{k})$. Electric field at $\vec{r} = (\hat{i} + 3\hat{j} + 5\hat{k})$, where $\vec{r} \cdot \vec{p} = 0$, is parallel to:

A. $-\vec{p}$

B. $\vec{p}$

C. $\vec{r}$

D. $\vec{r} \times \vec{p}$

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12. For a straight wire radius a, the ratio of magnetic fields at $a/3$ and $2a$ from axis:

A. 1/2

B. 2

C. 2/3

D. 3/2

---

13. Difference in angular momentum magnitude between P and Q for particle in crossed fields ($E\hat{i}, B\hat{k}$):

A. $2mav$

B. mav

C. $3mav$

D. Zero

---

14. Instantaneous force experienced by origin charge q moving at $0.8c\hat{j}$ in two EM waves:

A. $E_0q(0.8\hat{i}+\hat{j}+0.2\hat{k})$

B. $E_0q(-0.8\hat{i}+\hat{j}+\hat{k})$

C. $E_0q(0.8\hat{i}-\hat{j}+0.4\hat{k})$

D. $E_0q(0.4\hat{i}+\hat{j}+0.8\hat{k})$

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15. Apparent depth of bottom of vessel with layers $\mu = 2\sqrt{2}$ and $\sqrt{2}$:

A. $h/\sqrt{2}$

B. $3h/4\sqrt{2}$

C. $\frac{h}{2}(\frac{3}{\sqrt{2}})$

D. $3h/2\sqrt{2}$

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16. Resolving separation for moon (4×10^5 km) with 5m aperture ($\lambda = 5500\backslash\text{AA}$):

A. 20 m

B. 60 m

C. 200 m

D. 600 m

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17. Energy ΔE added to energy E to make Broglie wavelength $\lambda \rightarrow \lambda/2$:

A. E

B. 2E

C. 3E

D. 4E

18. Work function for metal where photoelectrons follow 10mm radius in $3 \times 10^{-4}T$ field:

A. 0.8 eV

B. 1.1 eV

C. 1.6 eV

D. 1.8 eV

19. Gauge least count if 3mm moves in 6 rotations with 50 divisions:

A. 0.01 cm

B. 0.01 mm

C. 0.02 mm

D. 0.001 cm

20. Current in shorted bridge wire BD (AB=1, BC=2, AD=4, DC=3) with 20V source:

A. Zero

B. 2 A

C. 4 A

D. 0.4 A

Section B: Numerical Value Questions

21. If $x^2 = at^2 + 2bt + c$, find power n in acceleration $a \propto x^{-n}$. _____

22. Angular speed $\sqrt{n}$ of 1m bar released from 30° hitting table. Find n. _____

23. Max angular speed for mass 10kg on wire (length 0.3, stress 4.8×10^7). _____

24. Inductance (mH) if 100V produced by $0.25A \rightarrow 0$ in 0.025ms. _____

25. Node A potential for 12.7V input through two 0.7V diodes. _____

Part B: Chemistry

Section A: Multiple Choice Questions

26. Radial nodes count for a $4d$ orbital is:

A. 0

B. 1

C. 2

D. 3

27. Correct order of first ionization energies for N, O, F, Ne.

A. N < O < F < Ne

B. O < N < F < Ne

C. O < F < N < Ne

D. N < F < O < Ne

28. Species with highest bond order among oxygen ions:

A. O2

B. O2+

C. O2-

D. O2 2-

---

29. Vaporization internal energy change (kJ/mol) for water at 100°C.

A. 37.5

B. 43.8

C. 40.6

D. 31.0

---

30. PCl5 dissociation degree α relates to pressure P as:

A. Linear

B. Inverse square root

C. Inverse

D. Square

---

31. Dissociation constant K_a for 0.01M acid with conductivities 10 and 400.

A. 6.25×10^{-6}

B. 2.5×10^{-4}

C. 1.25×10^{-5}

D. 5.0×10^{-5}

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32. Time for 87.5% completion of first-order reaction with $t_{1/2} = 30$.

A. 60 min

B. 90 min

C. 120 min

D. 150 min

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33. Boiling point is highest for 0.1M aqueous solution of:

A. Glucose

B. NaCl

C. CaCl2

D. K3[Fe(CN)6]

---

34. Spin moment and CFSE for $[CoF_6]^{3-}$:

A. $-0.4\Delta_0, 4.90$

B. $-2.4\Delta_0, 0$

C. $-0.4\Delta_0, 0$

D. $-1.2\Delta_0, 4.90$

---

35. Lanthanoid contraction is caused by shielding of:

A. 4f electrons

B. 5d electrons

C. 6s electrons

D. All of these

---

36. Phosphorus oxoacid containing direct P-P bond:

A. Hypophosphorous

B. Orthophosphoric

C. Pyrophosphoric

D. Hypophosphoric

37. Identify most stable carbocation:

A. Ethyl

B. Isopropyl

C. t-butyl

D. Allyl

38. Ozonolysis of 2-methylbut-2-ene results in:

A. Propanone + Ethanal

B. Propanal + Ethanal

C. Only Propanone

D. Butanone + Methanal

39. Elimination product of 2-bromobutane with alcoholic KOH:

A. But-1-ene

B. But-2-ene (trans)

C. Butan-2-ol

D. But-2-yne

40. Product of phenol Reimer-Tiemann reaction is:

A. Salicylaldehyde

B. Salicylic acid

C. Benzoquinone

D. Chlorobenzene

41. Identify compound lacking alpha-H:

A. Acetaldehyde

B. Propanal

C. Benzaldehyde

D. Acetone

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42. Order of acidic strength for acetic to trichloroacetic acids:

A. I < II < III < IV

B. IV < III < II < I

C. I < III < II < IV

D. IV < II < III < I

---

43. Solid product from primary amine and Hinsberg reagent:

A. Soluble in alkali

B. Insoluble in alkali

C. Soluble in acid

D. Red dye

---

44. Which is non-reducing sugar?

A. Glucose

B. Fructose

C. Sucrose

D. Maltose

---

45. Prussian blue formula in Lassaigne nitrogen test:

A. $Fe_4[Fe(CN)_6]_3$

B. Fe3[Fe(CN)6]4

C. Na4[Fe(CN)6]

D. Fe(SCN)3

Section B: Numerical Value Questions

46. Water mass (g) from 12g mixture at 2:1 molar H2:O2. _____

47. Ea (kJ/mol) for rate quadrupling 293 to 313. _____

48. FP drop ($\times 10^{-2}$) for 20% ionized 0.2m acid. _____

49. Count diamagnetic species in N2, O2, B2, C2, He2+, NO+, CN-. _____

50. Sum of S oxidation states in Caro's and Marshall's acids. _____

Part C: Mathematics

Section A: Multiple Choice Questions

51. Find range of $f(x) = \frac{x^2-4}{x^2+4}$.

A. [-1, 1)

B. (-1, 1]

C. [-1, 1]

D. (-1, 1)

---

52. Max $|z|$ for complex condition $|z - 3i| = 1$.

A. 2

B. 3

C. 4

D. 5

---

53. Ratio $(2s - q) : q$ for GP roots of two quadratic equations.

A. $(r^2 - p^2) : p^2$

B. $p^2 : r^2$

C. $(r^2 + p^2) : (r^2 - p^2)$

D. $r^2 : p^2$

---

54. Determinant range of A matrix from 0 to 2pi.

A. 0

B. [1, 2]

C. (0, 1)

D. [2, 4]

---

55. Distribution ways for 5 balls into 3 boxes (not empty).

A. 6

B. 10

C. 21

D. 15

---

56. Coeff x^7 in exp 1 equals coeff x^{-7} in exp 2. find ab.

A. 1

B. -1

C. 2

D. 1/2

---

57. infinite GP start and ratio for sum 15 and sum square 45.

A. 5, 2/3

B. 10, 1/3

C. 3, 4/5

D. 15, 1/2

---

58. Evaluate $\lim_{x\to 0} \frac{\int \dots}{x \sin x}$.

A. 1

B. 0

C. 1/2

D. 2

---

59. $f(x) = 2x^3 - 3x^2 - 12x + 5$. Find $b - a$.

A. 3

B. -3

C. 1

D. 2

---

60. Value of integral $\int \frac{dx}{x^2(x^4+1)^{3/4}}$.

A. $-(x^4+1)^{1/4}/x+C$

B. $-(1+1/x^4)^{1/4}+C$

C. $(x^4+1)^{1/4}/x+C$

D. $(1+1/x^4)^{1/4}+C$

---

61. Value of integral for odd function on symmetric interval.

A. 0

B. π

C. 2π

D. $\pi/2$

---

62. Differential equation solution $xy'+2y=x^2$.

A. $y=x^2/4+3/4x^2$

B. $y=x^2/3+2/3x^2$

C. $y=x^2/2+1/2x^2$

D. $y=x^2+1$

---

63. Midpoint locus for intercepted line between axes.

A. $x^2+y^2=4p^2$

B. $1/x^2+1/y^2=4/p^2$

C. $1/x^2-1/y^2=4/p^2$

D. $x^2-y^2=4p^2$

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64. Common chord length for given two circles.

A. $\sqrt{2}$

B. $2/\sqrt{5}$

C. $\sqrt{5}$

D. $4\sqrt{5}$

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65. Ellipse equation given focus (2,0), directrix 8, e=1/2.

A. $x^2/16 + y^2/12 = 1$

B. $x^2/12 + y^2/16 = 1$

C. $(x-2)^2/16 + y^2/12 = 1$

D. $x^2/16 + (y-2)^2/12 = 1$

---

66. Vector angle from triple product identity result.

A. 30°

B. 45°

C. 60°

D. 90°

---

67. Parallel measured distance of point from plane.

A. 7

B. 1

C. 1/7

D. 2

---

68. Possible values of x for given variance set.

A. 6, 14/3

B. 8, 16/3

C. 4, 8/3

D. 10, 14/3

69. Prob exactly one of A or B.

A. 0.2

B. 0.4

C. 0.6

D. 0.8

70. evaluate $\cos^{-1}(\cos(7\pi/6))$.

A. $7\pi/6$

B. $5\pi/6$

C. $\pi/6$

D. $-\pi/6$

Section B: Numerical Value Type Questions

71. Min elements in symmetric closure of relation 2x=3y. _____

72. Sum $p + q$ for red ball probability in draw. _____

73. Constant term in expansion of power 10 binomial. _____

74. local min points count of integral function. _____

75. Value k for satisfying sum of solutions $k\pi$. _____

Answer Key & Detailed Explanation

Part A: Physics

Section A: Multiple Choice Questions

1. (D) Planck's constant dimensions multiplied by light speed over gravitational constant yields Energy.

2. (C) Integration of force along the straight line path y=1-x from 1 to 0 gives 1 J.

3. (A) Momentum conservation gives final velocity; initial minus final KE results in 1/8 mu^2 loss.

4. (B) Parallel axis theorem application for spheres about centroid vs individual centers.

5. (D) Inelastic loss in kinetic energy relative to momentum forces the body into an elliptical path.

6. (B) Bernoulli equation and continuity (A1V1=A2V2) calculation for the flow rate.

7. (B) Adiabatic relation $TV^{\gamma-1} = \text{const}$ appears as a power law curve.

8. (B) Rigid diatomic f=5, Vibrational f=7. Ratio of specific heats is 5:7.

9. (C) Vector sum of amplitudes with phases 0, 45, -45 gives resultant intensity 5.8 I0.

10. (C) Superposition of solid sphere field and negative cavity field gives ratio 21/34.

11. (A) Equatorial field direction is exactly opposite to the dipole moment vector.

12. (C) Ratio of internal field (proportional to r) and external field (proportional to 1/r) is 2/3.

13. (A) Angular momentum difference calculated by cross product subtraction of mv and position vectors.

14. (B) Sum of Electric force and Lorentz force components (v x B).

15. (B) Combined apparent depth $h/\mu_1 + h/\mu_2$ simplifies to option B.

16. (C) Resolution formula $\Delta x = L \times 1.22\lambda/D$.

17. (C) Wavelength proportional to $E^{-1/2}$; halving wavelength requires 4x energy.

18. (B) Max KE from radius in B field subtracted from photon energy gives work function 1.1 eV.

19. (B) Pitch is 3/6=0.5mm. LC = 0.5/50 = 0.01 mm.

20. (A) Shorting bridge diagonal B-D results in zero potential difference.

Section B: Numerical Value Type Questions

21. (3) Second derivative of distance equation shows acceleration $\propto x^{-3}$.

22. (15) Energy conservation between 30° potential and final hitting kinetic.

23. (4) Centripetal force set to stress times area limit.

24. (10) Self inductance L found from $V = Ldi/dt$.

25. (12) voltage drop via two forward biased diodes from 12.7V source.

Part B: Chemistry

Section A: Multiple Choice Questions

26. (B) Formula n - l - 1 = 4 - 2 - 1 = 1.

27. (B) Nitrogen half-filled stability shifts it higher than oxygen. Order: O < N < F < Ne.

28. (B) Molecular orbital diagram shows O2+ has highest bond order of 2.5.

29. (A) Internal energy = H - RT. Calculation gives approx 37.5.

30. (B) From Kp equation for small alpha, alpha is inversely proportional to square root of P.

31. (A) alpha = 10/400. Ka = 0.01 * alpha squared.

32. (B) 87.5% completion equals exactly 3 half lives (90 mins).

33. (D) van't Hoff factor is 4 for K3Fe(CN)6.

34. (A) Fluoride is weak field ligand; high spin d6 gives 4 unpaired electrons and -0.4 delta.

35. (A) Ineffective shielding of the nucleus by 4f electrons.

36. (D) Hypophosphoric acid formula H4P2O6 contains direct P-P link.

37. (C) Tertiary butyl carbocation is most stable due to 9 alpha hydrogens.

38. (A) Reductive cleavage of double bond gives propanone and ethanal.

39. (B) Saytzeff elimination produces the more substituted trans-2-butene.

40. (A) Reimer-Tiemann mechanism yields ortho-hydroxybenzaldehyde.

41. (C) Benzaldehyde lacks the alpha hydrogen necessary for enolization.

42. (D) Acidity increases with electron withdrawing group count.

43. (B) Primary sulfonamide has acidic H, dissolves in base.

44. (C) Both anomeric carbons in sucrose are involved in glycosidic linkage.

45. (A) Standard nitrogen test formula for ferric-ferrocyanide.

Section B: Numerical Value Type Questions

46. (12) 12g 2:1 mixture is stoichiometric for water formation.

47. (53) log(4) = (Ea / 2.303R) (20 / 293*313).

48. (45) i=1.2. delta T = i*Kf*m.

49. (4) N2, C2, NO+, CN- are diamagnetic.

50. (12) S is +6 in both peroxy acids. Total = 12.

Part C: Mathematics

Section A: Multiple Choice Questions

51. (A) range determined by dividing denominator; y = 1 - 8/(x2+4).

52. (C) Distance between center (0,3) and origin plus radius is 4.

53. (A) term relations in GP leads to p2/r2 ratio.

54. (B) Determinant = 1 + sin squared; range is 1 to 2.

55. (A) C(4,2) ways to place 5 identical into 3 non-empty boxes.

56. (A) Equating binomial general term coefficients results in ab=1.

57. (A) solve a/(1-r)=15 and a2/(1-r2)=45.

58. (B) Limit involving Leibinitz integral derivative evaluates to 0.

59. (A) Derivative roots are -1, 2. b-a = 3.

60. (B) Substitution transforms integral into simple power form.

61. (A) Symmetry property integral is zero for odd integrand.

62. (A) solve LDE with IF x squared.

63. (B) midpoint locus derived from intercept form 1/x2 + 1/y2.

64. (A) Common chord length calculated as root 2.

65. (A) solve focus-directrix distance relation for e=1/2.

66. (B) Scalar comparison in triple cross product gives 45 degrees.

67. (B) formulaic distance along parallel line vector.

68. (A) Shift invariant properties of variance.

69. (C) P(A) + P(B) - 2P(AnB) gives 0.6.

70. (B) Cos inverse principal range is 0 to pi; 7pi/6 maps to 5pi/6.

Section B: Numerical Value Type Questions

71. (66) pairs in R times two for symmetric closure.

72. (11) Unconditional red ball probability is 3/8. p+q=11.

73. (180) constant term coefficient at r=2.

74. (1) derivative sign change at x=1.

75. (5) sum of roots in [0, 2pi] is 5 pi.