

JEE (Advanced) — Full Mock Test

Physics + Chemistry + Mathematics | Mock Test 7 (Set G) | Session 2026-27

Time Allowed: 3 Hours

Maximum Marks: 210

General Instructions

- The paper has three parts — Physics, Chemistry and Mathematics — each with the sections below.
- Section 1: 10 single-correct questions — +3 if correct, –1 if incorrect, 0 if unattempted.
- Section 2: 5 multiple-correct questions (one or more options correct) — +4 if all correct options and no wrong option are chosen; +3 if all four options are correct and exactly three are chosen; +2 if three or more options are correct and exactly two correct options are chosen; +1 if two or more options are correct and exactly one correct option is chosen; 0 if unattempted; –2 in all other cases.
- Section 3: 5 numerical value questions — enter the answer correct to two decimal places; +4 if correct, 0 otherwise.
- Use of a calculator is not permitted. The JEE (Advanced) pattern changes from year to year; this paper follows one clearly stated recent pattern.
- This is an original practice paper; it is not a reproduction of any official paper.

PHYSICS — SECTION 1: SINGLE CORRECT (QUESTIONS 1-10)

1. Two radioactive samples X and Y, with half-lives 2 h and 4 h, initially contain equal numbers of nuclei. After 8 h, the ratio of the activity of X to that of Y is
(a) $1/4$ (b) 2
(c) $1/8$ (d) $1/2$
2. Blocks of 1 kg and 2 kg on a smooth floor are joined by a spring. A force of 6 N pulls the 2 kg block. When the 1 kg block has an acceleration of 1 m/s^2 , the 2 kg block has an acceleration of
(a) 2.5 m/s^2 (b) 5 m/s^2
(c) 2 m/s^2 (d) 3 m/s^2
3. A 1 kg body starts from rest and is driven by a constant power of 2 W. The distance it covers in the first 9 s is
(a) 27 m (b) 54 m
(c) 18 m (d) 36 m
4. The radius of gyration of a uniform disc of radius R about a tangent perpendicular to its plane is
(a) R (b) $\sqrt{3/2} R$
(c) $R/\sqrt{2}$ (d) $\sqrt{5/4} R$
5. A satellite moves in a circular orbit of radius R round a planet. Its speed is suddenly increased, along its direction of motion, to $\sqrt{3/2}$ times the circular-orbit speed. The greatest distance from the centre of the planet in its new orbit is
(a) 2R (b) 3R
(c) 1.5R (d) 4R
6. A cylindrical tank of cross-section A has water to a height of 2 m. A small hole of area $a = A/100$ is opened at its bottom. The time taken to empty the tank completely is ($g = 10 \text{ m/s}^2$)
(a) 44.7 s (b) 63.2 s
(c) 89.4 s (d) 31.6 s

7. At high temperatures, when its vibrational mode is excited, the molar heat capacity at constant volume of a diatomic gas is
 (a) $5R/2$ (b) $3R/2$
 (c) $7R/2$ (d) $9R/2$
8. A simple pendulum has a bob of mass m and positive charge q in a uniform upward electric field E ($qE < mg$). Its period is
 (a) $2\pi\sqrt{l/(g - qE/m)}$ (b) $2\pi\sqrt{lm/(qE)}$
 (c) $2\pi\sqrt{l/(g + qE/m)}$ (d) $2\pi\sqrt{l/g}$
9. A charge Q is spread uniformly over a semicircular ring of radius R . The field at its centre is
 (a) $Q/(4\pi^2\epsilon_0 R^2)$ (b) zero
 (c) $Q/(2\pi^2\epsilon_0 R^2)$ (d) $Q/(4\pi\epsilon_0 R^2)$
10. A $2\ \mu\text{F}$ capacitor is in parallel with a $4\ \Omega$ resistor; this combination is in series with a $2\ \Omega$ resistor across $12\ \text{V}$. In the steady state the charge on the capacitor is
 (a) $16\ \mu\text{C}$ (b) zero
 (c) $8\ \mu\text{C}$ (d) $24\ \mu\text{C}$

PHYSICS — SECTION 2: MULTIPLE CORRECT (QUESTIONS 11-15)

11. A spherical conductor carries a charge Q in equilibrium. Which of the following is/are correct? one or more correct
 (a) The electric field inside the conductor is zero
 (b) The potential inside is zero
 (c) The field just outside the surface is tangential to it
 (d) The potential inside equals the potential on the surface
12. A charged particle moves in a uniform magnetic field (no other fields). Which of the following is/are correct? one or more correct
 (a) The period of revolution is independent of its speed
 (b) If its velocity is perpendicular to B , it moves in a circle
 (c) Its kinetic energy remains constant
 (d) It can be accelerated to higher speed by the field
13. Regarding nuclei, which of the following is/are correct? one or more correct
 (a) In α -decay, the mass number decreases by 4
 (b) γ -decay changes the atomic number
 (c) The nuclear radius is proportional to $A^{1/3}$
 (d) Binding energy per nucleon is highest near $A \approx 56$
14. In a collision between two bodies isolated from external forces, which of the following is/are correct? one or more correct
 (a) In a perfectly inelastic collision the bodies move together afterwards
 (b) Total kinetic energy is conserved in every collision
 (c) In a one-dimensional elastic collision of equal masses, the bodies exchange velocities
 (d) Total linear momentum is conserved
15. For a satellite in a circular orbit around the Earth, which of the following is/are correct? one or more correct
 (a) A larger orbit has a larger orbital speed
 (b) $T^2 \propto r^3$
 (c) Its kinetic energy is half the magnitude of its potential energy
 (d) Its angular momentum about the Earth's centre changes along the orbit

PHYSICS — SECTION 3: NUMERICAL VALUE (QUESTIONS 16-20)

16. In Young's double-slit experiment with light of wavelength 600 nm, a thin glass sheet ($\mu = 1.5$) placed in front of one slit shifts the central bright fringe to the position of the fifth bright fringe. Find the thickness of the sheet in μm . answer to 2 d.p.
17. A bead of mass 0.2 kg slides on a smooth circular wire of radius 0.5 m fixed in a vertical plane. Its speed at the lowest point is 6 m/s. Find the magnitude of the normal force (in N) exerted by the wire on the bead at the highest point ($g = 10 \text{ m/s}^2$). answer to 2 d.p.
18. A capillary tube of internal radius 0.2 mm is dipped vertically in water (surface tension 0.07 N/m, angle of contact 0° , density 1000 kg/m^3 , $g = 10 \text{ m/s}^2$). Find the height (in cm) to which water rises in the tube. answer to 2 d.p.
19. Capacitors of $3 \mu\text{F}$ and $6 \mu\text{F}$ are connected in series across a 12 V battery and fully charged. They are disconnected and then connected to each other with plates of like charge together. Find the energy (in μJ) now stored in the system. answer to 2 d.p.
20. A convex lens of focal length 20 cm and a concave lens of focal length 10 cm are placed coaxially 10 cm apart. An object is placed 30 cm in front of the convex lens. Find the distance (in cm) of the final image from the concave lens. answer to 2 d.p.

CHEMISTRY — SECTION 1: SINGLE CORRECT (QUESTIONS 21-30)

21. The pair of species having the same shape is
(a) XeF_2 and I_3^- (b) SF_4 and CH_4
(c) BF_3 and NH_3 (d) ClF_3 and BCl_3
22. For $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$, $\Delta H = -92.4 \text{ kJ}$ at 298 K. The value of ΔU is about ($R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$)
(a) -97.4 kJ (b) -92.4 kJ
(c) -87.4 kJ (d) -89.9 kJ
23. An inert gas is added to a gaseous equilibrium mixture at constant volume. The equilibrium
(a) shifts towards more moles of gas (b) does not shift
(c) shifts towards the exothermic side (d) shifts towards fewer moles of gas
24. The standard reduction potentials of $\text{Fe}^{3+}/\text{Fe}^{2+}$ and Fe^{2+}/Fe are $+0.77 \text{ V}$ and -0.44 V . The standard reduction potential of Fe^{3+}/Fe is
(a) -0.037 V (b) $+0.33 \text{ V}$
(c) -0.11 V (d) $+1.21 \text{ V}$
25. The first-order gas-phase reaction $\text{A}(\text{g}) \rightarrow \text{B}(\text{g}) + \text{C}(\text{g})$ is started with pure A at 100 mm Hg in a closed vessel at constant volume and temperature. After 10 min the total pressure is 150 mm Hg. The rate constant of the reaction is
(a) $3.47 \times 10^{-2} \text{ min}^{-1}$ (b) $6.93 \times 10^{-2} \text{ min}^{-1}$
(c) $1.39 \times 10^{-1} \text{ min}^{-1}$ (d) $4.05 \times 10^{-2} \text{ min}^{-1}$
26. The xenon fluoride with the largest number of lone pairs on Xe is
(a) all have the same number (b) XeF_4
(c) XeF_2 (d) XeF_6
27. The complex ion that shows both geometrical and optical isomerism is
(a) $[\text{Co}(\text{en})_2\text{Cl}_2]^+$ (b) $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]^+$
(c) $[\text{Co}(\text{en})_3]^{3+}$ (d) $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$

28. 2,2-Dimethylpropan-1-ol (neopentyl alcohol) is heated with concentrated H_2SO_4 . The major product is
- 2-methylbut-1-ene
 - 3-methylbut-1-ene
 - no alkene, since the alcohol has no β -hydrogen
 - 2-methylbut-2-ene
29. In the sequence $\text{C}_6\text{H}_5\text{NO}_2 \xrightarrow{(\text{Sn}/\text{HCl})} \text{A} \xrightarrow{(\text{NaNO}_2/\text{HCl}, 273 \text{ K})} \text{B} \xrightarrow{(\text{CuCN}/\text{KCN})} \text{C} \xrightarrow{(\text{H}_3\text{O}^+, \text{ heat})} \text{D}$, the compound D is
- benzamide
 - benzoic acid
 - benzonitrile
 - phenol
30. The volume of 1 M HCl needed to titrate 1.06 g of Na_2CO_3 to the phenolphthalein end point is
- 5 mL
 - 40 mL
 - 20 mL
 - 10 mL

CHEMISTRY — SECTION 2: MULTIPLE CORRECT (QUESTIONS 31-35)

31. Which of the following statements is/are correct according to VSEPR theory? one or more correct
- NH_4^+ is square planar
 - SF_4 is tetrahedral
 - ClF_3 is T-shaped
 - IF_7 has pentagonal bipyramidal geometry
32. Which of the following statements about buffers and salt hydrolysis is/are correct? one or more correct
- The pH of a solution of $\text{CH}_3\text{COONH}_4$ is independent of concentration (approximately)
 - NaCl solution is basic
 - Adding a common ion suppresses the ionisation of a weak electrolyte
 - An aqueous solution of NH_4Cl is acidic
33. Which of the following statements about reaction rates is/are correct? one or more correct
- The half-life of a first-order reaction is independent of the initial concentration
 - The Arrhenius factor A has the same units as the rate constant
 - The order of a reaction is always equal to its molecularity
 - A catalyst changes the equilibrium constant
34. Which of the following statements about coordination compounds is/are correct? one or more correct
- $[\text{Co}(\text{en})_3]^{3+}$ is optically active
 - $[\text{Ni}(\text{CO})_4]$ is tetrahedral and diamagnetic
 - In $[\text{Cu}(\text{NH}_3)_4]^{2+}$, Cu is in the +1 state
 - Tetrahedral complexes are generally high spin
35. Which of the following statements about carbohydrates and proteins is/are correct? one or more correct
- Sucrose is a non-reducing sugar
 - Denaturation destroys the primary structure of a protein
 - All naturally occurring α -amino acids except glycine are optically active
 - Cellulose has β -1,4 glycosidic links

CHEMISTRY — SECTION 3: NUMERICAL VALUE (QUESTIONS 36-40)

36. Find the emf (in V, to 2 decimal places) at 298 K of the cell $\text{Zn} \mid \text{Zn}^{2+}(0.01 \text{ M}) \parallel \text{Cu}^{2+}(1 \text{ M}) \mid \text{Cu}$, given $E^\circ_{\text{cell}} = 1.10 \text{ V}$ and $2.303RT/F = 0.0591 \text{ V}$. answer to 2 d.p.
37. Find the spin-only magnetic moment (in BM) of the complex ion $[\text{Fe}(\text{CN})_6]^{3-}$. answer to 2 d.p.
38. Find the volume (in mL) of 0.2 M H_2SO_4 needed to neutralise completely a mixture of 0.84 g of NaHCO_3 and 1.06 g of Na_2CO_3 . answer to 2 d.p.
39. Find the pH of a 0.1 M aqueous solution of NH_4Cl at 25 °C (pK_b of $\text{NH}_3 = 4.74$, $\text{pK}_w = 14$). answer to 2 d.p.
40. Find the total number of lone pairs of electrons on the xenon atoms of XeF_2 , XeF_4 and XeO_3 taken together. answer to 2 d.p.

MATHEMATICS — SECTION 1: SINGLE CORRECT (QUESTIONS 41-50)

41. A is a square matrix with $A^3 = O$. Then $(I - A)^{-1}$ equals
 (a) $I + A + A^2$ (b) $I - A$
 (c) $I + A$ (d) $I - A + A^2$
42. The value of $\lim_{x \rightarrow 0} [(1 - \cos 2x)(3 + \cos x)]/(x \tan 4x)$ is
 (a) $1/2$ (b) 4
 (c) 2 (d) $3/4$
43. The point on the curve $y = x^2$ that is nearest to the point (3, 0) is
 (a) (1, 1) (b) (0, 0)
 (c) (-1, 1) (d) ($\sqrt{2}$, 2)
44. The area of the region $\{(x, y): x^2/9 + y^2/4 \leq 1 \leq x/3 + y/2\}$ is
 (a) $6\pi - 3$ (b) $3(\pi - 2)/2$
 (c) $3\pi/2$ (d) $3(\pi - 2)$
45. The radical axis of $x^2 + y^2 - 4x = 0$ and $x^2 + y^2 + 2y = 0$ is
 (a) $x + 2y = 0$ (b) $2x - y = 0$
 (c) $x - 2y = 0$ (d) $2x + y = 0$
46. The plane containing the line $x = y = z$ and the point (1, 0, 0) is
 (a) $x + y + z = 1$ (b) $x = y$
 (c) $y + z = 0$ (d) $y = z$
47. The solution of $dy/dx + y \tan x = \sec x$ with $y(0) = 0$ is
 (a) $y = \sin x$ (b) $y = \cos x - 1$
 (c) $y = \tan x$ (d) $y = x \cos x$
48. If ω is a non-real cube root of unity, $(1 - \omega)(1 - \omega^2)(1 - \omega^4)(1 - \omega^8)$ equals
 (a) 1 (b) 9
 (c) 0 (d) 3
49. The least number of terms of $1 + 1/2 + 1/4 + \dots$ whose sum exceeds 1.99 is
 (a) 10 (b) 8
 (c) 7 (d) 9
50. If A is a 3×3 matrix with $|A| = 4$, then $|\text{adj}(2A)|$ is
 (a) 256 (b) 128
 (c) 1024 (d) 64

MATHEMATICS — SECTION 2: MULTIPLE CORRECT (QUESTIONS 51-55)

51. Let $f(x) = x^3 - 6x^2 + 9x + 1$. Which of the following is/are correct? one or more correct
 (a) f is increasing on $(1, 3)$ (b) f has a local minimum at $x = 3$
 (c) The local maximum value is 3 (d) f has a point of inflection at $x = 2$
52. For the parabola $y^2 = 8x$, which of the following is/are correct? one or more correct
 (a) The focus is $(2, 0)$
 (b) The tangent at the vertex is $y = 0$
 (c) The point $(2, 4)$ lies inside the parabola
 (d) The directrix is $x = -2$
53. For the differential equation $dy/dx = y/x + \tan(y/x)$, which of the following is/are correct? one or more correct
 (a) It is a homogeneous differential equation
 (b) Its general solution is $\sin(y/x) = Cx$
 (c) Its general solution is $\cos(y/x) = Cx$
 (d) The solution curve through $(1, \pi/2)$ is $\sin(y/x) = x$
54. For the expansion of $(1 + x)^n$ with n a positive integer, which of the following is/are correct? one or more correct
 (a) The middle term is always unique
 (b) The sum of all binomial coefficients is 2^n
 (c) The number of terms is n
 (d) The sum of the coefficients in odd positions equals the sum in even positions
55. Let $f(x) = |x| + |x - 1|$. Which of the following is/are correct? one or more correct
 (a) The minimum value of f is 1
 (b) f is not differentiable at $x = 0$ and $x = 1$
 (c) f is differentiable at $x = 1/2$
 (d) f is strictly increasing on $(0, 1)$

MATHEMATICS — SECTION 3: NUMERICAL VALUE (QUESTIONS 56-60)

56. Find the shortest distance between the lines $r = (\hat{i} + 2\hat{j} + \hat{k}) + \lambda(\hat{i} - \hat{j} + \hat{k})$ and $r = (2\hat{i} - \hat{j} - \hat{k}) + \mu(2\hat{i} + \hat{j} + 2\hat{k})$. answer to 2 d.p.
57. The coefficients of the 5th, 6th and 7th terms in the expansion of $(1 + x)^n$ are in arithmetic progression. Find the largest possible value of n . answer to 2 d.p.
58. Find the maximum area of a rectangle inscribed in the ellipse $x^2/16 + y^2/9 = 1$ with its sides parallel to the axes. answer to 2 d.p.
59. The image of the point $(1, 2, 3)$ in the plane $x + 2y + 4z = 38$ is (a, b, c) . Find $a + b + c$. answer to 2 d.p.
60. The sum of an infinite geometric progression is 4 and the sum of the squares of its terms is 8. Find its common ratio (to 2 decimal places). answer to 2 d.p.

MASTER TESTING AGENCY

Answer Key

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PHYSICS — SECTION 1: SINGLE CORRECT

1.	(d) $N_X = N_0/2^4$ and $N_Y = N_0/2^2$, and $A = \lambda N$ with $\lambda_X = 2\lambda_Y$, so $A_X/A_Y = 2 \times (1/16)/(1/4) = 1/2$.
2.	(a) The spring pulls each block with 1 N: $(6 - 1)/2$.
3.	(d) $v = \sqrt{2Pt/m} = 2\sqrt{t}$; $x = (4/3)t^{3/2} = 36$ m.
4.	(b) $I = MR^2/2 + MR^2 = (3/2)MR^2$.
5.	(b) With $v = kv_0$ at $r_1 = R$ (perigee), angular momentum and energy conservation give $r_2/r_1 = k^2/(2 - k^2) = 1.5/0.5 = 3$, so $r_2 = 3R$.
6.	(b) $A(-dh/dt) = a\sqrt{2gh}$ gives $t = (A/a)\sqrt{2H/g} = 100 \times \sqrt{4/10} = 63.2$ s.
7.	(c) 3 translational + 2 rotational + 2 vibrational (kinetic and potential) halves of R.
8.	(a) The effective gravity is $g - qE/m$.
9.	(c) $2k\lambda/R$ with $\lambda = Q/(\pi R)$.
10.	(a) $I = 12/6 = 2$ A; the capacitor has the 8 V across the 4 Ω resistor.

PHYSICS — SECTION 2: MULTIPLE CORRECT

11.	(a), (d) (A) Correct: in electrostatic equilibrium. (B) Incorrect: it equals kQ/R . (C) Incorrect: it is normal to the surface. (D) Correct: $E = 0$ inside means V is constant.
12.	(a), (b), (c) (A) Correct: $T = 2\pi m/(qB)$. (B) Correct: the force is always perpendicular to velocity. (C) Correct: the magnetic force does no work. (D) Incorrect: no work is done.
13.	(a), (c), (d) (A) Correct: an ${}^4\text{He}$ nucleus is emitted. (B) Incorrect: it only releases energy. (C) Correct: $R = R_0 A^{1/3}$. (D) Correct: iron-group nuclei are most tightly bound.
14.	(a), (c), (d) (A) Correct: that is the definition ($e = 0$). (B) Incorrect: only in elastic collisions. (C) Correct: from the elastic-collision formulas with $m_1 = m_2$. (D) Correct: no external impulse acts.
15.	(b), (c) (A) Incorrect: $v \propto 1/\sqrt{r}$. (B) Correct: Kepler's third law. (C) Correct: $K = GMm/(2r)$, $U = -GMm/r$. (D) Incorrect: gravity is a central force, so L is constant.

PHYSICS — SECTION 3: NUMERICAL VALUE

16.	6 The extra optical path $(\mu - 1)t = 5\lambda$, so $t = 5 \times 600 \text{ nm}/0.5 = 6000 \text{ nm} = 6.00 \text{ }\mu\text{m}$.
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17.	4.4 Energy: v^2 at the top = $u^2 - 4gR = 36 - 20 = 16 \text{ m}^2/\text{s}^2$. At the top, $N + mg = mv^2/R$, so $N = 0.2 \times 16/0.5 - 0.2 \times 10 = 6.4 - 2 = 4.4 \text{ N}$, directed towards the centre.
18.	7 $h = 2T \cos \theta / (\rho g r) = (2 \times 0.07) / (1000 \times 10 \times 2 \times 10^{-4}) = 0.07 \text{ m} = 7.00 \text{ cm}$.
19.	128 In series $C = 2 \text{ }\mu\text{F}$, so each carries $Q = 24 \text{ }\mu\text{C}$. Joined like-to-like they are in parallel: total charge $48 \text{ }\mu\text{C}$ on $9 \text{ }\mu\text{F}$, so $U = Q^2/2C = (48)^2/(2 \times 9) = 128.00 \text{ }\mu\text{J}$ (it was $144 \text{ }\mu\text{J}$ before).
20.	12.5 Convex lens: $1/v = 1/20 - 1/30$, so $v = 60 \text{ cm}$. This is 50 cm beyond the concave lens, a virtual object ($u = +50 \text{ cm}$): $1/v = -1/10 + 1/50 = -4/50$, so $v = -12.50 \text{ cm}$, a virtual image 12.50 cm in front of the concave lens.

CHEMISTRY — SECTION 1: SINGLE CORRECT

21.	(a) XeF_2 (3 lone pairs + 2 bond pairs on Xe) and I_3^- (3 lone pairs + 2 bond pairs on the central I) are both linear. SF_4 is see-saw but CH_4 tetrahedral; BF_3 is trigonal planar but NH_3 pyramidal; ClF_3 is T-shaped but BCl_3 trigonal planar.
22.	(c) $\Delta n_g = 2 - 4 = -2$, so $\Delta U = \Delta H - \Delta n_g RT = -92.4 + 2 \times 8.314 \times 298/1000 = -92.4 + 4.96 = -87.4 \text{ kJ}$.
23.	(b) The partial pressures of the reacting gases are unchanged.
24.	(a) Potentials are not additive but ΔG° values are: $-3FE^\circ = -1F(0.77) - 2F(-0.44)$, so $E^\circ = (0.77 - 0.88)/3 = -0.037 \text{ V}$.
25.	(b) If $p \text{ mm Hg}$ of A decomposes, the total pressure is $(100 - p) + 2p = 100 + p = 150$, so $p = 50$ and the pressure of A left is 50 mm Hg . $k = (2.303/10) \log(100/50) = 0.0693 \text{ min}^{-1}$ (the half-life is 10 min).
26.	(c) XeF_2 3, XeF_4 2, XeF_6 1.
27.	(a) $[\text{Co}(\text{en})_2\text{Cl}_2]^+$ has cis and trans forms, and the cis form is chiral. $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]^+$ and square-planar $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$ show only geometrical isomerism; $[\text{Co}(\text{en})_3]^{3+}$ shows only optical isomerism.
28.	(d) The neopentyl cation is not formed freely: loss of water from the protonated alcohol is assisted by a 1,2-methyl shift, which gives the tertiary cation $(\text{CH}_3)_2\text{C}^+-\text{CH}_2\text{CH}_3$. Loss of a proton then gives mainly the more substituted alkene (Saytzeff rule), 2-methylbut-2-ene, with less 2-methylbut-1-ene.
29.	(b) A is aniline, B benzenediazonium chloride, C benzonitrile (Sandmeyer reaction) and D, after complete hydrolysis of $-\text{CN}$, benzoic acid.
30.	(d) $\text{Na}_2\text{CO}_3 = 0.01 \text{ mol}$. Phenolphthalein changes colour when CO_3^{2-} has become HCO_3^- (one H^+ each): $0.01 \text{ mol HCl} = 10 \text{ mL}$. Methyl orange would need 20 mL .

CHEMISTRY — SECTION 2: MULTIPLE CORRECT

31.	(c), (d) (A) Incorrect: it is tetrahedral. (B) Incorrect: it is see-saw. (C) Correct: two lone pairs are equatorial. (D) Correct: seven bond pairs.
32.	(a), (c), (d)

	(A) Correct: $\text{pH} = 7 + \frac{1}{2}(\text{pK}_a - \text{pK}_b)$. (B) Incorrect: salt of a strong acid and strong base: neutral. (C) Correct: common-ion effect. (D) Correct: NH_4^+ hydrolyses to give H_3O^+ .
33.	(a), (b) (A) Correct: $t_{1/2} = 0.693/k$. (B) Correct: $\exp(-E_a/RT)$ is dimensionless. (C) Incorrect: only for elementary reactions. (D) Incorrect: it speeds up both directions equally.
34.	(a), (b), (d) (A) Correct: it has non-superimposable mirror images. (B) Correct: $\text{Ni}(0)$, sp^3 , all electrons paired. (C) Incorrect: it is +2. (D) Correct: Δt is small (about $4/9 \Delta_o$).
35.	(a), (c), (d) (A) Correct: no free hemiacetal group. (B) Incorrect: the peptide sequence stays intact. (C) Correct: glycine has two H on the α carbon. (D) Correct: which humans cannot digest.

CHEMISTRY — SECTION 3: NUMERICAL VALUE

36.	1.16 Cell reaction: $\text{Zn} + \text{Cu}^{2+} \rightarrow \text{Zn}^{2+} + \text{Cu}$, $n = 2$. $E = E^\circ - (0.0591/2) \log([\text{Zn}^{2+}]/[\text{Cu}^{2+}]) = 1.10 - 0.02955 \times \log(0.01) = 1.10 + 0.0591 = 1.16 \text{ V}$.
37.	1.73 Fe^{3+} is d^5 ; CN^- is a strong-field ligand, so the complex is low-spin t_2g^5 with one unpaired electron: $\mu = \sqrt{1 \times 3} = 1.73 \text{ BM}$.
38.	75 NaHCO_3 : $0.84/84 = 0.01 \text{ mol}$ needs $0.005 \text{ mol H}_2\text{SO}_4$; Na_2CO_3 : $1.06/106 = 0.01 \text{ mol}$ needs $0.01 \text{ mol H}_2\text{SO}_4$. Total 0.015 mol , so $V = 0.015/0.2 \text{ L} = 75.00 \text{ mL}$.
39.	5.13 NH_4^+ is the conjugate acid of a weak base: $\text{pH} = \frac{1}{2}(\text{pK}_w - \text{pK}_b - \log C) = \frac{1}{2}(14 - 4.74 + 1) = 5.13$.
40.	6 XeF_2 has 3 lone pairs on Xe (linear), XeF_4 has 2 (square planar) and XeO_3 has 1 (pyramidal): $3 + 2 + 1 = 6$.

MATHEMATICS — SECTION 1: SINGLE CORRECT

41.	(a) $(I - A)(I + A + A^2) = I - A^3$.
42.	(c) $1 - \cos 2x = 2 \sin^2 x \approx 2x^2$, $3 + \cos x \rightarrow 4$ and $x \tan 4x \approx 4x^2$, so the limit is $(2x^2 \times 4)/(4x^2) = 2$.
43.	(a) Minimise $D = (x - 3)^2 + x^4$: $D' = 2(x - 3) + 4x^3 = 0$, i.e. $2x^3 + x - 3 = 0$, whose only real root is $x = 1$ ($D'' > 0$). The point is $(1, 1)$.
44.	(b) The region lies in the first quadrant between the chord $x/3 + y/2 = 1$ and the ellipse: (quarter ellipse $6\pi/4$) – (triangle of area 3) = $3\pi/2 - 3$.
45.	(d) Subtract the equations.
46.	(d) It passes through the origin, and its normal is $(1, 1, 1) \times (1, 0, 0) = (0, 1, -1)$: $y - z = 0$.
47.	(a) Integrating factor = $e^{\int \tan x \, dx} = \sec x$, so $d(y \sec x)/dx = \sec^2 x$ and $y \sec x = \tan x + C$. $y(0) = 0$ gives $C = 0$, so $y = \sin x$.
48.	(b) $\omega^4 = \omega$ and $\omega^8 = \omega^2$, so the product is $[(1 - \omega)(1 - \omega^2)]^2 = (1 - \omega - \omega^2 + 1)^2 = 3^2 = 9$.
49.	(b) $S_n = 2 - 2^{1-n} > 1.99$ needs $2^{n-1} > 100$, i.e. $n - 1 \geq 7$, $n = 8$.

50.	(c) $ \text{adj } B = B ^{n-1}$ for an $n \times n$ matrix. $ 2A = 2^3 \times 4 = 32$, so $ \text{adj}(2A) = 32^2 = 1024$.
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MATHEMATICS — SECTION 2: MULTIPLE CORRECT

51.	(b), (d) (A) Incorrect: it is decreasing there. (B) Correct: $f''(3) > 0$. (C) Incorrect: $f(1) = 5$. (D) Correct: $f'(x) = 6x - 12$ changes sign at 2.
52.	(a), (d) (A) Correct: $4a = 8$. (B) Incorrect: it is $x = 0$. (C) Incorrect: it lies on the parabola ($16 = 16$). (D) Correct: $x = -a$.
53.	(a), (b), (d) (A) Correct: the right side is a function of y/x . (B) Correct: with $y = vx$, $x \, dv/dx = \tan v$, so $\int \cot v \, dv = \int dx/x$ and $\ln \sin v = \ln x + c$. (C) Incorrect: that would need $\int \tan v \, dv$. (D) Correct: $\sin(\pi/2) = C \times 1$ gives $C = 1$.
54.	(b), (d) (A) Incorrect: for odd n there are two middle terms. (B) Correct: put $x = 1$. (C) Incorrect: it is $n + 1$. (D) Correct: put $x = -1$.
55.	(a), (b), (c) (A) Correct: $f = 1$ on $[0, 1]$. (B) Correct: corners at both points. (C) Correct: f is constant near $1/2$. (D) Incorrect: it is constant there.

MATHEMATICS — SECTION 3: NUMERICAL VALUE

56.	2.12 $a_2 - a_1 = (1, -3, -2)$ and $b_1 \times b_2 = (-3, 0, 3)$. $SD = (a_2 - a_1) \cdot (b_1 \times b_2) / b_1 \times b_2 = -3 - 6 / \sqrt{18} = 3/\sqrt{2} = 2.12$.
57.	14 $2C(n, 5) = C(n, 4) + C(n, 6)$. Dividing by $C(n, 4)$: $2(n-4)/5 = 1 + (n-4)(n-5)/30$, i.e. $n^2 - 21n + 98 = 0$, so $n = 7$ or 14 ; the largest value is 14.
58.	24 A vertex at $(4 \cos \theta, 3 \sin \theta)$ gives area $= 4 \times 4 \cos \theta \times 3 \sin \theta = 24 \sin 2\theta$, with maximum 24.00 at $\theta = \pi/4$.
59.	20 Along the normal $(1, 2, 4)$: the foot is at t with $(1+t) + 2(2+2t) + 4(3+4t) = 38$, i.e. $17 + 21t = 38$, so $t = 1$. The image is at $2t$: $(3, 6, 11)$, and $a + b + c = 20.00$.
60.	0.33 $a/(1-r) = 4$ and $a^2/(1-r^2) = 8$. Dividing the square of the first by the second: $(1+r)/(1-r) = 16/8 = 2$, so $r = 1/3 \approx 0.33$ (and $a = 8/3$).