JEE(ADVANCED)-2013 PAPER 2

PHYSICS

[Time allowed: 3 hours] **[Maximum Marks: 180]**

Please read the instructions carefully. You are allotted 5 minutes specifically for this purpose

INSTRUCTIONS

A. General

1. This booklet is your Question paper. Do not break the seats of his booklet before being instructed to do so by the invigilators.
2. Blank papers, clipboards, log tables, slide rules, calculators, cameras, cellular phones, pagers, and electronic gadgets are NOT allowed inside the examination hall.
3. Write your name and roll number in the space provided on the back cover of this booklet.
4. Answers to the questions and personal details are to be filled on a two-part carbon-less paper, which is provided separately. You should not separate these parts. The invigilator will separate them at the end of examination. The upper sheet is machine-gradable Objective Response Sheet (ORS) which will be taken back by the invigilator. You will be allowed to take away the bottom sheet at the end of the examination
5. **Using a black ball point pen, darken the bubbles on the upper original sheet.** Apply sufficient pressure so that the impression is created on the bottom sheet.

B. Question Paper Format

6. This question paper consists three sections.
7. **Section 1** contains **8 multiple choice questions**. Each question has four choices (A), (B), (C) and (D) out of which **ONE OR MORE** are correct.
   Section 2 contains **4 paragraphs** each describing theory, experiment, data etc. Eight questions relate to four paragraphs with two questions on each paragraph. Each question of paragraph has **ONLY ONE CORRECT ANSWER** among the four choices (A), (B), (C) and (D).
8. **Section 3** contains **4 multiple choice questions** relate to four paragraphs with two questions on each paragraph. Each question of paragraph has **ONLY ONE CORRECT ANSWER** among the four choices (A), (B), (C) and (D).

C. Marking Scheme

9. For each question **Section 1,** you will be awarded **3 marks** if you darken the bubble corresponding to only the correct answer(s) and zero mark if no bubble are darkened. In all other cases, **minus one (-1)** mark will be awarded
10. For each question **Section 2 and 3,** you will be awarded **3 marks** if you darken the bubble corresponding to only the correct answer(s) and **zero mark** if no bubble are darkened. In all other cases, **minus one (-1) mark** will be awarded

SECTION - 1: (Only one option correct Type)

This section contains **8 multiple choice questions**. Each question has four choices (A), (B), (C) and (D) out of which **ONE OR MORE** are correct.

*1. Two bodies, each of mass M, are kept fixed with a separation $2L$. A particle of mass m is projected from the midpoint of the line joining their centres, perpendicular to the line. The gravitational constant is G. The correct statement (s) is (are)

(A) The minimum initial velocity of the mass m to escape the gravitational field of the two bodies is $4\sqrt{\frac{GM}{L}}$

(B) The minimum initial velocity of the mass m to escape the gravitational field of the two bodies is $2\sqrt{\frac{GM}{L}}$

(C) The minimum initial velocity of the mass m to escape the gravitational field of the two bodies is $\sqrt{\frac{2GM}{L}}$

(D) The energy of the mass m remains constant.

*2. A particle of mass m is attached to one end of a mass-less spring of force constant k, lying on a frictionless horizontal plane. The other end of the spring is fixed. The particle starts moving horizontally from its equilibrium position at time $t = 0$ with an initial velocity u_0. When the speed of the particle is $0.5u_0$ It collides elastically with a rigid wall. After this collision,

(A) the speed of the particle when it returns to its equilibrium position is u_0.

(B) the time at which the particle passes through the equilibrium position for the first time $t = \pi\sqrt{\frac{m}{k}}$

(C) the time at which the maximum compression of the spring occurs $t = \frac{4\pi}{3}\sqrt{\frac{m}{k}}$

(D) the time at which the particle passes through the equilibrium position for the second time is

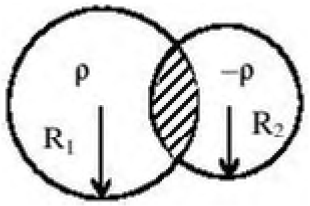
$t = \frac{5\pi}{3}\sqrt{\frac{m}{k}}$

3. A steady current I flows along an infinitely long hollow cylindrical conductor of radius R. This cylinder is placed coaxially inside an infinite solenoid of radius $2R$. The solenoid has n turns per unit length and carries a steady current I Consider a point P P at a distance r from the common axis. The correct statement (s) is (are)
(A) In the region $0 < r < R$, the magnetic field is non-zero
(B) In the region $R < r < 2R$, the magnetic field is along the common axis.
(C) In the region $R < r < 2R$, the magnetic field is tangential to the circle of radius r , centered on the axis.
(D) In the region $r > 2R$, the magnetic field is non-zero.

*4. Two vehicles, each moving with speed u on the same horizontal straight road, are approaching each other. Wind blows along the road with velocity w . One of these vehicles blows a whistle of frequency f_1 ,. An observer in the other vehicle hears the frequency of the whistle to be f_2 ,. The speed of sound in still air is V . The correct statement (s) is (are)
(A) If the wind blows from the observer to the source, $f_2 > f_1$.
(B) If the wind blows from the source to the observer, $f_2 > f_1$.
(C) If the wind blows from observer to the source, $f_2 < f_1$
(D) If the wind blows from the source to the observer $f_2 < f_1$

*5. Using the expression $2d\sin\theta = \lambda$, one calculates the values of d by measuring the corresponding angles θ in the range θ to $90°$. The wavelength λ is exactly known and the error in θ is constant for all values of θ. As θ increases from $0°$
(A) the absolute error in d remains constant.
(B) the absolute error in d increases
(C) the fractional error in d remains constant.
(D) the fractional error in d decreases.

6. Two non-conducting spheres of radii R_1 and R_2 and carrying uniform volume charge densities $+\rho$ and $-\rho$, respectively, are placed such that they partially overlap, as shown in the figure. At all points in the overlapping region,
(A) the electrostatic field is zero
(B) the electrostatic potential is constant
(C) the electrostatic field is constant in magnitude
(D) the electrostatic field has same direction



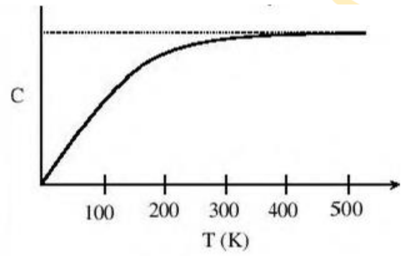
7. The figure shows the variation of specific heat capacity (C) of a solid as a function of temperature (T). The temperature is increased continuously from 0 to $500K$ at a constant rate. Ignoring any volume change, the following statement(s) is (are) correct to a reasonable approximation.

(A) the rate at which heat is absorbed in the range $0 - 100\,K$ varies linearly with temperature T.

(B) heat absorbed in increasing the temperature from $0 - 100\,K$ is less than the heat required for increasing the temperature from $400 - 500\,K$.

(C) there is no change in the rate of heat absorption in range $400 - 500\,K$.

(D) the rate of heat absorption increases in the range $200 - 300\,K$.



8. The radius of the orbit of an electron in a Hydrogen-like atom is $4.5 a_0$ where a_0 is the Bohr radius. Its orbital angular momentum is $\frac{3h}{2\pi}$. It is given that h is Planck's constant and R is Rydberg constant. The possible wavelength(s), when the atom de-excites, is (are)

(A) $\frac{9}{32R}$

(B) $\frac{9}{16R}$

(C) $\frac{9}{5R}$

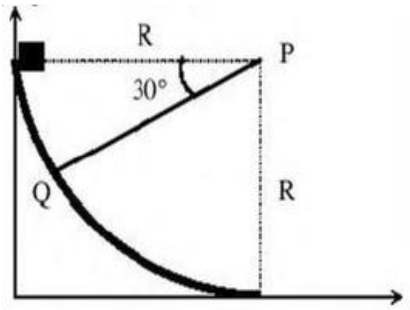
(D) $\frac{4}{3R}$

SECTION -2: (Paragraph Type)

This section contains **4 paragraphs** each describing theory, experiment, data etc. **Eight questions** relate to four paragraphs with two questions on each paragraph. Each question of paragraph has **ONLY ONE CORRECT ANSWER** among the four choice (A), (B), (C) and (D).

Paragraph for Questions 9 to 10

A small block of mass 1 kg is released from rest at the top of a rough track. The track is circular arc of radius 40 m. The block slides along the track without toppling and a frictional force acts on it in instantaneous velocity. The work done in overcoming the friction up to the point Q, as 150 J. (Take the acceleration due to gravity, $g = 10\, m/s^{-2}$).



*9. The speed of the block when it reaches the point Q is

(A) $5\,\text{ms}^{-1}$

(B) $10\,\text{ms}^{-1}$

(C) $10\sqrt{3}\,\text{ms}^{-1}$

(D) $20\,\text{ms}^{-1}$

*10. The magnitude of the normal reaction that acts on the block at the point Q is

(A) $7.5\,N$

(B) $8.6\,N$

(C) $11.5\,N$

(D) $22.5\,N$

Paragraph for Questions 11 to 12

A thermal power plant produces electric power of $600\,\text{kW}$ at $4000\,\text{kW}$, which is to be transported to a place $20\,\text{km}$ away from the power plant for consumers' usage. It can be transported either directly with a cable of large current carrying capacity or by using a combination of step-up and step-down transformers at the two ends. The drawback of the direct transmission is the large energy dissipation. In the method using transformers, the dissipation is much smaller. In this method, a step-up transformer is used at the plant side so that the current is reduced to a smaller value. At the consumers' end, a step-down transformer is used to supply power to the consumers at the specified lower voltage. It is reasonable to assume that the power cable is purely resistive and the transformers are ideal with the power factor unity. All the currents and voltage mentioned are rms values.

11. If the direct transmission method with a cable of resistance $0.4\,\Omega\,\text{km}^{-1}$ is used, the power dissipation (in $\%$) during transmission is
(A) 20
(B) 30
(C) 40
(D) 50

12. In the method using the transformers, assume that the ratio of the number of turns in the primary to that in the secondary in the step-up transformer is $1:10$. If the power to the consumers has to be supplied at $200V$, the ratio of the number of turns in the primary to that in the secondary in the step-down transformer is
(A) $200:1$
(B) $150:1$
(C) $100:1$
(D) $50:1$

Paragraph for Questions 13 to 14

A point Q is moving in a circular orbit of radius R in the $x-y$ plane with an angular velocity ω. This can be considered as equivalent to a loop carrying a steady current $\frac{Q\omega}{2\pi}$.
A uniform magnetic field along the positive z-axis is now switched on, which increases at a constant rate from $0\ to\ B$ in one second. Assume that the radius of the orbit remains constant. The application of the magnetic field induces an emf in the orbit. The induced emf is defined as the work done by an induced electric field in moving a unit positive charge around closed loop. It is known that, for an orbiting charge, the magnetic dipole moment is proportional to the angular momentum with a proportionality constant y.

13. The magnitude of the induced electric field in the orbit at any instant of time during the time interval of the magnetic field change, is
(A) $\frac{BR}{4}$

(B) $\frac{BR}{2}$
(C) BR
(D) $2BR$

14. The change in the magnetic dipole moment associated with the orbit, at the end of time interval of the magnetic field change, is
(A) $-\gamma BQR^2$
(B) $-\gamma \frac{BQR^2}{2}$
(C) $\gamma \frac{BQR^2}{2}$
(D) γBQR^2

Paragraph for Questions 15 to 16

The mass of nucleus ${}_Z^AX$ is less than the sum of the masses of $(A-Z)$ number of neutrons and Z number of protons in the nucleus. The energy equivalent to the corresponding mass difference is known as the binding energy of the nucleus. A heavy nucleus of mass M can break into two light nuclei of mass m_1 and m_2 only if $(m_1+m_2)<M$. Also two light nuclei of masses m_3 and m_4 can undergo complete fusion and form a heavy nucleus of mass M' only if $(m_1+m_2)>M'$. The masses of some neutral atoms are given in the table below:

${}_1^1H$	$1.007825u$	${}_1^2H$	$2.014102u$	${}_1^3H$	$3.016050u$	${}_2^4H$	$4.002603u$
${}_3^6Li$	$6.015123u$	${}_3^7Li$	$7.016004u$	${}_{30}^{70}Zn$	$69.925325u$	${}_{34}^{82}Se$	$81.916709u$
${}_{64}^{152}Gd$	$151.919803u$	${}_{82}^{206}Pb$	$205.974455u$	${}_{83}^{209}Po$	$208.980388u$	${}_{84}^{210}Po$	$209.982876u$

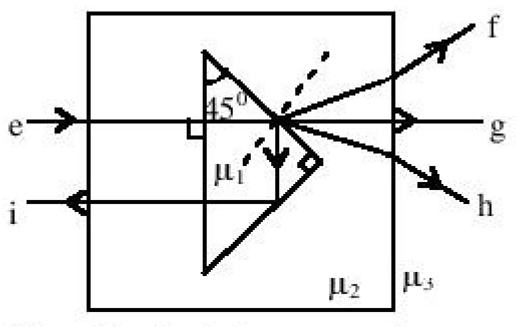
15. The correct statement is
(A) The nucleus ${}_3^6Li$ can emit an alpha particle
(B) The nucleus ${}_{84}^{210}Po$ can emit a proton.
(C) Deuteron and alpha particle can undergo complete fusion.
(D) The nuclei ${}_{30}^{70}Zn$ and ${}_{34}^{82}Se$ can undergo complete fusion.

16. The kinetic energy (in keV) of the alpha particle, when the nucleus ${}_{84}^{210}Po$ at rest undergoes alpha decay, is
(A) 5319
(B) 5422
(C) 5707
(D) 5818

SECTION -3 (Matching List Type)

This section contains **4 multiple choice questions**. Each question has matching lists. The codes for the lists have choices (A), (B), (C) and (D) out of which **ONLY ONE** is correct.

17. A right-angled prism of refractive index μ_1 is placed in a rectangular block of refractive index μ_2, which is surrounded by a medium of refractive index μ_3, as shown in figure. A ray of light 'e' enters the rectangular block at normal incidence. Depending upon the relationship between μ_1, μ_2 and μ_3 it takes one of the four possible paths 'ef', 'eg', 'eh', or 'ei'.



Match the paths in List I with conditions of refractive index in List II and select the correct answer using the codes given below the lists:

	List I		List II
P.	$e \to f$	1.	$\mu_1 > \sqrt{2}\mu_2$
Q.	$e \to g$	2.	$\mu_1 > \mu_1$ and $\mu_2 > \mu_3$
R.	$e \to h$	3.	$\mu_1 = \mu_2$
S.	$e \to i$	4.	$\mu_2 < \mu_1 < \sqrt{2}\mu_2$ and $\mu_2 > \mu_3$

Codes:

(A)

P	Q	R	S
2	3	1	4

(B)

P	Q	R	S
1	2	4	3

(C)

P	Q	R	S
4	1	2	3

(D)
P	Q	R	S
2	3	4	1

*18. Match List I with List II and select the correct answer using the codes given below the lists:

	List I		List II
P.	Boltzmann Constant	1.	$\left[ML^2T^{-1}\right]$
Q.	Coefficient of viscosity	2.	$\left[ML^{-1}T^{-1}\right]$
R.	Plank Constant	3.	$\left[MLT^{-3}K^{-1}\right]$
S.	Thermal conductivity	4.	$\left[ML^2T^{-2}K^{-1}\right]$

Codes:

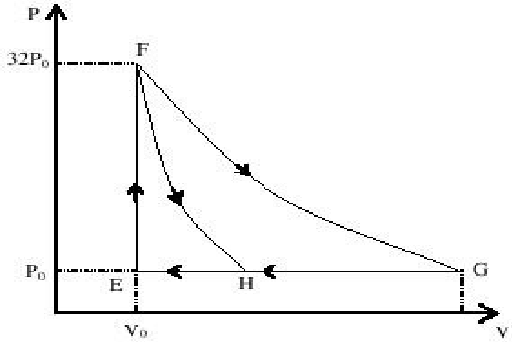
(A)
P	Q	R	S
3	1	2	4

(B)
P	Q	R	S
3	2	1	4

(C)
P	Q	R	S
4	2	1	3

(D)
P	Q	R	S
4	1	2	3

***19.** One mole of mono-atomic ideal gas is taken along two cyclic process $E \to F \to G \to E$ and $E \to F \to H \to E$ as shown in the PV diagram. The processes involved are purely isochoric, isobaric, isothermal or adiabatic.



Match the paths in List I with magnitudes of work done in List II and select the correct answer using the codes given below the lists:

	List I		List II
P.	$G \rightarrow E$	1.	$160 P_0 V_0 In 2$
Q.	$G \rightarrow H$	2.	$36 P_0 V_0$
R.	$F \rightarrow H$	3.	$24 P_0 V_0$
S.	$F \rightarrow G$	4.	$31 P_0 V_0$

(A) P Q R S
4 3 2 1

(B) P Q R S
4 3 1 2

(C) P Q R S
3 1 2 4

(D) P Q R S
1 3 2 4

20. Match List I of nuclear processes with List II containing parent nuclear and one of the end products of each process and then select the correct answer using the codes given below the lists:

	List I		List II
P.	Alpha decay	1.	${}^{15}_{8}O \rightarrow {}^{15}_{7}N + ...$
Q.	$\beta +$ decay	2.	${}^{238}_{92}U \rightarrow {}^{234}_{90}Th + ...$
R.	Fission	3.	${}^{185}_{83}Bi \rightarrow {}^{184}_{82}Pb + ...$
S.	Proton emission	4.	${}^{239}_{94}Pu \rightarrow {}^{140}_{57}La + ...$

(A) P Q R S
4 2 1 3

(B) P Q R S
1 3 2 4

(C) P Q R S
2 1 4 3

(D) $\begin{matrix} P & Q & R & S \\ 4 & 3 & 2 & 1 \end{matrix}$