MHT CET 2020 Mathematics Answer Key PDF

Part I: Physics

Question 1 Option: (c) – $1/3$
Explanation: The energy stored in parallel and series combinations is $E_p = \frac{1}{2}C_pV_p^2$ and $E_s = \frac{1}{2}C_sV_s^2$ respectively. Since $C_p = 3C$ and $C_s = C/3$, equating $E_p = E_s$ yields the ratio of the potential differences as $V_p/V_s = 1/3$.

Question 2 Option: (d) – $-1/\sqrt{2}$
Explanation: Since the unit vector is perpendicular to $\hat{i}+\hat{j}$, their dot product is zero, yielding $a + b = 0$. Using the unit magnitude condition $a^2 + b^2 = 1$ leads directly to $b = -1/\sqrt{2}$.

Question 3 Option: (c) – $F_1 + F_2$
Explanation: For the net torque about the center of the equilateral triangle to be zero, the sum of the moments of all forces must vanish. Taking torque about the center shows that F_3 must balance the combined action of F_1 and F_2, giving $F_3 = F_1 + F_2$.

Question 4 Option: (d) – 10 gram
Explanation: The fundamental frequency of the closed organ pipe is 100 Hz, which equals the first overtone frequency of the string. Substituting the values into the wave velocity formula $v = \sqrt{T/\mu}$ gives the total mass of the string as 10 grams.

Question 5 Option: (c) – pressure if $a = -1, b = 1, c = -2$
Explanation: The dimensional formula of pressure is $[\mathrm{M^1L^{-1}T^{-2}}]$, which corresponds to the indices $a = -1$, $b = 1$, and $c = -2$. This perfectly matches the dimensions of force divided by area.

Question 6 Option: (c) – 6 : 1
Explanation: Using the meter bridge balancing condition, the resistance ratio is $R_A/R_B = 40/60 = 2/3$. Since the diameter ratio is 3 : 1, the cross-sectional area ratio is 9 : 1, giving the specific resistance ratio as 6 : 1.

Question 7 Option: (a) – $i \approx 0, i_L = i_C \neq 0$
Explanation: In a parallel resonant circuit, the total impedance is theoretically infinite, which results in the net RMS line current i being approximately zero. However, the individual branch currents i_L and i_C remain non-zero and equal in magnitude.

Question 8 Option: (b) – 300 Hz
Explanation: The frequencies of the tuning forks are $1.015f_C$ and $0.975f_C$ respectively. Sounding them together produces a beat frequency of $0.04f_C = 12$ Hz, which yields the frequency of fork C as 300 Hz.

Question 9 Option: (a) – $\sqrt{\frac{T}{ml}}$
Explanation: For a mass moving in a horizontal circle at the end of a string, the tension provides the necessary centripetal force, $T = m\omega^2 l$. Solving this equation for the angular velocity directly yields $\omega = \sqrt{T/ml}$.

Question 10 Option: (c) – $\frac{v^2m}{2e}$
Explanation: The maximum kinetic energy of the emitted photoelectrons is equated to the stopping potential energy, $\frac{1}{2}mv^2 = eV_0$. Rearranging this equation to solve for the stopping potential V_0 yields $\frac{v^2m}{2e}$.

Question 11 Option: (a) – M_2/M_1
Explanation: By conservation of momentum, the two fragments possess equal and opposite momenta, $P_1 = -P_2$. Using the kinetic energy relation $K = P^2/2M$, the ratio of their kinetic energies is inversely proportional to their masses, yielding M_2/M_1.

Question 12 Option: (b) – repeat the experiment by interchanging the resistance in gaps.
Explanation: Contact resistance introduces systematic errors at the ends of the meter bridge wire. Interchanging the resistances in the left and right gaps and taking the mean of the two readings successfully eliminates this error.

Question 13 Option: (b) – $\frac{2BA^{3/2}}{\mu_0\pi^{1/2}}$
Explanation: Using the magnetic field formula at the center $B = \mu_0 I/2r$ and area $A = \pi r^2$ to substitute for r, we solve for the current I. The magnetic moment $M = IA$ is then calculated to be $\frac{2BA^{3/2}}{\mu_0\pi^{1/2}}$.

Question 14 Option: (b) – inversely as the absolute temperature.
Explanation: According to the Curie-Weiss law, the magnetic susceptibility of a ferromagnetic material in its paramagnetic phase above the Curie temperature varies inversely with the absolute temperature.

Question 15 Option: (a) – $\frac{3v^2}{4g}$
Explanation: Applying the conservation of energy for a solid cylinder rolling down an inclined plane yields $Mgh = \frac{1}{2}Mv^2(1 + K^2/R^2)$. Substituting the radius of gyration $K^2/R^2 = 1/2$ and simplifying gives the height $h = 3v^2/4g$.

Question 16 Option: (b) – $\sqrt{3}v_e$
Explanation: By conservation of energy, the total energy at the Earth's surface must equal the kinetic energy at infinity. Since $v = 2v_e$, the final velocity is calculated from the energy relation $v_\infty = \sqrt{v^2 - v_e^2} = \sqrt{3}v_e$.

Question 17 Option: (a) – $r_1 : r_2$
Explanation: Since both cars complete one full revolution in the exact same time interval, their angular speeds are equal. The ratio of their linear speeds is therefore directly proportional to their circular radii, giving $r_1 : r_2$.

Question 18 Option: (b) – $2(P^2 + Q^2)$
Explanation: The magnitudes of the two resultants are given by $R_1^2 = P^2 + Q^2 + 2PQ\cos\theta$ and $R_2^2 = P^2 + Q^2 - 2PQ\cos\theta$. Adding these two equations directly yields the simplified relation $R_1^2 + R_2^2 = 2(P^2 + Q^2)$.

Question 19 Option: (a) – valence band and conduction band overlap each other.
Explanation: In metallic conductors, the valence and conduction bands overlap, which eliminates any energy gap. This configuration allows a large number of free electrons to easily participate in electrical conduction.

Question 20 Option: (b) – 500 Hz
Explanation: The beat frequency is given by $f' - f = f(\sqrt{1.02} - 1) \approx 0.01f$. Setting this equal to the 5 beats per second produced by the wires yields an initial frequency of $f = 500$ Hz.

Part II: Chemistry

1. **Question 1 Option:** (b) – It increases the rates of both forward and backward reactions equally in reversible reaction.
   Explanation: A catalyst lowers the activation energy of both the forward and backward pathways of a reversible reaction by the same amount, thereby increasing both rates equally without altering the equilibrium position.

2. **Question 2 Option:** (c) – n-pentane > Isopentane > Neopentane
   Explanation: As branching increases in isomeric alkanes, the molecular shape becomes more spherical, reducing the surface area and the strength of the intermolecular van der Waals forces, which lowers the boiling point.

3. **Question 3 Option:** (d) – $H_2S_2O_2$
Explanation: Thiosulfurous acid ($H_2S_2O_2$) possesses a characteristic thiosulfur S = S double bond linkage in its structure, distinguishing it from other sulfur-containing oxy-acids.

4. **Question 4 Option:** (b) – iodomethane and iodoethane
Explanation: Cleavage of methoxyethane with hot concentrated hydroiodic acid (HI) involves nucleophilic substitution on both alkyl groups, converting the entire ether into iodomethane and iodoethane.

5. **Question 5 Option:** (a) – primary amine
Explanation: Reacting an alkyl halide with a large excess of alcoholic ammonia favors the nucleophilic substitution of the halide by ammonia, suppressing further alkylation to yield a primary amine as the major product.

6. **Question 6 Option:** (a) – $3.0\,\text{gL}^{-1}$ urea and $17.19\,\text{gL}^{-1}$ sucrose
Explanation: Isotonic solutions must have identical molar concentrations. Calculating the molarity of both solutions yields $3.0/60 = 0.05\,\text{M}$ and $17.19/342 \approx 0.05\,\text{M}$, showing they are isotonic.

7. **Question 7 Option:** (d) – 60°
Explanation: White phosphorus exists as discrete P_4 tetrahedral molecules where each phosphorus atom is situated at a corner, leading to a highly strained $P-P-P$ bond angle of 60°.

8. **Question 8 Option:** (d) – True solution is a heterogenous mixture of two or more substances with fixed composition.
Explanation: By definition, a true solution is a completely homogeneous mixture at the molecular level, making the statement describing it as heterogeneous incorrect.

9. **Question 9 Option:** (c) – $51.08\,\text{kJ mol}^{-1}$
Explanation: According to Hess's law, the enthalpy of sublimation is the sum of the enthalpy of fusion and the enthalpy of vaporization, which is calculated as $6.01 + 45.07 = 51.08\,\text{kJ mol}^{-1}$.

10. **Question 10 Option:** (d) – 74.5 g
Explanation: From the balanced equation, 3 moles (67.2 L) of O_2 produces 2 moles of KCl. Thus, 33.6 L (1.5 moles) of O_2 yields 1 mole of KCl, which has a molar mass of 74.5 g.

11. **Question 11 Option:** (a) – 128 pm
Explanation: Due to resonance, both oxygen-oxygen bonds in the ozone molecule are equivalent, exhibiting an intermediate bond length of 128 pm which is between a single and a double bond.

12. **Question 12 Option:** (b) – Zn
Explanation: Zinc has a completely filled d-subshell ($3d^{10}4s^2$), which prevents the formation of strong covalent metallic bonds, rendering it a soft metal compared to Co, W, and Mo.

13. **Question 13 Option:** (a) – Butyl rubber
Explanation: Copolymerization of isobutylene with a small amount of isoprene in the presence of an anhydrous aluminum chloride catalyst at low temperatures yields synthetic butyl rubber.

14. **Question 14 Option:** (a) – 4.3×10^{-8} cm
Explanation: For a body-centered cubic (bcc) structure, the unit cell edge length a is related to the atomic radius r by $a = 4r/\sqrt{3}$. Substituting $r = 1.86 \times 10^{-8}$ cm yields $a \approx 4.3 \times 10^{-8}$ cm.

15. **Question 15 Option:** (d) – Zero
Explanation: In glucose ($C_6H_{12}O_6$), the sum of the oxidation numbers of hydrogen (+1) and oxygen (-2) balances out, leaving the average oxidation state of carbon as exactly zero.

Part III: Mathematics

1. **Question 1 Option:** (a) – $\sin^{-1}\left(\frac{x-2}{3}\right) + c$
Explanation: Completing the square in the denominator yields $5+4x-x^2 = 9-(x-2)^2$. Applying the standard integration formula $\int \frac{dx}{\sqrt{a^2-u^2}}$ directly gives $\sin^{-1}((x-2)/3) + c$.

2. **Question 2 Option:** (c) – not defined
Explanation: Because the derivative dy/dx appears as an exponent in the term $e^{dy/dx}$, the differential equation cannot be written as a polynomial in its derivatives, making its degree undefined.

3. **Question 3 Option:** (d) – $n\pi \pm \left(\frac{\pi}{4} - \frac{\alpha}{2}\right), n \in \mathbb{Z}$
Explanation: Rewriting the equation gives $\cos 2\theta = \cos(\pi/2 - \alpha)$. The general solution is $2\theta = 2n\pi \pm (\pi/2 - \alpha)$, which simplifies to $\theta = n\pi \pm (\pi/4 - \alpha/2)$.

4. **Question 4 Option:** (a) – $\frac{x}{y} + \log|x| = c$
Explanation: Dividing the homogeneous equation by x^2 and substituting $y = vx$ leads to the variable-separable equation $\frac{dv}{v^2} = \frac{dx}{x}$. Integrating both sides and substituting back yields $\frac{x}{y} + \log|x| = c$.

5. **Question 5 Option:** (a) – e^7
Explanation: The maximum value of the linear combination $\sqrt{3}\sin x + \cos x$ is $\sqrt{3+1} = 2$. Therefore, the maximum exponent value is $5+2 = 7$, giving the maximum value of the function as e^7.

6. **Question 6 Option:** (a) – 1/2
Explanation: Simplifying the trigonometric expression gives $\sec x + \tan x = \tan(\pi/4 + x/2)$. Taking the arctangent yields $y = \pi/4 + x/2$, whose derivative with respect to x is $1/2$.

7. **Question 7 Option:** (d) – cube of the velocity
Explanation: The velocity is $v = \frac{1}{2}(1+t)^{-1/2}$ and the acceleration is $a = -\frac{1}{4}(1+t)^{-3/2}$. Expressing the acceleration in terms of velocity yields $a = -2v^3$, showing that $a \propto v^3$.

8. **Question 8 Option:** (b) – -5
Explanation: Evaluating the vector triple product inside the brackets shows it simplifies to $\vec{b} - 2\vec{a}$. Taking the dot product with $2\vec{a} - \vec{b}$ and utilizing the orthonormality of the vectors yields -5.

9. **Question 9 Option:** (a) – a contradiction
Explanation: Simplifying the statement using distributive laws yields $[(p \vee q) \wedge \sim p] \equiv \sim p \wedge q$. Consequently, the entire conjunction with $\sim q$ simplifies to F, which represents a contradiction.

10. **Question 10 Option:** (a) – 1/221
Explanation: The probability of drawing the first queen is 4/52 and the second queen

without replacement is 3/51. Multiplying these probabilities yields $(1/13) \times (1/17) = 1/221$.

11. **Question 11 Option:** (b) – $\pi/8$
Explanation: Substituting $u = \sin^2 x$ converts the integral into $\frac{1}{2}\int_0^1 \frac{du}{1+u^2}$. Evaluating this definite integral yields $\frac{1}{2}[\tan^{-1} u]_0^1 = \pi/8$.

12. **Question 12 Option:** (b) – 1
Explanation: Using the complementary relation $\tan(90^\circ - \theta) = \cot\theta$, the terms in the product pair up as $\tan\theta \cot\theta = 1$. The remaining unpaired central term is $\tan 45^\circ = 1$, yielding a product of 1.

13. **Question 13 Option:** (a) – 36 units^3
Explanation: The volume of the new parallelepiped is evaluated as the determinant of the coefficients times the original volume, which is calculated as $9 \times [\vec{a}\ \vec{b}\ \vec{c}] = 9 \times 4 = 36$ units^3.

14. **Question 14 Option:** (a) – 0
Explanation: The integrand $f(x) = \frac{e^x + e^{-x}}{e^x - e^{-x}}$ is an odd function because $f(-x) = -f(x)$. The definite integral of any odd function over a symmetric interval $[-5, 5]$ is always zero.

15. **Question 15 Option:** (c) – 32/3 sq. units
Explanation: The latus rectum is the vertical line $x = 2$. The bounded area is computed by evaluating the integral $2\int_0^2 \sqrt{8x}\, dx = 4\sqrt{2}\left[\frac{2}{3}x^{3/2}\right]_0^2 = 32/3$ square units.