

Questions
100 MCQs

Marks
200

Time
3 hours

Marking
+2 / -0.5 per wrong

Part	Section	Questions	Q. No.
Part A	Physics	33	1 to 33
Part B	Chemistry	33	34 to 66
Part C	Mathematics	34	67 to 100

Instructions

- There are 100 multiple-choice questions: Physics (1 to 33), Chemistry (34 to 66) and Mathematics (67 to 100).
- Each question has four options; choose the one correct answer.
- Each correct answer earns 2 marks and 0.5 mark (one quarter) is deducted for each wrong answer. Unattempted questions get 0. Maximum marks: 200.
- Attempt the paper in one sitting of 3 hours. Calculators and log tables are not allowed.
- In the real test, ties are broken by Mathematics marks, then Physics marks, so do not neglect Mathematics.
- The answer key and solutions are at the end. Check them only after you finish.

This is an AglaSem practice paper written on the latest published HPU UIT Common Entrance Test pattern (100 MCQs: Physics 33, Chemistry 33, Mathematics 34; 200 marks; 3 hours; +2/-0.5) and the syllabus in the Pravesh UIT prospectus. It is not an official HPU paper, and its questions are original.

Part A

Physics

- Which of the following pairs of physical quantities have the same dimensions?
(A) Momentum and energy (B) Work and torque
(C) Pressure and force (D) Force and power
- A car moving at 72 km/h is brought to rest with uniform retardation in 4 s. The distance it covers while stopping is:
(A) 20 m (B) 160 m
(C) 40 m (D) 80 m
- A ball is projected at 30° above the horizontal with a speed of 20 m/s. Its time of flight is ($g = 10 \text{ m/s}^2$):
(A) 1 s (B) $\sqrt{3}$ s
(C) 2 s (D) 4 s
- A 2 kg block lies on a rough horizontal floor ($\mu = 0.5$). A horizontal push of 15 N acts on it. Its acceleration is ($g = 10 \text{ m/s}^2$):
(A) 0 (B) 5 m/s^2
(C) 7.5 m/s^2 (D) 2.5 m/s^2
- A man of mass 60 kg stands on a weighing machine in a lift moving up with an acceleration of 2 m/s^2 . The machine reads ($g = 10 \text{ m/s}^2$):
(A) 600 N (B) 480 N
(C) 120 N (D) 720 N

6. A 4 kg body moving at 5 m/s hits a 1 kg body at rest and the two stick together. Their common velocity is:
- (A) 2.5 m/s (B) 5 m/s
(C) 4 m/s (D) 1 m/s
7. A force $F = (3\mathbf{i} + 4\mathbf{j})$ N moves a particle through a displacement $s = (2\mathbf{i} - \mathbf{j})$ m. The work done is:
- (A) 2 J (B) -2 J
(C) 10 J (D) 5 J
8. A motor raises a 50 kg load through 10 m in 5 s at constant speed. Its power output is ($g = 10 \text{ m/s}^2$):
- (A) 100 W (B) 2500 W
(C) 1000 W (D) 500 W
9. The moment of inertia of a thin uniform ring of mass M and radius R about a diameter is:
- (A) MR^2 (B) $MR^2/2$
(C) $2MR^2/5$ (D) $3MR^2/2$
10. A skater spinning with arms stretched pulls the arms in, so her moment of inertia becomes half. Her angular velocity:
- (A) Doubles (B) Becomes four times
(C) Halves (D) Remains the same
11. If the orbital speed of a satellite just above the Earth's surface is v , the escape speed from the surface is:
- (A) $2v$ (B) $\sqrt{2} v$
(C) v (D) $v/\sqrt{2}$
12. If the radius of a planet's circular orbit around the Sun were made four times, its period of revolution would become:
- (A) 8 times (B) 4 times
(C) 2 times (D) 16 times
13. Two wires of the same material have lengths L and $2L$ and radii r and $2r$. The same force stretches each. The ratio of their extensions (first : second) is:
- (A) 1 : 2 (B) 4 : 1
(C) 1 : 4 (D) 2 : 1
14. A particle executes SHM given by $x = 0.05 \sin(10t)$ m. Its maximum speed is:
- (A) 0.5 m/s (B) 0.05 m/s
(C) 50 m/s (D) 5 m/s
15. A string 1 m long is fixed at both ends. Waves travel on it at 200 m/s. Its fundamental frequency is:
- (A) 50 Hz (B) 400 Hz
(C) 100 Hz (D) 200 Hz
16. A source of sound of frequency f moves towards a stationary observer with one-tenth of the speed of sound. The frequency heard is:
- (A) $9f/10$ (B) $10f/9$
(C) f (D) $11f/10$
17. The ratio of specific heats $\gamma = C_p/C_v$ for a monoatomic ideal gas is:
- (A) $5/3$ (B) $7/5$
(C) $4/3$ (D) $9/7$

18. If the absolute temperature of a black body is doubled, the energy it radiates per second becomes:
 (A) 16 times (B) 8 times
 (C) 32 times (D) 4 times
19. The work done in moving a charge of $2\text{ }\mu\text{C}$ between two points with a potential difference of 50 V is:
 (A) $1 \times 10^{-6}\text{ J}$ (B) $25 \times 10^{-6}\text{ J}$
 (C) 100 J (D) $1 \times 10^{-4}\text{ J}$
20. A parallel-plate capacitor has capacitance C in air. The gap between the plates is doubled and filled completely with a dielectric of constant 4. The new capacitance is:
 (A) $8C$ (B) $4C$
 (C) $2C$ (D) $C/2$
21. In a balanced Wheatstone bridge $P = 10\text{ }\Omega$, $Q = 20\text{ }\Omega$ and $R = 15\text{ }\Omega$. The fourth resistance S is:
 (A) $45\text{ }\Omega$ (B) $20\text{ }\Omega$
 (C) $7.5\text{ }\Omega$ (D) $30\text{ }\Omega$
22. A cell of emf 2 V and internal resistance $0.5\text{ }\Omega$ is connected to a $3.5\text{ }\Omega$ resistor. The terminal voltage of the cell is:
 (A) 1.75 V (B) 0.25 V
 (C) 1.5 V (D) 2 V
23. The current in a circular coil is doubled and its radius is halved. The magnetic field at its centre becomes:
 (A) 4 times (B) 8 times
 (C) 2 times (D) Unchanged
24. A galvanometer is converted into an ammeter by connecting:
 (A) A high resistance in series (B) A low resistance in parallel
 (C) A low resistance in series (D) A high resistance in parallel
25. The current in a coil of self-inductance 2 H falls uniformly from 5 A to 1 A in 0.2 s. The magnitude of the induced emf is:
 (A) 80 V (B) 40 V
 (C) 20 V (D) 8 V
26. In a series LCR circuit at resonance, the phase difference between the current and the applied voltage is:
 (A) 180° (B) 90°
 (C) 45° (D) Zero
27. In Young's double-slit experiment $\lambda = 600\text{ nm}$, slit separation = 0.2 mm and screen distance = 1 m. The fringe width is:
 (A) 0.3 mm (B) 3 mm
 (C) 6 mm (D) 1.2 mm
28. An object is placed 30 cm in front of a convex lens of focal length 20 cm. The image is formed at a distance of:
 (A) 10 cm (B) 50 cm
 (C) 60 cm (D) 12 cm
29. The de Broglie wavelength of an electron accelerated from rest through 100 V is about:
 (A) $0.1227\text{ }\text{\AA}$ (B) $12.27\text{ }\text{\AA}$
 (C) $122.7\text{ }\text{\AA}$ (D) $1.227\text{ }\text{\AA}$

30. The energy of the electron in the second orbit ($n = 2$) of a hydrogen atom is:
 (A) -13.6 eV (B) -1.51 eV
 (C) -6.8 eV (D) -3.4 eV
31. Light of photon energy 5 eV falls on a metal of work function 2 eV . The stopping potential is:
 (A) 2.5 V (B) 7 V
 (C) 5 V (D) 3 V
32. A full-wave rectifier is fed with 50 Hz AC. The fundamental frequency of the ripple in its output is:
 (A) 25 Hz (B) 200 Hz
 (C) 50 Hz (D) 100 Hz
33. In β^- decay of a nucleus, its atomic number Z and mass number A change as follows:
 (A) Z increases by 2, A decreases by 4
 (B) Z increases by 1, A unchanged
 (C) Z decreases by 1, A unchanged
 (D) Both Z and A unchanged

Part B

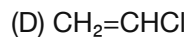
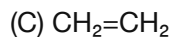
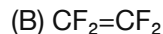
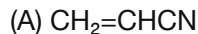
Chemistry

34. 4 g of NaOH is dissolved in water to make 250 mL of solution. The molarity of the solution is ($\text{Na} = 23$, $\text{O} = 16$, $\text{H} = 1$):
 (A) 0.4 M (B) 0.1 M
 (C) 1.6 M (D) 4 M
35. The number of orbitals in a subshell with $l = 2$ is:
 (A) 3 (B) 5
 (C) 7 (D) 10
36. Which set of quantum numbers is NOT possible for an electron?
 (A) $n = 1, l = 0, m = 0$ (B) $n = 2, l = 2, m = 0$
 (C) $n = 2, l = 1, m = -1$ (D) $n = 3, l = 2, m = +2$
37. The bond order of the superoxide ion O_2^- is:
 (A) 2.5 (B) 1.5
 (C) 2 (D) 1
38. The shape of the XeF_4 molecule is:
 (A) Tetrahedral (B) See-saw
 (C) Square planar (D) Octahedral
39. At the same temperature, the ratio of the rms speeds of H_2 and O_2 molecules is:
 (A) 1 : 16 (B) 4 : 1
 (C) 16 : 1 (D) 1 : 4
40. A reaction has $\Delta H < 0$ and $\Delta S > 0$. It is spontaneous:
 (A) At all temperatures (B) At no temperature
 (C) Only at high temperatures (D) Only at low temperatures

41. Given $\text{C(s)} + \text{O}_2\text{(g)} \rightarrow \text{CO}_2\text{(g)}$, $\Delta H = -393.5 \text{ kJ}$ and $\text{CO(g)} + \frac{1}{2}\text{O}_2\text{(g)} \rightarrow \text{CO}_2\text{(g)}$, $\Delta H = -283.0 \text{ kJ}$, the enthalpy change for $\text{C(s)} + \frac{1}{2}\text{O}_2\text{(g)} \rightarrow \text{CO(g)}$ is:
 (A) -110.5 kJ (B) -676.5 kJ
 (C) -393.5 kJ (D) $+110.5 \text{ kJ}$
42. For the equilibrium $\text{N}_2\text{(g)} + 3\text{H}_2\text{(g)} \rightleftharpoons 2\text{NH}_3\text{(g)}$, the relation between K_p and K_c is:
 (A) $K_p = K_c$ (B) $K_p = K_c(RT)^{-2}$
 (C) $K_p = K_c(RT)^2$ (D) $K_p = K_c(RT)^{-1}$
43. A buffer contains equal concentrations of acetic acid ($\text{pK}_a = 4.74$) and sodium acetate. Its pH is:
 (A) 2.37 (B) 7.00
 (C) 4.74 (D) 9.26
44. If the solubility of CaF_2 in water is $s \text{ mol L}^{-1}$, its solubility product K_{sp} is:
 (A) $2s^3$ (B) s^2
 (C) $27s^4$ (D) $4s^3$
45. For the cell $\text{Zn} | \text{Zn}^{2+} || \text{Cu}^{2+} | \text{Cu}$, $E^\circ(\text{Cu}^{2+}/\text{Cu}) = +0.34 \text{ V}$ and $E^\circ(\text{Zn}^{2+}/\text{Zn}) = -0.76 \text{ V}$. The standard emf is:
 (A) 0.42 V (B) 1.10 V
 (C) 0.76 V (D) -1.10 V
46. The quantity of electricity needed to deposit one mole of aluminium from Al^{3+} ions is:
 (A) 3 F (B) 6 F
 (C) 2 F (D) 1 F
47. The coordination number of each atom in a cubic close-packed (fcc) structure is:
 (A) 14 (B) 8
 (C) 12 (D) 6
48. According to Raoult's law, the relative lowering of vapour pressure of a solution of a non-volatile solute equals:
 (A) Mole fraction of the solvent (B) Molality of the solution
 (C) Molarity of the solution (D) Mole fraction of the solute
49. A first-order reaction has a half-life of 20 minutes. The time needed for 75% of it to be completed is:
 (A) 80 min (B) 40 min
 (C) 60 min (D) 30 min
50. Which of the following oxides of nitrogen is neutral?
 (A) N_2O (B) N_2O_5
 (C) N_2O_3 (D) NO_2
51. The hybridisation of phosphorus in PCl_5 is:
 (A) sp^3d^2 (B) dsp^2
 (C) sp^3 (D) sp^3d
52. The catalyst used in the Contact process for the manufacture of sulphuric acid is:
 (A) MnO_2 (B) V_2O_5
 (C) Fe_2O_3 (D) Ni
53. Plaster of Paris is:
 (A) CaSO_4 (B) $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$
 (C) $\text{CaCO}_3 \cdot \text{H}_2\text{O}$ (D) $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$

54. Which of the following ions is colourless in aqueous solution?
(A) Sc^{3+} (B) Fe^{3+}
(C) Cu^{2+} (D) Tl^{3+}
55. The spin-only magnetic moment of Mn^{2+} (Z of Mn = 25) is about:
(A) 3.87 BM (B) 1.73 BM
(C) 4.90 BM (D) 5.92 BM
56. The oxidation state of iron in $\text{K}_4[\text{Fe}(\text{CN})_6]$ is:
(A) +4 (B) +3
(C) +2 (D) +6
57. The number of structural isomers of pentane (C_5H_{12}) is:
(A) 5 (B) 4
(C) 2 (D) 3
58. Which of the following carbocations is the most stable?
(A) CH_3CH_2^+ (B) CH_3^+
(C) $(\text{CH}_3)_3\text{C}^+$ (D) $(\text{CH}_3)_2\text{CH}^+$
59. Which of the following is the strongest acid?
(A) ClCH_2COOH (B) Cl_2CHCOOH
(C) CH_3COOH (D) CCl_3COOH
60. Which of the following aldehydes undergoes aldol condensation?
(A) HCHO (B) CH_3CHO
(C) $(\text{CH}_3)_3\text{CCHO}$ (D) $\text{C}_6\text{H}_5\text{CHO}$
61. The carbylamine test (heating with CHCl_3 and alcoholic KOH to give a foul-smelling isocyanide) is given by:
(A) Quaternary ammonium salts (B) Secondary amines
(C) Tertiary amines (D) Primary amines
62. Phenol is more acidic than ethanol because:
(A) Phenol has a higher molar mass than ethanol
(B) Phenol forms hydrogen bonds with water
(C) The O–H bond in phenol is non-polar
(D) Phenoxide ion is resonance-stabilised
63. In the Lucas test (conc. HCl + anhydrous ZnCl_2), turbidity appears immediately with:
(A) Primary alcohols (B) Tertiary alcohols
(C) Phenols (D) Secondary alcohols
64. The linkage present between amino acid units in a peptide is:
(A) $-\text{CH}_2-\text{NH}-$ (B) $-\text{CO}-\text{O}-$
(C) $-\text{CO}-\text{NH}-$ (D) $-\text{NH}-\text{NH}-$
65. Nylon-6,6 is made by the condensation polymerisation of:
(A) Hexamethylenediamine and adipic acid
(B) Caprolactam
(C) Phenol and formaldehyde
(D) Ethylene glycol and terephthalic acid

66. The monomer of Teflon is:



Part C

Mathematics

67. The principal argument of the complex number $-1 - i$ is:

(A) $-3\pi/4$

(B) $\pi/4$

(C) $-\pi/4$

(D) $3\pi/4$

68. If ω is a non-real cube root of unity, then $(1 + \omega - \omega^2)^3$ equals:

(A) 8

(B) -8

(C) 0

(D) -1

69. If α and β are the roots of $x^2 - 3x + 1 = 0$, then $\alpha^2 + \beta^2$ equals:

(A) 11

(B) 9

(C) 7

(D) 5

70. For what values of k does $x^2 - kx + 9 = 0$ have equal roots?

(A) ± 18

(B) ± 9

(C) ± 6

(D) ± 3

71. The arithmetic mean of two positive numbers is 10 and their geometric mean is 8. Their harmonic mean is:

(A) 7.2

(B) 8

(C) 6.4

(D) 5

72. The value of $1^2 + 2^2 + 3^2 + \dots + 10^2$ is:

(A) 385

(B) 505

(C) 285

(D) 330

73. How many 4-digit numbers can be formed from the digits 1, 2, 3, 4, 5 if no digit is repeated?

(A) 60

(B) 625

(C) 120

(D) 24

74. A committee of 3 men and 2 women is to be chosen from 6 men and 5 women. The number of ways is:

(A) 150

(B) 462

(C) 100

(D) 200

75. The term independent of x in the expansion of $(x + 1/x)^8$ is:

(A) 56

(B) 1

(C) 70

(D) 28

76. The coefficient of x^3 in the expansion of $(1 + 2x)^5$ is:

(A) 80

(B) 40

(C) 160

(D) 10

77. The value of the determinant with rows (1, 2, 3), (4, 5, 6) and (7, 8, 9) is:

(A) 1

(B) 6

(C) -3

(D) 0

78. For what value of k do the equations $kx + 2y = 3$ and $3x + 6y = 9$ have infinitely many solutions?
 (A) 1 (B) 2
 (C) 6 (D) 3
79. The value of $\tan 15^\circ$ is:
 (A) $1/\sqrt{3}$ (B) $\sqrt{3} - 1$
 (C) $2 - \sqrt{3}$ (D) $2 + \sqrt{3}$
80. The general solution of $\tan \theta = \sqrt{3}$ is (n an integer):
 (A) $\theta = 2n\pi + \pi/3$ (B) $\theta = n\pi + \pi/3$
 (C) $\theta = n\pi \pm \pi/3$ (D) $\theta = n\pi + \pi/6$
81. In a triangle ABC, $a = 7$, $b = 5$ and $c = 3$. The angle A is:
 (A) 60° (B) 90°
 (C) 150° (D) 120°
82. The angle of elevation of the top of a 50 m tower from a point on level ground is 30° . The distance of the point from the foot of the tower is:
 (A) $50\sqrt{3}$ m (B) $25\sqrt{3}$ m
 (C) 100 m (D) $50/\sqrt{3}$ m
83. The acute angle between the lines $y = x$ and $y = \sqrt{3}x$ is:
 (A) 30° (B) 75°
 (C) 15° (D) 45°
84. The equation of the tangent to the circle $x^2 + y^2 = 25$ at the point (3, 4) is:
 (A) $3x + 4y = 25$ (B) $4x + 3y = 25$
 (C) $3x - 4y = 25$ (D) $3x + 4y = 5$
85. The focus of the parabola $y^2 = 12x$ is:
 (A) (3, 0) (B) (12, 0)
 (C) (-3, 0) (D) (0, 3)
86. The length of the latus rectum of the ellipse $x^2/25 + y^2/16 = 1$ is:
 (A) $32/5$ (B) $16/5$
 (C) $8/5$ (D) $25/4$
87. The eccentricity of the hyperbola $x^2/9 - y^2/16 = 1$ is:
 (A) $5/3$ (B) $5/4$
 (C) $3/5$ (D) $4/3$
88. The value of $\lim_{x \rightarrow \infty} (1 + 2/x)^x$ is:
 (A) $\sqrt{e}$ (B) e^2
 (C) e (D) 1
89. $f(x) = (x^2 - 4)/(x - 2)$ for $x \neq 2$ and $f(2) = k$. If f is continuous at $x = 2$, then k is:
 (A) -4 (B) 0
 (C) 2 (D) 4
90. The derivative of $\log(\sin x)$ with respect to x is:
 (A) $1/\sin x$ (B) $\cot x$
 (C) $-\cot x$ (D) $\tan x$

91. The tangent to the curve $y = x^3 - 3x + 2$ is parallel to the x-axis at:
 (A) $x = \pm 3$ (B) $x = \pm\sqrt{3}$
 (C) $x = \pm 1$ (D) $x = 0$
92. The function $f(x) = 2x^3 - 9x^2 + 12x$ is decreasing on the interval:
 (A) $(-\infty, 1)$ (B) $(0, 3)$
 (C) $(2, \infty)$ (D) $(1, 2)$
93. $\int x e^x dx$ equals:
 (A) $(x + 1)e^x + C$ (B) $x^2 e^x/2 + C$
 (C) $x e^x + C$ (D) $(x - 1)e^x + C$
94. The value of $\int_0^{\pi/2} \sin^2 x dx$ is:
 (A) $1/2$ (B) $\pi/2$
 (C) $\pi/4$ (D) π
95. The area enclosed between the curves $y = x^2$ and $y = x$ is:
 (A) $1/2$ (B) $1/3$
 (C) $1/6$ (D) $1/12$
96. The general solution of the differential equation $dy/dx = x/y$ is:
 (A) $x^2 + y^2 = C$ (B) $xy = C$
 (C) $y^2 - x^2 = C$ (D) $y = Cx$
97. The integrating factor of the differential equation $dy/dx + 2y = e^x$ is:
 (A) $2x$ (B) e^{2x}
 (C) e^{-2x} (D) e^x
98. A bag has 3 red and 5 black balls. Two balls are drawn one after another without replacement. The probability that both are red is:
 (A) $1/7$ (B) $9/64$
 (C) $3/28$ (D) $3/8$
99. If $|a| = 2$, $|b| = 3$ and the angle between a and b is 30° , then $|a \times b|$ equals:
 (A) 6 (B) 3
 (C) $\sqrt{3}$ (D) $3\sqrt{3}$
100. The volume of the parallelepiped with edges $a = i + j$, $b = j + k$ and $c = k + i$ is:
 (A) 2 (B) 3
 (C) 1 (D) 0

Answer Key

1	B	2	C	3	C	4	D	5	D	6	C	7	A	8	C	9	B	10	A
11	B	12	A	13	D	14	A	15	C	16	B	17	A	18	A	19	D	20	C
21	D	22	A	23	A	24	B	25	B	26	D	27	B	28	C	29	D	30	D
31	D	32	D	33	B	34	A	35	B	36	B	37	B	38	C	39	B	40	A
41	A	42	B	43	C	44	D	45	B	46	A	47	C	48	D	49	B	50	A
51	D	52	B	53	D	54	A	55	D	56	C	57	D	58	C	59	D	60	B
61	D	62	D	63	B	64	C	65	A	66	B	67	A	68	B	69	C	70	C
71	C	72	A	73	C	74	D	75	C	76	A	77	D	78	A	79	C	80	B
81	D	82	A	83	C	84	A	85	A	86	A	87	A	88	B	89	D	90	B
91	C	92	D	93	D	94	C	95	C	96	C	97	B	98	C	99	B	100	A

Solutions

Physics

- (B)** Work = force $\times$ distance and torque = force $\times$ lever arm; both are $[ML^2T^{-2}]$.
- (C)** $u = 72 \text{ km/h} = 20 \text{ m/s}$, $a = 20/4 = 5 \text{ m/s}^2$, $s = u^2/2a = 400/10 = 40 \text{ m}$.
- (C)** $T = 2u \sin \theta / g = 2 \times 20 \times 0.5 / 10 = 2 \text{ s}$.
- (D)** Limiting friction = $\mu mg = 0.5 \times 2 \times 10 = 10 \text{ N} < 15 \text{ N}$, so the block moves: $a = (15 - 10)/2 = 2.5 \text{ m/s}^2$.
- (D)** $N = m(g + a) = 60 \times 12 = 720 \text{ N}$.
- (C)** Momentum is conserved: $4 \times 5 = (4 + 1)v$, so $v = 4 \text{ m/s}$.
- (A)** $W = F \cdot s = (3)(2) + (4)(-1) = 6 - 4 = 2 \text{ J}$.
- (C)** $P = mgh/t = 50 \times 10 \times 10 / 5 = 1000 \text{ W}$.
- (B)** About the central axis $I = MR^2$. By the perpendicular axes theorem, two equal diameters share it: $I_d = MR^2/2$.
- (A)** No external torque, so lw is constant: halving l doubles ω .
- (B)** $v_{\text{orbit}} = \sqrt{gR}$ and $v_{\text{escape}} = \sqrt{2gR} = \sqrt{2} v_{\text{orbit}}$.
- (A)** Kepler's third law: $T^2 \propto r^3$, so $T \propto r^{3/2} = 4^{3/2} = 8$.
- (D)** $\Delta L = FL/(\pi r^2 Y) \propto L/r^2$. First: L/r^2 . Second: $2L/(4r^2) = L/(2r^2)$. Ratio = 2 : 1.
- (A)** $v_{\text{max}} = A\omega = 0.05 \times 10 = 0.5 \text{ m/s}$.
- (C)** $f_1 = v/2L = 200/2 = 100 \text{ Hz}$.
- (B)** $f' = f \cdot v/(v - v/10) = f \cdot 10/9$.
- (A)** $C_v = 3R/2$ and $C_p = 5R/2$, so $\gamma = 5/3$.
- (A)** Stefan's law: $E \propto T^4$, so $2^4 = 16$ times.
- (D)** $W = qV = 2 \times 10^{-6} \times 50 = 1 \times 10^{-4} \text{ J}$.
- (C)** $C = K\epsilon_0 A/d$: K becomes 4 and d becomes $2d$, so $C' = 4C/2 = 2C$.
- (D)** $P/Q = R/S$ gives $S = RQ/P = 15 \times 20/10 = 30 \Omega$.
- (A)** $I = 2/(3.5 + 0.5) = 0.5 \text{ A}$; $V = E - Ir = 2 - 0.25 = 1.75 \text{ V}$.
- (A)** $B = \mu_0 NI/2R \propto I/R = 2/(1/2) = 4$ times.
- (B)** A small shunt in parallel carries most of the current and keeps the ammeter's total resistance low.
- (B)** $e = L \Delta I/\Delta t = 2 \times 4/0.2 = 40 \text{ V}$.
- (D)** At resonance $X_L = X_C$, the circuit is purely resistive and current is in phase with voltage.
- (B)** $\beta = \lambda D/d = (6 \times 10^{-7} \times 1)/(2 \times 10^{-4}) = 3 \times 10^{-3} \text{ m} = 3 \text{ mm}$.

28. (C) $1/v - 1/u = 1/f$ with $u = -30$: $1/v = 1/20 - 1/30 = 1/60$, so $v = +60$ cm (real, on the other side).
29. (D) $\lambda = 12.27/\sqrt{V}$ Å = $12.27/10 = 1.227$ Å.
30. (D) $E_n = -13.6/n^2$ eV = $-13.6/4 = -3.4$ eV.
31. (D) $K_{\text{max}} = h\nu - \phi = 5 - 2 = 3$ eV, so the stopping potential is 3 V.
32. (D) Both half-cycles are rectified, so the output pulses repeat at twice the input frequency: 100 Hz.
33. (B) A neutron turns into a proton (emitting an electron and an antineutrino): Z goes up by 1, A stays the same.

Chemistry

34. (A) $4 \text{ g}/40 \text{ g mol}^{-1} = 0.1 \text{ mol}$ in 0.25 L, so $M = 0.4 \text{ mol L}^{-1}$.
35. (B) A subshell has $2l + 1$ orbitals: for $l = 2$ (d), 5 orbitals.
36. (B) l can take values only from 0 to $n - 1$, so $l = 2$ is not allowed when $n = 2$.
37. (B) O_2^- has 17 electrons: bonding 10, antibonding 7, so bond order = $(10 - 7)/2 = 1.5$.
38. (C) Xe has 4 bond pairs and 2 lone pairs (sp^3d^2 , octahedral geometry); the lone pairs sit opposite each other, leaving a square planar shape.
39. (B) $v_{\text{rms}} \propto 1/\sqrt{M}$: $\sqrt{(32/2)} = \sqrt{16} = 4$, so 4 : 1.
40. (A) $\Delta G = \Delta H - T\Delta S$ is negative for every T when ΔH is negative and ΔS is positive.
41. (A) By Hess's law, subtract the second equation from the first: $-393.5 - (-283.0) = -110.5$ kJ.
42. (B) $K_p = K_c(RT)^{\Delta n}$ with $\Delta n = 2 - 4 = -2$.
43. (C) Henderson equation: $\text{pH} = \text{pK}_a + \log([\text{salt}]/[\text{acid}]) = 4.74 + \log 1 = 4.74$.
44. (D) $\text{CaF}_2 \rightleftharpoons \text{Ca}^{2+} + 2\text{F}^-$: $K_{\text{sp}} = (s)(2s)^2 = 4s^3$.
45. (B) $E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}} = 0.34 - (-0.76) = 1.10$ V.
46. (A) $\text{Al}^{3+} + 3\text{e}^- \rightarrow \text{Al}$ needs 3 moles of electrons, i.e. 3 faraday.
47. (C) In ccp/fcc each atom touches 6 neighbours in its own layer and 3 each above and below: 12. (14 is the number of lattice points in the fcc cell outline.)
48. (D) $(p^\circ - p)/p^\circ = x(\text{solute})$ for a dilute ideal solution of a non-volatile solute.
49. (B) 75% complete means 25% left = $(1/2)^2$, i.e. two half-lives = 40 min.
50. (A) N_2O (like NO) is neutral; N_2O_3 , NO_2 and N_2O_5 are acidic oxides.
51. (D) P has 5 bond pairs and no lone pair: sp^3d , trigonal bipyramidal.
52. (B) SO_2 is oxidised to SO_3 over vanadium pentoxide (V_2O_5).
53. (D) Heating gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) at about 393 K gives the hemihydrate $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$, plaster of Paris.
54. (A) Sc^{3+} is 3d^0 , so no d-d transition is possible; Ti^{3+} (3d^1), Cu^{2+} (3d^9) and Fe^{3+} (3d^5) are coloured.
55. (D) Mn^{2+} is 3d^5 with 5 unpaired electrons: $\mu = \sqrt{n(n+2)} = \sqrt{35} \approx 5.92$ BM.
56. (C) $4(+1) + x + 6(-1) = 0$ gives $x = +2$.
57. (D) n-pentane, isopentane (2-methylbutane) and neopentane (2,2-dimethylpropane).
58. (C) The tertiary carbocation is stabilised most by the +I effect and hyperconjugation of three methyl groups.
59. (D) Three electron-withdrawing Cl atoms (-I effect) stabilise the carboxylate ion most, so trichloroacetic acid is strongest.
60. (B) Aldol condensation needs an α -hydrogen. Only ethanal has one; the others have none.
61. (D) Only primary amines (aliphatic or aromatic) form isocyanides in this test.
62. (D) The negative charge of phenoxide is delocalised over the benzene ring; ethoxide has no such stabilisation.
63. (B) Tertiary alcohols form stable carbocations fastest, so the alkyl chloride separates at once; secondary take minutes and primary do not react at room temperature.
64. (C) A peptide (amide) bond $-\text{CO}-\text{NH}-$ forms between the $-\text{COOH}$ of one amino acid and the $-\text{NH}_2$ of the next.
65. (A) Nylon-6,6 comes from hexamethylenediamine and adipic acid (each with 6 carbons). Caprolactam gives nylon-6, glycol + terephthalic acid gives terylene, and phenol + formaldehyde gives bakelite.

66. (B) Teflon is polytetrafluoroethene. $\text{CH}_2=\text{CHCl}$ gives PVC, $\text{CH}_2=\text{CH}_2$ polythene and $\text{CH}_2=\text{CHCN}$ polyacrylonitrile.

Mathematics

67. (A) $-1 - i$ lies in the third quadrant at 45° below the negative x-axis; the principal value in $(-\pi, \pi]$ is $-3\pi/4$.

68. (B) $1 + \omega = -\omega^2$, so $1 + \omega - \omega^2 = -2\omega^2$ and $(-2\omega^2)^3 = -8\omega^6 = -8$.

69. (C) $\alpha + \beta = 3$, $\alpha\beta = 1$, so $\alpha^2 + \beta^2 = 9 - 2 = 7$.

70. (C) $k^2 - 36 = 0$ gives $k = \pm 6$.

71. (C) For two numbers $G^2 = A \times H$, so $H = 64/10 = 6.4$.

72. (A) $\Sigma n^2 = n(n+1)(2n+1)/6 = 10 \times 11 \times 21/6 = 385$.

73. (C) ${}^5P_4 = 5 \times 4 \times 3 \times 2 = 120$.

74. (D) ${}^6C_3 \times {}^5C_2 = 20 \times 10 = 200$.

75. (C) $T(r+1) = {}^8C_r x^r (8-2r)$; $8-2r = 0$ gives $r = 4$ and ${}^8C_4 = 70$.

76. (A) ${}^5C_3 \times 2^3 = 10 \times 8 = 80$.

77. (D) $R_3 - R_2 = R_2 - R_1 = (3, 3, 3)$, so the rows are linearly dependent and the determinant is 0.

78. (A) Need $k/3 = 2/6 = 3/9 = 1/3$, so $k = 1$.

79. (C) $\tan(45^\circ - 30^\circ) = (1 - 1/\sqrt{3})/(1 + 1/\sqrt{3}) = (\sqrt{3} - 1)/(\sqrt{3} + 1) = 2 - \sqrt{3}$.

80. (B) $\tan \theta = \tan(\pi/3)$ gives $\theta = n\pi + \pi/3$, since $\tan$ has period π .

81. (D) $\cos A = (b^2 + c^2 - a^2)/2bc = (25 + 9 - 49)/30 = -1/2$, so $A = 120^\circ$.

82. (A) $\tan 30^\circ = 50/d$, so $d = 50\sqrt{3}$ m.

83. (C) The lines make 45° and 60° with the x-axis, so the angle between them is 15° .

84. (A) The tangent to $x^2 + y^2 = a^2$ at (x_1, y_1) is $xx_1 + yy_1 = a^2$: $3x + 4y = 25$.

85. (A) $y^2 = 4ax$ with $4a = 12$ gives $a = 3$, focus $(a, 0) = (3, 0)$.

86. (A) $a = 5$, $b = 4$: latus rectum $= 2b^2/a = 32/5$.

87. (A) $e = \sqrt{1 + b^2/a^2} = \sqrt{1 + 16/9} = 5/3$.

88. (B) $\lim (1 + a/x)^x = e^a$, here e^2 .

89. (D) For $x \neq 2$, $f(x) = x + 2$, which tends to 4 as $x \rightarrow 2$, so $k = 4$.

90. (B) By the chain rule, $(1/\sin x) \times \cos x = \cot x$.

91. (C) $dy/dx = 3x^2 - 3 = 0$ gives $x = \pm 1$.

92. (D) $f'(x) = 6x^2 - 18x + 12 = 6(x-1)(x-2)$, which is negative only between 1 and 2.

93. (D) By parts: $x e^x - \int e^x dx = x e^x - e^x + C = (x-1)e^x + C$.

94. (C) $\sin^2 x = (1 - \cos 2x)/2$; integrating from 0 to $\pi/2$ gives $(\pi/2)/2 - 0 = \pi/4$.

95. (C) They meet at $x = 0$ and 1: $\int_0^1 (x - x^2) dx = 1/2 - 1/3 = 1/6$.

96. (C) $y dy = x dx$; integrating, $y^2/2 = x^2/2 + c$, i.e. $y^2 - x^2 = C$.

97. (B) $IF = e^{\int 2 dx} = e^{2x}$.

98. (C) $(3/8) \times (2/7) = 6/56 = 3/28$.

99. (B) $|a \times b| = |a||b| \sin 30^\circ = 2 \times 3 \times 1/2 = 3$.

100. (A) $[a \ b \ c] = \det \text{ of rows } (1, 1, 0), (0, 1, 1), (1, 0, 1) = 1(1-0) - 1(0-1) + 0 = 2$.