

Questions
100 (25 per subject)

Marks
400 (4 each)

Time
150 minutes

Negative marking
None

Part	Section	Questions	Q. No.
Part I: Physics	Physics – MCQ (one correct option)	16	1 to 16
Part I: Physics	Physics – MSQ (one or more correct options)	4	17 to 20
Part I: Physics	Physics – Fill in the blanks (numerical answer)	5	21 to 25
Part II: Chemistry	Chemistry – MCQ (one correct option)	16	26 to 41
Part II: Chemistry	Chemistry – MSQ (one or more correct options)	4	42 to 45
Part II: Chemistry	Chemistry – Fill in the blanks (numerical answer)	5	46 to 50
Part III: Mathematics	Mathematics – MCQ (one correct option)	16	51 to 66
Part III: Mathematics	Mathematics – MSQ (one or more correct options)	4	67 to 70
Part III: Mathematics	Mathematics – Fill in the blanks (numerical answer)	5	71 to 75
Part IV: English	English – MCQ (one correct option)	20	76 to 95
Part IV: English	English – MSQ (one or more correct options)	5	96 to 100

Instructions

- This paper has 100 questions in four subjects: Physics (Q1–25), Chemistry (Q26–50), Mathematics (Q51–75) and English (Q76–100).
- Each question carries 4 marks. There is no negative marking for wrong or unanswered questions, so attempt every question.
- MCQ (multiple choice): four options, only ONE is correct.
- MSQ (multiple select): ONE OR MORE of the options (A)–(D) may be correct. Marks are given only if you select all the correct options and no wrong option; there are no partial marks.
- FIB (fill in the blank): type (here, write) the numerical answer in the box. Marks are given for the correct value.
- Time: 150 minutes for the whole paper. Calculators are not allowed.
- The answer key and short solutions are at the end. For MSQ and FIB questions the key shows the correct options or value.

This is an AglaSem practice paper written on the official LPUNEST 2027 B.Tech pattern (100 questions, 400 marks, 150 minutes, no negative marking) and the LPUNEST B.Tech syllabus. It is not an official Lovely Professional University paper, and its questions are original. This is the Mathematics version; candidates for programmes that need Biology take a Biology section (25 MCQs/MSQs) in place of Mathematics.

Part I: Physics

Physics – MCQ (one correct option)

- The dimensional formula of Planck's constant is:
 (A) $[MLT^{-1}]$ (B) $[ML^2T^{-3}]$
 (C) $[ML^2T^{-1}]$ (D) $[ML^2T^{-2}]$
- A projectile is fired with a speed of 30 m/s at 30° above the horizontal. Taking $g = 10 \text{ m/s}^2$, its horizontal range is:
 (A) 45 m (B) $90\sqrt{3} \text{ m}$
 (C) $45\sqrt{3} \text{ m}$ (D) 90 m

3. A 5 kg block on a rough horizontal floor (coefficient of kinetic friction 0.2) is pulled by a horizontal force of 20 N. Taking $g = 10 \text{ m/s}^2$, its acceleration is:
 (A) 3 m/s^2 (B) 1 m/s^2
 (C) 4 m/s^2 (D) 2 m/s^2
4. The moment of inertia of a uniform solid sphere of mass M and radius R about a tangent to its surface is:
 (A) $(3/5)MR^2$ (B) $(7/2)MR^2$
 (C) $(2/5)MR^2$ (D) $(7/5)MR^2$
5. The escape velocity from the Earth is 11.2 km/s . For a planet with the same mean density as the Earth but twice its radius, the escape velocity is:
 (A) 11.2 km/s (B) 15.8 km/s
 (C) 22.4 km/s (D) 44.8 km/s
6. A mass m on a spring of force constant k oscillates with period T . If the same mass hangs from two such springs joined in series, the new period is:
 (A) $\sqrt{2} T$ (B) $2T$
 (C) $T/\sqrt{2}$ (D) T
7. A Carnot engine works between a source at 527°C and a sink at 127°C . Its efficiency is:
 (A) 24% (B) 50%
 (C) 76% (D) 25%
8. Two point charges separated by a distance r repel each other with a force F . If each charge is doubled and the distance is halved, the force becomes:
 (A) $16F$ (B) $F/4$
 (C) $8F$ (D) $4F$
9. A wire of resistance R is stretched uniformly until its length doubles. Its new resistance is:
 (A) $2R$ (B) $8R$
 (C) $4R$ (D) $R/2$
10. The magnetic field at the centre of a circular loop of radius r carrying a current I is:
 (A) $\mu_0 I/(4r)$ (B) $\mu_0 I/(2\pi r)$
 (C) $\mu_0 I/(2r)$ (D) $\mu_0 I/r$
11. In a series LCR circuit at resonance, the phase difference between the current and the applied voltage is:
 (A) $\pi/2$ (B) π
 (C) 0 (D) $\pi/4$
12. A convex lens of focal length 20 cm is placed in contact with a concave lens of focal length 40 cm . The power of the combination is:
 (A) -2.5 D (B) $+2.5 \text{ D}$
 (C) $+5 \text{ D}$ (D) $+7.5 \text{ D}$
13. A Young's double-slit apparatus is completely immersed in water (refractive index $4/3$). The fringe width becomes:
 (A) $3/4$ of its value in air (B) $4/3$ of its value in air
 (C) $9/16$ of its value in air (D) unchanged

14. Photons of energy 5 eV fall on a metal surface of work function 3 eV. The stopping potential for the emitted photoelectrons is:
- (A) 2 V (B) 3 V
(C) 5 V (D) 8 V
15. A radioactive substance has a half-life of 10 days. The fraction of the original sample left undecayed after 30 days is:
- (A) $\frac{1}{6}$ (B) $\frac{1}{4}$
(C) $\frac{1}{8}$ (D) $\frac{1}{3}$
16. A p-type semiconductor is obtained when pure silicon is doped with:
- (A) aluminium (B) phosphorus
(C) antimony (D) arsenic

Physics – MSQ (one or more correct options)

17. Which of the following physical quantities is/are vectors? (One or more options may be correct.)
- (A) Displacement
(B) Work
(C) Torque
(D) Electric current
18. An ideal gas undergoes an isothermal process. Which of the following statements is/are correct? (One or more options may be correct.)
- (A) The change in internal energy of the gas is zero.
(B) The heat absorbed by the gas equals the work done by it.
(C) PV remains constant.
(D) The temperature of the gas rises when it is compressed.
19. Which of the following electromagnetic waves has/have a wavelength shorter than that of visible light? (One or more options may be correct.)
- (A) Microwaves
(B) X-rays
(C) Infrared rays
(D) Gamma rays
20. A charged particle enters a uniform magnetic field with its velocity perpendicular to the field. Which of the following statements is/are correct? (One or more options may be correct.)
- (A) Its speed remains constant.
(B) Its kinetic energy increases.
(C) It moves in a circular path.
(D) Its time period of revolution does not depend on its speed.

Physics – Fill in the blanks (numerical answer)

21. A car starts from rest and accelerates uniformly to 20 m/s in 5 s. The distance (in m) covered in this time is ____.
22. A 2 kg body moving at 3 m/s collides with a 1 kg body at rest and the two stick together. Their common velocity (in m/s) just after the collision is ____.
23. Resistors of $6\ \Omega$ and $3\ \Omega$ are connected in parallel, and this combination is connected in series with a $4\ \Omega$ resistor. The equivalent resistance (in Ω) is ____.
24. The radius of the first Bohr orbit of hydrogen is $0.53\ \text{\AA}$. The radius (in $\text{\AA}$) of its third orbit ($n = 3$) is ____.
25. An ideal transformer has 100 turns in its primary coil and 500 turns in its secondary coil. If the primary is connected to 220 V AC, the secondary voltage (in V) is ____.

Part II: Chemistry

Chemistry – MCQ (one correct option)

26. The number of moles in 4.4 g of carbon dioxide is:
(A) 1.0 (B) 0.2
(C) 0.4 (D) 0.1
27. The maximum number of electrons that can be present in the shell with principal quantum number $n = 3$ is:
(A) 9 (B) 8
(C) 18 (D) 32
28. Which of the following molecules is linear?
(A) SO_2 (B) NO_2
(C) H_2O (D) CO_2
29. The enthalpies of combustion of C(graphite), $\text{H}_2(\text{g})$ and $\text{CH}_4(\text{g})$ are -394 , -286 and $-890\ \text{kJ mol}^{-1}$. The enthalpy of formation of $\text{CH}_4(\text{g})$ is:
(A) $-210\ \text{kJ mol}^{-1}$ (B) $-76\ \text{kJ mol}^{-1}$
(C) $+76\ \text{kJ mol}^{-1}$ (D) $-1856\ \text{kJ mol}^{-1}$
30. Which of the following 0.1 M aqueous solutions has the highest boiling point?
(A) 0.1 M AlCl_3 (B) 0.1 M glucose
(C) 0.1 M NaCl (D) 0.1 M MgSO_4

31. The pH of a 0.001 M aqueous solution of HCl at 25 °C is:
 (A) 3 (B) 0.001
 (C) 1 (D) 11
32. For the reaction $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$, $\Delta H < 0$, the yield of ammonia at equilibrium is increased by:
 (A) adding a catalyst (B) removing some N_2
 (C) increasing the temperature (D) increasing the pressure
33. The quantity of electricity needed to deposit 1 mol of aluminium from Al^{3+} ions is:
 (A) 2 F (B) 1 F
 (C) 3 F (D) 6 F
34. A first-order reaction has a half-life of 69.3 s. Its rate constant is:
 (A) 0.1 s^{-1} (B) 1.0 s^{-1}
 (C) 0.01 s^{-1} (D) 0.001 s^{-1}
35. Among B, C, N and O, the element with the highest first ionisation enthalpy is:
 (A) O (B) C
 (C) B (D) N
36. Which of the following oxoacids of phosphorus is monobasic?
 (A) $\text{H}_4\text{P}_2\text{O}_7$ (B) H_3PO_3
 (C) H_3PO_4 (D) H_3PO_2
37. Which of the following ions is colourless in aqueous solution?
 (A) Fe^{3+} (B) Cu^{2+}
 (C) Zn^{2+} (D) Ti^{3+}
38. The oxidation state of iron in $\text{K}_4[\text{Fe}(\text{CN})_6]$ is:
 (A) +2 (B) +3
 (C) +4 (D) +6
39. The IUPAC name of $\text{CH}_3\text{--CH}(\text{CH}_3)\text{--CH}_2\text{--OH}$ is:
 (A) 1,1-dimethylethanol (B) butan-1-ol
 (C) 2-methylpropan-2-ol (D) 2-methylpropan-1-ol
40. Propene reacts with HBr in the presence of an organic peroxide to give mainly:
 (A) propane (B) 1-bromopropane
 (C) 2-bromopropane (D) 1,2-dibromopropane
41. The Lucas test (conc. HCl + anhydrous ZnCl_2) is used to distinguish between:
 (A) 1° , 2° and 3° amines (B) 1° , 2° and 3° alcohols
 (C) phenol and benzoic acid (D) aldehydes and ketones

Chemistry – MSQ (one or more correct options)

42. Which of the following is/are reducing sugars? (One or more options may be correct.)
 (A) Glucose
 (B) Sucrose
 (C) Fructose
 (D) Maltose

43. Which of the following compounds give(s) a positive carbylamine (isocyanide) test? (One or more options may be correct.)

- (A) Aniline
- (B) N-Methylaniline
- (C) Ethylamine
- (D) Triethylamine

44. Which of the following is/are redox reactions? (One or more options may be correct.)

- (A) $\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O}$
- (B) $\text{Zn} + \text{CuSO}_4 \rightarrow \text{ZnSO}_4 + \text{Cu}$
- (C) $\text{AgNO}_3 + \text{NaCl} \rightarrow \text{AgCl} + \text{NaNO}_3$
- (D) $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$

45. Which of the following diatomic molecules is/are paramagnetic? (One or more options may be correct.)

- (A) O_2
- (B) N_2
- (C) F_2
- (D) H_2

Chemistry – Fill in the blanks (numerical answer)

46. 4 g of NaOH (molar mass 40 g/mol) is dissolved in water to make 250 mL of solution. The molarity (in mol/L) of the solution is _____.

47. The number of unpaired electrons in the Fe^{3+} ion (atomic number of Fe = 26) is _____.

48. The hydroxide ion concentration of an aqueous solution at 25 °C is 1×10^{-4} M. The pH of the solution is _____.

49. A first-order reaction is 75% complete in 60 minutes. Its half-life (in minutes) is _____.

50. When excess AgNO_3 solution is added to a solution containing 1 mol of $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$, the number of moles of AgCl precipitated is _____.

Mathematics – MCQ (one correct option)

51. If a set A has 3 elements, the number of elements in the power set of $A \times A$ is:
(A) 64 (B) 512
(C) 81 (D) 256
52. The domain of the real function $f(x) = \sqrt{4 - x^2}$ is:
(A) $(-\infty, -2] \cup [2, \infty)$ (B) $[-2, 2]$
(C) $(-2, 2)$ (D) $[0, 2]$
53. The value of $\lim_{x \rightarrow 0} (\sin 3x)/x$ is:
(A) $1/3$ (B) 3
(C) 1 (D) 0
54. If $z = (1 + i)/(1 - i)$, then z^4 equals:
(A) $-i$ (B) 1
(C) i (D) -1
55. If the roots of $x^2 - kx + 9 = 0$ are real and equal, then k equals:
(A) ± 6 (B) ± 9
(C) 6 only (D) ± 3
56. The sum of the infinite geometric series $1 + 1/3 + 1/9 + 1/27 + \dots$ is:
(A) 3 (B) $2/3$
(C) $3/2$ (D) $4/3$
57. If A is a square matrix of order 3 with $|A| = 4$, then $|\text{adj } A|$ equals:
(A) 16 (B) 8
(C) 64 (D) 4
58. The general solution of $\tan x = \sqrt{3}$ is:
(A) $x = n\pi + \pi/3, n \in \mathbb{Z}$ (B) $x = n\pi + \pi/6, n \in \mathbb{Z}$
(C) $x = 2n\pi + \pi/3, n \in \mathbb{Z}$ (D) $x = n\pi - \pi/3, n \in \mathbb{Z}$
59. The angle between the vectors $a = \hat{i} + \hat{j}$ and $b = \hat{j} + \hat{k}$ is:
(A) 30° (B) 60°
(C) 90° (D) 45°
60. The number of diagonals of a regular decagon (10 sides) is:
(A) 45 (B) 70
(C) 40 (D) 35
61. The middle term in the expansion of $(x + 1/x)^{10}$ is:
(A) 462 (B) 210
(C) 126 (D) 252
62. If $y = x^x$ ($x > 0$), then dy/dx at $x = 1$ is:
(A) e (B) 0
(C) 2 (D) 1
63. The maximum value of $f(x) = x(12 - x)$ for real x is:
(A) 24 (B) 36
(C) 72 (D) 144

64. The value of $\int_0^{\pi/2} \sin^2 x \, dx$ is:
 (A) π (B) $\pi/2$
 (C) $1/2$ (D) $\pi/4$
65. The order and degree of the differential equation $(d^2y/dx^2)^3 + (dy/dx)^2 + y = 0$ are:
 (A) order 2, degree 3 (B) order 3, degree 2
 (C) order 3, degree 3 (D) order 2, degree 2
66. The distance between the parallel lines $3x + 4y = 5$ and $3x + 4y = 15$ is:
 (A) 2 (B) 1
 (C) 5 (D) 10

Mathematics – MSQ (one or more correct options)

67. For the parabola $y^2 = 8x$, which of the following statements is/are correct? (One or more options may be correct.)
 (A) Its focus is (2, 0).
 (B) Its directrix is $x = 2$.
 (C) The length of its latus rectum is 8.
 (D) The point (2, 4) lies on it.
68. Which of the following statements is/are correct (principal values)? (One or more options may be correct.)
 (A) $\sin^{-1}x + \cos^{-1}x = \pi/2$ for every x in $[-1, 1]$
 (B) $\tan^{-1}(1) = \pi/2$
 (C) $\cos^{-1}(-1) = \pi$
 (D) $\sin^{-1}(1/2) = \pi/3$
69. A and B are independent events with $P(A) = 0.5$ and $P(B) = 0.4$. Which of the following is/are correct? (One or more options may be correct.)
 (A) $P(A \cup B) = 0.9$
 (B) $P(A \cap B) = 0.2$
 (C) A and B are mutually exclusive.
 (D) $P(A | B) = 0.5$
70. For the line $(x - 1)/2 = (y + 1)/3 = (z - 2)/6$, which of the following is/are correct? (One or more options may be correct.)
 (A) Its direction cosines are $2/7, 3/7, 6/7$.
 (B) It passes through the point (1, -1, 2).
 (C) It passes through the point (3, 2, 8).
 (D) It is parallel to the plane $2x + 3y + 6z = 0$.

Mathematics – Fill in the blanks (numerical answer)

71. The sum of the first 15 terms of the arithmetic progression 2, 5, 8, 11, ... is ____.

72. The value of the determinant with rows (1, 2, 3), (0, 4, 5) and (0, 0, 6) is ____.

73. The variance of the observations 2, 4, 6, 8, 10 is ____.

74. The radius of the circle $x^2 + y^2 - 4x + 6y - 12 = 0$ is ____.

75. The value of $\sin^2 30^\circ + \cos^2 60^\circ + \tan^2 45^\circ$ is ____.

Part IV: English

English – MCQ (one correct option)

76. Choose the word closest in meaning to BENEVOLENT.
(A) hostile (B) fearful
(C) greedy (D) kindly
77. Choose the word opposite in meaning to SCARCE.
(A) plentiful (B) rare
(C) insufficient (D) meagre
78. Choose the correctly spelt word.
(A) Ocurrence (B) Occurrence
(C) Occurance (D) Occurence
79. Choose the one word for: a person who can speak two languages.
(A) bilingual (B) monolingual
(C) linguist (D) polyglot
80. Choose the correct meaning of the idiom: to beat around the bush.
(A) to avoid coming to the main point
(B) to search for something carefully
(C) to waste money on useless things
(D) to work very hard
81. Fill in the blank: By the time we reached the station, the train _____.
(A) has left (B) had left
(C) left (D) was leaving

82. Choose the correct passive form of: They are building a new bridge.
(A) A new bridge has been built by them.
(B) A new bridge is built by them.
(C) A new bridge is being built by them.
(D) A new bridge was being built by them.
83. Fill in the blank: You _____ wear a helmet while riding a motorcycle; it is the law.
(A) might (B) must
(C) would (D) can
84. Fill in the blank: There is _____ milk left in the jug, so we need to buy some.
(A) a little (B) few
(C) little (D) many
85. Fill in the blank: She has been working in this company _____ 2019.
(A) from (B) until
(C) for (D) since
86. Fill in the blank with the correct article: He is _____ honest man.
(A) no article (B) the
(C) an (D) a
87. Find the part of the sentence that has an error:
(P) Neither of the two boys / (Q) have finished / (R) the assigned work.
(A) Part (R) (B) Part (P)
(C) Part (Q) (D) No error
88. Find the part of the sentence that has an error:
(P) The news are / (Q) very encouraging / (R) for all of us.
(A) Part (P) (B) Part (Q)
(C) Part (R) (D) No error
89. Fill in the blank: Each of the players _____ given a medal after the match.
(A) are (B) have been
(C) was (D) were
90. Complete the analogy: AUTHOR : BOOK :: COMPOSER : _____
(A) piano (B) symphony
(C) concert (D) orchestra
91. Fill in the blank: The _____ of the story is that honesty is always rewarded.
(A) mortal (B) moral
(C) mural (D) morale

Read the passage and answer the questions that follow.

Bamboo has long been called the poor man's timber, but engineers are now taking a fresh look at it. A clump of bamboo can be harvested every three to five years, whereas a hardwood tree may need several decades to mature. Its hollow, jointed stem is light, yet some species are remarkably strong in tension for their weight. These qualities make bamboo attractive for scaffolding, low-cost housing and even bridges. The material does have weaknesses. Untreated bamboo is attacked by insects and fungi, and it absorbs moisture, which makes it swell and crack. Because each stem differs in thickness and strength, it is also hard to write the precise design rules that builders rely on for steel or concrete. Researchers are therefore working on simple chemical treatments and on laminated bamboo boards of uniform quality. If these efforts succeed, a plant that grows in thousands of villages could become a mainstream building material.

92. The main idea of the passage is that bamboo:
- (A) is too weak and irregular to be used for any kind of construction
 - (B) grows much faster than hardwood and so should replace all timber
 - (C) is already replacing steel and concrete in most new buildings
 - (D) has real strengths as a building material, but its weaknesses must be overcome first
93. According to the passage, why is it hard to write precise design rules for bamboo?
- (A) Each stem differs in thickness and strength.
 - (B) Bamboo is heavier than steel.
 - (C) Builders do not trust laminated boards.
 - (D) Bamboo grows only in a few villages.
94. The word 'mainstream' in the last line of the passage most nearly means:
- (A) costly and rare
 - (B) found near rivers
 - (C) used only in villages
 - (D) widely accepted and used
95. Which of the following uses of bamboo is NOT mentioned in the passage?
- (A) low-cost housing
 - (B) scaffolding
 - (C) furniture
 - (D) bridges

English – MSQ (one or more correct options)

96. Which of the following words is/are similar in meaning to OBSTINATE? (One or more options may be correct.)
- (A) stubborn
 - (B) flexible
 - (C) headstrong
 - (D) docile
-
97. Which of the following sentences is/are grammatically correct? (One or more options may be correct.)
- (A) She doesn't like coffee.
 - (B) He don't know the answer.
 - (C) Each of the girls have a book.
 - (D) The children are playing outside.
-

98. Which of the following words is/are correctly spelt? (One or more options may be correct.)

- (A) Necessary
- (B) Seperate
- (C) Embarrass
- (D) Definately

99. Which of the following words is/are opposite in meaning to EXPAND? (One or more options may be correct.)

- (A) enlarge
- (B) contract
- (C) extend
- (D) shrink

100. In which of the following sentences is the word 'bear' used as a verb? (One or more options may be correct.)

- (A) I cannot bear this noise any longer.
- (B) A brown bear lives in that cave.
- (C) These mango trees bear fruit in summer.
- (D) The company will bear the cost of the repairs.

Answer Key

1	C	2	C	3	D	4	D	5	C	6	A	7	B	8	A	9	C	10	C
11	C	12	B	13	A	14	A	15	C	16	A	17	A,C	18	A,B,C	19	B,D	20	A,C,D
21	50	22	2	23	6	24	4.77	25	1100	26	D	27	C	28	D	29	B	30	A
31	A	32	D	33	C	34	C	35	D	36	D	37	C	38	A	39	D	40	B
41	B	42	A,C,D	43	A,C	44	B,D	45	A	46	0.4	47	5	48	10	49	30	50	2
51	B	52	B	53	B	54	B	55	A	56	C	57	A	58	A	59	B	60	D
61	D	62	D	63	B	64	D	65	A	66	A	67	A,C,D	68	A,C	69	B,D	70	A,B,C
71	345	72	24	73	8	74	5	75	1.5	76	D	77	A	78	B	79	A	80	A
81	B	82	C	83	B	84	C	85	D	86	C	87	C	88	A	89	C	90	B
91	B	92	D	93	A	94	D	95	C	96	A,C	97	A,D	98	A,C	99	B,D	100	A,C,D

Solutions

Physics – MCQ (one correct option)

- (C)** From $E = hv$, $h = E/v$, so its unit is $J s = kg m^2 s^{-1}$, i.e. $[ML^2T^{-1}]$.
- (C)** $R = u^2 \sin 2\theta / g = (900 \times \sin 60^\circ)/10 = 90 \times (\sqrt{3}/2) = 45\sqrt{3} m$ (about 78 m).
- (D)** Friction $= \mu mg = 0.2 \times 5 \times 10 = 10 N$. Net force $= 20 - 10 = 10 N$, so $a = 10/5 = 2 m/s^2$.
- (D)** About a diameter $I = (2/5)MR^2$. By the parallel axis theorem, about a tangent $I = (2/5)MR^2 + MR^2 = (7/5)MR^2$.
- (C)** $v_e = \sqrt{2GM/R}$ and $M = (4/3)\pi R^3 \rho$, so $v_e = R\sqrt{(8\pi G\rho/3)} \propto R$ for the same density. Doubling R doubles v_e to 22.4 km/s.
- (A)** Two springs of constant k in series give $k/2$. $T = 2\pi\sqrt{(m/k)}$ becomes $2\pi\sqrt{(2m/k)} = \sqrt{2} T$.
- (B)** Use kelvin: $T_1 = 800 K$, $T_2 = 400 K$. $\eta = 1 - T_2/T_1 = 1 - 400/800 = 0.5 = 50\%$.
- (A)** $F \propto q_1q_2/r^2$. The product of charges becomes 4 times and $1/r^2$ becomes 4 times, so the force becomes 16F.
- (C)** The volume stays the same, so doubling the length halves the area. $R = \rho l/A$ becomes $\rho(2l)/(A/2) = 4R$.
- (C)** From the Biot–Savart law, B at the centre of a circular loop $= \mu_0 I/(2r)$. ($\mu_0 I/(2\pi r)$ is the field near a long straight wire.)
- (C)** At resonance $X_L = X_C$, so the impedance is purely resistive ($Z = R$) and the current is in phase with the voltage.
- (B)** $P = 1/f_1 + 1/f_2$ (in metres) $= 1/0.20 - 1/0.40 = 5 - 2.5 = +2.5 D$.
- (A)** $\beta = \lambda D/d$. In water the wavelength becomes $\lambda/\mu = 3\lambda/4$, so the fringe width becomes 3/4 of its value in air.
- (A)** $K_{\max} = hv - \phi = 5 - 3 = 2 eV$, so the stopping potential is 2 V.
- (C)** 30 days $= 3$ half-lives, so the fraction left is $(1/2)^3 = 1/8$.
- (A)** p-type needs a trivalent (Group 13) impurity, which creates holes. Aluminium is trivalent; phosphorus, arsenic and antimony are pentavalent and give n-type.

Physics – MSQ (one or more correct options)

- (A,C)** Correct options: (A), (C). Displacement and torque have direction and add by the vector law. Work is a scalar (dot product), and electric current, though it has a sense of flow, does not add by the vector law, so it is a scalar.
- (A,B,C)** Correct options: (A), (B), (C). Internal energy of an ideal gas depends only on T , so $\Delta U = 0$; then the first law gives $Q = W$. Boyle's law ($PV = \text{constant}$) holds at constant T . By definition T does not change, so (D) is wrong.
- (B,D)** Correct options: (B), (D). In order of decreasing wavelength: radio, microwaves, infrared, visible, ultraviolet, X-rays, gamma rays. X-rays and gamma rays are shorter than visible light; microwaves and infrared are longer.

20. (A,C,D) Correct options: (A), (C), (D). The magnetic force $qv \times B$ is always perpendicular to the velocity, so it does no work: speed and kinetic energy stay constant and the path is a circle. $T = 2\pi m/(qB)$, which does not depend on the speed.

Physics – Fill in the blanks (numerical answer)

21. (50) Answer: 50. Distance = average velocity $\times$ time = $((0 + 20)/2) \times 5 = 50$ m.

22. (2) Answer: 2. Momentum is conserved: $2 \times 3 = (2 + 1)v$, so $v = 2$ m/s.

23. (6) Answer: 6. $6 \, \Omega \parallel 3 \, \Omega = (6 \times 3)/(6 + 3) = 2 \, \Omega$; $2 + 4 = 6 \, \Omega$.

24. (4.77) Answer: 4.77. In the Bohr model $r_n = n^2 r_1$, so $r_3 = 9 \times 0.53 = 4.77 \, \text{\AA}$.

25. (1100) Answer: 1100. $V_s/V_p = N_s/N_p = 500/100 = 5$, so $V_s = 5 \times 220 = 1100$ V.

Chemistry – MCQ (one correct option)

26. (D) Molar mass of $\text{CO}_2 = 12 + 2 \times 16 = 44$ g/mol. Moles = $4.4/44 = 0.1$.

27. (C) The maximum number of electrons in a shell is $2n^2 = 2 \times 9 = 18$ ($3s^2, 3p^6, 3d^{10}$).

28. (D) In CO_2 the carbon has two bonding domains and no lone pair (sp), so $\text{O}=\text{C}=\text{O}$ is linear (180°). H_2O , SO_2 and NO_2 are bent because of lone pairs or an odd electron on the central atom.

29. (B) By Hess's law, $\Delta H_f(\text{CH}_4) = \Delta H_c(\text{C}) + 2\Delta H_c(\text{H}_2) - \Delta H_c(\text{CH}_4) = -394 + 2(-286) - (-890) = -394 - 572 + 890 = -76$ kJ mol^{-1} .

30. (A) Elevation of boiling point $\propto i \times$ concentration. AlCl_3 gives 4 ions ($i = 4$); NaCl and MgSO_4 give 2; glucose does not dissociate ($i = 1$).

31. (A) HCl is a strong acid, so $[\text{H}^+] = 10^{-3}$ M and $\text{pH} = -\log(10^{-3}) = 3$.

32. (D) The forward reaction reduces the number of gas moles ($4 \rightarrow 2$), so higher pressure shifts it forward (Le Chatelier). Being exothermic, it is favoured by lower temperature. A catalyst does not change the equilibrium yield, and removing N_2 shifts it backward.

33. (C) $\text{Al}^{3+} + 3e^- \rightarrow \text{Al}$. One mole of Al needs 3 mol of electrons, i.e. 3 faradays.

34. (C) For a first-order reaction $k = 0.693/t_{1/2} = 0.693/69.3 = 0.01 \, \text{s}^{-1}$.

35. (D) Ionisation enthalpy generally rises across the period, but N ($2p^3$, half-filled) has a higher value than O ($2p^4$), since removing one paired $2p$ electron from O is easier.

36. (D) Basicity equals the number of P–OH groups. H_3PO_2 (hypophosphorous acid) has one P–OH and two P–H bonds, so it is monobasic. H_3PO_3 is dibasic, H_3PO_4 tribasic and $\text{H}_4\text{P}_2\text{O}_7$ tetrabasic.

37. (C) Colour comes from d–d transitions, which need a partly filled d subshell. Zn^{2+} is $3d^{10}$ (full), so it is colourless. Cu^{2+} ($3d^9$), Fe^{3+} ($3d^5$) and Ti^{3+} ($3d^1$) are coloured.

38. (A) $4(+1) + x + 6(-1) = 0$ gives $x = +2$.

39. (D) The longest chain containing the C–OH carbon has 3 carbons (propanol), with OH on C-1 and a methyl group on C-2: 2-methylpropan-1-ol.

40. (B) In the presence of peroxide, HBr adds by a free-radical mechanism (peroxide or Kharasch effect), giving the anti-Markovnikov product $\text{CH}_3\text{CH}_2\text{CH}_2\text{Br}$, 1-bromopropane.

41. (B) With Lucas reagent, 3° alcohols turn turbid at once, 2° alcohols in about five minutes, and 1° alcohols do not react at room temperature. So it distinguishes 1° , 2° and 3° alcohols.

Chemistry – MSQ (one or more correct options)

42. (A,C,D) Correct options: (A), (C), (D). Glucose, fructose and maltose have a free (potential) aldehyde or ketone group and reduce Tollens' and Fehling's reagents. In sucrose both anomeric carbons are joined in the glycosidic bond, so it is non-reducing.

43. (A,C) Correct options: (A), (C). The carbylamine test ($\text{CHCl}_3 +$ alcoholic KOH , foul smell of isocyanide) is given only by primary amines, aliphatic or aromatic. Aniline and ethylamine are primary; N-methylaniline is secondary and triethylamine is tertiary.

44. (B,D) Correct options: (B), (D). In (B) Zn goes from 0 to +2 and Cu from +2 to 0; in (D) H goes from 0 to +1 and O from 0 to –2. (A) is neutralisation and (C) is precipitation: no oxidation number changes.

45. (A) Correct option: (A). By molecular orbital theory O_2 has two unpaired electrons in the π^*2p orbitals, so it is paramagnetic. N_2 , F_2 and H_2 have all electrons paired and are diamagnetic.

Chemistry – Fill in the blanks (numerical answer)

46. (0.4) Answer: 0.4. Moles = $4/40 = 0.1$ mol; volume = 0.25 L; molarity = $0.1/0.25 = 0.4$ M.

47. (5) Answer: 5. Fe is $[Ar]3d^64s^2$; Fe^{3+} is $[Ar]3d^5$, with five singly occupied d orbitals (Hund's rule).

48. (10) Answer: 10. $pOH = 4$, so $pH = 14 - 4 = 10$.

49. (30) Answer: 30. 75% completion leaves $1/4 = (1/2)^2$, i.e. two half-lives in 60 minutes, so $t_{1/2} = 30$ minutes.

50. (2) Answer: 2. The complex ionises as $[Co(NH_3)_5Cl]^{2+} + 2Cl^-$. Only the two ionisable chloride ions (outside the coordination sphere) are precipitated as $AgCl$.

Mathematics – MCQ (one correct option)

51. (B) $A \times A$ has $3 \times 3 = 9$ elements, so its power set has $2^9 = 512$ elements.

52. (B) We need $4 - x^2 \geq 0$, i.e. $x^2 \leq 4$, so $-2 \leq x \leq 2$.

53. (B) $(\sin 3x)/x = 3 \times (\sin 3x)/(3x) \rightarrow 3 \times 1 = 3$.

54. (B) $z = (1 + i)^2 / ((1 - i)(1 + i)) = 2i/2 = i$, so $z^4 = i^4 = 1$.

55. (A) Equal roots need discriminant = 0: $k^2 - 36 = 0$, so $k = \pm 6$.

56. (C) $S_\infty = a/(1 - r) = 1/(1 - 1/3) = 3/2$.

57. (A) $|\text{adj } A| = |A|^{n-1}$ for a matrix of order n . Here $4^2 = 16$.

58. (A) $\tan x = \tan(\pi/3)$, and $\tan$ has period π , so $x = n\pi + \pi/3$ for any integer n . ($2n\pi + \pi/3$ misses the solutions $4\pi/3$, $10\pi/3$, ...)

59. (B) $\cos \theta = (a \cdot b) / (|a||b|) = 1/(\sqrt{2} \times \sqrt{2}) = 1/2$, so $\theta = 60^\circ$.

60. (D) Number of diagonals = ${}^{10}C_2 - 10 = 45 - 10 = 35$ (or $n(n-3)/2 = 10 \times 7/2 = 35$).

61. (D) There are 11 terms, so the middle term is $T_6 = {}^{10}C_5 x^5 (1/x)^5 = {}^{10}C_5 = 252$.

62. (D) $\ln y = x \ln x$, so $y'/y = \ln x + 1$ and $y' = x^x(1 + \ln x)$. At $x = 1$: $1 \times (1 + 0) = 1$.

63. (B) $f'(x) = 12 - 2x = 0$ at $x = 6$, and $f''(x) = -2 < 0$, so the maximum is $f(6) = 6 \times 6 = 36$.

64. (D) $\sin^2 x = (1 - \cos 2x)/2$. $\int_0^{\pi/2} (1 - \cos 2x)/2 \, dx = (1/2)[x - (\sin 2x)/2]$ from 0 to $\pi/2 = \pi/4$.

65. (A) The highest derivative is d^2y/dx^2 (order 2), and its power is 3 (degree 3), since the equation is a polynomial in the derivatives.

66. (A) Distance = $|c_1 - c_2|/\sqrt{a^2 + b^2} = |15 - 5|/\sqrt{9 + 16} = 10/5 = 2$.

Mathematics – MSQ (one or more correct options)

67. (A,C,D) Correct options: (A), (C), (D). $y^2 = 4ax$ with $4a = 8$ gives $a = 2$: focus (2, 0), directrix $x = -2$ (not $x = 2$), latus rectum $4a = 8$. For (2, 4): $4^2 = 16 = 8 \times 2$, so it lies on the parabola.

68. (A,C) Correct options: (A), (C). (A) is a standard identity. $\tan^{-1}(1) = \pi/4$, not $\pi/2$. $\cos \pi = -1$ and π lies in $[0, \pi]$, so $\cos^{-1}(-1) = \pi$. $\sin^{-1}(1/2) = \pi/6$, not $\pi/3$.

69. (B,D) Correct options: (B), (D). $P(A \cap B) = 0.5 \times 0.4 = 0.2$, so $P(A \cup B) = 0.5 + 0.4 - 0.2 = 0.7$ (not 0.9). Since $P(A \cap B) \neq 0$ they are not mutually exclusive. $P(A | B) = 0.2/0.4 = 0.5 = P(A)$.

70. (A,B,C) Correct options: (A), (B), (C). Direction ratios 2, 3, 6 have magnitude $\sqrt{4 + 9 + 36} = 7$, giving direction cosines $2/7$, $3/7$, $6/7$. Putting each ratio = 0 gives (1, -1, 2); each = 1 gives (3, 2, 8). The plane's normal (2, 3, 6) is along the line, so the line is perpendicular to the plane, not parallel.

Mathematics – Fill in the blanks (numerical answer)

71. (345) Answer: 345. $a = 2$, $d = 3$: $S_{15} = (15/2)[2 \times 2 + 14 \times 3] = (15/2) \times 46 = 345$.

72. (24) Answer: 24. The matrix is upper triangular, so the determinant is the product of the diagonal entries: $1 \times 4 \times 6 = 24$.

73. (8) Answer: 8. Mean = $30/5 = 6$. Squared deviations: 16, 4, 0, 4, 16, total 40. Variance = $40/5 = 8$.

74. (5) Answer: 5. $(x - 2)^2 + (y + 3)^2 = 12 + 4 + 9 = 25$, so the centre is (2, -3) and the radius is 5.

75. (1.5) Answer: 1.5. $\sin^2 30^\circ = 1/4$, $\cos^2 60^\circ = 1/4$, $\tan^2 45^\circ = 1$. Sum = $1/4 + 1/4 + 1 = 1.5$.

English – MCQ (one correct option)

76. (D) Benevolent means well-meaning and kind, so 'kindly' is the synonym. Hostile is its opposite.
77. (A) Scarce means in short supply. Its opposite is plentiful. Rare, meagre and insufficient are close in meaning to scarce.
78. (B) The correct spelling has double c, double r and ends in -ence: occurrence.
79. (A) Bilingual means able to speak two languages. A polyglot knows many languages, a linguist studies languages, and monolingual means speaking only one.
80. (A) To beat around the bush is to talk about other things and avoid the main point.
81. (B) Of two past actions, the earlier one (the train leaving) takes the past perfect: 'had left'.
82. (C) Present continuous active (are building) becomes present continuous passive: is/are + being + past participle, so 'is being built'.
83. (B) A legal obligation is expressed by 'must'. 'Might' shows possibility, 'can' ability or permission, and 'would' a condition or habit.
84. (C) Milk is uncountable, so few and many are wrong. 'Little' means hardly any, which fits 'we need to buy some'; 'a little' would mean there is still some.
85. (D) With the present perfect continuous, a point of time (2019) takes 'since'; 'for' is used with a period, such as 'for six years'.
86. (C) 'Honest' begins with a vowel sound (the h is silent), so the indefinite article is 'an'.
87. (C) 'Neither' is singular and takes a singular verb: 'Neither of the two boys has finished the assigned work.'
88. (A) 'News' is an uncountable noun and takes a singular verb: 'The news is very encouraging for all of us.'
89. (C) 'Each' is singular and takes a singular verb; the past context needs 'was'.
90. (B) An author creates a book; a composer creates a symphony. An orchestra performs it, a piano is an instrument and a concert is an event.
91. (B) The 'moral' of a story is the lesson it teaches. Morale is spirit or confidence, mortal means subject to death, and a mural is a wall painting.
92. (D) The passage describes bamboo's advantages, then its weaknesses, then the research to overcome them, ending with 'if these efforts succeed'. The other options are either too negative or claim more than the passage says.
93. (A) The passage says: 'Because each stem differs in thickness and strength, it is also hard to write the precise design rules.'
94. (D) A mainstream building material is one that is normally and widely used, as steel and concrete are now.
95. (C) The passage mentions scaffolding, low-cost housing and even bridges. Furniture is not mentioned.

English – MSQ (one or more correct options)

96. (A,C) Correct options: (A), (C). Obstinate means refusing to change one's mind. Stubborn and headstrong mean the same; flexible and docile are opposites.
97. (A,D) Correct options: (A), (D). (B) should be 'He doesn't know', since a third person singular subject takes 'does'. (C) should be 'Each of the girls has a book', since 'each' is singular.
98. (A,C) Correct options: (A), (C). The correct spellings of the other two are 'separate' and 'definitely'.
99. (B,D) Correct options: (B), (D). To expand is to become larger. Contract and shrink mean to become smaller; enlarge and extend are synonyms of expand.
100. (A,C,D) Correct options: (A), (C), (D). In (A) bear means tolerate, in (C) produce, and in (D) pay for: all are verbs. In (B) 'bear' is a noun, the animal.