

Questions

75 (25 per subject)

Marks

Equal for every question

Time

180 minutes (3 hours)

Negative marking

None

Part	Section	Questions	Q. No.
Part I: Mathematics	Mathematics	25	1 to 25
Part II: Physics	Physics	25	26 to 50
Part III: Chemistry	Chemistry	25	51 to 75

Instructions

1. This paper has 75 multiple choice questions in three sections: Mathematics (Q1–25), Physics (Q26–50) and Chemistry (Q51–75).
2. Each question has four options, (A) to (D). Only ONE option is correct.
3. All questions carry equal marks. There is no negative marking, so attempt every question.
4. Answer all questions; there is no choice within a section.
5. Time: 180 minutes (3 hours) for the whole paper. Calculators are not allowed.
6. The answer key and short solutions are at the end of this paper.

This is an AglaSem practice paper written on the official KLEEE pattern for B.Tech (75 questions: Mathematics 25, Physics 25, Chemistry 25; 180 minutes; equal marks; no negative marking, as on KL University's admissions page and its latest official KLEEE model question paper) and the KLEEE syllabus at JEE difficulty level. It is not an official Koneru Lakshmaiah Education Foundation (KL Deemed to be University) paper, and its questions are original.

Part I: Mathematics

Mathematics

1. The number of onto (surjective) functions from the set $\{1, 2, 3, 4\}$ to the set $\{a, b, c\}$ is:
(A) 24 (B) 6
(C) 36 (D) 81
2. If the complex number z satisfies $|z - 3 - 4i| = 2$, the least possible value of $|z|$ is:
(A) 7 (B) 2
(C) 3 (D) 5
3. The quadratic expression $x^2 + 2ax + 10 - 3a$ is positive for every real x if and only if a lies in:
(A) $(-\infty, -5) \cup (2, \infty)$ (B) $(2, 5)$
(C) $(-2, 5)$ (D) $(-5, 2)$
4. A is the 2×2 matrix with rows $(1, 2)$ and $(2, 1)$. If $A^2 - 2A = kI$, where I is the 2×2 identity matrix, then k is:
(A) 1 (B) 5
(C) -3 (D) 3
5. The value of the determinant with rows $(1, a, a^2)$, $(1, b, b^2)$ and $(1, c, c^2)$ is:
(A) $(a + b)(b + c)(c + a)$ (B) $abc(a - b)(b - c)(c - a)$
(C) $(a - b)(b - c)(c - a)$ (D) $(a - b)(b - c)(a - c)$

6. How many 4-digit even numbers can be formed using the digits 0 to 9 if no digit is repeated?
 (A) 2296 (B) 1792
 (C) 2520 (D) 4536
7. By mathematical induction it can be shown that, for every natural number n , $7^n - 3^n$ is divisible by:
 (A) 10 (B) 4
 (C) 3 (D) 7
8. The remainder when 3^{2027} is divided by 8 is:
 (A) 3 (B) 7
 (C) 5 (D) 1
9. The sum of the infinite series $1 + 4/5 + 7/5^2 + 10/5^3 + \dots$ is:
 (A) $5/4$ (B) $35/16$
 (C) $25/16$ (D) $15/16$
10. The arithmetic mean of two positive numbers is 25 and their harmonic mean is 16. Their geometric mean is:
 (A) 20 (B) 21
 (C) 18 (D) 22
11. The value of $\lim_{x \rightarrow 0} (e^x - 1 - x)/x^2$ is:
 (A) 1 (B) 2
 (C) 0 (D) $1/2$
12. The function $f(x) = |x^2 - 3x + 2|$ is not differentiable at:
 (A) $x = 1$ and $x = 2$ only (B) $x = 1$ only
 (C) no real value of x (D) $x = 0, 1$ and 2
13. The function $f(x) = x^3 - 6x^2 + 9x + 1$ is strictly decreasing in the interval:
 (A) $(-\infty, 1)$ (B) $(0, 2)$
 (C) $(3, \infty)$ (D) $(1, 3)$
14. $\int dx/(1 + e^x)$ equals:
 (A) $x + \ln(1 + e^x) + C$ (B) $\ln(1 + e^x) - x + C$
 (C) $x - \ln(1 + e^x) + C$ (D) $\ln(1 + e^x) + C$
15. If $[t]$ denotes the greatest integer not exceeding t , then $\int_0^2 [x^2] dx$ equals:
 (A) $5 - \sqrt{2} - \sqrt{3}$ (B) $5 + \sqrt{2} - \sqrt{3}$
 (C) $1 + \sqrt{3}$ (D) $3 - \sqrt{2}$
16. The area of the region enclosed by the parabola $y = x^2$ and the line $y = 2x$ is:
 (A) $2/3$ sq. units (B) $1/3$ sq. units
 (C) $8/3$ sq. units (D) $4/3$ sq. units
17. The general solution of the differential equation $x(dy/dx) + y = x^2$ ($x > 0$) is:
 (A) $y = x^3/3 + C$ (B) $y = x^2/2 + C/x$
 (C) $y = x^2/3 + C/x$ (D) $y = x^2/3 + Cx$
18. The equation of the circle passing through the points $(0, 0)$, $(4, 0)$ and $(0, 6)$ is:
 (A) $x^2 + y^2 - 8x - 12y = 0$ (B) $x^2 + y^2 - 4x - 6y - 13 = 0$
 (C) $x^2 + y^2 + 4x + 6y = 0$ (D) $x^2 + y^2 - 4x - 6y = 0$

19. The length of the latus rectum of the ellipse $4x^2 + 9y^2 = 36$ is:
 (A) $4/3$ (B) $8/3$
 (C) $9/2$ (D) $16/3$
20. The line $(x - 1)/1 = (y + 2)/2 = (z - 3)/(-1)$ meets the plane $x + y + z = 8$ at the point:
 (A) (4, 4, 0) (B) (0, 4, 4)
 (C) (3, 2, 1) (D) (2, 0, 2)
21. If $|a| = 3$, $|b| = 4$ and $|a + b| = 5$ for vectors a and b , then $|a - b|$ is:
 (A) $\sqrt{7}$ (B) 5
 (C) 7 (D) 1
22. The mean of five observations is 4 and their variance is 5.2. If three of the observations are 1, 2 and 6, the other two are:
 (A) 3 and 8 (B) 2 and 9
 (C) 5 and 6 (D) 4 and 7
23. Box I has 2 red and 3 white balls; Box II has 4 red and 1 white ball. A box is chosen at random and a ball drawn from it is red. The probability that it came from Box II is:
 (A) $3/5$ (B) $1/3$
 (C) $2/3$ (D) $4/5$
24. The value of $\sin 20^\circ \sin 40^\circ \sin 60^\circ \sin 80^\circ$ is:
 (A) $1/16$ (B) $\sqrt{3}/16$
 (C) $3/16$ (D) $3/8$
25. The negation of the statement "If it rains, then the match is cancelled" ($p \rightarrow q$) is:
 (A) If the match is cancelled, then it rains ($q \rightarrow p$)
 (B) It does not rain or the match is cancelled ($\sim p \vee q$)
 (C) If it does not rain, the match is not cancelled ($\sim p \rightarrow \sim q$)
 (D) It rains and the match is not cancelled ($p \wedge \sim q$)

Part II: Physics

Physics

26. If velocity (v), time (T) and force (F) are chosen as the fundamental quantities, the dimensional formula of energy is:
 (A) $[F \vee T^{-1}]$ (B) $[F v^{-1} T]$
 (C) $[F \vee T]$ (D) $[F v^2 T]$
27. The position of a particle moving along a straight line is $x = 2t^3 - 15t^2 + 36t$ (x in metres, t in seconds). The distance it covers in the first 4 seconds is:
 (A) 32 m (B) 28 m
 (C) 34 m (D) 36 m
28. A bob of a conical pendulum hangs from a string of length L that makes an angle θ with the vertical. The time period of its circular motion is:
 (A) $2\pi\sqrt{L \sin \theta/g}$ (B) $2\pi\sqrt{L \cos \theta/g}$
 (C) $2\pi\sqrt{L/(g \cos \theta)}$ (D) $2\pi\sqrt{L/g}$

29. A 2 kg block moving at 6 m/s on a smooth horizontal surface hits a light spring of force constant 800 N/m. The maximum compression of the spring is:
 (A) 0.6 m (B) 0.15 m
 (C) 0.3 m (D) 0.09 m
30. A bullet of mass 10 g moving horizontally at 400 m/s gets embedded in a wooden block of mass 1.99 kg hanging from a long string. The block rises to a height of ($g = 10 \text{ m/s}^2$):
 (A) 0.4 m (B) 2 m
 (C) 0.02 m (D) 0.2 m
31. A circular hole of radius $R/2$ is cut from a uniform disc of radius R , the hole touching the edge of the disc. The centre of mass of the remaining part is shifted from the centre of the disc by:
 (A) $R/2$ (B) $R/6$
 (C) $R/3$ (D) $R/4$
32. A uniform solid sphere rolls down a rough inclined plane of inclination θ without slipping. Its acceleration is:
 (A) $(1/2) g \sin \theta$ (B) $(5/7) g \sin \theta$
 (C) $g \sin \theta$ (D) $(2/3) g \sin \theta$
33. A satellite of mass m circles the Earth (mass M , radius R) at a distance $2R$ from the Earth's centre. The minimum energy needed to shift it to an orbit of radius $3R$ is:
 (A) $GMm/(12R)$ (B) $GMm/(2R)$
 (C) $GMm/(6R)$ (D) $GMm/(3R)$
34. The surface tension of a soap solution is T . The work done in blowing a soap bubble of radius r (starting from zero size, at constant temperature) is:
 (A) $4\pi r^2 T$ (B) $16\pi r^2 T$
 (C) $8\pi r^2 T$ (D) $2\pi r^2 T$
35. One mole of an ideal gas expands isothermally and reversibly at 300 K from 10 L to 20 L. The work done by the gas is about ($R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$, $\ln 2 = 0.693$):
 (A) 2.49 kJ (B) 1.73 kJ
 (C) 0.86 kJ (D) 3.46 kJ
36. One mole of a monatomic ideal gas is mixed with one mole of a diatomic ideal gas (rigid molecules). The ratio C_p/C_v for the mixture is:
 (A) $3/2$ (B) $4/3$
 (C) $5/3$ (D) $7/5$
37. A particle performs simple harmonic motion $x = A \sin \omega t$ with time period T . The minimum time it takes to go from the mean position to a point at $x = A/2$ is:
 (A) $T/12$ (B) $T/8$
 (C) $T/6$ (D) $T/4$
38. A wave on a string is $y = 0.02 \sin[2\pi(10t - 0.5x)]$, with x and y in metres and t in seconds. The speed of the wave is:
 (A) 5 m/s (B) 20 m/s
 (C) 10 m/s (D) 0.05 m/s
39. Four equal point charges q are placed at the corners of a square of side a . With $k = 1/(4\pi\epsilon_0)$, the electric field and the potential at the centre of the square are:
 (A) $E = 0$ and $V = 4\sqrt{2} kq/a$ (B) $E = 0$ and $V = 4kq/a$
 (C) $E = 4\sqrt{2} kq/a^2$ and $V = 0$ (D) $E = 0$ and $V = 0$

40. A $2\ \mu\text{F}$ capacitor charged to $100\ \text{V}$ is connected across an identical uncharged $2\ \mu\text{F}$ capacitor. The energy lost in the process is:
- (A) zero (B) $5\ \text{mJ}$
(C) $10\ \text{mJ}$ (D) $2.5\ \text{mJ}$
41. Two cells, of emf $6\ \text{V}$ and $4\ \text{V}$, each with internal resistance $1\ \Omega$, are connected in parallel (positive to positive) across a $3\ \Omega$ resistor. The current in the $3\ \Omega$ resistor is:
- (A) $2\ \text{A}$ (B) $10/7\ \text{A}$
(C) $2/7\ \text{A}$ (D) $10/3\ \text{A}$
42. A long straight wire carrying current I has a semicircular loop of radius R in it, and both straight parts lie along a line passing through the centre of the semicircle. The magnetic field at the centre is:
- (A) $\mu_0 I / (4\pi R)$ (B) $\mu_0 I / (2R)$
(C) $\mu_0 I / (2\pi R)$ (D) $\mu_0 I / (4R)$
43. A metal rod of length l rotates with angular speed ω about an axis through one end, perpendicular to the rod, in a uniform magnetic field B parallel to the axis. The emf between its ends is:
- (A) $\frac{1}{4} B \omega l^2$ (B) $2 B \omega l^2$
(C) $B \omega l^2$ (D) $\frac{1}{2} B \omega l^2$
44. A series circuit of a $30\ \Omega$ resistor and an inductor of reactance $40\ \Omega$ is connected to a $200\ \text{V}$ (rms) ac supply. The rms current is:
- (A) $2.86\ \text{A}$ (B) $6.67\ \text{A}$
(C) $4\ \text{A}$ (D) $5\ \text{A}$
45. For an equilateral glass prism the angle of minimum deviation is 30° . The refractive index of the glass is:
- (A) $\sqrt{3}$ (B) $2/\sqrt{3}$
(C) 1.5 (D) $\sqrt{2}$
46. In Young's double-slit experiment with light of wavelength $600\ \text{nm}$, a thin film of refractive index 1.5 and thickness $6\ \mu\text{m}$ is placed over one slit. The central bright fringe shifts by:
- (A) 2.5 fringe widths (B) 15 fringe widths
(C) 10 fringe widths (D) 5 fringe widths
47. A proton and an alpha particle are accelerated from rest through the same potential difference. The ratio of their de Broglie wavelengths (proton : alpha) is:
- (A) 2 (B) $\sqrt{2}$
(C) $2\sqrt{2}$ (D) $1/(2\sqrt{2})$
48. The ionisation energy of a hydrogen atom in its ground state is $13.6\ \text{eV}$. The ionisation energy of a Li^{2+} ion in its ground state is:
- (A) $122.4\ \text{eV}$ (B) $40.8\ \text{eV}$
(C) $54.4\ \text{eV}$ (D) $13.6\ \text{eV}$
49. Input A is fed to one NOT gate and input B to another NOT gate. The two outputs are then fed to a NOR gate. The whole combination is equivalent to:
- (A) a NOR gate (B) an AND gate
(C) a NAND gate (D) an OR gate
50. A screw gauge has a pitch of $0.5\ \text{mm}$ and 50 divisions on its circular scale, and no zero error. While measuring a wire, the linear scale shows 2 divisions (of $0.5\ \text{mm}$ each) and the 25th circular division is on the reference line. The diameter of the wire is:
- (A) $2.25\ \text{mm}$ (B) $0.75\ \text{mm}$
(C) $1.25\ \text{mm}$ (D) $1.025\ \text{mm}$

Chemistry

51. The mass of oxygen needed for the complete combustion of 4.4 g of propane (C_3H_8) is:
(A) 8 g (B) 32 g
(C) 16 g (D) 3.2 g
52. The wavelength of the spectral line emitted when the electron in a hydrogen atom falls from $n = 4$ to $n = 2$ is about ($R = 1.097 \times 10^7 \text{ m}^{-1}$):
(A) 486 nm (B) 122 nm
(C) 656 nm (D) 434 nm
53. The numbers of angular nodes and radial nodes in a 4d orbital are:
(A) 2 angular and 2 radial (B) 2 angular and 1 radial
(C) 1 angular and 2 radial (D) 3 angular and 0 radial
54. Among H_2O , NH_3 , CH_4 and H_2S , the molecule with the smallest bond angle is:
(A) CH_4 (B) H_2S
(C) NH_3 (D) H_2O
55. For the reaction $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ at temperature T , the value of $\Delta H - \Delta U$ is:
(A) $-RT$ (B) $-2RT$
(C) zero (D) $+2RT$
56. For a reaction, $\Delta H = +45 \text{ kJ mol}^{-1}$ and $\Delta S = +150 \text{ J K}^{-1} \text{ mol}^{-1}$. Taking both as independent of temperature, the reaction is feasible only above:
(A) 30 K (B) 3000 K
(C) 0.3 K (D) 300 K
57. 3.42 g of sucrose (molar mass 342 g/mol) is dissolved in 50 g of water. If K_f for water is $1.86 \text{ K kg mol}^{-1}$, the depression in freezing point is:
(A) 0.0372 K (B) 3.72 K
(C) 0.186 K (D) 0.372 K
58. The solubility product of a sparingly soluble salt AB_2 is 4×10^{-12} at 298 K. Its molar solubility is:
(A) $1 \times 10^{-4} \text{ M}$ (B) $1 \times 10^{-6} \text{ M}$
(C) $2 \times 10^{-4} \text{ M}$ (D) $1 \times 10^{-3} \text{ M}$
59. For the cell $Zn | Zn^{2+}(0.01 \text{ M}) || Cu^{2+}(1 \text{ M}) | Cu$, $E^\circ_{\text{cell}} = 1.10 \text{ V}$. Taking $2.303RT/F = 0.059 \text{ V}$, the cell emf at 298 K is:
(A) 1.159 V (B) 1.100 V
(C) 1.218 V (D) 1.041 V
60. The rate constant of a first-order reaction is $4.606 \times 10^{-3} \text{ s}^{-1}$. The time needed for 99% of the reactant to be used up is:
(A) 500 s (B) 1000 s
(C) 2000 s (D) 100 s
61. Which of the following is true of physical adsorption (physisorption)?
(A) It always increases with temperature
(B) It is highly specific to the adsorbate
(C) It needs a high activation energy
(D) It can form layers several molecules thick

62. The correct order of the radii of the isoelectronic ions N^{3-} , O^{2-} , F^- , Na^+ and Mg^{2+} is:
 (A) $\text{O}^{2-} > \text{N}^{3-} > \text{F}^- > \text{Mg}^{2+} > \text{Na}^+$ (B) $\text{N}^{3-} > \text{O}^{2-} > \text{F}^- > \text{Na}^+ > \text{Mg}^{2+}$
 (C) $\text{Mg}^{2+} > \text{Na}^+ > \text{F}^- > \text{O}^{2-} > \text{N}^{3-}$ (D) $\text{F}^- > \text{O}^{2-} > \text{N}^{3-} > \text{Na}^+ > \text{Mg}^{2+}$
63. Which alkali metal combines directly with nitrogen to form a nitride?
 (A) Na (B) Li
 (C) Cs (D) K
64. The shape of the XeO_3 molecule is:
 (A) trigonal pyramidal (B) tetrahedral
 (C) trigonal planar (D) T-shaped
65. In acidic solution, the number of moles of KMnO_4 needed to oxidise one mole of oxalate ion ($\text{C}_2\text{O}_4^{2-}$) to CO_2 is:
 (A) $5/2$ (B) 1
 (C) $1/5$ (D) $2/5$
66. The spin-only magnetic moment of the tetrahedral complex ion $[\text{NiCl}_4]^{2-}$ is about:
 (A) 3.87 BM (B) 1.73 BM
 (C) 2.83 BM (D) 0 BM
67. $[\text{Co}(\text{NH}_3)_5(\text{NO}_2)]\text{Cl}_2$ and $[\text{Co}(\text{NH}_3)_5(\text{ONO})]\text{Cl}_2$ are examples of:
 (A) coordination isomerism (B) geometrical isomerism
 (C) linkage isomerism (D) ionisation isomerism
68. The number of chiral (asymmetric) carbon atoms in the open-chain form of D-glucose is:
 (A) 5 (B) 3
 (C) 4 (D) 6
69. But-2-yne is reduced with sodium in liquid ammonia. The product is:
 (A) trans-but-2-ene (B) butane
 (C) cis-but-2-ene (D) but-1-ene
70. 2-Bromo-2-methylpropane is heated with sodium ethoxide in ethanol. The main organic product is:
 (A) 2-methylpropene (B) 2-methylpropane
 (C) 2-methylpropan-2-ol (D) 2-ethoxy-2-methylpropane
71. Methoxybenzene (anisole) is heated with HI. The products are:
 (A) phenol and methyl iodide (B) phenol and methane
 (C) iodobenzene and methanol (D) iodobenzene and methyl iodide
72. Which of the following does NOT give a positive iodoform test?
 (A) propanone (B) propan-2-ol
 (C) pentan-3-one (D) ethanol
73. Which of the following amines cannot be prepared by Gabriel phthalimide synthesis?
 (A) propan-1-amine (B) aniline
 (C) ethylamine (D) benzylamine
74. On prolonged heating with HI, glucose gives:
 (A) sorbitol (B) gluconic acid
 (C) saccharic acid (D) n-hexane

75. A salt solution, mixed with freshly prepared FeSO_4 solution, gives a brown ring when concentrated H_2SO_4 is poured carefully along the side of the test tube. The salt contains the:
- (A) nitrate ion (B) sulphate ion
(C) carbonate ion (D) chloride ion

Answer Key

1	C	2	C	3	D	4	D	5	C	6	A	7	B	8	A	9	B	10	A
11	D	12	A	13	D	14	C	15	A	16	D	17	C	18	D	19	B	20	A
21	B	22	D	23	C	24	C	25	D	26	C	27	C	28	B	29	C	30	D
31	B	32	B	33	A	34	C	35	B	36	A	37	A	38	B	39	A	40	B
41	B	42	D	43	D	44	C	45	D	46	D	47	C	48	A	49	B	50	C
51	C	52	A	53	B	54	B	55	B	56	D	57	D	58	A	59	A	60	B
61	D	62	B	63	B	64	A	65	D	66	C	67	C	68	C	69	A	70	A
71	A	72	C	73	B	74	D	75	A										

Solutions

Mathematics

- (C)** Total functions $3^4 = 81$. Remove those missing at least one image (inclusion-exclusion): $81 - 3(2^4) + 3(1^4) = 81 - 48 + 3 = 36$.
- (C)** z lies on a circle with centre $3 + 4i$ (distance 5 from the origin) and radius 2. The nearest point is $5 - 2 = 3$ from the origin.
- (D)** Leading coefficient is positive, so we need discriminant < 0 : $4a^2 - 4(10 - 3a) < 0$, i.e. $a^2 + 3a - 10 < 0$, i.e. $(a + 5)(a - 2) < 0$, so $-5 < a < 2$.
- (D)** A^2 has rows (5, 4) and (4, 5); $2A$ has rows (2, 4) and (4, 2). So $A^2 - 2A$ has rows (3, 0) and (0, 3), which is $3I$.
- (C)** This is a Vandermonde determinant; $R_2 - R_1$ and $R_3 - R_1$ and taking out the common factors give $(b - a)(c - a)(c - b)$, which equals $(a - b)(b - c)(c - a)$. Option $(a - b)(b - c)(a - c)$ has the opposite sign.
- (A)** Units digit 0: $9 \times 8 \times 7 = 504$. Units digit 2, 4, 6 or 8: $4 \times (8 \text{ choices for the first digit, not 0 or the units digit}) \times 8 \times 7 = 1792$. Total = 2296.
- (B)** For $n = 1$ the value is 4. If 4 divides $7^k - 3^k$, then $7^{k+1} - 3^{k+1} = 7(7^k - 3^k) + 4(3^k)$ is also divisible by 4. ($n = 1$ rules out 3, 7 and 10.)
- (A)** $3^2 = 9 \equiv 1 \pmod{8}$. $3^{2027} = (3^2)^{1013} \times 3 \equiv 1 \times 3 = 3 \pmod{8}$.
- (B)** This is an AGP with $a = 1$, $d = 3$, $r = 1/5$. $S = a/(1 - r) + dr/(1 - r)^2 = 5/4 + (3/5)/(16/25) = 5/4 + 15/16 = 35/16$.
- (A)** For two positive numbers $G^2 = A \times H = 25 \times 16 = 400$, so $G = 20$. (The numbers are 40 and 10.)
- (D)** $e^x = 1 + x + x^2/2 + \dots$, so $(e^x - 1 - x)/x^2 \rightarrow 1/2$.
- (A)** $x^2 - 3x + 2 = (x - 1)(x - 2)$ changes sign with a non-zero slope at $x = 1$ and $x = 2$, so the modulus makes sharp corners there; it is smooth elsewhere.
- (D)** $f'(x) = 3x^2 - 12x + 9 = 3(x - 1)(x - 3)$, which is negative only for $1 < x < 3$.
- (C)** $1/(1 + e^x) = 1 - e^x/(1 + e^x)$. Integrating: $x - \ln(1 + e^x) + C$.
- (A)** $[x^2] = 0$ on $[0, 1)$, 1 on $[1, \sqrt{2})$, 2 on $[\sqrt{2}, \sqrt{3})$, 3 on $[\sqrt{3}, 2)$. Integral = $(\sqrt{2} - 1) + 2(\sqrt{3} - \sqrt{2}) + 3(2 - \sqrt{3}) = 5 - \sqrt{2} - \sqrt{3}$.
- (D)** They meet at $x = 0$ and $x = 2$. Area = $\int_0^2 (2x - x^2) dx = 4 - 8/3 = 4/3$.
- (C)** The left side is $d(xy)/dx$, so $xy = x^3/3 + C$ and $y = x^2/3 + C/x$.
- (D)** Take $x^2 + y^2 + 2gx + 2fy + c = 0$. (0, 0) gives $c = 0$; (4, 0) gives $16 + 8g = 0$, $g = -2$; (0, 6) gives $36 + 12f = 0$, $f = -3$.
- (B)** $x^2/9 + y^2/4 = 1$, so $a = 3$, $b = 2$ and the latus rectum = $2b^2/a = 8/3$.
- (A)** A general point is $(1 + t, -2 + 2t, 3 - t)$. Substituting: $2 + 2t = 8$, so $t = 3$ and the point is (4, 4, 0). (3, 2, 1) is on the line but not the plane.
- (B)** $|a + b|^2 = 9 + 16 + 2a \cdot b = 25$ gives $a \cdot b = 0$. Then $|a - b|^2 = 9 + 16 - 0 = 25$, so $|a - b| = 5$.

- 22. (D)** Sum = 20, so $a + b = 11$. $\sum x^2 = 5(5.2 + 4^2) = 106$, so $a^2 + b^2 = 106 - 41 = 65$. Then $2ab = 121 - 65 = 56$, $ab = 28$: $a, b = 4$ and 7 .
- 23. (C)** By Bayes' theorem: $(\frac{1}{2} \times \frac{4}{5}) / (\frac{1}{2} \times \frac{2}{5} + \frac{1}{2} \times \frac{4}{5}) = (\frac{4}{5}) / (\frac{6}{5}) = \frac{2}{3}$.
- 24. (C)** $\sin \theta \sin(60^\circ - \theta) \sin(60^\circ + \theta) = (\frac{1}{4}) \sin 3\theta$. With $\theta = 20^\circ$: $\sin 20^\circ \sin 40^\circ \sin 80^\circ = (\frac{1}{4}) \sin 60^\circ = \sqrt{3}/8$. Multiplying by $\sin 60^\circ = \sqrt{3}/2$ gives $3/16$.
- 25. (D)** $p \rightarrow q$ is equivalent to $\sim p \vee q$. Its negation is $\sim(\sim p \vee q) = p \wedge \sim q$.

Physics

- 26. (C)** Energy = force $\times$ distance, and distance = velocity $\times$ time, so $E = [F \vee T]$.
- 27. (C)** $v = 6t^2 - 30t + 36 = 6(t - 2)(t - 3)$, so it reverses at $t = 2$ s and $t = 3$ s. $x(0) = 0$, $x(2) = 28$, $x(3) = 27$, $x(4) = 32$. Distance = $28 + 1 + 5 = 34$ m (displacement 32 m).
- 28. (B)** $T \cos \theta = mg$ and $T \sin \theta = m\omega^2(L \sin \theta)$ give $\omega^2 = g/(L \cos \theta)$, so the period is $2\pi\sqrt{L \cos \theta/g}$.
- 29. (C)** $\frac{1}{2}mv^2 = \frac{1}{2}kx^2$: $2 \times 36 = 800x^2$, so $x^2 = 0.09$ and $x = 0.3$ m.
- 30. (D)** Momentum: $0.01 \times 400 = 2 \times V$, so $V = 2$ m/s. Energy after impact: $h = V^2/2g = 4/20 = 0.2$ m.
- 31. (B)** The removed part has mass $M/4$ with its centre at $R/2$. $x = -(M/4)(R/2)/(3M/4) = -R/6$, i.e. $R/6$ on the side away from the hole.
- 32. (B)** $a = g \sin \theta / (1 + I/mr^2) = g \sin \theta / (1 + 2/5) = (5/7) g \sin \theta$.
- 33. (A)** Total orbital energy is $-GMm/(2r)$. $\Delta E = -GMm/(6R) - (-GMm/(4R)) = GMm(1/4 - 1/6)/R = GMm/(12R)$.
- 34. (C)** A soap bubble has two surfaces, so the new surface area is $2 \times 4\pi r^2$. $W = T \times 8\pi r^2 = 8\pi r^2 T$.
- 35. (B)** $W = nRT \ln(V_2/V_1) = 1 \times 8.31 \times 300 \times 0.693 \approx 1728 \text{ J} \approx 1.73 \text{ kJ}$.
- 36. (A)** $C_v(\text{mix}) = (3R/2 + 5R/2)/2 = 2R$ and $C_p(\text{mix}) = C_v + R = 3R$. $\gamma = 3R/2R = 3/2$.
- 37. (A)** $A/2 = A \sin \omega t$ gives $\omega t = \pi/6$, so $t = (\pi/6)/(2\pi/T) = T/12$.
- 38. (B)** $\omega = 20\pi \text{ rad/s}$ and $k = \pi \text{ rad/m}$, so $v = \omega/k = 20 \text{ m/s}$ (frequency 10 Hz, wavelength 2 m).
- 39. (A)** Fields from opposite corners cancel, so $E = 0$. Each charge is $a/\sqrt{2}$ from the centre, so $V = 4kq/(a/\sqrt{2}) = 4\sqrt{2} kq/a$.
- 40. (B)** Initial energy $\frac{1}{2} \times 2 \mu\text{F} \times 100^2 = 10 \text{ mJ}$. Common voltage 50 V; final energy $2 \times \frac{1}{2} \times 2 \mu\text{F} \times 50^2 = 5 \text{ mJ}$. Loss = 5 mJ (in heat and radiation).
- 41. (B)** Let the terminal voltage be V : $(6 - V)/1 + (4 - V)/1 = V/3$, so $10 = 7V/3$ and $V = 30/7 \text{ V}$. Current = $V/3 = 10/7 \text{ A}$.
- 42. (D)** The straight parts point along the line through the centre, so $d\mathbf{l} \times \mathbf{r} = 0$ and they give no field. The semicircle gives half the field of a full loop: $\mu_0 I/(4R)$.
- 43. (D)** $e = \int B(\omega x) dx$ from 0 to $l = \frac{1}{2}B\omega l^2$.
- 44. (C)** $Z = \sqrt{(30^2 + 40^2)} = 50 \Omega$. $I = 200/50 = 4 \text{ A}$. (Adding R and X directly would wrongly give $200/70 = 2.86 \text{ A}$.)
- 45. (D)** $\mu = \sin[(A + \delta m)/2] / \sin(A/2) = \sin 45^\circ / \sin 30^\circ = (1/\sqrt{2}) / (1/2) = \sqrt{2}$.
- 46. (D)** Extra optical path = $(\mu - 1)t = 0.5 \times 6 \mu\text{m} = 3 \mu\text{m}$. Number of fringes = $3 \mu\text{m} / 0.6 \mu\text{m} = 5$.
- 47. (C)** $\lambda = h/\sqrt{(2mqV)}$, so $\lambda(p)/\lambda(\alpha) = \sqrt{[(m(\alpha)q(\alpha))/(m(p)q(p))]} = \sqrt{(4 \times 2)} = 2\sqrt{2}$.
- 48. (A)** For a hydrogen-like ion $E \propto Z^2$. For Li^{2+} , $Z = 3$: $13.6 \times 9 = 122.4 \text{ eV}$.
- 49. (B)** $Y = (A' + B')' = A \cdot B$ by De Morgan's theorem, which is the AND operation.
- 50. (C)** Least count = $0.5/50 = 0.01 \text{ mm}$. Reading = $2 \times 0.5 + 25 \times 0.01 = 1.00 + 0.25 = 1.25 \text{ mm}$.

Chemistry

- 51. (C)** $\text{C}_3\text{H}_8 + 5\text{O}_2 \rightarrow 3\text{CO}_2 + 4\text{H}_2\text{O}$. 4.4 g propane = 0.1 mol, which needs 0.5 mol $\text{O}_2 = 16 \text{ g}$.
- 52. (A)** $1/\lambda = R(1/4 - 1/16) = 3R/16$, so $\lambda = 16/(3 \times 1.097 \times 10^7) \text{ m} \approx 4.86 \times 10^{-7} \text{ m} = 486 \text{ nm}$ (the blue-green Balmer line).
- 53. (B)** Angular nodes = $l = 2$. Radial nodes = $n - l - 1 = 4 - 2 - 1 = 1$.
- 54. (B)** In H_2S the bonds use almost pure p orbitals of the large, less electronegative S, so the angle is about 92° , against 104.5° for H_2O , 107° for NH_3 and 109.5° for CH_4 .
- 55. (B)** $\Delta H = \Delta U + \Delta n(g)RT$ with $\Delta n(g) = 2 - 4 = -2$, so $\Delta H - \Delta U = -2RT$.

56. (D) $\Delta G = \Delta H - T\Delta S < 0$ when $T > \Delta H/\Delta S = 45000/150 = 300$ K.
57. (D) Moles = 0.01; molality = $0.01/0.050$ kg = 0.2 mol/kg. $\Delta T_f = 1.86 \times 0.2 = 0.372$ K.
58. (A) $AB_2 \rightleftharpoons A^{2+} + 2B^-$, so $K_{sp} = s(2s)^2 = 4s^3 = 4 \times 10^{-12}$. $s^3 = 10^{-12}$, $s = 10^{-4}$ M.
59. (A) $E = E^\circ - (0.059/2) \log([Zn^{2+}]/[Cu^{2+}]) = 1.10 - 0.0295 \times (-2) = 1.10 + 0.059 = 1.159$ V.
60. (B) $t = (2.303/k) \log([A]_0/[A]) = (2.303/4.606 \times 10^{-3}) \times \log 100 = 500 \times 2 = 1000$ s.
61. (D) Physisorption is due to weak van der Waals forces: it is non-specific, reversible, has low enthalpy (about 20–40 kJ/mol), needs no activation energy, decreases with temperature and can be multimolecular.
62. (B) All have 10 electrons. The greater the nuclear charge, the more strongly they are pulled in, so the radius falls from N ($Z = 7$) to Mg ($Z = 12$).
63. (B) Lithium, like magnesium (diagonal relationship), burns in N_2 to form Li_3N . The other alkali metals do not form nitrides directly.
64. (A) Xe in XeO_3 has three bond pairs (double bonds to O) and one lone pair: sp^3 hybridisation with a pyramidal shape.
65. (D) $2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \rightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$. Mn gains $5e^-$ and each oxalate loses $2e^-$, so $2/5$ mol per mol of oxalate.
66. (C) Ni^{2+} is d^8 . Cl^- is a weak-field ligand and the complex is tetrahedral (sp^3), leaving 2 unpaired electrons: $\mu = \sqrt{8} \approx 2.83$ BM. ($[Ni(CN)_4]^{2-}$, square planar, is diamagnetic.)
67. (C) The ambidentate NO_2^- ligand is bonded through N (nitro) in one and through O (nitrito) in the other.
68. (C) In $CHO-(CHOH)_4-CH_2OH$, carbons 2, 3, 4 and 5 each carry four different groups. C1 (CHO) and C6 (CH_2OH) are not chiral.
69. (A) Birch-type (dissolving metal) reduction adds the two H atoms anti, giving the trans (E) alkene. Lindlar's catalyst would give the cis alkene.
70. (A) With a strong base, a tertiary halide undergoes elimination (E2) rather than substitution, so the alkene is the main product.
71. (A) The O- CH_3 bond is cleaved: I^- attacks the methyl carbon (SN_2). The O-aryl bond is strong (partial double bond), so phenol is formed, not iodobenzene.
72. (C) The test needs CH_3CO- or $CH_3CH(OH)-$ group. Pentan-3-one ($CH_3CH_2COCH_2CH_3$) has neither.
73. (B) The step needs SN_2 attack of the phthalimide anion on an alkyl halide. Aryl halides such as chlorobenzene do not undergo it, so aromatic primary amines cannot be made this way.
74. (D) HI reduces all the oxygen-bearing groups; formation of n-hexane shows that the six carbon atoms of glucose are in a straight chain.
75. (A) Nitrate is reduced to NO, which forms the brown complex $[Fe(H_2O)_5(NO)]^{2+}$ at the junction of the two layers.