

1. $\mathbf{F}(\mathbf{r}) = f(r)\mathbf{r}/r$ represents a vector point function. What will be $\nabla \times \mathbf{F}$ equal to?
 A) Zero B) $3\mathbf{r}$ C) $f'(r)\mathbf{r}$ D) $-f(r)\mathbf{r}/r^2$
2. Stoke's theorem relates a pair of two quantities. Pick the correct pair from the following :
 A) Surface integral and volume integral
 B) Line integral and surface integral
 C) Line integral and volume integral
 D) Curl of the vector and its divergence
3. A skew-Hermitian matrix
 A) Has all of its off-diagonal elements zero
 B) Has all of its diagonal elements zero
 C) Has all of its diagonal elements real
 D) Has every diagonal element either purely imaginary or zero
4. \mathbf{A} and \mathbf{B} are two arbitrary vectors. ϵ_{ijk} is the Levi-Civeta symbol. What does the quantity $\epsilon_{ijk} A_j B_k$ represent?
 A) $\mathbf{A} \cdot \mathbf{B}$ B) $\mathbf{A} \times \mathbf{B}$
 C) $\mathbf{A} - \mathbf{B}$ D) $\nabla \times (\mathbf{A} \times \mathbf{B})$
5. $f(z) = u(x,y) + i v(x,y)$ is a complex function. It is known to be analytic at all points in the complex plane. This means that
 A) $\partial^2 u / \partial x^2 = -\partial^2 u / \partial y^2$ and $\partial^2 v / \partial x^2 = -\partial^2 v / \partial y^2$
 B) $\partial^2 u / \partial x^2 = \partial^2 u / \partial y^2$ and $\partial^2 v / \partial x^2 = -\partial^2 v / \partial y^2$
 C) $\partial^2 u / \partial x^2 = -\partial^2 u / \partial y^2$ and $\partial^2 v / \partial x^2 = \partial^2 v / \partial y^2$
 D) The partial derivatives of u and v are independent of each other
6. A complex function $f(z)$ has poles at $z = +2i$ and $-2i$ with the residues at the poles being 3 and -3 respectively. The contour integral of the function over the circle $z^2 - 6i = 0$ is
 A) Zero B) $6i$
 C) $-6i$ D) $3i$
7. The complete solution of the equation $y'' + 2y' + 5y = 0$ is
 A) $y = A \cos 2x$ B) $y = A \sin 2x$
 C) $y = Ae^{2x} + Be^{-2x}$ D) $y = e^{-x} (Ae^{2ix} + Be^{-2ix})$
8. A Fourier sine series is used to represent a function $f(x)$. Choose the correct expression for the function from among the following:
 A) $f(-x)$ B) $\frac{1}{2} [f(x) + f(-x)]$
 C) $\frac{1}{2} [f(x) - f(-x)]$ D) $\zeta [f(x)f(-x)]$

9. In a lab experiment to determine the value of a physical quantity a given by the expression $a = b c^{1/4} / d^3$, the measured values of the quantities b , c and d are respectively, 0.303 ± 0.009 , 2.51 ± 0.25 and 1.50 ± 0.02 . What is the correct way to quote the value of a ? (Given $2.51^{1/4} = 1.258688981$).

- A) 0.355007 ± 0.019773
 B) 0.355 ± 0.005
 C) 0.355 ± 0.034
 D) 0.355 ± 0.020

10. Given the 3 X 3 rotation matrix

$$\begin{bmatrix} \cos\theta & \sin\theta & 0 \\ -\sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

What will be the diagonal elements when this matrix is diagonalized?

- A) $1, 1, 1$
 B) $i, -i, 1$
 C) $e^i, e^{-i}, 1$
 D) $e^i, e^{-i}, 0$

11. Two bodies M and N of equal masses are suspended from two separate massless springs of spring constants K_1 and K_2 , respectively. If the two bodies oscillate vertically such that their maximum velocities are equal, then the ratio of the amplitude of vibration of M to that of N is :

- A) K_2/K_1
 B) $\zeta [K_2/K_1]$
 C) K_1/K_2
 D) $\zeta [K_1/K_2]$

12. A central force F acts on a particle. Then it

- A) Experiences a force directed along the radial direction only.
 B) Always moves normal to the radial direction.
 C) Always moves in the radial direction only.
 D) Always moves in a circular orbit.

13. In the Rutherford scattering experiment, the alpha particles impinge on a thin gold foil with a velocity of $5 \times 10^6 \text{ ms}^{-1}$ with an impact parameter of 10 fermis. What is the areal velocity?

- A) $5 \times 10^6 \text{ fermis}^2 \text{ s}^{-1}$
 B) $2.5 \times 10^{-8} \text{ m}^2 \text{ s}^{-1}$
 C) $5 \times 10^{-8} \text{ m}^2 \text{ s}^{-1}$
 D) Cannot calculate the areal velocity from the given data.

14. A wave motion is represented by the expression $f = 15 \cos \{4 [(x+y) + 25t]\}$ where x and y are in meters and t is in seconds. Pick the correct statement regarding the wave :
- It is travelling along the Z axis with a wavelength = 2 m and frequency 314
 - It is travelling in the XY plane along a direction making an angle of 45° to the X axis with a wavelength = 0.5 m and frequency 50 Hz
 - It is travelling in the XY plane along a direction making an angle of 135° to the X axis with a wavelength = 0.354 m and frequency 50 Hz
 - It is travelling in the X axis with a wavelength = 0.354 m and velocity 314 m
15. Light travels with a velocity c in vacuum. What will be the phase velocity and group velocity in glass?
- Greater than c and less than c respectively
 - Less than c and greater than c respectively
 - Both equal to c
 - c and less than c respectively
16. H represents the Hamiltonian and L represents the Lagrangian of a system of particles. What can be said about the dependence of these quantities on the kinetic energy T and potential energy V of the system?
- H depends only on T and L depends only on V
 - H depends only on V and L depends only on T
 - H depends only on T but L depends on both T and V
 - Both H and L depend on T and V
17. In a non-holonomic system,
- Constraints are absent and the number of degrees of freedom is the same as the number of independent co-ordinates.
 - Constraints are imposed and the number of degrees of freedom is less than the number of independent co-ordinates.
 - No constraints are imposed and the number of degrees of freedom is more than the number of independent co-ordinates.
 - Constraints are imposed and the number of degrees of freedom is more than the number of independent co-ordinates.
18. In a head on collision of an alpha particle with a heavy nucleus, the closest distance of approach between the collision partners will be
- | | |
|------------|-------------|
| A) Zero | B) Largest |
| C) Minimum | D) Infinity |
19. A canonical transformation is effected changing the (q,p) to $(p, -q)$. What is the corresponding generating function F ?
- | | |
|----------------|--------------|
| A) $F = qQ$ | B) $F = -qQ$ |
| C) $F = q / Q$ | D) $F = pP$ |

27. Within a waveguide, the wavelength of the transmitted waves will be
 A) The same as the free space wavelength.
 B) Longer than the free space wavelength.
 C) Smaller than the free space wavelength
 D) There is no definite relation between the wavelengths inside the waveguide and in free space.
28. Two electrons are moving in circular orbits with radii r_1 and r_2 in the ratio 1: 3 in the X-Y plane under the influence of a magnetic field. If relativistic effects can be neglected, what will be the corresponding ratio of their velocities v_1 and v_2 ?
 A) 1/9 B) 1 C) 1/3 D) 3
29. A coil of wire having a resistance of $10 \text{ } \Omega$ encloses an area 100 cm^2 perpendicular to a magnetic field of 1 T. It is suddenly removed from the magnetic field. What will be the total charge flowing in the circuit in Coulombs?
 A) 10^{-4} B) 10^{-3} C) 10^{-2} D) 1
30. The same current I flows along a long straight conductor and a circular wire loop of radius r . What is the ratio of the magnetic fields at the centre of the loop to that due to the straight wire at a distance r from it?
 A) 3.14 : 1 B) 1 : 3.14 C) 1 : 1 D) 6.28 : 1
31. One of the following modes cannot be propagated through a hollow wave guide. Which one is it?
 A) TEM B) TE
 C) TM D) Both TE and TM
32. In which of the following cases the tangential component of the electric field has a continuous value?
 A) Only across the boundary between two conducting media when there is no surface current.
 B) Only across the boundary between two dielectric media when there is no surface charge.
 C) Only across the boundary between two conducting media when there is no surface current nor any surface charge.
 D) Across the boundary of any two media irrespective of the surface current or charge
33. A magnetic field $\mathbf{B} = B_0(\mathbf{i} + 2\mathbf{j} - 4\mathbf{k})$ exists at a point. A test charge is moving with a velocity $\mathbf{v} = v_0(3\mathbf{i} - \mathbf{j} + 2\mathbf{k})$ experiences no force at a certain point. This means that there exists an electric field given by the expression :
 A) $\mathbf{E} = -v_0 B_0(3\mathbf{i} + 2\mathbf{j} - 4\mathbf{k})$ B) $\mathbf{E} = -v_0 B_0(\mathbf{i} + \mathbf{j} - 7\mathbf{k})$
 C) $\mathbf{E} = v_0 B_0(14\mathbf{j} + 7\mathbf{k})$ D) $\mathbf{E} = -v_0 B_0(14\mathbf{j} + 7\mathbf{k})$

34. The Poynting's vector gives
- The rate of energy flow per unit area along the direction of flow of an electromagnetic wave
 - The energy density of the electromagnetic wave
 - The amplitude of the electromagnetic wave
 - The direction of the electric field in the electromagnetic wave
35. A magnetic field $\mathbf{B}(\mathbf{r})$ and the corresponding vector potential $\mathbf{A}(\mathbf{r})$ exist in a region of space containing a current distribution $\mathbf{J}(\mathbf{r})$. One of the following quantities is necessarily zero. Which one is it?
- $\nabla^2 \mathbf{B}$
 - $\nabla \cdot \mathbf{A}$
 - $\nabla \cdot \mathbf{B}$
 - $\nabla \times \mathbf{B}$
36. The value of the skin depth for electromagnetic waves of frequency 1 MHz in copper ($\sigma = 5.8 \times 10^7$ mhos m^{-1}) is given to be 0.066 mm. What will be its value for an alloy of aluminium ($\sigma = 2.9 \times 10^7$ mhos m^{-1}) at 10 MHz?
- 0.0295 mm
 - 0.147 mm
 - 0.295 mm
 - 0.013 mm
37. A beam of light is incident from air on the surface of a dielectric medium having a refractive index 1.4 at normal incidence. What fraction of the incident intensity is reflected back into air?
- 97.2%
 - 2.8%
 - 16.7%
 - 83.3%
38. An electromagnetic wave is passing through a certain medium. What can be said about the instantaneous energy density at a point in this region of space?
- It remains a constant.
 - It oscillates with the same frequency as that of the wave itself.
 - It oscillates with half the frequency of the wave itself.
 - It oscillates with twice the frequency as that of the wave itself.
39. The transformation $\mathbf{A}' = \mathbf{A} + \nabla \phi$, where \mathbf{A} is the vector potential and ϕ is a scalar function preserves the magnetic field. What is such a transformation called?
- Gauge transformation
 - Symmetry transformation
 - Canonical transformation
 - Lorentz transformation
40. A square coil of wire of side a has a current I passing through it. It is situated in a uniform magnetic field B parallel to the plane of the coil and one pair of sides of the coil. What is the moment of the couple acting on the coil?
- IBa
 - IB/a
 - IBa^2
 - IB/a^2

41. The magnetic field vector of a plane electromagnetic wave in free space is given by the expression $\mathbf{B}(y) = (\mathbf{j} + 3\mathbf{k}) B_0 \cos(x + ct)$ where the vector \mathbf{j} is a unit vector in the Y direction, \mathbf{k} is a unit vector in the Z direction, x is in meters and t is in seconds and c is the velocity of light. What is the direction and amplitude of the associated electric field vector?
- A) Along the vector $(\mathbf{j} + 3\mathbf{k})$, Amplitude : $\frac{1}{c} 10cB_0$
 B) Along the vector $(-3\mathbf{j} + \mathbf{k})$, Amplitude : cB_0
 C) Along the vector $(\mathbf{j} - 3\mathbf{k})$, Amplitude : cB_0
 D) Along the vector $(-3\mathbf{j} + \mathbf{k})$, Amplitude : $\frac{1}{c} 10cB_0$
42. The Helmholtz free energy function F of a system is intimately connected to the partition function Z . Pick the correct expression for the same from among the following (k is the Boltzmann constant)?
- A) $F = -kT \ln Z$ B) $F = Z^{-kT}$
 C) $F = e^{-kTZ}$ D) $F = e^{-Z/kT}$
43. The energy emitted by a hot body at any temperature is distributed among the different wavelengths
- A) Equally
 B) Unequally
 C) More in the long wavelength region
 D) More in the short wavelength region
44. The average energy of a Planck oscillator is
- A) $h\nu$ B) $kT/2$
 C) $3kT/2$ D) $h\nu / (e^{h\nu/kT} - 1)$
45. Which of the following thermodynamic relations is **NOT** true ?
- A) $(\partial S / \partial T)_V = C_P / T$ B) $(\partial S / \partial T)_P = C_P / T$
 C) $(\partial H / \partial P)_T = V - T(\partial V / \partial T)_P$ D) $(\partial U / \partial V)_T = T(\partial P / \partial T)_V - P$
46. At low temperatures the heat capacity of crystals follows a T^3 variation i.e, $C = aT^3$, a being a constant. In this temperature range, the entropy S of the crystal is given by :
- A) $aT^4/4$ B) $aT^3/3$ C) $aT^2/2$ D) $3aT^2$
47. What is the order of magnitude of the wavelength of De Broglie waves for the earth due to its motion around the sun? (Mean radius of earth's orbit is 1.5×10^{11} km and mass is 6×10^{24} kg).
- A) 10^{-30} m B) 10^{-3} m C) 10^{-67} m D) 10^{-20} m

48. ψ is a normalized wave function and Q is an operator corresponding to an observable q . The quantity $\int \psi^* Q \psi$ is integrated over all space. The result will yield
- A) The square of the normalization constant
 B) The normalization constant
 C) The probability for the measured value of q being equal to the mean value
 D) The mean value of q

49. In the quantum mechanical treatment of the harmonic oscillator, a and a^+ represent the annihilation and creation operators. If $|0\rangle$ is the ground state wave function of harmonic oscillator with a frequency ν , what is the eigen value of the state represented by the expression $(a^+)^n |0\rangle$?
- A) Zero
 B) $nh\nu/2$
 C) $(n+1/2)h\nu$
 D) $h\nu/2$

50. A particle of mass m moving in a two dimensional box of side a . Which of the following is **NOT** a possible energy eigen value for the particle?
- A) $h^2/4ma^2$
 B) $3h^2/8ma^2$
 C) $5h^2/8ma^2$
 D) $10h^2/8ma^2$

51. A potential barrier V_0 exists between $x = 0$ and $x = a$ with $a > 0$. A particle of energy $E < V_0$ is incident on the barrier from the left. What is the wave function of the particle for $x > a$ (k is the wave vector and A and B are constants)?
- A) $A e^{ikx}$
 B) $A e^{-kx}$
 C) $A e^{ikx} + B e^{-ikx}$
 D) $A e^{kx} + B e^{-kx}$

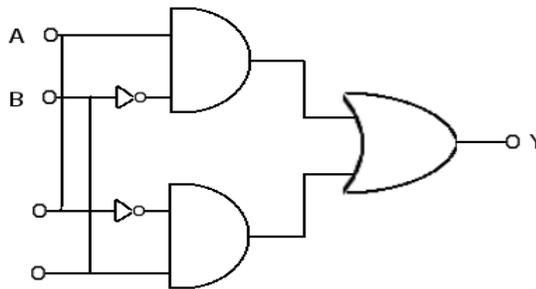
52. A particle with spin $1/2$ is described by the wave function

$$\psi = A \begin{pmatrix} 1+i \\ 2 \end{pmatrix}$$

where A is a normalization constant. Choose from the following the correct probability for observing a spin projection $S_z = -1/2 \hbar$:

- A) $1/6$
 B) $1/3$
 C) $2/3$
 D) $1/2$
53. The spatial part of a two electron state wave function is symmetric under the exchange of the two electrons. If ψ_1 and ψ_2 represent the spin-up and spin-down states respectively of the electrons, the spin part of the two particle state is
- A) $\psi_1 \psi_2$
 B) $\psi_1 \psi_2 - \psi_2 \psi_1$
 C) $(\psi_1 \psi_2 + \psi_2 \psi_1)/\sqrt{2}$
 D) $(\psi_1 \psi_2 - \psi_2 \psi_1)/\sqrt{2}$

62. A NAND gate can be transformed into a NOT gate
- A) By shorting the two input terminals and giving a common digital input signal
 - B) By shorting one input terminal to the output and giving a digital input signal to the other input terminal
 - C) By grounding one input terminal and giving digital input signal to the other input terminal
 - D) By grounding the output terminal
63. For a p-n diode with a built-in potential of 0.62 V, what is the potential across the depletion region at an applied forward voltage 0.5 Volt?
- A) 1.12 V
 - B) 0 V
 - C) 0.12 V
 - D) 0.62 V
64. The following diagram represents a gate formed by a suitable combination of five other gates. To which other simpler gate does this correspond to in its logic function?



- A) XOR
 - B) NAND
 - C) OR
 - D) AND
65. The common base configuration of the transistor is characterized by
- A) Low voltage gain and high current gain.
 - B) Low input resistance and low current gain.
 - C) High voltage gain and low output resistance.
 - D) High current gain and low input resistance.
66. What is the effect of removing the emitter bypass capacitor in a common emitter amplifier?
- A) Decreases input resistance and decreases voltage gain
 - B) Increases input resistance and increases voltage gain
 - C) Increases input resistance and decreases voltage gain
 - D) Decreases input resistance and increases voltage gain

67. A pn junction diode has an acceptor concentration N_A on the p side and a donor concentration N_D on the n side. If $N_A > N_D$, what is the net charge on the diode?
- A) $e(N_A - N_D)$ B) $e(N_D - N_A)$
 C) $e N_A$ D) Zero
68. An OPAMP is used in a differentiator configuration. One disadvantage is that
- A) High frequency noise will be much more amplified than the actual signals.
 B) Low frequency noise will be much more amplified than the actual signals.
 C) The actual signals will be saturated.
 D) There is a high frequency cutoff
69. Which among the following has a negative resistance region in its VI characteristics?
- A) FET B) Tunnel diode
 C) LED D) Zener diode
70. In a MOSFET application, as V_{GS} is increased from zero to larger reverse bias values, what will happen to g_m ?
- A) Increases B) Decreases
 C) Remains constant D) Falls rapidly to zero
71. How many minimum number of flip-flops are required for a scale-of-seven counter?.
- A) 7 B) 4
 C) 8 D) 3
72. A Multichannel analyzer (MCA) for analyzing the output pulses from a radiation detector invariably consists of an Analog to digital converter (ADC). If the ADC has 8 bit output and the MCA accepts input pulses upto a maximum amplitude of 10 Volts, what will be the MCA output corresponding to an analog detector signal of 2.5 Volts?
- A) 01000000 B) 00001000
 C) 10000000 D) 00100000
73. One difference between the emitter and collector of a transistor is
- A) The emitter is always of the p type whereas the collector is of n type.
 B) The emitter is always of the n type whereas the collector is of p type.
 C) The emitter is more heavily doped than the collector.
 D) The collector is more heavily doped than the emitter.
74. Which of the following filters will act as a resonant circuit with a high Q factor?
- A) A band reject filter with a narrow band width
 B) A band pass filter with a narrow band width
 C) A high pass filter with a small cut off frequency
 D) A low pass filter with a small cut off frequency

75. A basic OPAMP integrator consists of an OPAMP with the signal to be integrated given at the inverting terminal through a resistor R , grounding the non-inverting terminal and providing a feedback capacitance C . What is the scale factor relating the integrated output voltage to the input signal?
 A) $-CR$ B) C/R C) $-1/RC$ D) R/C
76. An amplitude modulated waveform is represented by $s(t) = 0.5 \cos(1800t) + 20 \cos(2000t) + 0.5 \cos(2200t)$. What is the modulation index?
 A) 0.5 B) 0.25 C) 0.1 D) 0.05
77. A FET as a switch is OFF when V_{GS} is zero. It turns ON with non-zero V_{GS} of appropriate polarity. Which type of FET is it?
 A) Enhancement type MOSFET
 B) Depletion type MOSFET
 C) Any type of MOSFET
 D) JFET
78. An OPAMP has a difference mode gain of 8000 and has an output of V_o for given inputs. When the two inputs are so changed that the difference signal increases by a factor of 10 without altering the common mode signal, the output changes by 100 mVolts. What is the original difference signal amplitude?
 A) 1.39 mV B) 1.39 μ V
 C) 12.5 μ V D) 12.5 mV
79. The orbital and spin angular momenta of the electrons in an atom can couple via two mechanisms : j-j coupling and L-S coupling. In the first case
 A) The spin-orbit interaction is very weak and occurs in light atoms.
 B) The spin-orbit interaction is very weak and occurs in heavy atoms.
 C) A strong coupling exists between spin and orbital components and is dominant in heavy atoms.
 D) There is a strong coupling between spin and orbital components and is dominant in lighter atoms.
80. Let v_1 be the velocity of an electron in the first Bohr orbit of the hydrogen atom. What will be the corresponding velocity in the nth orbit?
 A) $v_n = v_1 n$ B) $v_n = v_1 / n$
 C) $v_n = v_1 n^2$ D) $v_n = v_1 / n^2$
81. A hydrogen atom is in the $n = 2, j = 3/2, m_j = 3/2$ state. It is subjected to a magnetic field \mathbf{B} along the Z-axis. What is the energy of interaction with the field?
 A) $3\hbar B/4m$ B) $3\hbar B/2m$
 C) $\hbar B/2m$ D) $3\hbar B/4m$

103. The major differences between Type I and Type II super conductors are that
- Type I superconductors have high critical fields and show incomplete Meissner effect whereas Type II have low critical fields and show complete Meissner effect.
 - Type I superconductors have low critical fields and show complete Meissner effect whereas Type II have high critical fields and show incomplete Meissner effect.
 - Type I superconductors have high critical fields and the current flows throughout the material, whereas type II superconductors have low critical fields and the current flows only along the surface.
 - Type I superconductors have high critical fields and the current flows only along the surface, whereas type II superconductors have low critical fields and the current flows throughout the material.
104. A superconductor behaves like a
- Perfect diamagnetic material
 - Perfect ferromagnetic material
 - Perfect paramagnetic material
 - Non magnetic material
105. Which among the following is a direct band gap semiconductor?
- Silicon
 - Diamond
 - Germanium
 - Gallium Arsenide
106. It is known that the volume of a nucleus varies as the mass number. A ${}_{13}\text{Al}^{27}$ nucleus has a radius of 3.9 fermis. What will be the energy of Coulomb interaction between the ${}_{13}\text{Al}^{27}$ nucleus and a ${}_{28}\text{Ni}^{64}$ nucleus when they just touch each other in a nuclear reaction?
- 57.6 MeV
 - 28.7 MeV
 - 41.6 MeV
 - 40.1 MeV
107. What was one of the reasons for proposing the existence of the neutrino?
- To explain the mass defect in nuclear reactions.
 - To explain the apparent energy non conservation in beta decay.
 - To explain the existence of the strong nuclear force.
 - To explain the emission of two types of electrons during beta decay.
108. The spin and parity of the ground state of a nucleus having 24 protons and 32 neutrons will be
- 1^+
 - 0^-
 - 0^+
 - 1^-
109. A plane wave representing a neutron is scattered from a nuclear potential and the resulting scattering length is observed to be negative. Then the potential will be :
- Zero
 - Imaginary
 - Attractive
 - Repulsive

110. It is known that the range of nuclear force is about 1.4 fermis. If the pions were twice as massive as they are now, the range would
- Increase to 2.8 fermis
 - Decrease to 0.7 fermis
 - Remain the same
 - Increase to 1.98 fermis
111. In a semiconductor radiation detector, the final output pulse is formed as a result of
- Collection of electrons and holes produced by the incident radiation in the semiconductor.
 - Interaction of the incident radiations with the cathode.
 - Interaction of the incident radiations with the anode.
 - Collection of light produced by the incident radiation.
112. The mass of a deuteron is 2.013553 amu whereas the combined mass of a free proton and neutron is 2.015941 amu (1 amu = 931.4 MeV). This implies that
- A deuteron is an unbound system.
 - The deuteron always exists in an excited state with an energy of 2.224 MeV
 - When a proton and neutron combine to form a deuteron, a gamma ray of energy 2.224 MeV will be released.
 - A minimum energy of 2.224 MeV is required to combine a proton and neutron to form a deuteron.
113. A 5 MeV proton impinges on a ${}_{82}\text{Au}^{197}$ nucleus and manages to penetrate the nucleus without any interaction. Approximately how much time would the proton take to penetrate the nucleus?
- 1 ns
 - 1 μs
 - 10^{-15} s
 - 10^{-21} s
114. What is the specialty of an iron nucleus?
- It is the most tightly bound nucleus.
 - It is very lightly bound and decays very easily.
 - It is the most abundant atom in the universe.
 - It is the most highly deformed nucleus.
115. In a radioactive series a nucleus decays through several steps. One series starts ${}_{90}\text{Th}^{232}$ and follows a sequence of successive decays emitting the following particles. One alpha, two electrons, four alphas, an electron, an alpha and finally an electron to reach the final stable nucleus. Identify the final stable nucleus.
- ${}_{82}\text{Pb}^{220}$
 - ${}_{82}\text{Pb}^{208}$
 - ${}_{88}\text{Ra}^{220}$
 - ${}_{88}\text{Ra}^{208}$

