CBSE
Class XII Physics
Sample Paper 3

Time: 3 Hours **Maximum Marks: 70**

General Instructions:

1. All questions are compulsory. There are 33 questions in all.
2. This question paper has five sections: Section A, Section B, Section C, Section D and Section E.
3. Section A contains ten very short answer questions and four assertion reasoning MCQs of 1 mark each, Section B has two case based questions of 4 marks each, Section C contains nine short answer questions of 2 marks each, Section D contains five short answer questions of 3 marks each and Section E contains three long answer questions of 5 marks each.
4. There is no overall choice. However internal choice is provided. You have to attempt only one of the choices in such questions

$c = 3 \times 10^{8}$ m/s

$h = 6.63 \times 10^{-34}$ Js

$e = 1.6 \times 10^{-19}$ C

$\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}

$\varepsilon_0 = 8.854 \times 10^{-12}$ C^2 N^{-1} m^{-2}

$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^{9}$ N m^2 C^{-2}

$m_e = 9.1 \times 10^{-31}$ kg

mass of neutron $= 1.675 \times 10^{-27}$ kg

mass of proton $= 1.673 \times 10^{-27}$ kg

Avogadro's number $= 6.023 \times 10^{23}$ per gram mole

Boltzmann constant $= 1.38 \times 10^{-23}$ JK^{-1}

Section A

Directions (Q1-Q10) Select the most appropriate option from those given below each question.

1. The work done in bringing a unit positive charge from infinite distance to a point at distance x from a positive charge Q is W. What is the potential at that point?

OR

What is the value of dielectric Dielectric constant for a metal?

2. At room temperature 27°C, the resistance of a heating element is 100 Ω. What will be the temperature of the element if the resistance is found to be 117 Ω, provided the temperature coefficient of the material of the resistor is $1.70 \times 10^{-4}/°C$.

3. In an L–R circuit, reactance and resistance are equal. By how much phase voltage differ current?

4. Which of the following is not a condition for sustained interference of light?
   a) Two sources of light should emit light continuously.
   b) Light waves should have different wavelength.
   c) Two sources must lie close to each other.
   d) Two sources must be very narrow.

5. What is the relation between n and n_h in n-type semiconductors?

6. A parallel plate capacitor with air as dielectric is charged by a DC source to a potential V. Without discharging the capacitor from its source, air is replaced by another dielectric medium of dielectric constant K. What would be the new energy stored in the capacitor(taking initial stored energy as U)

7. Magnetic field due to a current-carrying solenoid is
   a) $\mu_0 n I$
   b) $\frac{\mu_0 n I}{2r}$
   c) zero
   d) $\frac{\mu_0 n I}{2}$

OR

A charged particle of mass m and charge q travels on a circular path of radius r i.e., perpendicular to the magnetic field B. Find time taken by particle to complete one revolution?

8. What is the dimensional formula for current density?

9. Find the ratio of nuclear radii of the gold isotope $^{197}_{79}Au$ and the silver isotope $^{107}_{47}Ag$.

OR

Find the energy of photon of wavelength 450 nm.

10. What would happen to the width of the interference fringes in Young's double slit experiment, if the frequency of the source is increased?

OR

In Young's double slit experiment the two source S1 and S2 illuminated by two independent but identical sources, is it possible to observe interference pattern. Give reason for your answer.

For question numbers 11, 12, 13 and 14, 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) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false and R is also false

Directions (Q11–Q15) Fill in the blanks with the appropriate answer.

11. Assertion: An electric lamp connected in series with a variable capacitor and ac source, its brightness increases with increase in capacitance.
Reason: Capacitive reactance decrease with increase in capacitance of capacitor. in a conductor

12. Assertion: Bohr had to postulate that the electrons in stationary orbits around the nucleus do not radiate.
Reason: According to classical physical all moving electrons radiate.

13. Assertion: The drift velocity of electrons in a metallic wire will decrease, if the temperature of the wire is increased.
Reason: On increasing temperature, conductivity of metallic wire decreases.

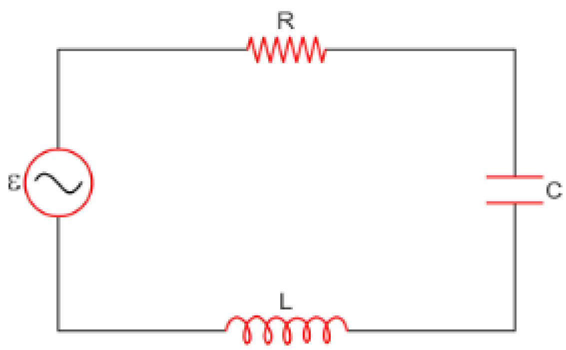
14. Assertion: The strength of photoelectric current depends upon the intensity of incident radiation.

Reason: A photon of energy E possesses a mass equal to $m = \frac{E}{C^2}$ and momentum equal to $p = \frac{E}{C}$

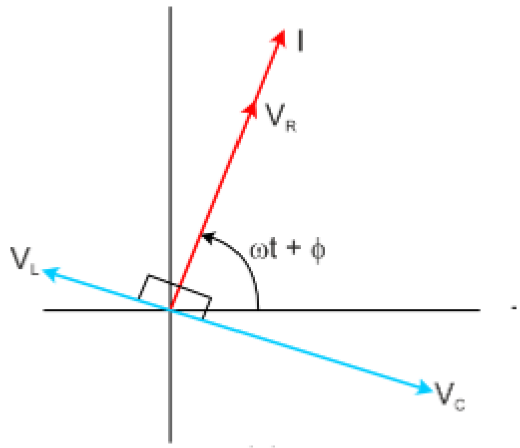
Section B

Questions 15 and 16 are Case Study based questions and are compulsory. Attempt any 4 sub parts from each question. Each question carries 1 mark.

15. A series LCR circuit is connected to an a.c. source of variable frequency. A suitable phasor dagram for the amplitude of the current and phase angle has been mentioned below. Answer the following questions based on the concept of LCR circuit



Series *LCR* circuit
connected to an AC source

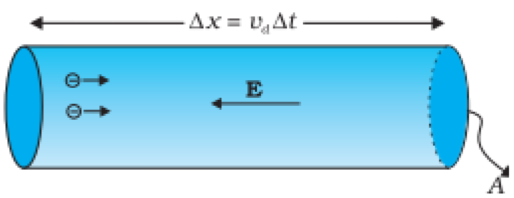


1. If $X_c > X_L$, and φ is positive, the circuit is predominantly
   i. Inductive
   ii. Capacitive
   iii. Neutral
   iv. None of these
2. If $X_c < X_L$, and φ is negative, the circuit is predominantly
   i. Inductive
   ii. Capacitive
   iii. Neutral
   iv. None of these
3. At resonant frequency
   i. $\omega = \sqrt{\frac{L}{C}}$
   ii. $\omega = \frac{1}{\sqrt{LC}}$
   iii. $\omega = \sqrt{LC}$
   iv. None of these
4. At resonant frequency the impedance of the LCR circuit is
   i. Maximum
   ii. Minimum
   iii. $Z = \sqrt{R^2 + (X_c - X_L)^2}$
   iv. None of these
5. The ratio $\frac{\omega_0 L}{R}$ is also called the quality factor, Q of the circuit .The larger the value of Q
   i. The sharper the resonance
   ii. The less sharp the resonance
   iii. Resonance is independent of the value of Q
   iv. None of these

16. Drift velocity is defined as the average velocity with which free electrons gets drifted in a direction opposite to that of electric field .Let's say m is the mass of the electron and e be the charge of electron then acceleration a=eE/m. As per the first equation of motion V=u+at. The average initial velocity u=0 and final velocity $v=V_d$, time taken $t=\tau$(relaxation time) then $V_d=a\ \tau$. On substituting the value of a we get $V_d=eE\ \tau/m$. Because of the drift, there will be net transport of charges across any area perpendicular to E. Consider a planar area A, located inside the conductor such that the normal to the area is parallel to E . Then because of the drift, in an infinitesimal amount of time Δt, all electrons to the left of the area at distances upto $|V_d|\Delta t$ would have crossed the area. If n is the number of free electrons per unit volume in the metal, then there are $n\ \Delta t\ |V_d|A$ such electrons. Since each electron carries a charge −e, the total charge transported across this area A to the right in time Δt is $-neA|V_d|\Delta t$. E is directed towards the left and hence the total charge transported along E across the area is negative of this. The amount of charge crossing the area A in time Δt is by definition I Δt, where I is the magnitude of the current. Hence,

$$I\Delta t = neAV_d\Delta t$$

$$I = neAV_d$$



$I = neAV_d$

Now consider the following situation, Potential difference V is applied across the ends of copper wire of length l and diameter D.

1. When V is doubled the drift velocity of electron gets
   i. Half
   ii. Doubled
   iii. Quadrupled
   iv. Remain unchnged
2. When length(l) is doubled the drift velocity of electron gets
   i. Half
   ii. Doubled
   iii. Quadrupled
   iv. Remain Unchanged
3. When the diameter D is doubled the drift velocity of electron gets
   i. Half
   ii. Doubled
   iii. Quadrupled
   iv. Remain Unchanged
4. Mobility' of charge carriers in a conductor

i. $\mu = \frac{e\tau}{m}$

ii. $\mu = \frac{eE}{m}$

iii. $\mu = \frac{neAV_d}{m}$

iv. None of these

5. With increases in temperature the drift velocity of electrons in a metallic conductor will
   i. Decreases
   ii. Increases
   iii. Remains constant
   iv. None of these

Section C

All questions are compulsory. In case of internal choices, attempt anyone.

17. Write the distinguishing features between a diffraction pattern due to a single slit and the interference fringes produced in Young's double slit experiment? (2)

18. Why is the NAND gate called a universal gate? How can it be used to realise a basic OR gate? (2)

19. What is modulation? What are the different types of modulation? (2)

OR

Distinguish between frequency modulation and amplitude modulation.

20. Nuclear density of hydrogen is 2.3×10^{17} kg/m^3. Given A = 56 for iron, find its nuclear density. (2)

21. An electric bulb B and a parallel plate capacitor C are connected in series to the AC mains. The bulb glows with some brightness. How will the glow of the bulb be affected on introducing a dielectric slab between the plates of the capacitor? Give reasons in support of your answer. (2)

OR

15.0μF capacitor is connected to a 220V, 50Hz source. Find the capacitive reactance and the rms current in the circuit. If the frequency is doubled, what happens to the capacitive reactance and the current? (2)

22. Find the current flowing through a copper wire of length 0.2 m, area of cross-section 1 mm^2, when connected to a battery of 4 V. Given that electron mobility = 4.5×10^{-6}

$m^2 V^{-1} s^{-1}$ and charge on electron = 1.6×10^{-19} C. The number of density of electrons in copper is 8.5×10^{28} m^{-3}. (2)

23. On which factors does the internal resistance of a cell depend? (2)

24. In Young's double slit experiment using monochromatic light of wavelength λ, the intensity at a point on the screen where the path difference is λ is K units. What is the intensity of light at a point where the path difference is $\lambda/3$? (2)

25. An electron, α-particle and a proton have the same de Broglie wavelength. Which of these particles has (i) minimum kinetic energy, (ii) maximum kinetic energy, and why? (2)

OR

Why does photoelectric emission not take place if the frequency of incident radiation is less than the threshold value?

Section D

All questions are compulsory. In case of internal choices, attempt anyone.

26. Explain how a transistor can be used as a switch. (3)

27. Magnetic field at the centre of a circular loop of area A carrying current I is B. What is the magnetic moment of this loop? (3)

28. A parallel plate capacitor is charged to potential V by a source of emf E. After removing the source, the separation between the plates is doubled.

How will the following change

(i) electric field

(ii) potential difference

(iii) capacitance of the capacitor (3)

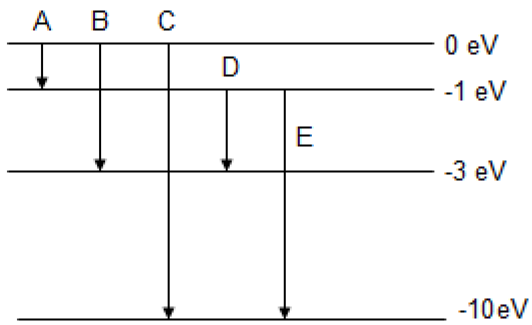
29. For a transistor, the current amplification factor is 0.8 when the transistor is connected in common emitter configuration. Calculate the change in the collector current when the base current changes by 6 mA. (3)

OR

When a transistor amplifier of current gain of 75 is given an input signal, $V_i = 2 \sin(157t + \pi/2)$, the output signal is found to be $V_0 = 200 \sin(157t + 3\pi/2)$.

In which mode is the transistor being used? Justify your result with proper explanation.

30. The energy levels of an atom of an element are shown in the following diagram. Which one of the level transitions will result in the emission of photons of wavelength 620 nm? Support your answer with mathematical calculations. (3)



OR

In the fusion reaction $_1H^2 + {}_1H^2$ --------->$_2He^3 + {}_0n^1$, the masses of deuteron, helium andneutron expressed in amu are 2.015, 3.017 and 1.009, respectively. If 1 kg deuterium undergoes complete fusion, find the amount of total energy released.

Section E

All questions are compulsory. In case of internal choices, attempt anyone.

31. Write the logic symbol and truth table of an AND gate. Explain how this gate is realised in practice by using two diodes. (5)

OR

A transistor is used in common emitter mode in an amplifier circuit. When a signal of 20 mV is added to the base-emitter voltage, the base current changes by 20 μA and the collector current changes by 2 mA. The load resistance is 5 $k\Omega$. Calculate (a) the factor β, (b) input resistance R_{BE}, (c) transconductance and (d) voltage gain. (5)

32.

(a) State Lenz's law. Which conservation law can be used to explain this law?

(b) A wheel with 10 metallic spokes each 0.5m long is rotated with a speed of 120rev/min in a plane normal to the horizontal component of the Earth's magnetic field at a place where the Earth's field is 0.4×10^{-4}G. What is the induced emf between the axle and the rim of the wheel?

(c) Two moving coil meters M_1 and M_2 have the following particulars:

$R_1 = 10\ \Omega$, $N_1 = 30$,

$A_1 = 3.6 \times 10^{-3}$ m^2, $B_1 = 0.25$ T

$R_2 = 14\ \Omega$, $N_2 = 42$

$A_2 = 1.8 \times 10^{-3}$ m^2, $B_2 = 0.50$ T

(The spring constants are identical for the two meters). Determine the ratio of (a) current sensitivity and (b) voltage sensitivity of M_2 and M_1. (5)

OR

(a) An electron and a proton moving with the same speed enter a uniform magnetic field B perpendicularly. Which particle will have larger radius of its circular path? Find the ratio of their radii. The masses of electron and proton are 9.1 x 10^{-31} kg and 1.67 x 10^{-27} kg.

(b) Show that for a moving charged particle in a uniform magnetic field, the kinetic energy of the particle remains constant.

(c) A coil placed in the plane of the page has a current in the clockwise direction when looking from above. What will be the change in the magnetic field at the centre of the coil if

(i) the current through the coil is reduced to half

(ii) the radius of the coil is doubled

(iii) what will be the direction of the magnetic field (5)

33.

(i) When monochromatic light is incident on a surface separating two media, the reflected and refracted light both have the same frequency as the incident frequency. Explain why?

(ii) When light travels from a rarer to a denser medium, the speed decreases. Does this decrease in speed imply a reduction in the energy carried by the wave?

(iii) In the wave picture of light, intensity of light is determined by the square of the amplitude of the wave. What determines the intensity in the photon picture of light?

(iv) Calculate the distance of an object of height 'h' from a concave mirror of radius of curvature 20 cm, so as to obtain a real image of magnification 2. Find the location of image also.

(v) Using mirror formula, explain why does a convex mirror always produce a virtual image (5)

OR

Prove that $\frac{-\mu_1}{u} + \frac{\mu_2}{v} = \frac{\mu_2 - \mu_1}{R}$ when refraction occurs from a rarer to a denser medium at a convex refracting spherical surface.

CBSE
Class XII – Physics
Sample Paper 3–Solution

Section B

1. W

OR

Infinite

2. 1027°C

Resistance at room temperature, $R_{27} = 100\ \Omega$

$R_t = 117\ \Omega$

$R_t = R_{27}\ [1+\alpha\ (t-27)]$

$117 = 100\ [1 + 1.70 \times 10^{-4}\ (t - 27)]$

$t = 1000 + 27 = 1027°C$

3. We know

$$\tan\phi = \frac{X_L}{R}$$

$$\text{Thus}, \phi = \tan^{-1}(1) = 45°$$

4. b) Light waves should have different wavelength.

Light waves should have the same wavelength for the sustained interference of light.

5. In n-type semiconductors, $n_e >> n_h$, i.e. electrons are majority carriers and holes are minority carriers.

6. KU_0

$$U_0 = \frac{1}{2}C_0V_0^2$$

Thus, change in energy stored is given as,

$$U = \frac{1}{2}(KC_0)V_0^2 = KU_0$$

7. d) $\frac{\mu_0 nI}{2}$

The magnetic field due to a current-carrying solenoid is $\frac{\mu_0 nI}{2}$.

OR

b) $\frac{2\pi m}{Bq}$

8. $[L^{-2}A]$

Current density, j = I/A

9. $(1.84)^{1/3}$

We know

$R \approx A^{1/3}$

$$\therefore \frac{R_1}{R_2} = \left(\frac{A_1}{A_2}\right)^{1/3} = \left(\frac{197}{107}\right)^{1/3} = (1.84)^{1/3}$$

OR

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

$$E = \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{450 \times 10^{-9}}$$

$$4.4 \times 10^{-19} J$$

10. Decreases Fringe width 'β' is inversely proportional to frequency of the source 'υ'.

OR

No interference pattern is observed as there is no constant phase difference between the waves emitted by two sources.

11. (A) Both assertion and reason are true and the reason is the correct explanation of the assertion Capacitive reactance XC=1/ωC. When capacitance increases, the capacitive reactance decreases. Due to decrease in its values, the current in the circuit will increases and hence brightness of source (or electric lamp) will also increases

12. (B) Both assertion and reason are true but reason is not the correct explanation of assertion.

Bohr postulated that electrons in stationary orbits around the nucleus do not radiate. This is the one of Bohr's postulate. According to this the moving electrons radiate only when they go from one orbit to the next lower orbit

13. (B) If both assertion and reason are true but reason is not the correct explanation of the assertion.

On increasing temperature of wire the kinetic energy of free electrons increase and so they collide more rapidly with each other and hence their drift velocity decreases. Also when temperature increases, resistivity increase and resistivity is inversely proportional to conductivity of material.

14. (A) Both assertion and reason are correct and reason is the correct explanation for assertion A photon is an imaginary particle which is believed to have rest mass zero. But it has some mass when in motion, this mass an be calculated by using einstein's special theory of relativity. Thus using $E=mc^2$, we have $m = \frac{E}{c^2}$. Also momentum is defined as the mass multiplied by velocity. So momentum =mc. Therefore p=E/C.

Section B

15. 1. ii Capacitive

2. i Inductive

3. ii. $\omega = \frac{1}{\sqrt{LC}}$

4. Maximum

5. The sharper the resonance

16. 1.ii Doubled

Since

$$V_d = \frac{I}{neA} = \frac{V}{R(neA)}$$

$$= \frac{V}{\frac{\rho l}{A}(neA)} = \frac{V}{ne\rho l}$$

2.i. Half. Length is doubled the velocity gets halved

3.iv. Remain Unchanged. Since V is independent of D, drift velocity remain unchanged

4.i. $\mu = \frac{e\tau}{m}$

5. Decreases.

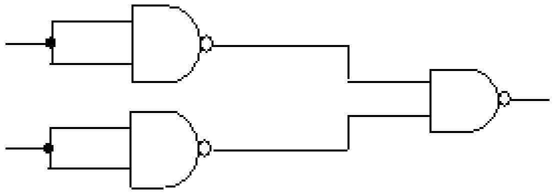
As the temperature increases, the thermal agitation of the electrons increases thereby, increasing the number of collision. Hence, drift velocity of the electrons decreases.

Section C

17.

Interference	Diffraction
Interference is due to superposition of two distinct waves com-ing from two coherent sources.	Diffraction is due to super-position of the secondary wavelets coming from dif-ferent parts of the same wavefront.
The intensity of minima is generally zero.	The intensity of minima is never zero.
All bright fringes are of uniform intensity.	All bright fringes are not of uniform intensity.

18. The NAND gate is called a universal gate because it can be used to obtain other basic gates like AND, NOT and OR gates. NAND gates can be combined (as shown below) to realise a basic OR gate.



19. Some characteristics of the carrier signal are varied in accordance with the modulating or message signal. This is called modulation.
Amplitude modulation, frequency modulation and phase modulation of waves are the different types of modulation.

OR

In amplitude modulation (AM), the amplitude of the modulated (carrier) wave varies in accordance with the amplitude of the information (signal) wave. When amplitude of the information wave increases, the amplitude of modulated wave also increases and *vice versa*.
In frequency modulation (FM), the frequency of modulated wave varies in accordance with the frequency of the signal wave. In this case, the amplitude of the modulated wave is fixed.

20. Nuclear density of iron will be 2.3×10^{17} kg/m^3.
Nuclear density is independent of mass number A, so iron also has the same nuclear density as hydrogen.

21. On introducing a dielectric in the capacitor, its capacitance will increase.

The total impedance of the circuit will decrease as $Z = \sqrt{R^2 + \left(\frac{1}{\omega C}\right)^2}$.

Hence, the current in the circuit increases and the brightness of the lamp increases.

OR

The capacitive reactance is

$$X_C = \frac{1}{2\pi f C} = \frac{1}{2\pi(50)(15.0 \times 10^{-6})} = 212\Omega$$

The rms current is

$$i = \frac{V}{X_C} = \frac{220}{212} = 1.04\,A \quad (1/2)$$

The peak current $\sqrt{2}\, i = \sqrt{2}(1.04) = 1.47\,A$

If the frequency is doubled, the capacitive reactance is halved and the current gets doubled.

22. Here, l =0.2 m, A = 1mm^2 = 10^{-6} m^2 , V =4 V , μ = 4.5 x 10^{-6} m^2 V^{-1} s^{-1}, e = 1.6 x 10^{-19} C, n= 8.5 x 10^{28} m^{-3}

E = V / l = 4/ 0.2 = 20 V/m

Current through wire,

I = n A e v_d = n A eμ E = 8.5 x 10^{28} x 10^{-6} x 1.6 x 10^{-19} x 4.5 x 10^{-6} x 20 = 1.22 A

23. Internal resistance of cells depends on

a) the nature, concentration and temperature of the electrolyte
b) the nature of electrodes
c) the distance between the electrodes
d) the area of electrodes immersed in the electrolyte

24. Intensity is I= $4I_0 \cos^2 \Phi/2$

When path difference is λ, phase difference is 2π.

I= $4I_o \cos^2\pi$ = 4 I_o= K (given)

When path difference is $\Delta = \lambda /3$, then the phase difference will be

$\Phi' = 2\pi \Delta / \lambda$

$= 2 \pi \times \lambda/3\lambda = 2\pi/3$

Hence, the intensity at a point where the path difference is $\lambda/3$ is

I'=$4I_0 \cos^2 2\pi /6$ (since K = $4I_0$)

= K $\cos^2 \pi/3$= K x {1/2}2 = (¼) K

25. The de Broglie wavelength is

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mK}}$$

For the electron, proton and α-particle, λ is same

$$m_e K_e = m_p K_p = m_\alpha K_\alpha = \text{constant}$$

As mass of the electron is minimum, its kinetic energy will be maximum.

As mass of the alpha particle is maximum, its kinetic energy is minimum.

OR

According to Einstein's photoelectric equation,

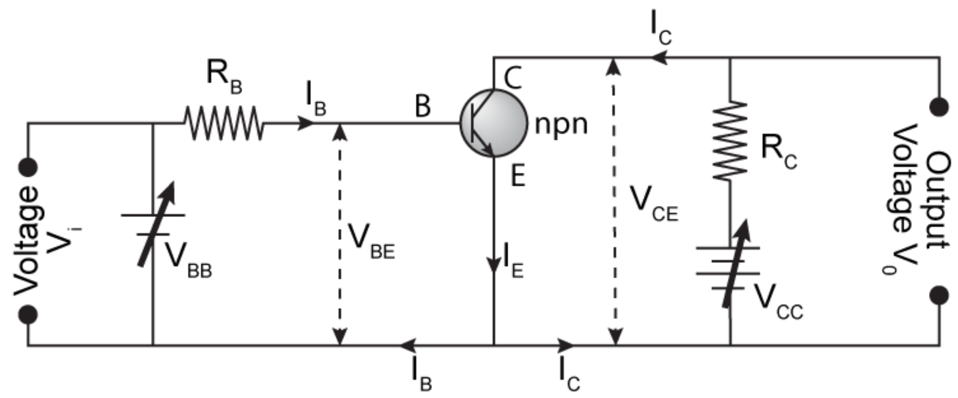
$(1/2)\ mv^2_{max} = h f - h f_0$

wherem = mass of the electron
f = frequency of incident radiation
f_0 = threshold frequency

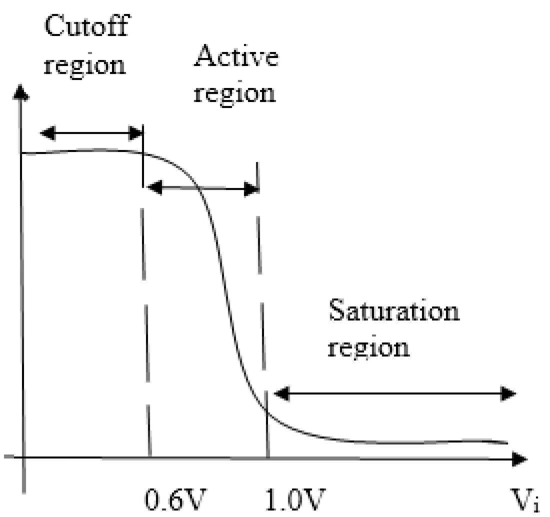
If the frequency of incident radiation is less than the threshold value ($f < f_0$), the KE of the emitted electron is negative, i.e. photoelectric emission will not take placeno matter how large the intensity of incident radiation.

Section D

26.



(i) When $V_i \geq 1.0$ V, the variation of V_i and V_0 is non-linear, as with increase in V_i, V_0 is found to decrease towards zero but never becomes zero. In this case, collector current I_c becomes maximum and transistor is in the saturation state.



(ii) If we plot a graph of V_0 and V_i, then we get a curve as shown in the figure.

(iii) From this graph, we understand that as long as V_i is low, V_0 is high. $(=V_{cc})$ and I_c is nearly equal to zero. Here, the transistor is in the cut-off state (switched-off state).

(iv) When V_i is high, $V_0$is low and is nearly equal to maximum or saturated. Now, the transistor is fully conducting. Here, the transistor is said to be in the switched-on state.

(v) Thus, if we define low and high input states as below and above certain voltage levels corresponding to the cut-off and saturation state of the transistor, then we say that low input state switches the transistor off and high input state switches it on. This indicates that a transistor acts as a switch.

27. Let R be the radius of the circular loop. Then A = πr^2 or R = $\sqrt{A/\pi}$

Magnetic field of induction at the centre of the circular loop carrying current is

$$B = \frac{\mu_0}{4\pi}\frac{2\pi I}{R} \text{ or } I = \frac{2BR}{\mu_0}$$

$$M = IA = \frac{2BR}{\mu_0}A = \frac{2BA}{\mu_0}\sqrt{\frac{A}{\pi}}$$

28.

(i) E remains the same as it depends on the charge on the plates and the medium between the plates. Q remains the same as the charge does not change on the plates.

(ii) V = Ed, so as the distance is doubled, V also doubles.

(iii) C = Q/V and V is doubled, whereas Q remains the same. So, C is halved.

29.

$\alpha = 0.8$

$\beta = \alpha/(1-\alpha)$

$= 0.8/(1-0.8) = 4$

$\Delta I_c = \beta \Delta I_b = 6 \times 4 = 24 \text{ mA}$

OR

Here, the current gain is 75, i.e. >1.

Besides, there is a phase difference of π between the signal at the input and the output.

Both these factors indicate that the amplifier is connected in the commonemitter mode.

30. Energy of the photon of wavelength λ is $E = \frac{hc}{\lambda}$

Here, λ = 620 nm = 620 x 10^{-9} m

$$E = \frac{hc}{\lambda} = \frac{6.62 \text{x} 10^{-34} \text{x} 3 \text{x} 10^{8}}{620 \text{x} 10^{-9}} J$$

$$= \frac{6.62 \text{x} 10^{-34} \text{x} 3 \text{x} 10^{8}}{620 \text{x} 10^{-9} \text{x} 1.6 \text{x} 10^{-19}} eV = 2 eV$$

Transition D will result in the emission of photons of wavelength 620 nm.

OR

amu = 931.5 MeV

$\Delta m = 2(2.015) - (3.017 + 1.009) = 0.004 \text{ amu}$

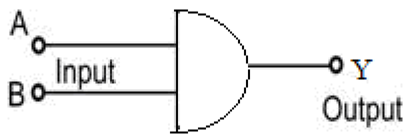
Hence, energy released per deuteron = (0.004 x 931.5)/2 = 1.863 MeV

The number of deuterons in 1kg = $N_A/2$ = 6.023 × $10^{26}/2$

Energy released = (3.01 × 10^{26})(1.863 × 10^{6})(1.6×10^{-19}) J = 9.0×10^{13} J

Section E

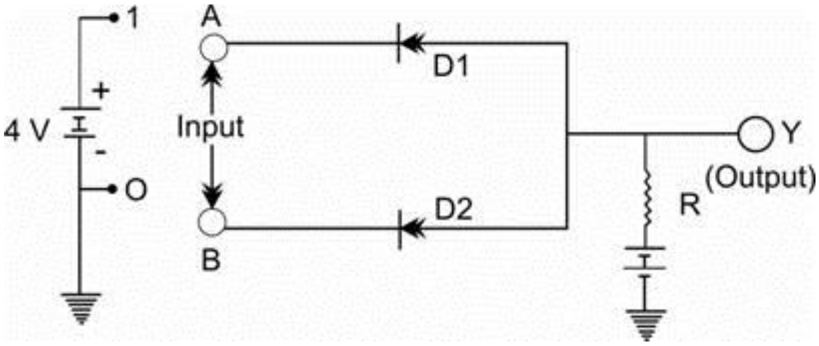
31. The logic symbol of the AND gate is shown in the figure.



The truth table of the AND gate is given below:

A	B	Output
0	0	0
0	1	0
1	0	0
1	1	1

Realisation of the AND gate:
To realise an AND gate having two inputs A and B, we complete the electrical circuit (as shown in the figure below) using two diodes D_1 and D_2.



Operation:

(i) When A = 0, B = 0, both diodes conduct and offer low(almost zero) resistance. Hence, the whole voltage drop is across resistor R and the net output voltage level at Y will be zero.

(ii) When A = 1, B = 0, diode D_1 does not conduct but D_2 conducts and provides a low resistive path. As a result, the output voltage level at Y is still zero.

(iii) When A = 0, B = 1, diode D_1 conducts and provides a low resistance path but D_2 does not conduct. Output voltage level at Y is even now zero.

(iv) When A = B = 1, none of the two diodes conduct, and there would be no drop in voltage across resistance R. Hence, voltage of Y will be 4V, i.e. Y will be at voltage level 1.

Thus, the output level is 1 only when both inputs A and B are at 1 level, which is the condition of the AND gate.

OR

(i) $\beta = \frac{\Delta I_C}{\Delta I_B} = \frac{2\ mA}{20\ \mu A} = 100$

(ii) The input resistance $R_{BE} = \frac{\Delta V_{BE}}{\Delta I_B} = \frac{20\ mV}{20\ \mu A} = 1\ k\Omega$

(iii) Transconductance = $\frac{\Delta I_C}{\Delta V_{BE}} = \frac{2\ mA}{20\ mV} = 0.1\ mho$

(iv) The change in input voltage is $R_L \Delta I_C = (5\ k\Omega)(2\ mA) = 10\ V$

The applied signal voltage = 20 mV

Thus, the voltage gain is

$$= \frac{10\ V}{20\ mV} = 500$$

32.

(a) Lenz's law states that the polarity of the induced emf is such that it tends to produce a current which opposes the change in the magnetic flux that produces it. This law can be explained by the law of conservation of energy.

(b) Induced emf = $(1/2)\omega BR^2 = (1/2) \times 4\pi \times 0.4 \times 10^{-4} \times (0.5)^2 = 6.28 \times 10^{-5}$ V

(c) Given

$R_1 = 10\ \Omega$, $N_1 = 30$, $A_1 = 3.6 \times 10^{-3}\ m^2$, $B_1 = 0.25$ T

$R_2 = 14\ \Omega$, $N_2 = 42$, $A_2 = 1.8 \times 10^{-3}\ m^2$, $B_2 = 0.50$ T

Current sensitivity is $\frac{\phi}{i} = \left(\frac{NAB}{K}\right)$

Thus, the ratio of current sensitivities is $= \frac{N_1}{N_2}\frac{A_1}{A_2}\frac{B_1}{B_2} = \frac{S_1}{S_2}$

$$= \frac{30}{42}\left(\frac{3.6}{1.8}\right)\left(\frac{0.25}{0.50}\right)$$

$$= \left(\frac{5}{7}\right)$$

Ratio of voltage sensitivities $= \left(\frac{S_1}{S_2}\right)\left(\frac{R_2}{R_1}\right)$

$$= \left(\frac{5}{7}\right)\left(\frac{14}{10}\right) = 1$$

OR

(a) Radius of the circular path in a magnetic field

$$r = \frac{mv}{qB}$$

Since $m_p > m_e$

Therefore, the radius of the proton's circle will be larger.

$$\frac{r_p}{r_e} = \frac{m_p}{m_e} = \frac{1.67 \times 10^{-37}}{9.1 \times 10^{-31}} = 1835$$

(b) Lorentz force on moving a charged particle in the magnetic field is always perpendicular to the velocity of the particle.

The work done by the magnetic force

$dW = \vec{F}.d\vec{\ell}$

$dW = Fd\ell \cos\theta$

but $\theta = 90^\circ$

$dW = 0$

Thus, on moving the charged particle in a uniform magnetic field, no work is performed. Hence, the kinetic energy of the charged particle will remain constant.

(c)

(i) the field is reduced to half

(ii) the field will be halved

(iii) the field will be perpendicular to the plane of the page, pointing downwards

33.

(i) Reflection and refraction arise through interaction of incident light with atomic constituents of matter which vibrate with the same frequency as that of the incident light. Hence frequency of reflected and refracted light both have the same frequency as the incident frequency.

(ii) No, energy carried by a wave depends on the amplitude of the wave and not on the speed of wave propagation.

(iii) For a given frequency, intensity of light in the photon picture is determined by the number of photons incident normally on crossing a unit area per unit time

(iv) $R = -20cm$ and magnification , $m = -2$

$f = -R/2 = -10cm$

$m = \frac{-v}{u}$

$-2 = \frac{-v}{u}$

$v = 2u$

Using mirror formula

$\frac{1}{f} = \frac{1}{v} + \frac{1}{u} \Rightarrow \frac{1}{-10} = \frac{1}{2u} + \frac{1}{u}$

$u = -15cm$

$v = 2 \times -15 = -30cm$

(v)

$\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$

Using dign convention , for convex mirror, we have

$f > 0, \mu < 0$

Therefore f is positive and μ is negative

v is always positive , hence image is always virtual

OR

Let μ_1 be the refracting index of the rarer medium and μ_2 be the refracting index of the spherical convex refracting surface XY of small aperture.

From A draw AM such that $AM \perp OI$

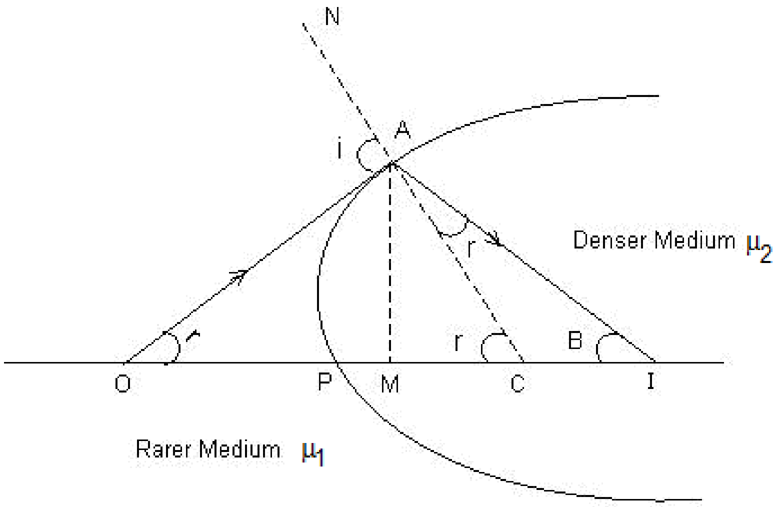
In ΔIAC

$$r + B = \gamma \text{ (Exterior angle property)}$$

$$\therefore \quad r = \gamma - \beta$$

Similarly in $\Delta\ OAC$

$$i = \alpha + \gamma$$



According to Snell's law,

$$\frac{\mu_2}{\mu_1} = \frac{\sin i}{\sin r} \approx \frac{i}{r} \Rightarrow \mu_2 r = \mu_1 i$$

So, $\mu_1(\alpha + \gamma) = \mu_2(\gamma - \beta)$ ... (1)

Let $\alpha \approx \tan\alpha = \dfrac{AM}{OM} = \dfrac{AM}{PO}$

$$\beta = \tan\beta = \frac{AM}{MI} = \frac{AM}{PC}$$

As the spherical surface has a small aperture, we have

$$y = \tan\beta = \frac{AM}{MC} = \frac{AM}{PC}$$

Substituting the value in equation (1), we have

$$\frac{\mu_1}{PO} + \frac{\mu_2}{PI} = \frac{\mu_2 - \mu_1}{PC}$$

By sign convention, put

$PO = -u,\ PI = +v,\ PC = +R$

We get

$$\frac{\mu_1}{-u} + \frac{\mu_2}{v} = \frac{\mu_2 - \mu_1}{R}$$

which is the required relation.