

Questions
120 MCQs

Marks
480

Time
3 hours

Marking
+4 correct, –1 wrong

Part	Section	Questions	Q. No.
Part A	Physics	40	1 to 40
Part B	Chemistry	40	41 to 80
Part C	Mathematics	40	81 to 120

Instructions

- This paper has 120 multiple-choice questions: Physics (1 to 40), Chemistry (41 to 80) and Mathematics (81 to 120).
- Each question has four options and only one correct answer. Marking more than one option counts as a wrong answer.
- Each correct answer earns 4 marks and each wrong answer loses 1 mark. Unattempted questions get 0. Maximum marks: 480.
- Attempt the paper in one sitting of 3 hours, marking answers as you would on the OMR sheet. Calculators are not allowed.
- Matrices are written row by row, with rows separated by semicolons. For example, [1 2; 3 4] has first row 1, 2.
- The answer key and solutions are at the end. Check them only after you finish.

This is an AglaSem practice paper written on the official Assam CEE pattern (120 MCQs, 480 marks, 3 hours, +4/–1) and the Class 11 and 12 Physics, Chemistry and Mathematics syllabus. It is not an official ASTU paper.

Part A

Physics

- A physical quantity is given by $Z = A^2B/C$. The percentage errors in A, B and C are 1%, 2% and 3%. The maximum percentage error in Z is:
(A) 4% (B) 7%
(C) 2% (D) 6%
- A ball is thrown vertically upward with a speed of 20 m/s ($g = 10 \text{ m/s}^2$). The distance it travels during the 3rd second of its motion is:
(A) 0 m (B) 25 m
(C) 5 m (D) 15 m
- A projectile is launched with a speed of 40 m/s at 30° to the horizontal ($g = 10 \text{ m/s}^2$). Its maximum height is:
(A) 60 m (B) 80 m
(C) 20 m (D) 40 m
- Two blocks of masses 2 kg and 3 kg are in contact on a frictionless horizontal floor. A horizontal force of 10 N pushes the 2 kg block. The contact force between the blocks is:
(A) 5 N (B) 10 N
(C) 4 N (D) 6 N

5. A block resting on a rough inclined plane just begins to slide when the angle of the incline is raised to 30° . The coefficient of static friction is:
 (A) $\sqrt{3}$ (B) $1/2$
 (C) $\sqrt{3}/2$ (D) $1/\sqrt{3}$
6. A body of mass 2 kg moving at 4 m/s is acted on by a force that increases its speed to 6 m/s. The work done by the force is:
 (A) 40 J (B) 4 J
 (C) 52 J (D) 20 J
7. A pump lifts 600 kg of water through a height of 20 m in 1 minute ($g = 10 \text{ m/s}^2$). The power delivered by the pump is:
 (A) 2 kW (B) 0.2 kW
 (C) 20 kW (D) 120 kW
8. A 1 kg ball moving at 6 m/s collides head-on and perfectly elastically with a stationary 2 kg ball. The velocity of the 2 kg ball after the collision is:
 (A) 6 m/s (B) 3 m/s
 (C) 4 m/s (D) 2 m/s
9. A solid sphere rolls without slipping on a horizontal surface. The fraction of its total kinetic energy that is rotational is:
 (A) $2/7$ (B) $2/5$
 (C) $1/2$ (D) $5/7$
10. A person standing on a freely rotating turntable pulls in the arms, reducing the moment of inertia of the system from 6 kg m^2 to 4 kg m^2 . If the initial angular speed was 2 rad/s, the final angular speed is:
 (A) 2 rad/s (B) 1.33 rad/s
 (C) 3 rad/s (D) 4 rad/s
11. A planet has the same mean density as the Earth but twice its radius. If the escape speed on Earth is 11.2 km/s, the escape speed on the planet is:
 (A) 11.2 km/s (B) 22.4 km/s
 (C) 44.8 km/s (D) 15.8 km/s
12. The acceleration due to gravity at a height $R/2$ above the Earth's surface (R = radius of Earth, g = value at the surface) is:
 (A) $4g/9$ (B) $g/2$
 (C) $g/4$ (D) $2g/3$
13. A wire 2 m long with cross-sectional area 1 mm^2 carries a load of 10 kg ($g = 10 \text{ m/s}^2$, $Y = 2 \times 10^{11} \text{ N/m}^2$). The extension of the wire is:
 (A) 0.1 mm (B) 1 mm
 (C) 0.5 mm (D) 10 mm
14. Water flows at 2 m/s through a pipe of diameter 4 cm, which narrows to a diameter of 2 cm. The speed of water in the narrow part is:
 (A) 8 m/s (B) 1 m/s
 (C) 16 m/s (D) 4 m/s
15. 100 g of water at 80°C is mixed with 300 g of water at 20°C . Ignoring heat losses, the final temperature of the mixture is:
 (A) 40°C (B) 30°C
 (C) 50°C (D) 35°C

16. A Carnot engine works between a source at 527°C and a sink at 127°C . Its efficiency is:
 (A) 50% (B) 76%
 (C) 40% (D) 25%
17. 2 mol of a monatomic ideal gas is heated at constant pressure so that its temperature rises by 30 K ($R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$). The heat supplied is about:
 (A) 748 J (B) 499 J
 (C) 1247 J (D) 1746 J
18. The rms speed of the molecules of an ideal gas at 27°C is v . The temperature at which the rms speed becomes $2v$ is:
 (A) 327°C (B) 927°C
 (C) 108°C (D) 1200°C
19. A mass of 0.5 kg attached to a spring of force constant 200 N/m oscillates on a smooth horizontal surface. Its time period is:
 (A) $\pi/10 \text{ s}$ (B) $\pi/20 \text{ s}$
 (C) $\pi/5 \text{ s}$ (D) $10\pi \text{ s}$
20. A pipe closed at one end is 85 cm long. If the speed of sound in air is 340 m/s, the frequency of its fundamental mode is:
 (A) 50 Hz (B) 200 Hz
 (C) 100 Hz (D) 400 Hz
21. A point charge q is placed at the centre of a cube. The electric flux through any one face of the cube is:
 (A) $q/6\epsilon_0$ (B) $6q/\epsilon_0$
 (C) $q/8\epsilon_0$ (D) q/ϵ_0
22. A parallel-plate capacitor storing energy U is charged and then disconnected from the battery. A slab of dielectric constant 4 is inserted to fill the gap. The stored energy becomes:
 (A) U (B) $U/16$
 (C) $4U$ (D) $U/4$
23. A wire of resistance R is stretched uniformly so that its length doubles. Its new resistance is:
 (A) $R/4$ (B) $2R$
 (C) $4R$ (D) $R/2$
24. A cell of emf 12 V and internal resistance 1Ω is connected to an external resistance of 5Ω . The potential difference across the terminals of the cell is:
 (A) 12 V (B) 10 V
 (C) 2 V (D) 8 V
25. In a metre bridge, an unknown resistance is in the left gap and 6Ω in the right gap. The balance point is 40 cm from the left end. The unknown resistance is:
 (A) 4Ω (B) 6Ω
 (C) 9Ω (D) 2.4Ω
26. A circular coil of 50 turns and radius 10 cm carries a current of 2 A ($\mu_0 = 4\pi \times 10^{-7} \text{ T m/A}$). The magnetic field at its centre is:
 (A) $2\pi \times 10^{-4} \text{ T}$ (B) $4\pi \times 10^{-4} \text{ T}$
 (C) $\pi \times 10^{-4} \text{ T}$ (D) $2\pi \times 10^{-5} \text{ T}$

27. A proton and an alpha particle with the same kinetic energy enter a uniform magnetic field perpendicular to it. The ratio of the radii of their circular paths (proton : alpha) is:
 (A) 1 : 2 (B) 1 : 1
 (C) 2 : 1 (D) 1 : $\sqrt{2}$
28. A galvanometer of resistance $100\ \Omega$ gives full-scale deflection for 1 mA. To convert it into an ammeter of range 0–1 A, one should connect:
 (A) about $999\ \Omega$ in series (B) about $0.1\ \Omega$ in parallel
 (C) about $100\ \Omega$ in parallel (D) about $0.1\ \Omega$ in series
29. Which material has a small negative magnetic susceptibility that hardly changes with temperature?
 (A) Iron (B) Aluminium
 (C) Liquid oxygen (D) Bismuth
30. A coil of 100 turns and area $0.01\ \text{m}^2$ is placed perpendicular to a magnetic field of 0.5 T. The field is reduced to zero uniformly in 0.1 s. The average induced emf is:
 (A) 0.5 V (B) 5 V
 (C) 50 V (D) 0.05 V
31. In a series LCR circuit, $R = 30\ \Omega$, $X_L = 80\ \Omega$ and $X_C = 40\ \Omega$. The power factor of the circuit is:
 (A) 1.0 (B) 0.5
 (C) 0.6 (D) 0.8
32. In a plane electromagnetic wave in vacuum, the peak electric field is 30 V/m. The peak magnetic field is:
 (A) $1 \times 10^{-8}\ \text{T}$ (B) $3 \times 10^{-7}\ \text{T}$
 (C) $1 \times 10^{-7}\ \text{T}$ (D) $9 \times 10^9\ \text{T}$
33. An object is placed 30 cm in front of a concave mirror of focal length 20 cm. The image is:
 (A) real, inverted, 12 cm in front of the mirror, magnification -0.4
 (B) virtual, erect, 60 cm behind the mirror, magnification $+2$
 (C) virtual, erect, 12 cm behind the mirror, magnification $+0.4$
 (D) real, inverted, 60 cm in front of the mirror, magnification -2
34. A prism of angle 60° is made of glass of refractive index $\sqrt{2}$. Its angle of minimum deviation is:
 (A) 45° (B) 60°
 (C) 15° (D) 30°
35. In Young's double-slit experiment, the slit separation is 0.5 mm, the screen is 1 m away and the wavelength is 600 nm. The fringe width is:
 (A) 0.12 mm (B) 12 mm
 (C) 2.4 mm (D) 1.2 mm
36. Light of wavelength 400 nm falls on a metal of work function 2.0 eV (take $hc = 1240\ \text{eV nm}$). The stopping potential is:
 (A) 5.1 V (B) 1.1 V
 (C) 3.1 V (D) 2.0 V
37. The ratio of the longest wavelength in the Lyman series to the longest wavelength in the Balmer series of hydrogen is:
 (A) $4/9$ (B) $27/5$
 (C) $5/27$ (D) $9/4$

38. After 24 hours, one-eighth of a radioactive sample remains undecayed. The half-life of the sample is:
(A) 3 h (B) 12 h
(C) 8 h (D) 6 h
39. Pure silicon becomes a p-type semiconductor when it is doped with:
(A) Antimony (B) Arsenic
(C) Boron (D) Phosphorus
40. A full-wave rectifier is fed with an AC supply of 50 Hz. The fundamental frequency of the ripple in its output is:
(A) 200 Hz (B) 100 Hz
(C) 50 Hz (D) 25 Hz

Part B

Chemistry

41. The number of molecules in 4.4 g of CO_2 is ($N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$):
(A) 6.022×10^{23} (B) 3.011×10^{22}
(C) 6.022×10^{22} (D) 1.807×10^{23}
42. 4 g of NaOH is dissolved in water to make 250 mL of solution. The molarity of the solution is:
(A) 0.04 M (B) 0.4 M
(C) 0.1 M (D) 1.6 M
43. A compound contains 40.0% carbon, 6.67% hydrogen and 53.3% oxygen by mass. Its empirical formula is:
(A) $\text{C}_2\text{H}_4\text{O}$ (B) CH_2O_2
(C) CHO (D) CH_2O
44. The number of radial nodes in a 3p orbital is:
(A) 3 (B) 0
(C) 1 (D) 2
45. Which set of quantum numbers (n, l, m_l) is NOT allowed?
(A) (3, 2, -2) (B) (2, 2, 1)
(C) (4, 0, 0) (D) (2, 1, 0)
46. Using the Bohr model, the energy of the electron in the $n = 2$ orbit of He^+ is:
(A) -6.8 eV (B) -13.6 eV
(C) -54.4 eV (D) -3.4 eV
47. The correct order of first ionisation enthalpy is:
(A) $\text{O} < \text{N} < \text{C} < \text{B}$ (B) $\text{B} < \text{C} < \text{N} < \text{O}$
(C) $\text{B} < \text{C} < \text{O} < \text{N}$ (D) $\text{C} < \text{B} < \text{N} < \text{O}$
48. The shape of the ClF_3 molecule is:
(A) T-shaped (B) Trigonal planar
(C) Trigonal pyramidal (D) See-saw
49. According to molecular orbital theory, the bond order of the superoxide ion O_2^- is:
(A) 1 (B) 2.5
(C) 2 (D) 1.5

50. For $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$ at 300 K, $\Delta U = -87.0$ kJ. The value of ΔH is about ($R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$):
 (A) -82.0 kJ (B) -89.5 kJ
 (C) -92.0 kJ (D) -87.0 kJ
51. For a reaction, $\Delta H = +40 \text{ kJ mol}^{-1}$ and $\Delta S = +100 \text{ J K}^{-1} \text{ mol}^{-1}$. Assuming both are constant, the reaction becomes spontaneous above:
 (A) 400 K (B) 4000 K
 (C) 40 K (D) 0.4 K
52. Given: $\text{C}(\text{s}) + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g})$, $\Delta H = -393.5$ kJ; $\text{CO}(\text{g}) + \frac{1}{2}\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g})$, $\Delta H = -283.0$ kJ. The enthalpy of formation of $\text{CO}(\text{g})$ is:
 (A) $-110.5 \text{ kJ mol}^{-1}$ (B) $-393.5 \text{ kJ mol}^{-1}$
 (C) $-676.5 \text{ kJ mol}^{-1}$ (D) $+110.5 \text{ kJ mol}^{-1}$
53. The pH of a 0.001 M aqueous NaOH solution at 25 °C is:
 (A) 10 (B) 3
 (C) 12 (D) 11
54. The solubility product of AgCl at 25 °C is 1.6×10^{-10} . Its solubility in pure water is about:
 (A) $4 \times 10^{-5} \text{ mol L}^{-1}$ (B) $8 \times 10^{-11} \text{ mol L}^{-1}$
 (C) $1.6 \times 10^{-5} \text{ mol L}^{-1}$ (D) $1.26 \times 10^{-5} \text{ mol L}^{-1}$
55. A buffer contains 0.1 M CH_3COOH and 0.2 M CH_3COONa . If pK_a of acetic acid is 4.74 ($\log 2 = 0.30$), the pH of the buffer is:
 (A) 4.74 (B) 5.04
 (C) 9.26 (D) 4.44
56. The oxidation number of sulphur in peroxodisulphuric acid, $\text{H}_2\text{S}_2\text{O}_8$, is:
 (A) +5 (B) +6
 (C) +7 (D) +8
57. The IUPAC name of $(\text{CH}_3)_2\text{CH}-\text{CH}_2-\text{CH}_2-\text{OH}$ is:
 (A) 2-Methylpentan-1-ol (B) 3-Methylbutan-2-ol
 (C) 2-Methylbutan-4-ol (D) 3-Methylbutan-1-ol
58. The number of σ and π bonds in acrylonitrile, $\text{CH}_2=\text{CH}-\text{C}\equiv\text{N}$, is:
 (A) 6 σ and 2 π (B) 5 σ and 3 π
 (C) 7 σ and 3 π (D) 6 σ and 3 π
59. Propene reacts with HBr in the presence of benzoyl peroxide. The main product is:
 (A) 1,2-Dibromopropane (B) Propan-2-ol
 (C) 1-Bromopropane (D) 2-Bromopropane
60. Which of the following species is aromatic?
 (A) Cyclopentadienyl cation (B) Cyclopentadienyl anion
 (C) Cycloheptatriene (D) Cyclooctatetraene
61. 1.8 g of glucose ($M = 180 \text{ g mol}^{-1}$) is dissolved in 100 g of water. If K_b of water is $0.52 \text{ K kg mol}^{-1}$, the elevation in boiling point is:
 (A) 0.104 K (B) 0.52 K
 (C) 0.0052 K (D) 0.052 K
62. The osmotic pressure of a 0.1 M solution of a non-electrolyte at 300 K is ($R = 0.0821 \text{ L atm K}^{-1} \text{ mol}^{-1}$):
 (A) 24.6 atm (B) 0.246 atm
 (C) 2.46 atm (D) 4.92 atm

63. For the Daniell cell, $\text{Zn} | \text{Zn}^{2+} || \text{Cu}^{2+} | \text{Cu}$, $E^\circ(\text{Zn}^{2+}/\text{Zn}) = -0.76 \text{ V}$ and $E^\circ(\text{Cu}^{2+}/\text{Cu}) = +0.34 \text{ V}$. The standard Gibbs energy change is ($F = 96500 \text{ C mol}^{-1}$):
- (A) $-106.2 \text{ kJ mol}^{-1}$ (B) $-81.1 \text{ kJ mol}^{-1}$
 (C) $-212.3 \text{ kJ mol}^{-1}$ (D) $+212.3 \text{ kJ mol}^{-1}$
64. A current of 2 A is passed through CuSO_4 solution for 965 s. The mass of copper deposited at the cathode is ($\text{Cu} = 63.5$, $F = 96500 \text{ C mol}^{-1}$):
- (A) 0.0635 g (B) 1.27 g
 (C) 0.3175 g (D) 0.635 g
65. The electrode potential of a hydrogen electrode ($p_{\text{H}_2} = 1 \text{ bar}$) dipped in a solution of pH 3 at 298 K is:
- (A) +0.177 V (B) 0.000 V
 (C) -0.059 V (D) -0.177 V
66. $\Lambda^\circ \text{m}$ (in $\text{S cm}^2 \text{ mol}^{-1}$) of CH_3COONa , HCl and NaCl are 91, 426 and 126. $\Lambda^\circ \text{m}$ of CH_3COOH is:
- (A) $391 \text{ S cm}^2 \text{ mol}^{-1}$ (B) $209 \text{ S cm}^2 \text{ mol}^{-1}$
 (C) $461 \text{ S cm}^2 \text{ mol}^{-1}$ (D) $643 \text{ S cm}^2 \text{ mol}^{-1}$
67. A first-order reaction has a half-life of 69.3 s. The time required for 90% completion of the reaction is:
- (A) 100 s (B) 230.3 s
 (C) 62.4 s (D) 207.9 s
68. For the rate law, $\text{rate} = k[\text{A}][\text{B}]^2$, the concentration of A is doubled and that of B is halved. The rate becomes:
- (A) the same (B) double the original
 (C) half the original (D) one-quarter of the original
69. The rate of a reaction doubles when the temperature rises from 300 K to 310 K. The activation energy is about ($R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$, $\log 2 = 0.301$):
- (A) 26.8 kJ mol^{-1} (B) 5.36 kJ mol^{-1}
 (C) $107.2 \text{ kJ mol}^{-1}$ (D) 53.6 kJ mol^{-1}
70. The spin-only magnetic moment of Mn^{2+} (Z of Mn = 25) is about:
- (A) 1.73 BM (B) 3.87 BM
 (C) 4.90 BM (D) 5.92 BM
71. Zirconium (4d) and hafnium (5d) have almost identical atomic radii. This is mainly due to:
- (A) Lanthanoid contraction (B) Diagonal relationship
 (C) Inert pair effect (D) Actinoid contraction
72. The IUPAC name of $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$ is:
- (A) Chloridopentaamminecobalt(III) chloride
 (B) Pentaamminecobalt(III) trichloride
 (C) Pentaamminechloridocobalt(II) chloride
 (D) Pentaamminechloridocobalt(III) chloride
73. The number of unpaired electrons in the low-spin complex $[\text{Fe}(\text{CN})_6]^{3-}$ is:
- (A) 0 (B) 5
 (C) 3 (D) 1
74. Which of the following complexes shows optical isomerism?
- (A) $\text{cis-}[\text{Co}(\text{en})_2\text{Cl}_2]^+$ (B) $[\text{Co}(\text{NH}_3)_6]^{3+}$
 (C) $\text{trans-}[\text{Co}(\text{en})_2\text{Cl}_2]^+$ (D) $\text{trans-}[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$

75. Which alkyl halide reacts fastest by the S_N2 mechanism?
 (A) $\text{CH}_3\text{CH}_2\text{Br}$ (B) CH_3Br
 (C) $(\text{CH}_3)_3\text{CBr}$ (D) $(\text{CH}_3)_2\text{CHBr}$
76. Which compound undergoes the Cannizzaro reaction with concentrated NaOH ?
 (A) Acetaldehyde (B) Acetone
 (C) Propanal (D) Benzaldehyde
77. Which is the strongest acid?
 (A) CCl_3COOH (B) CF_3COOH
 (C) CH_3COOH (D) ClCH_2COOH
78. Which of the following does NOT give the iodoform test?
 (A) Propan-2-ol (B) Acetone
 (C) Ethanol (D) Methanol
79. Which amine is the most basic in aqueous solution?
 (A) $(\text{CH}_3)_2\text{NH}$ (B) $\text{C}_6\text{H}_5\text{NH}_2$
 (C) CH_3NH_2 (D) $(\text{CH}_3)_3\text{N}$
80. Which of the following is a non-reducing sugar?
 (A) Glucose (B) Sucrose
 (C) Lactose (D) Maltose

Part C

Mathematics

81. In a class of 60 students, 35 study Physics, 30 study Mathematics and 10 study neither. The number of students who study both is:
 (A) 5 (B) 25
 (C) 15 (D) 20
82. If A has 2 elements and B has 3 elements, the number of relations from A to B is:
 (A) 64 (B) 32
 (C) 8 (D) 6
83. The value of $\sin^2(\pi/8) + \sin^2(3\pi/8)$ is:
 (A) $1/2$ (B) 0
 (C) 1 (D) $\sqrt{2}$
84. The general solution of $\tan x = \sqrt{3}$ is:
 (A) $x = 2n\pi + \pi/3, n \in \mathbb{Z}$ (B) $x = n\pi + \pi/6, n \in \mathbb{Z}$
 (C) $x = n\pi \pm \pi/3, n \in \mathbb{Z}$ (D) $x = n\pi + \pi/3, n \in \mathbb{Z}$
85. The value of $(1 + i)^8$ is:
 (A) 16 (B) $16i$
 (C) -16 (D) 8
86. The roots of $x^2 - 6x + k = 0$ differ by 2. The value of k is:
 (A) 7 (B) 5
 (C) 8 (D) 9

87. The solution set of $|x - 2| < 3$, $x \in \mathbb{R}$, is:
 (A) $[-1, 5]$ (B) $(-\infty, -1) \cup (5, \infty)$
 (C) $(-5, 1)$ (D) $(-1, 5)$
88. The number of different arrangements of all the letters of the word ASSAM is:
 (A) 20 (B) 30
 (C) 60 (D) 120
89. A committee of 3 men and 2 women is to be chosen from 6 men and 5 women. The number of ways is:
 (A) 120 (B) 30
 (C) 200 (D) 462
90. The term independent of x in the expansion of $(x + 1/x^2)^6$ is:
 (A) 15 (B) 6
 (C) 30 (D) 20
91. The sum of the first 20 terms of the AP 3, 7, 11, 15, ... is:
 (A) 840 (B) 820
 (C) 780 (D) 800
92. The arithmetic mean of two positive numbers is 10 and their geometric mean is 8. The numbers are:
 (A) 16 and 4 (B) 12 and 8
 (C) 14 and 6 (D) 18 and 2
93. The distance between the parallel lines $3x + 4y = 5$ and $6x + 8y = 25$ is:
 (A) 4 (B) $3/2$
 (C) 3 (D) 2
94. The length of the latus rectum of the ellipse $x^2/25 + y^2/16 = 1$ is:
 (A) $25/2$ (B) $16/5$
 (C) $32/5$ (D) $8/5$
95. The focus of the parabola $y^2 = -12x$ is:
 (A) $(-3, 0)$ (B) $(0, -3)$
 (C) $(3, 0)$ (D) $(-12, 0)$
96. The eccentricity of the hyperbola $9x^2 - 16y^2 = 144$ is:
 (A) $5/4$ (B) $4/5$
 (C) $\sqrt{7}/4$ (D) $5/3$
97. The point on the x -axis that is equidistant from $A(1, 2, 3)$ and $B(3, 4, 5)$ is:
 (A) $(9, 0, 0)$ (B) $(6, 0, 0)$
 (C) $(-9, 0, 0)$ (D) $(2, 0, 0)$
98. The value of $\lim_{x \rightarrow 2} (x^3 - 8)/(x^2 - 4)$ is:
 (A) 12 (B) 3
 (C) 2 (D) 4
99. The variance of the observations 2, 4, 6, 8, 10 is:
 (A) 10 (B) 40
 (C) 8 (D) $2\sqrt{2}$
100. Two fair dice are thrown. The probability that the sum of the numbers is 8 is:
 (A) $5/36$ (B) $7/36$
 (C) $1/9$ (D) $1/6$

- 101.** If $f(x) = (2x - 1)/(x + 3)$, $x \neq -3$, then $f^{-1}(x)$ is (for $x \neq 2$):
 (A) $(3x - 1)/(2 - x)$ (B) $(3x + 1)/(2 - x)$
 (C) $(x + 3)/(2x - 1)$ (D) $(2x + 1)/(x - 3)$
- 102.** The principal value of $\sin^{-1}(\sin(2\pi/3))$ is:
 (A) $\pi/3$ (B) $\pi/6$
 (C) $-\pi/3$ (D) $2\pi/3$
- 103.** If $A = \begin{bmatrix} 2 & 3 \\ 1 & 2 \end{bmatrix}$ satisfies $A^2 - 4A + I = O$, then A^{-1} equals:
 (A) $\begin{bmatrix} -2 & 3 \\ 1 & -2 \end{bmatrix}$ (B) $\begin{bmatrix} 2 & 3 \\ 1 & 2 \end{bmatrix}$
 (C) $\begin{bmatrix} 2 & -1 \\ -3 & 2 \end{bmatrix}$ (D) $\begin{bmatrix} 2 & -3 \\ -1 & 2 \end{bmatrix}$
- 104.** The system $x + y + z = 1$, $x + 2y + 3z = 2$, $x + 3y + kz = 3$ does NOT have a unique solution when k equals:
 (A) 4 (B) 6
 (C) 5 (D) 3
- 105.** The function $f(x) = (\sin 3x)/x$ for $x \neq 0$ and $f(0) = k$ is continuous at $x = 0$ if k equals:
 (A) 1 (B) 3
 (C) $1/3$ (D) 0
- 106.** If $y = x^x$, then dy/dx at $x = 1$ is:
 (A) 0 (B) e
 (C) 2 (D) 1
- 107.** If $x = a \cos^3 t$ and $y = a \sin^3 t$, then dy/dx is:
 (A) $\cot t$ (B) $-\tan t$
 (C) $-\cot t$ (D) $\tan t$
- 108.** The radius of a circle increases at 0.5 cm/s. The rate of increase of its area when the radius is 10 cm is:
 (A) $20\pi \text{ cm}^2/\text{s}$ (B) $100\pi \text{ cm}^2/\text{s}$
 (C) $5\pi \text{ cm}^2/\text{s}$ (D) $10\pi \text{ cm}^2/\text{s}$
- 109.** The function $f(x) = 2x^3 - 9x^2 + 12x + 1$ has a local maximum at:
 (A) $x = -1$ (B) $x = 1$
 (C) $x = 2$ (D) $x = 3$
- 110.** $\int dx/(x^2 + 4x + 13)$ equals:
 (A) $(1/6) \log|(x - 1)/(x + 5)| + C$ (B) $(1/3) \tan^{-1}((x + 2)/3) + C$
 (C) $\tan^{-1}((x + 2)/3) + C$ (D) $(1/3) \tan^{-1}((x - 2)/3) + C$
- 111.** The value of $\int$ (from 0 to $\pi/2$) $\sin x/(\sin x + \cos x) dx$ is:
 (A) $\pi/4$ (B) π
 (C) 1 (D) $\pi/2$
- 112.** The value of $\int$ (from 0 to 1) $x e^x dx$ is:
 (A) 1 (B) e
 (C) $2e - 1$ (D) $e - 1$
- 113.** The area of the region enclosed between the curves $y = x^2$ and $y = x$ is:
 (A) $1/12$ sq unit (B) $1/2$ sq unit
 (C) $1/6$ sq unit (D) $1/3$ sq unit

114. The order and degree of the differential equation $(d^2y/dx^2)^3 + (dy/dx)^4 + y = 0$ are:
(A) order 3, degree 2 (B) order 1, degree 4
(C) order 2, degree 3 (D) order 2, degree 4
115. The integrating factor of the differential equation $dy/dx + y/x = x^2$ ($x > 0$) is:
(A) x (B) $\log x$
(C) $1/x$ (D) e^x
116. The area of the parallelogram whose adjacent sides are $a = 3i + j + 4k$ and $b = i - j + k$ is:
(A) $\sqrt{42}$ sq units (B) 42 sq units
(C) $\sqrt{42}/2$ sq units (D) $\sqrt{26}$ sq units
117. The distance of the point $(2, 3, -5)$ from the plane $x + 2y - 2z = 9$ is:
(A) 3 units (B) 1 unit
(C) 6 units (D) 9 units
118. The maximum value of $Z = 3x + 2y$ subject to $x + y \leq 4$, $x + 3y \leq 6$, $x \geq 0$, $y \geq 0$ is:
(A) 4 (B) 11
(C) 14 (D) 12
119. Bag I has 3 red and 2 black balls; Bag II has 2 red and 4 black balls. A bag is chosen at random and a ball drawn from it is red. The probability that it came from Bag I is:
(A) $1/2$ (B) $9/14$
(C) $5/14$ (D) $3/5$
120. A fair die is thrown twice. If X is the number of sixes obtained, the mean of X is:
(A) $1/2$ (B) $1/6$
(C) $1/3$ (D) $2/3$

Answer Key

1	B	2	C	3	C	4	D	5	D	6	D	7	A	8	C	9	A	10	C
11	B	12	A	13	B	14	A	15	D	16	A	17	C	18	B	19	A	20	C
21	A	22	D	23	C	24	B	25	A	26	A	27	B	28	B	29	D	30	B
31	C	32	C	33	D	34	D	35	D	36	B	37	C	38	C	39	C	40	B
41	C	42	B	43	D	44	C	45	B	46	B	47	C	48	A	49	D	50	C
51	A	52	A	53	D	54	D	55	B	56	B	57	D	58	D	59	C	60	B
61	D	62	C	63	C	64	D	65	D	66	A	67	B	68	C	69	D	70	D
71	A	72	D	73	D	74	A	75	B	76	D	77	B	78	D	79	A	80	B
81	C	82	A	83	C	84	D	85	A	86	C	87	D	88	B	89	C	90	A
91	B	92	A	93	B	94	C	95	A	96	A	97	A	98	B	99	C	100	A
101	B	102	A	103	D	104	C	105	B	106	D	107	B	108	D	109	B	110	B
111	A	112	A	113	C	114	C	115	A	116	A	117	A	118	D	119	B	120	C

Solutions

Physics

- (B)** Maximum % error = $2(1\%) + 2\% + 3\% = 7\%$; errors always add, even for the quantity in the denominator.
- (C)** The ball reaches the top at $t = 2$ s ($h = 20$ m) and falls $\frac{1}{2} \cdot 10 \cdot 1^2 = 5$ m during the 3rd second.
- (C)** $H = u^2 \sin^2 \theta / 2g = 1600 \times (1/4) / 20 = 20$ m.
- (D)** $a = 10/5 = 2$ m/s²; the 3 kg block needs $F = 3 \times 2 = 6$ N, which is the contact force.
- (D)** At the angle of repose, $\mu_s = \tan \theta = \tan 30^\circ = 1/\sqrt{3}$.
- (D)** $W = \Delta K = \frac{1}{2} \times 2 \times (6^2 - 4^2) = 36 - 16 = 20$ J.
- (A)** $P = mgh/t = 600 \times 10 \times 20/60 = 2000$ W = 2 kW.
- (C)** $v_2 = 2m_1u/(m_1 + m_2) = 2 \times 1 \times 6/3 = 4$ m/s.
- (A)** $K_{\text{rot}} = \frac{1}{2}(2/5 mR^2)\omega^2 = (1/5)mv^2$ and $K_{\text{total}} = (1/2 + 1/5)mv^2 = (7/10)mv^2$, so the fraction is $2/7$.
- (C)** Angular momentum is conserved: $6 \times 2 = 4 \times \omega$, so $\omega = 3$ rad/s.
- (B)** $v_g = \sqrt{2GM/R} = R\sqrt{8\pi G\rho/3}$ varies as R for equal density, so it doubles to 22.4 km/s.
- (A)** $g' = gR^2/(R+h)^2 = g/(3/2)^2 = 4g/9$.
- (B)** $\Delta L = FL/(AY) = (100 \times 2)/(10^{-6} \times 2 \times 10^{11}) = 10^{-3}$ m = 1 mm.
- (A)** Continuity: $A_1v_1 = A_2v_2$ and A varies as d^2 , so $v_2 = 2 \times (4/2)^2 = 8$ m/s.
- (D)** Heat lost = heat gained: $100(80 - T) = 300(T - 20)$, giving $T = 14000/400 = 35$ °C.
- (A)** $\eta = 1 - T_2/T_1 = 1 - 400 \text{ K}/800 \text{ K} = 0.5 = 50\%$ (temperatures must be in kelvin).
- (C)** $Q = nC_p\Delta T = 2 \times (5/2)R \times 30 = 1247$ J; 748 J would be $nC_v\Delta T$.
- (B)** v_{rms} varies as $\sqrt{T}$, so T must become $4 \times 300 \text{ K} = 1200 \text{ K} = 927$ °C.
- (A)** $T = 2\pi\sqrt{m/k} = 2\pi\sqrt{0.5/200} = 2\pi \times 0.05 = \pi/10$ s.
- (C)** For a closed pipe $f_1 = v/4L = 340/(4 \times 0.85) = 100$ Hz; 200 Hz would be an open pipe.
- (A)** By Gauss's law the total flux is q/ϵ_0 , shared equally by the 6 faces by symmetry.
- (D)** Charge stays constant and C becomes $4C$, so $U = Q^2/2C$ falls to $U/4$.
- (C)** Volume is constant, so doubling L halves A ; $R = \rho L/A$ becomes $2 \times 2 = 4$ times.
- (B)** $I = 12/(5 + 1) = 2$ A; terminal voltage $V = E - Ir = 12 - 2 = 10$ V.
- (A)** $X/6 = 40/60$, so $X = 4$ Ω.

26. (A) $B = \mu_0 NI/2r = 4\pi \times 10^{-7} \times 50 \times 2/(2 \times 0.1) = 2\pi \times 10^{-4} \text{ T}$.
27. (B) $r = \sqrt{(2mK)/(qB)}$; the alpha has 4 times the mass and 2 times the charge, so $\sqrt{4/2} = 1$ and the radii are equal.
28. (B) Shunt $S = IgG/(I - Ig) = (0.001 \times 100)/0.999 \approx 0.1 \Omega$, connected in parallel.
29. (D) Bismuth is diamagnetic (χ small and negative, nearly temperature-independent); Al and O_2 are paramagnetic, Fe is ferromagnetic.
30. (B) $e = NA\Delta B/\Delta t = 100 \times 0.01 \times 0.5/0.1 = 5 \text{ V}$.
31. (C) $Z = \sqrt{(30^2 + 40^2)} = 50 \Omega$; power factor $= R/Z = 30/50 = 0.6$.
32. (C) $B_0 = E_0/c = 30/(3 \times 10^8) = 1 \times 10^{-7} \text{ T}$.
33. (D) $1/v = 1/f - 1/u = -1/20 + 1/30 = -1/60$, so $v = -60 \text{ cm}$ and $m = -v/u = -2$.
34. (D) $\sqrt{2} = \sin((60^\circ + \delta)/2)/\sin 30^\circ$ gives $\sin((60^\circ + \delta)/2) = 1/\sqrt{2}$, so $(60^\circ + \delta)/2 = 45^\circ$ and $\delta = 30^\circ$.
35. (D) $\beta = \lambda D/d = (600 \times 10^{-9} \times 1)/(0.5 \times 10^{-3}) = 1.2 \times 10^{-3} \text{ m} = 1.2 \text{ mm}$.
36. (B) Photon energy $= 1240/400 = 3.1 \text{ eV}$; $K_{\text{max}} = 3.1 - 2.0 = 1.1 \text{ eV}$, so $V_0 = 1.1 \text{ V}$.
37. (C) $1/\lambda_L = R(1 - 1/4) = 3R/4$ and $1/\lambda_B = R(1/4 - 1/9) = 5R/36$, so $\lambda_L/\lambda_B = (5/36)/(3/4) = 5/27$.
38. (C) $1/8 = (1/2)^3$, so 3 half-lives $= 24 \text{ h}$ and $T_{1/2} = 8 \text{ h}$.
39. (C) Trivalent boron creates holes (acceptor impurity); P, As and Sb are pentavalent donors giving n-type.
40. (B) Both half-cycles are rectified, so the output repeats twice per input cycle: $2 \times 50 = 100 \text{ Hz}$.

Chemistry

41. (C) Moles $= 4.4/44 = 0.1$, so molecules $= 0.1 \times 6.022 \times 10^{23} = 6.022 \times 10^{22}$; 1.807×10^{23} is the number of atoms.
42. (B) Moles of NaOH $= 4/40 = 0.1$; molarity $= 0.1/0.250 \text{ L} = 0.4 \text{ M}$.
43. (D) Mole ratio C : H : O $= 40/12 : 6.67/1 : 53.3/16 = 3.33 : 6.67 : 3.33 = 1 : 2 : 1$.
44. (C) Radial nodes $= n - l - 1 = 3 - 1 - 1 = 1$.
45. (B) l can only take values 0 to $n - 1$, so $l = 2$ is impossible when $n = 2$.
46. (B) $E_n = -13.6 Z^2/n^2 \text{ eV} = -13.6 \times 4/4 = -13.6 \text{ eV}$.
47. (C) IE rises across the period, but N (half-filled $2p^3$) is higher than O, so $B < C < O < N$.
48. (A) Cl has 3 bond pairs and 2 lone pairs (sp^3d); the lone pairs sit equatorially, giving a T shape.
49. (D) O_2^- has 10 bonding and 7 antibonding valence electrons: $(10 - 7)/2 = 1.5$.
50. (C) $\Delta n_g = 2 - 4 = -2$; $\Delta H = \Delta U + \Delta n_g RT = -87.0 - 2 \times 8.314 \times 300/1000 = -92.0 \text{ kJ}$.
51. (A) $\Delta G = \Delta H - T\Delta S < 0$ when $T > \Delta H/\Delta S = 40000/100 = 400 \text{ K}$.
52. (A) Subtract the second equation from the first (Hess's law): $-393.5 - (-283.0) = -110.5 \text{ kJ mol}^{-1}$.
53. (D) $[OH^-] = 10^{-3} \text{ M}$, so $pOH = 3$ and $pH = 14 - 3 = 11$.
54. (D) $K_{sp} = s^2$, so $s = \sqrt{(1.6 \times 10^{-10})} \approx 1.26 \times 10^{-5} \text{ mol L}^{-1}$.
55. (B) $pH = pK_a + \log([salt]/[acid]) = 4.74 + \log 2 = 5.04$.
56. (B) $H_2S_2O_8$ has one peroxide (O-O) link, each of those O is -1 : $2 + 2x - 12 - 2 = 0$ gives $x = +6$, not $+7$.
57. (D) The longest chain with the -OH has 4 C; number from the -OH end, so -OH is at C-1 and -CH₃ at C-3.
58. (D) σ : 3 C-H + C=C + C-C + C≡N = 6; π : one in C=C and two in C≡N = 3.
59. (C) Peroxide effect (Kharasch): free-radical addition gives the anti-Markovnikov product, 1-bromopropane.
60. (B) The cyclopentadienyl anion is cyclic, planar and fully conjugated with 6 π electrons ($4n + 2$, $n = 1$).
61. (D) Molality $= 0.01 \text{ mol}/0.1 \text{ kg} = 0.1 \text{ m}$; $\Delta T_b = 0.52 \times 0.1 = 0.052 \text{ K}$.
62. (C) $\pi = CRT = 0.1 \times 0.0821 \times 300 = 2.46 \text{ atm}$.
63. (C) $E^\circ_{\text{cell}} = 0.34 - (-0.76) = 1.10 \text{ V}$; $\Delta G^\circ = -nFE^\circ = -2 \times 96500 \times 1.10 = -212.3 \text{ kJ mol}^{-1}$.
64. (D) $Q = 1930 \text{ C} = 0.02 \text{ F}$; $\text{Cu}^{2+} + 2e^- \rightarrow \text{Cu}$, so $0.01 \text{ mol Cu} = 0.635 \text{ g}$.
65. (D) $E = -0.059 \times pH = -0.059 \times 3 = -0.177 \text{ V}$.
66. (A) Kohlrausch's law: $\Lambda^\circ(\text{CH}_3\text{COOH}) = 91 + 426 - 126 = 391 \text{ S cm}^2 \text{ mol}^{-1}$.

67. (B) $k = 0.693/69.3 = 0.01 \text{ s}^{-1}$; $t = (2.303/k) \log(100/10) = 230.3 \text{ s}$.
68. (C) New rate $= k(2[A])([B]/2)^2 = (2/4) \times \text{original} = \frac{1}{2} \times \text{original}$.
69. (D) $\log 2 = (E_a/2.303R)(10/(300 \times 310))$; $E_a = 2.303 \times 8.314 \times 0.301 \times 9300 \approx 53\,600 \text{ J mol}^{-1}$.
70. (D) Mn^{2+} is $3d^5$ with 5 unpaired electrons: $\mu = \sqrt{n(n+2)} = \sqrt{35} \approx 5.92 \text{ BM}$.
71. (A) Poor shielding by the 4f electrons that fill before Hf cancels the expected size increase from 4d to 5d.
72. (D) Ligands are named alphabetically (ammine before chlorido); Co: $x + 0 - 1 = +2$, so $x = +3$.
73. (D) Fe^{3+} is $3d^5$; strong-field CN^- pairs the electrons as t_2g^5 , leaving 1 unpaired electron.
74. (A) The cis isomer has no plane of symmetry, so it is chiral; the trans isomer has a mirror plane.
75. (B) SN_2 needs backside attack, so the least hindered halide (methyl) reacts fastest.
76. (D) Cannizzaro reaction needs an aldehyde with no α -hydrogen; benzaldehyde has none.
77. (B) Three strongly electron-withdrawing F atoms stabilise the carboxylate ion most ($-I$ effect: $F > Cl$).
78. (D) The test needs a $\text{CH}_3\text{CO}-$ group or $\text{CH}_3\text{CH}(\text{OH})-$ group; methanol has neither.
79. (A) In water, inductive effect, solvation and steric effects together make the secondary amine $(\text{CH}_3)_2\text{NH}$ the most basic.
80. (B) In sucrose the glycosidic link joins C1 of glucose and C2 of fructose, so no free carbonyl group remains.

Mathematics

81. (C) $n(P \cup M) = 60 - 10 = 50$, so $n(P \cap M) = 35 + 30 - 50 = 15$.
82. (A) $A \times B$ has $2 \times 3 = 6$ elements, and each subset is a relation: $2^6 = 64$.
83. (C) $3\pi/8 = \pi/2 - \pi/8$, so $\sin^2(3\pi/8) = \cos^2(\pi/8)$ and the sum is 1.
84. (D) $\tan x = \tan(\pi/3)$, and $\tan$ has period π , so $x = n\pi + \pi/3$.
85. (A) $(1 + i)^2 = 2i$, so $(1 + i)^8 = (2i)^4 = 16i^4 = 16$.
86. (C) $(\alpha - \beta)^2 = (\alpha + \beta)^2 - 4\alpha\beta = 36 - 4k = 4$, so $k = 8$.
87. (D) $-3 < x - 2 < 3$ gives $-1 < x < 5$.
88. (B) 5 letters with A twice and S twice: $5!/(2! 2!) = 120/4 = 30$.
89. (C) ${}^6C_3 \times {}^5C_2 = 20 \times 10 = 200$.
90. (A) $T(r+1) = {}^6C_r x^r (6-3r)$; $6-3r = 0$ gives $r = 2$, so the term is ${}^6C_2 = 15$.
91. (B) $S_{20} = (20/2)[2 \times 3 + 19 \times 4] = 10 \times 82 = 820$.
92. (A) $a + b = 20$ and $ab = 64$, so a and b are roots of $t^2 - 20t + 64 = 0$, that is 16 and 4.
93. (B) Write the second line as $3x + 4y = 12.5$; distance $= |12.5 - 5|/\sqrt{(3^2 + 4^2)} = 7.5/5 = 3/2$.
94. (C) Latus rectum $= 2b^2/a = 2 \times 16/5 = 32/5$.
95. (A) $y^2 = -4ax$ with $4a = 12$ gives $a = 3$; the parabola opens left, so the focus is $(-3, 0)$.
96. (A) $x^2/16 - y^2/9 = 1$, so $e = \sqrt{(1 + 9/16)} = 5/4$.
97. (A) $(x-1)^2 + 4 + 9 = (x-3)^2 + 16 + 25$ gives $4x = 36$, so $x = 9$.
98. (B) $(x^3 - 8)/(x^2 - 4) = (x^2 + 2x + 4)/(x + 2) \rightarrow 12/4 = 3$.
99. (C) Mean $= 6$; variance $= (16 + 4 + 0 + 4 + 16)/5 = 8$.
100. (A) Favourable pairs: (2,6), (3,5), (4,4), (5,3), (6,2), so $P = 5/36$.
101. (B) $y = (2x - 1)/(x + 3)$ gives $xy + 3y = 2x - 1$, so $x = (3y + 1)/(2 - y)$.
102. (A) $\sin(2\pi/3) = \sin(\pi/3)$ and $\pi/3$ lies in $[-\pi/2, \pi/2]$, so the value is $\pi/3$.
103. (D) Multiply $A^2 - 4A + I = O$ by A^{-1} : $A - 4I + A^{-1} = O$, so $A^{-1} = 4I - A = [2 \ -3; -1 \ 2]$.
104. (C) The coefficient determinant is $1(2k - 9) - 1(k - 3) + 1(3 - 2) = k - 5$, which is zero for $k = 5$.
105. (B) $\lim_{x \rightarrow 0} \sin 3x/x = 3 \times \lim_{x \rightarrow 0} \sin 3x/3x = 3$, so $k = 3$.
106. (D) $\ln y = x \ln x$ gives $dy/dx = x^x(1 + \ln x)$, which equals 1 at $x = 1$.
107. (B) $dy/dt = 3a \sin^2 t \cos t$ and $dx/dt = -3a \cos^2 t \sin t$; dividing gives $-\tan t$.

108. (D) $dA/dt = 2\pi r dr/dt = 2\pi \times 10 \times 0.5 = 10\pi \text{ cm}^2/\text{s}$.
109. (B) $f'(x) = 6(x-1)(x-2) = 0$ at $x = 1, 2$; $f''(1) = -6 < 0$, so $x = 1$ is a local maximum.
110. (B) $x^2 + 4x + 13 = (x+2)^2 + 3^2$, and $\int dx/(u^2 + a^2) = (1/a) \tan^{-1}(u/a) + C$.
111. (A) Using $x \rightarrow \pi/2 - x$, the integral equals $\int \cos x/(\sin x + \cos x) dx$; adding both gives $2I = \pi/2$, so $I = \pi/4$.
112. (A) By parts: $[x e^x - e^x]$ from 0 to 1 = $(e - e) - (0 - 1) = 1$.
113. (C) The curves meet at $x = 0$ and 1; area = $\int (\text{from } 0 \text{ to } 1) (x - x^2) dx = 1/2 - 1/3 = 1/6$.
114. (C) The highest derivative is d^2y/dx^2 (order 2), and its power is 3 (degree 3).
115. (A) IF = $e^{\int (1/x) dx} = e^{\log x} = x$.
116. (A) $a \times b = 5i + j - 4k$, and $|a \times b| = \sqrt{(25 + 1 + 16)} = \sqrt{42}$.
117. (A) $d = |2 + 6 + 10 - 9|/\sqrt{(1 + 4 + 4)} = 9/3 = 3$ units.
118. (D) Corner points (0, 0), (4, 0), (3, 1), (0, 2) give $Z = 0, 12, 11, 4$; the maximum is 12 at (4, 0).
119. (B) Bayes: $(\frac{1}{2} \times 3/5)/(\frac{1}{2} \times 3/5 + \frac{1}{2} \times 1/3) = (3/10)/(14/30) = 9/14$.
120. (C) $P(X = 0, 1, 2) = 25/36, 10/36, 1/36$; $E(X) = 10/36 + 2/36 = 12/36 = 1/3$.