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PUMEET Sample Paper 2027

Panjab University Migration Engineering Entrance Test (common paper for all B.E. branches) · Practice Paper 1

Questions	Marks	Time	Negative marking
100 MCQs	**100**	**1 hour 40 minutes**	**1/4 per wrong answer**

Part	Section	Questions	Q. No.
Section I	Mathematics	30	1 to 30
Section II	Physics	20	31 to 50
Section III	Chemistry	20	51 to 70
Section IV	General Engineering	20	71 to 90
Section V	Communication Skills	10	91 to 100

Instructions

1. There are 100 multiple-choice questions in five sections: Mathematics (30), Physics (20), Chemistry (20), General Engineering (20) and Communication Skills (10).
2. Each question has four options (A, B, C, D); choose the one correct answer.
3. Each correct answer carries 1 mark and 1/4 mark is deducted for each wrong answer. Unattempted questions get 0.
4. Attempt the paper in one sitting of 1 hour 40 minutes, as in the real OMR test. Calculators are not allowed.
5. The paper is in English only, as in the real PUMEET. The answer key and solutions are at the end.

This is an AglaSem practice paper written on the official PUMEET pattern (100 MCQs, 1 hour 40 minutes, 1/4 negative marking) and the syllabus in the Panjab University PUMEET prospectus. It is not an official Panjab University paper, and its questions are original.

Section I

Mathematics

1. The series $\sum 1/n^p$ ($n = 1$ to ∞) converges if and only if:

(A) $p < 1$ (B) $p > 1$

(C) $0 < p \le 1$ (D) $p \ge 1$

2. The radius of convergence of the power series $\sum x^n/2^n$ ($n = 0$ to ∞) is:

(A) 1 (B) ∞

(C) 2 (D) 1/2

3. In the Maclaurin series of sin x, the coefficient of x^3 is:

(A) $-1/3$ (B) 1/3

(C) $-1/6$ (D) 1/6

4. The series $1 - 1/2 + 1/3 - 1/4 + \ldots$ is:

(A) Finitely oscillating, not convergent

(B) Divergent to infinity

(C) Absolutely convergent

(D) Conditionally convergent

5. If $u = x^3 + y^3 + 3x^2y$, then $x\,\partial u/\partial x + y\,\partial u/\partial y$ equals:

(A) 2u (B) u

(C) 6u (D) 3u

6. If $u = x^2y + y^3$, then $\partial^2 u/\partial x \partial y$ is:

(A) 6y (B) 2y

(C) 2x (D) x^2

7. The function $f(x, y) = x^2 + y^2 - 4x + 6y$ has its stationary point at:

(A) (2, –3) (B) (–2, –3)

(C) (–2, 3) (D) (2, 3)

8. For $f(x, y) = x^2 - y^2$, the origin is:

(A) Not stationary (B) A local maximum

(C) A saddle point (D) A local minimum

9. Using Lagrange's method of multipliers, the maximum value of xy subject to $x + y = 10$ is:

(A) 20 (B) 25

(C) 100 (D) 50

10. The gradient of $\phi = x^2y + yz$ at the point (1, 1, 1) is:

(A) 2i + 2j + k (B) i + 2j + k

(C) 2i + j + k (D) 2i + 2j + 2k

11. The curl of the vector field $F = -y\,i + x\,j$ is:

(A) –2k (B) 2k

(C) k (D) 0

12. Gauss's divergence theorem converts the surface integral of F over a closed surface into:

(A) A volume integral

(B) A line integral

(C) A single definite integral

(D) A contour integral in the complex plane

13. The area of the region bounded by $y = x^2$ and $y = x$ is:

(A) 1/3 (B) 2/3

(C) 1/2 (D) 1/6

14. The volume generated when the area under $y = \sqrt{x}$ from $x = 0$ to $x = 4$ is rotated about the x-axis is:

(A) 8π (B) 4π

(C) 32π/3 (D) 16π

15. The length of the curve $y = (2/3)\ x^{(3/2)}$ from $x = 0$ to $x = 3$ is:

(A) 16/3 (B) 2

(C) 14/3 (D) 7/3

16. Changing to polar coordinates, $\iint (x^2 + y^2)\,dx\,dy$ over the disc $x^2 + y^2 \le 1$ equals:

(A) π (B) π/2

(C) 2π (D) π/4

17. The value of $\int_0^1 \int_0^1 \int_0^1 (x + y + z)\,dx\,dy\,dz$ is:

(A) 3/2 (B) 1

(C) 3 (D) 1/2

18. The differential equation $M(x, y)\,dx + N(x, y)\,dy = 0$ is exact if:

(A) $\partial M/\partial y = \partial N/\partial x$ (B) $\partial M/\partial x = -\partial N/\partial y$

(C) $M \cdot N = 1$ (D) $\partial M/\partial x = \partial N/\partial y$

19. The integrating factor of the equation $dy/dx + y/x = x^2$ is:

(A) x^2 (B) $1/x$

(C) e^(1/x) (D) x

20. The general solution of $y'' - 5y' + 6y = 0$ is:

(A) $y = c_1 e^{x} + c_2 e^{(6x)}$ (B) $y = c_1 e^{(-2x)} + c_2 e^{(-3x)}$

(C) $y = c_1 e^{(2x)} + c_2 e^{(3x)}$ (D) $y = (c_1 + c_2 x)\, e^{(3x)}$

21. The general solution of $y'' + 4y = 0$ is:

(A) $y = c_1 \cos 4x + c_2 \sin 4x$ (B) $y = (c_1 + c_2 x)\, e^{(2x)}$

(C) $y = c_1 e^{(2x)} + c_2 e^{(-2x)}$ (D) $y = c_1 \cos 2x + c_2 \sin 2x$

22. The Wronskian of the functions e^{x} and e^{2x} is:

(A) e^(3x) (B) e^(2x)

(C) 3e^(3x) (D) 2e^(3x)

23. The general solution of the Euler–Cauchy equation $x^2y'' - 2y = 0$ is:

(A) $y = c_1x^2 + c_2/x$ (B) $y = (c_1 + c_2 \log x)\, x$

(C) $y = c_1x + c_2/x^2$ (D) $y = c_1x^2 + c_2x$

24. The Fourier series of an odd function defined on $(-\pi, \pi)$ contains:

(A) Only cosine terms (B) Only sine terms

(C) A constant only (D) Both sine and cosine

25. For $f(x) = x^2$ on $(-\pi, \pi)$, with $a_0 = (1/\pi) \int f(x)\,dx$ taken from $-\pi$ to π, the value of a_0 is:

(A) π^2 (B) $2\pi^2/3$

(C) $\pi^2/3$ (D) $4\pi^2/3$

26. The one-dimensional heat equation $\partial u/\partial t = c^2\, \partial^2 u/\partial x^2$ is a partial differential equation of the type:

(A) Hyperbolic (B) Elliptic

(C) Non-linear (D) Parabolic

27. Eliminating the arbitrary constants a and b from $z = (x + a)(y + b)$ gives ($p = \partial z/\partial x$, $q = \partial z/\partial y$):

(A) $p + q = z$ (B) $pq = z$

(C) $p = q$ (D) $pz = q$

28. The Laplace transform of t^2 is:

(A) $2/s^2$ (B) $1/s^2$

(C) $2/s^3$ (D) $1/s^3$

29. The inverse Laplace transform of $1/(s^2 + 9)$ is:

(A) (1/3) cos 3t (B) sin 3t

(C) cos 3t (D) (1/3) sin 3t

30. The Laplace transform of the unit step function $u(t - a)$, where $a > 0$, is:

(A) e^(−as) (B) e^(as)/s

(C) 1/s (D) e^(−as)/s

Section II

Physics

31. A lightly damped forced oscillator has a resonant frequency of 1000 Hz and a bandwidth (full width at half power) of 20 Hz. Its quality factor is:

(A) 500 (B) 100

(C) 20 (D) 50

32. The equation of a damped oscillator is $x'' + 2b\,x' + \omega_0^2\,x = 0$. The motion is critically damped when:

(A) $b < \omega_0$ (B) $b = 2\omega_0$

(C) $b > \omega_0$ (D) $b = \omega_0$

33. In a forced oscillator at velocity resonance (driving frequency equal to the natural frequency), the velocity is:

(A) Behind the force by 90° (B) In phase with the force

(C) Ahead of the force by 90° (D) Opposite in phase to the force

34. In Newton's rings experiment, the diameter of the nth dark ring is proportional to:

(A) $\sqrt{n}$ (B) n

(C) n^2 (D) $1/n$

35. In a Michelson interferometer using light of wavelength 500 nm, how many fringes cross the field of view when the movable mirror is moved by 0.1 mm?

(A) 200 (B) 400

(C) 100 (D) 800

36. A plane transmission grating has 6000 lines per cm. For light of wavelength 600 nm, the highest order of spectrum that can be seen is:

(A) 1 (B) 2

(C) 3 (D) 4

37. Light is reflected from glass of refractive index $\sqrt{3}$. The angle of incidence at which the reflected light is completely plane polarised is:

(A) 45° (B) 60°

(C) 30° (D) 90°

38. Unpolarised light of intensity I_0 passes through a polariser and then an analyser whose axis is at 60° to that of the polariser. The intensity of the light that emerges is:

(A) $I_0/4$ (B) $I_0/2$

(C) $I_0/8$ (D) $3I_0/8$

39. In a helium–neon laser, the laser transitions take place in:

(A) Neon ions (B) Neon atoms

(C) Helium ions (D) Helium atoms

40. The null result of the Michelson–Morley experiment showed that:

(A) The ether drift could not be detected

(B) The earth is at absolute rest in space

(C) Light slows down in a moving frame

(D) Light needs a material medium to travel

41. A particle has a proper mean life of 3 μs. Its mean life as measured in the laboratory when it moves at 0.8c is:

(A) 5 μs (B) 3 μs

(C) 3.75 μs (D) 1.8 μs

42. A rod of proper length 1 m moves along its length at 0.6c. Its length measured by a stationary observer is:

(A) 1.25 m (B) 0.8 m

(C) 0.6 m (D) 0.4 m

43. Two spaceships move towards each other, each at 0.5c relative to the earth. The speed of one as measured from the other is:

(A) 0.75c (B) 0.5c

(C) 0.8c (D) c

44. X-rays are Compton scattered by free electrons through 180°. Taking $h/m_0c = 2.43$ pm, the increase in wavelength is:

(A) Zero (B) 2.43 pm

(C) 1.22 pm (D) 4.86 pm

45. Light with a photon energy of 5 eV falls on a metal surface of work function 2 eV. The stopping potential is:

(A) 2 V (B) 3 V

(C) 7 V (D) 5 V

46. X-rays are diffracted by crystal planes 2 Å apart. If the first-order Bragg reflection occurs at a glancing angle of 30°, the wavelength of the X-rays is:

(A) 2 Å (B) $\sqrt{3}$ Å

(C) 4 Å (D) 1 Å

47. For a particle in a one-dimensional infinite potential well, the ratio E_3/E_1 of the energy of the third level to that of the ground level is:

(A) 27 (B) 3

(C) 9 (D) 6

48. According to the Heisenberg uncertainty principle, the product $\Delta x \cdot \Delta p$ is:

(A) $\leq h/4\pi$ (B) $= 0$

(C) $\geq 2\pi h$ (D) $\geq h/4\pi$

49. The packing fraction of a face-centred cubic (FCC) structure is about:

(A) 0.34 (B) 0.74

(C) 0.52 (D) 0.68

50. A crystal plane makes intercepts of 2a, 3b and ∞ (it is parallel to the c-axis) on the three axes. Its Miller indices are:

(A) (3 2 0) (B) (2 3 0)

(C) (1 1 0) (D) (2 3 ∞)

Section III

Chemistry

51. According to molecular orbital theory, the bond order of O_2^+ is:

(A) 1.5 (B) 3

(C) 2 (D) 2.5

52. Which of the following molecules is paramagnetic according to molecular orbital theory?

(A) H_2 (B) O_2

(C) N_2 (D) F_2

53. Which of the following has a bond order of zero and therefore does not exist as a stable molecule?

(A) Li_2 (B) H_2

(C) H_2^+ (D) He_2

54. In the sodium chloride (rock salt) structure, the coordination number of each ion is:

(A) 6 (B) 12

(C) 8 (D) 4

55. In a cubic close-packed arrangement of N atoms, the numbers of octahedral and tetrahedral voids are respectively:

(A) N and N (B) 2N and 2N

(C) 2N and N (D) N and 2N

56. Bakelite is a condensation polymer of:

(A) Melamine and formaldehyde (B) Urea and formaldehyde

(C) Phenol and formaldehyde (D) Phenol and acetaldehyde

57. In diamond, each carbon atom is:

(A) sp^3d hybridised and bonded to five carbon atoms

(B) sp hybridised and bonded to two carbon atoms

(C) sp^2 hybridised and bonded to three carbon atoms

(D) sp^3 hybridised and bonded to four carbon atoms

58. The crystal field stabilisation energy (CFSE) of a d^3 ion in an octahedral field is:

(A) −0.4 Δo (B) −0.8 Δo

(C) −1.2 Δo (D) −1.6 Δo

59. For the same metal ion, ligands and metal–ligand distance, the tetrahedral splitting Δt is related to the octahedral splitting Δo by:

(A) $\Delta t = \Delta o$ (B) $\Delta t \approx (1/2)\ \Delta o$

(C) $\Delta t \approx (9/4)\ \Delta o$ (D) $\Delta t \approx (4/9)\ \Delta o$

60. In an octahedral crystal field, the d orbitals that are raised to the higher energy level (the eg set) are:

(A) dxy and dyz (B) $dx^2–y^2$ and dz^2

(C) dxz and dz^2 (D) dxy, dyz and dxz

61. The square planar complex $[Ni(CN)_4]^{2-}$ is:

(A) Paramagnetic, 4 unpaired electrons

(B) Paramagnetic, 1 unpaired electron

(C) Paramagnetic, 2 unpaired electrons

(D) Diamagnetic, all d electrons paired

62. Ozone depletion in the stratosphere is mainly caused by:

(A) Methane from paddy fields

(B) Carbon dioxide from burning fuels

(C) Sulphur dioxide from power plants

(D) Chlorine atoms released from CFCs

63. Itai-itai disease, a well-known case of heavy-metal poisoning, was caused by:

(A) Mercury (B) Cadmium

(C) Arsenic (D) Lead

64. For protecting buried iron pipelines by the sacrificial anode method, the metal commonly used as the anode is:

(A) Palladium (B) Copper

(C) Magnesium (D) Silver

65. In waterline corrosion of a steel tank partly filled with water, the maximum corrosion occurs:

(A) Just below the waterline (B) Just above the waterline

(C) Uniformly over the whole tank (D) At the bottom of the tank

66. One mole of an ideal gas expands isothermally and reversibly at 300 K from 10 L to 100 L. The work done on the gas is about ($R = 8.314\ J\ mol^{-1}\ K^{-1}$):

(A) −0.57 kJ (B) −5.74 kJ

(C) −2.49 kJ (D) +5.74 kJ

67. A reversible heat engine works between 500 K and 300 K. Its efficiency is:

(A) 40% (B) 25%

(C) 67% (D) 60%

68. A process is spontaneous at all temperatures when:

(A) $\Delta H > 0$ and $\Delta S < 0$ (B) $\Delta H < 0$ and $\Delta S > 0$

(C) $\Delta H < 0$ and $\Delta S < 0$ (D) $\Delta H > 0$ and $\Delta S > 0$

69. Pure benzene has a vapour pressure of 100 mm Hg at a certain temperature. A non-volatile solute is dissolved so that the mole fraction of benzene is 0.9. The vapour pressure of the solution is:

(A) 100 mm Hg (B) 10 mm Hg

(C) 90 mm Hg (D) 111 mm Hg

70. Nylon-6,6 is a polyamide made by the condensation of:

(A) Caprolactam alone

(B) Phenol and formaldehyde

(C) Hexamethylenediamine and adipic acid

(D) Ethylene glycol and terephthalic acid

Section IV

General Engineering

71. A 12 V source with an internal (series) resistance of 4 Ω feeds a 4 Ω resistor connected across terminals A and B. The Thevenin equivalent seen at A–B is:

(A) 12 V in series with 2 Ω (B) 12 V in series with 4 Ω

(C) 6 V in series with 2 Ω (D) 6 V in series with 8 Ω

72. A 10 V source has an internal resistance of 5 Ω. The maximum power it can deliver to a load resistor is:

(A) 5 W (B) 20 W

(C) 2.5 W (D) 10 W

73. The resonant frequency of a series RLC circuit with L = 10 mH and C = 1 μF is about:

(A) 10 kHz (B) 159 Hz

(C) 1.59 kHz (D) 15.9 kHz

74. In a balanced star-connected three-phase system the line voltage is 400 V. The phase voltage is about:

(A) 693 V (B) 400 V

(C) 133 V (D) 231 V

75. The RMS EMF induced in a 200-turn transformer winding at 50 Hz, when the maximum core flux is 0.01 Wb, is:

(A) 314 V (B) 100 V

(C) 444 V (D) 222 V

76. A transformer works at maximum efficiency when:

(A) Copper loss equals iron loss

(B) Copper loss is twice the iron loss

(C) The load is purely inductive

(D) Iron loss is zero

77. A 4-pole, 50 Hz three-phase induction motor runs with a slip of 4%. Its rotor speed is:

(A) 1500 rpm (B) 1200 rpm

(C) 1560 rpm (D) 1440 rpm

78. For a transistor with common-base current gain $\alpha = 0.98$, the common-emitter current gain β is:

(A) 49 (B) 50

(C) 0.98 (D) 98

79. The hexadecimal number 2F is equal to the decimal number:

(A) 215 (B) 32

(C) 47 (D) 45

80. A JK flip-flop with J = K = 1, on every clock pulse:

(A) Sets its output to 1 (B) Complements its output

(C) Holds its previous state (D) Resets its output to 0

81. A block just begins to slide down a rough plane inclined at 30° to the horizontal. The coefficient of friction between the block and the plane is:

(A) $\sqrt{3}$ (B) 1/2

(C) $\sqrt{3}/2$ (D) $1/\sqrt{3}$

82. For a material with Young's modulus E = 200 GPa and Poisson's ratio 0.25, the modulus of rigidity G is:

(A) 80 GPa (B) 50 GPa

(C) 160 GPa (D) 100 GPa

83. The lathe operation that produces a diamond-shaped or straight-line pattern on a cylindrical surface to give a better grip is:

(A) Facing (B) Taper turning

(C) Knurling (D) Chamfering

84. In first-angle projection, the top view (plan) is drawn:

(A) Below the front view (B) Above the front view

(C) To the left of the front view (D) To the right of the front view

85. For a perfectly elastic collision, the coefficient of restitution is:

(A) 1 (B) 0.5

(C) Infinity (D) 0

86. A temperature difference of 10 °C is equal to a temperature difference of:

(A) 18 °F (B) 42 °F

(C) 10 °F (D) 50 °F

87. Hydrogen and oxygen react as $2H_2 + O_2 \rightarrow 2H_2O$. If 4 mol of H_2 is fed with 3 mol of O_2, the percentage excess of oxygen is:

(A) 50% (B) 25%

(C) 100% (D) 33.3%

88. In a process with a recycle stream, a purge stream is taken out mainly to:

(A) Reduce the fresh feed to zero

(B) Prevent build-up of inerts in the loop

(C) Increase the conversion in each pass of the reactor

(D) Return all the unreacted feed to the reactor

89. Air at 30 °C has a partial pressure of water vapour of 2.1 kPa. If the saturation vapour pressure of water at 30 °C is 4.2 kPa, the relative humidity is:

(A) 100% (B) 200%

(C) 25% (D) 50%

90. The number of moles in 44.8 L of an ideal gas at 0 °C and 1 atm is:

(A) 4 (B) 2

(C) 0.5 (D) 1

Section V

Communication Skills

91. Choose the past continuous form of: 'She writes a report.'

(A) She has been writing a report. (B) She wrote a report.

(C) She was writing a report. (D) She had written a report.

92. Choose the passive voice of: 'The engineer tested the circuit.'

(A) The circuit is tested by the engineer.

(B) The engineer was tested by the circuit.

(C) The circuit has been tested by the engineer.

(D) The circuit was tested by the engineer.

93. Fill in the blank with the correct article: He is ___ honest engineer.

(A) a (B) no article

(C) the (D) an

94. Arrange the parts to form a correct sentence:
P: the report Q: submitted R: has S: the manager

(A) S Q R P (B) P R Q S

(C) S R Q P (D) R S Q P

95. In the sentence 'The machine runs smoothly', the word 'smoothly' is:

(A) A noun
(B) An adjective
(C) An adverb
(D) A verb

96. Choose the correct verb: The quality of these components ___ improved.

(A) have
(B) were
(C) has
(D) are

97. Proxemics, a component of non-verbal communication, deals with:

(A) Gestures and body movements
(B) Use of personal space and distance
(C) The tone and pitch of the voice
(D) Facial expressions and eye contact

98. Which of the following is NOT a form of non-verbal communication?

(A) A hand gesture
(B) A facial expression
(C) A written memo
(D) Eye contact

99. The informal channel of communication in an organisation is often called the:

(A) Chain of command
(B) Grapevine
(C) Hierarchy
(D) Wheel

100. In a 'wheel' communication network:

(A) All messages pass through one central person
(B) Members form a closed circle
(C) Messages pass along a single line of members
(D) Every member talks freely to every other member

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

Mathematics

1. (B) This is the p-series test: the series converges for $p > 1$ and diverges for $p \le 1$ ($p = 1$ gives the divergent harmonic series).

2. (C) Ratio test: $|a_{n+1}/a_n| = |x|/2 < 1$ gives $|x| < 2$, so $R = 2$.

3. (C) $\sin x = x - x^3/3! + x^5/5! - \ldots$, so the coefficient of x^3 is $-1/6$.

4. (D) The terms decrease to 0, so the series converges by Leibniz's test, but the series of absolute values $\sum 1/n$ diverges. Hence it is conditionally convergent.

5. (D) u is homogeneous of degree 3, so by Euler's theorem x u_x + y u_y = 3u.

6. (C) $\partial u/\partial x = 2xy$; differentiating with respect to y gives 2x.

7. (A) $f_x = 2x - 4 = 0$ gives $x = 2$ and f_y = 2y + 6 = 0 gives $y = -3$. (It is a minimum, since $r = t = 2$ and $s = 0$.)

8. (C) $f_x = 2x$ and f_y = −2y vanish at the origin, so it is stationary. $rt - s^2 = (2)(-2) - 0 = -4 < 0$, so it is a saddle point.

9. (B) With $F = xy + \lambda(10 - x - y)$: $y = \lambda$ and $x = \lambda$, so $x = y = 5$ and the maximum of xy is 25.

10. (A) $\nabla\phi = (2xy)\,i + (x^2 + z)\,j + (y)\,k = 2i + 2j + k$ at (1, 1, 1).

11. (B) curl $F = (\partial F_2/\partial x - \partial F_1/\partial y)\,k = (1 - (-1))\,k = 2k$; the i and j components are zero.

12. (A) $\oiint F \cdot n\, dS = \iiint$ div F dV over the volume enclosed by the surface. Stokes's theorem is the one that links a surface integral to a line integral.

13. (D) The curves meet at x = 0 and x = 1. Area = $\int_0^1 (x - x^2)\,dx = 1/2 - 1/3 = 1/6$.

14. (A) $V = \pi \int_0^4 y^2\,dx = \pi \int_0^4 x\,dx = \pi \times 16/2 = 8\pi$.

15. (C) $y' = \sqrt{x}$, so length = $\int_0^3 \sqrt{(1 + x)}\,dx$ = (2/3)[(1 + x)^(3/2)]$_0^3$ = (2/3)(8 − 1) = 14/3.

16. (B) $\int_0$^2π $\int_0^1 r^2 \cdot r\,dr\,d\theta = 2\pi \times 1/4 = \pi/2$.

17. (A) Each of x, y and z integrates to 1/2 over the unit cube, so the total is 3 × 1/2 = 3/2.

18. (A) The test for exactness is $\partial M/\partial y = \partial N/\partial x$.

19. (D) For dy/dx + P y = Q, IF = e^(∫P dx) = e^(∫dx/x) = e^(log x) = x.

20. (C) The auxiliary equation $m^2 - 5m + 6 = 0$ has roots m = 2, 3, so $y = c_1 e^{(2x)} + c_2 e^{(3x)}$.

21. (D) $m^2 + 4 = 0$ gives $m = \pm 2i$, so $y = c_1 \cos 2x + c_2 \sin 2x$.

22. (A) $W = e^x \cdot 2e^{2x} - e^{2x} \cdot e^x = 2e^{3x} - e^{3x} = e^{3x}$.

23. (A) Putting $y = x^m$: $m(m - 1) - 2 = 0$, i.e. $m^2 - m - 2 = 0$, so m = 2 or −1. Hence $y = c_1x^2 + c_2x^{-1}$.

24. (B) For an odd function $a_0 = a_n = 0$, because f(x) cos nx is odd. Only the b_n (sine) terms remain.

25. (B) $a_0 = (1/\pi) \times [x^3/3]$ from $-\pi$ to $\pi = (1/\pi) \times 2\pi^3/3 = 2\pi^2/3$.

26. (D) With A = c^2, B = 0, C = 0 in A u_xx + B u_xt + C u_tt, $B^2 - 4AC = 0$, so the equation is parabolic. The wave equation is hyperbolic and Laplace's equation elliptic.

27. (B) p = y + b and q = x + a, so pq = (x + a)(y + b) = z.

28. (C) $L\{t^n\} = n!/s^{n+1}$, so $L\{t^2\} = 2/s^3$.

29. (D) $L\{\sin at\} = a/(s^2 + a^2)$. With a = 3, $1/(s^2 + 9) = (1/3) \times 3/(s^2 + 9)$, whose inverse is (1/3) sin 3t.

30. (D) L{u(t − a)} = ∫ from a to ∞ of e^(−st) dt = e^(−as)/s. (e^(−as) alone is the transform of the delta function δ(t − a).)

Physics

31. (D) Q = resonant frequency ÷ bandwidth = 1000/20 = 50.

32. (D) The roots are $-b \pm \sqrt{(b^2 - \omega_0^2)}$. Critical damping is the boundary case $b = \omega_0$; $b > \omega_0$ is overdamped and $b < \omega_0$ underdamped (oscillatory).

33. (B) At $\omega = \omega_0$ the mechanical impedance is purely resistive, so the velocity is in phase with the driving force and power absorption is maximum. The displacement then lags the force by 90°.

34. (A) For the nth dark ring $D_n^2 = 4n\lambda R$, so $D_n \propto \sqrt{n}$.

35. (B) $N = 2d/\lambda = 2 \times 0.1 \times 10^{-3} / (500 \times 10^{-9}) = 400$. The path changes by twice the mirror movement.

36. (B) Grating element d = 1/6000 cm = 1.67×10^{-6} m. n_max < $d/\lambda = 1.67 \times 10^{-6} / 6 \times 10^{-7} \approx 2.8$, so the highest order is 2.

37. (B) Brewster's law: tan θ_p = μ = √3, so θ_p = 60°.

38. (C) The polariser passes $I_0/2$. By Malus's law the analyser passes $(I_0/2) \cos^2 60° = (I_0/2)(1/4) = I_0/8$.

39. (B) Helium atoms are excited by the discharge and transfer energy to neon atoms by collision. The lasing transitions (such as 632.8 nm) are between levels of neutral neon atoms.

40. (A) No shift of fringes was seen, so no motion of the earth relative to an ether could be detected. This supported the postulate that the speed of light is the same in all inertial frames.

41. (A) $\gamma = 1/\sqrt{(1 - 0.64)} = 1/0.6 = 5/3$. Dilated life = γ × 3 μs = 5 μs.

42. (B) $L = L_0 \sqrt{(1 - v^2/c^2)} = 1 \times \sqrt{(1 - 0.36)} = 0.8$ m.

43. (C) Relativistic addition: u = (0.5c + 0.5c)/(1 + 0.25) = c/1.25 = 0.8c.

44. (D) $\Delta\lambda = (h/m_0c)(1 - \cos\theta) = 2.43 \times (1 - (-1)) = 4.86$ pm.

45. (B) K_max = hν − φ = 5 − 2 = 3 eV, so the stopping potential is 3 V.

46. (A) Bragg's law: $n\lambda = 2d \sin\theta$, so $\lambda = 2 \times 2 \times \sin 30° = 2$ Å.

47. (C) $E_n = n^2h^2/(8mL^2)$, so $E_3/E_1 = 3^2 = 9$.

48. (D) $\Delta x \cdot \Delta p \geq \hbar/2 = h/4\pi$.

49. (B) FCC has 4 atoms per cell and $a = 2\sqrt{2}\, r$, giving $\pi/(3\sqrt{2}) \approx 0.74$. BCC is 0.68, simple cubic 0.52 and diamond 0.34.

50. (A) Intercepts in units of a, b, c: 2, 3, ∞. Reciprocals: 1/2, 1/3, 0. Multiplying by 6 gives (3 2 0).

Chemistry

51. (D) O_2 (16 electrons) has bond order (10 − 6)/2 = 2. Removing one antibonding π* electron gives O_2^+ a bond order of (10 − 5)/2 = 2.5.

52. (B) O_2 has two unpaired electrons in the degenerate π*2p orbitals. N_2, F_2 and H_2 have all electrons paired.

53. (D) He_2 has 2 bonding and 2 antibonding electrons, so its bond order is 0. H_2 has 1, Li_2 has 1 and H_2^+ has 0.5.

54. (A) In NaCl each Na^+ is surrounded octahedrally by 6 Cl^- ions and vice versa (6:6 coordination).

55. (D) A close-packed array has one octahedral void and two tetrahedral voids per atom.

56. (C) Bakelite is a phenol-formaldehyde resin. Urea and melamine with formaldehyde give other thermosetting resins.

57. (D) Diamond is a 3-D network in which every carbon is sp^3 hybridised and bonded tetrahedrally to four others. Graphite carbons are sp^2 hybridised.

58. (C) $d^3 = t_2g^3$. Each t_2g electron is stabilised by 0.4 Δo, so CFSE = 3 × (−0.4 Δo) = −1.2 Δo.

59. (D) Crystal field theory gives Δt = (4/9) Δo, which is why tetrahedral complexes are almost always high spin.

60. (B) $dx^2–y^2$ and dz^2 point directly at the ligands along the axes, so they are raised in energy (eg). dxy, dyz and dxz form the lower t_2g set.

61. (D) Ni^{2+} is d^8. In the strong square planar field of CN^- all eight electrons pair up in the four lower orbitals, leaving the $dx^2–y^2$ orbital empty, so the complex is diamagnetic.

62. (D) UV light breaks CFCs to release Cl atoms, which destroy ozone in a chain reaction: $Cl + O_3 \rightarrow ClO + O_2$ and $ClO + O \rightarrow Cl + O_2$.

63. (B) Itai-itai disease in Japan was caused by cadmium in river water used for rice fields. Minamata disease was caused by mercury.

64. (C) The sacrificial anode must be more active (more negative electrode potential) than iron. Magnesium (or zinc) corrodes in place of iron; copper, silver and palladium are nobler than iron.

65. (A) This is differential aeration corrosion. The metal just below the waterline gets less oxygen than the metal at the surface, so it becomes the anode and corrodes most.

66. (B) $w = -nRT \ln(V_2/V_1) = -1 \times 8.314 \times 300 \times 2.303 \log 10 = -5744$ J ≈ -5.74 kJ (the gas does work on the surroundings).

67. (A) $\eta = 1 - T_2/T_1 = 1 - 300/500 = 0.4 = 40\%$.

68. (B) $\Delta G = \Delta H - T\Delta S$. With ΔH negative and ΔS positive, ΔG is negative at every temperature.

69. (C) Raoult's law: $p = x(\text{benzene}) \times p^\circ = 0.9 \times 100 = 90$ mm Hg.

70. (C) Nylon-6,6 is made from hexamethylenediamine and adipic acid (6 carbons each). Ethylene glycol and terephthalic acid give polyester (terylene); caprolactam gives nylon-6.

General Engineering

71. (C) Open-circuit voltage $= 12 \times 4/(4 + 4) = 6$ V. With the source shorted, $R_{th} = 4\ \Omega \parallel 4\ \Omega = 2\ \Omega$.

72. (A) Maximum power transfer occurs at $R_L = 5\ \Omega$: $P_{max} = V^2/(4R) = 100/20 = 5$ W.

73. (C) $f_0 = 1/(2\pi\sqrt{(LC)}) = 1/(2\pi\sqrt{(10^{-2} \times 10^{-6})}) = 1/(2\pi \times 10^{-4}) \approx 1592$ Hz ≈ 1.59 kHz.

74. (D) In star connection $V_{line} = \sqrt{3}\, V_{phase}$, so $V_{phase} = 400/1.732 \approx 231$ V.

75. (C) $E = 4.44\, f\, N\, \Phi m = 4.44 \times 50 \times 200 \times 0.01 = 444$ V.

76. (A) Efficiency is maximum when the variable (copper) loss equals the constant (iron) loss.

77. (D) $N_s = 120f/P = 120 \times 50/4 = 1500$ rpm. $N = N_s(1 - s) = 1500 \times 0.96 = 1440$ rpm.

78. (A) $\beta = \alpha/(1 - \alpha) = 0.98/0.02 = 49$.

79. (C) $(2F)_{16} = 2 \times 16 + 15 = 47$.

80. (B) J = K = 1 is the toggle mode: the output changes to its complement on each clock pulse. J = K = 0 holds the state.

81. (D) At the point of sliding the angle of inclination equals the angle of repose, so $\mu = \tan 30^\circ = 1/\sqrt{3} \approx 0.577$.

82. (A) $E = 2G(1 + \nu)$, so $G = 200/(2 \times 1.25) = 80$ GPa.

83. (C) Knurling presses a pattern into the surface (as on tool handles). Facing makes a flat end, chamfering bevels an edge and taper turning produces a cone.

84. (A) In first-angle projection the object lies in the first quadrant; when the HP is rotated, the plan comes below the elevation. In third-angle projection it is above.

85. (A) e = (velocity of separation)/(velocity of approach) = 1 for a perfectly elastic collision and 0 for a perfectly plastic one.

86. (A) A Celsius degree is 1.8 Fahrenheit degrees, so $\Delta = 10 \times 1.8 = 18$ °F. (50 °F is the temperature reading equal to 10 °C, not a difference.)

87. (A) 4 mol H_2 needs 2 mol O_2, so H_2 is limiting. Excess $O_2 = (3 - 2)/2 \times 100 = 50\%$.

88. (B) Inerts or impurities entering with the fresh feed would keep accumulating in the recycle loop; a small purge removes them so their level stays steady.

89. (D) Relative humidity $= p(\text{water})/p(\text{sat}) \times 100 = 2.1/4.2 \times 100 = 50\%$.

90. (B) One mole of an ideal gas occupies 22.4 L at 0 °C and 1 atm, so $n = 44.8/22.4 = 2$.

Communication Skills

91. (C) The past continuous is was/were + verb-ing: 'She was writing a report.'

92. (D) Simple past active becomes was/were + past participle: 'The circuit was tested by the engineer.'

93. (D) 'Honest' begins with a vowel sound (the h is silent), so it takes 'an'.

94. (C) 'The manager has submitted the report' = S R Q P (subject, auxiliary, main verb, object).

95. (C) 'Smoothly' tells how the machine runs, so it modifies the verb and is an adverb.

96. (C) The subject is 'the quality' (singular); 'of these components' does not change it. So the verb is 'has'.

97. (B) Proxemics is the study of how people use space and distance when they communicate. Body movements are kinesics and voice qualities are paralanguage.

98. (C) A written memo uses words, so it is verbal (written) communication. The other three are non-verbal.

99. (B) The grapevine is the informal network through which news and rumours spread. The chain of command and hierarchy are formal channels.

100. (A) The wheel is a centralised network: one person at the hub links all others. The all-channel network lets everyone talk to everyone; the chain is a single line; the circle is closed.