2014

Part: I

Question: 1   [5]
Answer all questions

1. Choose the correct alternative (a), (b), (c) or (d) for each of the questions given below:

a. Intensity of electric field at a point at a perpendicular distance '*r*' from an infinite line charge, having linear charge density 'λ' is given by:

○ $E = (\dfrac{1}{4\pi \epsilon_0})\dfrac{\lambda}{r}$

○ $E = (\dfrac{1}{4\pi \epsilon_0})\dfrac{2\lambda}{r}$

○ $E = (\dfrac{1}{4\pi \epsilon_0})\dfrac{\lambda}{r^2}$

○ $E = (\dfrac{1}{4\pi \epsilon_0})\dfrac{2\lambda}{r^2}$

Answer:

$E = (\dfrac{1}{4\pi \epsilon_0})\dfrac{2\lambda}{r}$

b. If R_1 and R_2 are filament resistances of a 200 W and a 100 W bulb respectively, designed to operate on the same voltage, then:

○ $R_1 = R_2$

○ $R_2 = 2R_1$

○ $R_2 = 4R_1$

○ $R_1 = 4R_2$

Answer:
$R_2 = 2R_1$

c. A metallic wire having length of 2 m and weight of 4 10-3 N is found to remain at rest in a uniform and transverse magnetic field of 2 10-4 T. Current flowing through the wire is:

○ 10A

○ 5A

○ 2A

○ 1A

Answer:

10A

_____

d. When a beam of white light is passed through sodium vapours and then through a spectrometer, spectrum so obtained has two dark lines present in the yellow region. This spectrum is called:

○ Band spectrum

○ Continuous spectrum

○ Absorption spectrum of sodium

○ Emission spectrum of sodium

Answer*:*
Absorption spectrum of sodium.

e. If l_3 and l_2 represent angular momenta of an orbiting electron in III and II Bohr orbits respectively, then $l_3:l_2$ is:

○ 3:2

○ 9:4

○ 2:3

○ 4:9

Answer*:*
3:2

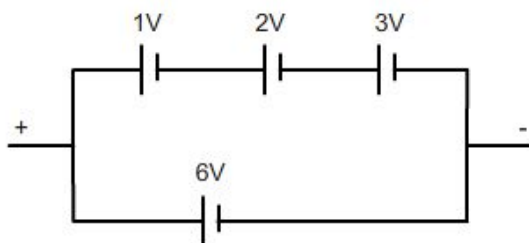2. Answer all questions briefly and to the point: [15]

a. A parallel plate air capacitor has a capacitance of 5 F. It becomes 50 F when a dielectric medium occupies the entire space between its two plates. What is the dielectric constant of the medium?

Answer*:*
10

b. Find the emf of the battery shown in Figure 1:

_____

Answer:
6V

c. Two substances A and B have their relative permeabilities slightly greater and slightly less than 1 respectively. What do you conclude about A and B as far as their magnetic materials are concerned?

Answer:
A : Paramagnetic
B : Diamagnetic   (both correct)

d. When does a moving charged particle not experience any force while moving through a uniform magnetic field?

Answer:
When charged particle is moving parallel to the external magnetic field/ in the direction of the magnetic field OR opposite to the direction of the magnetic field. OR velocity of charged particle v is parallel / antiparallel to B field OR $\vec{\upsilon} \| \vec{B}$.

e. What is the turns ratio i.e. transformer ratio, ns:np, in an ideal transformer which increases ac voltage from 220 V to 33000 V?

Answer:
$$\left(\frac{n_s}{n_p} \right) = 150$$

f. What is meant by coherent sources of light?

Answer:
Those emitting light waves having constant or zero phase difference. $\Delta\phi$ =0 or constant.

g. A ray of light is incident on a transparent medium at polarizing angle. What is the angle between the reflected ray and the refracted ray?

Answer:
90^0 OR $\frac{\pi}{2}$ OR diagram with angle marked 90^0.

h. Name the physical principle on which the working of optical fibers is based.

Answer:
Total internal reflection OR TIR

i. What is meant by shortsightedness?

Answer*:*
That defect of vision when a person is unable to see clearly objects at large distance. OR The far point of the eye is nearer than infinity. OR he can see clearly only objects near his eye OR Images of distant objects formed in front of the retina OR correct diagram.

j. How does focal length of a convex lens change with increase in wavelength of incident light?

Answer:
(Focal length of the convex lens) increases. Or $f_r > f_v$

k. With reference to photo-electric effect, what is meant by threshold wavelength?

Answer*:*
Maximum wavelength of incident (ultra violet) radiation which causes emission of electrons. Or wavelength of light (em radiation) having the minimum energy required for the emission of electrons.

l. Half-life of a certain radioactive element is 3 465 days. Find its disintegration constant.

Answer*:*
0 2 per day or 0 2 day^{-1}.

m. Binding energy per nucleon for helium nucleus $^4_2$He is 7 0 MeV. Find the value of mass defect for helium nucleus.

Answer*:*
$$\Delta m = \frac{28\,\text{MeV}}{(931\,\text{Me}\frac{V}{u})}$$
= 0.0301 u
Or 5.00 x 10^{-29} kg
Or 0.03 u
Or 4.98 to 5.0 x 10^{-29} kg

n. Write one balanced reaction representing nuclear fusion.

Answer*:*
$4^1_1H \rightarrow {}^4_2He + 2^0_1e$ + energy
Or $4^1H + 2e \rightarrow {}^4He + 2v + 6\gamma$

$^2_1H + {}^3_1H \rightarrow {}^4_2He + {}^1_0n$ + energy
Or $He^4 + He^4 + He^4 \rightarrow C^{12} + \gamma$
Equivalent OR $^2H + {}^2H \rightarrow {}^3He + {}^1n$
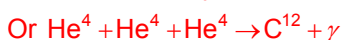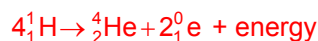
o. Draw the truth table of a NOR gate.

Answer*:*

A	B	Y
0	0	1
1	0	0

0	1	0
1	1	0

Part: II

Answer six questions in this part, choosing two questions from each of the Sections A, B and C

Section: A

Answer any two questions

Question: 2

1. An electric dipole of dipole moment $\vec{p}$ is placed in a uniform electric field $\vec{E}$ with its axis inclined to the field. Write an expression for the torque $\vec{\tau}$ experienced by the dipole in **vector** form. Show diagrammatically how the dipole should be kept in the electric field so that the torque acting on it is: [3]
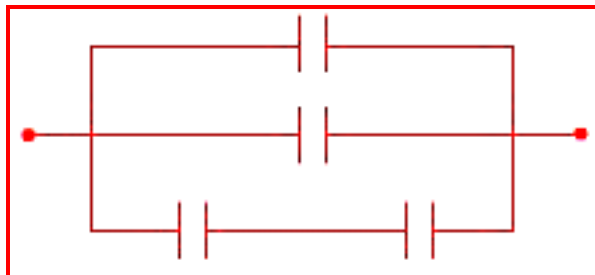
   a. Maximum.
   b. Zero.

Answer:
$(\vec{\tau}) = \vec{p} \times \vec{E}$

a.

b.
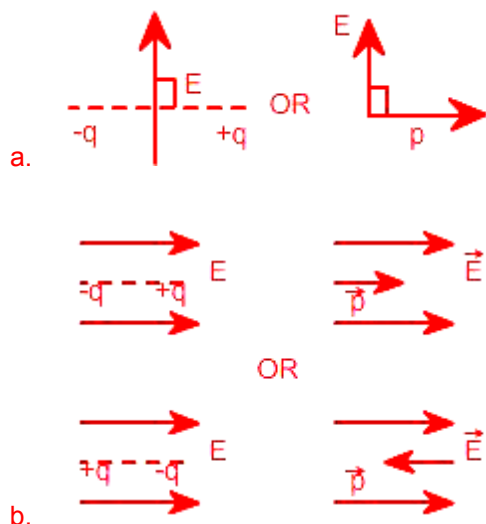
2. You are provided with 8 µ F capacitors. Show with the help of a diagram how you will arrange **minimum** number of them to get a resultant capacitance of 20 μ F [3]

Answer:

_____

(Diagram is compulsory). Any two Cs shown in parallel in the diagram any two capacitors shown in series in the diagram. All 4 Capacitors shown correctly in the diagram

3.   [3]
    a.   Define temperature coefficient of resistance of the material of a conductor.

Answer*:*
It is defined as fractional increase in resistance per degree rise in temperature. Or Equivalent statement OR Defining equation.

    b.   When the cold junction of a thermocouple is maintained at 0^0 C, the thermo emf 'e', generated by this thermocouple is given by the relation:

$e = [16.8\ \theta + \dfrac{1}{2}\ (-0.048)\ \theta^2]\ \times 10^{-6}$ where θ is the temperature of the hot junction in ^{0}C.

Find the neutral temperature of this thermocouple.

Answer*:*

$e = [16.8\ \theta + \dfrac{1}{2}\ (-0.048)\ \theta^2]\ \times 10^{-6}$

$\dfrac{de}{d\theta} = [16.80 - \dfrac{1}{2}\ \times -0.048 \times 2\theta]\ \times 10^{-6}$

$\dfrac{de}{d\theta} = 0 \Rightarrow \theta = 350^0C$

Or, $\theta = (\dfrac{a}{b}) = \dfrac{16.80}{0.048}\ \dfrac{1}{2}$

$\theta = 350^0C$
$\theta_i = 700^0C$ with formula and working
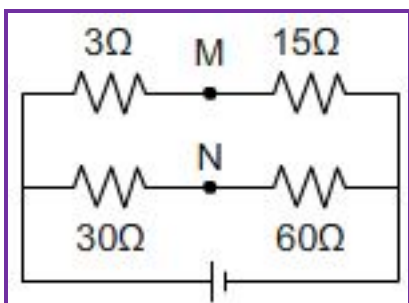$\theta_n = 350^0C$

Question: 3
1. Draw a **labelled** circuit diagram of a **potentiometer** to compare emfs of two cells. Write the working formula (Derivation not required).   [3]

Answer*:*
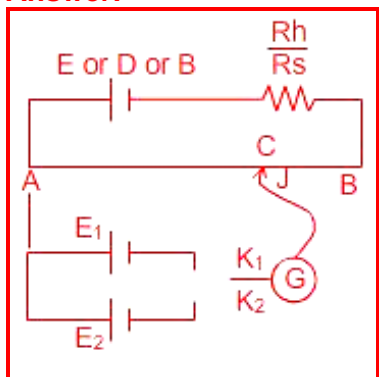
$E_1 : E_2 = l_1 : l_2$

2. How much resistance should be connected to 15 Ω resistor shown in the circuit in Figure 2 below so that the points M and N are at the same potential: [3]

_____

Answer:

$$\frac{3}{R} = \frac{30}{60}$$

$$\Rightarrow R = 60\Omega$$

$$\frac{1}{15} + \frac{1}{x} = \frac{1}{6}$$

or, $\dfrac{15 \times l}{15 + x} = 6$

x = 10 Ω

3.

a. With reference to free electron theory of conductivity, explain the terms: [3]

   i.   Drift speed

Answer:
The speed with which a free electron moves in a direction opposite to that of applied electric field OR The (average constant) speed acquired by the free electrons in a conductor when a voltage is applied across its ends.

   ii.   Relaxation time

Answer:
Time spent by a free electron between two consecutive collisions with the atoms /ions. OR The mean time between collisions of conduction electrons, (with the lattice).

b. What is the color code of a carbon resistor having a resistance of 470Ω and a tolerance of 5%?   [3]

Answer:
Yellow, violet, brown and golden yellow OR Yellow, violet, brown and gold OR YVBG.

Question: 4
1.
a. State Tangent Law in magnetism.   [2]

Answer:
When a magnet is freely suspended or a compass needle is pivoted to move freely in a horizontal plane in two (uniform and) perpendicular magnetic fields, BH and BF it comes to an equilibrium position in which

Tan $\theta = \dfrac{B_F}{B_H}$ where θ is the angle with B_H

Or, tan $\theta = \dfrac{F}{H}$

Or, $\dfrac{B_1}{B_2}$

Or, $\dfrac{B_c}{B_H}$ with labelled diagram

Or, equivalent verbal statement

b. At a certain temperature, a ferromagnetic material becomes paramagnetic. What is this temperature called?

Answer*:*
Curie temperature.

2.   [3]

a. State Biot Savart law.

Answer*:*

$dB = \dfrac{\mu_0}{4\pi}\, \dfrac{i\,\overline{dl}\, x\, \hat{r}}{r^2}$

Or, $dB = \dfrac{\mu_0\, i\,\overline{dl}\,\mathrm{Sin}\theta}{4\pi r^2}$

(Vector or scalar equation between dB, I and I (with some explanation or labelled diagram)

Or, dB α I, α - $\dfrac{1}{r^2}$, α Sin θ

b. Find magnetic flux density at a point on the axis of a long solenoid having 5000 turns/m when it is carrying a current of 2 A.

Answer*:*
Correct substitution with or without correct formula.

B = μ_0 n I
= 4π x 10^{-7} x 5000 x 2 Correct formula or substitution
Correct result with unit i.e
B = 12.56 x 10^{-3} T
or, = 0.0126 T
or, $\dfrac{Wb}{m^2}$

3. An alternating emf of 110V is applied to a circuit containing a resistance R of 80 Ω and an inductor L in series. The current is found to lag behind the supply voltage by an angle

     θ = tan^{-1} ($\dfrac{3}{4}$)   [4]

     a. Inductive reactance

Answer*:*

$\tan\theta = \dfrac{X_L}{R}$

or, $\dfrac{3}{4} = \dfrac{X_L}{80}$

$\therefore X_L = 60\,\Omega$

      b.   Impedance of the circuit

Answer:
$Z^2 = X_L{}^2 + R^2$
or, $60^2 + 80^2$
$\therefore Z = 100\,\Omega$

      c.   Current flowing in the circuit

Answer:
$I = \dfrac{V}{Z}$

or, $\dfrac{E}{Z}$

or, $\dfrac{110}{100}$

= 1.1 A

      d.   If the inductor has a coefficient of self-inductance of 0 1 H, what is the frequency of the applied emf ?

Answer:
$X_L = 2\pi f L$

or, $\omega = \dfrac{X_L}{L}$

$= \dfrac{60}{0.1}$

$= 600\ \dfrac{\text{rad}}{\text{s}}$

or, $60 = 2 \times 3.14 \times f \times 0.1$

$f = \dfrac{\omega}{2\pi}\ \text{or}\ \dfrac{600}{6.28}$

= 95.5 Hz

Or, $\therefore f = \dfrac{60}{0.628}$

= 95.5Hz

Section: B

Question: 5
1.   Name the part of the electromagnetic spectrum which is: [2]

      a.   Suitable for radar systems used in aircraft navigation.

Answer:
Micro waves or Radio wave.

b. Produced by bombarding a metal target with high speed electrons.

Answer*:*
X rays.

2. In Young's double slit experiment, using monochromatic light, fringes are obtained on a screen placed at some distance from the slits. If the screen is moved by 5×0^{-2} m towards the slits, the change in the fringe width is 3×10^{-5} m. If the distance between the two slits is 10^{-3} m, calculate wavelength of the light used. [3]

Answer*:*

$$y = \frac{\lambda D}{a}$$

or, $\Delta y = \dfrac{\lambda}{a} \Delta D$

$\dfrac{\lambda}{a} = \dfrac{3 \times 10^{-5}}{5 \times 10^{-2}}$ One correct substitution in a correct formula

$= 0.6 \times 10^{-3}$

$\lambda = 0.6 \times 10^{-6}$ m Correct result with unit

or, 6×10^{-7} m

or, 600nm

3. [3]
   a. State Brewster's law of polarization of light.

Answer*:*
When ordinary /unpolarised light is incident on a transparent medium, the reflected light is completely plane polarized for a certain angle of incidence θp and

tan θp = $\dfrac{n_2}{n_1}$

or, tan θp = n

or, tan θ = n where θ is the polarising angle (and n is the refractive index of the transparent medium).

   b. How will you identify with the help of an experiment whether a given beam of light is of polarized light or of unpolarized light?

Answer*:*
Incident light is allowed to fall on a polariser which is then rotated (compulsory). If intensity of transmitted light varies, it is polarised light. If intensity of transmitted light remains constant, it is unpolarized light.

Question: 6

1. A narrow beam of monochromatic light, PQ, is incident normally on one face of an equiangular glass prism of refractive index 1 45. When the prism is immersed in a certain liquid, the ray makes a grazing emergence along the other face. Find the **refractive index** of this liquid. [2]

_____

Answer:

θ_c or $c = 60^0$

or, $_g\mu_1 = \dfrac{\sin 60^0}{\sin 90^0}$
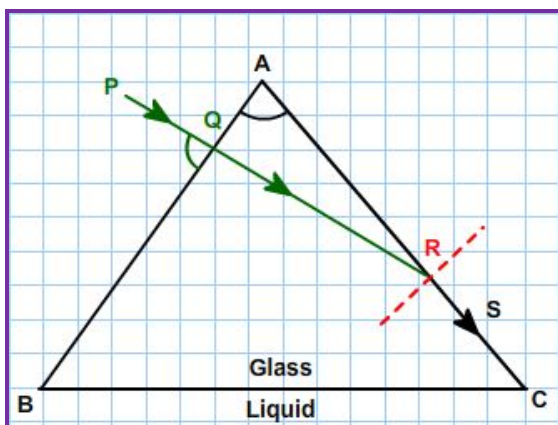
$\dfrac{_a\mu_1}{_a\mu_g} = \sin 60^0$

or, $\therefore {}_a\mu_1 = {}_a\mu_g \times \sin 60^0$

$= 1045 \times 0.866$

$= 1.26$

2.   When two thin lenses of focal lengths f_1 and f_2 are kept coaxially and in contact, prove that their combined focal length "f" is given by: [3]

$\dfrac{1}{f} = \dfrac{1}{f_1} + \dfrac{1}{f_2}$

Answer:

Any sign convention is acceptable. Correct diagram showing Object O, intermediate image I and final image I. Lens formula to first lens, $\dfrac{1}{v'} - \dfrac{1}{u} = \dfrac{1}{f_1}$

Lens formula to second lens $\dfrac{1}{v} - \dfrac{1}{v'} = \dfrac{1}{f_2}$ Adding the above two equations, $\dfrac{1}{v} - \dfrac{1}{u} = \dfrac{1}{f_1} + \dfrac{1}{f_2}$ But for

an equivalent single lens, let f be the focal length, for the same u and v. Then we have $\dfrac{1}{v} - \dfrac{1}{u} = \dfrac{1}{f}$

Comparing these two equations, we get $\dfrac{1}{f} = \dfrac{1}{f_1} + \dfrac{1}{f_2}$.

3.   The Figure below shows the positions of a point object O, two lenses, a plane mirror and the final image I which coincides with the object. The focal length of the convex lens is 20 cm. Calculate the focal length of the concave lens. [3]

_____
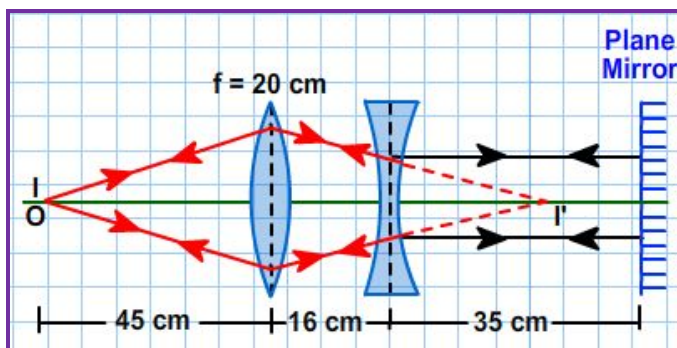
Answer:
Lens formula to convex lens: Use any sign convention.

$$\frac{1}{v}+\frac{1}{u}=\frac{1}{f_1} \quad \text{or} \quad \frac{1}{v}-\frac{1}{u}=\frac{1}{f}$$

i.e. $\dfrac{1}{v}+\dfrac{1}{45}=\dfrac{1}{20} \qquad \dfrac{1}{v}+\dfrac{1}{-45}=\dfrac{1}{20}$ } Correct substitution

$\therefore v = 36 cm$

For concave lens:
Either $f_2 = 36 - 16$
$= 20$ cm

Question: 7
1.
a. What is meant by dispersive power of a transparent material? [4]

Answer:
The ability of the material to split (separate) white light into its constituent colors.
Or, It is defined as a ratio of angular dispersion to the mean deviation.

Or, $\omega = \dfrac{\delta_v - \delta_r}{y}$

or, $\omega = \dfrac{(\mu_v - \mu_r)}{(\mu_y - 1)}$

b. Show that, two thin lenses kept in contact, form an achromatic doublet if they satisfy the condition: $\dfrac{\omega}{f}+\dfrac{\omega'}{f'}=0$ where the terms have their usual meaning.

Answer:
$F_v = F_R$

$\dfrac{1}{F_v}=\dfrac{1}{F_R}$

$\dfrac{1}{f_{1v}}+\dfrac{1}{f_{2v}}=\dfrac{1}{f_{1r}}+\dfrac{1}{f_{2r}}$

$\dfrac{1}{f_{1v}}-\dfrac{1}{f_{1r}}+\dfrac{1}{f_{2v}}-\dfrac{1}{f_{2r}}=0$ Any one of above 3 equations correct

$$\frac{1}{f}=(\mu-1)\left(\frac{1}{R_1}\mp\frac{1}{R_2}\right)$$

$$\frac{1}{f_r}=(\mu_r-1)\left(\frac{1}{R_1}\mp\frac{1}{R_2}\right)$$ Any one equation correct

$$\frac{1}{f_v}=(\mu_v-1)\left(\frac{1}{R_1}\mp\frac{1}{R_2}\right)$$

$$\left(\mu_{1v}-\mu_{1r}\right)\left(\frac{1}{R_1}\mp\frac{1}{R_2}\right)+\left(\mu_{2v}-\mu_{2r}\right)\left(\frac{1}{R_1}\mp\frac{1}{R_2}\right)=0$$

or, $$\frac{\left(\mu_{1v}-\mu_{1r}\right)}{\left(\mu_{1y}-1\right)f_1}+\frac{\left(\mu_{2v}-\mu_{2r}\right)}{\left(\mu_{2y}-1\right)f_2}=0$$

$$\left(\text{Hence }\frac{w_1}{f_1}+\frac{w_2}{f_2}=0\right)$$

2.
a. Define magnifying power of a microscope in terms of visual angles. [2]

Answer:
It is defined as a ratio of angle subtended by the final image (β) to the angle subtended by the object, at the eye when kept at D.

b. What is the advantage of a compound microscope over a simple microscope?

Answer:
Compound microscope has a larger magnifying power.

3. An astronomical telescope uses two lenses of powers 10 dioptre and 1 dioptre. If the final image of a distant object is formed at infinity, calculate the length of the telescope. [2]

Answer:
$$f_1=\frac{1}{P_1}$$

$$=\frac{1}{10}$$
= 0.1 $\rightarrow$ (Eyepiece)

$$f_2=\frac{1}{P_2}$$

$$=\frac{1}{1}$$
= 1.0 m $\rightarrow$ (Objective) or implied in the next step.
L=$f_o + f_e$
or,= 1.0 +0.1
=1.1m
or, L = $f_o + f_e$

or, 1 + $\dfrac{1}{10}$

= 11 m (in onestep)

_____

Section: C

Question: 8
1. Answer the following questions with reference to Millikan's oil drop experiment:

a. What is an atomiser?   [3]

Answer:
It is a sprayer (of oil drops) or breaks up oil into small droplets.

b. What is the use of an X-ray tube?

Answer:
To help oil drops acquire more charge OR for ionising air.

c. What is the unique property shown by the charge of an oil drop?

Answer:
Charge on it is always an integral multiple of $\pm e$
or, Quantization of charge
or, q = ne
Atomicity of charge
or, Minimum charge of an oil drop = $\pm e$

2.   [3]
    a. Write Einstein's photo electric equation.

Answer:
$hf = hf_o + K_{max}$ or w +K_{max}
or, interms of λ
or, equivalent.

    b. If the frequency of the incident radiation is increased from 4 x 10^{15} Hz to 8 x 10^{15} Hz by
        how much will the stopping potential for a given photosensitive surface go up?

Answer:
Correct substitution in e.ΔV =h.Δf
Correct result with unit (V)= 16.5 V

3.   [2]
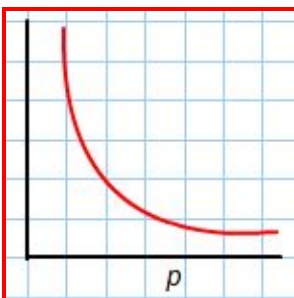   a. What are matter waves?

Answer:
Waves associated with moving particles or with the wave nature of particles are called matter waves or equivalent.

    b. Show with the help of a labelled graph how their wavelength (λ) varies with their linear
        momentum (*p*).

Answer:

_____

Question: 9

1. The energy levels of an atom of a certain element are shown in the given **Figure which** one of the transitions A, B, C, D or E will result in the emission of photons of electromagnetic radiation of wavelength 618 75 nm? Support your answer with mathematical calculations. [3]
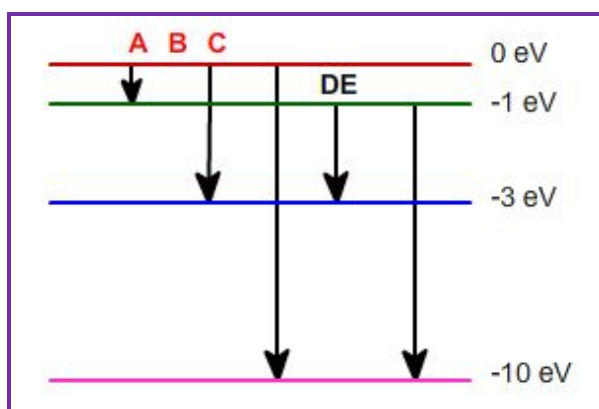
Answer:

$E = \dfrac{hc}{\lambda}$ = correct formula or substitution for J or eV

= 2eV

or, $E = \dfrac{1240}{618.85}$

= 2eV i.e Transition D.

2. Voltage applied between cathode and anode of an X-ray tube is 18 kV. Calculate the minimum wavelength of the X-rays produced. [2]

Answer:

$\lambda_{min} = \dfrac{hc}{eV}$

$\dfrac{1240}{18000}$ = 0.069 nm

or, correct substitution with or without formula correct result i.e

$\lambda_{min} = 0.69 \overset{o}{A}$

or, = 0.069 nm

3. In a nuclear reactor, what is the function of: [3]

a. The moderator

Answer:
Moderator: To slow down, fast moving neutrons or to convert fast neutrons to slow (thermal) neutrons.

b. The control rods.

Answer:
Control rods: To control the rate of production of energy or to control the rate of fission To shut down the nuclear reactor or Absorbs (slow) neutrons.

c. The coolant.

Answer:
Coolant: To cool the reactor or To remove / extract heat energy from the (heat of the) reactor or To keep the temperature of the reactor down.

Question: 10

1.
   a. The atomic mass of Uranium $^{238}_{92}U$ is 238.0508 u, while that of Thorium $^{234}_{92}Th$ is 234.0436 u, ans that of Helium $^{4}_{2}He$ is 4.0026 u. Alpha decay converts $^{238}_{92}U$ into $^{234}_{92}Th$ as shoe below. $^{238}_{92}U \rightarrow ^{234}_{92}Th + ^{4}_{2}He + energy$. Determine the energy released in this reaction. [3]

Answer:
Δm = 238.0508 – (234.0436 + 4.0026)
= 238.0508 – (238.0462)
= 0.0046 (u) or implied in next step
E = 0.0046 x 931
= 4.28 MeV
or, E = {238.0508 - (234.0436 + 4.0026)} x 931
= 4.28 MeV
or, 4.285 MeV

b. What is a neutrino?

Answer:
Neutrinos are one of the fundamental particles which make up the universe. They are also one of the least understood. Neutrinos are similar to the more familiar electron, with one crucial difference: neutrinos do not carry electric charge.

2. In semi conductor physics, what is meant by: [3]

   a. A rectifier.

Answer:
A rectifier converts ac (voltage) to dc (voltage).

b. An amplifier.

Answer:
An amplifier increases the magnitude of voltage/count of the input signal.

    c.   An oscillator.

Answer:
An oscillator is an electronic device which generates/produces ac voltage/signal.