25/07/2022
Morning

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Answers & Solutions

Time : 3 hrs. *for* M.M. : 300

JEE (Main)-2022 (Online) Phase-2

(Physics, Chemistry and Mathematics)

IMPORTANT INSTRUCTIONS:

(1) The test is of **3 hours** duration.

(2) The Test Booklet consists of 90 questions. The maximum marks are 300.

(3) There are **three** parts in the question paper consisting of **Physics, Chemistry** and **Mathematics** having 30 questions in each part of equal weightage. Each part (subject) has two sections.

(i) **Section-A:** This section contains 20 multiple choice questions which have only one correct answer. Each question carries **4 marks** for correct answer and **–1 mark** for wrong answer.

(ii) **Section-B:** This section contains 10 questions. In Section-B, attempt any **five questions out of 10.** The answer to each of the questions is a numerical value. Each question carries **4 marks** for correct answer and **–1 mark** for wrong answer. For Section-B, the answer should be rounded off to the nearest integer.

PHYSICS

SECTION - A

Multiple Choice Questions: This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.

Choose the correct answer :

1. If momentum [P], area [A] and time [T] are taken as fundamental quantities, then the dimensional formula for coefficient of viscosity is

(A) $[PA^{-1}T^{0}]$ (B) $[PAT^{-1}]$

(C) $[PA^{-1}T]$ (D) $[PA^{-1}T^{-1}]$

Answer (A)

Sol. $[\eta] = [ML^{-1}T^{-1}]$

Now if $[\eta] = [P]^a[A]^b[T]^c$

$\Rightarrow [ML^{-1}T^{-1}] = [ML^{1}T^{-1}]^a[L^2]^b[T]^c$

$\Rightarrow a = 1, a + 2b = -1, -a + c = -1$

$\Rightarrow a = 1, b = -1, c = 0$

$\Rightarrow [\eta] = [P][A]^{-1}[T]^{0}$

$= [PA^{-1}T^{0}]$

2. Which of the following physical quantities have the same dimensions?

(A) Electric displacement $(\vec{D})$ and surface charge density

(B) Displacement current and electric field

(C) Current density and surface charge density

(D) Electric potential and energy

Answer (A)

Sol. Electric displacement $(\vec{D}) = \varepsilon_0\vec{E}$

$\Rightarrow [\bar{D}] = [\varepsilon_0][\bar{E}]$

$= [M^{-1}L^{-3}T^{4}A^{2}][M^{1}L^{1}A^{-1}T^{-3}]$

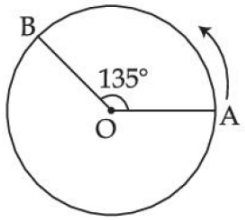
$[\bar{D}] = [L^{-2}T^{1}A^{1}]$

$[\text{Surface charge density}] = \frac{[Q]}{[A]}$

$[\sigma] = [ATL^{-2}]$

$\Rightarrow \vec{D}$ and $[\sigma]$ have same dimensions

3. A person moved from *A* to *B* on a circular path as shown in figure. If the distance travelled by him is 60 m, then the magnitude of displacement would be (Given cos135°= –0.7)



(A) 42 m (B) 47 m

(C) 19 m (D) 40 m

Answer (B)

Sol. Distance travelled = 60 m

$\Rightarrow$ Angle covered = 135°

$\text{Displacement} = 2R\sin\left(\frac{135^\circ}{2}\right)$

$= 2\left(\frac{60}{135}\times\frac{180}{\pi}\right)\left[\frac{1-\cos(135^\circ)}{2}\right]^{1/2}$

$= 2\left(\frac{80}{\pi}\right)(0.85)^{1/2}$

≈ 47 m

4. A body of mass 0.5 kg travels on straight line path with velocity $v = (3x^2 + 4)$ m/s. The net workdone by the force during its displacement from $x = 0$ to $x = 2$ m is

(A) 64 J (B) 60 J

(C) 120 J (D) 128 J

Answer (B)

Sol. $v = 3x^2 + 4$

at $x = 0$, $v_1 = 4$ m/s

$x = 2$, $v_2 = 16$ m/s

$\Rightarrow$ Work done = Δ kinetic energy

$= \frac{1}{2}\times m\left(v_2^2 - v_1^2\right)$

$= \frac{1}{4}(256 - 16)$

$= 60$ J

5. A solid cylinder and a solid sphere, having same mass M and radius R, roll down the same inclined plane from top without slipping. They start from rest. The ratio of velocity of the solid cylinder to that of the solid sphere, with which they reach the ground, will be

(A) $\sqrt{\frac{5}{3}}$ (B) $\sqrt{\frac{4}{5}}$

(C) $\sqrt{\frac{3}{5}}$ (D) $\sqrt{\frac{14}{15}}$

Answer (D)

Sol. $a = \frac{g\sin\theta}{1+\frac{K^2}{R^2}}$

$$v = \sqrt{\frac{2Sg\sin\theta}{1+\frac{K^2}{R^2}}}$$

$$\Rightarrow \frac{v_c}{v_{ss}}\sqrt{\frac{1+\frac{K_{ss}^2}{R^2}}{1+\frac{K_c^2}{R^2}}} = \sqrt{\frac{1+\frac{2}{5}}{1+\frac{1}{2}}}$$

$$\Rightarrow \sqrt{\frac{\frac{7}{5}}{\frac{3}{2}}} = \sqrt{\frac{14}{15}}$$

6. Three identical particles A, B and C of mass 100 kg each are placed in a straight line with $AB = BC = 13$ m. The gravitational force on a fourth particle P of the same mass is F, when placed at a distance 13 m from the particle B on the perpendicular bisector of the line AC. The value of F will be approximately

(A) $21G$

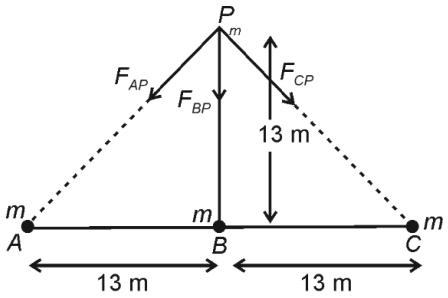
(B) $100G$

(C) $59G$

(D) $42G$

Answer (B)

Sol.



$m = 100$ kg

$$F_{AP} = \frac{Gm^2}{\left(13\sqrt{2}\right)^2}$$

$$F_{BP} = \frac{Gm^2}{13^2}$$

$$F_{CP} = \frac{Gm^2}{\left(13\sqrt{2}\right)^2}$$

$F_{net} = F_{BP} + F_{AP}\cos45° + F_{CP}\cos45°$

$$= \frac{Gm^2}{13^2}\left(1+\frac{1}{\sqrt{2}}\right)$$

$$= \frac{G100^2}{169}(1+0.707)$$

$$\simeq 100G$$

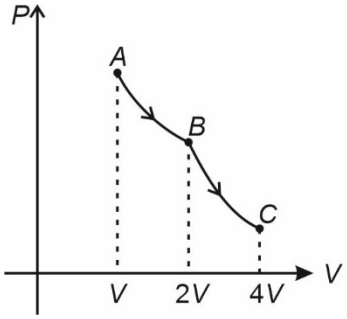
7. A certain amount of gas of volume V at 27°C temperature and pressure 2×10^7 Nm^{-2} expands isothermally until its volume gets doubled. Later it expands adiabatically until its volume gets redoubled. The final pressure of the gas will be (Use, $\gamma = 1.5$)

(A) 3.536×10^5 Pa (B) 3.536×10^6 Pa

(C) 1.25×10^6 Pa (D) 1.25×10^5 Pa

Answer (B)

Sol.



Let AB is isothermal process and BC is adiabatic process then for AB process

$P_AV_A = P_BV_B$

$\Rightarrow \quad P_B = 10^7\ Nm^{-2}$

For process BC

$P_BV_B^r = P_CV_C^r$

$P_C = 3.536\ x \times 10^6\ Pa$

8. Following statements are given:

(A) The average kinetic energy of a gas molecule decreases when the temperature is reduced.

(B) The average kinetic energy of a gas molecule increases with increase in pressure at constant temperature.

(C) The average kinetic energy of a gas molecule decreases with increase in volume.

(D) Pressure of a gas increases with increase in temperature at constant pressure.

(E) The volume of gas decreases with increase in temperature.

Choose the correct answer from the options given below:

(A) (A) and (D) only (B) (A), (B) and (D) only

(C) (B) and (D) only (D) (A), (B) and (E) only

Answer (Bonus)

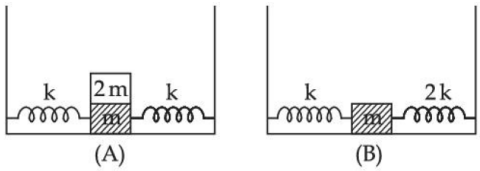
Sol. Because KE $\propto T$ so A is correct, B is incorrect, statement C can not be said, statement D is contradicting it self, statement E is incorrect (Isothermal process)

So No answer correct (Bonus)

If the statement of D would have been.

"Pressure of gas increases with increase in temperature at constant volume, "then statement D would have been correct, so in that case answer would have been 'A'

9. In figure (A), mass '2 m' is fixed on mass 'm' which is attached to two springs of spring constant k. In figure (B), mass 'm' is attached to two springs of spring constant 'k' and '2k'. If mass 'm' in (A) and in (B) are displaced by distance' x' horizontally and then released, then time period T_1 and T_2 corresponding to (A) and (B) respectively follow the relation.



(A) $\frac{T_1}{T_2} = \frac{3}{\sqrt{2}}$ (B) $\frac{T_1}{T_2} = \sqrt{\frac{3}{2}}$

(C) $\frac{T_1}{T_2} = \sqrt{\frac{2}{3}}$ (D) $\frac{T_1}{T_2} = \frac{\sqrt{2}}{3}$

Answer (A)

Sol. Both the springs are in parallel combination in both the diagrams so

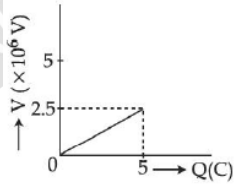
$T_1 = 2\pi\sqrt{\frac{3m}{2k}}$

and $T_2 = 2\pi\sqrt{\frac{m}{3k}}$

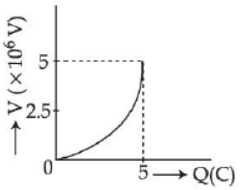
So, $\frac{T_1}{T_2} = \frac{3}{\sqrt{2}}$

10. A condenser of 2μF capacitance is charged steadily from 0 to 5 C. Which of the following graph represents correctly the variation of potential difference (V) across it's plates with respect to the charge (Q) on the condenser?

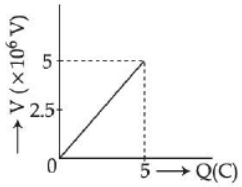
(A)



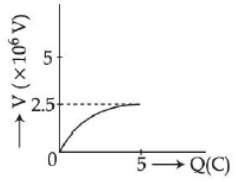
(B)



(C)



(D)



Answer (A)

Sol. $Q = CV$

As capacitance is constant $Q \propto V$

and $V_f = \frac{Q_f}{C} = \frac{5}{2\times10^{-6}} = 2.5\times10^6$ V

So correct graph will be *A*

11. Two charged particles, having same kinetic energy, are allowed to pass through a uniform magnetic field perpendicular to the direction of motion. If the ratio of radii of their circular path is 6 : 5 and their respective masses ratio is 9 : 4. Then, the ratio of their charges will be :

(A) 8 : 5 (B) 5 : 4

(C) 5 : 3 (D) 8 : 7

Answer (B)

Sol. We know that $R = \frac{mv}{Bq} = \sqrt{\frac{2mK}{Bq}}$

$\Rightarrow$ Ratio of radii $= \frac{R_1}{R_2} = \sqrt{\frac{m_1}{m_2}\frac{q_2}{q_1}}$

$\Rightarrow \frac{6}{5} = \sqrt{\frac{9}{4}\frac{q_2}{q_1}}$

$\Rightarrow \frac{q_1}{q_2} = \frac{3}{2}\times\frac{5}{6} = \frac{5}{4}$

12. To increase the resonant frequency in series LCR circuit,

(A) Source frequency should be increased.

(B) Another resistance should be added in series with the first resistance.

(C) Another capacitor should be added in series with the first capacitor.

(D) The source frequency should be decreased.

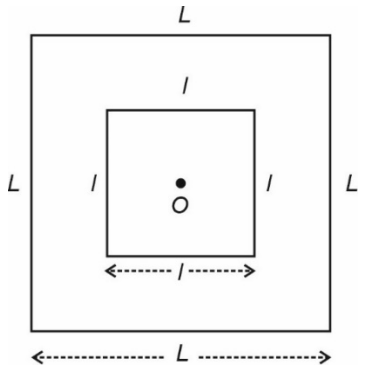
Answer (C)

Sol. Resonant frequency $= \frac{1}{\sqrt{LC}} = \omega_0$

$\Rightarrow$ If we decrease *C*, ω_0 would increase

$\Rightarrow$ Another capacitor should be added in series.

13. A small square loop of wire of side *l* is placed inside a large square loop of wire *L*(*L* >> *l*). Both loops are coplanar and their centres coincide at point *O* as shown in figure. The mutual inductance of the system is :



(A) $\frac{2\sqrt{2}\,\mu_0 L^2}{\pi l}$ (B) $\frac{\mu_0 l^2}{2\sqrt{2}\,\pi L}$

(C) $\frac{2\sqrt{2}\,\mu_0 l^2}{\pi L}$ (D) $\frac{\mu_0 L^2}{2\sqrt{2}\,\pi l}$

Answer (C)

Sol. We know $\phi = Mi$

Let *i* current be flowing in the larger loop

$\Rightarrow \phi \simeq \left[4\times\frac{\mu_0 i}{4\pi(L/2)}[\sin45^\circ + \sin45^\circ]\right]\times$ Area

$= \frac{2\sqrt{2}\mu_0 i}{\pi L}\times l^2$

$\Rightarrow M = \frac{\phi}{i} = \frac{2\sqrt{2}\mu_0 l^2}{\pi L}$

14. The rms value of conduction current in a parallel plate capacitor is 6.9 μA. The capacity of this capacitor, if it is connected to 230 V ac supply with an angular frequency of 600 rad/s, will be :

(A) 5 pF (B) 50 pF

(C) 100 pF (D) 200 pF

Answer (B)

Sol. $Z_C = \frac{V}{I}$

$\Rightarrow \frac{1}{\omega C} = \frac{230}{6.9}\,M\Omega$

$\Rightarrow C = \frac{6.9}{230\,\omega}\,\mu$F

$= \frac{6.9}{230\times600}\mu$F

C = 50 pF

15. Which of the following statement is correct?

(A) In primary rainbow, observer sees red colour on the top and violet on the bottom

(B) In primary rainbow, observer sees violet colour on the top and red on the bottom

(C) In primary rainbow, light wave suffers total internal reflection twice before coming out of water drops

(D) Primary rainbow is less bright than secondary rainbow

Answer (A)

Sol. In primary rainbow, observer sees red colour on the top and violet on the bottom.

16. Time taken by light to travel in two different materials A and B of refractive indices μ_A and μ_B of same thickness is t_1 and t_2 respectively. If $t_2 - t_1 = 5 \times 10^{-10}$ s and the ratio of μ_A to μ_B is 1 : 2. Then, the thickness of material, in meter is: (Given v_A and v_B are velocities of light in A and B materials respectively.)

(A) $5 \times 10^{-10} v_A$ m (B) 5×10^{-10} m

(C) 1.5×10^{-10} m (D) $5 \times 10^{-10} v_B$ m

Answer (A)

Sol. $t_2 - t_1 = 5 \times 10^{-10}$

$$\Rightarrow \frac{d}{v_B} - \frac{d}{v_A} = 5 \times 10^{-10}$$

and, $\frac{v_B}{v_A} = \frac{\mu_A}{\mu_B} = \frac{1}{2}$

$$\Rightarrow d\left(1 - \frac{v_B}{v_A}\right) = 5 \times 10^{-10} \times v_B$$

$$\Rightarrow d\left(1 - \frac{1}{2}\right) = 5 \times 10^{-10} \times v_B$$

$\Rightarrow d = 10 \times 10^{-10} \times v_B$ m

$\Rightarrow d = 5 \times 10^{-10} \times v_A$ m

17. A metal exposed to light of wavelength 800 nm and emits photoelectrons with a certain kinetic energy. The maximum kinetic energy of photo-electron doubles when light of wavelength 500 nm is used. The workfunction of the metal is:

(Take hc = 1230 eV-nm)

(A) 1.537 eV (B) 2.46 eV

(C) 0.615 eV (D) 1.23 eV

Answer (C)

Sol. $\because \quad K_m = \frac{hc}{\lambda} - \phi$

$$\Rightarrow K = \frac{1230}{800} - \phi$$

and, $2K = \frac{1230}{500} - \phi$

$$\Rightarrow 2 \times \frac{1230}{800} - 2\phi = \frac{1230}{500} - \phi$$

$\Rightarrow \phi = 0.615$ eV

18. The momentum of an electron revolving in n^{th} orbit is given by: (Symbols have their usual meanings)

(A) $\frac{nh}{2\pi r}$

(B) $\frac{nh}{2r}$

(C) $\frac{nh}{2\pi}$

(D) $\frac{2\pi r}{nh}$

Answer (A)

Sol. $\because \quad mvr = \frac{nh}{2\pi}$

$$\Rightarrow mv = \frac{nh}{2\pi r}$$

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

(A) $\vec{\mu_L} = \frac{\vec{eL}}{2m}$

(B) $\vec{\mu_L} = -\frac{\vec{eL}}{2m}$

(C) $\vec{\mu_l} = -\frac{\vec{eL}}{m}$

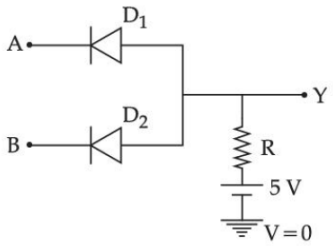
(D) $\vec{\mu_l} = \frac{2\vec{eL}}{m}$

Answer (B)

Sol. $\because \quad \vec{\mu} = \frac{q\vec{L}}{2m}$

$$\Rightarrow \vec{\mu} = \frac{-e\vec{L}}{2m}$$

20. In the circuit, the logical value of $A = 1$ or $B = 1$ when potential at A or B is 5 V and the logical value of $A = 0$ or $B = 0$ when potential at A or B is 0 V.



The truth table of the given circuit will be:

(A)

A	B	Y
0	0	0
1	0	0
0	1	0
1	1	1

(B)

A	B	Y
0	0	0
1	0	1
0	1	1
1	1	1

(C)

A	B	Y
0	0	0
1	0	0
0	1	0
1	1	0

(D)

A	B	Y
0	0	1
1	0	1
0	1	1
1	1	0

Answer (A)

Sol. Given circuit is equivalent to an AND gate.

$\therefore$

A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

SECTION - B

Numerical Value Type Questions: This section contains 10 questions. In Section B, attempt any five questions out of 10. The answer to each question is a **NUMERICAL VALUE.** For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the second decimal place; e.g. 06.25, 07.00, –00.33, –00.30, 30.27, –27.30) using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.

1. A car is moving with speed of 150 km/h and after applying the break it will move 27 m before it stops. If the same car is moving with a speed of one third the reported speed then it will stop after travelling ___ m distance.

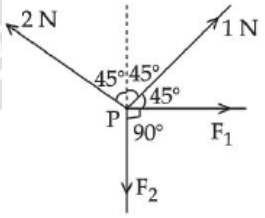
Answer (3)

Sol. $F_R\, d = \frac{1}{2}mv^2$

$$\frac{d_2}{d_1} = \left(\frac{v_2}{v_1}\right)^2 = \left(\frac{1}{3}\right)^2$$

$$d_2 = d_1 \times \frac{1}{9} = 3\text{m}$$

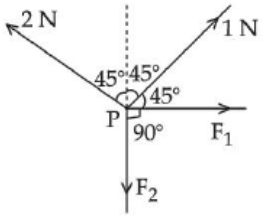
2. For forces are acting at a point P in equilibrium as shown in figure. The ratio of force F_1 to F_2 is 1 : x where x =___.



Answer (3)

Sol. $F_1 = +2 \times \frac{1}{\sqrt{2}} - \frac{1}{\sqrt{2}} = \frac{1}{\sqrt{2}}$

$$F_2 = 2 \times \frac{1}{\sqrt{2}} + \frac{1}{\sqrt{2}} = \frac{3}{\sqrt{2}}$$



$$\frac{F_1}{F_2} = \frac{1}{3} = \frac{1}{x} \Rightarrow x = 3$$

3. A wire of length L and radius r is clamped rigidly at one end. When the other end of the wire is pulled by a force F, its length increases by 5 cm. Another wire of the same material of length 4L and radius 4r is pulled by a force 4F under same conditions. The increase in length of this wire is ___ cm.

Answer (5)

Sol. $\frac{F/A}{\Delta L/L} = Y$

$\Rightarrow \Delta L = \frac{FL}{AY}$

$\frac{\Delta L_2}{\Delta L_1} = \left(\frac{F_2}{F_1}\right) \times \left(\frac{L_2}{L_1}\right) \times \left(\frac{A_1}{A_2}\right)$

$= 4 \times 4 \times \frac{1}{16} = 1$

$\Delta L_2 = \Delta L_1 = 5$ cm.

4. A unit scale is to be prepared whose length does not change with temperature and remains 20 cm, using a bimetallic strip made of brass and iron each of different length. The length of both components would change in such a way that difference between their lengths remains constant. If length of brass is 40 cm and length of iron will be ___ cm.

($\alpha_{iron} = 1.2 \times 10^{-5}$ K^{-1} and $\alpha_{brass} = 1.8 \times 10^{-5}$ K^{-1}).

Answer (60)

Sol. $\Delta L_1 = \alpha_1 L_1 \Delta T$

$\Delta L_2 = \alpha_2 L_2 \Delta T$

$\alpha_1 L_1 = \alpha_2 L_2$

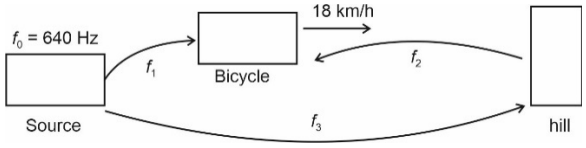
$1.2 \times 10^{-5} \times L_1 = 1.8 \times 10^{-5} L_2$

$L_1 = \frac{1.8}{1.2} \times 40 = 60$ cm

5. An observer is riding on a bicycle and moving towards a hill at 18 kmh^{-1}. He hears a sound from a source at some distance behind him directly as well as after its reflection from the hill. If the original frequency of the sound as emitted by source is 640 Hz and velocity of the sound in air is 320 m/s, the beat frequency between the two sounds heard by observer will be ___ Hz.

Answer (20)

Sol.



$f_1 = f_0\left(\frac{320-5}{320}\right) = 640\left(\frac{315}{320}\right)$

= 630 Hz

$f_3 = f_0$ [No relative motion]

$f_2 = f_0\left[\frac{320+5}{320}\right] = 640\left(\frac{325}{320}\right)$

= 650

Beat frequency = $f_2 - f_1$

= 650 – 630 = 20 Hz

6. The volume charge density of a sphere of radius 6 m is 2 μC cm^{-3}. The number of lines of force per unit surface area coming out from the surface of the sphere is _____ $\times 10^{10}$ NC^{-1}.

[Given : Permittivity of vacuum $\in_0 = 8.85 \times 10^{-12}$ C^2 N^{-1} – m^{-2}).

Answer (45)

Sol. $\rho = 2$ μc/cm^3

$R = 6$ m

Number of lines of force per unit area = Electric field at surface.

$= \frac{KQ}{R^2}$

$= \frac{1}{4\pi\varepsilon_0} \frac{\rho \frac{4}{3}\pi R^3}{R^2}$

$= \frac{\rho R}{3\epsilon_0}$

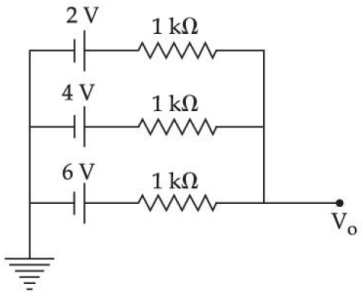
$= \frac{2 \times 10^{-6} \times 10^6 \times 6}{3 \times 8.85 \times 10^{-12}}$

$= 0.45197 \times 10^{12}$

$= 45.19 \times 10^{10}$ N/C

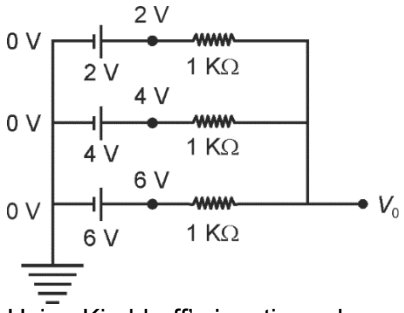
$\simeq 45 \times 10^{10}$

7. In the given figure, the value of V_0 will be _____ V.



Answer (4)

Sol.



Using Kirchhoff's junction rule.

$$\frac{2-V_0}{1}+\frac{4-V_0}{1}+\frac{6-V_0}{1}=0$$

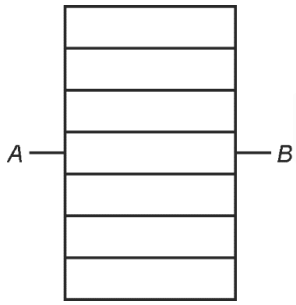
$12 - 3V_0 = 0$

$V_0 = 4$ V

8. Eight copper wire of length l and diameter d are joined in parallel to form a single composite conductor of resistance R. If a single copper wire of length $2l$ have the same resistance (R) then its diameter will be _____ d.

Answer (4)

Sol.



$RAB = R$

$$R=\frac{1}{8}\text{(Resistance of one wire)}$$

$$=\frac{1}{8}\rho\frac{l}{\pi\frac{d^2}{4}}=\frac{\rho l}{2\pi d^2}$$

Resistance of copper wire of length $2l$ and diameter $x = R$.

$$\rho\frac{2l}{\pi\frac{x^2}{4}}=R$$

$$\frac{8\rho l}{\pi x^2}=\frac{\rho l}{2\pi d^2}$$

$16d^2 = x^2$

$x = 4d$

9. The energy band gap of semiconducting material to produce violet (wavelength = 4000 Å) LED is _____ eV. (Round off to the nearest integer).

Answer (3)

Sol. Energy corresponding to wavelength 4000 Å

$$E=\frac{hc}{\lambda}$$

$$=\frac{6.6\times10^{-34}\times3\times10^{8}}{4000\times10^{-10}\times1.6\times10^{-19}}\text{ eV}$$

$$=\frac{12400}{4000}$$

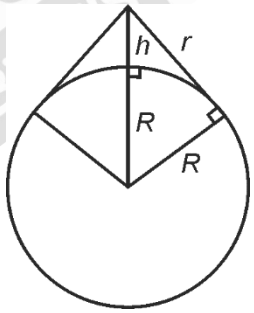
= 3.1 eV

≈ 3 eV

10. The required height of a TV tower which can cover the population of 6.03 lakh is h. If the average population density is 100 per square km and the radius of earth is 6400 km, then the value of h will be _____ m.

Answer (150)

Sol.



$$r=\sqrt{(h+R)^2-R^2}\cong\sqrt{2hR}$$

$$A=\frac{6.03\times10^5}{100}$$

$\pi r^2 = 6.03 \times 10^3$

$\pi 2Rh = 6.03 \times 10^3$

$$h=\frac{6.03\times10^3}{2\times\pi\times R}=0.015\times10\times10^3\text{ m}$$

= 150 m