FIITJEE (JEE-Advanced)

BATCHES – NWCM721O1S, NWCM921X1W, NWCM921A1W & PANINI921-XIIG1

PHYSICS, CHEMISTRY & MATHEMATICS

QP Code: **Test - 21**

Time Allotted: 3 Hours **Maximum Marks: 180**

- Please read the instructions carefully. You are allotted 5 minutes specifically for this purpose.
- You are not allowed to leave the Examination Hall before the end of the test.

INSTRUCTIONS

Caution: Question Paper CODE as given above MUST be correctly marked in the answer OMR sheet before attempting the paper. Wrong CODE or no CODE will give wrong results.

A. General Instructions

1. Attempt ALL the questions. Answers have to be marked on the OMR sheets.
2. This question paper contains **Three Sections**.
3. **Section-I** is Physics, **Section-II** is Chemistry and **Section-III** is Mathematics.
4. In Each Section is **One Part:** Part-A.
5. Rough spaces are provided for rough work inside the question paper. No additional sheets will be provided for rough work.
6. Blank Papers, clip boards, log tables, slide rule, calculator, cellular phones, pagers and electronic devices, in any form, are not allowed.

B. Filling of OMR Sheet

1. Ensure matching of OMR sheet with the Question paper before you start marking your answers on OMR sheet.
2. On the OMR sheet, darken the appropriate bubble with HB pencil for each character of your Enrolment No. and write in ink your Name, Test Centre and other details at the designated places.
3. OMR sheet contains alphabets, numerals & special characters for marking answers.

C. Marking Scheme For All Three Sections.

(i) **Part-A (01-15)** contains Six (15) Numerical based questions, the answer of which maybe positive or negative numbers or decimals (e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30) and each question carries **+4 marks** for correct answer and **there will be no negative marking.**

Name of the Candidate :_____

Batch :_____ **Date of Examination :**_____

Enrolment Number :_____

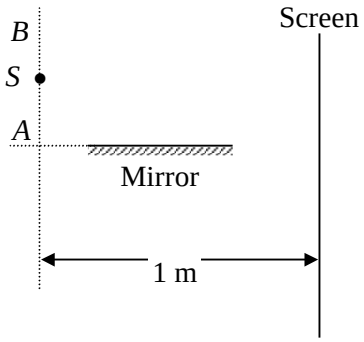
SECTION-1 : PHYSICS

PART – A

(Numerical based)

This section contains **15 questions**, numerical based questions, (answer of which maybe positive or negative numbers or decimals).

1. In an interference experiment as shown in the figure, the source and the screen are separated by a distance of 1m. At a certain position of source the fringe-width is $\frac{1}{4}$ mm and by moving the source away from the mirror along the line *AB* by 0.6 mm the fringe width changed to $\frac{1}{6}$ mm. If the wavelength of light used is X × 10^{-7} m, then value of X is ?

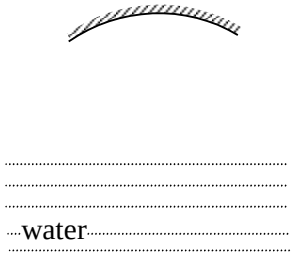


1. **6**

2. A point light source is moving with a constant velocity *v* inside a transparent thin spherical shell of radius *R*, which is filled with a transparent liquid. If at *t* = 0 light source is at the centre of the sphere, then at what time a thin dark ring will be visible for an observer outside the sphere. The refractive index of liquid with respect to that of shell is $\sqrt{2}$. (Given: R=2m and v = 1m/sec).

2. **1.414 (Range: 1.40 to 1.42)**

3. A concave mirror of focal length 15 cm is placed in air at a height of 45 cm above the water surface as shown. The axis of the mirror is vertical and the reflecting surface faces the water surface. A point object is placed on the axis of concave mirror at a distance 35 cm above the water surface. Find the position of image(w.r.t water surface) formed after two successive processes- first reflection from the concave mirror and then refraction from the water. Give the distance of image from water surface. Reflective Index of water $\frac{4}{3}$.

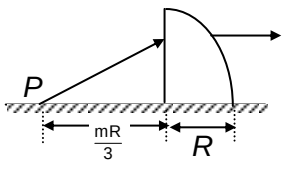


3. **100**

4. A point source of power 4W is placed 1m below the free surface of liquid whose refractive index is '$\frac{2}{\sqrt{3}}$'. Find the rate of transfer of energy (in watt) from the liquid surface to air. Ignore any absorption or scattering of light energy.

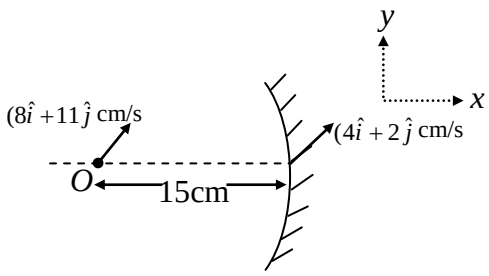
4. **1**

5. A quarter cylinder of glass of radius *R* and refractive index 1.5 is placed on a table. A point object *P* is kept at a distance of *mR/3* from it. Find the value of *m* for which a ray from *P* will emerge parallel to the table as shown in the figure.



5. **4**

6. A point object is located at a distance 15 cm from the pole of a concave mirror of focal length 10 cm on its principal axis is moving with a velocity $(8\hat{i}+11\hat{j})$ cm/sand velocity of mirror is $(4\hat{i}+2\hat{j})$ cm/s as shown. If $\vec{V}$ is the velocity of image. Then find the value of $\left|\vec{V}\right|$ (in cm/s).



6. **20**

7. A convex lens is placed in such a way that the left side of lens has refractive index 2 and right of lens has refractive index 3. If parallel ray coming from left side focus at 20 cm from lens, find the distance from lens where rays will focus if they are coming from right side.

7. **13.33 (Range: 13.33 to 13.34)**

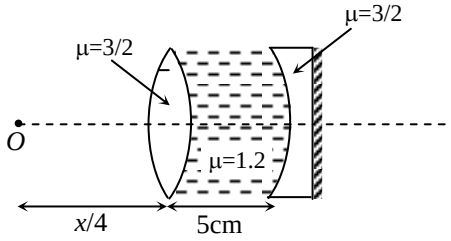
8. A double convex lens forms a real image of an object on a screen which is fixed. Now the lens is given a constant velocity v_0 along its axis and away from the screen. For the purpose of forming the image always on the screen, the object is also required to be given an appropriate velocity. Find the velocity of the object at the instant its size is n times the size of image. (Take n = 1/2 and v_0 = 1 m/s)

8. **3**

9. A solid glass sphere with radius R = 40 cm and an index of refraction 1.5 is silvered over one hemisphere. A small object is located on the axis of the sphere at a distance 2R to the left of the unsilvered hemisphere. Find the position of final image from the centre of sphere after all refractions and reflections have taken place (in cm).

9. **40**

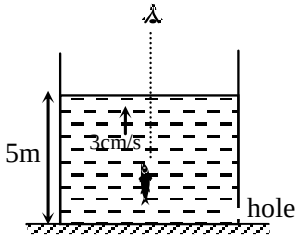
10. A thin equiconvex lens of radius of curvature 10 cm and refractive index μ = 3/2 is placed at a distance 5 cm from thin plano concave lens (silvered from plane surface) having radius of curvature 10 cm and refractive index 3/2. Space between lens is filled with a medium of refractive index μ = 1.2. Find the value of *x(in m)*, if image of object (kept at a distance x/4 cm from convex lens) coincides with the object.



10. **0.75**

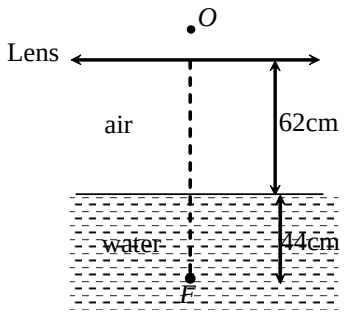
11. A tank having cross sectional area A has a hole at the bottom of area of cross section $A_1 = A/1000$. Bottom of the tank is a plane mirror. The tank contains water of refractive index 4/3. At the instant, when height of the water in the tank is 5m, a fish is rising vertically in the tank with a velocity 3 cm/sec toward the surface.

    The velocity (in cm/s) with which surface is falling down inside container is



11. **1**

12. A stationary observer *O* looking at a fish *F* in water (μ_w = 4/3) through a converging lens of focal length 90.0 cm. The lens is allowed to fall freely from a height 62.0 cm with its axis vertical. The fish and the observer are on the principal axis of the lens. The fish moves up with constant velocity 100 cm/s. Initially it was at a depth of 44.0 cm. Find the velocity(in cm/s) with which the fish appears to move with respect to lens to the observer at t = 0.2 sec.(take g = 10 m/s^2)



12. **2475**

13. A double-slit interference pattern is formed on a screen in a Young's double slit experiment performed with light consisting of two wavelengths λ_1 = 6000 Å and λ_2 = 4800 Å. It is observed that the maximum of the 16th order corresponding to λ = 6000 Å coincides with a maximum of the nth order corresponding to λ = 4800 Å. The value of n is x × 10, then x is

13. **2**

14. Fringes are produced using light of wavelength λ = 4800 Å in a double-slit experiment. One of the slits is covered by a thin plate of glass of refractive index 1.4 and other slit by another plate of glass of double the thickness and of refractive index 1.7. During this process, the central bright fringe shifts to a position originally occupied by the fifth bright fringe from the centre. If the thickness of glass plate (or double thickness) is x μm then $\frac{10x}{24}$ is

14. **2**

15. In a Young's double-slit experiment, the slits are 2 mm apart and are illuminated with a mixture of two wavelengths λ = 750 nm and λ' = 900 nm. At what minimum distance (in mm) from the common central bright fringe on a screen 4m from the slits will a bright fringe from one interference pattern coincide with a bright fringe from the other?

15. **9**

SECTION-2 : CHEMISTRY

PART – A

(Numerical based)

This section contains **15 questions**, numerical based questions, (answer of which maybe positive or negative numbers or decimals).

1. How many of the following ligands have at least one nitrogen atom as donor atom?
py, $IMDA^{2-}$, $acac^{-}$, trine, NTA^{3-}, dien, gly^{-}, DMG^{-}, $EDTA^{3-}$ and $(sac)^{-}$

1. 8

2. How many of the following complexes are optically active?
$[Pt(NH_2CH(Ph)COO)_2]$, $[Be(gly)_2]$, $[Cr(en)_3]Cl_3$, $[Co(gly)(NH_3)(H_2O)ClBr]$, cis-$[Co(NH_3)_4Cl_2]$, $K_4[Fe(CN)_6]$, cis-$[Co(NH_3)_2(en)_2]Cl_3$, $[Fe(H_2O)_5(CN)]Cl_2$, trans-$[CrBrCl(NH_3)_2(en)]Cl$, $[Zn(NH_2CH(Ph)COO)_2]$

2. 6

3. The total number of stereoisomers of the complex $[Fe(H_2O)_3\{(P(CH_3)(Ph)(H)\}ClBr]$ will be

3. 5

4. The specific rate constant of the decomposition of N_2O_5 is 0.008 min^{-1}. The volume of O_2 collected after 20 minute is 16 mL. Find the volume that would be collected at the end of reaction. NO_2 formed is dissolved in CCl_4.

4. 108.23 (Range: 108.20 to 108.30)

5. A vessel contains dimethyl ether at a pressure of 0.4 mm. Dimethyl ether decomposes as

$$CH_3OCH_3(g) \longrightarrow CH_4(g) + CO(g) + H_2(g)$$

The rate constant of decomposition is 4.78×10^{-3} min^{-1}. Calculate the ratio of initial rate of diffusion to rate of diffusion after 4.5 hours of initiation of decomposition. Assume the composition of gas present and gas diffused to be same.

5. 0.26(Range: 0.26 to 0.30)

6. Compounds A and B react to form C and D in a reaction that was found to be second-order overall and second-order in A. The rate constant at 30°C is 0.622 L mol^{-1} min^{-1}. What is the half-life of A when 4.10×10^{-2} M of A is mixed with excess B?

6. 39.20 (Range: 39.15 to 39.25)

7. Acetoacetic acid, CH_3COCH_2COOH, in acid solution decomposes to CO_2 and acetone by a first-order reaction. From the following data find the half-life time for this reaction at 37°C. A solution containing 6 mmol sodium acetoacetate was rapidly brought into about 0.2M HCl so that the total volume was 200ml. After 220 min. at 37°C, a sample of 10 ml was taken out and immediately put into an excess of NaOH, which put an end to the decomposition. The acetone that had formed was blown away by bubbling air. The sample was again acidified and boiled; all the remaining acetoacetic acid was then transformed to acetone, which was distilled with water vapour. To this distillate, NaOH and 10.00 ml 50 mM I_2 solution were added, transforming all acetone to iodoform

$$CH_3COCH_3 + 3I_2 + 4OH^- \longrightarrow CHI_3 + CH_3COO^- + 3I^- + 3H_2O$$

After acidification the remaining iodine was decolorize by 4.5 ml thiosulfate solution. Ten ml 50 mM I_2 solution was decolourized by 10 ml of the same thiosulfate solution. At pH = 0 to 3 the reaction rate is independent of pH.

7. 52.7 (Range: 52.6 to 52.8)

8. How many of the following salts impart characteristic colours to the Bunsen flame?
NaCl, KCl, $CuCl_2$, $BaCl_2$, $CaCl_2$, $SrCl_2$, $ZnCl_2$, $MgCl_2$, $AlCl_3$

8. 6

9. How many of the following liberate coloured vapour/gas with concentrated H_2SO_4?
KCl (s) + $K_2Cr_2O_7$(s), KNO_2 (s), KI(s), KBr(s), KCl(s)
KBr (s) + MnO_2 (s), KNO_3, KCI(s) + MnO_2, K_2SO_3

9. 7

10. How many of the following pairs of ions can be separated by H_2S in dilute HCl?
Bi^{3+} and Sn^{4+}, Al^{3+} and Hg^{2+}, Cd^{2+} and Zn^{2+}, Fe^{3+} and Cu^{2+}, As^{3+} and Sb^{3+}

10. 3

11. Amongst the following, the total number of compounds soluble in concentrated NH_3 solution is :
(A) Ag_2CrO_4, (B) $Cu(OH)_2 . CuSO_4$, (C) $PbSO_3$, (D) $Al(OH)_3$,
(E) $Ni(OH)_2$, (F) $Zn_3(PO_4)_2$ (G) $BaSO_4$, (H)$Bi(OH)_2NO_3$,
(I) $Mn(OH)_2$

11. 4

12. An alcoholic solution of dimethylglyoxime is added to an aqueous solution of nickel(II) chloride. Slow addition of ammonium hydroxide led to the precipitation of a bright-red coloured metal complex.
Find out the number of hydrogen bonds present in the structure of the complex.

12. 2

13. An aqueous solution contains Hg^{2+}, Hg_2^{2+}, Pb^{2+}, Ag^{+}, Bi^{3+} and Cd^{2+}. Out of these, how many ions will produce white precipitate with dilute HCl?

13. 3

14. The freezing point of an aqueous solution of KCN containing 0.1892 mol kg^{-1} was –0.704ºC. On adding 0.095 mole $Hg(CN)_2$, the freezing point of the solution was –0.530ºC.
If complex formation takes place according to the equation, $Hg(CN)_2$ + m KCN $\rightleftharpoons$ $K_m[Hg(CN)_{m+2}]$, if the formula of the complex is $K_a[Hg_b(CN)_c]$, then calculate the value of (a + b + c)/2? K_f (H_2O) is 1.86 kg mol^{-1} K.

14. 3.5

15. A stream of air is bubbled slowly through liquid benzene in a flask at 20.0ºC against an ambient pressure of 100.56 kP_a. After the passage of 4.80 L of air, measured at 20.0ºC.and 100.56 kP_a before it contains benzene vapor, it is found that 1.705 g of benzene have been evaporated. Assuming that the air is saturated with benzene vapor when it leaves the flask. Calculate the equilibrium vapor pressure of the benzene at 20.0ºC.

15. 11.08 (Range: 11.00 to 11.20)

SECTION-3 : MATHEMATICS

PART – A

(Numerical based)

This section contains **15 questions**, numerical based questions, (answer of which maybe positive or negative numbers or decimals).

1. A normal is drawn at a point P (x, y) on a curve. It meets the x – axis and the y – axis at A and B respectively such that (x – intercept)$^{-1}$ + (y – intercept)$^{-1}$ = 1, where O is origin, then find radius of the director circle of the curve passing through (3, 3).

1. 4

2. If $\int \frac{(x-1)dx}{\left(x+x\sqrt{x}+\sqrt{x}\right)\sqrt{\sqrt{x}(x+1)}} = 4\tan^{-1}\left[g(x)\right]+C,$ where C is an arbitrary constant of integration. Find $g^2(1)$.

2. 2

3. If $\int(\cot 2x\cot 3x-\tan 2x\tan 7x)\tan 5x = a\ln(\tan 2x)+b\ln(\sin 3x)+c\ln(\sec 5x)+d\ln(\cos 7x)+C$ and $a,b,c,d\in Q$ and C is the constant of integration. If $(a+b+c+d)$ can be expressed as $\frac{m}{n}$ in the lowest form, find $(m+n)$.

3. 499

4. Let P (x) be a polynomial with real coefficients such that $\left(x^2+x+1\right)P(x-1)=\left(x^2-x+1\right)P(x)\,\forall\, x\in R$ and $P(1)=3$. If $\int_0^1 \tan^{-1}\left(\frac{2x}{1+P\left(x^2\right)}\right)dx=\int_0^1\tan^{-1}(x+1)dx=\frac{k}{16}(\pi-\ln 4)$ then find the value of k.

4. 12

5. Let $f(x)=\cos^{-1}\left(\frac{2x}{1+x^2}\right), g(x)=\cot^{-1}\left(\frac{2x}{x^2-1}\right)$ where $x\in(-1,1)$. If area bounded by the curves $y=f(x)+g(x)$ and $y=\pi x^2$ is A then find the value of $[A]$.
[Note: [K] denotes greatest integer less than or equal to K.]

5. 4

6. If value of $\int_0^{\pi}\frac{x^2\cos^2 x-x\sin x-\cos x-1}{(1+x\sin x)^2}$ is α then value of $\alpha+2$ is

6. 2

7. Let f_1, f_2 and f_3 be three curves satisfying the differential equation $y\left(1-y^2\right)dx = x\left(y^2+1\right)dy$. If f_3 cuts the curves f_1 and f_2 at A and B respectively and one of the curves is passing through C (2, –1), then find the area of ΔABC.

7. 2

8. Suppose $\int \frac{1-7\cos^2 x}{\sin^7 x \cos^2 x}dx = \frac{g(x)}{\sin^7 x} + C,$ where C is an arbitrary constant of integration. Then find the value of $g'(0) + g''\left(\frac{\pi}{4}\right)$.

8. 5

9. Let $f(x)$ be a continuous function defined from $[0, 2] \to R$ and satisfying the equation $\int_0^2 f(x)\left(x - f(x)\right)dx = \frac{2}{3}$. Find the value of $2f(1)$.

9. 1

10. Let C_1 and C_2 be two curves which satisfy the differential equation $\left|x - y\frac{dx}{dy}\right| = 2\left|\frac{dy}{dx}\right|$ and passes through M (1, 1). If the area enclosed by curves C_1, C_2 and co – ordinate axes is $\frac{m}{n}(m,n \in N)$ then find the least value of $(m+n)$.

10. 0009

11. If $\frac{\int_0^1 \left(1-\left(1-x^2\right)^{100}\right)^{201}.x\,dx}{\int_0^1 \left(1-\left(1-x^2\right)^{100}\right)^{202}.x\,dx} = \frac{p}{q}$ where $p, q \in N,$ then find the least value of $(p-q)$.

11. 1

12. Let A_n be the area bounded by the curve $y = x^n (n \geq 1)$ and the line $x = 0, y = 0$ and $x = \frac{1}{2}$. If $\sum_{n=1}^{n} \frac{2^n A_n}{n} = \frac{1}{3}$ then find the value of n.

12. 2

13. Let $y = f(x)$ be a curve C_1 passing through (2, 2) and $\left(8, \frac{1}{2}\right)$ and satisfying a differential equation $y\left(\frac{d^2y}{dx^2}\right) = 2\left(\frac{dy}{dx}\right)^2$. Curve C_2 is the director circle of the circle $x^2 + y^2 = 2$. If the shortest distance between the curves C_1 and C_2 is $\left(\sqrt{p} - q\right)$ where $p, q \in N$, then find the value of $\left(p^2 - q\right)$.

13. 62

14. Let f be a continuous function satisfying the equation $\int_0^x f(t)dt + \int_0^x t f(x-t)dt = e^{-x} - 1$, then find the value of $e^{10} f(10)$.

14. 9

15. Let $y = f(x)$ defined in $[0,2]$ satisfies the differential equation $y^3 y'' + 1 = 0$ where $f(x) \geq 0 \forall x \in D_f$ and $f'(1) = 0, f(1) = 1$ then find the maximum value of $f(x)$.
[Note: D_f denotes the domain of the function and y'' denotes the 2nd derivative of y w.r.t. x]

15. 1

ANSWERS

SECTION-1 : PHYSICS

PART – A

SECTION – 2 : CHEMISTRY

PART – A

SECTION – 3 : MATHEMATICS

PART – A