UGC POINT ACADEMY

DEC-2015

UGC POINT

LEADING INSTITUE FOR CSIR-JRF/NET, GATE & JAM

BOOKLET CODE **PH**

SUBJECT CODE **01**

PHYSICAL SCIENCE

TEST SEREIS # 2

Electromagnetic Theory + Nuclear & Particle Physics

Date: 26/11/2015

Timing: 2:00 H
Maximum Marks: 100

Instructions

1. This test paper has a total of 50 questions carrying 100 marks. The entire question paper is divided in two sections, A and B. All sections are compulsory. Question in each section are different type.
2. Read the Questions carefully and mark your appropriate response to the **OMR** sheet
3. There is Negative marking of **1/4** for Each wrong answer
4. Mark the response by **Black** or **Blue** Ball Pen only
5. Any other belongings like Book/ Notes / Electronic device etc are not permitted in the examination hall.
6. Submit your answer sheet (OMR Sheet) to the invigilator before leaving the examination hall
7. Do not write in the question paper

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1. A parallel plate capacitor of circular cross section with radius $r >> d$, when d is the spacing between the plates, is charged to a potential V and then disconnected from the charging circuit. If , now the plates are slowly pulled apart (keeping them parallel) so that their separation is increased from d to d', the work done will be

(1) $\frac{\pi\varepsilon_0 r^2 V^2}{2d}\left(1-\frac{d}{d'}\right)$ (2) $\frac{\pi\varepsilon_0 r^2 V^2}{2d}\frac{d'}{d}$

(3) $\frac{\pi\varepsilon_0 r^2 V^2}{2d}\left(\frac{d'}{d}-1\right)$ (4) $\frac{\pi\varepsilon_0 r^2 V^2}{2d}\frac{d}{d'}$

2. A spherical capacitor consists of two concentric conducting hollow spheres of radii R_1(inner) and R_2(outer), with a dielectric of permittivity ε_r in the space between the spheres. What is the capacitance of such a device?

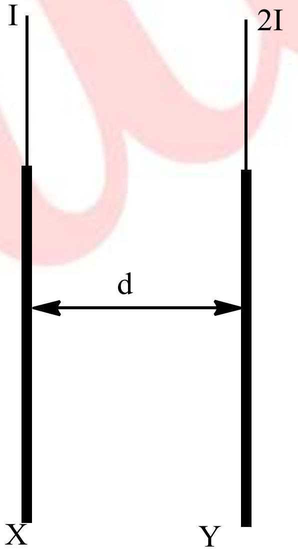
(1) $4\pi\varepsilon_0\varepsilon_r/(1/R_1 - 1/R_2)$ (2) $4\pi\varepsilon_0\varepsilon_r/R_2$

(3) $4\pi\varepsilon_0\varepsilon_r/R_1$ (4) $4\pi\varepsilon_0\varepsilon_r/(1/R_1 + 1/R_2)$

3. The amplitude of an electromagnetic wave decays exponentially upon incidence on an electrically conducting medium as $E(z) = E_0\exp(-z/\delta)$, where z is the distance travelled inside the medium and δ is the skin-depth. An enclosure is to be constructed out of copper sheet (conductivity $\sigma = 6\times10^7\,\Omega^{-1}m^{-1}$), within which an external RF radiation (of frequency $f = 1MHz$) is to be reduced below 1% of its outside intensity. What is the required minimum thickness of the copper sheet? For copper $\mu_r = 1$

(1) 150 mm (2) 15 mm (3) 1.5 mm (4) 0.15 mm

4. Consider two infinitely long current carrying conductors X and Y, separated by a distance d, Y caries a current 2I which is twice the current I carried by X in the same direction. At what distance from X will the net magnetic field produced by the wires be zero

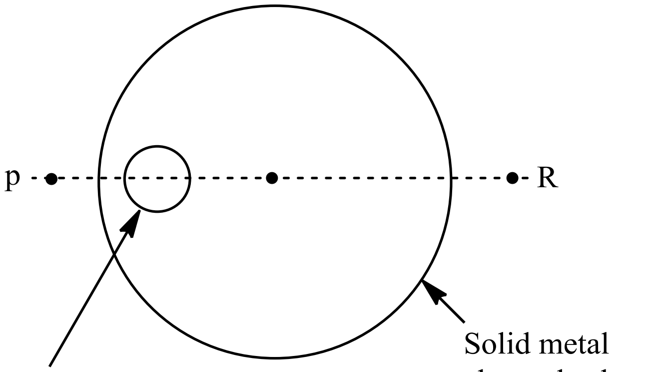


(1) d/4 (2) d/3 (3) d/2 (4) 2d/3

5. A spatially uniform time-dependent magnetic field is changing with time at the constant rate of 1 T/s. a unit positive charge is moved around a circle of radius R=2m perpendicular to this field. The magnitude of the work done on the charge for one complete revolution is

(1) 0 (2) 2J (3) 6.28 J (4) 12.56 J

6. A solid metal sphere with a spherical cavity as shown below has a total charge +Q



O is the centre of the sphere, and P and R are two points equidistance from it. If E_P and E_R represent the magnitude of the electric field at P and R respectively, which of the following statements is correct

(1) $E_P = E_R$ (2) $E_P = 0$ and $E_R = 0$ (3) $E_P > E_R$ (4) $E_P < E_R$

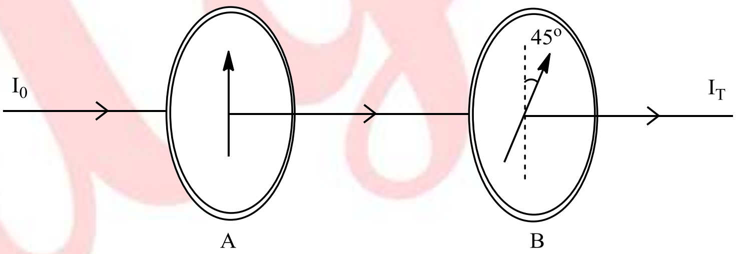
7. Three equal charges Q are successively brought from infinity and each is placed at one of the three vertices of an equilateral triangle. Assuming the rest of the universe as a whole to be neutral, the energy E_0 of the electrostatic field will increases successively to

$E_0 + \Delta_1$, $E_0 + \Delta_1 + \Delta_2$, $E_0 + \Delta_1 + \Delta_2 + \Delta_3$

Where $\Delta_1 : \Delta_2 : \Delta_3 =$

(1) 1:2:3 (2) 1: 1: 1 (3) 0: 1: 1 (4) 0: 1: 2

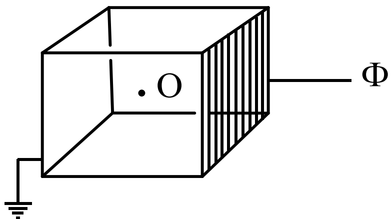
8. Unpolarised light of intensity I_0 passes successively through two identical linear polarisers A and B, placed such that their polarization axes are at an angle of 45^o (see figure) with respect to one another



Assuming A and B to be perfect polarisers (i.e. no absorption losses), the intensity of the transmitted light will be $I_T =$

(1) $I_0 / 4$ (2) $I_0 / 2\sqrt{2}$ (3) $I_0 / 2$ (4) $I_0 / \sqrt{2}$

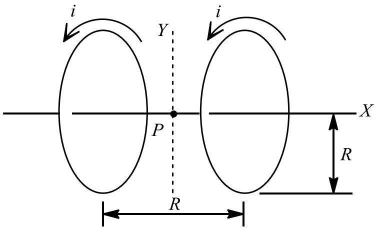
9. Five sides of a hollow metallic cube are grounded and the sixth side is insulated from the rest and is held at a potential Φ (see figure)



The potential at the centre O of the cube is

(1) 0 (2) $\Phi / 6$ (3) $\Phi / 5$ (4) $2\Phi / 3$

10. A system of two circular co-axial coils carrying equal currents I along same direction having equal radius R and separated by a distance R (as shown in the figure below). The magnitude of magnetic field at the midpoint P is given by



(1) $\frac{\mu_0 I}{2\sqrt{2}R}$ (2) $\frac{4\mu_0 I}{5\sqrt{5}R}$ (3) $\frac{8\mu_0 I}{5\sqrt{5}R}$ (4) 0

11. An electron is executing simple harmonic motion along the y-axis in right handed coordinate system. Which of the following statements is true for emitted radiation?
(1) The radiation will be most intense in *xz* plane
(2) The radiation will be most intense in *xy* plane
(3) The radiation will violate causality
(4) The electron's rest mass energy will reduce due to radiation loss

12. A conducting sphere of radius *r* has charge *Q* on its surface. If the charge on the sphere is doubled and its radius is halved, the energy associated with the electric field will
(1) increases four times (2) increases eight times
(3) remain the same (4) decrease four times

13. At equilibrium there cannot be any free charge inside a metal. However, if you forcibly put charge in the interior then it takes some finite time to 'disappear' i.e. move to the surface. If the conductivity, σ ,of a metal $10^6\ (\Omega m)^{-1}$ and the dielectric constant $\varepsilon_0 = 8.85\times10^{-12}$ Farad/m this time will be approximately:
(1) 10^{-5} sec (2) 10^{-11} sec (3) 10^{-9} sec (4) 10^{-17} sec

14. The electric fields outside $(r > R)$ and inside $(r < R)$ a solid sphere with a uniform volume charge density are given by $\vec{E}_{r>R} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}\hat{r}$ and $\vec{E}_{r<R} = \frac{1}{4\pi\varepsilon_0}\frac{q}{R^3}r\hat{r}$ respectively, while the electric field outside a spherical shell with a uniform surface charge density is given by $\vec{E}_{r>R} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}\hat{r}$, q being the total charge. The correct ratio of the electrostatic energies for the second case to the first case is
(1) 1:3 (2) 9:16 (3) 3:8 (4) 5:6

15. The electric and magnetic field caused by an accelerated charged particle are found to scale as $E \propto r^{-n}$ and $B \propto r^{-m}$ at large distances. What are the value of n and m?
(1) $n=1, m=2$ (2) $n=2, m=1$ (3) $n=1, m=1$ (4) $n=2, m=2$

16. If $\vec{E}_1 = xy\hat{i} + 2yz\hat{j} + 3xz\hat{k}$ and $\vec{E}_2 = y^2\hat{i} + (2xy + z^2)\hat{j} + 2yz\hat{k}$ then
(1) Both are impossible electrostatic fields (2) Both are possible electrostatic fields
(3) Only $\vec{E}_1$ is a possible electrostatic fields (4) Only $\vec{E}_2$ is a possible electrostatic fields

17. An electromagnetic wave of frequency ω travels in the *x*-direction through vacuum. It is polarized in the y-direction and the amplitude of the electric field is E_0. With $k = \omega / c$ where *c* is the speed of light in vacuum, the electric and the magnetic fields are then conventionally given by
(1) $\vec{E} = E_0\cos(ky - \omega t)\hat{x}$ and $\vec{B} = \frac{E_0}{c}\cos(ky - \omega t)\hat{z}$ (2) $\vec{E} = E_0\cos(kx - \omega t)\hat{y}$ and $\vec{B} = \frac{E_0}{c}\cos(kx - \omega t)\hat{z}$

(3) $\vec{E} = E_0 \cos(kx - \omega t)\hat{z}$ and $\vec{B} = \frac{E_0}{c}\cos(ky - \omega t)\hat{y}$ (4) $\vec{E} = E_0 \cos(kx - \omega t)\hat{x}$ and $\vec{B} = \frac{E_0}{c}\cos(ky - \omega t)\hat{y}$

18. A loop of radius r carries a uniformly distributed charged. Assuming the potential at infinitely to be zero the ratio of the potential at a height 2r on the axis to that at a height 3r is
(1) 1/2 (2) 2 (3) $\sqrt{1/2}$ (4) $\sqrt{2}$

19. A magnetic field $\vec{B} = B_0(\hat{i} + 2\hat{j} - 4\hat{k})$ exists at point. If a test charge moving with a velocity, $\vec{v} = v_0(3\hat{i} - \hat{j} + 2\hat{k})$ experiences no force at a certain point, the electric field at that point in SI units is
(1) $\vec{E} = -v_0 B_0(3\hat{i} - 2\hat{j} - 4\hat{k})$ (2) $\vec{E} = -v_0 B_0(\hat{i} + \hat{j} + 7\hat{k})$
(3) $\vec{E} = v_0 B_0(14\hat{j} + 7\hat{k})$ (4) $\vec{E} = -v_0 B_0(14\hat{j} + 7\hat{k})$

20. A circular conducting ring of radius *R* rotates with constant angular velocity ω about its diameter placed along the *x*-axis. A uniform magnetic field *B* is applied along the *y*-axis. If at time $t = 0$ the ring is entirely in the *xy*-plane. The emf induced in the ring at time $t > 0$ is
(1) $B\omega^2 \pi R^2 t$ (2) $B\omega\pi R^2 \tan(\omega t)$
(3) $B\omega\pi R^2 \sin(\omega t)$ (4) $B\omega\pi R^2 \cos(\omega t)$

21. An electric field in a region is given by $\vec{E}(x, y, z) = ax\hat{i} + cz\hat{j} + 6by\hat{k}$. For which values of a, b, c does this represent an electrostatic field?
(1) 13, 1, 12 (2) 17, 6, 1 (3) 13, 1, 6 (4) 45, 6, 1

22. When unpolarised light is incident on a glass plate at a particular angle. It is observed that the reflected beam is linearly polarized. What is the angle of the refracted beam with respect to the surface normal? Refractive index of glass is 1.52
(1) 56.7^o (2) 33.4^o (3) 23.3^o
(4) The light is completely reflected and there is not refracted beam

23. Consider two point charges *q* and λq located at the points, $x = a$ and $x = \mu a$ respectively. Assuming that the sum of the two charges is constant, what is the value of λ for which the magnitude of the electrostatic force is maximum?
(1) μ (2) 1 (3) $1/\mu$ (4) $1+\mu$

24. A spherical shell of inner and outer radii *a* and *b*, respectively, is made of a dielectric material with frozen polarization $\vec{P}(r) = \frac{k}{r}\hat{r}$, where k is a constant and *r* is the distance from the its centre. The electric field in the region $a < r < b$ is
(1) $\vec{E} = \frac{k}{\varepsilon_0 r}\hat{r}$ (2) $\vec{E} = -\frac{k}{\varepsilon_0 r}\hat{r}$ (3) $\vec{E} = 0$ (4) $\vec{E} = \frac{k}{\varepsilon_0 r^2}\hat{r}$

25. The electrostatic potential due to a charge distribution is given by $V(r) = A\frac{e^{-\lambda r}}{r}$, where '*A*' and λ are constants. The total charge enclosed within a sphere of radius $1/\lambda$, with its origin at $r = 0$ is given by,
(1) $\frac{8\pi\varepsilon_0 A}{e}$ (2) $\frac{4\pi\varepsilon_0 A}{e}$ (3) $\frac{\pi\varepsilon_0 A}{e}$ (4) 0

26. A charged particle is released at time $t = 0$, from the origin in the presence of uniform static electric and magnetic fields given by $E = E_0\hat{y}$ and $B = B_0\hat{z}$, respectively. Which of the following statements is true for $t > 0$?

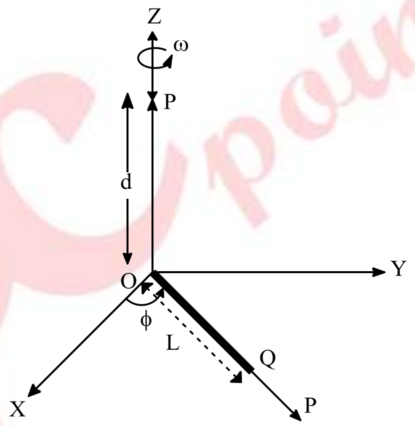
(1) The particle moves along the $x-$axis (2) The particle moves in a circular orbit

(3) The particle moves in the (x,y) plane (4) The particle moves in the (y,z) plane

27. Which of the following expressions represents an electric field due to a time varying magnetic field?
(1) $K(x\hat{x}+y\hat{y}+z\hat{z})$ (2) $K(x\hat{x}+y\hat{y}-z\hat{z})$
(3) $K(x\hat{x}-y\hat{y})$ (4) $K(y\hat{y}-x\hat{y}+2z\hat{z})$

28. Two identical point charges of mass m and charge are separated by a distance d and are moving at a relative speed u. what is their relative speed when they are at a large distance from each other.
(1) $\sqrt{y^2-Q^2/\pi\varepsilon_0 md}$ (2) $\sqrt{u^2+2Q^2/\pi\varepsilon_0 md}$
(3) $\sqrt{u^2+Q^2/\pi\varepsilon_0 md}$ (4) $\sqrt{u^2-2Q^2/\pi\varepsilon_0 md}$

29. A rod of length L with uniform charge density λ per unit length is in the XY-plane and rotating about Z-axis passing through one its edge with an angular velocity $\vec{\omega}$ as shown in the figure below. $(\hat{r},\hat{\phi},\hat{z})$ refer to the unit vectors at Q, $\vec{A}$ is the vector potential at a distance d from the origin O along Z-axis for $d \ll L$ and $\vec{J}$ is the current density due to the motion of the rod. Which one of the following statements is correct



(1) $\vec{J}$ along $\hat{r}$; $\vec{A}$ along $\hat{z}$; $|\vec{A}| \propto \frac{1}{d}$
(2) $\vec{J}$ along $\hat{\phi}$; $\vec{A}$ along $\hat{\phi}$; $|\vec{A}| \propto \frac{1}{d^2}$
(3) $\vec{J}$ along $\hat{r}$; $\vec{A}$ along $\hat{\phi}$; $|\vec{A}| \propto \frac{1}{d^2}$
(4) $\vec{J}$ along $\hat{\phi}$; $\vec{A}$ along $\hat{\phi}$; $|\vec{A}| \propto \frac{1}{d}$

30. At time $t=0$, a charge distribution $\rho(\vec{r},0)$ exists within an ideal homogeneous conductor of permittivity ε and conductivity σ. At a later time $\rho(\vec{r},t)$ is given by
(1) $\rho(\vec{r},t)=\rho(\vec{r},0)\exp\left(-\frac{\sigma t}{\varepsilon}\right)$ (2) $\rho(\vec{r},t)=\frac{\rho(\vec{r},0)}{1+(\sigma t/\varepsilon)^2}$
(3) $\rho(\vec{r},t)=\rho(\vec{r},0)\exp\left[-\left(\frac{\sigma t}{\varepsilon}\right)^2\right]$ (4) $\rho(\vec{r},t)=\rho(\vec{r},0)\exp\frac{\varepsilon}{\sigma t}\sin\left(\frac{\sigma t}{\varepsilon}\right)$

31. The semi-empirical mass formula for the binding energy of nucleus contains a surface correction term. This term depends on the mass number A of the nucleus as
(1) $A^{-1/3}$ (2) $A^{1/3}$ (3) $A^{2/3}$ (4) A

32. A neutron passing through a detector is detected because of
(1) The ionization it produces
(2) The scintillation light it produces
(3) The electron-hole pairs it produces
(4) The secondary particles produced in a nuclear reaction in the detector medium

33. The basic process underlying the neutron β decay is
(1) $d \to u+e^- +\bar{V}_e$ (2) $d \to u+e^-$
(3) $s \to u+e^- +\bar{V}_e$ (4) $u \to d+e^- +\bar{V}_e$

34. In the nuclear shell model the spin parity of ^{15}N is given by

(1) $\frac{1}{2}^-$ (2) $\frac{1}{2}^+$ (3) $\frac{3}{2}^-$ (4) $\frac{3}{2}^+$

35. Match the reactions on the left with the associated interactions on the right

a) $\pi^+ \to \mu^+ + \nu_\mu$ (i) Strong

b) $\pi^0 \to \gamma + \gamma$ (ii) Electromagnetic

c) $\pi^0 \to n + \pi^- + p$ (iii) Weak

(1) a-iii, b-ii, c-i (2) a-i, b-ii, c-iii
(3) a-ii, b-i, c-iii (4) a-iii, b-i, c-ii

36. Pick the wrong statement
(1) The nuclear force is independent of electric charge
(2) The Yukawa potential is proportional to $r^{-1}\exp\left(\frac{mc}{h}r\right)$, where r is the separation between two nucleons
(3) The range of nuclear force is of the order of $10^{-15}m - 10^{-14}m$
(4) The nucleons interact among each other by the exchange of mesons

37. In the quark model which one of the following represents a proton?
(1) udd (2) uud (3) $u\bar{b}$ (4) $c\bar{c}$

38. Consider a nucleus with N neutrons and Z protons. If m_p, m_n and BE represents the mass of the proton, the mass of the neutron and the binding energy of the nucleus respectively and c is the velocity of light in free space, the mass of the nucleus is given by
(1) $Nm_n + Zm_p$ (2) $Nm_p + Zm_n$
(3) $Nm_n + Zm_p - \frac{BE}{c^2}$ (4) $Nm_p + Zm_n + \frac{BE}{c^2}$

39. An O^{16} nucleus is spherical and has a charge radius R and a volume $V = \frac{4}{3}\pi R^3$. According to the empirical observation of the charge radii, the volume of the $^{128}_{54}Xe$ nucleus assumed to be spherical is
(1) 8 V (2) 2 V (3) 6.75 V (4) 1.89 V

40. The interaction potential between two quarks separated by a distance r inside a nucleon can be described by (a, b and β are positive constants)

(1) $ae^{-\beta r}$ (2) $\frac{a}{r} + br$ (3) $-\frac{a}{r} + br$ (4) $\frac{a}{r}$

41. According to the single particle nuclear shell model, the spin parity of the ground state of $^{17}_{8}O$ is

(1) $\frac{1}{2}^-$ (2) $\frac{3}{2}^-$ (3) $\frac{3}{2}^+$ (4) $\frac{5}{2}^+$

42. In the $\beta-$decay of neutron $n \to p + e^- + \bar{\nu}_e$, the anti-neutrino $\bar{\nu}_e$ escapes detection. Its existence is inferred from the measurement of
(1) Energy distribution of electrons (2) Angular distribution of electrons
(3) Helicity distribution of electrons (4) Forward backward asymmetry of electrons

43. The isospin and the strangeness of Ω^- Baryon are
(1) $1, -3$ (2) $0, -3$ (3) $1, 3$ (4) $0, 3$

44. The lifetime of an atomic state is 1ns. The natural line width of the spectral line in the emission spectrum of this state is of the order of

(1) $10^{-10}eV$ (2) $10^{-9}eV$ (3) $10^{-6}eV$ (4) $10^{-4}eV$

45. The first three energy levels of $^{228}_{90}Th$ are shown below

4^+ ———————— 187 keV
2^+ ———————— 57.5 keV
0^+ ———————— 0 keV

The expected spin parity and energy of the next level are given by

(1) $(6^+; 400keV)$ (2) $(6^+; 300keV)$ (3) $(2^+; 400keV)$ (4) $(4^+; 300keV)$

46. The quark content of Σ^+, K^-, π^- and ρ is indicated

$|\Sigma^+\rangle = |uus\rangle; |K^+\rangle = |s\bar{u}\rangle; |\pi\rangle = |d\rangle; |p\rangle = |uud\rangle$

In the process, $\pi^+ + p \to K^- + \Sigma^+$, considering strong interactions only, which of the following statements is true?

(1) The process is allowed because $\Delta S = 0$
(2) The process is allowed because $\Delta l_3 = 0$
(3) The process is not allowed because $\Delta S \neq 0$ and $\Delta l_3 = 0$
(4) The process is not allowed because the Baryon number is violated

47. Let $|n\rangle$ and $|p\rangle$ denote the isopin state with $I = \frac{1}{2},\ I_3 = \frac{1}{2}$ and $I = \frac{1}{2}, I_3 = -\frac{1}{2}$ of a nucleon respectively. Which one of the following two-nucleon states has $I = 0, I_3 = 0$?

(1) $\frac{1}{\sqrt{2}}(|nn\rangle - |pp\rangle)$ (2) $\frac{1}{\sqrt{2}}(|nn\rangle + |pp\rangle)$

(3) $\frac{1}{\sqrt{2}}(|np\rangle - |pn\rangle)$ (4) $\frac{1}{\sqrt{2}}(|np\rangle + |pn\rangle)$

48. The four possible configurations of neutrons in the ground state of $^{9}_{4}Be$ nucleus according to the shell model, and the associated nuclear spin are listed below. Choose the correct one

(1) $(1s_{1/2})^2(1p_{3/2})^3; J = \frac{3}{2}$ (2) $(1s_{1/2})^2(1p_{1/2})^2(1p_{3/2})^1; J = \frac{3}{2}$

(3) $(1s_{1/2})^1(1p_{3/2})^4; J = \frac{1}{2}$ (4) $(1s_{1/2})^2(1p_{3/2})^2(1p_{1/2})^1; J = \frac{1}{2}$

49. The mass difference between the pair of mirror nuclei $^{11}_{6}C$ and $^{11}_{5}B$ is given to be $\Delta MeV/c^2$. According to the semi-empirical mass formula, the mass difference between the pair of mirror nuclei $^{17}_{9}F$ and $^{17}_{8}O$ will approximately be (rest mass of proton $m_p = 938.27MeV/c^2$ and rest mass of neutron $m_n = 939.57MeV/c^2$)

(1) $1.39\Delta MeV/c^2$ (2) $(1.39\Delta + 0.5)MeV/c^2$

(3) $1.86\Delta MeV/c^2$ (4) $(1.6\Delta + 0.78)MeV/c^2$

50. A heavy nucleus is found to contain more neutrons than protons. This fact is related to which one of the following statements.

(1) The nuclear force between neutron is stronger than that between protons
(2) The nuclear force between protons is of a shorter range than those between neutrons, so that a smaller number of protons are held together by the nuclear force
(3) Protons are unstable so their number in a nucleus diminishes
(4) It costs more energy to add a proton to a (heavy) nucleus than a neutron because of the coulomb repulsion between protons