

AIPMT 2014 — Physics Question Paper with Solutions

37 Physics questions as set in the paper · answers checked by RankUp

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1. A conducting sphere of radius R is given a charge Q . The electric potential and the electric field at the centre of the sphere respectively are:

- (A) $Q/(4\pi\epsilon_0 R)$ and Zero
- (B) $Q/(4\pi\epsilon_0 R)$ and $Q/(4\pi\epsilon_0 R^2)$
- (C) Both are zero
- (D) Zero and $Q/(4\pi\epsilon_0 R^2)$

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2. If n_1 , n_2 and n_3 are the fundamental frequencies of three segments into which a string is divided, then the original fundamental frequency n of the string is given by:

- (A) $1/\sqrt{n} = 1/\sqrt{n_1} + 1/\sqrt{n_2} + 1/\sqrt{n_3}$
- (B) $\sqrt{n} = \sqrt{n_1} + \sqrt{n_2} + \sqrt{n_3}$
- (C) $n = n_1 + n_2 + n_3$
- (D) $1/n = 1/n_1 + 1/n_2 + 1/n_3$

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3. Copper of fixed volume ' V ' is drawn into wire of length ' l '. When this wire is subjected to a constant force ' F ', the extension produced in the wire is ' Δl '. Which of the following graphs is a straight line?

- (A) Δl versus l^2
- (B) Δl versus $1/l^2$
- (C) Δl versus l
- (D) Δl versus $1/l$

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4. The resistances in the two arms of the meter bridge are $5\ \Omega$ and $R\ \Omega$, respectively. When the resistance R is shunted with an equal resistance, the new balance point is at $1.6\ l_1$. The resistance ' R ', is: (l_1 is the initial balance length measured from end A, on the side of the $5\ \Omega$ resistance)

- (A) $15\ \Omega$
- (B) $20\ \Omega$
- (C) $25\ \Omega$
- (D) $10\ \Omega$

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5. A particle is moving such that its position coordinates (x, y) are $(2\text{ m}, 3\text{ m})$ at time $t = 0$, $(6\text{ m}, 7\text{ m})$ at time $t = 2\text{ s}$ and $(13\text{ m}, 14\text{ m})$ at time $t = 5\text{ s}$. Average velocity vector ($\vec{V}_{av}$) from $t = 0$ to $t = 5\text{ s}$ is:

- (A) $(7/3)(\hat{i} + \hat{j})$
- (B) $2(\hat{i} + \hat{j})$
- (C) $(11/5)(\hat{i} + \hat{j})$
- (D) $(1/5)(13\hat{i} + 14\hat{j})$

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6. Two identical long conducting wires AOB and COD are placed at right angle to each other, with one above other such that 'O' is their common point for the two. The wires carry I_1 and I_2 currents respectively. Point 'P' is lying at distance ' d ' from 'O' along a direction perpendicular to the plane containing the wires. The magnetic field at the point 'P' will be:

- (A) $(\mu_0/2\pi d)(I_1 + I_2)$
- (B) $(\mu_0/2\pi d)(I_1^2 - I_2^2)$
- (C) $(\mu_0/2\pi d)(I_1^2 + I_2^2)^{1/2}$
- (D) $(\mu_0/2\pi d)(I_1/I_2)$

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7. A system consists of three masses m_1 , m_2 and m_3 connected by a string passing over a pulley P. The mass m_1 hangs freely and m_2 and m_3 are on a rough horizontal table (the coefficient of friction = μ). The pulley is frictionless and of negligible mass. The downward acceleration of mass m_1 is: (Assume $m_1 = m_2 = m_3 = m$)

- (A) $2g\mu/3$
- (B) $g(1 - 2\mu)/3$
- (C) $g(1 - 2\mu)/2$
- (D) $g(1 - g\mu)/9$

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8. In an ammeter 0.2% of main current passes through the galvanometer. If resistance of galvanometer is G , the resistance of ammeter will be:

- (A) $(499/500)G$
- (B) $(1/500)G$
- (C) $(500/499)G$
- (D) $(1/499)G$

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9. If the focal length of objective lens is increased then magnifying power of:

- (A) microscope and telescope both will increase
- (B) microscope and telescope both will decrease
- (C) microscope will decrease but that of telescope will increase
- (D) microscope will increase but that of telescope will decrease

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10. The angle of a prism is 'A'. One of its refracting surfaces is silvered. Light rays falling at an angle of incidence $2A$ on the first surface returns back through the same path after suffering reflection at the silvered surface. The refractive index μ , of the prism is:

- (A) $2 \cos A$
- (B) $(1/2) \cos A$
- (C) $\tan A$
- (D) $2 \sin A$

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11. The number of possible natural oscillations of air column in a pipe closed at one end of length 85 cm whose frequencies lie below 1250 Hz are: (velocity of sound = 340 ms^{-1})

- (A) 5
- (B) 7
- (C) 6
- (D) 4

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12. Two cities are 150 km apart. Electric power is sent from one city to another city through copper wires. The fall of potential per km is 8 volt and the average resistance per km is 0.5Ω . The power loss in the wire is:

- (A) 19.2 kW
- (B) 19.2 J
- (C) 12.2 kW
- (D) 19.2 W

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13. A beam of light of $\lambda = 600$ nm from a distant source falls on a single slit 1 mm wide and the resulting diffraction pattern is observed on a screen 2 m away. The distance between first dark fringes on either side of the central bright fringe is:

- (A) 1.2 mm
- (B) 2.4 cm
- (C) 2.4 mm
- (D) 1.2 cm

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14. If force (F), velocity (V) and time (T) are taken as fundamental units, then the dimensions of mass are:

- (A) $[F V T^{-2}]$
- (B) $[F V^{-1} T^{-1}]$
- (C) $[F V^{-1} T]$
- (D) $[F V T^{-1}]$

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15. The barrier potential of a p-n junction depends on: (a) type of semi conductor material (b) amount of doping (c) temperature. Which one of the following is correct?

- (A) (b) only
- (B) (b) and (c) only
- (C) (a), (b) and (c)
- (D) (a) and (b) only

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16. The Binding energy per nucleon of ${}^7_3\text{Li}$ and ${}^4_2\text{He}$ nuclei are 5.60 MeV and 7.06 MeV, respectively. In the nuclear reaction ${}^7_3\text{Li} + {}^1_1\text{H} \rightarrow {}^4_2\text{He} + {}^4_2\text{He} + Q$, the value of energy Q released is:

- (A) -2.4 MeV
- (B) 8.4 MeV
- (C) 17.3 MeV
- (D) 19.6 MeV

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17. If the kinetic energy of the particle is increased to 16 times its previous value, the percentage change in the de-Broglie wavelength of the particle is:

- (A) 75
- (B) 60
- (C) 50
- (D) 25

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18. Light with an energy flux of $25 \times 10^4 \text{ Wm}^{-2}$ falls on a perfectly reflecting surface at normal incidence. If the surface area is 15 cm^2 , the average force exerted on the surface is:

- (A) $2.50 \times 10^{-6} \text{ N}$
- (B) $1.20 \times 10^{-6} \text{ N}$
- (C) $3.0 \times 10^{-6} \text{ N}$
- (D) $1.25 \times 10^{-6} \text{ N}$

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19. In a region, the potential is represented by $V(x, y, z) = 6x - 8xy - 8y + 6yz$, where V is in volts and x, y, z are in meters. The electric force experienced by a charge of 2 coulomb situated at point (1, 1, 1) is:

- (A) 30 N
- (B) 24 N
- (C) $4\sqrt{35}$ N
- (D) $6\sqrt{5}$ N

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20. A speeding motorcyclist sees traffic jam ahead of him. He slows down to 36 km/hour. He finds that traffic has eased and a car moving ahead of him at 18 km/hour is honking at a frequency of 1392 Hz. If the speed of sound is 343 m/s, the frequency of the honk as heard by him will be:

- (A) 1372 Hz
- (B) 1412 Hz
- (C) 1454 Hz
- (D) 1332 Hz

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21. The ratio of the accelerations for a solid sphere (mass ' m ' and radius ' R ') rolling down an incline of angle ' θ ' without slipping and slipping down the incline without rolling is:

- (A) 2 : 3
- (B) 2 : 5
- (C) 7 : 5
- (D) 5 : 7

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22. In the Young's double-slit experiment, the intensity of light at a point on the screen where the path difference is λ is K , (λ being the wave length of light used). The intensity at a point where the path difference is $\lambda/4$, will be:

- (A) $K/4$
- (B) $K/2$
- (C) Zero
- (D) K

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23. A balloon with mass ' m ' is descending down with an acceleration ' a ' (where $a < g$). How much mass should be removed from it so that it starts moving up with an acceleration ' a '?

- (A) $2ma/(g - a)$
- (B) $ma/(g + a)$
- (C) $ma/(g - a)$
- (D) $2ma/(g + a)$

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24. A potentiometer circuit has been set up for finding the internal resistance of a given cell. The main battery, used across the potentiometer wire, has an emf of 2.0 V and a negligible internal resistance. The potentiometer wire itself is 4 m long. When the resistance, R , connected across the given cell, has values of (i) infinity (ii) 9.5Ω , the 'balancing lengths', on the potentiometer wire are found to be 3 m and 2.85 m, respectively. The value of internal resistance of the cell is:

- (A) 0.95Ω
- (B) 0.5Ω
- (C) 0.75Ω
- (D) 0.25Ω

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25. A monoatomic gas at a pressure P , having a volume V expands isothermally to a volume $2V$ and then adiabatically to a volume $16V$. The final pressure of the gas is: (take $\gamma = 5/3$)

- (A) $32P$
- (B) $P/64$
- (C) $16P$
- (D) $64P$

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26. A certain number of spherical drops of a liquid of radius ' r ' coalesce to form a single drop of radius ' R ' and volume ' V '. If ' T ' is the surface tension of the liquid, then:

- (A) energy = $3VT(1/r + 1/R)$ is absorbed
- (B) energy = $3VT(1/r - 1/R)$ is released
- (C) energy is neither released nor absorbed
- (D) energy = $4VT(1/r - 1/R)$ is released

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27. A body of mass ($4m$) is lying in x - y plane at rest. It suddenly explodes into three pieces. Two pieces, each of mass (m) move perpendicular to each other with equal speeds (v). The total kinetic energy generated due to explosion is:

- (A) $(3/2)mv^2$
- (B) $2mv^2$
- (C) $4mv^2$
- (D) mv^2

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28. Hydrogen atom in ground state is excited by a monochromatic radiation of $\lambda = 975 \text{ \AA}$. Number of spectral lines in the resulting spectrum emitted will be:

- (A) 2
- (B) 6
- (C) 10
- (D) 3

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29. A black hole is an object whose gravitational field is so strong that even light cannot escape from it. To what approximate radius would earth (mass = $5.98 \times 10^{24} \text{ kg}$) have to be compressed to be a black hole?

- (A) 10^{-6} m
- (B) 10^{-2} m
- (C) 100 m
- (D) 10^{-9} m

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30. A projectile is fired from the surface of the earth with a velocity of 5 ms^{-1} and angle θ with the horizontal. Another projectile fired from another planet with a velocity of 3 ms^{-1} at the same angle follows a trajectory which is identical with the trajectory of the projectile fired from the earth. The value of the acceleration due to gravity on the planet is (in ms^{-2}) is: (given $g = 9.8 \text{ ms}^{-2}$)

- (A) 5.9
- (B) 16.3
- (C) 110.8
- (D) 3.5

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31. Certain quantity of water cools from 70°C to 60°C in the first 5 minutes and to 54°C in the next 5 minutes. The temperature of the surroundings is:

- (A) 20°C
- (B) 42°C
- (C) 10°C
- (D) 45°C

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32. A solid cylinder of mass 50 kg and radius 0.5 m is free to rotate about the horizontal axis. A massless string is wound round the cylinder with one end attached to it and other hanging freely. Tension in the string required to produce an angular acceleration of 2 revolutions s^{-2} is:

- (A) 50 N
- (B) 78.5 N
- (C) 157 N
- (D) 25 N

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33. Steam at 100°C is passed into 20 g of water at 10°C. When water acquires a temperature of 80°C, the mass of water present will be: [Take specific heat of water = 1 cal g^{-1} °C $^{-1}$ and latent heat of steam = 540 cal g^{-1}]

- (A) 31.5 g
- (B) 42.5 g
- (C) 22.5 g
- (D) 24 g

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34. A radio isotope 'X' with a half life 1.4×10^9 years decays to 'Y' which is stable. A sample of the rock from a cave was found to contain 'X' and 'Y' in the ratio 1 : 7. The age of the rock is:

- (A) 3.92×10^9 years
- (B) 4.20×10^9 years
- (C) 8.40×10^9 years
- (D) 1.96×10^9 years

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35. A transformer having efficiency of 90% is working on 200 V and 3 kW power supply. If the current in the secondary coil is 6 A, the voltage across the secondary coil and the current in the primary coil respectively are:

- (A) 450 V, 15 A
- (B) 450 V, 13.5 A
- (C) 600 V, 15 A
- (D) 300 V, 15 A

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36. When the energy of the incident radiation is increased by 20%, the kinetic energy of the photoelectrons emitted from a metal surface increased from 0.5 eV to 0.8 eV. The work function of the metal is:

- (A) 1.0 eV
- (B) 1.3 eV
- (C) 1.5 eV
- (D) 0.65 eV

37. The mean free path of molecules of a gas, (radius 'r') is inversely proportional to:

- (A) r^2
- (B) r
- (C) $\sqrt{r}$
- (D) r^3

Answer key and explanations

1. Answer: (A) $Q/(4\pi\epsilon_0 R)$ and Zero

The charge sits on the surface and the field inside a conductor is zero, so the field at the centre is zero. Since $E = 0$ inside, the potential is constant throughout and equals the surface value $Q/(4\pi\epsilon_0 R)$; a zero potential at the centre is the common trap.

2. Answer: (D) $1/n = 1/n_1 + 1/n_2 + 1/n_3$

At fixed tension and linear density the fundamental frequency is $n = (1/2l)\sqrt{T/\mu}$, so $l \propto 1/n$. Since the segment lengths add up to the whole length, $1/n = 1/n_1 + 1/n_2 + 1/n_3$; simply adding the frequencies would wrongly treat $n \propto l$.

3. Answer: (A) Δl versus l^2

$\Delta l = Fl/(AY)$, and with fixed volume $A = V/l$, so $\Delta l = Fl^2/(VY)$. Hence Δl is proportional to l^2 , giving a straight line against l^2 , not against l .

4. Answer: (A) 15 Ω

Initially $5/R = l_1/(100 - l_1)$. After shunting, the arm becomes $R/2$: $10/R = 1.6l_1/(100 - 1.6l_1)$. Dividing, $2 = 1.6(100 - l_1)/(100 - 1.6l_1)$ gives $l_1 = 25$ cm, so $R = 5 \times 75/25 = 15 \Omega$.

5. Answer: (C) $(11/5)(\hat{i} + \hat{j})$

Average velocity = total displacement/total time. Displacement from (2, 3) to (13, 14) is $11\hat{i} + 11\hat{j}$ in 5 s, giving $(11/5)(\hat{i} + \hat{j})$; dividing the final position by time ignores the starting point.

6. Answer: (C) $(\mu_0/2\pi d)(l_1^2 + l_2^2)^{1/2}$

P is at distance d from each long wire, so each gives $B = \mu_0 I/(2\pi d)$. The two wires are perpendicular, so their fields at P are perpendicular and add as vectors: $B = (\mu_0/2\pi d)\sqrt{l_1^2 + l_2^2}$, not the simple sum.

7. Answer: (B) $g(1 - 2\mu)/3$

The driving force is $m_1 g = mg$ and friction on the two table masses is $2\mu mg$, while all three masses (3m) accelerate together. $a = (mg - 2\mu mg)/(3m) = g(1 - 2\mu)/3$.

8. Answer: (B) $(1/500)G$

The galvanometer carries $I/500$, and since it is in parallel with the shunt, the voltage across the ammeter is $(I/500)G$. Ammeter resistance = $V/I = G/500$; $G/499$ is the shunt alone, not the combination.

9. Answer: (C) microscope will decrease but that of telescope will increase

For a compound microscope $M \approx (L/f_o)(D/f_e)$, so a larger objective focal length lowers M . For a telescope $M = f_o/f_e$, so it rises; the two instruments respond oppositely.

10. Answer: (A) $2 \cos A$

To return along its path the ray must strike the silvered face normally, so the refraction angle at the first face equals the prism angle, $r = A$. Then $\mu = \sin 2A/\sin A = 2 \cos A$.

11. Answer: (C) 6

For a closed pipe the fundamental is $v/4L = 340/(4 \times 0.85) = 100$ Hz and only odd harmonics exist: 100, 300, 500, 700, 900, 1100 Hz. That makes 6 below 1250 Hz; counting all harmonics would wrongly give more.

12. Answer: (A) 19.2 kW

Over 150 km, the voltage drop is $150 \times 8 = 1200$ V and the resistance is $150 \times 0.5 = 75 \Omega$. Power lost = $V^2/R = 1200^2/75 = 19\,200$ W = 19.2 kW.

13. Answer: (C) 2.4 mm

First minima lie at $y = \pm \lambda D/a$, so their separation is $2\lambda D/a = 2 \times 600 \times 10^{-9} \times 2/10^{-3} = 2.4 \times 10^{-3}$ m = 2.4 mm. Forgetting the factor 2 gives 1.2 mm.

14. Answer: (C) $[F V^{-1} T]$

$F = ma = m(V/T)$, so $m = FT/V$, i.e. $[F V^{-1} T]$.

15. Answer: (C) (a), (b) and (c)

The barrier potential depends on the semiconductor (about 0.7 V for Si, 0.3 V for Ge), increases with doping, and falls as temperature rises. So all three factors matter.

16. Answer: (C) 17.3 MeV

$Q = \text{BE of products} - \text{BE of reactants} = 2 \times 4 \times 7.06 - 7 \times 5.60 = 56.48 - 39.20 = 17.28 \approx 17.3 \text{ MeV}$
(the proton has no binding energy).

17. Answer: (A) 75

$\lambda = h/\sqrt{2mK}$, so $\lambda \propto 1/\sqrt{K}$. Increasing K 16 times makes λ one quarter of its value, a 75% decrease; 25% is the remaining fraction, not the change.

18. Answer: (A) $2.50 \times 10^{-6} \text{ N}$

For a perfect reflector the momentum change doubles, $F = 2IA/c = 2 \times 25 \times 10^4 \times 15 \times 10^{-4}/(3 \times 10^8) = 2.5 \times 10^{-6} \text{ N}$. Using IA/c (absorbing surface) would give half this.

19. Answer: (C) $4\sqrt{35} \text{ N}$

$E = -\nabla V$: $E_x = -(6 - 8y) = 2$, $E_y = -(-8x - 8 + 6z) = 10$, $E_z = -6y = -6$ at $(1, 1, 1)$. $|E| = \sqrt{4 + 100 + 36} = \sqrt{140} = 2\sqrt{35} \text{ V/m}$, so $F = qE = 4\sqrt{35} \text{ N}$.

20. Answer: (B) 1412 Hz

Motorcyclist (10 m/s) moves towards the car, and the car (5 m/s, the source) moves away from him. $f' = 1392 \times (343 + 10)/(343 - 5) = 1392 \times 353/348 = 1412 \text{ Hz}$.

21. Answer: (D) 5 : 7

Rolling solid sphere: $a = g \sin \theta / (1 + k^2/R^2) = g \sin \theta / (1 + 2/5) = (5/7)g \sin \theta$. Slipping without rolling: $a = g \sin \theta$. Ratio = 5 : 7, not the inverse 7 : 5.

22. Answer: (B) $K/2$

Path difference λ is a maximum, so $K = I_{\text{max}}$. Path difference $\lambda/4$ means phase difference $\pi/2$, so $I = I_{\text{max}} \cos^2(\pi/4) = K/2$.

23. Answer: (D) $2ma/(g + a)$

Descending: $mg - U = ma$, so the upthrust $U = m(g - a)$. Rising with mass m' : $U - m'g = m'a$, so $m' = m(g - a)/(g + a)$. Mass removed = $m - m' = 2ma/(g + a)$.

24. Answer: (B) 0.5 Ω

With $R = \infty$ the balancing length gives the emf, and with R connected it gives the terminal voltage, so $r = R(l_1/l_2 - 1) = 9.5 \times (3/2.85 - 1) = 9.5 \times 0.15/2.85 = 0.5 \Omega$.

25. Answer: (B) $P/64$

Isothermal doubling halves the pressure to $P/2$. Adiabatic from 2V to 16V: $P_f = (P/2)(2/16)^{(5/3)} = (P/2)(1/32) = P/64$. Pressure must fall on expansion, so the large multiples are impossible.

26. Answer: (B) energy = $3VT(1/r - 1/R)$ is released

With $n = R^3/r^3$ drops, the area lost is $4\pi(nr^2 - R^2) = 4\pi R^3(1/r - 1/R) = 3V(1/r - 1/R)$. Since surface area decreases, surface energy $3VT(1/r - 1/R)$ is released, not absorbed.

27. Answer: (A) $(3/2)mv^2$

The two m pieces have perpendicular momenta mv each, so the $2m$ piece carries $\sqrt{2}mv$ and moves at $v/\sqrt{2}$. Total KE = $2 \times (1/2)mv^2 + (1/2)(2m)(v^2/2) = (3/2)mv^2$.

28. Answer: (B) 6

Photon energy = $12400/975 \approx 12.7 \text{ eV}$, which matches $E_4 - E_1 = 13.6(1 - 1/16) = 12.75 \text{ eV}$, so the atom reaches $n = 4$. Lines emitted = $n(n - 1)/2 = 6$.

29. Answer: (B) 10^{-2} m

Setting escape speed $\sqrt{2GM/R}$ equal to c gives $R = 2GM/c^2 = 2 \times 6.67 \times 10^{-11} \times 5.98 \times 10^{24}/(9 \times 10^{16}) \approx 8.9 \times 10^{-3} \text{ m}$, which is of the order 10^{-2} m .

30. Answer: (D) 3.5

The trajectory $y = x \tan \theta - gx^2/(2u^2 \cos^2 \theta)$ is identical when g/u^2 is the same. $g' = 9.8 \times 3^2/5^2 = 3.53 \approx 3.5 \text{ m s}^{-2}$; scaling with u instead of u^2 gives the wrong value.

31. Answer: (D) 45°C

Using Newton's law with average temperatures: $10/5 = k(65 - T_0)$ and $6/5 = k(57 - T_0)$. Dividing, $5/3 = (65 - T_0)/(57 - T_0)$, so $T_0 = 45^\circ\text{C}$.

32. Answer: (C) 157 N

$I = (1/2)MR^2 = (1/2)(50)(0.5)^2 = 6.25 \text{ kg m}^2$ and $\alpha = 2 \text{ rev s}^{-2} = 4\pi \text{ rad s}^{-2}$. $TR = I\alpha$ gives $T = 6.25 \times 4\pi/0.5 = 50\pi \approx 157 \text{ N}$; using $\alpha = 2 \text{ rad s}^{-2}$ gives the 25 N trap.

33. Answer: (C) 22.5 g

Heat from steam condensing and cooling to 80°C : $m(540 + 20) = 560m$. Heat gained by water: $20 \times 1 \times 70 = 1400 \text{ cal}$, so $m = 2.5 \text{ g}$. Total water = $20 + 2.5 = 22.5 \text{ g}$.

34. Answer: (B) 4.20×10^9 years

$X : Y = 1 : 7$ means $1/8$ of the original X remains, i.e. 3 half-lives. Age = $3 \times 1.4 \times 10^9 = 4.2 \times 10^9$ years.

35. Answer: (A) 450 V, 15 A

Primary current = $3000/200 = 15$ A. Output power = $0.9 \times 3000 = 2700$ W, so secondary voltage = $2700/6 = 450$ V; ignoring efficiency gives 500 V, which is not offered.

36. Answer: (A) 1.0 eV

$E - \phi = 0.5$ eV and $1.2E - \phi = 0.8$ eV. Subtracting, $0.2E = 0.3$ eV, so $E = 1.5$ eV and $\phi = 1.0$ eV; 1.5 eV is the photon energy, not the work function.

37. Answer: (A) r^2

$\lambda = 1/(\sqrt{2} \pi d^2 n)$ with molecular diameter $d = 2r$, so the mean free path is inversely proportional to r^2 .

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