# ATOMIC STRUCTURE

## INTRODUCTION

**1.** Rutherford's $\alpha$-particle scattering experiment proved that atom has :-

(1) Electrons (2) Neutrons
(3) Nucleus (4) Orbitals

**2.** Find out the atoms which are isoneutronic :-

(1) $^{14}_{6}C$, $^{15}_{7}N$, $^{17}_{9}F$ (2) $^{12}_{6}C$, $^{14}_{7}N$, $^{19}_{9}F$
(3) $^{14}_{6}C$, $^{14}_{7}N$, $^{17}_{9}F$ (4) $^{14}_{6}C$, $^{14}_{7}N$, $^{19}_{9}F$

**3.** Species which are isoelectronic to one another are

(a) $CN^-$ (b) $OH^-$ (c) $CH_3^+$ (d) $N_2$
(e) CO

Correct answer is :–

(1) a, b, c (2) a, c, d (3) a, d, e (4) b, c, d

**4.** Which of the following pairs is correctly matched :

(1) Isotopes $^{40}_{20}Ca$, $^{40}_{19}K$
(2) Isotones $^{30}_{14}Si$, $^{31}_{15}P$, $^{32}_{16}S$
(3) Isobars $^{16}_{8}O$, $^{17}_{8}O$, $^{18}_{8}O$
(4) Isoelectronic $N^{-3}$, $O^{-2}$, $Cr^{+3}$

**5.** The atom A, B, C have the configuration
A $\rightarrow$ [Z(90) + n(146)], B $\rightarrow$ [Z(92) + n(146)], C $\rightarrow$ [Z(90) + n(148)] So that :-

(a) A and C - Isotones (b) A and C - Isotopes
(c) A and B - Isobars (d) B and C - Isobars
(e) B and C - Isotopes

The wrong statements are:-

(1) a, b only (2) c, d, e only
(3) a, c, d only (4) a, c, e only

**6.** The relative abundance of two rubidium isotopes of atomic weights 85 and 87 are 75% and 25% respectively. The average atomic weight of rubidium is:–

(1) 75.5 (2) 85.5 (3) 86.5 (4) 87.5

**7.** Atomic weight of Ne is 20.2. Ne is mixture of $^{20}Ne$ and $^{22}Ne$, relative abundance of heavier isotope is :-

(1) 90 (2) 20 (3) 40 (4) 10

**8.** The value of planck's constant is $6.63 \times 10^{-34}$ Js. The velocity of light is $3.0 \times 10^8$ m $s^{-1}$. Which value is closest to the wavelength in metres of a quantum of light with frequency of $8 \times 10^{15}$ $s^{-1}$ ?

(1) $3 \times 10^{7}$ (2) $2 \times 10^{-25}$
(3) $5 \times 10^{-18}$ (4) $3.75 \times 10^{-8}$

**9.** If change in energy ($\Delta E$) = $3 \times 10^{-8}$ J, h = $6.64 \times 10^{-34}$ J-s and c = $3 \times 10^8$ m/s, then wavelength of the light is :-

(1) $6.64 \times 10^3$ Å (2) $6.64 \times 10^5$ Å
(3) $6.64 \times 10^{-8}$ Å (4) $6.64 \times 10^{18}$ Å

## BOHR'S ATOMIC MODEL

**10.** Angular momentum in second Bohr orbit of H-atom is x. Then find out angular momentum in Ist excitetd state of $Li^{+2}$ ion :

(1) 3x (2) 9x (3) $\frac{x}{2}$ (4) x

**11.** The radius of a shell for H-atom is 4.761A°. The value of n is :-

(1) 3 (2) 9 (3) 5 (4) 4

**12.** The velocity of electron in third excited state of $Be^{3+}$ ion will be :–

(1) $\frac{3}{4}(2.188 \times 10^8)$ $ms^{-1}$ (2) $\frac{3}{4}(2.188 \times 10^6)ms^{-1}$
(3) $(2.188 \times 10^6)$ $Kms^{-1}$ (4) $(2.188 \times 10^3)$ $Kms^{-1}$

**13.** According to Bohr theory, the radius (r) and velocity (v) of an electron vary with the increasing principal quantum number 'n' as :-

(1) r increases, v decreases
(2) r and v both increases
(3) r & v both decreases
(4) r decreases, v increases

**14.** The ratio of radius of first orbit in hydrogen to the radius of first orbit in deuterium will be :-

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

**15.** The energy of second Bohr orbit of the hydrogen atom is –328 kJ/mol. Hence the energy of fourth Bohr orbit should be :

(1) –41 kJ/mol (2) –1312 kJ/mol
(3) –164 kJ/mol (4) –82 kJ/mol

**16.** The ratio between kinetic energy and the total energy of the electron of hydrogen atom according to Bohr's model is :-

(1) 2 : 1 (2) 1 : 1 (3) 1 : –1 (4) 1 : 2

**17.** Maximum frequency of emission is obtained for the transition :–

(1) n = 2 to n = 1 (2) n = 6 to n = 2

(3) n = 1 to n = 2 (4) n = 2 to n = 6

**18.** The radiation of low frequency will be emitted in which transition of hydrogen atom :–

(1) n = 1 to n = 4 (2) n = 2 to n = 5

(3) n = 3 to n = 1 (4) n = 5 to n = 2

**19.** A single electron orbits a stationary nucleus (z = 5). The energy required to excite the electron from third to fourth Bohr orbit will be :-

(1) 4.5 eV (2) 8.53 eV

(3) 25 eV (4) 16.53 eV

**20.** Which of the following is a correct relationship :-

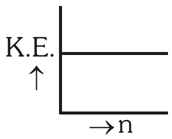
(1) $E_1$ of H = 1/2 $E_2$ of $He^+$ = 1/3 $E_3$ of $Li^{+2}$ = 1/4 $E_4$ of $Be^{+3}$

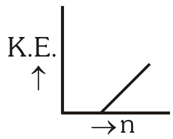
(2) $E_1$ (H) = $E_2$ ($He^+$) = $E_3$ ($Li^{+2}$) = $E_4$ ($Be^{+3}$)

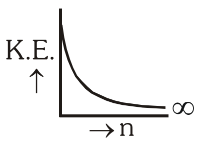
(3) $E_1$ (H) = 2 $E_2$ ($He^+$) = 3 $E_3$ ($Li^{+2}$) = 4 $E_4$ ($Be^{+3}$)

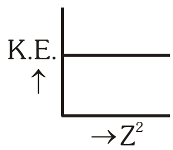
(4) No relation

**21.** Which of the following is a correct graph :-

(1) 


(2) 


(3) 


(4) 


**22.** The ionisation potential of the hydrogen atom is 13.6 eV. The energy needed to ionise a hydrogen atom which is in its second excited state is about:-

(1) 13.6 eV (2) 10.2 eV

(3) 3.4 eV (4) 1.5 eV

**23.** The ionisation potential of a singly ionised helium ion is equivalent to :-

(1) Kinetic energy of first orbit

(2) Energy of last orbit

(3) Average energy in orbits

(4) Maximum energy in orbits

## SPECTRUM AND SPECTRAL LINES

**24.** The spectrum of He is expected to be similar to that of :-

(1) H (2) Na (3) $He^+$ (4) $Li^+$

**25.** Which one of the following electron transitions between energy levels produces the line of shortest wavelength in hydrogen spectrum ?

(1) $n_2 \rightarrow n_1$ (2) $n_3 \rightarrow n_1$

(3) $n_4 \rightarrow n_1$ (4) $n_4 \rightarrow n_3$

**26.** Find out ratio of following for photon

$$(\nu_{max.})_{Lyman} : (\nu_{max})_{Brakett}$$

(1) 1 : 16 (2) 16 : 1 (3) 4 : 1 (4) 1 : 4

**27.** If the shortest wavelength of Lyman series of H atom is x, then the wave length of first line of Balmer series of H atom will be :-

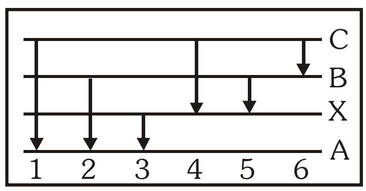
(1) $\frac{9x}{5}$ (2) $\frac{36x}{5}$ (3) $\frac{5x}{9}$ (4) $\frac{5x}{36}$

**28.** The first emission line in the H-atom spectrum in the Balmer series will have wave number :-

(1) $\frac{5R}{36}$ $cm^{-1}$ (2) $\frac{3R}{4}$ $cm^{-1}$

(3) $\frac{7R}{144}$ $cm^{-1}$ (4) $\frac{9R}{400}$ $cm^{-1}$

**29.** The figure indicates the energy level diagram for the origin of six spectral lines in emission spectrum (e.g. line no. 5 arises from the transition from level B to X) which of the following spectral lines will not occur in the absorption spectrum :-




(1) 1, 2, 3

(2) 3, 2

(3) 4, 5, 6

(4) 3, 2, 1

## DE-BROGLIE CONCEPT AND HEISENBERG PRINCIPLE

**30.** An electron has a kinetic energy of $2.8 \times 10^{-23}$ J. de-Broglie wavelength will be nearly :- ($m_e$ = $9.1 \times 10^{-31}$ kg)

(1) $9.28 \times 10^{-24}$ m (2) $9.28 \times 10^{-7}$ m

(3) $9.28 \times 10^{-8}$ m (4) $9.28 \times 10^{-10}$ m

**31.** Number of waves in fourth orbit :–

(1) 4 (2) 5 (3) 0 (4) 1

**32.** What is the ratio of the de-Broglie wavelengths for electrons accelerated through 200 volts and 50 volts :-

(1) 1 : 2 (2) 2 : 1

(3) 3 : 10 (4) 10 : 3

**33.** A particle X moving with a certain velocity has a debroglie wavelength of 1Å. If particle Y has a mass of 25% that of X and velocity 75% that of X, de-Broglie wavelength of Y will be :-

(1) 3Å (2) 5.33 Å

(3) 6.88 Å (4) 48 Å

**34.** The uncertainity in position of an electron & helium atom are same. If the uncertainity in momentum for the electron is $32 \times 10^5$ , then the uncertainity in momentum of helium atom will be

(1) $32 \times 10^5$ (2) $16 \times 10^5$

(3) $8 \times 10^5$ (4) None

**35.** Calculate the uncertainty in the position of an electron (mass $9.1 \times 10^{-28}$g) moving with a velocity of $3 \times 10^4$ cm $sec^{-1}$, if the uncertainity in velocity is 0.011% ?

(1) 1.92 cm (2) 7.68 cm

(3) 0.175 cm (4) 3.84 cm

**36.** What should be the momentum (in gram centimetre per second) of a particle if its de-Broglie wavelength is 1Å and the value of h is $6.6252 \times 10^{-27}$ erg second ?

(1) $6.6252 \times 10^{-19}$ gcm/s

(2) $6.6252 \times 10^{-21}$ gcm/s

(3) $6.6252 \times 10^{-24}$ gcm/s

(4) $6.6252 \times 10^{-27}$ gcm/s

**37.** What should be the mass of the photon of sodium if its wavelength is 5894Å, the velocity of light is $3 \times 10^8$ metre/second and the value of h is $6.6252 \times 10^{-34}$ kg $m^2$/s ?

(1) $3.746 \times 10^{-26}$ kg (2) $3.746 \times 10^{-30}$ kg

(3) $3.746 \times 10^{-34}$ kg (4) $3.746 \times 10^{-36}$ kg

**38.** Which of the following has least de-Broglie $\lambda$ ?

(1) $e^-$ (2) p (3) $CO_2$ (4) $SO_2$

## QUANTUM NUMBERS

**39.** The following quantum no. are possible for how many orbitals n = 3, $\ell$ = 2, m = +2 ?

(1) 1 (2) 2 (3) 3 (4) 4

**40.** Which sub–shell is not permissible :–

(1) 2d (2) 4f (3) 6p (4) 3s

**41.** Which of the following is correct for a 4d–electron

(1) n = 4, $\ell$ = 2, $s = +\frac{1}{2}$

(2) n = 4, $\ell$ = 2, s = 0

(3) n = 4, $\ell$ = 3, s = 0

(4) n = 4, $\ell$ = 3, $s = +\frac{1}{2}$

**42.** Which statement is not correct for n = 5, m = 2 :-

(1) $\ell$ = 4

(2) $\ell$ = 0, 1,2,3 ; s = + 1/2

(3) $\ell$ = 3

(4) $\ell$ = 2, 3, 4

**43.** Spin angular momentum for electron :-

(1) $\sqrt{s(s+1)}\ \frac{h}{2\pi}$ (2) $\sqrt{2s(s+1)}\ \frac{h}{2\pi}$

(3) $\sqrt{s(s+2)}\ \frac{h}{2\pi}$ (4) None

**44.** $_{36}Kr$ has the electronic configuration ($_{18}Ar$) $4s^2$ $3d^{10}$ $4p^6$. The 39th electron will go into which one of the following sub-levels :-

(1) 4f (2) 4d (3) 3p (4) 5s

## RULES FOR FILLING OF ORBITALS

**45.** Which configuration does not obey pauli's exclusion principle :-

(1) [↑↓] [↑][ ][ ] (2) [↑↓] [↑↑] [↑][ ][ ]

(3) [↑↓] [↑↓] [↑↓][↑][ ] (4) [↑↓] [↑↓] [↑][↑][ ]

**46.** Which of the following configuration follows the Hund's rule :–

(1) [He] 2s [↑↓] 2p [↑][↑][ ] (2) [He] 2s [↑↓] 2p [↑↓][↑][ ]

(3) [He] 2s [↑↓] 2p [↑][↑↓][ ] (4) [He] 2s [↑↓] 2p [↓][↑][ ]

**47.** n and $\ell$ values of an orbital 'A' are 3 and 2 and for another orbital 'B' are 5 and 0. The energy of :-

(1) B is more than A

(2) A is more than B

(3) A and B are of same energy

(4) None

**48.** Electronic configuration [↑↓] [↑↓] [↑↓|↑↓| ] has violated :–

(1) Hund's rule (2) Pauli's principle

(3) Aufbau principle (4) (n + $\ell$) rule

**49.** Which of the following set of quantum numbers is correct for the 19th electron of Chromium :-

| | n | $\ell$ | m | s |
|---|---|---|---|---|
| (1) | 3 | 0 | 0 | 1/2 |
| (2) | 3 | 2 | –2 | 1/2 |
| (3) | 4 | 0 | 0 | 1/2 |
| (4) | 4 | 1 | –1 | 1/2 |

**50.** An atom of Cr [Z = 24] loses 2 electrons. How many unpaired electrons shall be there in $Cr^{+2}$ :

(1) 4 (2) 3 (3) 2 (4) 1

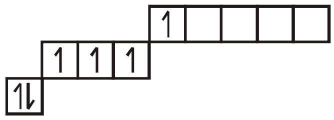
**51.** The atomic number of an element is 17, the number of orbitals containing electron pairs in the valence shell is:-

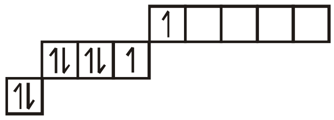
(1) 8 (2) 2 (3) 3 (4) 6

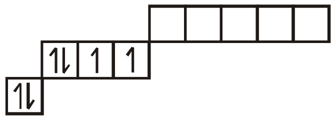
**52.** The atomic number of the element having maximum number of unpaired 3p electrons is (in ground state):-

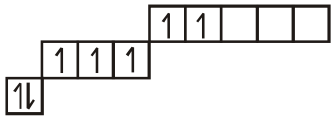
(1) 15 (2) 10 (3) 12 (4) 8

**53.** Which one represent ground state configuration :-

(1) 

(2) 

(3) 

(4) 

**54.** The number of electrons in the M-shell of the element with atomic number 24 is :-

(1) 24 (2) 12 (3) 8 (4) 13

# SOLUTION

## ATOMIC STRUCTURE

**1.** Rutherfords $\propto$ particle
Scattering proved existance of nucleous at center of atom.

**2.** Isoneutronic : Same no. of neutron.
i.e. $6^{14}_{C}$ = 14 – 6 = 8 neutron
$7^{15}_{N}$ = 15 – 7 = 8 neutron
$9^{17}_{F}$ = 17 – 9 = 8 neutron

**3.** isolectronic : Same no. of $e^-$
i.e $CN^-$ : 6 + 7 + 1 = 14 $e^-$
$N_2$ : 7 + 7 = 14 $e^-$
CO : 6 + 8 = 14 $e^-$

**4.** Isotopes : same no. of Z
Isotones : same no. of neutron
Isobars : same mass number
isoelectronic : same no. of $e^-$

**5.** A & C are not isotones
A & B are not isobars
B & C are not isotopes

**6.** Av. atomic ωt $\frac{85\times75+87\times25}{75+25}$
= 85.5

**7.** Let havier $^{22}Ne$ has relative abundance is x %
Av. Atomic ωt = $\frac{x\times22+(100-x)20}{100}$
20.2 = $\frac{x\times22+(100-x)20}{100}$
x = 10

**8.** $\nu=\frac{C}{\lambda} \Rightarrow \lambda=\frac{C}{\nu}=\frac{3\times10^8 m/sec}{8\times10^{15} sec^{-1}}$
= 3.75 × $10^{-8}$ m

**9.** $\Delta E=\frac{hc}{\lambda} \Rightarrow 3\times10^{-8} = \frac{6.64\times10^{-34}\times3\times10^8}{\lambda}$
λ = 6.64 × $10^{-18}$ m
= 6.64 × $10^{-8}$ A°

**10.** $(mvr)_{2nd\ bohr\ orbit}$ of H = x = 2 × $\hbar$
$(mvr)_{2nd\ bohr\ orbit}$ of $Li^{2+}$ = 2 × $\hbar$ = x

**11.** $r_n$ = (0.53A°) $\frac{n^2}{z}$
4.761 A° = (0.53Å) $\frac{n^2}{1}$ (Z=1)
n = 3

**12.** $3^{rd}$ excited state n = 4
$v_n(Be^{3+})=(2.188\times10^6 m/sec)\frac{Z}{n}$
= (2.188 × $10^6$) × $\frac{4}{4}$ m/sec
= 2.188 × $10^3$ km/sec

**13.** $r_n \propto n^2$
$v_n \propto \frac{1}{n}$

**14.** ${}^1_1H \Rightarrow Z_1$ = 1
$1^2D \Rightarrow Z_2$ = 1
$r_n \propto \frac{n^2}{z}$
$\frac{r_1(H)}{r_1(D)}=\frac{1}{1}$

**15.** $E_n=(-13.6eV)\frac{z^2}{n^2}$
$\frac{E_2}{E_4}=\frac{4^2}{2^2} \Rightarrow \frac{-328kJ/mole}{E_4}=4$
$E_4$ = –82 kJ/mole

**16.** $E_{total} = -E_{KE}$
So $\frac{E_{KE}}{E_{total}}=\frac{1}{-1}$
$E_{KE}$ : Etotal = 1 : –1

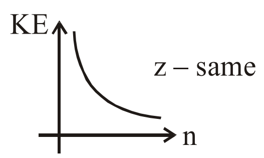
**17.** $\nu_{max} \propto \Delta E_{max}$ (emmision)
n = 2 to n = 1

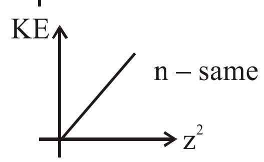
**18.** $\nu_{min} \propto \Delta E_{min}$ (emmision)
n = 5 to n = 2

**19.** $\Delta E = E_4 - E_3$
= –13.6eV $\left(\frac{1}{4^2}-\frac{1}{3^2}\right).5^2$
= 16.53 eV

**20.** $E_n=(-13.6ev)\frac{z^2}{n^2}$
So $E_1(H) = E_2(He^+) = E_4(Be^{3+})$

**21.** KE = $-E_n$ = (13.6eV) $\frac{z^2}{n^2}$

K.E vs n



KE vs $z^2$


**22.** $(I.E.)_n = \frac{(I.E_H)_1}{n^2}$

$(IE)_3 = \frac{13.6eV}{3^2} = 1.51eV$

**23.** $(I\ E_{He^+}) = (13.6\ eV) \times 2^2$
$= -E_1(He^+)$
$= KE_1(He^+)$

**24.** He ; N(e) = 2 ; $1s^2$
Li+ ; N(e) = 2 ; $1s^2$
So expected spectrum is similar

**25.** $\lambda_{shortest} \propto \frac{1}{\nu_{max}} \propto \frac{1}{\Delta E_{max}}$
$n_4$ to $n_1$

**26.** $\frac{(\nu_{max})_{Lymen}}{(\nu_{max})_{Bracket}} = \frac{(\Delta E_{max})_{Lymen}}{(\Delta E_{man})_{Bracket}} = \frac{\Delta E_{\infty to1}}{\Delta E_{\infty to4}}$

$$= \frac{-13.6eV\left(\frac{1}{\infty^2} - \frac{1}{1^2}\right)}{-13.6eV\left(\frac{1}{\infty^2} - \frac{1}{4^2}\right)}$$

$= \frac{16}{1}$

**27.** $\frac{1}{\lambda} = RZ^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

Shortest wavelength of lymen

$\frac{1}{x} = R(1)^2\left(\frac{1}{1^2} - \frac{1}{\infty^2}\right)$ ......(i)

1st line of balmer series.

$\frac{1}{\lambda} = R(1)^2\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$ ......(ii)

(i) / (ii)

$\frac{\lambda}{x} = \frac{1}{5/36}$

$\lambda = \frac{36x}{5}$

**28.** $\frac{1}{\lambda} = R(1)^2\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$

1st line in balmer series

$\bar{\nu} = \frac{1}{\lambda} = \frac{5R}{36}\ cm^{-1}$

**29.** Absorption spectrum take place from A level to uper level So 4, 5, 6 lines not possible.

**30.** $\lambda_{De.brog} = \frac{h}{\sqrt{2m\,k\varepsilon}} = \frac{6.62 \times 10^{-34}}{\sqrt{(2 \times 9.1 \times 10^{-31} \times 2.8 \times 10^{-23})}}$

$= 9.28 \times 10^{-8}$ m

**31.** $(mvr)_4 = 4.\frac{h}{2\pi}$
So number of wave = 4

**32.** $\lambda_{De.\ brog\ for\ e^-} = \sqrt{\frac{150}{V}}$ Å

$\frac{(\lambda_{e^-})_1}{(\lambda_{e^-})_2} = \sqrt{\frac{v_2}{v_1}} = \sqrt{\frac{50}{200}} = \frac{1}{2}$

**33.** $\frac{\lambda_{Debrog}(x)}{\lambda_{De.brog}(y)} = \frac{(h/mv)_x}{(h/mv)_y} = \frac{(mv)_y}{(mv)_x}$

$$= \frac{\frac{25}{100} \times m_x \times \frac{75}{100} \times v_x}{m_x v_x}$$

$\frac{1A°}{\lambda_{De.brog(y)}} = \frac{3}{16}$

$\lambda_{De\,brag}(y) = \frac{16}{3}A°$
$= 5.33A°$

**41.** 4d $e^-$
n = 4
$\ell$ = 2
$S = \pm\frac{1}{2}$

**42.** for n = 5 ; m = 2
$\ell$ may be 2, 3, 4

**43.** Spin angular momentum of $e^- = \sqrt{s(s+1)}\frac{h}{2\pi}$

**44.** $36^{Kr}$ : $18^{Ar}$ : $4s^2$ $3d^{10}$, $4p^6$
$39^{th}$ $e^-$ goes in to 4d

**45.** Pauli's exclusion principle: No two $e^-$ have some spin in any orbital

**46.** Hund's Rule; Maximum multiplicity

**47.** $(n + \ell)_A = 3 + 2 = 5$
$(n + \ell)_B = 5 + 0 = 5$
$n_B > n_A$ so $E_B < E_A$

**48.** Configuration voilating Hund Rule

**49.** $19^{th}$ $e^-$ of $24^{Cr}$ : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^5$

n = 4; $\ell$ = 0 ; m = 0 ; $s = \pm\frac{1}{2}$

**50.** $_{14}Cr^{2+}$ : no. of unpaired $e^-$ = 4

**51.** 17 : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$
Orbitals in valence shell containing $e^-$ hair =3

**52.** 15 : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$

**53.** Without complete pairing in P orbital d orbital can not filled.

**54.** M-shell means n = 3
24 : $1s^2$, $1s^2$, $2p^6$, $3s^2$, $3p^6$, $4s^1$, $3d^5$ N(e) = 13