BITSAT - Paper 2023 Shift 1

Solved Paper

Question 1

An object moves with speed v_1, v_2 and v_3 along a line segment AB, BC and CD respectively as shown in figure. Where AB = BC and AD = 3 AB, then average speed of the object will be:

Options:

A. $\frac{v_1 v_2 v_3}{3(v_1 v_2 + v_2 v_3 + v_3 v_1)}$

B. $\frac{3 v_1 v_2 v_3}{(v_1 v_2 + v_2 v_3 + v_3 v_1)}$

C. $\frac{(r^2 + r_2 + r_3)}{3}$

D. $\frac{(v_1 + v_2 + v_3)}{3 v_1 v_2 v_3}$

Answer: B

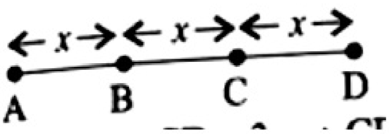
Solution:

Solution:

Consider,

$AB = x$

$BC = x$



$2x + CD = 3x \Rightarrow CD = 3x - 2x = x$

Average speed of the object $\langle v \rangle$

$= \frac{\text{Total distance}}{\text{Total time}}$

$< v > = \frac{3x}{\frac{x}{v_1} + \frac{x}{v_2} + \frac{x}{v_3}} = \frac{3 v_1 v_2 v_3}{v_2 v_3 + v_1 v_3 + v_1 v_2}$

Question 2

The effect of increase in temperature on the number of electrons in

conduction band (n_e) and resistance of a semiconductor will be as:

Options:

A. Both n_e and resistance decrease

B. Both n_e and resistance increase

C. n_e increases, resistance decreases

D. n_e decreases, resistance increases

Answer: C

Solution:

Solution:

When temperature increases, more electrons excite to conduction band and hence conductivity increases, therefore resistance decreases.

Question 3

A radio-active material is reduced to 1 / 8 of its original amount in 3 days. If 8×10^{-3} kg of the material is left after 5 days. The initial amount of the material is

Options:

A. 700 gm

B. 900 gm

C. 475 gm

D. 256 gm

Answer: D

Solution:

Solution:

$N = N_0\left(\frac{1}{2}\right)^n \quad N = \frac{N_0}{8}$

$\frac{N_0}{8} = N_0\left(\frac{1}{2}\right)^n \Rightarrow \left(\frac{1}{2}\right)^3 = \left(\frac{1}{2}\right)^n$

$n = 3$

3 half lives = 3 days

1 half life = 1 day

5 days = 5 half life

$N = N_0\left(\frac{1}{2}\right)^n \Rightarrow 8 \times 10^{-3} = N_0\left(\frac{1}{2}\right)^5$

$\Rightarrow N_0 = 2^5 \times 8 \times 10^{-3} = 256 \text{ gm}$

Question 4

A 12.5 eV electron beam is used to bombard gaseous hydrogen at room temperature. The number of spectral lines emitted will be:

Options:

A. 2

B. 1

C. 3

D. 4

Answer: C

Solution:

Solution:

If we assume electron in hydrogen atom takes energy 12.09 eV from the incoming radiation, the maximum excited state of electron will be $n = 3$. So, number of spectral lines is $\frac{3(3-1)}{2} = 3$.

Here we assume some part of energy $12.5 \text{ eV} - 12.09 \text{ eV} = 0.41 \text{ eV}$ get lost due to collision.

Question 5

If 1000 droplets of water of surface tension 0.07 N / m. having same radius 1 mm each, combine to from a single drop. In the process the released surface energy is- $\left(\text{Take } \pi = \frac{22}{7}\right)$

Options:

A. 7.92×10^{-6}J

B. 7.92×10^{-4}J

C. 9.68×10^{-4}J

D. 8.8×10^{-5}J

Answer: B

Solution:

Solution:

We have

$V_f = V_i$

$\Rightarrow \frac{4}{3}\pi r_f^3 = 1000 \times \frac{4}{3}\pi r_i^3 \Rightarrow r_f^3 = 1000 r_i^3$

$\Rightarrow r_f = 10 r_i$

So, released energy

= Initial surface energy − final surface energy

$= 1000 \times T \times 4\pi r_i^2 - T \times 4\pi r_f^2$

$= 4\pi T(1000 r_i^2 - r_f^2)$

$= 4\pi \times 0.07(1000 r_i^2 - 100 r_i^2)$

$= 4\pi \times 0.07 \times 900 r_i^2$

$= 4\pi \times 63 \times 10^{-6} = 7.92 \times 10^{-4}$J

Question 6

The force between two small charged spheres having charges of 1×10^{-7}C and 2×10^{-7}C placed 20 cm apart in air is

Options:

A. 4.5×10^{-2}N

B. 4.5×10^{-3}N

C. 5.4×10^{-2}N

D. 5.4×10^{-3}N

Answer: B

Solution:

Solution:

Here, $q_1 = 1 \times 10^{-7}$C, q_2 and 2×10^{-7}C,

$r = 20\text{ cm} = 20 \times 10^{-2}\text{m}$

$$F = \frac{q_1 q_2}{4\pi\varepsilon_0 r^2} = \frac{9 \times 10^9 \times 1 \times 10^{-7} \times 2 \times 10^{-7}}{(20 \times 10^{-2})^2}$$

$= 4.5 \times 10^{-3}\text{N}$

Question 7

The work done in placing a charge of 8×10^{-18} coulomb on a condenser of capacity 100 microfarad is

Options:

A. 3.1×10^{-26} joule

B. 4×10^{-10} joule

C. 32×10^{-32} joule

D. 16×10^{-32} joule

Answer: C

Solution:

Solution:

$$\text{Work done} = \frac{1}{2}\frac{q^2}{C} = \frac{(8 \times 10^{-18})^2}{2 \times 100 \times 10^{-6}} = 32 \times 10^{-32}\text{J}$$

Question 8

The resistance of a wire is 5Ω. It's new resistance in ohm if stretched to 5 times of its original length will be :

Options:

A. 625

B. 5

C. 125

D. 25

Answer: C

Solution:

Solution:

Let resistance of a wire R and length l.

$R = \frac{\rho\ell}{A} = 5\Omega$

$\therefore$ Volume of wire is constant in stretching

$V_i = V_f \Rightarrow A_i\ell_i = A_f\ell_f$

$A\ell = A'(5\ell) \Rightarrow A' = \frac{A}{5}$

$R_f = \frac{\rho\ell_f}{A_f} = \frac{\rho(5\ell)}{\left(\frac{A}{5}\right)} = 25\left(\frac{\rho\ell}{A}\right) = 25 \times 5 = 125\Omega$

Question 9

A charge particle is moving in a uniform magnetic field $(2\hat{i} + 3\hat{j})$T. If it has an acceleration of $(\alpha\hat{i} - 4\hat{j})$ m / s^2, then the value of α will be :

Options:

A. 3

B. 6

C. 12

D. 2

Answer: B

Solution:

Solution:

(b) Given that uniform magnetic field, $\vec{B} = (2\hat{i} + 3\hat{j})T$

Acceleration $\vec{a} = (\alpha\hat{i} - 4\hat{j})\text{m}/s^2$

We know that

$F = q(\vec{v} \times \vec{B}) \Rightarrow ma = q(\vec{v} \times \vec{B})$

Here, $\vec{a} \perp \vec{B}$, so, $\vec{a} \cdot \vec{B} = 0$

$(\alpha\hat{i} - 4\hat{j})(2\hat{i} + 3\hat{j}) = 0 \Rightarrow 2\alpha - 12 = 0 \Rightarrow \alpha = 6$

Question 10

Proton (p) and electron (e) will have same de-Broglie wavelength when

the ratio of their momentum is (assume, m_n = 1849m_e)

Options:

A. 1:43

B. 43 : 1

C. 1 : 1849

D. 1 : 1

Answer: D

Solution:

Solution:

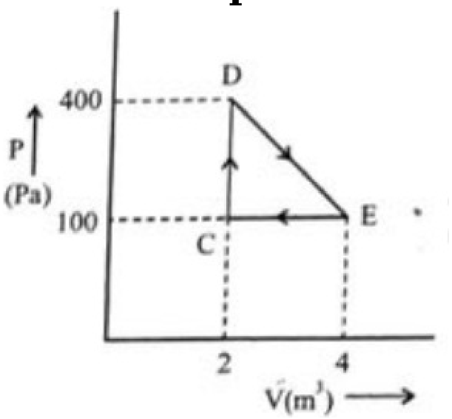
De Broglie wavelength is $\lambda = \frac{h}{mv}$

$$\lambda_p = \lambda_e \Rightarrow \frac{h}{m_p v_p} = \frac{h}{m_e v_e}$$

$$m_e v_e = m_p v_p \Rightarrow p_e = p_p \quad \therefore \frac{p_p}{p_e} = \frac{1}{1}$$

Question 11

A thermodynamic system is taken through cyclic process. The total work done in the process is :



Options:

A. 100J

B. 300J

C. Zero

D. 200J

Answer: B

Solution:

Solution:

Work done = Area under the curve

$$\Rightarrow W = \frac{1}{2} \times (4-2) \times (400-100) = \frac{1}{2}(2) \times 300$$

$$W = 300J$$

Question 12

In a reflecting telescope, a secondary mirror is used to:

Options:

A. reduce the problem of mechanical support

B. remove spherical aberration

C. make chromatic aberration zero

D. move the eyepiece outside the telescopic tube

Answer: D

Solution:

Solution:

To redirect the light that enters the telescope to the eyepiece or camera. The primary mirror of a reflecting telescopes gathers the light and reflects towards the secondary mirror which then reflect the light towards the eyepiece allowing the observer to see image.

It has advantage of a large focal length in a short telescope.

Question 13

The magnetic moment of an electron (e) revolving in an orbit around nucleus with an orbital angular momentum is given by:

Options:

A. $\vec{\mu}_L = \frac{e\vec{L}}{2m}$

B. $\vec{\mu}_L = -\frac{e\vec{L}}{2m}$

C. $\vec{\mu}_l = -\frac{e\vec{L}}{m}$

D. $\vec{\mu}_l = \frac{2e\vec{L}}{m}$

Answer: A

Solution:

Solution:

As $\vec{M} = I\vec{A}$

$$\Rightarrow \left|\vec{M}\right| = \frac{e}{\frac{2\pi R}{v}}\pi R^2 \quad \left[\because I = \frac{Q}{T} = \frac{e}{\frac{2\pi R}{v}}\right]$$

$$\Rightarrow \left|\vec{M}\right| = \frac{1}{2}evR \Rightarrow \left|\vec{M}\right| = \frac{mvR}{1} \cdot \frac{e}{2m}$$

$$\Rightarrow \left|\vec{M}\right| = \frac{eL}{2m} \Rightarrow \left|\vec{M}\right| = -\frac{e\vec{L}}{2m}$$

[$\because$ Here $\vec{M}$ and $\vec{L}$ will always be opposite]

Question 14

The ratio of intensities at two points P and Q on the screen in a Young's double slit experiment where phase difference between two wave of same amplitude are $\frac{\pi}{3}$ and $\frac{\pi}{2}$, respectively are

Options:

A. 1 : 3

B. 3 : 1

C. 3 : 2

D. 2 : 3

Answer: C

Solution:

Solution:

Intensity at a point in Young's double slit experiment is given by

$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\varphi$

Here $I_1 = I_2 = I_0$ (say)

At P

$\therefore I_p = I_0 + I_0 + 2I_0 \cos\frac{\pi}{3} = 2I_0 + 2I_0 \times \frac{1}{2} = 3I_0$

At Q

$I_Q = I_0 + I_0 + 2I_0 \cos 90^\circ = 2I_0$

$\frac{I_P}{I_Q} = \frac{3}{2}$

Question 15

A bicycle tyre is filled with air having pressure of 270 kPa at 27°C. The approximate pressure of the air in the tyre when the temperature increases to 36°C is

Options:

A. 270 kPa

B. 262 KPa

C. 278 kPa

D. 360 kPa

Answer: C

Solution:

Solution:

From the ideal gas equation $PV = nRT$

Here, volume is constant $\therefore \frac{P_1}{T_1} = \frac{P_2}{T_2}$

Here, $T_1 = 27 + 273 = 300K$

$P_1 = 270\,kPa$

$T_2 = 36 + 273 = 309K$

$\Rightarrow P_2 = \frac{P_1}{T_1} \times T_2 = \frac{270 \times (309)}{300} = 278\,kPa.$

Question 16

A particle executes SHM of amplitude A. The distance from the mean position when it's kinetic energy becomes equal to its potential energy is

Options:

A. $\sqrt{2}A$

B. 2A

C. $\frac{1}{\sqrt{2}}A$

D. $\frac{1}{2}A$

Answer: C

Solution:

Solution:

Let the distance from the mean position is X.

Given KE = PE

So, $\frac{1}{2}M\omega^2(A^2 - x^2) = \frac{1}{2}M\omega^2 x^2 \; A^2 - x^2 = x^2 \Rightarrow A^2 = 2 \times 2$

$\therefore x = \pm \frac{A}{\sqrt{2}}$

Question 17

Electric field in a certain region is given by $\vec{E} = \left(\frac{A}{x^2}\hat{i} + \frac{B}{y^3}\hat{j} \right)$. The SI unit of A and B are:

Options:

A. Nm^3C^{-1}; Nm^2C^{-1}

B. Nm^2C^{-1}; Nm^3C^{-1}

C. Nm^3C; Nm^2C

D. Nm^2C; Nm^3C

Answer: B

Solution:

Solution:

Electric field in a certain region is given by,

$\vec{E} = \frac{A}{x^2}\hat{i} + \frac{B}{y^3}\hat{j}$

$\left[\frac{A}{x^2}\right] = NC^{-1} \Rightarrow [A] = Nm^2C^{-1}$

$\left[\frac{B}{y^3}\right] = NC^{-1} \Rightarrow [B] = Nm^3C^{-1}$

Question 18

At any instant the velocity of a particle of mass 500g is $\left(2t\hat{i} + 3t^2\hat{j}\right) ms^{-1}$. If the force acting on the particle at t = 1s is $\left(\hat{i} + x\hat{j}\right)$N . Then the value of x will be:

Options:

A. 3

B. 4

C. 6

D. 2

Answer: A

Solution:

Solution:

Mass of particle,

$m = 500g = 0.5 \text{ kg}$

velocity of a particle,

$\vec{v} = 2t\hat{i} + 3t^2\hat{j}$

$\vec{a} = \frac{d\vec{v}}{dt} = 2\hat{i} + 6t\hat{j}$

at $t = 1, \vec{a} = 2\hat{i} + 6\hat{j}$

Force acting on the particle,

$\vec{F} = m\vec{a} = 0.5(2\hat{i} + 6\hat{j}) = \hat{i} + 3\hat{j}$

$\vec{F} = \hat{i} + x\hat{j}$

Hence $x = 3$

Question 19

A particle of mass m moving with velocity v collides with a stationary particle of mass 2m. After collision, they stick together and continue to move together with velocity

Options:

A. v

B. $\frac{v}{2}$

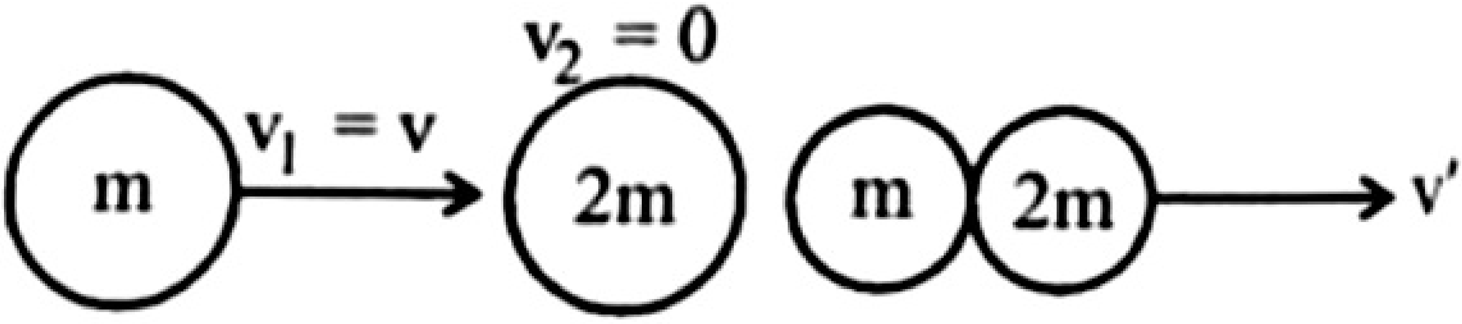
C. $\frac{v}{3}$

D. $\frac{V}{4}$

Answer: C

Solution:

Solution:



Applying conservation of linear momentum

$$\Rightarrow \vec{P}_i = \vec{P}_f (\because P = mv)$$

$$mv_1 + 2mv_2 = (m + 2m)v'$$

$$mv + 2m \times 0 = (3m)v'$$

$$\Rightarrow mv = 3\,mvv' \Rightarrow v' = \frac{v}{3}$$

Question 20

Which of the following Maxwell's equations is valid for time varying conditions but not valid for static conditions :

Options:

A. $\oint \vec{B} \cdot \vec{dl} = \mu_0 I$

B. $\oint \vec{E} \cdot \vec{dl} = 0$

C. $\oint \vec{E} \cdot \vec{dl} = -\frac{\partial \varphi_B}{\partial t}$

D. $\oint \vec{D} \cdot \vec{dA} = Q$

Answer: C

Solution:

Solution:

For time varying condition Maxwell's equation, $\oint \vec{E} \cdot \vec{dl} = -\frac{d\varphi_B}{dt}$

Question 21

In an LC oscillator, if values of inductance and capacitance become twice and eight times, respectively, then the resonant frequency of

oscillator becomes x times its initial resonant frequency ω_0. The value of x is:

Options:

A. 1 / 4

B. 16

C. 1 / 16

D. 4

Answer: A

Solution:

Solution:

The resonance frequency of LC oscillations circuit is

$$\omega = \frac{1}{\sqrt{L'C'}} \Rightarrow L' \rightarrow 2L$$

$$C' \rightarrow 8C$$

$$\omega = \frac{1}{\sqrt{2L \times 8C}} = \frac{1}{4\sqrt{LC}} 9\omega_0 = \frac{1}{\sqrt{LC}}$$

$$\omega = \frac{\omega_0}{4} \text{ So, } x = \frac{1}{4}$$

Question 22

A conducting loop of radius $\frac{10}{\sqrt{\pi}}$ cm is placed perpendicular to a uniform magnetic field of 0.5T. The magnetic field is decreased to zero in 0.5 s at a steady rate. The induced emf in the circular loop at 0.25s is:

Options:

A. emf = 1 mV

B. emf = 10 mV

C. emf = 100 mV

D. emf = 5 mV

Answer: B

Solution:

Solution:

As $\varepsilon|_{t=0.5\ sec} = -\frac{d\varphi}{dt}$

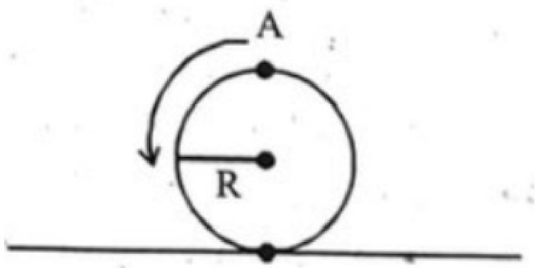
$$= -A\frac{dB}{dt}\ [\because \theta = 0^\circ \Rightarrow \cos\theta = 1]$$

$$= -\pi \times \left(\frac{10}{\sqrt{\pi}}\right)^2 \times 10^{-4} \times \frac{0-0.5}{0.5} = 10^{-2}V = 10\,mV$$

As $\frac{dB}{dt} =$ constant $\Rightarrow$ Induced emf will not change with time. So, $e|_{0.5\ sec} = e|_{0.25\ sec} = 10\,mV$

Question 23

A disc is rolling without slipping on a surface. The radius of the disc is R. At t = 0, the top most point on the disc is A as shown in figure. When the disc completes half of its rotation, the displacement of point A from its initial position is



Options:

A. $R\sqrt{(\pi^2 + 4)}$

B. $R\sqrt{(\pi^2 + 1)}$

C. 2R

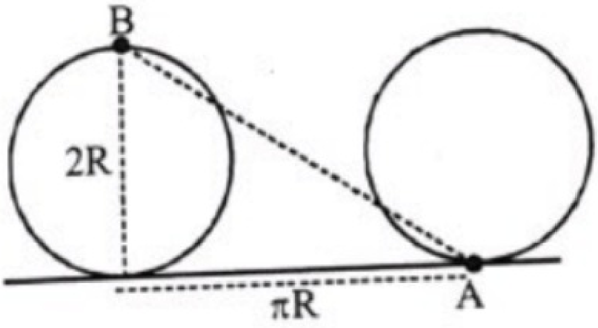
D. $2R\sqrt{(1 + 4\pi^2)}$

Answer: A

Solution:

Solution:

From figure,



Displacement,

$BA = \sqrt{(2R)^2 + (\pi R)^2} = R\sqrt{4+\pi^2}$

Question 24

Two planets A and B of radii R and 1.5R have densities ρ and ρ / 2 respectively. The ratio of acceleration due to gravity at the surface of B to A is :

Options:

A. 2 : 3

B. 2 : 1

C. 3 : 4

D. 4 : 3

Answer: C

Solution:

Solution:

Acceleration due to gravity,

$$g = \frac{GM}{R^2} = \frac{4}{3}\pi G\rho R$$

$$\therefore \frac{g_2}{g_1} = \frac{\rho_2}{\rho_1} \times \frac{R_2}{R_1} = \frac{1}{2} \times 1.5 = \frac{3}{4}$$

Question 25

A 100m long wire having cross-sectional area $6.25 \times 10^{-4} m^2$ and Young's modulus is $10^{10}\ Nm^{-2}$ is subjected to a load of 250N, then the elongation in the wire will be :

Options:

A. $6.25 \times 10^{-3} m$

B. 4×10^{-4}m

C. 6.25×10^{-6}m

D. 4×10^{-3}m

Answer: D

Solution:

Solution:

$$\Delta \ell = \frac{F\ell}{YA} = \frac{250 \times 100}{10^{10} \times 6.25 \times 10^{-4}} = 40 \times 10^{-4}\text{m}$$

$$= 4 \times 10^{-3}\text{m}$$

Question 26

The ratio of speed of sound in hydrogen gas to the speed of sound in oxygen gas at the same temperature is:

Options:

A. 4 : 1

B. 1 : 2

C. 1 : 4

D. 1 : 1

Answer: A

Solution:

Solution:

Given $M_{H_2} = 2; M_{O_2} = 32$

Speed of sound, $v = \sqrt{\frac{\gamma RT}{M}}$

$$\Rightarrow \quad v \propto \frac{1}{\sqrt{M}}$$

$$\therefore \quad \frac{v_{H_2}}{v_{O_2}} = \sqrt{\frac{M_{O_2}}{M_{H_2}}} = \sqrt{\frac{32}{2}} = 4 : 1$$

Question 27

The free space inside a current carrying toroid is filled with a material of susceptibility 2×10^{-2}. The percentage increase in the value of magnetic field inside the toroid will be

Options:

A. 2%

B. 0.2%

C. 0.1%

D. 1%

Answer: A

Solution:

Solution:

Given,

Susceptibility of material, $\chi_m = 2 \times 10^{-2}$

Using $\mu_r = 1 + \chi_m = 1 + 0.02 = 1.02$

$B_{final} = \mu_r B_0$ (here, $B_0 =$ initial magnetic field)

% increase in magnetic field

$$= \frac{B_{final} - B_0}{B_0} \times 100 = \frac{\mu_r B_0 - B_0 \times 100}{B_0}$$

$$= \frac{(\chi + 1) - 1 \times 100}{1} = 0.02 \times 100 = 2\%$$

Question 28

The ratio of average electric energy density and total average energy density of electromagnetic wave is :

Options:

A. 2

B. $\frac{1}{2}$

C. 1

D. 3

Answer: B

Solution:

Solution:

We have $\frac{U_E}{U_T} = \frac{U_E}{U_E + U_B} = \frac{U_E}{2U_E} = \frac{1}{2}$

$$\left[\because U_E = U_B = \frac{1}{2} \varepsilon_0 E_0^2 = \frac{B_0^2}{2\mu_0} \right]$$

Question 29

In a Young's double slit experiment, the intensities at two points, for the path difference $\frac{\lambda}{4}$ and $\frac{\lambda}{3}$ (λ being the wavelength of light used) are I_1 and I_2 respectively. If I_0 denotes the intensity produced by each one of the individual slits, then $\frac{I_1 + I_2}{I_0}$ = ...

Options:

A. 3

B. 5

C. 7

D. 10

Answer: A

Solution:

Solution:

Resultant intensity in Young's double slit experiment

$I = 4I_0 \cos^2\left(\frac{\Delta\varphi}{2}\right)$

For path difference $\frac{\lambda}{4}$ phase difference,

$\Delta\varphi = \frac{2\pi}{\lambda} \times \frac{\lambda}{4} = \frac{\pi}{4}$

$\therefore I_1 = 4I_0 \cos^2\left(\frac{\pi}{4}\right)' = 2I_0$

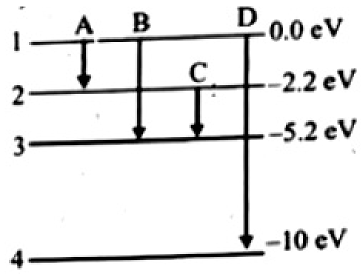
For path difference $\frac{\lambda}{3}$

$I_2 = 4I_0 \cos^2\left(\frac{2\pi}{\lambda} \times \frac{\lambda}{3}\right) = I_0$

$\therefore \frac{I_1 + I_2}{I_0} = 3$

Question 30

The energy levels of an atom is shown is figure. Which one of these transitions will result in the emission of a photon of wavelength 124.1 nm ? Given (h = 6.62×10^{-34} Js)



Options:

A. B

B. A

C. C

D. D

Answer: D

Solution:

Solution:

As $E(eV) = \frac{1240}{\lambda(nm)} = \frac{1240}{124.1} \simeq 10\,eV$ Only is transition (D), the energy gap is $10\,eV$ So, option (d) is correct

$$K_a = 0.001\left(\frac{\alpha^2}{1-\alpha}\right) = \frac{0.001 \times \left(\frac{2}{19}\right)^2}{1-\left(\frac{2}{19}\right)}$$
