CBSE Class 12th Exam 2024
PHYSICS

Q.1.

1. Two charges + q each are kept '2a' distance apart. A third charge – 2q is placed midway between them. The potential energy of the system is –

(A) $\frac{q^2}{8\pi\varepsilon_0 a}$

(B) $-\frac{6q^2}{8\pi\varepsilon_0 a}$

(C) $\frac{-7q^2}{8\pi\varepsilon_0 a}$

(D) $\frac{9q^2}{8\pi\varepsilon_0 a}$

Ans: 1 (C)

2. Two identical small conducting balls B_1 and B_2 are given -7 pC and + 4 PC charges respectively. They are brought in contact with a third identical ball B_3 and then separated. If the final charge on each ball is -2 pC, the initial charge on B_3 was

(A) -2 pC
(B) 3-53
(C) -5 pC
(D) -15 pC

Ans: 2 (B)

3. The quantum nature of light explains the observations on photoelectric effect as-

(A) there is a minimum frequency of incident radiation below which no electrons are emitted.
(B) the maximum kinetic energy of photoelectrons depends only on the frequency of incident radiation.
(C) when the metal surface is illuminated, electrons are ejected from the surface after sometime.
(D) the photoelectric current is independent of the intensity of incident radiation.

Ans: 3 (B)

4. The radius (r_n) of n^{th} orbit in Bohr model of hydrogen atom varies with n as

(A) $r_n \propto n$

(B) $r_n \propto \frac{1}{n}$

(C) $r_n \propto n^2$

(D) $r_n \propto \frac{1}{n^2}$

Ans: 4 (C)

5. A straight wire is kept horizontally along east-west direction. If a steady current flows in wire from east to west, the magnetic field at a point above the wire will point towards

(A) East
(B) West
(C) North
(D) South

Ans: 5 (C)

6. The magnetic susceptibility for a diamagnetic material is

(A) small and negative
(B) small and positive
(D) large and positive
(C) large and negative

Ans: 6 (A)

7. A galvanometer of resistance 100Ω is converted into an ammeter of range (0-1 A) using a resistance of 0.1Ω. The ammeter will show full scale deflection for a current of about

(A) 0.1 mA
(B) 1 mA
(C) 10 mA
(D) 0.1 A

Ans: 7 (D)

8. A circular loop A of radius R carries a current I. Another circular loop B of radius r(= R/20) is placed concentrically in the plane of A. The magnetic flux linked with loop B is

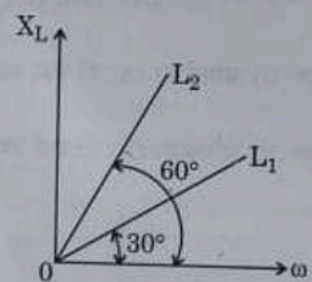
proportional to

(A) R (B) $\sqrt{R}$

(C) $R^{\frac{3}{2}}$ (D) R^2

Ans: 8 (C)

9. Figure shows the variation of inductive reactance X_L of two ideal inductors of inductance L_1 and L_2, with angular frequency ω. The value of $\frac{L_1}{L_2}$ is



(A) $\sqrt{3}$ (B) $\frac{1}{\sqrt{3}}$

(C) 3 (D) $\frac{1}{3}$

Ans: 9 (C)

10. The phase difference between electric field $\vec{E}$ and magnetic field $\vec{B}$ in an electromagnetic wave propagating along z-axis is –

(A) zero (B) π

(C) $\frac{\pi}{2}$ (D) $\frac{\pi}{4}$

Ans: 10 (A)

11. A coil of N turns is placed in a magnetic field $\vec{B}$ such that $\vec{B}$ is perpendicular to the plane of the coil. $\vec{B}$ changes with time as $B = B_0 \cos\left(\frac{2\pi}{T}t\right)$ where T is time period. The magnitude of emf induced in the coil will be maximum at

(A) $t = \frac{nT}{8}$

(B) $t = \frac{nT}{4}$

(C) $t = \frac{nT}{2}$

(D) $t = nT$

Here, n = 1, 2, 3, 4, ...

Ans: 11 (C**)**

12. In Balmer series of hydrogen atom, as the wavelength of spectral lines decreases, they appear

(A) equally spaced and equally intense.
(B) further apart and stronger in intensity.
(C) closer together and stronger in intensity.
(D) closer together and weaker in intensity.

Ans: 12 (C)

Note: For questions number 13 to 16, two statements are given - one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (A), (B), (C) and (D) as given below:

(A) If both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
(B) If both Assertion (A) and Reason (R) are true and Reason (R) is not the correct explanation of Assertion (A).
(C) If Assertion (A) is true and Reason (R) is false.
(D) If both Assertion (A) and Reason (R) are false.

13. Assertion (A): Electrons are ejected from the surface of zinc when it is irradiated by yellow light.
Reason (R): Energy associated with a photon of yellow light is more than the work function of zinc.

Ans: 13 (C)

14. Assertion (A): The temperature coefficient of resistance is positive for metals and negative for p-type semiconductors.

Reason (R): The charge carriers in metals are negatively charged, whereas the majority charge carriers in p-type semiconductors are positively charged.

Ans: 14 (A)

15. Assertion (A): When electrons drift in a conductor, it does not mean that all free electrons in the conductor are moving in the same direction.
Reason (R): The drift velocity is superposed over large random velocities of electrons.

Ans: 15 (A)

16. Assertion (A): In interference and diffraction of light, light energy reduces in one region producing a dark fringe. It increases in another region and produces a bright fringe.
Reason (R): This happens because energy is not conserved in the phenomena of interference and diffraction.
Ans: 16 (B)

Section - B

17. Draw the circuit diagram of a p-n junction diode in (i) forward biasing and (ii) reverse biasing. Also draw its I-V characteristics in the two cases.

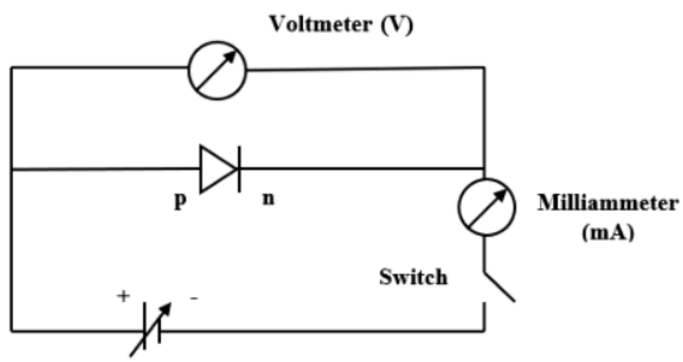
Ans: (a) There are three possible biasing conditions for a p-n junction diode and these are:

1) Zero bias: In this biasing condition, no external voltage potential is applied to the diode.

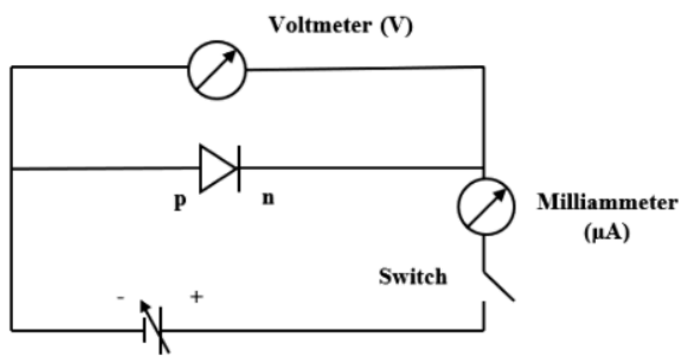
2) Forward bias: In this biasing condition, a negative voltage is applied to the N-type material and a positive voltage is applied to the P-type material, Due to this type of biasing, the width of the p-n junction diode decreases.

3) Reverse bias: In this biasing condition, a positive voltage is applied to the N-type material and a negative voltage is applied to the P-type material, Due to this type of biasing, the width of the p-n junction diode increases.

The circuit arrangement for studying V-I characteristics of a p-n junction diode in forward bias is given below.

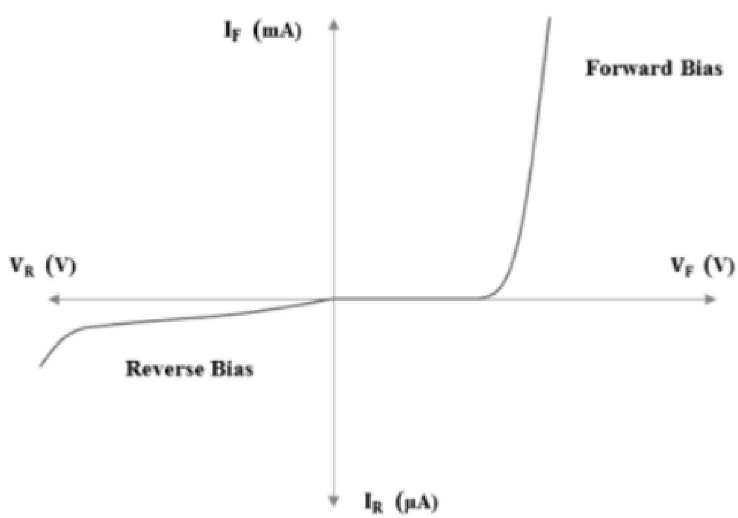


The circuit arrangement for studying V-I characteristics of a p-n junction diode in reverse bias is given below.



Typical V-I characteristic of a silicon diode is given below.

Typical V-I characteristic of a silicon diode is given below.



18. A proton and a-particle are accelerated through different potentials V_1 and V_2 respectively so that they have the same de Broglie wavelengths.
Find V_1/V_2.

Ans:-----------

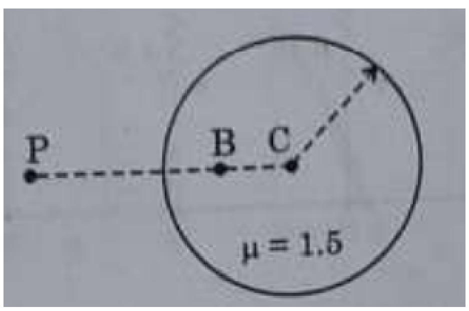
19. A ray of light is incident normally on one face of an equilateral glass prism of refractive index μ. When the prism is completely immersed in a transparent medium, it is observed that the emergent ray just grazes the adjacent face. Find the refractive index of the medium.

Ans: -----------

20. Two electric heaters have power ratings P_1 and P_2, at voltage V. They are connected in series to a de source of voltage V. Find the power consumed by the combination. Will they consume the same power if connected in parallel across the same source?

Ans:-----------

21. (a) An air bubble is trapped at point B (CB = 20 cm) in a glass sphere of radius 40 cm and refractive index 1.5 as shown in figure. Find the nature and position of the image of the bubble as seen by an observer at point P.



22. (a) Differentiate between nuclear fission and fusion.
(b) The fission properties of ${}_{94}Pu^{239}$ are very similar to those of ${}_{92}U^{235}$.
How much energy (in MeV), is released if all the atoms in 1 g of pure ${}_{94}Pu^{239}$ undergo fission? The average energy released per fission is 180 MeV.

Ans:

Nuclear Fission	**Nuclear Fusion**
Nuclear fission is the process by which an atom's nucleus breaks into two lighter nuclei during a nuclear reaction.	In the process of nuclear fusion, two or more light nuclei collide to create a heavier nucleus.
An enormous quantity of energy is produced when each atom divides.	Compared to nuclear fission, nuclear fusion produces energy that is several times more powerful.

Natural fission reactions do not take place in nature.	Stars and the sun undergo fusion processes.
In a fission reaction, less energy is required to divide an atom.	In a fusion reaction, high energy is required to fuse two or more atoms together.
The nuclear fission principle underpins the operation of an atomic bomb.	The hydrogen bomb operates on the nuclear fusion principle.

(b)

Average energy released per fission of ${}^{239}_{94}\text{Pu}$, $E_{av} = 180\text{MeV}$

Amount of pure ${}_{94}\text{Pu}^{239}$ m = 1 kg = 1000 g

N_A= Avogadro number = 6.023×10^{23}

Mass number of ${}^{239}_{94}\text{Pu}$= 239 g

1 mole of ${}_{94}\text{Pu}^{239}$ contains N_A atoms.

$\therefore$ mg of ${}_{94}\text{Pu}^{239}$ contain $\left(\frac{N_A}{\text{Mass number}} \times m\right)$ atom

$= \frac{6.023 \times 10^{23}}{239} \times 1000 = 2.52 \times 10^{24}$ atoms

$\therefore$ Total energy released during the fission of 1 kg of ${}^{239}_{94}\text{Pu}$ is calculated as:

$E = E_{av} \times 2.52 \times 10^{24}$

$= 180 \times 2.52 \times 10^{24} = 4.536 \times 10^{26}$ MeV

Hence, 4.536×10^{26} is released if all the atoms in 1 kg of pure ${}_{94}\text{Pu}^{239}$ undergo fission.

23. The electric field in a region is given by

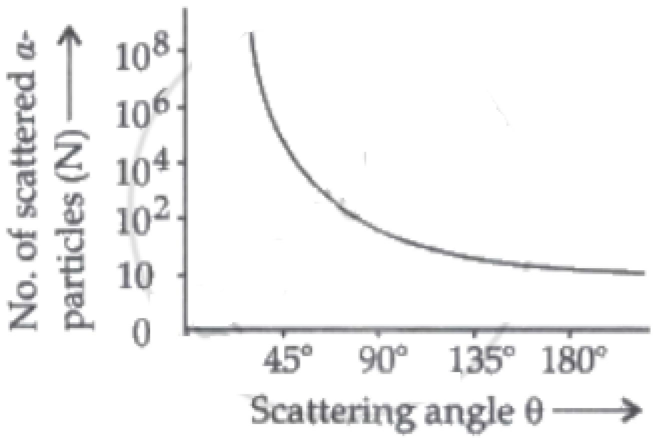
$\vec{E} = (10x + 4)\hat{i}$

where x is in m and E is in N/C. Calculate the amount of work done in taking a unit charge from
(i) (5 m, 0) to (10 m, 0)
(ii) (5 m, 0) to (5 m, 10 m)

Ans: —-------

24. Draw the graph showing variation of scattered particles detected (N) with the scattering angle (0) in Geiger-Marsden experiment. Write two conclusions that you can draw from this graph. Obtain the expression for the distance of closest approach in this experiment.

Ans: Graph showing the variation of the number of particles scattered (N) with the scattering angle (θ):



The strongly repulsive force exerted by the positively charged nucleus causes the scattering of α-particles at θ > 90°. Because the nucleus is so small, there are fewer distributed α-particles.

Note: Questions number 29 to 30 are Case Study based questions.

Read the following paragraph and answer the questions that follow.
A pure semiconductor like Ge or Si, when doped with a small amount of suitable impurity, becomes an extrinsic semiconductor. In thermal equilibrium, the electron and hole concentration in it are related to the concentration of intrinsic charge carriers. A p-type semiconductor can be converted into a p-n junction by doping it with or n-type suitable impurity. Two processes, diffusion and drift take place during formation of a p-n junction. A semiconductor diode is basically a p-n junction with metallic contacts provided at the ends for the application of an external voltage. A p-n junction diode allows currents to pass only in one direction when it is forward biased. Due to this property, a diode is widely used to rectify alternating voltages, in half-wave or full wave configuration.

(i) When Ge is doped with pentavalent impurity, the energy required to free the weakly bound electron from the dopant is about
(A) 0.001 eV
(B) 0.01 eV
(C) 0.72 eV
(D) 1.1 eV

Ans: (i) (B) 0.01 eV

(ii) At a given temperature, the number of intrinsic charge carriers in a semiconductor is 2.0×10^{10} cm^{-3}. It is doped with pentavalent impurity atoms. As a result, the number of holes in it becomes 8×10^{3} cm^{-3}. The number of electrons in the semiconductor is
(A) 2×10^{24} m^{-3}
(C) 1×10^{22} m^{-3}
(B) 4×10^{23} m^{-3}
(D) 5×10^{22} m^{-3}

Ans: (ii) (C) 1×10^{22} m^{-3}

(iii) During the formation of a p-n junction -
(A) electrons diffuse from p-region into n-region and holes diffuse from n-region into p-region.
(B) both electrons and holes diffuse from n-region into p-region.
(C) electrons diffuse from n-region into p-region and holes diffuse from p-region into n-region.
(D) both electrons and holes diffuse from p-region into n-region.

Ans: (C) electrons diffuse from n-region into p-region and holes diffuse from p-region into n-region.

(iv) An ac voltage V = 0.5 sin (100 лt) volt is applied, in turn, across a half-wave rectifier and a full-wave rectifier. The frequency of the output voltage across them respectively will be
(A) 25 Hz, 50 Hz
(B) 25 Hz, 100 Hz
(C) 50 Hz, 50 Hz
(D) 50 Hz, 100 Hz

Ans: (B) 25 Hz, 100 Hz

30. A lens is a transparent optical medium bounded by two surfaces; at least one of which should be spherical. Applying the formula of image formation by a single spherical surface successively at the two surfaces of a thin lens, a formula known as lens maker's formula and hence the basic lens formula can be obtained. The focal length (or power) of a lens depends on the radii of its surfaces and the refractive index of its material with respect to the surrounding medium. The refractive index of a material depends on the wavelength of light used. Combination of lenses helps us to obtain diverging or converging lenses of desired power and magnification.

(1) A thin converging lens of focal length 20 cm and a thin diverging lens of focal length 15 cm are placed coaxially in contact. The power of the combination is

(A) $\frac{-5}{6}$ D

(B) $\frac{-5}{3}$ D

(C) $\frac{4}{3}$ D

(D) $\frac{3}{2}$ D

Ans: (A)

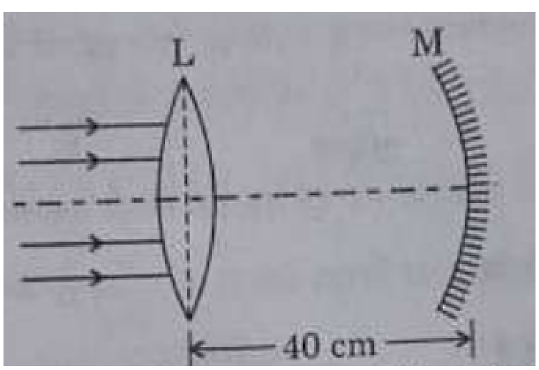
(ii) The radii of curvature of two surfaces of a convex lens are R and 2R.
If the focal length of this lens is (4/3) R, the refractive index of the material of the lens is:
(A) 5/3
(B) 4/3
(C) 3/2
(D) 7/5

Ans: (C) 3/2

(iii) The focal length of an equiconvex lens
(A) increases when the lens is dipped in water.
(B) increases when the wavelength of incident light decreases.
(C) increases with decrease in radius of curvature of its surface.
(D) decreases when the lens is cut into two identical parts along its principal axis.

Ans: (C) increases with decrease in radius of curvature of its surface.

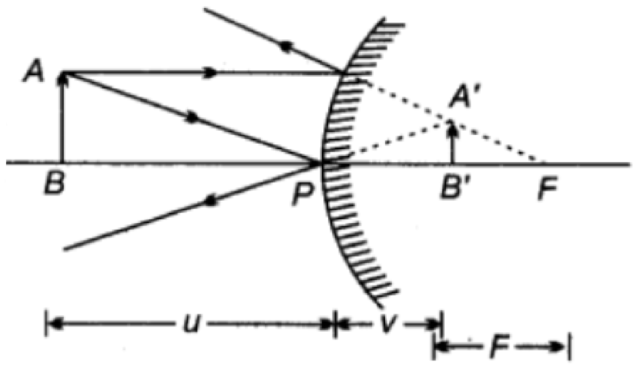
(iv) A thin convex lens L of focal length 10 cm and a concave mirror M of focal length 15 cm are placed coaxially 40 cm apart as shown in figure. A beam of light coming parallel to the principal axis is incident on the lens. The final image will be formed at a distance of



Ans: —------------

31. (a) (i) Draw a ray diagram for the formation of the image of an object by a convex mirror. Hence, obtain the mirror equation.

Ans: A ray diagram for a convex mirror showing the image formation of an object placed anywhere in front of the mirror.



(ii) Why are multi-component lenses used for both the objective and the eyepiece in optical instruments?

Ans: —-----------

(iii) The magnification of a small object produced by a compound microscope is 200. The focal length of the eyepiece is 2 cm and the final image is formed at infinity. Find the magnification produced by the objective.

Ans: —-----------

32. (a) (i) A dielectric slab of dielectric constant 'K' and thickness 't' is inserted between plates of a parallel plate capacitor of plate separation d and plate area A. Obtain an expression for its capacitance.

Ans:

(ii) Two capacitors of different capacitances are connected first (1) in series and then (2) in parallel across a de source of 100 V. If the total energy stored in the combination in the two cases are 40 mJ and 250 mJ respectively, find the capacitance of the capacitors.

Ans:

33. (i) Mention the factors on which the resonant frequency of a series LCR circuit depends. Plot a graph showing variation of impedance of a series LCR circuit with the frequency of the applied a.c. source.

Ans:

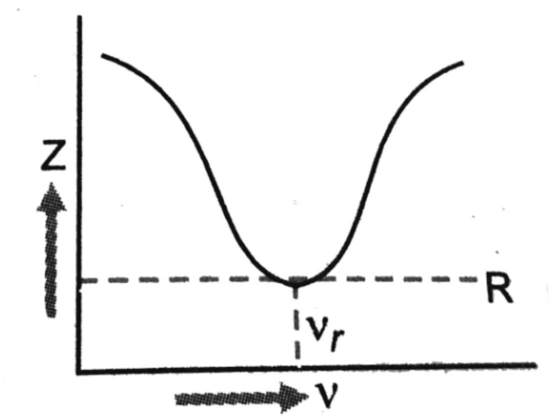
The impedance of LCR circuit is

$$Z=\sqrt{R^2+(X_L-X_C)^2}$$

$$\sqrt{R^2+\left(2\pi vL-\frac{1}{2\pi vC}\right)^2}$$

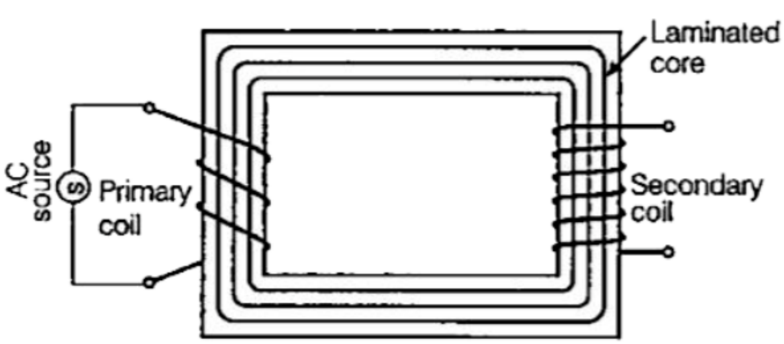
The variation or Z with iv is shown if Fig

At $v=v_r, X_L=X_C, Z=R=$ minimum.



(ii) With the help of a suitable diagram, explain the working of a step-up transformer.

Ans: Working of step-up Transformer



Working and Principle The value of the emf depends on the number of turns in the secodary. We consider an ideal transformer in which the primary coil has negligble resistane and all the flux in the core links both primary and secondary windings. Let ϕ be the flux in each turn in the core at time t due to current in the primanry when a voltage V_p is applied to it.

Then, the indued emf or voltage ε_s, in the secondary coil with N_s turns is

$\varepsilon_s = N_s \frac{d\phi}{dt}$ The altenating flux ϕ also induces an emf, called back emf in the primary. This is

$$\varepsilon_s = -N_p = \frac{d\phi}{dt}$$

Now, we can see how a transformer affects the voltage a current we have

$$V_s = \left(\frac{N_s}{N_p}\right) V_p$$

and $I_s = \left(\frac{N_p}{N_s}\right) I_p$

i.e., if the secondary coil has a greator number of turns than the primary coil $(N_s > N_p)$ the voltage is stepped up $(V_s > V_p)$ This type of arrangement is called a step - up trnasformer.
As voltage increases then current decreases so, it does not voltage conservation of energy.

(iii) Write two causes of energy loss in a real transformer.

Ans: 1. Copper Loss: This is the heat energy lost due to the inherent resistance of the copper wires used in the transformer's primary and secondary windings. As current flows through the wires, it encounters resistance, which dissipates some of the electrical energy as heat. The larger the current and the smaller the wire diameter, the greater the copper loss.

2. Hysteresis Loss: This energy loss is associated with the repeated magnetization and demagnetization of the transformer's iron core. When an alternating current is applied to the primary coil, it generates a changing magnetic field in the core. This process involves overcoming a phenomenon called hysteresis, which represents the energy required to repeatedly magnetize and demagnetize the core material. This energy is lost as heat.