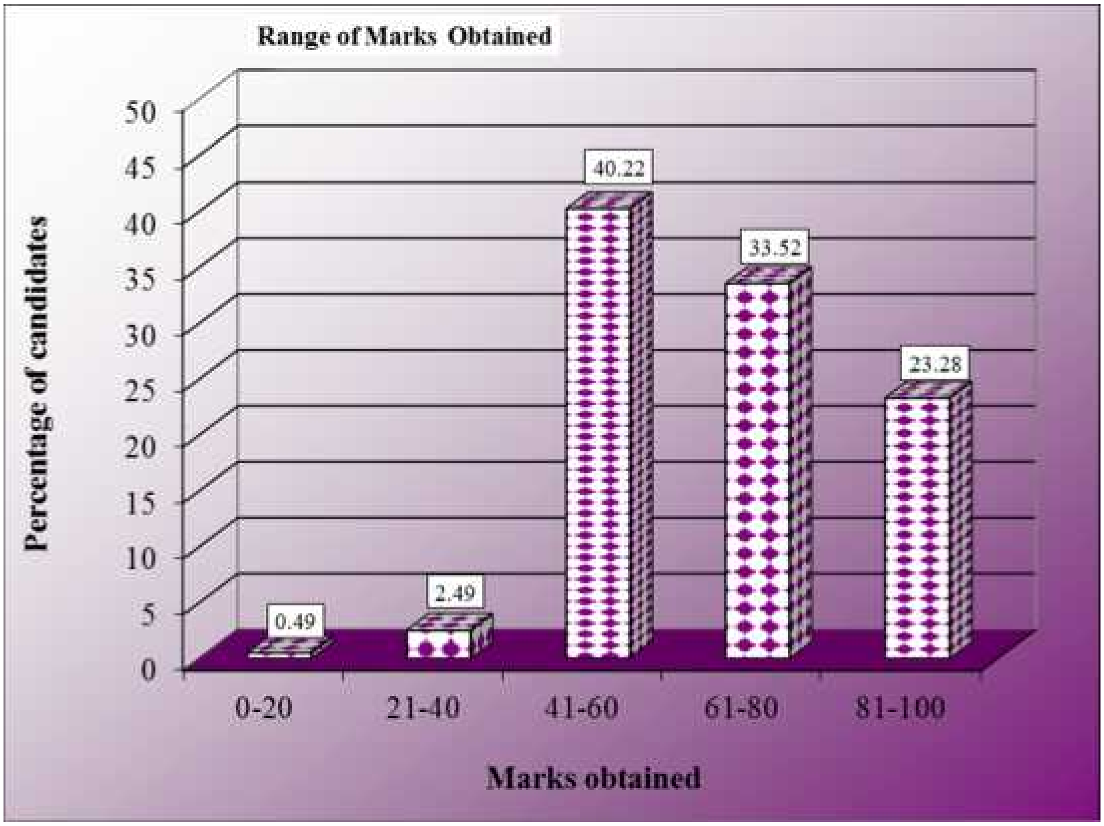
PHYSICS

A. STATISTICS AT A GLANCE

Total number of students taking the examination	35,192
Highest marks obtained	100
Lowest marks obtained	4
Mean marks obtained	66.1

Percentage of candidates according to marks obtained

	Mark Range				
	0-20	***21-40***	***41-60***	***61-80***	***81-100***
Number of candidates	171	878	14154	11798	8191
Percentage of candidates	0.49	2.49	40.22	33.52	23.28
Cumulative Number	171	1049	15203	27001	35192
Cumulative Percentage	0.49	2.98	43.20	76.72	100



B. ANALYSIS OF PERFORMANCE

PHYSICS PAPER 1 (THEORY)

PART I (20 Marks)

Answer **all** *questions.*

Question 1

A. Choose the correct alternative (a), (b), (c) or (d) for each of the questions given below: **[5]**

(i) 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:

(a) $E = \left(\frac{1}{4\pi \in_0}\right)\frac{\lambda}{r}$

(b) $E = \left(\frac{1}{4\pi \in_0}\right)\frac{2\lambda}{r}$

(c) $E = \left(\frac{1}{4\pi \in_0}\right)\frac{\lambda}{r^2}$

(d) $E = \left(\frac{1}{4\pi \in_0}\right)\frac{2\lambda}{r^2}$

(ii) 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:

(a) $R_1 = R_2$

(b) $R_2 = 2R_1$

(c) $R_2 = 4R_1$

(d) $R_1 = 4R_2$

(iii) 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:

(a) 10 A

(b) 5 A

(c) 2 A

(d) 1 A

(iv) 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:

(a) band spectrum

(b) continuous spectrum

(c) absorption spectrum of sodium

(d) emission spectrum of sodium

(v) If l_3 and l_2 represent angular momenta of an orbiting electron in III and II **Bohr** orbits respectively, then $\boldsymbol{l_3 : l_2}$ is:

(a) 3:2

(b) 9:4

(c) 2:3

(d) 4:9

B. Answer **all** questions given below briefly and to the point: **[15]**

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

(ii) Find the emf of the battery shown in ***Figure 1***:

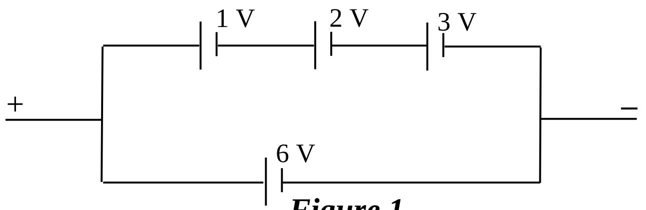


Figure 1

(iii) 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?

(iv) When does a moving charged particle **not** experience any force while moving through a uniform magnetic field?

(v) What is the turns ratio i.e. **transformer ratio,** $\mathbf{n_s : n_p}$, in an ideal transformer which increases ac voltage from 220 V to 33000 V?

(vi) What is meant by **coherent sources of light?**

(vii) 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?

(viii) Name the physical **principle** on which the working of **optical fibres** is based.

(ix) What is meant by **shortsightedness**?

(x) How does focal length of a convex lens change with **increase** in **wavelength** of incident light?

(xi) With reference to photo-electric effect, what is meant by **threshold wavelength?**

(xii) Half life of a certain radioactive element is 3·465 days. Find its *disintegration constant*.

(xiii) Binding energy per nucleon for helium nucleus $\left({}^{4}_{2}He\right)$ is 7·0 MeV. Find the value of **mass defect** for helium nucleus.

(xiv) Write *one* balanced reaction representing **nuclear fusion**.

(xv) Draw the truth table of a NOR gate.

Comments of Examiners

A. (i) Most candidates were able to answer this part correctly. Some did not know the correct expression required. Also, a few candidates were not sure about $1/r$ or $1/r^2$ dependence of E.

(ii) Some candidates did not know the correct relation, $P = V^2/R$; instead, they took $P = V^2xR$ and got the wrong answer, $R_1 = 2R_2$ in place of $R_2 = 2R_1$.

(iii) Wrong choices were made by candidates, such as, I = 2 A and 5 A in place of the correct value of I = 10 A. Some candidates missed the unit.

(iv) Most of the candidates gave the correct answer.

(v) Some candidates did not understand the question. So, unwanted formulas like, l = mvr and mv^2/r were used.

B. (i) A number of candidates did not know the simple relation, $k = C/C_o$. Many used lengthy work out using formulas $C = k.\varepsilon_o A/d$ and $C_o = \varepsilon_o A/d$ and then dividing these to get k, making the answer very lengthy; also, substituted the value of $\mu = 10^{-6}$ making the work still lengthier.

(ii) Some candidates combined the values of *emf*s without any logic or formula. Some applied the formula for R in parallel; since Rp = R/2, they deduced Ɛp = Ɛ/2 =6/2 =3 V which was incorrect.

(iii) Several candidates answered A as 'diamagnetic' and B as 'paramagnetic'.

(iv) Instead of starting with the expression for the force, F = q.vxB and hence v is along B for F to become zero, some got confused with equilibrium in a crossed field and wrote, $qE = mv^2/r$.

(v) Some candidates left the answer as 300/2 and did not simplify it to 150.

(vi) Some candidates wrote that amplitude / frequency is the same.

Suggestions for teachers

- Make sure that students learn by heart, the correct expressions for E required in the syllabus. Teach correct use of $1/4\pi\varepsilon_o$.
- Tell students that MCQ answers should be given as (a), (b), (c) or (d).
- Emphasize learning the three expressions for electrical power $P = V.I = V^2/R= I^2.R$. Also, students should be able to recognise the one factor among P, V, I and R that is constant or have the same value for both.
- Stress upon the importance of writing units.
- While teaching 'Spectrum', point out the difference between the various types of spectra, especially between absorption spectra and emission spectra.
- Teach that *emf* do not combine like resistance. In parallel combination, the greatest of the *emf* on either side is the effective *emf*.
- Stress upon the importance of the vector equation for Lorentz force acting on a charged particle, q moving in a B field with velocity, v, given by F = q.vxB and the property of the vector (cross) product, F=0 for v || B. or angle θ= 0.

(vii) Many candidates gave the equation for Brewster's law, tan i_p = n or angle i_p + r = 90. These are not asked.

(viii) Most candidates were able to attempt this part correctly.

(ix) Many candidates gave the opposite explanation – "Cannot see nearby objects clearly, Difficulty in viewing near objects" etc.

(x) Some candidates wrote that it remains unaffected; some wote that f decreases with increase in λ.

(xi) Several candidates were unable to explain the meaning.

(xii) Many candidates left out the unit 'day^{-1}' from the answer. Some converted day to second, unnecessarily. A few candidates had unit of λ as m(metre).

(xiii) Some candidates took the BE of the atom as 7 MeV.

(xiv) Several incorrect unbalanced equations were given by candidates. A number of candidates gave the equation for beta decay or nuclear fission.

(xv) Candidates were able to score marks in this part.

- Explain clearly the nature of the two defects of the eye using ray diagrams.
- Teach properly the meaning of μ, and χ and the relation, $\mu_r = 1 + \chi_m$. For paramagnetic $\chi_m > 0$ and for diamagnetic $\chi_m < 0$.
- Instruct students to read the question carefully and understand what exactly is asked.
- Explaining chromatic aberration of a lens, point out that the red ray touches the axis at a farther point compared to the violet ray. The focal length of the lens is larger for red light than for violet light $\left(f_r > f_v\right)$.
- Explain the relevance of the word, 'threshold' in photoelectric effect.
- Explain the special nature of fission and fusion reactions.
- Consult the Scope of syllabus and follow it strictly.

MARKING SCHEME

Question 1.

A.	(i)	(b) or E = $\left(\frac{1}{4\pi \epsilon_0}\right)\frac{2\lambda}{r}$
	(ii)	(b) or $R_2 = 2R_1$
	(iii)	(a) or 10 A
	(iv)	(c) or absorption spectrum (of sodium)
	(v)	(a) or 3:2 or $l_2:l_3$ = 2:3
B.	(i)	10
	(ii)	6 V
	(iii)	A : Paramagnetic B : Diamagnetic (both correct)
	(iv)	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 ɤ || $\vec{B}$.

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

(vi) Those emitting light waves having constant or zero phase difference. $\Delta\phi=0$ or constant.

(vii) 90^o OR ®/2 OR diagram with angle marked 90^o.

(viii) Total internal reflection OR TIR

(ix) 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.

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

(xi) 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.

(xii) 0·2 per day or 0·2 day^{-1}

(xiii) Δm =28 MeV/(931MeV/u) =0.0301 u Or 5.00×10^{-29} kg.

OR 0.03 u OR 4.98 to 5.0 x 10^{-29} kg

(xiv) $4\,{}^1_1H \rightarrow {}^4_2He + 2\,{}^0_1e + Energy$ OR $4\,{}^1H + 2e \rightarrow {}^4He + 2$¬ + 6¥

${}^2_1H + {}^3_1H \rightarrow {}^4_2He + {}^1_0n + Energy$ OR $He^4 + He^4 + He^4 \rightarrow C^{12}$ + ¥

Equivalent OR ${}^2H + {}^2H \rightarrow {}^3He + {}^1n$

(xv)

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

PART II (50 Marks)

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

(a) 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 $\vec{2}$ 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:

(i) maximum **[3]**

(ii) zero

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

(c) (i) Define **temperature coefficient** of resistance of the material of a conductor. **[3]**

(ii) When the cold junction of a thermocouple is maintained at 0^0C, the thermo emf ‘e’, generated by this thermocouple is given by the relation:

$$e = [16{\cdot}8\,\theta + \frac{1}{2}(-\,0{\cdot}048)\,\theta^2] \times 10^{-6},$$

where θ is the temperature of the hot junction in ^{0}C. Find the **neutral temperature** of this thermocouple.

<u>Comments of Examiners</u>

(a) The question was to write down the expression for the torque experienced by an electric dipole in an electric field, in **vector form.** However, many candidates gave a scalar expression, p.E cos θ. Also, some derived this with the help of a labelled diagram. Unwanted details were given by many candidates.
The question said ‘show diagrammatically ….’ However, many candidates did not give the diagram; instead, they gave algebraic equations and conditions - angle θ = 90 for maximum torque and θ = 0 for minimum torque.

(b) The question said ‘show------diagram’. However, many candidates showed steps for obtaining effective capacitance which were not required. Some put two Cs

<u>Suggestions for teachers</u>

- Stress upon the importance of reading the question carefully, noting what exactly is asked and giving just that.
- Tell students that when an equation is asked, they should give just that. Also, stress the importance of the use of vector equations correctly.
- Ask students to always draw diagrams needed to illustrate principles or derive equations.

in series and two Cs in parallel. Several candidates showed the symbol of r for C. Some had no symbol.

(c) (i) Temperature coefficient was defined wrongly by many candidates.

(ii) Several candidates had trouble with differentiation. Some got the correct value 350 but took it to be in kelvin and subtracted 273 to get 77°C.

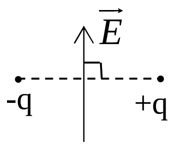
- Teach symbols thoroughly. Check total effective C. Avoid confusion between formulas for Resistance combination and for capacitance combination.
- Use the defining eqn $\alpha = (R_t - R_o)/(R_o.\Delta t)$. Explain this in words. Mention similarity in the defining equations of expansion coefficients. The correct unit has to be per degree C or K.
- Elementary differentiation must be taught.

MARKING SCHEME

Question 2.

(a) $(\vec{2}) = \vec{p} \times \vec{E}$

(i)



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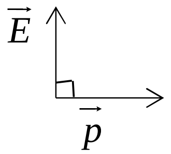
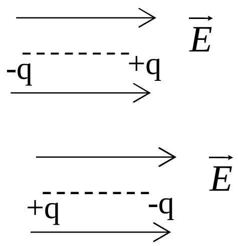


(ii)



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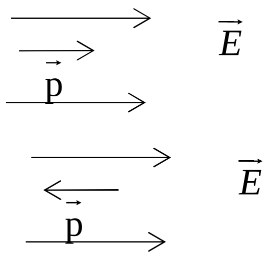
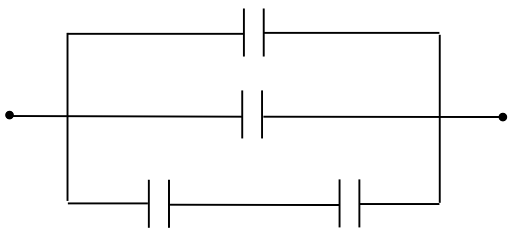


(b)



(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

(c) (i) It is defined as fractional increase in resistance per degree rise in temperature.

or

Equivalent statement OR Defining equation.

(ii) $e = [16\cdot8\ \theta + \frac{1}{2}(-0\cdot048)\ \bar{\ }^{2}] \times 10^{-6}$

$$\frac{de}{d\bar{\ }} = [16\cdot80 - \tfrac{1}{2}\times 0\cdot048 \times 2\bar{\ }]\times 10^{-6}$$

$$\frac{de}{d\bar{\ }} = 0 \Rightarrow \bar{\ } = 350^{\circ}C$$

OR

$$\theta = \left(\frac{a}{b}\right) = \frac{16\cdot80}{0\cdot048}$$

$\theta = 350^{o}C$ OR

$\theta_i = 700^{\circ}C$ with formula and working

$\theta_n = 350^{\circ}C$

Question 3

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

(b) 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]**

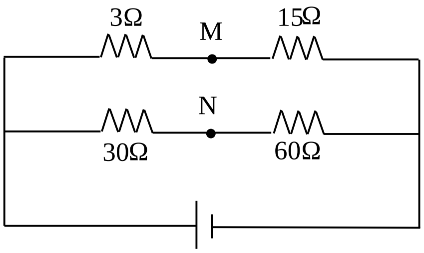


Figure 2

(c) (i) With reference to **free electron theory of conductivity**, explain the terms: **[3]**

(1) Drift speed

(2) Relaxation time

(ii) What is the **colour code** of a carbon resistor having a resistance of 470Ω and a tolerance of 5%?

Comments of Examiners

(a) In the figure, many candidates drew four or five lines to represent 400 or 500 cm potentiometer wire – this made it clumsy and more susceptible to mistakes. Many candidates left out the key/switch, rheostat, or ammeter. In place of two cells, some made only one cell. A few candidates left out the galvanometer. In some cases, the polarity of cells was incorrect; at times labels were absent. Some candidates gave the working principle instead of the formula asked.

(b) A number of candidates did not realise that it was a balanced bridge. Lengthy calculations were done by many candidates. In several cases, calculation of final value of R was wrong.

(c) (i) A number of candidates gave very lengthy answers, being unsure of the meaning of drift speed.
(ii) Several candidates were not sure of the right colours for each number.

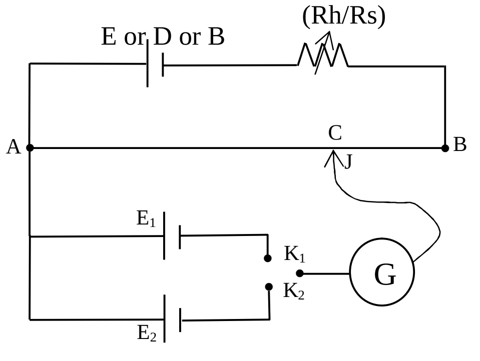
Suggestions for teachers

- Tell students that: the circuit diagram is symbolic; only one line is enough to represent any length of potentiometer wire; a switch is a must in any electric circuit diagram.
- The use of two-way key should be explained.
- Show the correct connection of galvanometer and voltmeter and correct polarity of cells.
- Explain the principle and working of 'Wheatstone bridge' and the meaning of a balanced bridge. Explain that effective R decreases when connected in parallel.
- Explain the process of conduction of electricity in terms of free electron gas model- drift speed and relaxation time and the correct definitions.

MARKING SCHEME

Question 3.

(a)



$E_1 : E_2 = l_1 : l_2$

(b) $\frac{3}{R} = \frac{30}{60} \Rightarrow R = 6\Omega$

$\frac{1}{15} + \frac{1}{x} = \frac{1}{6}$ Or $15x/(15+x) = 6$ $x = 10\ \Omega$

(c) (i) (1) 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.

(2) 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).

(ii) Yellow, violet, brown and golden yellow OR

Yellow, violet, brown and gold OR

YVBG.

Question 4

(a) (i) State **Tangent Law** in magnetism. **[2]**

(ii) At a certain temperature, a ferromagnetic material becomes paramagnetic. What is this temperature called?

(b) (i) State **Biot Savart law**. **[3]**

(ii) 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.

(c) 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 ¯ = $\tan^{-1}$(3/4). Find the: **[4]**

(i) Inductive reactance

(ii) Impedance of the circuit

(iii) Current flowing in the circuit

(iv) If the inductor has a coefficient of self inductance of 0·1 H, what is the frequency of the applied emf ?

Comments of Examiners

(a) (i) Many candidates were unable to correctly define the 'Tangent Law' in magnetism.

(ii) In place of 'Curie temperature', several candidates gave the answer as: Temperature of inversion.

(b) (i) While stating the 'Biot-Savart Law' several candidates left out the vector sign. Some gave only the scalar expression without explaining the symbols used. Some mixed up unit vector, r^2 and r^3.

(ii) Several candidates used the wrong formula or did wrong simplification. In some cases, the unit was left out. Candidates seemed to be confused between flux, flux density and B field.

(c) Some candidates did not write the units.

Suggestions for teachers

- Stress upon the importance of reading the question carefully, noting what exactly is asked and giving just that.
- Teach Curie temperature and Curie's law.
- Biot-Savart Law - teach the vector form with illustration.
- Stress upon the importance of writing units.
- Teach *ac* theory thoroughly and give practice in problem solving.

MARKING SCHEME

Question 4.

(a) (i) 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, B_H and B_F it comes to an equilibrium position in which

$\tan\theta = \frac{B_F}{B_H}$ where θ is the angle with B_H OR

$\tan\theta = F/H$ OR B_1/B_2 OR B_C/B_H with labelled diagram OR

equivalent verbal statement

(ii) Curie temperature.

(b) (i) $$dB = \frac{\mu_0}{4\pi}\frac{i\,\vec{dl}\times\hat{r}}{r^2}$$

OR

$$dB = \frac{\mu_0}{4\pi}\frac{i\,dl\,\text{Sin}\theta}{r^2}$$

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

OR dB α I, $\alpha - 1/r^2$, α Sinθ.

(ii) Correct substitution with or without correct formula.

$B = \mu_o\ n\ I$

$= 4\pi\times10^{-7}\times5000\times2$ Correct formula or substitution

Correct result with unit i.e.

$B = 12{\cdot}56\times10^{-3}$ T Or

$= 0.0126$ T or Wb/m^2

(c) (i) $\tan\theta = \frac{X_L}{R}$ OR

$\frac{3}{4} = \frac{X_L}{80}$ $\quad\therefore X_L = 60\Omega$

(ii) $Z^2 = X_L^2 + R^2$ OR $60^2 + 80^2$

$\therefore Z = 100\Omega$

(iii) $I = \frac{V}{Z}$ OR $\frac{E}{Z}$ OR

$= \frac{110}{100}$

$= 1{\cdot}1$ A

(iv) $X_L = 2\,\pi f L$ OR $\omega = X_L/L = 60/0.1 = 600$ rad/s

OR $60 = 2 \times 3{\cdot}14 \times f \times 0{\cdot}1$

$f = \frac{\omega}{2\pi}$ or $\frac{600}{6.28} = 95.5$Hz

OR $\therefore f = \frac{60}{0{\cdot}628}$

$= 95{\cdot}5$Hz

SECTION B

Answer any **two** *questions*

Question 5

(a) Name the part of the **electromagnetic spectrum** which is: **[2]**

(i) Suitable for radar systems used in aircraft navigation.

(ii) Produced by bombarding a metal target with high speed electrons.

(b) 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 5×10^{-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]**

(c) (i) State **Brewster's law** of polarization of light. **[3]**

(ii) How will you identify **with the help of an experiment** whether a given beam of light is of polarized light or of unpolarized light?

Comments of Examiners

(a) (i) Several candidates gave the answer as: infra-red rays or gamma rays which was incorrect.

(ii) Some candidates answered as: gamma rays, beta rays instead of X-rays.

(b) The formula used by a number of candidates was incorrect. Many did not know the correct meaning of symbols used. Mistakes were also made by candidates in simplifying the exponents.

(c) (i) Many candidates were not able to define Brewster's law of polarisation of light correctly.

(ii) Instead of answering how to identify polarised light, many candidates wrote on how to produce polarised light or the difference between polarised and unpolarised light.

Suggestions for teachers

– Stress upon the nature and common use of various types of electromagnetic radiations.

– Give practice problems based on Young's Experiment. Explain simplification with exponents. Point out simpler calculations.

– Use of polariser and analyser should be taught clearly.

– Production, properties and analysis must be well distinguished and the need for the rotation of the polariser explained.

MARKING SCHEME

Question 5.

(a) (i) Micro waves Or Radio wave

(ii) X rays

(b) $y = \frac{\lambda D}{a}$

OR

$\Delta Y = \frac{\lambda}{a} \Delta D$

$\frac{\lambda}{a} = \frac{3\times10^{-5}}{5\times10^{-2}}$ One correct substitution in a correct formula

$= 0{\cdot}6\times10^{-3}$

$\lambda = 0{\cdot}6\times10^{-6}$ m Correct result with unit

OR 6×10^{-7} m OR 600 nm

(c) (i) When ordinary /unpolarised light is incident on a transparent medium, the reflected light is completely plane polarized for a certain angle of incidence θ_p and $\tan \theta_p = n_2/n_1$

OR $\tan \theta_p = n$ OR $\tan \theta = n$ where θ is the polarising angle (and n is the refractive index of the transparent medium).

(ii) Incident light is allowed to fall on a polariser

which is then <u>rotated</u> *(compulsory)*

If intensity of transmitted light varies, it is polarised light.

If intensity of transmitted light remains constant, it is unpolarized light.

Question 6

(a) 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 (See ***Figure 3)***. Find the **refractive index** of this liquid. **[2]**

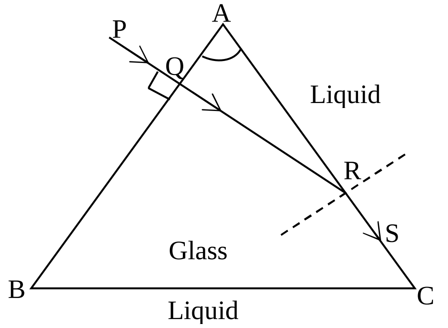


Figure 3

(b) 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]**

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

(c) The ***Figure 4*** 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]**

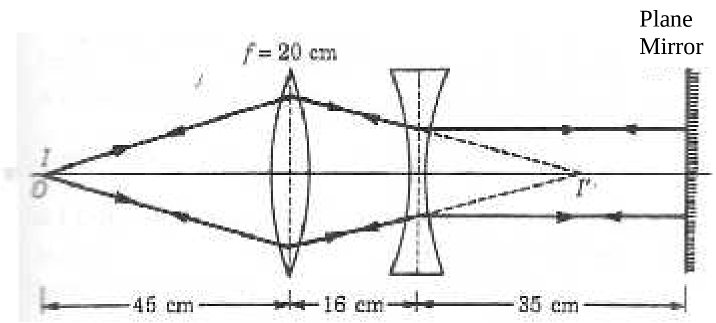


Figure 4

Comments of Examiners

(a) Several candidates could not get angle c = 60°. Some calculated c from 1/sin c = n = n_g =1.45 which was incorrect. Some candidates did not note that the given refraction was from glass to liquid. Relation between the angles was not well understood.
(b) Many candidates wrote down the first three equations correctly, but without any explanation. Some candidates introduced the sign of *u* as –ve. A few candidates did not draw arrows for ray diagrams. Some got confused with the lens maker's formula.
(c) A number of candidates took the sign for *u* =45 cm incorrectly. Some did not recognise I' as the focus of the 2nd lens, L_2.

Suggestions for teachers

- Teach students the important concept of critical angle of incidence, with *r* = 90.
- Explain that for refraction in the 2nd lens, the real image formed in L_1 becomes a virtual object for refraction in L_2. Explain the idea of equivalent lens.
- Discourage the learning of derivations by heart. Help students understand the logic behind each step.
- Teach correct use of sign convention.
- Teach how to draw correct ray diagrams, understanding the relations involved. Stress upon arrows for rays.
- Problems with combination of lenses/mirrors should be given for practice.

MARKING SCHEME

Question 6.

(a) θ_c or c = 60^o

OR $\quad {}_g\mu_l = \dfrac{sin\,60^o}{sin\,90^o}$

$$\frac{{}_a\mu_l}{{}_a\mu_g} = sin\,60^o$$

OR $\therefore\ {}_a\mu_l = {}_a\mu_g \times sin\,60^o$

$= 1{\cdot}45 \times 0{\cdot}866$

$= 1{\cdot}26$

(b) Any sign convention is acceptable.

Correct diagram showing Object O, intermediate image I′ and final image I.

Lens formula to first lens,

$$\frac{1}{v'} - \frac{1}{u} = \frac{1}{f_1}$$

Lens formula to second lens

$$\frac{1}{v} - \frac{1}{v'} = \frac{1}{f_2}$$

Adding the above two equations, $1/v - 1/u = 1/f_1 + 1/f_2$

But for an equivalent single lens, let f be the focal length, for the same u and v.

Then we have $1/v - 1/u = 1/f$

Comparing these two equations, we get $1/f = 1/f_1 + 1/f_2$

(c) 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. $\frac{1}{v} + \frac{1}{45} = \frac{1}{20}$ $\quad$ $\frac{1}{v} + -\frac{1}{-45} = \frac{1}{20}$ Correct substitution

$\therefore v = 36$ cm

For concave lens:

Either $f_2 = 36 - 16 = 20$ cm

Question 7

(a) (i) What is meant by **dispersive power** of a transparent material? **[4]**

(ii) Show that, two thin lenses kept in contact, form an **achromatic doublet** if they satisfy the condition:

$$\frac{\mu}{f} + \frac{\mu'}{f'} = 0$$

where the terms have their usual meaning.

(b) (i) Define **magnifying power** of a **microscope** in terms of **visual angles**. **[2]**

(ii) What is the advantage of a **compound microscope** over a simple microscope?

(c) 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]**

Comments of Examiners

(a) The definition of ω was mostly given correctly by candidates.
Some candidates derived the longitudinal chromatic aberration for one lens. The condition for achromatism was not understood, nor applied correctly by a number of candidates.
(b) Many candidates were unable to answer this part correctly.
(c) Some candidates took $P = P_1 + P_2$ and then f =1/P as L. Some candidates used wrong units.

Suggestions for teachers

– Teach students how to draw correct ray diagrams. Derivations should be written down for practice.
– In teaching/learning, make sure that angle subtended by the object placed at D is emphasised. Draw a neat diagram on the black board; do some comparison of the magnifying powers.
– First, show with the help of a ray diagram, length, $L = f_o + f_e$. Then stress the relation between P and f with proper units. P(in D) =100/f(cm) =1/f(m).

MARKING SCHEME

Question 7.

(a) (i) The ability of the material to split (separate) white light into its constituent colours.

OR

It is defined as a ratio of angular dispersion to the mean deviation.

OR

$$\omega = \frac{\delta_v - \delta_r}{y} \quad \text{or } \omega = \frac{(\mu_v - \mu_r)}{(\mu_y - 1)}$$

(ii) $F_v = F_R$

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

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

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

$$\left.\begin{array}{l}\dfrac{1}{f}=(\mu-1)\left(\dfrac{1}{R_1}\mp\dfrac{1}{R_2}\right)\\[2ex]\dfrac{1}{f_r}=(\mu_r-1)\left(\dfrac{1}{R_1}\mp\dfrac{1}{R_2}\right)\\[2ex]\dfrac{1}{f_v}=(\mu_v-1)\left(\dfrac{1}{R_1}\mp\dfrac{1}{R_2}\right)\end{array}\right\}\text{ Any one equation correct}$$

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

OR

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

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

(b) (i) 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.

(ii) Compound microscope has a larger magnifying power.

(c) $f_1=\dfrac{1}{P_1}=\dfrac{1}{10}=0\cdot 1\text{m} \;\rightarrow (\text{Eyepiece})$

$f_2=\dfrac{1}{P_2}=\dfrac{1}{1}=1\cdot 0\text{ m} \;\rightarrow (\text{Objective})$ or implied in the next step.

$L = f_o + f_e$

OR $= 1\cdot 0 + 0\cdot 1 = 1\cdot 1$ m

OR $L = f_o + f_e$ or 1+ 1/10 = 1.1 m (in one step)

SECTION C

Answer any **two** *questions.*

Question 8

(a) Answer the following questions with reference to **Millikan's oil drop experiment**: **[3]**

(i) What is an atomiser?

(ii) What is the use of an X-ray tube?

(iii) What is the unique property shown by the charge of an oil drop?

(b) (i) Write **Einstein's photo electric equation**. **[3]**

(ii) If the frequency of the incident radiation is increased from 4×10^{15} Hz to 8×10^{15} Hz, by how much will the **stopping potential** for a given photosensitive surface go up?

(c) (i) What are **matter waves**? **[2]**

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

Comments of Examiners

(a) (i) Many candidates could not define 'atomiser' correctly.

(ii) Several candidates did not know the use of the X-ray tube in the experiment.

(iii) A number of candidates gave incorrect answers for this part.

(b) (i) Some candidates gave the answer as: $eV_s = hf - hf_o$; some gave K or ½ $m.v^2$ which was not correct.

(ii) Several candidates followed a very lengthy, round about method, as they could not follow the direct short method.

(c) (i) Many incorrect definitions were given by candidates.

(ii) Graphs were mostly correct except for some, where the shape was not correct; some graphs were a straight line with a negative slope.

Suggestions for teachers

– Point out that Einstein's equation for photoelectric effect is, $hf - hf_o = K_{max}$ or ½ mv^2_{max}. The difference between energy input from incident photon and the work function is = the maximum kinetic energy of the electron emitted.

– Give practice to students in plotting graphs to show variation of $y = mx$, $y=mx^2$, $y=m/x$ etc. Always label the axes. Explain the meaning of different shapes of graphs.

MARKING SCHEME

Question 8.

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

(ii) To help oil drops acquire more charge OR for ionising air.

(iii) Charge on it is always an integral multiple of $\pm$ e OR

Quantisation of charge OR q = ne

Atomicity of charge OR

Minimum charge of an oil drop = $\pm$ e

(b) (i) $hf = hf_o + K_{max}$ or $w + K_{max}$ OR interms of λ OR equivalent

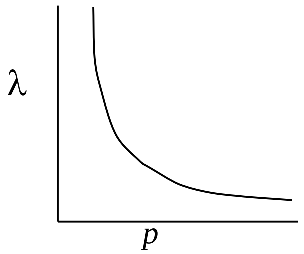
(ii) correct substitution in $e.\Delta V = h.\Delta f$

correct result with unit

$(\Delta V) = 16{\cdot}5$ V

(c) (i) Waves associated with moving particles or with the wave nature of particles are called matter waves or equivalent.

(ii)



Question 9

(a) The energy levels of an atom of a certain element are shown in the given ***Figure 5.*** **[3]**
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.

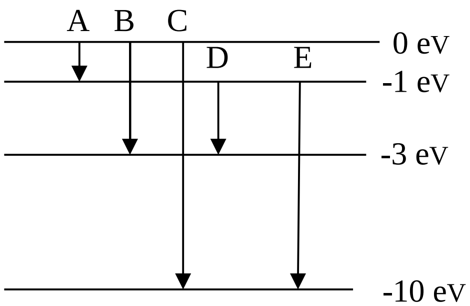


Figure 5

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

(c) In a **nuclear reactor**, what is the function of: **[3]**

(i) The moderator

(ii) The control rods

(iii) The coolant

Comments of Examiners

(a) Many candidates calculated λ for the five given transitions unnecessarily, then tried to match with the given λ. Very lengthy and round-about methods were followed by candidates. Some candidates took it as energy level diagram of H atom which was incorrect.

(b) In place of λ_{min} = 1240/V or 1237.5/V, some used the formula λ= √(1.5/V) wrongly. This is the formula for de Broglie wavelength of electron accelerated through a pd = V.
Some candidates used V = 18 instead of 18000 V (given 18 kV).

(c) (i) Several candidates wrote that a Moderator slows down the rate of fission reaction/ absorbs neutrons.

(ii) Some mixed up 'control rods' and 'moderators'.

(iii) The function of 'Coolant' was given correctly by most of the candidates.

Suggestions for teachers

- Explain clearly the expressions for the momentum and energy of particles like electron and photons.
- Discourage learning by heart these short-cut formulae, without grasping the context.

MARKING SCHEME

Question 9.

(a) $E = \frac{hc}{\lambda}$ = correct formula or substitution for J or eV

= 2 eV

OR E = 1240/618.85 = 2 eV…

i.e. Transition D

(b) $\lambda_{min} = \frac{hc}{eV}$ = 1240/18000 = 0.069 nm

OR correct substitution with or without formula

correct result i.e.

$\lambda_{min} = 0{\cdot}69\ \mathring{A}$ OR

= 0·069 nm.

(c)	(i)	Moderator:	To slow down, fast moving neutrons. OR To convert fast neutrons to slow (thermal) neutrons.
	(ii)	Control rods:	To control the rate of production of energy OR To control the rate of fission OR To shut down the nuclear reactor OR Absorbs (slow) neutrons.
	(iii)	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

(a) (i) The atomic mass of Uranium $^{238}_{92}U$ is 238·0508 u, while that of Thorium $^{234}_{90}Th$ is 234·0436 u, and that of Helium $^{4}_{2}He$ is 4·0026 u. Alpha decay converts $^{238}_{92}U$ into $^{234}_{90}Th$ as shown below: **[3]**

$$^{238}_{92}U \rightarrow ^{234}_{90}Th + ^{4}_{2}He + \text{energy}$$

Determine the energy released in this reaction.

(ii) What is a *neutrino?*

(b) In **semi conductor physics**, what is meant by: **[3]**

(i) a rectifier

(ii) an amplifier

(iii) an oscillator

(c) With the help of a diagram, show how you can use several NAND gates to obtain an OR gate. **[2]**

Comments of Examiners

(a) (i) Many candidates calculated the mass defect Δm correctly in terms of u, but wrongly used $E = m.c^2$ and got wrong value of energy released.

(ii) Most candidates did not know what a 'neutrino' is.

(b) In all the three cases, many candidates gave circuit diagrams, electronic components, waveforms, etc. These were not required nor asked. In part (i) some candidates gave the types of rectifier which was not asked. Many candidates were unable to define parts (ii) and (iii) correctly.

Suggestions for teachers

- Tell students that when *m* or Δ*m* is in 'u' as in this problem, use the conversion factor 1 u = 931.5 MeV or 931 MeV given in QP.
- Neutrino is a neutral particle of negligible size and mass, released during beta decay. Include this in the explanation of beta decay.
- Teach the meanings of different operative verbs used in questions: define, state, explain, describe, etc. Here, 'what is meant by' implies what is the function/work of this device.
- Follow the syllabus and the scope of syllabus for the current year.

MARKING SCHEME

Question 10.

(a) (i) $\Delta m = 238{\cdot}0508 - (234{\cdot}0436 + 4{\cdot}0026)$

$= 238{\cdot}0508 - (238{\cdot}0462)$

$= 0{\cdot}0046$ (u) Or implied in next step

$E = 0{\cdot}0046 \times 931$

$= 4{\cdot}28$ MeV

OR

$E = \{238{\cdot}0508 - (234{\cdot}0436 + 4{\cdot}0026)\} \times 931$

$= 4{\cdot}28$ MeV OR 4.285 MeV

(b) (i) A rectifier converts ac (voltage) to dc (voltage).

(ii) An amplifier increases the magnitude of voltage/count of the input signal.

(iii) An oscillator is an electronic device which generates/produces ac voltage/signal

GENERAL COMMENTS:

(a) Topics found difficult by candidates in the Question Paper:

- EMF of a battery with cells in parallel.
- Combination of C, minimum number.
- Magnetic properties of materials and their mutual relations.
- Temperature coefficient of resistance.
- Drift speed of electrons in a conductor.
- Refraction through combination of lenses/mirrors.
- Applying sign convention in Optics.
- Vector form of Biot-Savart law.
- Tangent law of magnetic fields.
- Definition of visual angle of an object.
- Derivations: Achromatic combination of lenses.
- Energy calculation from mass defect in terms of u.
- Neutrino.
- Use of x-ray tube in Millikan's oil drop expt.
- What is meant by an oscillator?

(b) Concepts in which candidates got confused:

- Paramagnetism and diamagnetism.
- Threshold wavelength and threshold frequency.
- Long sightedness and short sightedness.
- Distinction between polarised light and un-polarised light using a polariser.
- Neutral temperature and temperature of inversion.
- Einstein's equation for photo-electric effect.
- Mass defect, binding energy, energy released, and conversion factor (1 u = 931.5 MeV).

(c) Suggestions for students:

- While reading your text, mark important definitions, formulas, and vector equations. Make a list.
- Prepare notes combining your own reading and the class-room lecture material.
- Review the classroom lessons on the same day.
- Learn derivations step by step, understanding the logic of each step; start from defining equations or the given equations. Include diagrams if relevant.
- Work out as many problems as possible, related to each topic.
- Practice drawing figures, graphs and circuit diagrams with labels, noting the function of each.
- Write down answers to questions at the end of each chapter and from the Board question papers.
- Discuss your doubts with your teachers.
- Keep your eyes/mind open for easier, shorter, and faster solutions/derivations.
- Read each question very carefully, underline the data given (if any), and plan out the steps, solution and results **exactly as required in the question**.
- Do not leave out **units** of final results, and **arrows** in ray diagrams. These are very important.
- Try to understand **what exactly is asked; do just that and that only.** Do not waste your time giving unasked, un-necessary details. Save time and revise your answers at the end.
- Keep your answers neat, legible and well-spaced.
- Keep the length of your answers proportional to the marks allotted.
- Do not copy diagrams, Tables etc. from your question paper to your answer scripts.
- Work systematically, with a definite plan of study and revision. Remain cool and focussed on your goal, in a well-disciplined manner.