Use the following codes to answer Q1-Q5.

(1) If both assertion (A) as well as reason (R) are correct and (R) is the correct explanation of (A)
(2) If both (A) and (R) are correct but (R) is not the correct explanation of (A)
(3) If (A) is correct but (R) is incorrect
(4) If (A) is incorrect but (R) is correct

Q1. Assertion (A): The fundamental frequency of an open organ pipe increases as the temperature is increased.

Reason (R): As the temperature increases, the velocity of sound increases more rapidly than length of the pipe.

Q2. Assertion (A) :In a process if initial volume is equal to the final volume, work done by the gas is zero.

Reason (R) : In an isochoric process work done by the gas is zero.

Q3. Assertion (A) : Critical angle of the light passing from glass to air is minimum from violet color .

Reason (R) : The wavelength of violet color is greater than the light of other colors

Q4. Assertion (A) : if length of the conductor is double , the drift velocity will become half of the original value (keeping the potential difference unchanged)

Reason (R): at constant potential difference , drift velocity is inversely proportional to the length of the conductor .

Q5. Assertion (A) : metallic shield in the form of a hollow shell , can be built to block an electric field.

Reason (R) : in a hollow spherical shell, the electric field inside it is zero at every point.

Following questions are based on a paragraph. Read the paragraph carefully and answer the questions that follow.

For Q6-Q8. One particle of mass 1 kg is moving along positive x axis with velocity 3 m/s . Another particle of mass 2 kg is moving along y-axis with velocity 6 m/s. At time t = 0 , 1 kg mass is at (3m,0) and 2 kg mass is at (0, 9m) . x-y plane is the horizontal plane (surface is smooth for Q6 and rough for Q7 and Q8

Q6. The centre of mass of the two particles is moving in a straight line :

(1) $y = x + 2$
(2) $y = 4x + 2$
(3) $y = 2x - 4$
(4) $y = 2x + 4$

Q7. If both the particles have the same value of coefficient of 0.2 . The centre of mass will stop at time t = ……. Seconds :

(1) 1. 5
(2) 4. 5
(3) 3.0
(4) 2.0

Q8. Co-ordinates of centre of mass where it will stop finally are :

(1) (2.0 m , 14.25 m)
(2) (2.25 m, 10 m)
(3) (3.75 m , 9 m)
(4) (1.75 m , 12 m)

In a conservative force field we can find the radial component of force from the potential energy function by using $F = -\frac{dU}{dr}$. Here, a positive force means repulsion and a negative force means

Attraction. From the given potential energy function U(r) we can find the equilibrium position where force is zero. We can also find the ionization energy which is the work done to move the particle from a certain position to infinity .

Let us consider a case where a particle is bound to a certain point at a distance r from the centre of the force .The potential energy of the particle is : $U(r) = \frac{A}{r^2} - \frac{B}{r}$, where r is the distance from the centre of the force and A and B are positive constants. Answer the following questions.

Q9. The equilibrium distance is given by :

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

Q10. The equilibrium state is :

(1) Stable
(2) Unstable
(3) Neutral
(4) Cannot be predicted

Q11. The work required to move the particle from equilibrium distance to infinity is :

(1) B/4A
(2) 4B/A
(3) $B^2/4A$
(4) $4B^2/A$

Q12. If the total energy of the particle is $E = -\frac{3B^2}{16A}$ and it is known that the motion is radial only then the velocity is zero at : (where r_0 *is the equilibrium distance*)

(1) $\frac{r_0}{3}$

(2). $\frac{2r_0}{3}$

(3). r_0

(4). $\frac{2r_0}{5}$

Q13. A particle moves in a circular path with decreasing speed. Choose the correct statement :

(1) Angular momentum remains constant.
(2) Acceleration is towards the centre.
(3) Particle moves in a spiral path with decreasing radius.
(4) The direction of angular momentum remains constant.

Q14. The potential at the surface of a planet of mass M and radius R is assumed to be zero. Choose the most appropriate option :

(1) The potential at infinity is GM/R.
(2) The potential at the centre of planet is – GM/2R
(3) Both (1) and (2) are correct.
(4) Both (1) and (2) are wrong.

Q15. A satellite revolves around the earth. Air pressure inside the satellite is maintained at 76 cm of mercury. What will be the height of mercury column in a barometer tube 90 cm long placed in the satellite ?

(1) 76 cm
(2) 90 cm
(3) Zero
(4) None of these.

Q16. An ideal gas is allowed to expand against a vaccum in a rigid insulator container. Choose the correct alternative (s) :

(a) Work done by the gas is zero.
(b) Pressure of the gas is inversely proportional to volume of the gas.

(c) Change internal energy of the gas is zero.
(d) Temperature of the gas remains constant during expansion.

(1) Only (a)
(2) Only (a) and (b)
(3) Only (a), (b) and (c)
(4) All the four

Q17. A gas mixture consists of 2 moles of oxygen and 4 moles of argon at temperature T . Neglecting all vibrational modes , the total internal energy of the system is :

(1) 4RT
(2) 15RT
(3) 9RT
(4) 11 RT

Q18. A ray of light undergoes deviation of 30^0 when incident on an equilateral prism of refraction index $= \sqrt{2}$. The angle made by the ray inside the prism with the base of the prism is :

(1) 15^0
(2) 0^0
(3) 45^0
(4) 30^0

Q19. Potential difference across the terminals of an non ideal battery is :

(a) Zero when it is short circuited.
(b) Less than its emf when current flows from negative terminal to positive terminal inside the battery.
(c) Zero when no current is drawn from the battery.
(d) Greater than its emf when current flows from positive terminal to negative terminal inside the battery.

(1) Only (a)
(2) Only (a) and (c)
(3) Only (a) , (b) and (d)
(4) All of the four.

Q20. A hollow metal sphere of radius r = 5 cm is charged such that the potential on its surface is 10V. the potential at the centre of the sphere is :

(1) Zero
(2) 10 V
(3) Same as at a point 5 cm away from the surface.
(4) Same as at a point 25 cm away from the surface.

Q21. An electron is moving along x-axis . A uniform electric field exists towards negative y- axis. What should be the direction of magnetic field of suitable magnitude so that net force on electron is zero ?

(1) Positive z axis
(2) Negative z-axis
(3) Positive y –axis
(4) Negative y-axis

Q22. An inductor coil having some resistance is connected to an AC source. Which of the following have zero average value over a cycle ?

(1) Induced emf in the inductor
(2) Current
(3) Both (1) and (2)
(4) None of the above

Q23. Two identical coaxial circular loops carry a current i each circulating in the same direction . if the loops approach each other :

(1) The current in each loop will decrease
(2) The current in each loop will increase
(3) The current in each loop will remain the same
(4) The current in one loop will increase and in

In the other loop will decreases.

Q24. The angular momentum of an electron in an orbit is quantized because it is a necessary condition for the compatibility with :

(1) The wave nature of electron
(2) Particle nature of electron
(3) Paulli's exclusion behavior
(4) None of the above

Q25. The ratio between total acceleration of the electron in singly ionized helium atom and hydrogen (both in ground state) :

(1) 1
(2) 8
(3) 4
(4) 16

Q26. In an x-ray tube when the accelerating voltage is halved the difference between the wavelengths of K_α and minimum wavelength of continuous X-ray spectrum.

(1) Remains constant
(2) Becomes more than two times
(3) Becomes half
(4) Becomes less than two times

Q27. The current throught an inductor of 1 H is given by $i = 3t\sin t$. the voltage across the inductor is :

(1) $3\sin t + 3\cos t$
(2) $3\cos t + t\sin t$
(3) $3\sin t + 3\,\mathrm{tcos}\,t$
(4) $3\,\mathrm{tcos}\,t + \sin t$

Q28. At a frequency ω_0 the reactance of a certain capacitor equals that of a certain inductor .if the frequency is changed to $2\omega_0$, what is the ratio of the reactance of the inductor to that of the capacitor ?

(1) 4 :1
(2) $\sqrt{2} : 1$
(3) $1{:}2\sqrt{2}$
(4). 1: 2

Q29. The ratio of intensities of two coherent sound sources is **4:1** . the difference of loudness in decibles (dB) between maximum and minimum intensities ,when they interfere in space is :

(1) 10 log 2
(2) 20 log 3
(3) 10 log 3
(4) 20 log 2

Q30. Speed of transverse waves in a stringn of density 1000kg/m^3 and area of cross-section 10mm^2 under a tension of 1000 N is :

(1) 100 m/s
(2) 1000 m/s
(3) 200 m/s
(4) 2000 m/s

Solution :

Q1. Ans (1)

Q2. Ans (4)

Q3. Ans (3)

Q4. Ans (1)

Q5. Ans (1)

Q6. Ans (2) . At time t , $x_1 = 3 + 3t$, $x_2 = 0$ and $y_2 = 9 + 6t, y_1 = 0$

As position of center of mass will be

$$x_c = \frac{m_1 x_1 + m_2 x_2}{m_1 + m_2} \quad and \quad y_c = \frac{m_1 y_1 + m_2 y_2}{m_1 + m_2}$$

Substitute the values of x_1 , x_2, y_2 and y_1 $and\ eliminate\ t\ , to\ get\ the\ relation$

$$y_c = 4\, x_c + 2 \ \ as\ the\ answer$$

Q7. Ans (3). The first particle will stop after time $t_1 = \frac{V_1}{\mu g} = 1.5\ seconds$ and second particle will stop after time $t_2 = \frac{V_2}{\mu g} = 3\ seconds.$ so the centre of mass will stop when both the particles will stop i.e., at 3 seconds.

Q8. Ans (4). Mass 1 kg will stop at : $x_1 = \ 3 + \frac{v_1^2}{2\mu g} = 3 + \frac{9}{4} = 1.75\ m$ $and\ x_2 = 0$

Similarly mass 2 kg will stop at : $y_2 = 9 + \frac{v_2^2}{2\mu g} = 9 + \frac{36}{4} = 18\ m$ $and\ y_1 = 0$

Again using

$$x_c = \frac{m_1 x_1 + m_2 x_2}{m_1 + m_2} \quad and \quad y_c = \frac{m_1 y_1 + m_2 y_2}{m_1 + m_2}$$

And putting the values of x_1 , x_2, y_2 and y_1 we get the answer for the co-ordinate as (as 1.75 m , 12m)

Q9. Ans (2) . At equilibrium , force is equal to zero. Get force by differentiating the potential energy function with respect to r and then equate it to zero to get the value of r = 2A/B

Q10. Ans (1) . Take the second derivative of the potential energy function and check its sign for equilibrium value of r = 2A/B , you will find that the second derivative is positive and hence potential energy is minimum which corresponds to stable equilibrium

Q11. Ans (4). Potential at infinity is zero and hence potential energy is zero at infinity (put r = infinity in the given expression), potential energy at r = 2A/B is U = $-\frac{B^2}{4A}$ and hence the work done equal to the change in potential energy = $B^2/4A$ as the answer.

Q12. ans (2) . velocity is zero when K.E is zero or when total energy is equal to potential energy . At r = $\frac{2r_0}{3} = \frac{4A}{B}$, $we\ find\ potential\ energy = -\frac{3B^2}{16A}$ $which\ is\ equal\ to\ the\ given\ value.$

Q13. Ans (4).

Q14. Ans (3). At all places potential will increase by GM/R

Q15. Ans (2). Inside the satellite $g_{effective} = 0$. So, there will be no pressure difference inside the mercury. Hence, the mercury will rise to full length of the tube i.e., 90 cm because air pressure outside the tube is 76 cm of mercury , while pressure above the tube is zero.

Q16. Ans (4)

Q17. Ans (4). Internal energy for n moles of an ideal gas at temperature T is given by U = n (f/2)RT , where f is the degrees of freedom .For oxygen f = 5 and for argon f = 3 . Hence internal energy is equal to the sum of internal energy of oxygen and argon = 2(5/2RT) + 4 (3/2RT) = 11RT as the answer

Q18. Ans (2). For minimum deviation $= \sin\left(\frac{A+\delta_{min}}{2}\right) / (\sin A/2)$, Putting the value of $\mu\ and\ A\ gives\ \delta_{min} = 30^0$ i.e., the given deviation is actually the minimum deviation. At minimum deviation the ray inside the prism is parallel to the base in case of an equilateral prism.

Q19. Ans (3) .

Q20. Ans (2). Electric potential at any point inside a hollow metallic sphere is constant. Therefore , if potential at surface is 10V , potential at the centre will also be 10 V.

Q21. Ans (2)

Q22. Ans (3)

Q23. Ans (1)

Q24. Ans (1)

Q25. Ans (2). The acceleration of an electron varies with atomic number as $a \propto z^3$, so for the two cases , the ratio is $\left(\frac{2}{1}\right)^3 = 8:1$

Q26. Ans (4). We know that $\Delta\lambda = \lambda_{K_\alpha} - \lambda_{min}$. when V is halved λ_{min} becomes two times but λ_{K_α} remains the same . hence $\Delta\lambda' = \lambda_{K_\alpha} - 2\lambda_{min} = 2(\Delta\lambda) - \lambda_{K_\alpha}$ so $\Delta\lambda' < 2(\Delta\lambda)$.

Q27. Ans (3). di/dt = $3\sin t + 3\,\text{tcos}\,t$, so V = L di/dt = $1 \times (\ 3\sin t + 3\,\text{tcos}\,t)$ *as the answer*

Q28. Ans(1). $\omega_0 = \frac{1}{\sqrt{LC}}$, $so\ \frac{X_L}{X_C} = \frac{\omega L}{\frac{1}{\omega C}} = \omega^2 LC$. Here $\omega = 2\omega_0 = \frac{2}{\sqrt{LC}}$. so the required ratio = 4

Q29. Ans(2). given that $\frac{I_1}{I_2} = \frac{4}{1}$ or $\sqrt{\frac{I_1}{I_2}} = \frac{2}{1}$ so $\frac{I_{max}}{I_{min}} = \left(\frac{\sqrt{\frac{I_1}{I_2}}+1}{\sqrt{\frac{I_1}{I_2}}-1}\right)^2 = \left(\frac{2+1}{2-1}\right)^2 = 9$

As $L_1 - L_2$= 10 Log $(\frac{I_{max}}{I_{min}}) = 10\log(9) = 20\log(3)$ as the answer.

Q30. Ans(2). we know that the speed of transverse wave is given by $v = \sqrt{\frac{T}{m}}$ here m is the mass per unit length = ρA ,A is the area . so the speed is given by $v = \sqrt{\frac{1000}{100\times10\times10^{-6}}} = 1000\,\frac{m}{s}$ as the answer