KSEAB PYQ 2022

Physics

1. Name the apparatus used to detect electric charge on a body.

2. Define 'electric dipole moment'.

3. State Ohm's law.

4. The resistance of a carbon resistor with four coloured rings is $(500 \pm 50)\Omega$. Identify the colour of fourth ring.

5. What is the magnitude of the magnetic force on a charged particle moving anti-parallel to a uniform magnetic field?

6. Define the magnetic declination at a place on the Earth.

7. Mention the significance of Lenz's law.

8. Write the expression for the natural frequency of oscillations in an LC circuit.

9. Write the relation between the magnitude of the electric and magnetic fields in an electromagnetic wave.

10. Name the type of electromagnetic rays lying between ultraviolet and gamma rays.

11. What are coherent sources?

12. How does the resolving power of a telescope change on increasing the diameter of the objective lens?

13. What is meant by the ionization energy of an atom?

14. Give an example for elemental semiconductor.

15. Draw the logic symbol of NOT-gate.

16. What are polar and non-polar molecules?

17. Show with schematic graphs, variation of resistivity with absolute temperature for (a) Nichrome and (b) Silicon.

18. The current in a coil falls from 25 mA to 0 mA in 1 ms and induces an emf of 10 V in it. Find the self-inductance of the coil.

19. Give the working principle of AC generator. Why the current generated by it is called alternating current?

20. What is displacement current? Write its expression.

21. Give the reasons for the following statements: (a) The sun is visible a little before the actual sunrise & until a little after the actual sunset (b) The sky appears blue

22. Write any two uses of polaroids.

23. What are de Broglie waves? Name an experiment which verified the wave nature of electrons.

24. Draw the labeled diagram representing the schematic arrangement of Geiger-Marsden experiment for alpha-particle scattering.

25. Give any two advantages of LEDs over conventional incandescent low power lamps.

26. Mention the three factors on which the capacitance of a dielectric parallel plate capacitor depends.

27. Derive the expression for the drift velocity of electrons in a conductor in terms of their relaxation time.

28. Write the two reasons to show that, 'the galvanometer as such can not be used as an ammeter'. Give the method of converting the galvanometer into an ammeter.

29. List any three properties of ferromagnetic substances

30. Write any three applications in which advantage of eddy currents are used

31. Mention any three sources of energy loss in an actual transformer

32. Using Huygen's principle, show that the angle of incidence is equal to the angle of reflection, when a plane wavefront is reflected by a plane surface.

33. Write the three postulates of Bohr model of the hydrogen atom.

34. Define 'mass defect' and 'binding energy' of a nucleus. Write the relation between them.

35. Give any three differences between intrinsic and extrinsic semiconductors

36. What is an electric field line? Write the four general properties of electric field lines.

37. Using Kirchhoff's rules, obtain the expression for the balancing condition of Wheatstone bridge.

38. With the help of a diagram, derive the expression for the torque on a rectangular loop placed in a uniform magnetic field.

39. Derive the expression for the magnitude of the magnetic field at a point on the axis of a current carrying solenoid. Hence show that it is equivalent to a bar magnet.

40. Show that the current lags the voltage by $\pi/2$ in an AC circuit containing a pure inductor. Draw the phasor diagram for it.

41. Derive lens maker's formula for a convex lens.

42. Define photoelectric work function. Write the 4 experimental observations of photoelectric effect.

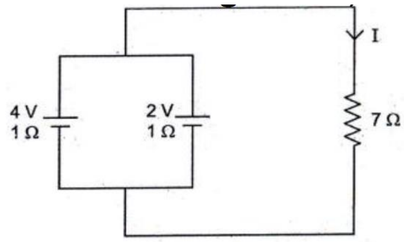
43. What is rectifier? With the suitable circuit diagram, explain the working of p-n junction diode as a full-wave rectifier. Draw the input and the output waveforms.

44. Two small charged spheres having charges of $2\times10^{-7}C$ and $3\times10^{-7}C$ are placed 3 cm apart in vacuum. Find the electrostatic force between them. Find the new force, when the distance between them is doubled.

Given: $1/4\pi\varepsilon_0 = 9\times10^9\ \text{N m}^2\text{C}^{-2}$

45. A charge of 8 mC is located at the origin. Calculate the work done in taking a small charge of $-2\times10^{-8}C$ from a point $A(3\text{ cm},0,0)$ to a point $B(0,4\text{ cm},0)$ via a point $C(3\text{ cm},4\text{ cm},0)$. Given: $1/4\pi\varepsilon_0 = 9\times10^9\ \text{N m}^2\text{C}^{-2}$

46. In the following circuit, find the current I



47. A circular copper coil of mean radius 6.284 cm has 20 turns. If a current of 2 A is passed through this coil, find the magnitude of the magnetic field at its centre. Also find the magnetic dipole moment of this current coil. Given: $\mu_0 = 4\pi\times10^{-7}\,\text{Hm}^{-1}$

48. A ray of light passes through an equilateral glass prism such that the refracted ray inside the prism is parallel to its base. Calculate the (a) Angle of deviation of the ray and (b) Speed of light ray inside the prism.
Given: the refractive index of glass $=3/2$ and the speed of light in vacuum $=3\times10^{8}\ \mathrm{ms}^{-1}$.

49. Two slits separated by 1 mm in Young's double slit experiment are illuminated by the violet light of the wavelength 400 nm . The interference fringes are obtained on the screen placed at 1 m from the slits. Find the fringe width. If the violet light is replaced by the light of the wavelength 700 nm , find the percentage change in fringe width.

50. The normal activity of living carbon ($C-14$) containing matter in found to be about 15 decays per minute per gram of carbon. A specimen found in an archaeological excavation has an activity of 1.5 decays per minute per gram of carbon matter. Estimate the age of the specimen. Given: the half-life of carbon ($C-14$) is 5730 years.

Hint & Solution

1. Gold leaf electroscope or Electroscope

2 It is defined as the product of the magnitude of either charge and the separation (or the distance) between the charges (or dipole length). OR if q is the magnitude of either charge and 2 a is separation between the charges (or dipole length), then dipole moment is defined as $p = q \times 2a$

3. The current through a conductor is directly proportional to the pd across its ends provided temperature remains constant. OR If I is the current through a conductor and V is the pd across its end, then Ohm's law states $I \propto V$

4. Silver

5. Zero

6. The angle between the true geographic north and the north shown by the compass needle. OR the angle between the geographic meridian and the magnetic meridian at that place.

7. Conservation of energy OR It gives the polarity of induced emf OR It gives the direction of induced current. (Any one)

8. $\omega = \frac{1}{\sqrt{LC}}$ OR $v = \frac{1}{2\pi\sqrt{LC}}$

9. $B_0 = E_0 / c$

10. X-rays

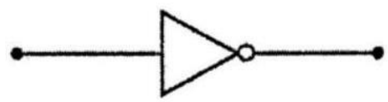
11. Two sources of light which emit light waves of same wavelength (or frequency) and constant phase difference.

12. Increases

13. The minimum energy required to remove an electron from the atom (or to infinity or infinite orbit).

14. Silicon or Germanium (or Si or Ge)

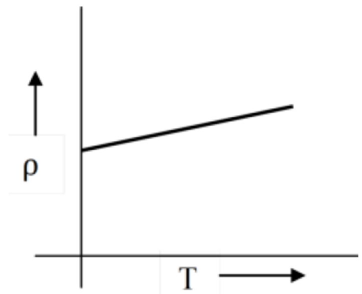
15.



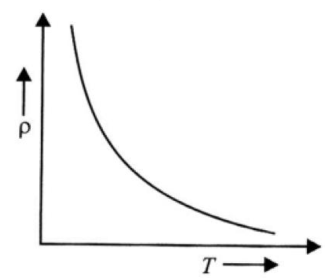
16. Polar molecule: A molecule in which the center of positive charge and the center of negative charge do not coincide.
Non-polar molecule: A molecule in which the center of positive charge and the center of negative charge coincide.

17.

(a)



(b)



18.

Formula: $\varepsilon = -L\frac{dI}{dt}$ OR $|\varepsilon| = L\left|\frac{dI}{dt}\right|$

Sub and Ans: 0.4 H

19. Principle: Electromagnetic induction
The direction of current changes or reverses periodically

20. Current due to the changing electric field or changing electric flux. $i_d = \varepsilon_0 \frac{d\phi_E}{dt}$

21. Ans (a) Refraction of light through the atmosphere
Ans (b) Scattering of light by the atmospheric particles

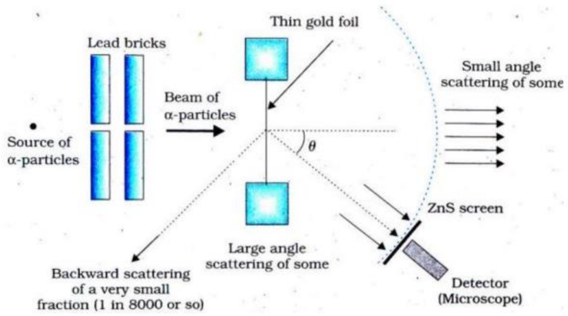
22.

1. To produce and analyze the polarised light.
2. In sun glasses or goggles.
3. To view 3-D pictures/movies.
4. In window panes of trains and aero planes.
5. To eliminate head light glares of vehicles.

Note: Any other correct use should be considered.

23. Waves associated with moving material particle is called de Broglie wave.
Experiment: Davisson and Germer experiment or G P Thomson experiment

24.



25. 1. Low operating voltage and current and less power consumption
2. Fast on-off switching ability
3.Durable

26. 1. Area of the plates
2. Distance between the plates
3. Dielectric constant of the material between the plates

27.

$\vec{v}_0 = \frac{1}{N}\sum_{i=1}^{N}\vec{v}_i = 0$ and $\vec{a} = \frac{-e\vec{E}}{m}$ $(\because F = qE$ and $q = -e)$

Using $\vec{v}_d = \vec{v}_0 + \vec{a}\tau$

Arriving at $\vec{v}_d = -\frac{e\vec{E}}{m}\tau$ or $|\vec{v}_d| = \frac{eE}{m}\tau$

Note: Any other correct method should be considered

28.
1. It is a sensitive device
2. It is connected in series and it has high resistance

Method: By connecting low resistance in parallel with it OR by shunting the galvanometer

29.

1. Their susceptibility is large and positive.
2. Their permeability is very large i.e., $\mu_r \gg 1$ ***OR*** $\mu_r \gg \mu_0$
3. As temperature increases, magnetization/susceptibility decreases.
4. Ferromagnetic substance becomes paramagnetic when heated above critical temperature.
5. They have strong tendency to move from weaker region to stronger region of magnetic field OR they get strongly attracted by magnets.
6. When placed in magnetic field, field lines get concentrated inside the sample.

Note: Any other correct property should be considered

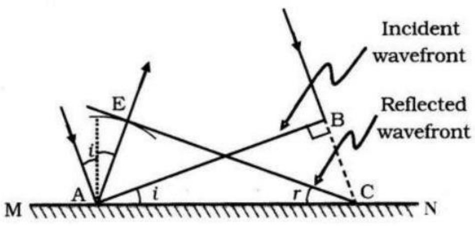
30.
1. Induction furnace
2. Magnetic braking in trains
3. Electromagnetic damping
4. Electric power meter

Note: Any other correct application should be considered

31.
1. Loss due to heating OR Copper loss OR heating of coils due to resistance
2. Loss due to flux leakage OR Magnetic loss
3. Loss due to eddy current OR Core or iron loss OR heating of core due to eddy currents
4. Hysteresis loss

Note: Any other correct source should be considered

32.



Ray diagram

Showing $BC = vt$ and $AE = vt$

$\angle ABC = \angle AEC\left(\because \text{ each angle is } 90^{\circ}\right)$ and

Thus the triangle ABC is congruent to AEC . $\therefore$

$$\left.\begin{array}{l} BC = AE\left(\because \text{ each} = vt\right) \\ \angle BAC = \angle ECA \therefore\ \angle i = \angle r \end{array}\right]$$

33.

1. An electron in atom can revolve in certain stable orbits without the emission of radiant energy.
2. An electron revolves around the nucleus only in those orbits for which its angular momentum is an integral multiple of $\left(h/2\pi\right)$, where h is the Planck's constant.
3. An electron can jump from higher energy orbit to lower energy orbit. In this process a photon is emitted whose energy is equal to the energy difference between the initial and final states.

34.

Mass defect: The difference between the sum of masses of nucleons and the nuclear mass.

Binding energy: Energy required to break the nucleus into its constituent particles (nucleons). OR energy released when a nucleus is formed by constituent particles/nucleons.

Relation:

$$E_b = (\Delta \mathrm{M})c^2 \text{ OR } E_b = (\Delta \mathrm{M})931.5\mathrm{MeV}$$

35.

Intrinsic Semiconductor	Extrinsic Semiconductor
1. It is a pure form of semiconductor.	1. It is a doped semiconductor.
2. It contains equal number of electrons and holes. (holes in VB=electrons in CB)	**2.** It contains un-equal number of electrons and holes.
3. Electric conductivity is due to both electrons and holes.	**3.** Electric conductivity is mainly due to majority charge carriers.
4. Conductivity depends only on temperature.	**4.** Conductivity depends both on temperature and impurity added.
5. At 0 K , charge carriers vanish.	**5.** At 0 K , majority charge carriers exist.
6. Conductivity is low	**6.** Conductivity is high

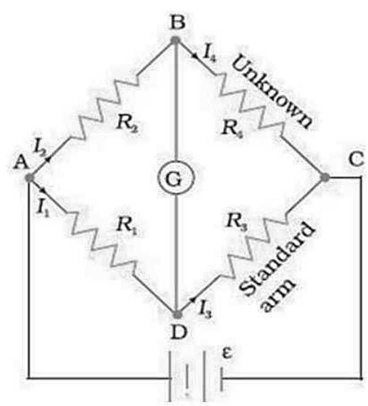
36.

An electric field line is a curve drawn in an electric field so that the tangent to it at any point is in the direction of the net field at that point OR it is an imaginary path along which a free test charge tends to move OR it is a way of pictorially/graphically representing/mapping an electric field in a given region (or any other correct answer).

1. Electric field lines always start from positive charge and end at negative charge. If there is single charge, they start or end at infinity.
2. In a charge-free region, field lines can be taken to be continuous curves without any breaks.
3. Two field lines never cross each other.
4. Electrostatic field lines never form closed loops.

Note: Any other correct property should be considered.

37.



Current through Galvanometer $I_g = 0$

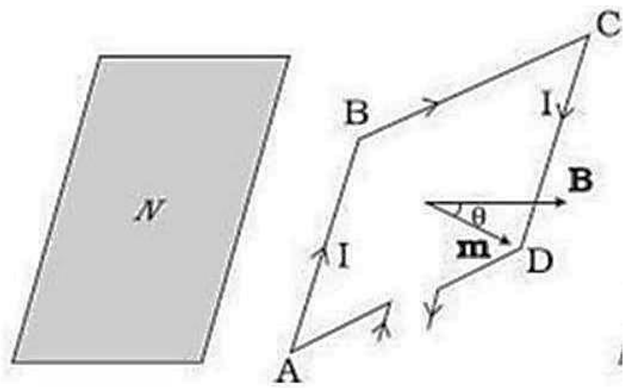
KVL to loop ABDA : $-I_1R_1+0 + I_2R_2 = 0$

KVL to loop BCDB : $-I_2R_4 + 0 - I_1R_3 = 0$

Arriving at

$\frac{R_2}{R1} = \frac{R_4}{R3}$

38. With the help of a diagram, derive the expression for the torque on a rectangular loop placed in a uniform magnetic field.

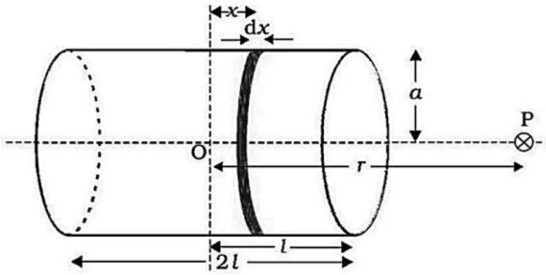


The forces on arm AD and BC cancel each other

The force on arms AB and CD $F_1 = F_2 = IbB$

Torque $\tau = F_1\frac{a}{2}\sin\theta + F_2\frac{a}{2}\sin\theta$

Final expression $\tau = IabB\sin\theta = IAB\sin\theta$



Magnetic field at P due to this circular element:

$$dB = \frac{\mu_0}{4\pi}\frac{2\pi(ndx)Ia^2}{\left[a^2+(r-x)^2\right]^{3/2}}$$

Magnetic field at P due to whole solenoid:

$$B = \int_{x=-l}^{x=+l}\frac{\mu_0}{4\pi}\frac{2\pi nIa^2}{r^3}dx = \frac{\mu_0}{4\pi}\frac{2}{r^3}\left[2\pi nIa^2 l\right]$$

Final expression: $B = \frac{\mu_0}{4\pi}\frac{2m}{r^3}$

This expression is same as the expression for the magnetic field due to a bar magnet at its axial point. Thus the current carrying solenoid is equivalent to a bar magnet.

40.

AC voltage applied across a pure inductor:

$v = v_m \sin\omega t$

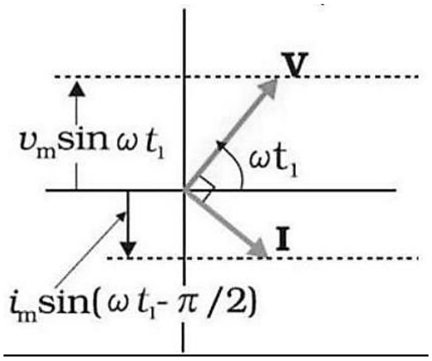
Applying KVR to the loop:

$$v_m\sin\omega t - L\frac{di}{dt} = 0 \therefore\ di = \frac{v_m}{L}\sin\omega t dt$$

Instantaneous current by integration:

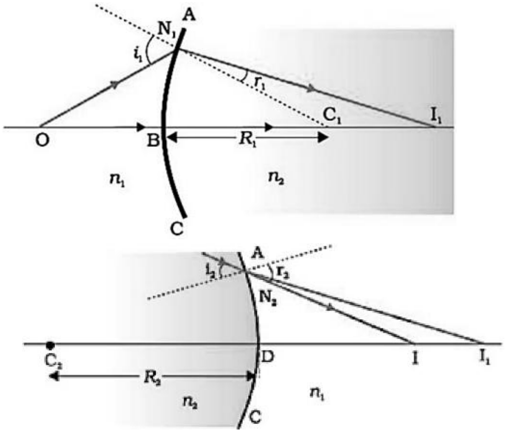
$$\int di = \int\frac{v_m}{L}\sin\omega t dt = \frac{v_m}{\omega L}(-\cos\omega t)$$

Arriving at $i = i_m\sin\left(\omega t - \frac{\pi}{2}\right) \Rightarrow$ Current lags the voltage by $\pi/2$



Phasor diagram

41.



Ray diagram

Formula for refraction at I surface:

$$\frac{n_2}{BI_1} - \frac{n_1}{OB} = \frac{n_2 - n_1}{BI_1}$$

Formula for refraction at II surface:

$$\frac{n_1}{DI} - \frac{n_2}{DI_1} = \frac{n_1 - n_2}{R_2} = \frac{n_2 - n_1}{-DC_2}$$

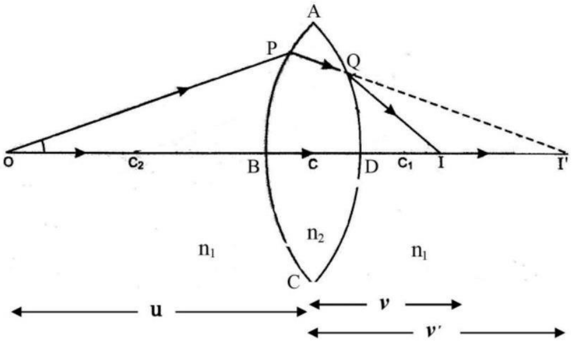
Combining the two equations and simplification:

$$\frac{1}{DI}-\frac{1}{OB}=\left(n_2-n_1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

And using the condition $u=\infty \Rightarrow v=f$

Arriving at lens makers formula:

$$\frac{1}{f}=\left(n_{21}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right) \text{ OR}$$



Ray diagram

Formula for refraction at I surface:

$$\frac{n_2}{v'}-\frac{n_1}{u}=\frac{n_2-n_1}{R_1}$$

Formula for refraction at II surface:

$$\frac{n_1}{v}-\frac{n_2}{v'}=\frac{n_1-n_2}{R_2}=\frac{n_2-n_1}{-R_2}$$

Combining the two equations and simplification:

$$\frac{1}{v}-\frac{1}{u}=\left(n_2-n_1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

And using the condition $u=\infty \Rightarrow v=f$

Arriving at lens makers formula:

$$\left.\frac{1}{f}=\left(n_{21}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)\right\}$$

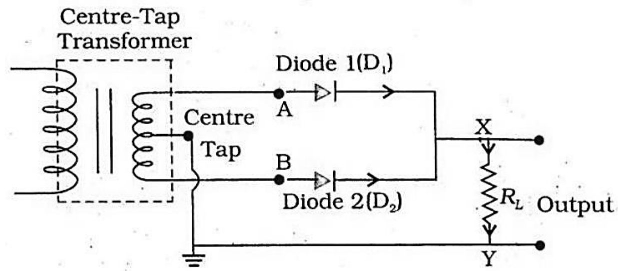
42. **Work function:**It is the minimum amount of energy required to liberate an electron from metal surface.

1. Photoelectric effect is instantaneous process.
2. There exists certain minimum cut-off frequency called threshold frequency below which photoelectric emission does not take place.
3. The photoelectric current is directly proportional to the intensity of incident radiation, provided the frequency of incident radiation is greater than threshold frequency.

   Also the saturation current is directly proportional to the intensity of incident radiation.
4. The stopping potential or maximum KE of emitted photoelectrons is directly proportional to the frequency of incident radiation but independent of intensity.

43.

Rectifier: It is a circuit (or a device) which converts AC into DC (or pulsating DC).



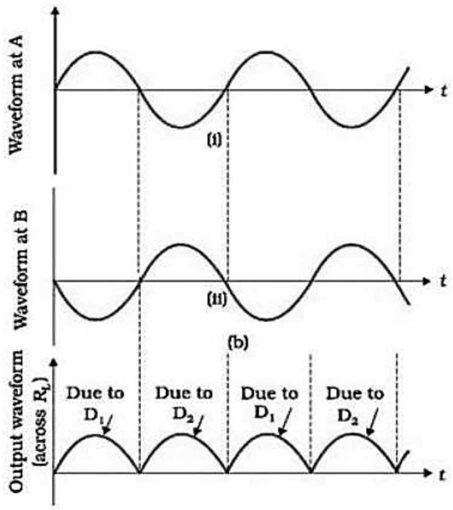
Circuit diagram

OR any other correct circuit diagram

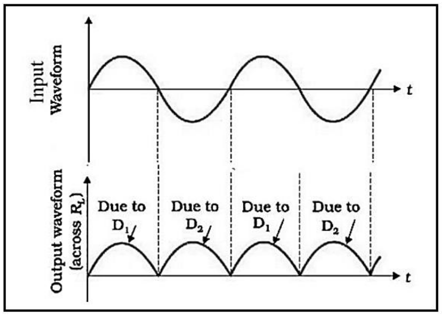
During the positive half cycle of input ac voltage, $\boldsymbol{D_1}$ becomes forward biased and $\boldsymbol{D_2}$ reverse biased. So D_1 conducts the current. The current flows through the load in the direction AD_1XR_LYA.

During the negative half cycle of input ac voltage, $\boldsymbol{D_1}$ becomes reverse biased and $\boldsymbol{D_2}$ forward biased. So D_2 conducts the current. The current flows through the load in the direction BD_2XR_LYB.

Thus the current flows through the diode during both half cycles in the same direction. Hence DC output is obtained.



OR



44.

Formula for the Coulomb force: $F = k\dfrac{q_1 q_2}{r^2}$ OR

$$F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$$

Substitution and simplification:

$$F = 9\times10^9 \times \frac{2\times10^{-7}\times3\times10^{-7}}{\left(3\times10^{-2}\right)^2}$$

Force between the charges: $F = 0.6N$

New force: $F' = k\dfrac{q_1 q_2}{(2r)^2} = \dfrac{F}{4}$

Final answer with approapriate unit: $F' = 0.15N$

45.

Formula for the potential at a point: $V = k\dfrac{Q}{r}$ OR

$$V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$$

Potential at A: $V_A = 9\times10^9 \times \dfrac{8\times10^{-3}}{3\times10^{-2}} = 24\times10^8 V$

Potential at B: $V_B = 9\times10^9 \times \dfrac{8\times10^{-3}}{4\times10^{-2}} = 18\times10^8 V$

Work done: $W = pd\times$ charge $= \left(V_B - V_A\right)q$

Final answer with approapriate unit:

$$W = \left(18\times10^8 - 24\times10^8\right)\left(-2\times10^{-8}\right) = 12J$$

Note: $W = W_{ac} + W_{cb}$ should be considered

46.

Formula for the Equivalent emf: $\varepsilon_{eq} = \dfrac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2}$

OR $\dfrac{\varepsilon_{eq}}{r_{eq}} = \dfrac{\varepsilon_1}{r_1} + \dfrac{\varepsilon_2}{r_2}$ $\quad \varepsilon_{eq} = \dfrac{(4\times1)+(2\times1)}{1+1} = 3$ V

Formula for the Equivalent internal resistance:

$r_{eq} = \dfrac{r_1 r_2}{r_1 + r_2}$ OR $r_{eq} = \dfrac{r}{n} = \dfrac{r}{2} = 0.5\Omega$

Current with approapriate unit: $I = \dfrac{\varepsilon_{eq}}{R + r_{eq}}$

$$I = \frac{3}{7+0.5} = 0.4 \text{ A}$$

47.

Formula for the magnetic field at the centre:

$$B = \frac{\mu_0 NI}{2R}$$

Substitution and simplification:

$$B = \frac{4\pi\times10^{-7}\times20\times2}{2\times6.284\times10^{-2}}$$

Final answer with appropriate unit:

$$B = 40\times10^{-5}T$$

Magnetic dipole moment: $m = NIA = NI\pi R^2$

$$m = 20\times2\times3.142\times\left(6.284\times10^{-2}\right)^2$$

$$= 4962.93\times10^{-4} = 0.4963Am^2 = 0.5Am^2$$

48.

(a) Formula for the minimum deviation:

$$n = \frac{\sin\left(\dfrac{A+D_m}{2}\right)}{\sin\left(\dfrac{A}{2}\right)}$$

Substitution and simplification:

$$\frac{3}{2}=\frac{\sin\left(\frac{60^\circ+D_m}{2}\right)}{\sin\left(\frac{60^\circ}{2}\right)}=\frac{\sin\left(30^\circ+\frac{D_m}{2}\right)}{\sin\left(30^\circ\right)}$$

Angle of minimum deviation: $D_m = 37^\circ 10'$ OR

$D_m = 37.17^\circ$

OR

$A = 2r \Rightarrow r = 30^\circ$

$n=\frac{\sin i}{\sin r}\Rightarrow \frac{3}{2}=\frac{\sin i}{\sin 30^\circ}\Rightarrow i=48^\circ 35'$

$\delta = 2i - A = 2\times 48^\circ 35' - 60^\circ$

$= 37^\circ 10'$ OR $D_m = 37.17^\circ$

(b) Formula related to speed of light in a medium:

$n=\frac{c}{v}$

Speed of light in glass: $v = 2\times 10^8\ \text{ms}^{-1}$

49.

Formula for fringe width: $\beta = \frac{\lambda D}{d}$

$\beta = \frac{400\times 10^{-9}\times 1}{1\times 10^{-3}} = 400\times 10^{-6} = 0.4$ mm Fringe width when light is replaced: $\beta' = \frac{\lambda' D}{d}$ OR

$\beta' = \beta\times\frac{\lambda'}{\lambda}$

New fringe width:

$\beta' = \frac{700\times 10^{-9}\times 1}{1\times 10^{-3}} = 700\times 10^{-6} = 0.7$ mm OR

$\beta' = 0.4\ \text{mm}\times\frac{700}{400} = 0.7$ mm Percentage change in fringe width

$= \frac{\beta'-\beta}{\beta}\times 100 = \frac{0.7-0.4}{0.4}\times 100 = 75\%$

50.

Formula related to decay constant: $T_{1/2} = \frac{0.693}{\lambda}$

Decay constant: $\lambda = \frac{0.693}{5730} = 1.209\times 10^{-4}$ per year

Formula for activity: $R = R_0 e^{-\lambda t}$ OR

$t = \frac{2.303}{\lambda}\log_{10}\left(\frac{R_0}{R}\right)$

Sub and simple: $1.5 = 15\times e^{-1.20942\times 10^{-4}t}$ OR

$t = \frac{2.303}{1.209\times 10^{-4}}\log_{10}\left(\frac{15}{1.5}\right)$

Estimated age: $t = 19048 \cong 19000$ years

Approximated to 2 SF

Note: Ans between 19000 to 19050 years may be considered

In minutes; $\lambda = \frac{0.693}{3.01\times 10^9} = 0.230\times 10^{-9}$ per min

and $t = 10.0\times 10^9$ minutes

In second; $\lambda = \frac{0.693}{3.01\times 10^9} = 0.383\times 10^{-11}\ \text{s}^{-1}$ and

$t = 6.01\times 10^{11}$ s