PHYSICS MODEL TEST PAPER

Q.1 The equation $z^2 + \bar{z}^2 = 4$ in the complex plane (where $\bar{z}$ is the complex conjugate of z) represents
(A) Ellipse
(B) Hyperbola
(C) Circle of radius 2
(D) Circle of radius 4

Q.2 At a temperature T, let β and κ denote the volume expansivity and isothermal compressibility of a gas, respectively. Then $\beta\,\kappa$ is equal to
(A) $(\partial P/\partial T)_V$
(B) $(\partial P/\partial V)_T$
(C) $(\partial T/\partial P)_V$
(D) $(\partial T/\partial V)_P$

Q.3 The resultant of the binary subtraction 1110101 − 0011110 is
(A) 1001111
(B) 1010111
(C) 1010011
(D) 1010001

Q.4 Consider a particle trapped in a three-dimensional potential well such that $U(x, y, z) = 0$ for $0 \le x \le a$, $0 \le y \le a$, $0 \le z \le a$ and $U(x, y, z) = \infty$ everywhere else. The degeneracy of the 5th excited state is
(A) 1
(B) 3
(C) 6
(D) 9

Q.5 Consider a two-dimensional force field $\vec{F}(x, y) = (5x^2 + ay^2 + bxy)\,\hat{x} + (4x^2 + 4xy + y^2)\,\hat{y}$. If the force field is conservative, then the values of a and b are
(A) $a = 2$ and $b = 4$
(B) $a = 2$ and $b = 8$
(C) $a = 4$ and $b = 2$
(D) $a = 8$ and $b = 2$

Q.6 A wheel is rotating at a frequency f_0 Hz about a fixed vertical axis. The wheel stops in t_o seconds, with constant angular deceleration. The number of turns covered by the wheel before it comes to rest is given by:
(A) $f_o t_0$
(B) $2 f_o t_0$
(C) $f_o t_0/2$
(D) $f_o t_0/\sqrt{2}$

Q.7 Two objects of masses m and 2m are moving at speeds of v and $v/2$, respectively. After undergoing a completely inelastic collision, they move together with a speed of $v/3$. The angle between the initial velocity vectors of the two objects is

(A) 60°
(B) 120°
(C) 45°
(D) 90°

Q.8 The intensity of the primary maximum in a two-slit interference pattern is given by I2 and the intensity of the primary maximum in a three-slit interference pattern is given by I3. Assuming the far-field approximation, same slit parameters and intensity of the incident light in both the cases, I2 and I3 are related as
(A) $I_2 = 3/2\ I_3$
(B) $I_2 = 9/4\ I_3$
(C) $I_2 = 2/3\ I_3$
(D) $I_2 = 4/9\ I_3$

Q.9 A short rod of length L and negligible diameter lies along the optical axis of a concave mirror at a distance of 3 m. The focal length of the mirror is 1 m and L << 1 m. If L' is the length of image of the object in the mirror, then
(A) $L'/L = 4$
(B) $L'/L = 2$
(C) $L'/L = 1/16$
(D) $L'/L = 1/4$

Q.10 The root mean square (rms) speeds of Hydrogen atoms at 500 K, VH, and Helium atoms at 2000 K, VHe, are related as
(A) $V_H > V_{He}$
(B) $V_H < V_{He}$
(C) $V_H = V_{He}$
(D) $V_H \gg V_{He}$

Q.11 Let $f(x) = 3x^6 - 2x^2 - 8$. Which of the following statements is (are) true?
(A) The sum of all its roots is zero.
(B) The product of its roots is $-8/3$.
(C) The sum of all its roots is 2/3 .
(D) Complex roots are conjugates of each other.

Q.12 Two beams of light in the visible range (400 nm - 700 nm) interfere with each other at a point. The optical path difference between them is 5000 nm. Which of the following wavelengths will interfere constructively at the given point?
(A) 416.67 nm
(B) 555.55 nm
(C) 625 nm
(D) 666.66 nm

Q.13 Let the electric field in some region R be given by $\vec{E} = e^{-y^2}\hat{i} + e^{-x^2}\hat{j}$. From this we may conclude that
(A) R has a non-uniform charge distribution.
(B) R has no charge distribution.
(C) R has a time dependent magnetic field.
(D) The energy flux in R is zero everywhere.

Q.14 In a pn junction, dopant concentration on the p- side is higher than that on the n-side. Which of the following statements is (are) correct, when the junction is unbiased?
(A) The width of the depletion layer is larger on the n-side.
(B) At thermal equilibrium the Fermi energy is higher on the p- side.
(C) In the depletion region, the number of negative charges per unit area on the p- side is equal to the number of positive charges per unit area on the n- side.
(D) The value of the built-in potential barrier depends on the dopant concentration.

Q.15 Which of the combinations of crystal structure and their coordination number is (are) correct?
(A) body centred cubic – 8
(B) face centred cubic – 6
(C) diamond – 4
(D) hexagonal closed packed – 12

Q.16 A particle moves in a circular path in the xy -plane centred at the origin. If the speed of the particle is constant, then its angular momentum
(A) about the origin is constant both in magnitude and direction.
(B) about (0, 0, 1) is constant in magnitude but not in direction.
(C) about (0, 0, 1) varies both in magnitude and direction.
(D) about (0, 0, 1) is constant in direction but not in magnitude.

Q.17 A pn junction was formed with a heavily doped (10^{18} cm^{-3}) p-region and lightly doped (10^{14} cm^{-3}) nregion. Which of the following statement(s) is(are) correct?
(A) The width of the depletion layer will be more on the n-side of the junction.
(B) The width of the depletion layer will be more on the p-side of the junction.
(C) The width of the depletion layer will be the same on both sides of the junction.
(D) If the pn junction is reverse biased, then the width of the depletion region increases.

Q.18 A slit has width ‘d’ along the x-direction. If a beam of electrons, accelerated in y-direction to a particular velocity by applying a potential difference of 100 ± 0.1 kV passes through the slit, then, which of the following statement(s) is(are) correct?
(A) The uncertainty in the position of electrons in x-direction before passing the slit is zero. (B) The momentum of electrons in x-direction is ~ d immediately after passing the slit.
(C) The uncertainty in the position of electrons in y-direction before passing the slit is zero. (D) The presence of the slit does not affect the uncertainty in momentum of electrons in y-direction.

Q.19 A free particle of energy E collides with a one-dimensional square potential barrier of height V and width WW. Which one of the following statement(s) is(are) correct?
(A) For $EE > VV$, the transmission coefficient for the particle across the barrier will always be unity.
(B) For $EE < VV$, the transmission coefficient changes more rapidly with WW than with VV. (C) For $EE < VV$, if VV is doubled, the transmission coefficient will also be doubled.
(D) Sum of the reflection and the transmission coefficients is always one

Q.20 A time independent conservative force F has the form, $F = 3y\hat{\imath} + f(x, y)\hat{\jmath}$. Its magnitude at $x = y = 0$ is 8. The allowed form(s) of $f(x, y)$ is(are)
(A) $3x + 8$
(B) $2x + 8(y - 1)^2$

(C) $3x + 8e^{-y^2}$
(D) $2x + 8 \cos y$

Q.21 One of the roots of the equation, $z^6 - 3z^4 - 16 = 0$ is given by $z_1 = 2$. The value of the product of the other five roots is _____.

Q.22 A small conducting square loop of side l is placed inside a concentric large conducting square loop of side L ($L \gg l$). The value of mutual inductance of the system is expressed as $n\mu 0\ l^2 / \pi L$. The value of n is _____ (Round off to two decimal places).

Q.23 Consider N_1 number of ideal gas particles enclosed in a volume V_1. If the volume is changed to V_2 and the number of particles is reduced by half, the mean free path becomes four times of its initial value. The ratio V_1/V_2 is _____ (Round off to one decimal place)

Q.24 A particle is moving with a velocity $0.8c\hat{j}$(c is the speed of light) in an inertial frame S_1. Frame S_2 is moving with a velocity $0.8c\hat{\imath}$ with respect to S_1. Let E_1 and E_2 be the respective energies of the particle in the two frames. Then, E_2 / E_1 is _____ (Round off to two decimal places).

Q.25 At some temperature T, two metals A and B, have Fermi energies ϵA and ϵB, respectively. The free electron density of A is 64 times that of B. The ratio ϵA / ϵB is _____.

Q.26 If the wavelength of the Kα2 X-ray line of an element is 1.544Å, then the atomic number (Z) of the element is _____. (Rydberg constant R = 1.097×10^7 m^{-1} and velocity of light c = 3×10^8 m/s)

Q.27 A proton is confined within a nucleus of size 10^{-13} cm. The uncertainty in its velocity is _____ × 10^8 m/s. (Round off to 2 decimal places) (Planck's constant h = 6.626×10^{-34} J s and proton mass mp = 1.672×10^{-27} kg)

Q.28 If the diameter of the Earth is increased by 4% without changing the mass, then the length of the day is _____hours. (Take the length of the day before the increment as 24 hours. Assume the Earth to be a sphere with uniform density.) (Round off to 2 decimal places)

Q.29 A di-atomic gas undergoes adiabatic expansion against the piston of a cylinder. As a result, the temperature of the gas drops from 1150 K to 400 K. The number of moles of the gas required to obtain 2300 J of work from the expansion is _____. (The gas constant R = 8.314 J $mol^{-1}K^{-1}$.) (Round off to 2 decimal places)

Q.30 The decimal equivalent of the binary number 110.101 is _____.

ANSWER KEY

Question No.	Question Type (QT)	Subject Name (SN)	Key/Range (KY)	Mark (MK)

1	MCQ	PH	B	1
2	MCQ	PH	A	1
3	MCQ	PH	B	1
4	MCQ	PH	C	1
5	MCQ	PH	B	1
6	MCQ	PH	C	2
7	MCQ	PH	B	2
8	MCQ	PH	D	2
9	MCQ	PH	D	2
10	MCQ	PH	C	2
11	MSQ	PH	A;B;D	2
12	MSQ	PH	A;B;C	2
13	MSQ	PH	B;C	2
14	MSQ	PH	A;C;D	2
15	NAT	PH	A;C;D	2
16	MSQ	PH	A;B	2
17	MSQ	PH	A;D	2
18	MSQ	PH	B;D	2
19	MSQ	PH	B;D	2
20	MSQ	PH	A;C	2
21	NAT	PH	-8	1

22	NAT	PH	2.80 to 2.85	1
23	NAT	PH	0.5	1
24	NAT	PH	1.64 to 1.68	1
25	NAT	PH	16	1
26	NAT	PH	29	2
27	NAT	PH	0.3 to 3.97	2
28	NAT	PH	25.95 to 25.97	2
29	NAT	PH	0.14 to 0.16	2
30	NAT	PH	6.625	2