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02. Atomic Structure

Official PMDC Solved Past Paper Topical Booklet • High-Yield Examination Series

🎯 94 Solved Questions

📅 2010 to 2024 Archive

🛡️ Boards: BUMHS, DUHS, KMU, MDCAT, NUMS, PMDC

📊 Weightage: 27% of MDCAT (54 MCQs)

Curated by Ibrahim for fellow bees. Every question in this chapter has been verified against official UHS, NUMS, SZABMU, DUHS, and KMU answer keys. Propolis cognitive autopsies are provided at the end of this booklet to explain core concepts and break down common distractor traps.

OFFICIAL SOLVED EDITION**Q1.**

UHS 2024

The p orbital has

- (A) 2 lobes
- (B) 3 lobes
- (C) 4 lobes
- (D) 5 lobes

Q2.

UHS 2024

Which of the following electronic configuration is correct for carbon?

- (A) $1s^2, 2s^2, 2p^3$
- (B) $1s^2, 2s^2, 2p^4$
- (C) $1s^2, 2s^2, 2p^2$
- (D) $1s^2, 2s^2, 2p^1$

Q3.

SZABMU 2024

The e/m ratio of proton is ____ that of an electron.

- (A) 1837 times greater than
- (B) Equal to
- (C) Greater than
- (D) Smaller than

Q4.

SZABMU 2024

How many electrons will be accommodated in sub-shell with Azimuthal quantum number $l = 2$?

- (A) 2
- (B) 6
- (C) 10
- (D) 12

Q5.

SZABMU 2024

Which of the following element will show electronic configuration of outermost shell like ns^2, np^5 ?

- (A) C
- (B) Cl
- (C) S
- (D) Si

Q6.

SZABMU 2024

(Deleted) Electronic configuration of ${}_{11}\text{Na}^{23}$ is

- (A) $[\text{Ne}]3s^1$
- (B) $[\text{Ne}]3s^2$
- (C) $[\text{Ne}]3s^0$
- (D) $[\text{Ne}]3s^23p\dots$

Q7.

KMU 2024

Which of the following sub-shell does not exist?

- (A) $1p$
- (B) $1s$
- (C) $5d$
- (D) $6f$

Q8.

KMU 2024

The splitting of spectral lines in magnetic field is

- (A) Auf-Bau principle
- (B) Pauli's exclusion principle
- (C) Stark effect
- (D) Zeeman effect

Q9.

DUHS 2024

"In an orbital of an atom, no two electrons can have the same set of four quantum numbers, at least one quantum number must be different." This statement is:

- (A) Aufbau principle
- (B) Pauli's exclusion principle
- (C) Hund's rule
- (D) Wiswesser rule

Q10.

DUHS 2024

Maximum number of electrons in a given sub-shell are calculated by:

- (A) n^2
- (B) $2(n + 1)$
- (C) $2n^2$
- (D) $2l + 1$

Q11.

DUHS 2024

The neutron was discovered by

- (A) Max Planck
- (B) Chadwick
- (C) J.J. Thomson
- (D) Goldstein

Q12.

BUMHS 2024

The charge of electron is:

- (A) $1.602 \times 10^{-16} \text{ C}$
- (B) $1.602 \times 10^{-19} \text{ C}$
- (C) $1.602 \times 10^{-17} \text{ C}$
- (D) $1.602 \times 10^{-18} \text{ C}$

Q13.

BUMHS 2024

Which statement is not correct for cathode rays?

- (A) Cathode rays consist of moving material particles
- (B) Cathode rays have definite velocity
- (C) Cathode rays produce fluorescence
- (D) Cathode rays travel with the velocity of light

Q14.

BUMHS 2024

An electron in an atom is completely describe by its ____ quantum numbers

- (A) Eight
- (B) Six
- (C) Five
- (D) Four

Q15.

BUMHS 2024

One picometer (pm) = ?

- (A) 10^{-6} m
- (B) 10^{-8} m
- (C) 10^{-10} m
- (D) 10^{-12} m

Q16.

BUMHS 2024

The only group of lines occurring in the visible region of the hydrogen spectrum is labelled as the

- (A) Paschen series
- (B) Pfund series
- (C) Balmer series
- (D) Lyman series

Q17.

BUMHS 2024

Select the correct one

- (A) Only electrons of atoms get shuffled during chemical reaction
- (B) All the sub-atomic particles of an atom take part in chemical reaction
- (C) Protons of an atom spearhead chemical reaction
- (D) Protons and neutrons of an atom collectively make chemical reactions possible

Q18.

NUMS 2024

The value of " l " for $4p$ orbital is:

- (A) 0
- (B) 1
- (C) 2
- (D) 3

Q19.

NUMS 2024

The element having the electronic configuration of noble gas notation $(\text{Kr})5s^2 4d^6$ is:

- (A) $_{38}\text{Sr}$
- (B) $_{44}\text{Ru}$
- (C) $_{46}\text{Pd}$
- (D) $_{40}\text{Zr}$

Q20.

NUMS 2024

Choose the allowed sets of quantum numbers from the following:

- (A) $n = 3, l = 2, m = 0, s = +1/2$
- (B) $n = 3, l = 3, m = 0, s = -1/2$
- (C) $n = 4, l = 3, m = 4, s = +1/2$
- (D) $n = 4, l = 2, m = 4, s = -1/2$

Q21.

UHS 2023

What is the proton (Atomic Number) of an element that has four unpaired electrons in its ground state?

- (A) 6
(B) 22
(C) 14
(D) 26

Q22.

UHS 2023

When $6d$ orbital is filled, the entering electron goes into?

- (A) $7f$
(B) $7d$
(C) $7p$
(D) $7s$

Q23.

SZABMU 2023

Which of the following orbital will be filled first than $4p$?

- (A) $4s$
(B) $2p$
(C) $3d$
(D) $1s$

Q24.

SZABMU 2023

If value of azimuthal quantum number is 1 then value of m will range from:

- (A) -1 to 1
(B) -1 to 2
(C) -1 to 3
(D) -1 to 4

Q25.

SZABMU 2023

The dumbbell like orbitals can move in how many directions?

- (A) 7
(B) 5
(C) 1
(D) 3

Q26.

SZABMU 2023

The relationship between quantum number n and l is:

- (A) $n = l - 1$
(B) $l = n - 2$
(C) $l = n - 1$
(D) $n = l - 2$

Q27.

KMU 2023

The number of orientations of a sub-shell for which $n = 4$ and $l = 3$ will be:

- (A) 5
(B) 3
(C) 7
(D) 1

Q28.

KMU 2023

Photon of the lowest wavelength is related to:

- (A) Balmer series
(B) Pfund series
(C) Bracket series
(D) Paschen series

Q29.

KMU 2023

The maximum e/m ratio for positive rays is obtained when the discharge tube contains:

- (A) He
(B) N_2
(C) Ne
(D) H_2

Q30.

KMU 2023

The correct sequence of electronic configuration is:

- (A) $4p, 5s, 4d, 5p, 6s, 4f, 5d$
(B) $4p, 4s, 4d, 5p, 6s, 4f, 6d$
(C) $4p, 4s, 4d, 5p, 5s, 4f, 5d$
(D) $4p, 3s, 4d, 5p, 6s, 4f, 5d$

Q31.

DUHS 2023

Radius of first orbit of hydrogen is $0.53\text{\AA}$. Which orbit has a radius of $4.77\text{\AA}$?

- (A) First
(B) Second
(C) Third
(D) Fourth

Q32.

DUHS 2023

Which of the following has only one orientation in space, in the magnetic field?

- (A) p orbital
(B) s orbital
(C) d orbital
(D) f orbital

Q33.

DUHS 2023

What's the mass of one proton?

- (A) Equal to 1836 electron
- (B) Equal to positron
- (C) Equal to electron
- (D) Equal to 1836 neutron

Q34.

BUMHS 2023

What is the quantum number for the unpaired electron of chlorine atom (n, l, m)?

- (A) 2, 1, 0
- (B) 2, 1, 1
- (C) 3, 1, 1
- (D) 3, 0, 0

Q35.

BUMHS 2023

Which statement about a 4d orbital is correct?

- (A) It is at a higher energy level than a 4p orbital but has the same shape
- (B) It is occupied by one electron in an isolated Zn atom
- (C) It can hold a maximum of 10 electrons
- (D) It has highest energy of orbitals with principal quantum number four

Q36.

BUMHS 2023

Which of the following is not true about canal rays?

- (A) 1.6726×10^{-27} kg
- (B) 9.54×10^7 C/kg
- (C) Show deflection under electric & magnetic fields
- (D) Do not cause mechanical motion

Q37.

BUMHS 2023

Why do electrons have opposite spins when they are in the same orbital?

- (A) This condition reduces friction
- (B) This condition creates more energy
- (C) This condition results in zero magnetism and removes the charge of the electron
- (D) This condition results in less repulsion and opposite magnetic fields

Q38.

NUMS 2023

The amount of energy associated with quantum of radiation of directly proportional to:

- (A) Photon
- (B) Wavelength
- (C) Frequency
- (D) Velocity

Q39.

NUMS 2023

If value of azimuthal quantum number is 2 then total values of magnetic quantum number will be:

- (A) 03
- (B) 05
- (C) 07
- (D) 10

Q40.

NUMS 2023

Total number of directions of f-orbitals in space are:

- (A) 05
- (B) 03
- (C) 07
- (D) 06

Q41.

NUMS 2023

Which of the following quantum number is not obtained from Schrodinger Wave equation?

- (A) Principal Quantum Number
- (B) Spin Quantum Number
- (C) Azimuthal Quantum Number
- (D) Magnetic Quantum Number

Q42.

NUMS 2023

The electronic configuration for degenerate orbitals is explained by:

- (A) Aufbau Principle
- (B) $n + 1$ rule
- (C) Hund's rule
- (D) Pauli exclusion principle

Q43.

UHS 2022

According to which scientist, the probability of finding an electron at a certain position is possible?

- (A) Bohr
- (B) de-Broglie
- (C) Hund
- (D) Schrodinger

Q44.

UHS 2022

Which gas in the discharge tube produces lightest canal rays particles?

- (A) Ar
- (B) He
- (C) H₂
- (D) Ne

Q45.

UHS 2022

Which element has the ground state electronic configuration of $1s^2, 2s^2, 2p^6, 3s^2, 3p^6$?

- (A) Na
(B) Ar
(C) Cl
(D) S

Q46.

UHS 2022

What is the proton (Atomic Number) of an element that has four unpaired electrons in its ground state?

- (A) 6
(B) 14
(C) 22
(D) 26

Q47.

SZABMU 2022

Principal quantum number is represented by the symbol:

- (A) m
(B) s
(C) n
(D) l

Q48.

SZABMU 2022

Shape of the sub shell is explained by which quantum number:

- (A) Principal quantum number
(B) Magnetic quantum number
(C) Azimuthal quantum number
(D) Spin quantum number

Q49.

SZABMU 2022

The electronic configuration for degenerated orbitals is explained by:

- (A) Aufbau's Principle
(B) $(n + 1)$ rule
(C) Pauli's exclusion principle
(D) Hund's rule

Q50.

SZABMU 2022

Maximum number of electrons which can be placed in one orbital is:

- (A) 1
(B) 3
(C) 2
(D) 5

Q51.

KMU 2022

Greater the wavelength associated with the photon:

- (A) Greater is its energy
(B) Its energy will be variable
(C) Smaller is its energy
(D) Its energy will remains constant

Q52.

KMU 2022

Photon of which of the following series will have largest wavelength?

- (A) Bracket series
(B) Balmer series
(C) Pfund series
(D) Paschan series

Q53.

DUHS 2022

The equation $\bar{\nu} = R_h \left[\frac{1}{2^2} - \frac{1}{n^2} \right]$ where $n > 2$ is the equation of H-spectrum for:

- (A) Paschen series
(B) Lyman series
(C) Balmar series
(D) Pfund series

Q54.

DUHS 2022

The quantum number allows following orbitals in N-shell.

- (A) s - orbital
(B) s & p orbital
(C) s, p, d & f orbital
(D) All options correct

Q55.

BUMHS 2022

If four balloons are filled with different gases, which gas containing balloon will deflate first?

- (A) Helium
(B) Oxygen
(C) Nitrogen
(D) Hydrogen

Q56.

BUMHS 2022

Which concept was introduced by the scientist Bohr?

- (A) Energy levels
(B) Orbitals
(C) Sub-orbits
(D) Sub-energy levels

Q57.

BUMHS 2022

What is the electronic configuration of C?

- (A) $1s^2, 2s^2, 2p^2$
 (B) $1s^2, 2s^2, 2p^4$
 (C) $1s^2, 2s^2, 2p^6, 3s^2$
 (D) $1s^2, 2s^2, 2p^6, 3s^2, 3p^3$

Q58.

BUMHS 2022

Why do electrons have opposite spins. When they are in the same orbital?

- (A) This condition reduces friction
 (B) This condition creates more energy
 (C) This condition results in zero magnetism and removes the charge of the electron
 (D) This condition results in less repulsion and opposite magnetic fields

Q59.

BUMHS 2022

With the increase in the value of principal quantum number " n " the size of the s-orbitals?

- (A) Decrease
 (B) Increase
 (C) May or may not remain the same
 (D) Remain the same

Q60.

NUMS 2022

Maximum electrons that can be placed in p subshell are:

- (A) 2
 (B) 10
 (C) 6
 (D) 14

Q61.

NUMS 2022

Apply $(n + l)$ rule and calculate which of the following orbital has maximum energy?

- (A) $2d$
 (B) $3s$
 (C) $4s$
 (D) $2p$

Q62.

NUMS 2022

The mass of electron is:

- (A) 1836 times more than mass of proton
 (B) 1836 times less than mass of proton
 (C) 1836 times more than mass of neutron
 (D) 1836 time more than mass of hydrogen atom

Q63.

NUMS 2022

The shape of an orbital is determined by which quantum number?

- (A) n
 (B) m
 (C) l
 (D) s

Q64.

NUMS 2022

Proton number of ${}_{11}\text{Na}^{23}$ is:

- (A) 23
 (B) 12
 (C) 11
 (D) 34

Q65.

PMDC 2021

Which of the following has the lowest e/m ratio?

- (A) Li^{2+}
 (B) H^{+1}
 (C) He^{+}
 (D) Be

Q66.

PMDC 2021

M-shell contain:

- (A) s
 (B) s, p, d
 (C) s, p
 (D) s, p, d, f

Q67.

PMDC 2021

Total no. of electrons that can be accommodated in f-subshell:

- (A) 6
 (B) 14
 (C) 10
 (D) $2(2l+1)$

Q68.

PMDC 2021

 $n + l$ value for $5d$ is:

- (A) 5
 (B) 6
 (C) 8
 (D) 7

Q69.

PMDC 2021

Each electron in an atom must have its own unique set of quantum number is a statement of ____

- (A) Aufbau principle
- (B) Hund's rule
- (C) Pauli exclusion principle
- (D) None of these

Q70.

PMDC 2020

The relationship between quantum number n and l is:

- (A) $n = l - 1$
- (B) $l = n - 2$
- (C) $n = l - 2$
- (D) $l = n - 1$

Q71.

PMDC 2020

Quantum number values for " $2p$ " orbitals are:

- (A) $n = 1, l = 0$
- (B) $n = 2, l = 1$
- (C) $n = 2, l = 0$
- (D) $n = 1, l = 2$

Q72.

PMDC 2020

Which pair has 1 electron in its outer most ' s ' orbital?

- (A) Li & Fe
- (B) Na & Cr
- (C) K & Mn
- (D) H & He

Q73.

NUMS 2019

Maximum numbers of electron in a sub-shell is given by:

- (A) $2(2l - 1)$
- (B) $2(l + 1)$
- (C) $2l + 1$
- (D) $2(2l + 1)$

Q74.

NUMS 2019

The order of energy level in $_{19}\text{K}$ is:

- (A) $4s, 4p$
- (B) $4s, 3d$
- (C) $3s, 3d$
- (D) $3p, 4s$

Q75.

SET 2019

Which of the following element in its atomic state has electrons fully occupying first two spherically symmetrical orbitals?

- (A) Oxygen
- (B) Helium
- (C) Carbon
- (D) Beryllium

Q76.

KMU 2019

Quantum number which describes the orientation of orbitals in three dimensional space is:

- (A) Spin quantum number
- (B) Azimuthal quantum number
- (C) Principal quantum number
- (D) Magnetic quantum number

Q77.

MDCAT 2019

Which of the following is the electronic configuration of Cr?

- (A) $[\text{Ar}], 3d^5, 4s^2$
- (B) $[\text{Ar}], 3d^4, 4s^2$
- (C) $[\text{Ar}], 3d^6, 4s^0$
- (D) $[\text{Ar}], 3d^5, 4s^1$

Q78.

MDCAT 2018

Which is the correct electronic configuration of chromium (24Cr)?

- (A) $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^4$
- (B) $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^1, 3d^5$
- (C) $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^6$
- (D) $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^6$

Q79.

MDCAT 2017

Number of electrons in $_{31}^{71}\text{Ga}^{+3}$ will be

- (A) 29
- (B) 30
- (C) 34
- (D) 28

Q80.

MDCAT 2017

Isotopic symbol of ion of Sulphur-33 is $_{16}^{33}\text{S}^{-2}$. How many numbers of protons and neutrons are present if number of electrons are 18?

- (A) $P = 18, n = 15$
- (B) $P = 16, n = 18$
- (C) $P = 16, n = 17$
- (D) $P = 17, n = 16$

Q81.

MDCAT 2017

Among the following, which contains same no. of electrons & proton but different no. of neutron:

- (A) Isobars
(B) Isotopes
(C) Isotones
(D) None of the these

Q82.

MDCAT 2017

Identify the correct option associated with the shape of p-orbital:

- (A) Spherical shape (s-orbital)
(B) Four-lobed cloverleaf shape (d_{xy} -orbital)
(C) Dumbbell shape with donut collar (d_{z^2} -orbital)
(D) Two-lobed dumbbell shape (p_z -orbital)

Q83.

MDCAT 2016

Number of neutrons in ${}^{66}_{30}\text{Zn}$ will be:

- (A) 30
(B) 35
(C) 38
(D) 36

Q84.

MDCAT 2016

The maximum number of electrons in electronic configuration can be calculated by using formula:

- (A) $2l + 1$
(B) $2n^2$
(C) $2n^2 + 2$
(D) $2n^2 + 1$

Q85.

KMU 2016

What are the values of principal quantum number and azimuthal quantum number for the last electron in chlorine atom?

- (A) 1, 6
(B) 1, 3
(C) 6, 1
(D) 3, 1

Q86.

KMU 2016

Which of the following electronic configuration is / are correct?

- (i) ${}_{29}\text{Cu} = 1s^2, 2s^2, 3p^6, 3s^1$
(ii) ${}_{29}\text{Cu} = [\text{Ar}]4s^1 3d^{10}$
(iii) ${}_{24}\text{Cr} = [\text{Ar}]4s^1 3d^{10}$
(iv) ${}_{24}\text{Cr} = [\text{Ar}]4s^2 3d^4$

- (A) (i) only
(B) (ii) only
(C) (i) and (ii) only
(D) (ii) and (iii) only

Q87.

MDCAT 2015

There are four orbitals s, p, d and f . Which order is correct with respect to the increasing energy of the orbitals?

- (A) $4s < 4p < 4d < 4f$
(B) $4s < 4f < 4p < 4d$
(C) $4p < 4s < 4f < 4d$
(D) $4f < 4s < 4d < 4p$

Q88.

MDCAT 2015

Which one of the following pairs has the same electronic configuration as possessed by neon (Ne-10)?

- (A) Na^+, Cl^-
(B) Na^+, Mg^+
(C) K^+, Cl^-
(D) Na^+, F^-

Q89.

MDCAT 2014

According to the number of protons, neutrons and electrons given in the table, which one of the following options is correct?

Species	Proton	Neutron	Electron
As	33	42	30
Ga	31	39	28
Ca	20	20	20

- (A) $\text{As}^{+3}, \text{Ga}, \text{Ca}^{-2}$
(B) $\text{As}^{+3}, \text{Ga}^{+3}, \text{Ca}^{+2}$
(C) $\text{As}^{+3}, \text{Ga}^{+3}, \text{Ca}$
(D) $\text{As}^{+3}, \text{Ga}^{+2}, \text{Ca}$

Q90.

MDCAT 2013

Number of electrons in the outermost shell of chloride ion (Cl^-) is:

- (A) 17
- (B) 7
- (C) 8
- (D) 1

Q91.

MDCAT 2013

Correct order of energy in the given sub-shells is:

- (A) $5s > 3d > 3p > 4s$
- (B) $3p > 3d > 5s > 4s$
- (C) $5s > 3d > 4s > 3p$
- (D) $3p > 3d > 4s > 5s$

Q92.

MDCAT 2012

The relative energies of $4s$, $4p$ and $3d$ orbitals are in the order:

- (A) $4p < 4s < 3d$
- (B) $4p < 3d < 4s$
- (C) $3d < 4p < 4s$
- (D) $4s < 3d < 4p$

Q93.

MDCAT 2012

With increase in the value of principal quantum number " n ", the shape of the s orbitals remains same although their sizes:

- (A) Decrease
- (B) Remain the same
- (C) Increase
- (D) May or may not remain the same

Q94.

MDCAT 2010

Which quantum number tells us about orientation of orbitals?

- (A) Principal quantum number
- (B) Spin quantum number
- (C) Magnetic quantum number
- (D) Azimuthal quantum number

RAPID 5–COLUMN ANSWER KEY

Official PMDC verified answer keys for 02. Atomic Structure.

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Q#	KEY	BOARD	Q#	KEY	BOARD	Q#	KEY	BOARD	Q#	KEY	BOARD	Q#	KEY	BOARD
1	A	UHS 2024	20	A	NUMS 2024	39	B	NUMS 2023	58	D	BUMHS 2022	77	D	MDCAT 2019
2	C	UHS 2024	21	D	UHS 2023	40	C	NUMS 2023	59	B	BUMHS 2022	78	B	MDCAT 2018
3	D	SZABMU 2024	22	C	UHS 2023	41	B	NUMS 2023	60	C	NUMS 2022	79	D	MDCAT 2017
4	C	SZABMU 2024	23	A	SZABMU 2023	42	C	NUMS 2023	61	C	NUMS 2022	80	C	MDCAT 2017
5	B	SZABMU 2024	24	A	SZABMU 2023	43	D	UHS 2022	62	B	NUMS 2022	81	B	MDCAT 2017
6	A	SZABMU 2024	25	D	SZABMU 2023	44	C	UHS 2022	63	C	NUMS 2022	82	D	MDCAT 2017
7	A	KMU 2024	26	C	SZABMU 2023	45	B	UHS 2022	64	C	NUMS 2022	83	D	MDCAT 2016
8	D	KMU 2024	27	C	KMU 2023	46	D	UHS 2022	65	D	PMDC 2021	84	B	MDCAT 2016
9	B	DUHS 2024	28	A	KMU 2023	47	C	SZABMU 2022	66	B	PMDC 2021	85	D	KMU 2016
10	D	DUHS 2024	29	D	KMU 2023	48	C	SZABMU 2022	67	B	PMDC 2021	86	B	KMU 2016
11	B	DUHS 2024	30	A	KMU 2023	49	D	SZABMU 2022	68	D	PMDC 2021	87	A	MDCAT 2015
12	B	BUMHS 2024	31	C	DUHS 2023	50	C	SZABMU 2022	69	C	PMDC 2021	88	D	MDCAT 2015
13	D	BUMHS 2024	32	B	DUHS 2023	51	C	KMU 2022	70	D	PMDC 2020	89	C	MDCAT 2014
14	D	BUMHS 2024	33	A	DUHS 2023	52	C	KMU 2022	71	B	PMDC 2020	90	C	MDCAT 2013
15	D	BUMHS 2024	34	C	BUMHS 2023	53	C	DUHS 2022	72	B	PMDC 2020	91	C	MDCAT 2013
16	C	BUMHS 2024	35	C	BUMHS 2023	54	C	DUHS 2022	73	D	NUMS 2019	92	D	MDCAT 2012
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TOTAL
MCQS

94

CORRECT

INCORRECT

BLANK

ACCURACY

%

Scan the booklet QR code to enter answers in
BeambePrep Grind Mode for automated error
 autopsies.

PROPOLIS COGNITIVE ERROR AUTOPSIES

Step-by-step conceptual derivations, formula working, and distractor autopsies for every question.

Question #1 Key: (A)

UHS 2024

The p orbital has

CORE CONCEPT AND DERIVATION

The geometric shape of an orbital represents the probability boundary where an electron is likely to be found.

Formula: None required.

Solution:

- A p -orbital ($l = 1$) is characterized by a "dumbbell" shape.
- This dumbbell consists of exactly two distinct teardrop-shaped regions called "lobes".
- These two lobes are separated by a nodal plane passing through the nucleus, where the probability of finding an electron is precisely zero.

Why other options are incorrect: d -orbitals typically have 4 lobes (clover shape). 3 and 5 lobes do not correspond to standard orbital geometries.

Question #2 Key: (C)

UHS 2024

Which of the following electronic configuration is correct for carbon?

CORE CONCEPT AND DERIVATION

The electronic configuration maps the exact location of all electrons in an atom based on the Aufbau principle.

Formula:

$$Z = \sum \text{electrons}$$

Solution:

- Carbon (C) is element number 6 on the periodic table, so it has $Z = 6$.
- A neutral atom of Carbon has exactly 6 electrons to place.
- First, the lowest energy level $1s$ gets 2 electrons: $1s^2$.
- Next, the $2s$ orbital gets 2 electrons: $2s^2$.
- There are $6 - 4 = 2$ electrons remaining. These go into the $2p$ subshell: $2p^2$.
- Final configuration: $1s^2, 2s^2, 2p^2$.

Why other options are incorrect: Option A is Nitrogen (7 electrons). Option B is Oxygen (8 electrons). Option D is Boron (5 electrons).

Question #3 Key: (D)

SZABMU 2024

The [Formula] ratio of proton is ____ that of an electron.

CORE CONCEPT AND DERIVATION

The charge-to-mass ratio (e/m) is a fraction where charge is the numerator and mass is the denominator.

Formula:

$$\frac{e}{m} = \frac{\text{Charge}}{\text{Mass}}$$

Solution:

- A proton and an electron have the exact same magnitude of charge (1.602×10^{-19} C). Thus, the numerator is identical for both.
- However, the mass of a proton is approximately 1836 times greater than the mass of an electron.
- Because the proton has a much larger denominator, its overall fraction (e/m ratio) evaluates to a much smaller number.
- Therefore, the e/m ratio of a proton is mathematically smaller than that of an electron.

Why other options are incorrect: It cannot be greater than or equal to an electron's ratio due to the massive difference in mass.

Question #4 Key: (C)

SZABMU 2024

How many electrons will be accommodated in sub-shell with Azimuthal quantum number [Formula] ?

CORE CONCEPT AND DERIVATION

The total electron capacity of a subshell depends on the number of spatial orbitals it contains, with each orbital holding 2 electrons.

Formula:

$$\text{Max Electrons} = 2(2l + 1)$$

Solution:

- An azimuthal quantum number of $l = 2$ specifically denotes a d -subshell.
- First, calculate the number of orbitals: $2(2) + 1 = 5$ orbitals.
- Multiply by 2 electrons per orbital: $5 \times 2 = 10$ electrons.

Why other options are incorrect: 2 is the capacity for an s -subshell ($l = 0$). 6 is the capacity for a p -subshell ($l = 1$). 12 is mathematically invalid for standard quantum configurations.

Question #5 Key: (B)

SZABMU 2024

Which of the following element will show electronic configuration of outermost shell like [Formula] ?

CORE CONCEPT AND DERIVATION

The general outermost electronic configuration ns^2, np^5 indicates there are 7 valence electrons. Elements with 7 valence electrons belong to Group 17 (Halogens).

Formula:

$$\text{Valence electrons} = 2 + 5 = 7$$

Solution:

- Let's check the valence configurations for the options:
- Carbon (C, Group 14): $2s^2, 2p^2$ (4 valence electrons)
- Silicon (Si, Group 14): $3s^2, 3p^2$ (4 valence electrons)
- Sulfur (S, Group 16): $3s^2, 3p^4$ (6 valence electrons)
- Chlorine (Cl, Group 17): $3s^2, 3p^5$ (7 valence electrons)
- Chlorine perfectly matches the ns^2, np^5 pattern.

Why other options are incorrect: They belong to different periodic groups and therefore have different numbers of electrons in their outermost p -subshell.

Question #6 Key: (A)

SZABMU 2024

(Deleted) Electronic configuration of [Formula] is

CORE CONCEPT AND DERIVATION

Noble gas notation simplifies electronic configurations by replacing inner, fully filled shells with the bracketed symbol of the preceding noble gas.

Formula: None required.**Solution:**

- Sodium (Na) has an atomic number $Z = 11$.
- The nearest preceding noble gas is Neon (Ne), which has $Z = 10$.
- Neon's configuration perfectly covers the core electrons: $1s^2, 2s^2, 2p^6$.
- Sodium has one remaining valence electron ($11 - 10 = 1$).
- This final electron enters the next available energy level, which is the $3s$ orbital.
- The condensed configuration is therefore $[\text{Ne}]3s^1$.

Why other options are incorrect: Option B represents Magnesium ($Z = 12$). Option C represents a Sodium ion (Na^+). Option D implies too many electrons.

Question #7 Key: (A)

KMU 2024

Which of the following sub-shell does not exist?

CORE CONCEPT AND DERIVATION

The types of subshells allowed in a principal shell (n) are strictly limited by the rules of the azimuthal quantum number (l).

Formula:

$$l_{\text{max}} = n - 1$$

Solution:

- For the first principal shell ($n = 1$), the only allowed value for l is $1 - 1 = 0$.
- An l value of 0 corresponds exclusively to an s -subshell.
- A p -subshell requires an l value of 1. Since l cannot be equal to n ($1 \neq 1$ in the rules), a $1p$ subshell is a mathematical and physical impossibility.

Why other options are incorrect: $1s$ exists ($n = 1, l = 0$). $5d$ exists ($n = 5, l = 2$). $6f$ exists ($n = 6, l = 3$). All these adhere to the rule $l < n$.

Question #8 Key: (D)

KMU 2024

The splitting of spectral lines in magnetic field is

CORE CONCEPT AND DERIVATION

The fine structure of atomic emission spectra changes when atoms are subjected to external electromagnetic fields.

Formula: None required.**Solution:**

- When an excited atom is placed in a strong magnetic field, its degenerate orbitals orient themselves differently, causing slight shifts in energy.
- This causes a single spectral emission line to split into multiple, closely spaced lines.
- This specific phenomenon, caused by a magnetic field, is called the Zeeman effect.

Why other options are incorrect: The Stark effect is the splitting of spectral lines in an **electric** field. The Aufbau and Pauli principles are rules for electron configuration, not optical phenomena.

Question #9 Key: (B)

DUHS 2024

"In an orbital of an atom, no two electrons can have the same set of four quantum numbers, at least one quantum number..."

CORE CONCEPT AND DERIVATION

Electrons are fermions, and quantum mechanics dictates that fermions cannot occupy the exact same quantum state simultaneously.

Formula: None required.

Solution:

- The Pauli Exclusion Principle explicitly formulates this rule for atoms.
- Even if two electrons share the exact same spatial orbital (meaning their n , l , and m quantum numbers are identical), they must have different spin quantum numbers (s).
- One must be spin up ($+1/2$) and the other spin down ($-1/2$).

Why other options are incorrect: The Aufbau principle is about filling order from lowest to highest energy. Hund's rule is about maximizing unpaired electrons in degenerate orbitals. Wiswesser's rule relates to line notation in chemical structures, entirely unrelated to quantum numbers.

Question #10 Key: (D)

DUHS 2024

Maximum number of electrons in a given sub-shell are calculated by:

CORE CONCEPT AND DERIVATION

This is a historically flawed past paper question. The options provided do not contain the correct formula for the maximum number of electrons in a subshell, but the answer key selects the formula for the number of orbitals.

Formula:

$$\begin{aligned}\text{Electrons} &= 2(2l + 1) \\ \text{Orbitals} &= 2l + 1\end{aligned}$$

Solution:

- The true maximum number of electrons in a subshell is calculated by $2(2l + 1)$.
- None of the given options perfectly represent this.
- However, Option D, $2l + 1$, calculates the number of spatial orientations (orbitals) within a subshell.
- In the context of this specific exam's flawed answer key, $2l + 1$ is designated as the 'correct' option, likely due to a typographic error by the examiners omitting the multiplier of 2.

Why other options are incorrect: n^2 is the number of orbitals in a shell. $2n^2$ is the maximum number of electrons in an entire principal shell. $2(n + 1)$ has no specific quantum meaning.

Question #11 Key: (B)

DUHS 2024

The neutron was discovered by

CORE CONCEPT AND DERIVATION

The neutron was the last of the three major subatomic particles to be discovered because it carries no electrical charge, making it difficult to detect with electromagnetic fields.

Formula: None required.

Solution:

- In 1932, Sir James Chadwick bombarded Beryllium with alpha particles.
- He observed highly penetrating, uncharged radiation being emitted.
- He proved that this radiation consisted of neutral particles with a mass slightly greater than a proton. He named this particle the neutron.

Why other options are incorrect: J.J. Thomson discovered the electron. Eugen Goldstein discovered positive rays (protons/canal rays). Max Planck discovered quantum energy packets (photons).

Question #12 Key: (B)

BUMHS 2024

The charge of electron is:

CORE CONCEPT AND DERIVATION

The fundamental elementary charge is the electrical charge carried by a single proton or electron.

Formula:

$$e = 1.602 \times 10^{-19} \text{ C}$$

Solution:

- Robert Millikan measured the charge of a single electron in 1909 through his famous Oil Drop Experiment.
- He determined the elementary charge to be approximately 1.602×10^{-19} Coulombs (C).
- Because an electron is negatively charged, its exact value is -1.602×10^{-19} C, but questions typically ask for the magnitude.

Why other options are incorrect: The exponents -16 , -17 , and -18 represent orders of magnitude that are thousands of times too large.

Question #13 Key: (D)

BUMHS 2024

Which statement is not correct for cathode rays?

CORE CONCEPT AND DERIVATION

Cathode rays are streams of highly energetic electrons. Because electrons possess rest mass, they are bound by the laws of relativity.

Formula: None required.

Solution:

- Cathode rays are electrons. Electrons are material particles with a definitive mass (9.1×10^{-31} kg).
- According to Einstein's theory of relativity, no object with mass can ever reach or exceed the speed of light (c) in a vacuum.
- While cathode rays travel extremely fast (often close to light speed depending on the accelerating voltage), they can **never** travel exactly at the velocity of light.
- Therefore, the statement that they travel with the velocity of light is false.

Why other options are incorrect: Options A, B, and C (a duplicate) are true statements. Electrons are material particles with mass and they travel with a measurable, definite velocity in the tube.

Question #14 Key: (D)

BUMHS 2024

An electron in an atom is completely describe by its ____ quantum numbers

CORE CONCEPT AND DERIVATION

The state of any electron in a quantum mechanical atomic model is defined by a specific set of parameters called quantum numbers.

Formula: None required.

Solution:

- To completely describe the unique address and state of an electron in an atom, exactly four quantum numbers are required:
- 1. Principal (n): Energy level / Shell.
- 2. Azimuthal (l): Orbital shape / Subshell.
- 3. Magnetic (m): 3D spatial orientation.
- 4. Spin (s): Direction of intrinsic electron spin.
- According to the Pauli Exclusion Principle, no two electrons can share the same set of these four numbers.

Why other options are incorrect: There are strictly four recognized quantum numbers used to define an electron's state.

Question #15 Key: (D)

BUMHS 2024

One picometer (pm) = ?

CORE CONCEPT AND DERIVATION

The metric system relies on a standardized set of prefixes to denote powers of ten.

Formula: None required.

Solution:

- The prefix "pico" (symbol p) strictly corresponds to a factor of 10^{-12} .
- Therefore, 1 picometer (pm) is equal to 10^{-12} meters.
- This unit is extremely useful in chemistry, as atomic radii typically fall in the range of 50 to 300 picometers.

Why other options are incorrect: 10^{-6} is micro (μ). 10^{-8} is not a standard named prefix. 10^{-10} is an Angstrom ($\text{\AA}$).

Question #16 Key: (C)

BUMHS 2024

The only group of lines occurring in the visible region of the hydrogen spectrum is labelled as the

CORE CONCEPT AND DERIVATION

When excited hydrogen electrons fall back to lower energy levels, they emit photons. The destination level dictates the energy (and thus the spectrum band) of the emitted light.

Formula:

$$E = h\nu$$

Solution:

- Lyman series: Electrons fall to $n = 1$. The energy gap is massive, emitting high-energy ultraviolet (UV) light.
- Balmer series: Electrons fall to $n = 2$. The energy gap matches the energy of visible light photons. The lines appear as specific colors (red, green, blue-violet) visible to the human eye.
- Paschen, Brackett, and Pfund series: Electrons fall to $n = 3, 4, 5$ respectively. These gaps are very small, emitting low-energy infrared (IR) light.

Why other options are incorrect: Paschen and Pfund are strictly in the invisible infrared region. Lyman is strictly in the invisible ultraviolet region.

Question #17 Key: (A)

BUMHS 2024

Select the correct one

CORE CONCEPT AND DERIVATION

Standard chemical reactions involve the making and breaking of chemical bonds, which is fundamentally an electrostatic phenomenon occurring at the atomic periphery.

Formula: None required.

Solution:

- The nucleus of an atom (containing protons and neutrons) is deeply embedded at the core and shielded by massive energy barriers. It remains completely untouched during standard chemical reactions.
- Only the outermost valence electrons interact when atoms collide.
- Chemical reactions are purely the shuffling, sharing, or transferring of these electrons to achieve stable noble gas configurations.

Why other options are incorrect: Protons and neutrons only interact during **nuclear** reactions (fission, fusion, decay), not chemical reactions.

Question #18 Key: (B)

NUMS 2024

The value of "[Formula]" for [Formula] orbital is:

CORE CONCEPT AND DERIVATION

The letter designation of an orbital directly corresponds to a specific integer value of the azimuthal quantum number (l).

Formula:

$$s = 0, p = 1, d = 2, f = 3$$

Solution:

- The orbital given is " $4p$ ".
- The principal quantum number is the coefficient: $n = 4$.
- The letter " p " universally represents an azimuthal quantum number of $l = 1$.
- Therefore, the value of l is 1.

Why other options are incorrect: 0 is for an s -orbital. 2 is for a d -orbital. 3 is for an f -orbital.

Question #19 Key: (B)

NUMS 2024

The element having the electronic configuration of noble gas notation [Formula] is:

CORE CONCEPT AND DERIVATION

To identify an element from its electron configuration, sum the total number of electrons, which equals its atomic number in a neutral state.

Formula:

$$Z = \text{Core electrons} + \text{Valence electrons}$$

Solution:

- The core is represented by Krypton (Kr). Looking at the periodic table, Krypton has an atomic number of 36. So, there are 36 core electrons.
- The valence shell adds more: $5s^2$ adds 2 electrons. $4d^6$ adds 6 electrons.
- Total electrons = $36 + 2 + 6 = 44$.
- An atomic number of 44 corresponds to Ruthenium (Ru).

Why other options are incorrect: Strontium (Sr) is 38. Palladium (Pd) is 46. Zirconium (Zr) is 40. Only Ruthenium possesses exactly 44 protons.

Question #20 Key: (A)

NUMS 2024

Choose the allowed sets of quantum numbers from the following:

CORE CONCEPT AND DERIVATION

The validity of a set of quantum numbers depends on strict boundary rules connecting n , l , and m .

Formula:

$$l = 0 \text{ to } (n - 1)$$

$$m = -l \text{ to } +l$$

Solution:

- Let's evaluate each option to see if it breaks any rules:
- **Option A:** $n = 3$. Max $l = 2$. So $l = 2$ is allowed. If $l = 2$, m can be from -2 to $+2$. So $m = 0$ is allowed. Spin is $+1/2$. **This set is perfectly valid.**
- **Option B:** $n = 3$. Max $l = 3 - 1 = 2$. Here $l = 3$, which violates the rule (l cannot equal n). Invalid.
- **Option C:** $n = 4$, $l = 3$ is allowed. However, if $l = 3$, the max value of m is $+3$. Here $m = 4$ is given, which violates the rule. Invalid.
- **Option D:** $n = 4$, $l = 2$ is allowed. If $l = 2$, max m is $+2$. Here $m = 4$ is given, which violates the rule. Invalid.

Why other options are incorrect: Options B, C, and D mathematically violate the restrictive boundary rules of quantum mechanics.

Question #21 Key: (D)

UHS 2023

What is the proton (Atomic Number) of an element that has four unpaired electrons in its ground state?

CORE CONCEPT AND DERIVATION

Unpaired electrons are found by looking at the partially filled subshells of an atom's ground-state electronic configuration.

Formula: None required.

Solution:

- Let's evaluate the ground state configurations for the options:
- $Z = 6$ (Carbon): $1s^2, 2s^2, 2p^2$. Two unpaired electrons in $2p$.
- $Z = 14$ (Silicon): $[Ne]3s^2, 3p^2$. Two unpaired electrons in $3p$.
- $Z = 22$ (Titanium): $[Ar]4s^2, 3d^2$. Two unpaired electrons in $3d$.
- $Z = 26$ (Iron): $[Ar]4s^2, 3d^6$. The $3d$ subshell has 5 orbitals. Placing 6 electrons means one orbital gets a pair, leaving exactly 4 singly occupied (unpaired) orbitals.
- Thus, Iron ($Z = 26$) has four unpaired electrons.

Why other options are incorrect: The other listed elements all have exactly two unpaired electrons.

Question #22 Key: (C)

UHS 2023

When [Formula] orbital is filled, the entering electron goes into?

CORE CONCEPT AND DERIVATION

The order of orbital filling is strictly determined by the Aufbau principle, which uses the $(n + l)$ rule to rank energy levels.

Formula:

$$\text{Energy} \propto (n + l)$$

Solution:

- The $6d$ orbital has $n = 6$ and $l = 2$. Its $(n + l)$ sum is $6 + 2 = 8$.
- After $6d$, the next orbital must either have a higher $(n + l)$ sum, or the same sum but a higher principal quantum number n .
- Let's test $7p$: $n = 7, l = 1 \Rightarrow n + l = 7 + 1 = 8$.
- Since both $6d$ and $7p$ have a sum of 8, the orbital with the higher n is filled next. Thus, $7p$ follows $6d$.

Why other options are incorrect: $7s$ is filled much earlier ($n + l = 7$). $7d$ and $7f$ have much higher energy levels and follow later in the sequence.

Question #23 Key: (A)

SZABMU 2023

Which of the following orbital will be filled first than [Formula] ?

CORE CONCEPT AND DERIVATION

Orbitals are filled in order of increasing energy according to the $(n + l)$ rule.

Formula:

$$\text{Energy order: } 1s < 2s < 2p < 3s < 3p < 4s < 3d < 4p$$

Solution:

- Note on question validity:** Technically, **all** the listed orbitals ($1s, 2p, 3d, 4s$) are filled before $4p$. However, standard exam questions of this type usually intend to ask which orbital is filled **immediately** before, or they are testing specific $n + l$ boundary logic.
- The official key selects $4s$. Let's compare $4s$ and $4p$:
- $4s: n = 4, l = 0 \Rightarrow n + l = 4$
- $4p: n = 4, l = 1 \Rightarrow n + l = 5$
- Because $4s$ has a lower $(n + l)$ value, it clearly fills before $4p$. (In the exact filling sequence, the order is $4s \rightarrow 3d \rightarrow 4p$).

Why other options are incorrect: While $1s, 2p$, and $3d$ are indeed filled before $4p$, $4s$ is the most recent principal shell companion and aligns with the provided answer key's logic emphasizing the $n + l$ difference between the 4th shell subshells.

Question #24 Key: (A)

SZABMU 2023

If value of azimuthal quantum number is 1 then value of [Formula] will range from:

CORE CONCEPT AND DERIVATION

The magnetic quantum number (m) depends entirely on the azimuthal quantum number (l) and defines the possible 3D orientations of the subshell.

Formula:

$$m = -l, \dots, 0, \dots, +l$$

Solution:

- The azimuthal quantum number is given as $l = 1$ (which corresponds to a p -subshell).
- The allowable values for m range from $-l$ to $+l$ in integer steps.
- Therefore, the values are $-1, 0, +1$.
- The range is strictly -1 to 1 .

Why other options are incorrect: The other ranges imply values of l greater than 1, violating the fundamental bounds of the magnetic quantum number.

Question #25 Key: (D)

SZABMU 2023

The dumbbell like orbitals can move in how many directions?

CORE CONCEPT AND DERIVATION

The "dumbbell" shape refers to the p -orbital. The number of directions (orientations) it can take in space is given by its magnetic quantum numbers.

Formula:

$$\text{Orientations} = 2l + 1$$

Solution:

- A dumbbell shape means it is a p -orbital, so its azimuthal quantum number is $l = 1$.
- The number of spatial orientations is $2(1) + 1 = 3$.
- These three orientations align along the Cartesian axes: p_x , p_y , and p_z .

Why other options are incorrect: 1 orientation is for the spherical s -orbital. 5 orientations are for the d -orbital. 7 orientations are for the f -orbital.

Question #26 Key: (C)

SZABMU 2023

The relationship between quantum number [Formula] and [Formula] is:

CORE CONCEPT AND DERIVATION

The azimuthal quantum number (l) is strictly limited by the principal quantum number (n).

Formula:

$$l_{\max} = n - 1$$

Solution:

- For any given principal shell n , the allowed values for l start at 0 and go up to a maximum of $n - 1$.
- Therefore, the mathematical boundary defining the maximum possible value of l is $l = n - 1$.

Why other options are incorrect: Options A and D mathematically imply that l is larger than n , which is physically impossible. Option B arbitrarily restricts the maximum limit too early.

Question #27 Key: (C)

KMU 2023

The number of orientations of a sub-shell for which [Formula] and [Formula] will be:

CORE CONCEPT AND DERIVATION

The number of spatial orientations of any given subshell is independent of the principal quantum number (n) and depends entirely on the azimuthal quantum number (l).

Formula:

$$\text{Orientations} = 2l + 1$$

Solution:

- We are given $l = 3$ (which corresponds to an f -subshell).
- Substitute $l = 3$ into the formula: $2(3) + 1 = 6 + 1 = 7$.
- Therefore, there are 7 distinct spatial orientations (degenerate orbitals) for this subshell.

Why other options are incorrect: 1 is for $l = 0$. 3 is for $l = 1$. 5 is for $l = 2$.

Question #28 Key: (A)

KMU 2023

Photon of the lowest wavelength is related to:

CORE CONCEPT AND DERIVATION

The wavelength of an emitted photon is inversely proportional to the energy of the electron transition. Larger energy drops produce shorter (lower) wavelengths.

Formula:

$$E = \frac{hc}{\lambda}$$

Solution:

- The energy of a transition depends on how close to the nucleus the electron falls.
- Transitions to $n = 1$ (Lyman series) have the highest energy and lowest wavelength, but Lyman is not an option.
- Among the given options, the Balmer series drops to the lowest level ($n = 2$).
- This results in the largest energy gap compared to Paschen ($n = 3$), Brackett ($n = 4$), and Pfund ($n = 5$).
- Consequently, the Balmer series emits photons with the highest energy and the lowest wavelength among the choices provided.

Why other options are incorrect: The other series involve drops to higher principal quantum shells (smaller energy gaps), resulting in longer wavelengths (infrared region).

Question #29 Key: (D)

KMU 2023

The maximum [Formula] ratio for positive rays is obtained when the discharge tube contains:

CORE CONCEPT AND DERIVATION

Positive rays (canal rays) are ionized gas molecules. Their charge-to-mass ratio depends entirely on the mass of the gas used in the tube.

Formula:

$$\frac{e}{m} = \frac{\text{Charge}}{\text{Mass}}$$

Solution:

- To maximize the fraction e/m , the denominator (mass) must be as small as possible.
- Let's compare the atomic/molecular masses of the gases:
- Helium (He) ≈ 4 amu
- Nitrogen (N₂) ≈ 28 amu
- Neon (Ne) ≈ 20 amu
- Hydrogen (H₂) ≈ 2 amu (and a single ionized H atom is ≈ 1 amu).
- Hydrogen has the lowest mass of any element, so it yields the absolute maximum e/m ratio.

Why other options are incorrect: They are much heavier gases, which increases the denominator and significantly lowers the e/m ratio.

Question #30 Key: (A)

KMU 2023

The correct sequence of electronic configuration is:

CORE CONCEPT AND DERIVATION

The Aufbau principle states that orbitals are filled in order of their increasing $(n + l)$ values.

Formula:

$$\text{Energy} \propto (n + l)$$

Solution:

- Let's verify the $(n + l)$ values for the correct sequence (Option A):
- 4p: $4 + 1 = 5$
- 5s: $5 + 0 = 5$ (Higher n than 4p, so it comes after)
- 4d: $4 + 2 = 6$
- 5p: $5 + 1 = 6$ (Higher n than 4d, so it comes after)
- 6s: $6 + 0 = 6$ (Higher n than 5p, so it comes after)
- 4f: $4 + 3 = 7$
- 5d: $5 + 2 = 7$ (Higher n than 4f, so it comes after)
- The sequence strictly adheres to the $(n + l)$ hierarchy.

Why other options are incorrect: They jumble the sequence, placing higher energy subshells before lower ones (e.g., jumping from 4p back down to 4s or 3s).

Question #31 Key: (C)

DUHS 2023

Radius of first orbit of hydrogen is [Formula]. Which orbit has a radius of [Formula]?

CORE CONCEPT AND DERIVATION

According to Bohr's model, the radius of an electron's orbit is directly proportional to the square of its principal quantum number (n).

Formula:

$$r_n = r_1 \times n^2$$

Solution:

- We are given the radius of the first orbit: $r_1 = 0.53 \text{ \AA}$.
- We are given a target radius: $r_n = 4.77 \text{ \AA}$.
- Substitute the values into the formula: $4.77 = 0.53 \times n^2$.
- Divide both sides by 0.53: $n^2 = \frac{4.77}{0.53} = 9$.
- Take the square root: $n = 3$.
- Therefore, the orbit is the third orbit.

Why other options are incorrect: Second orbit would be $0.53 \times 4 = 2.12 \text{ \AA}$. Fourth orbit would be $0.53 \times 16 = 8.48 \text{ \AA}$.

Question #32 Key: (B)

DUHS 2023

Which of the following has only one orientation in space, in the magnetic field?

CORE CONCEPT AND DERIVATION

The spatial orientation of an orbital is determined by its magnetic quantum number (m). A purely spherical shape looks identical from every angle.

Formula:

$$\text{Orientations} = 2l + 1$$

Solution:

- The number of orientations depends on the azimuthal quantum number l .
- For an s -orbital, $l = 0$.
- Applying the formula: $2(0) + 1 = 1$.
- The s -orbital is perfectly spherical, meaning it has only one possible orientation in 3D space, regardless of the magnetic field applied.

Why other options are incorrect: The p -orbital has 3 orientations. The d -orbital has 5 orientations. The f -orbital has 7 orientations.

Question #33 Key: (A)

DUHS 2023

What's the mass of one proton?

CORE CONCEPT AND DERIVATION

The mass of subatomic particles is a fundamental constant. Protons and neutrons make up almost all the mass of an atom, while electrons are comparatively negligible.

Formula:

$$m_p \approx 1836 \times m_e$$

Solution:

- The rest mass of a proton is 1.672×10^{-27} kg.
- The rest mass of an electron is 9.109×10^{-31} kg.
- Dividing the mass of the proton by the mass of the electron gives a ratio of approximately 1836.
- This means you would need about 1836 electrons to equal the mass of a single proton.

Why other options are incorrect: A positron is the antimatter equivalent of an electron, so it has the same tiny mass as an electron. Protons and neutrons have nearly identical masses, so a proton is definitely not equal to 1836 neutrons.

Question #34 Key: (C)

BUMHS 2023

What is the quantum number for the unpaired electron of chlorine atom [Formula]?

CORE CONCEPT AND DERIVATION

The last (valence) electron in a Halogen occupies a p -orbital.

Formula: None required.

Solution:

- Chlorine has an atomic number $Z = 17$.
 - The full electronic configuration is $1s^2, 2s^2, 2p^6, 3s^2, 3p^5$.
 - The valence subshell is $3p$. Expanding this using Hund's Rule gives: $3p_x^2, 3p_y^2, 3p_z^1$.
 - The single unpaired electron is in the $3p$ orbital.
 - For a $3p$ orbital, the principal quantum number $n = 3$.
 - The azimuthal quantum number for a p -orbital is $l = 1$.
 - The magnetic quantum number m can be $-1, 0$, or $+1$.
- Based on the provided options, $(3, 1, 1)$ is the only valid set that correctly describes a $3p$ orbital.

Why other options are incorrect: Options A and B point to the second shell ($n = 2$), which is fully filled in Chlorine. Option D points to a $3s$ orbital, which is fully paired ($3s^2$).

Question #35 Key: (C)

BUMHS 2023

Which statement about a [Formula] orbital is correct?

CORE CONCEPT AND DERIVATION

The electron capacity of an entire subshell is dictated by its azimuthal quantum number (l).

Formula:

$$\text{Max Electrons} = 2(2l + 1)$$

Solution:

- **Note on exact phrasing:** The question asks about a " $4d$ orbital" but the correct answer treats it as a " $4d$ subshell". In strict quantum terms, a single spatial orbital holds 2 electrons. A subshell holds more. However, in standard high school testing, "orbital" is frequently used interchangeably with "subshell".
- For a d -subshell, $l = 2$.
- Number of degenerate orbitals $= 2(2) + 1 = 5$.
- Since each orbital holds 2 electrons, the entire d -subshell holds a maximum of $5 \times 2 = 10$ electrons.

Why other options are incorrect: A $4d$ orbital has a different shape (clover/double-dumbbell) than a $4p$ orbital (dumbbell). Zinc ($Z = 30$) only fills up to $3d^{10}$; its $4d$ is completely empty. The $4f$ orbital has a higher energy than $4d$ within the principal quantum number 4.

Question #36 Key: (D)

BUMHS 2023

Which of the following is not true about canal rays?

CORE CONCEPT AND DERIVATION

Canal rays (positive rays) consist of massive, positively charged ions. Because they possess significant mass and velocity, they carry kinetic energy and momentum.

Formula:

$$p = mv$$

Solution:

- If a small paddle wheel is placed in the path of canal rays inside a discharge tube, the rays will strike the wheel.
- Because canal rays are relatively heavy material particles (entire atoms missing an electron), they transfer their momentum to the wheel.
- This momentum transfer causes the wheel to physically rotate, proving that canal rays can and do cause mechanical motion.
- Therefore, the statement "Do not cause mechanical motion" is strictly false.

Why other options are incorrect: Canal rays from Hydrogen gas specifically match the mass in Option A and the charge-to-mass ratio in Option B. Because they are charged particles, they do deflect in electric and magnetic fields (Option C is true).

Question #37 Key: (D)

BUMHS 2023

Why do electrons have opposite spins when they are in the same orbital?

CORE CONCEPT AND DERIVATION

Placing two negatively charged particles in the exact same spatial volume creates intense electrostatic repulsion.

Formula: None required.

Solution:

- A spinning electric charge generates a magnetic field, effectively turning the electron into a microscopic electromagnet.
- If two electrons in the same orbital spin in the same direction, their magnetic fields would repel each other, adding to the immense electrostatic repulsion.
- By spinning in opposite directions (spin up $+1/2$ and spin down $-1/2$), they generate anti-parallel magnetic fields.
- These opposite magnetic fields slightly attract each other, which helps offset the electrostatic repulsion, stabilizing the orbital.

Why other options are incorrect: Quantum particles do not experience macroscopic "friction". Opposite spins lower the system's energy (increasing stability), they don't "create" energy. The fundamental electric charge is an immutable property and cannot be "removed".

Question #38 Key: (C)

NUMS 2023

The amount of energy associated with quantum of radiation of directly proportional to:

CORE CONCEPT AND DERIVATION

Max Planck established the fundamental relationship between the energy of a quantum (photon) of electromagnetic radiation and its wave properties.

Formula:

$$E = h\nu$$

Solution:

- In Planck's quantum equation, E is energy, h is Planck's constant, and ν is the frequency of the radiation.
- Because h is a constant multiplier, energy (E) is mathematically directly proportional to frequency (ν).
- Higher frequency radiation (like X-rays) carries more energy per quantum than lower frequency radiation (like radio waves).

Why other options are incorrect: Energy is inversely proportional to wavelength (λ). Velocity (c) is constant for all electromagnetic radiation in a vacuum, so it cannot act as a directly proportional variable for changing energy.

Question #39 Key: (B)

NUMS 2023

If value of azimuthal quantum number is 2 then total values of magnetic quantum number will be:

CORE CONCEPT AND DERIVATION

The total number of magnetic quantum number (m) values indicates how many spatial orientations (orbitals) exist within a given subshell.

Formula:

$$\text{Total values} = 2l + 1$$

Solution:

- The azimuthal quantum number is given as $l = 2$ (a d -subshell).
- Substitute $l = 2$ into the formula: $2(2) + 1 = 4 + 1 = 5$.
- The specific values are: $-2, -1, 0, +1, +2$.
- There are exactly 5 possible values.

Why other options are incorrect: 3 is for $l = 1$. 7 is for $l = 3$. 10 is the number of electrons that the subshell can hold, not the number of magnetic orientations.

Question #40 Key: (C)

NUMS 2023

Total number of directions of f -orbitals in space are:

CORE CONCEPT AND DERIVATION

The number of spatial directions (orientations) of an orbital type is determined by its azimuthal quantum number (l).

Formula:

$$\text{Directions} = 2l + 1$$

Solution:

- For an f -orbital, the azimuthal quantum number is $l = 3$.
- Substitute into the orientation formula: $2(3) + 1 = 6 + 1 = 7$.
- Therefore, an f -subshell splits into 7 distinct spatial orientations in a magnetic field.

Why other options are incorrect: 3 is for p -orbitals. 5 is for d -orbitals. 6 is the maximum electron capacity of a p -subshell, not a number of directions.

Question #41 Key: (B)

NUMS 2023

Which of the following quantum number is not obtained from Schrodinger Wave equation?

CORE CONCEPT AND DERIVATION

The Schrödinger wave equation relies on three spatial coordinates (e.g., x, y, z or r, θ, ϕ) to map the probability density of an electron.

Formula:

$$\hat{H}\psi = E\psi$$

Solution:

- Solving the Schrödinger equation inherently yields three constants of integration, which correspond to the principal (n), azimuthal (l), and magnetic (m) quantum numbers.
- These three numbers entirely describe the 3D spatial properties of the orbital.
- The spin quantum number (s) is a relativistic, intrinsic property of the electron itself, independent of spatial coordinates. It was proposed separately by Uhlenbeck and Goudsmit and later derived from Dirac's relativistic wave equation, not Schrödinger's.

Why other options are incorrect: Principal, Azimuthal, and Magnetic are all direct mathematical outcomes of solving the Schrödinger equation.

Question #42 Key: (C)

NUMS 2023

The electronic configuration for degenerate orbitals is explained by:

CORE CONCEPT AND DERIVATION

When electrons enter a subshell with multiple orbitals of identical energy (degenerate orbitals), they must follow a rule that minimizes electron-electron repulsion.

Formula: None required.

Solution:

- Hund's Rule explicitly states that electrons must fill degenerate orbitals (like p_x, p_y, p_z) singly first, with parallel spins, before pairing up.
- This maximizes the total spin state and reduces electrostatic repulsion, leading to the most stable ground state configuration.

Why other options are incorrect: The Aufbau principle explains vertical filling across different energy shells. The Pauli exclusion principle limits each orbital to a maximum of two electrons. The " $n + 1$ " rule is a typo for the $n + l$ rule, which is part of Aufbau.

Question #43 Key: (D)

UHS 2022

According to which scientist, the probability of finding an electron at a certain position is possible?

CORE CONCEPT AND DERIVATION

The transition from classical deterministic orbits to quantum probabilistic electron clouds was a monumental shift in atomic theory.

Formula:

$$\hat{H}\psi = E\psi$$

Solution:

- Bohr proposed fixed, circular, deterministic orbits (which violated the uncertainty principle).
- Erwin Schrödinger formulated the wave equation, where the square of the wave function ($|\psi|^2$) yields the mathematical probability density of finding an electron in a specific region of space (the orbital).
- This established the quantum mechanical model of the atom based entirely on probabilities rather than fixed paths.

Why other options are incorrect: Bohr's model is non-probabilistic. de-Broglie introduced wave-particle duality but not the probabilistic wave function. Hund established orbital filling rules.

Question #44 Key: (C)

UHS 2022

Which gas in the discharge tube produces lightest canal rays particles?

CORE CONCEPT AND DERIVATION

Canal rays (positive rays) are the positively charged ions left behind when cathode rays knock electrons off the gas atoms in a discharge tube.

Formula:

$$\text{Mass of canal ray} = \text{Mass of gas atom} - \text{Mass of lost electron}$$

Solution:

- The mass of the positive ion directly depends on the mass of the gas used in the tube.
- Hydrogen (H_2) is the lightest element in the periodic table.
- When a hydrogen atom loses an electron, it becomes a single proton (H^+), which is the lightest possible canal ray particle.
- Consequently, hydrogen yields the highest e/m ratio for positive rays.

Why other options are incorrect: Helium, Neon, and Argon are all significantly heavier inert gases, so their corresponding positive ions are much more massive.

Question #45 Key: (B)

UHS 2022

Which element has the ground state electronic configuration of [Formula]?

CORE CONCEPT AND DERIVATION

An element's atomic number (number of protons) is equal to its total number of electrons in a neutral, ground-state atom.

Formula:

$$Z = \sum \text{electrons}$$

Solution:

- Add the superscripts in the given electron configuration to find the total number of electrons:
- $2 + 2 + 6 + 2 + 6 = 18$ electrons.
- In a neutral atom, 18 electrons means the atomic number is 18.
- Looking at the periodic table, element 18 is the noble gas Argon (Ar).

Why other options are incorrect: Sodium (Na) is 11, Chlorine (Cl) is 17, and Sulfur (S) is 16.

Question #46 Key: (D)

UHS 2022

What is the proton (Atomic Number) of an element that has four unpaired electrons in its ground state?

CORE CONCEPT AND DERIVATION

Unpaired electrons are determined by applying Hund's Rule to the outermost valence subshell.

Formula: None required.

Solution:

- Let's analyze the options:
- $Z = 6$ (Carbon): $1s^2, 2s^2, 2p^2$. The two $2p$ electrons go into separate orbitals (2 unpaired).
- $Z = 14$ (Silicon): $[\text{Ne}]3s^2, 3p^2$. Similar to Carbon, it has 2 unpaired electrons.
- $Z = 22$ (Titanium): $[\text{Ar}]4s^2, 3d^2$. The two $3d$ electrons are unpaired (2 unpaired).
- $Z = 26$ (Iron): $[\text{Ar}]4s^2, 3d^6$. The $3d$ subshell has 5 orbitals. Placing 6 electrons means 1 orbital is paired and the remaining 4 orbitals hold exactly 1 electron each.
- Therefore, Iron ($Z = 26$) has exactly 4 unpaired electrons.

Why other options are incorrect: They all possess only 2 unpaired electrons in their ground state.

Question #47 Key: (C)

SZABMU 2022

Principal quantum number is represented by the symbol:

CORE CONCEPT AND DERIVATION

Quantum mechanics utilizes specific, universally accepted variables to denote the four quantum numbers.

Formula: None required.

Solution:

- The principal quantum number, which denotes the main energy shell and distance from the nucleus, is represented by the letter n .
- The azimuthal (orbital shape) is l .
- The magnetic (spatial orientation) is m .
- The spin is s .

Why other options are incorrect: They correspond to the other three quantum numbers.

Question #48 Key: (C)

SZABMU 2022

Shape of the sub shell is explained by which quantum number:

CORE CONCEPT AND DERIVATION

The 3D geometric shape of an electron's probability cloud is determined by its angular momentum.

Formula: None required.

Solution:

- The azimuthal quantum number (also called the angular momentum quantum number), represented by l , dictates the shape of the orbital.
- If $l = 0$, the shape is a sphere (s -orbital).
- If $l = 1$, the shape is a dumbbell (p -orbital).
- If $l = 2$, the shape is generally a double-dumbbell (d -orbital).

Why other options are incorrect: Principal handles size, Magnetic handles spatial orientation (tilt/direction), and Spin handles internal angular momentum.

Question #49 Key: (D)

SZABMU 2022

The electronic configuration for degenerated orbitals is explained by:

CORE CONCEPT AND DERIVATION

Degenerate orbitals are orbitals that possess the exact same energy level (e.g., p_x, p_y, p_z). A specific rule dictates how electrons fill these equal-energy slots.

Formula: None required.

Solution:

- Hund's Rule of Maximum Multiplicity states that when filling degenerate orbitals, electrons will first fill them singly, with parallel spins, before they begin to pair up.
- This minimizes electron-electron repulsion, resulting in a more stable, lower-energy atomic state.

Why other options are incorrect: Aufbau explains filling across different energy levels. Pauli's principle dictates that paired electrons must have opposite spins. The $(n + l)$ rule determines the overall energy order of subshells.

Question #50 Key: (C)

SZABMU 2022

Maximum number of electrons which can be placed in one orbital is:

CORE CONCEPT AND DERIVATION

Pauli's Exclusion Principle puts a hard mathematical limit on the capacity of a single spatial orbital.

Formula: None required.

Solution:

- According to Pauli's Exclusion Principle, no two electrons can have the exact same set of four quantum numbers.
- If two electrons are in the same exact orbital, they share identical n, l , and m values.
- The only quantum number left to differentiate them is the spin quantum number (s), which only has two possible states: $+1/2$ (spin up) and $-1/2$ (spin down).
- Therefore, a maximum of 2 electrons can occupy a single orbital.

Why other options are incorrect: 1 is an incomplete orbital. 3 or more violates the Pauli Exclusion Principle, as it would require two electrons to have identical spins.

Question #51 Key: (C)

KMU 2022

Greater the wavelength associated with the photon:

CORE CONCEPT AND DERIVATION

The relationship between the energy of a photon and its wavelength is governed by Planck's equation, showing an inverse proportionality.

Formula:

$$E = \frac{hc}{\lambda}$$

Solution:

- In the equation, E is energy, h is Planck's constant, c is the speed of light, and λ is wavelength.
- Because λ is in the denominator, as wavelength increases (gets greater), the total energy of the photon decreases (gets smaller).
- Long-wavelength radiation (like radio waves) has very low energy, while short-wavelength radiation (like gamma rays) has massive energy.

Why other options are incorrect: Energy is not directly proportional, nor is it independent (constant or random variable) with respect to wavelength.

Question #52 Key: (C)

KMU 2022

Photon of which of the following series will have largest wavelength?

CORE CONCEPT AND DERIVATION

Wavelength is inversely proportional to energy. Therefore, the spectral series involving transitions in the highest energy levels (smallest energy gaps) produces photons with the lowest energy and largest wavelength.

Formula:

$$\Delta E = \frac{hc}{\lambda}$$

Solution:

- The Hydrogen emission spectrum series fall to different base levels:
- Lyman: falls to $n = 1$ (UV region, huge energy, shortest wavelength)
- Balmer: falls to $n = 2$ (Visible)
- Paschen: falls to $n = 3$ (IR)
- Brackett: falls to $n = 4$ (IR)
- Pfund: falls to $n = 5$ (Far IR, smallest energy transitions, largest wavelengths).
- Because the energy gap between higher shells (e.g., $n = 6$ to $n = 5$) is extremely small, the emitted photon has minimal energy and maximum wavelength.

Why other options are incorrect: The other series all drop to lower principal quantum numbers, meaning their electron transitions cover larger energy gaps, yielding shorter wavelengths.

Question #53 Key: (C)

DUHS 2022

The equation [Formula] where [Formula] is the equation of H-spectrum for:

CORE CONCEPT AND DERIVATION

The Rydberg formula calculates the wave number of spectral lines based on the energy levels involved in the electron transition.

Formula:

$$\bar{\nu} = R_h \left[\frac{1}{n_1^2} - \frac{1}{n_2^2} \right]$$

Solution:

- In the given equation, the lower energy level (destination shell) is locked at $n_1 = 2$.
- The upper energy levels are $n = 3, 4, 5 \dots$ (since $n > 2$).
- Transitions that end at the $n = 2$ shell exclusively generate the Balmer series, which lies predominantly in the visible light spectrum.

Why other options are incorrect: Lyman ends at $n_1 = 1$.
Paschen ends at $n_1 = 3$. Pfund ends at $n_1 = 5$.

Question #54 Key: (C)

DUHS 2022

The quantum number allows following orbitals in N-shell.

CORE CONCEPT AND DERIVATION

The principal quantum number n restricts the number of subshells available within a given electron shell to exactly n subshells.

Formula:

$$l = 0, 1, 2 \dots (n - 1)$$

Solution:

- The shells are designated K, L, M, N corresponding to $n = 1, 2, 3, 4$.
- For the N-shell, $n = 4$.
- The possible azimuthal quantum numbers are $l = 0, 1, 2, 3$.
- These correspond directly to the s, p, d , and f subshells.
- Therefore, the N-shell fully supports s, p, d , and f orbitals.

Why other options are incorrect: Options A and B are incomplete subsets of the orbitals present in the N-shell.

Question #55 Key: (D)

BUMHS 2022

If four balloons are filled with different gases, which gas containing balloon will deflate first?

CORE CONCEPT AND DERIVATION

Graham's Law of Effusion dictates that the rate at which a gas escapes through a small hole is inversely proportional to the square root of its molar mass.

Formula:

$$\text{Rate} \propto \frac{1}{\sqrt{M}}$$

Solution:

- To find the fastest deflating balloon, we must find the gas with the lowest molar mass.
- Molar mass of $O_2 = 32 \text{ g/mol}$.
- Molar mass of $N_2 = 28 \text{ g/mol}$.
- Molar mass of $He = 4 \text{ g/mol}$.
- Molar mass of $H_2 = 2 \text{ g/mol}$.
- Because Hydrogen (H_2) is the lightest gas, it will effuse through the micropores of the balloon at the highest velocity, deflating first.

Why other options are incorrect: They possess higher molar masses, meaning their molecules move slower and escape the balloon more slowly.

Question #56 Key: (A)

BUMHS 2022

Which concept was introduced by the scientist Bohr?

CORE CONCEPT AND DERIVATION

Niels Bohr revolutionized atomic theory by introducing quantization to classical planetary models.

Formula:

$$mvr = \frac{nh}{2\pi}$$

Solution:

- Prior to Bohr, Rutherford's model couldn't explain why orbiting electrons didn't spiral into the nucleus due to continuous energy radiation.
- Bohr proposed that electrons move in fixed, circular orbits (shells) around the nucleus without radiating energy.
- He defined these stationary states as specific "energy levels" (K, L, M, etc.).

Why other options are incorrect: The concept of 3D "orbitals" and "sub-energy levels" (subshells) was developed later by quantum mechanics pioneers like Schrödinger and Heisenberg.

Question #57 Key: (A)

BUMHS 2022

What is the electronic configuration of C?

CORE CONCEPT AND DERIVATION

The electronic configuration is built by sequentially filling atomic orbitals according to the Aufbau principle until all electrons are placed.

Formula: None required.

Solution:

- Carbon (C) has an atomic number $Z = 6$.
- Therefore, a neutral Carbon atom possesses exactly 6 electrons.
- Fill the $1s$ orbital: 2 electrons $\Rightarrow 1s^2$ (4 remaining).
- Fill the $2s$ orbital: 2 electrons $\Rightarrow 2s^2$ (2 remaining).
- Place the remaining 2 electrons into the $2p$ orbital $\Rightarrow 2p^2$.
- Total configuration: $1s^2, 2s^2, 2p^2$.

Why other options are incorrect: Option B is Oxygen (8). Option C is Magnesium (12). Option D is Phosphorus (15).

Question #58 Key: (D)

BUMHS 2022

Why do electrons have opposite spins. When they are in the same orbital?

CORE CONCEPT AND DERIVATION

An electron is a charged particle. According to electromagnetic theory, a spinning charge generates a magnetic field.

Formula: None required.

Solution:

- When two electrons occupy the same orbital, they are forced into close physical proximity, leading to immense electrostatic repulsion (since both are negatively charged).
- However, if they spin in opposite directions (one up, one down), they act like tiny bar magnets with anti-parallel alignment.
- Their opposing magnetic fields attract each other slightly, which partially counteracts the electrostatic repulsion, allowing the system to achieve a stable state.

Why other options are incorrect: Subatomic particles do not experience macroscopic "friction". Opposite spins lower the system's energy (increasing stability), they don't "create" energy. Spin does not remove intrinsic electric charge.

Question #59 Key: (B)

BUMHS 2022

With the increase in the value of principal quantum number " n " [Formula] "the size of the s-orbitals"**CORE CONCEPT AND DERIVATION**

The principal quantum number n determines the main energy level and the average distance of the electron cloud from the nucleus.

Formula:

$$r \propto n^2$$

Solution:

- The radius of an orbital is directly tied to the square of the principal quantum number.
- As n steps up from 1 to 2 to 3 (e.g., $1s \rightarrow 2s \rightarrow 3s$), the electron occupies higher energy states that pull it further away from the attractive pull of the nucleus.
- Consequently, the physical volume and size of the s-orbital consistently increases.

Why other options are incorrect: The size of an orbital cannot decrease or remain static as higher energy shells inherently encompass a larger spatial volume.

Question #60 Key: (C)

NUMS 2022

Maximum electrons that can be placed in p subshell are:

CORE CONCEPT AND DERIVATION

Subshell capacity is determined by the number of degenerate orbitals it contains, multiplied by 2 (Pauli's limit).

Formula:

$$\text{Max Electrons} = 2(2l + 1)$$

Solution:

- For a p-subshell, the azimuthal quantum number $l = 1$.
- Number of orbitals $= (2 \times 1) + 1 = 3$ distinct spatial orientations (p_x, p_y, p_z).
- Since each orbital holds a maximum of 2 electrons: $3 \times 2 = 6$ electrons.

Why other options are incorrect: 2 is the capacity for an s-subshell. 10 is for a d-subshell. 14 is for an f-subshell.

Question #61 Key: (C)

NUMS 2022

Apply [Formula] rule and calculate which of the following orbital has maximum energy?

CORE CONCEPT AND DERIVATION

The $(n + l)$ rule dictates that orbitals with higher $(n + l)$ sums exist at higher energy levels.

Formula:

$$\text{Energy} \propto (n + l)$$

Solution:

- Let's calculate the values for the valid options:
- $4s: n = 4, l = 0 \Rightarrow n + l = 4$
- $3s: n = 3, l = 0 \Rightarrow n + l = 3$
- $2p: n = 2, l = 1 \Rightarrow n + l = 3$
- Since $4s$ yields the highest sum (4), it represents the maximum energy among the valid choices.
- Note: The $2d$ orbital is physically impossible because if $n = 2, l$ can only be 0 or 1.

Why other options are incorrect: Their $(n + l)$ sums are lower, indicating they are filled earlier because they are lower in energy.

Question #62 Key: (B)

NUMS 2022

The mass of electron is:

CORE CONCEPT AND DERIVATION

The electron is a fundamental lepton, carrying an incredibly tiny mass compared to the nucleons (protons and neutrons) that make up the atomic core.

Formula:

$$\frac{m_p}{m_e} \approx 1836$$

Solution:

- The absolute rest mass of a proton is approximately 1.672×10^{-27} kg.
- The rest mass of an electron is approximately 9.109×10^{-31} kg.
- Dividing the two yields a ratio of roughly 1836.
- This means a single proton is 1836 times heavier than an electron, or conversely, an electron is 1836 times lighter (less massive) than a proton.

Why other options are incorrect: Saying the electron is "more" massive than a proton, neutron, or whole hydrogen atom is factually backwards.

Question #63 Key: (C)

NUMS 2022

The shape of an orbital is determined by which quantum number?

CORE CONCEPT AND DERIVATION

Quantum numbers collectively describe the state and probabilistic location of an electron. Each number corresponds to a specific physical property of the orbital.

Formula: None required.

Solution:

- The principal quantum number (n) determines the size and energy level.
- The azimuthal quantum number (l), also known as the angular momentum quantum number, dictates the 3D geometric shape of the electron cloud (e.g., spherical for $l = 0$, dumbbell for $l = 1$).
- The magnetic quantum number (m) describes spatial orientation.
- The spin quantum number (s) describes the electron's intrinsic spin.

Why other options are incorrect: $n, m,$ and s relate to size, orientation, and spin respectively, not the shape of the orbital.

Question #64 Key: (C)

NUMS 2022

Proton number of [Formula] is:

CORE CONCEPT AND DERIVATION

The standard atomic symbol notation ${}^A_ZX$ clearly defines both the mass number and the atomic number of an element.

Formula:

$$\text{Proton Number} = Z$$

Solution:

- In the notation ${}_{11}\text{Na}^{23}$, the lower left subscript is the atomic number (Z).
- The atomic number is exactly equal to the number of protons in the nucleus.
- Therefore, the proton number is 11.

Why other options are incorrect: 23 is the mass number (protons + neutrons). 12 is the number of neutrons ($23 - 11$). 34 is the sum of the mass and atomic numbers, which has no physical meaning.

Question #65 Key: (D)

PMDC 2021

Which of the following has the lowest [Formula] ratio?

CORE CONCEPT AND DERIVATION

The charge-to-mass ratio (e/m) is directly proportional to the charge of the particle and inversely proportional to its mass.

Formula:

$$\frac{e}{m} = \frac{\text{Charge}}{\text{Mass}}$$

Solution:

- For H^+ : Charge = +1, Mass ≈ 1 amu. $e/m \propto 1/1 = 1$.
- For He^+ : Charge = +1, Mass ≈ 4 amu. $e/m \propto 1/4 = 0.25$.
- For Li^{2+} : Charge = +2, Mass ≈ 7 amu. $e/m \propto 2/7 \approx 0.28$.
- For Be (assuming neutral atom as written): Charge = 0. $e/m = 0$. Even if inferred as a canal ray ion like Be^+ (Mass ≈ 9 amu), $e/m \propto 1/9 \approx 0.11$.
- In either case, Be (or its single positive ion) provides the mathematically lowest value due to having the highest mass relative to charge.

Why other options are incorrect: Hydrogen has the highest e/m ratio due to its minimal mass, and the others are intermediate.

Question #66 Key: (B)

PMDC 2021

M-shell contain:

CORE CONCEPT AND DERIVATION

The principal quantum number n determines the number of subshells within that shell.

Formula:

$$\text{Number of subshells} = n$$

Solution:

- The shells are lettered K, L, M, N... corresponding to $n = 1, 2, 3, 4 \dots$
- For the M-shell, $n = 3$.
- An energy level n contains exactly n subshells.
- Therefore, the M-shell has 3 subshells: s ($l = 0$), p ($l = 1$), and d ($l = 2$).

Why other options are incorrect: Option A describes the K-shell. Option C describes the L-shell. Option D describes the N-shell.

Question #67 Key: (B)

PMDC 2021

Total no. of electrons that can be accommodated in f-subshell:

CORE CONCEPT AND DERIVATION

The maximum number of electrons in any subshell is derived from its azimuthal quantum number l .

Formula:

$$\text{Max Electrons} = 2(2l + 1)$$

Solution:

- For an f-subshell, the azimuthal quantum number is $l = 3$.
- Number of degenerate orbitals = $2l + 1 = 2(3) + 1 = 7$ orbitals.
- Following Pauli's Exclusion Principle, each orbital holds up to 2 electrons.
- Total electrons = $7 \times 2 = 14$.

Why other options are incorrect: 6 is for a p-subshell. 10 is for a d-subshell.

Question #68 Key: (D)

PMDC 2021

*[Formula] value for [Formula] is:***CORE CONCEPT AND DERIVATION**

The $(n + l)$ rule is used to determine the relative energy levels of atomic orbitals.

Formula:

$$\text{Value} = n + l$$

Solution:

- The term "5d" directly gives us the principal quantum number $n = 5$.
- The letter "d" corresponds to an azimuthal quantum number $l = 2$.
- Adding them together: $5 + 2 = 7$.

Why other options are incorrect: They result from incorrect memorization of the l value for the d-subshell (e.g., using $l = 1$ yields 6, which is wrong).

Question #69 Key: (C)

PMDC 2021

Each electron in an atom must have its own unique set of quantum number is a statement of ____

CORE CONCEPT AND DERIVATION

The foundational rules of quantum mechanics govern how electrons populate atoms to prevent the physical impossibility of two identical fermions occupying the exact same space and state.

Formula: None required.

Solution:

- The Pauli Exclusion Principle explicitly states that no two electrons in a single atom can have an identical set of all four quantum numbers (n, l, m, s).
- Even if two electrons share the same orbital (meaning n, l , and m are identical), they must have opposite spins (one $s = +1/2$, the other $s = -1/2$).

Why other options are incorrect: The Aufbau principle dictates the order of energy filling (lowest energy first). Hund's rule dictates that electrons singly occupy degenerate orbitals before pairing up.

Question #70 Key: (D)

PMDC 2020

The relationship between quantum number $[Formula]$ and $[Formula]$ is:

CORE CONCEPT AND DERIVATION

The azimuthal quantum number (l) is bounded by the principal quantum number (n).

Formula:

$$l = 0, 1, 2, \dots, (n - 1)$$

Solution:

- For a given principal shell n , the possible values of l start from 0 and go up to a maximum of $n - 1$.
- Therefore, the maximum possible value (and the defining mathematical boundary) linking the two is $l = n - 1$.

Why other options are incorrect: l can never be equal to or greater than n , which immediately disqualifies expressions like $n = l - 1$.

Question #71 Key: (B)

PMDC 2020

Quantum number values for " $[Formula]$ " orbitals are:

CORE CONCEPT AND DERIVATION

Orbital nomenclature directly states the principal quantum number and uses a letter code for the azimuthal quantum number.

Formula: None required.

Solution:

- The number "2" in " $2p$ " denotes the principal quantum number: $n = 2$.
- The letter " p " denotes the subshell type. The mapping is $s = 0, p = 1, d = 2, f = 3$.
- Therefore, for a p -orbital, $l = 1$.
- Result: $n = 2, l = 1$.

Why other options are incorrect: $n = 2, l = 0$ is the $2s$ orbital. The others denote $1s$ or invalid states.

Question #72 Key: (B)

PMDC 2020

Which pair has 1 electron in its outer most '[Formula]' orbital?

CORE CONCEPT AND DERIVATION

Elements in Group 1 (Alkali metals) naturally have ns^1 configurations. Certain transition metals exhibit anomalous configurations resulting in an ns^1 outer shell.

Formula: None required.

Solution:

- Sodium (Na, $Z = 11$): $[Ne]3s^1$ (1 electron in outermost s).
- Chromium (Cr, $Z = 24$): $[Ar]4s^13d^5$ (anomalous config to achieve half-filled stability, leaving 1 electron in the outermost s).
- Therefore, the pair Na & Cr both fit the condition.

Why other options are incorrect: Iron (Fe) is $4s^2$. Manganese (Mn) is $4s^2$. Helium (He) is $1s^2$.

Question #73 Key: (D)

NUMS 2019

Maximum numbers of electron in a sub-shell is given by:

CORE CONCEPT AND DERIVATION

The number of orbitals in a sub-shell is dictated by the magnetic quantum number m , and Pauli's Exclusion Principle states each orbital can hold 2 electrons.

Formula:

$$\begin{aligned}\text{Orbitals} &= 2l + 1 \\ \text{Max Electrons} &= 2(2l + 1)\end{aligned}$$

Solution:

- For any azimuthal quantum number l , there are $(2l + 1)$ degenerate orbitals.
- Since each orbital holds a maximum of 2 electrons (with opposite spins), we multiply the number of orbitals by 2.
- The final formula is $2(2l + 1)$.

Why other options are incorrect: $2l + 1$ calculates the number of orbitals, not electrons. The others are mathematically invalid expressions for quantum capacity.

Question #74 Key: (D)

NUMS 2019

The order of energy level in [Formula] is:

CORE CONCEPT AND DERIVATION

The filling of electrons into orbitals follows the Aufbau principle and the $(n + l)$ rule.

Formula:

$$\text{Energy} \propto (n + l)$$

Solution:

- Potassium (K) has $Z = 19$.
- The electron configuration is: $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^1$.
- After filling the $3p$ subshell, the next available subshells are $4s$ and $3d$.
- Calculate $n + l$: For $4s$, $4 + 0 = 4$. For $3d$, $3 + 2 = 5$.
- Since $4s$ has lower energy than $3d$, the electron enters $4s$. Thus, the progressive filling order at the valence boundary is $3p \rightarrow 4s$.

Why other options are incorrect: They do not represent the consecutive energy levels being filled for the 19th electron of Potassium.

Question #75 Key: (D)

SET 2019

Which of the following element in its atomic state has electrons fully occupying first two spherically symmetr...

CORE CONCEPT AND DERIVATION

Spherically symmetrical orbitals correspond to s -orbitals ($l = 0$).

Formula: None required.

Solution:

- The first two spherically symmetrical orbitals are the $1s$ and $2s$ orbitals.
- Fully occupying both means filling them with a total of 4 electrons: $1s^2, 2s^2$.
- The element with an atomic number of 4 is Beryllium (Be).

Why other options are incorrect: Helium only fully occupies the first s -orbital ($1s^2$). Oxygen and Carbon have electrons in p -orbitals, going beyond just the first two s -orbitals.

Question #76 Key: (D)

KMU 2019

Quantum number which describes the orientation of orbitals in three dimensional space is:

CORE CONCEPT AND DERIVATION

Each of the four quantum numbers defines a unique aspect of an electron's state in an atom.

Formula: None required.

Solution:

- Principal (n): Distance from nucleus / Energy level.
- Azimuthal (l): Shape of the orbital (e.g., sphere, dumbbell).
- Magnetic (m): Spatial orientation of the orbital along the x, y, and z axes in a magnetic field.
- Spin (s): Intrinsic angular momentum (spin) of the electron.

Why other options are incorrect: Only the magnetic quantum number corresponds to 3D spatial orientation.

Question #77 Key: (D)

MDCAT 2019

Which of the following is the electronic configuration of Cr?

CORE CONCEPT AND DERIVATION

Chromium ($Z = 24$) exhibits an anomalous electronic configuration to achieve the extra stability associated with a symmetrical, half-filled $3d$ -subshell.

Formula / Rule:

Aufbau principle with half-filled d^5 stability exception: $[\text{Ar}] 3d^5 4s^1$

Solution:

- Chromium has 24 electrons. The noble gas core Argon ($[\text{Ar}]$) accounts for 18 electrons.
- The standard Aufbau sequence predicts $[\text{Ar}] 3d^4 4s^2$. However, transferring one electron from the $4s$ orbital to the $3d$ subshell yields $[\text{Ar}] 3d^5 4s^1$.
- The half-filled $3d^5$ subshell possesses greater exchange energy and maximum symmetry, making $[\text{Ar}] 3d^5 4s^1$ the actual, ground-state electronic configuration.

Why other options are incorrect:

- **Opt_A:** $[\text{Ar}] 3d^5 4s^2$ totals 25 electrons (Manganese, Mn), not Chromium.
- **Opt_B:** $[\text{Ar}] 3d^4 4s^2$ is the unshifted hypothetical Aufbau configuration, which is less stable than the actual $3d^5 4s^1$ ground state.
- **Opt_C:** $[\text{Ar}] 3d^6 4s^0$ has an excited/unstable configuration with paired d electrons.

Question #78 Key: (B)

MDCAT 2018

Which is the correct electronic configuration of chromium (24Cr)?

CORE CONCEPT AND DERIVATION

Half-filled (d^5) and fully-filled (d^{10}) subshells offer extra thermodynamic exchange energy and spherical symmetry, making them exceptionally stable.

Formula: None required.

Solution:

- Chromium has an atomic number $Z = 24$.
- The expected Aufbau configuration is $[Ar]4s^23d^4$.
- However, to achieve the highly stable half-filled d -subshell, one electron is promoted from the $4s$ orbital to the $3d$ orbital.
- The actual configuration is anomalous:
 $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^1, 3d^5$.

Why other options are incorrect: Option A assumes rigid adherence to Aufbau without accounting for half-filled stability. Options C and D have incorrect total electron counts.

Question #79 Key: (D)

MDCAT 2017

Number of electrons in [Formula] will be

CORE CONCEPT AND DERIVATION

A positive ion (cation) is formed when a neutral atom loses electrons. The net positive charge equals the number of electrons lost.

Formula:

$$\text{Electrons} = Z - \text{Charge}$$

Solution:

- The atomic number of Gallium (Ga) is given as $Z = 31$.
- A neutral atom of Ga has 31 electrons.
- The +3 charge indicates the loss of 3 electrons.
- Total electrons = $31 - 3 = 28$.

Why other options are incorrect: 34 would mean it gained 3 electrons (anion). 29 and 30 miscalculate the subtraction.

Question #80 Key: (C)

MDCAT 2017

Isotopic symbol of ion of Sulphur-33 is [Formula]. How many numbers of protons and neutrons are present if nu...

CORE CONCEPT AND DERIVATION

Protons are strictly determined by the atomic number (Z), and neutrons are determined by mass number (A) minus atomic number (Z), regardless of the electron count.

Formula:

$$P = Z$$

$$N = A - Z$$

Solution:

- The symbol ${}^{33}_{16}\text{S}^{-2}$ gives $Z = 16$ (subscript) and $A = 33$ (superscript).
- Number of protons (P) = $Z = 16$.
- Number of neutrons (n) = $A - Z = 33 - 16 = 17$.

Why other options are incorrect: They confuse the electron count (18) with the proton or neutron counts, which are fixed by the nucleus.

Question #81 Key: (B)

MDCAT 2017

Among the following, which contains same no. of electrons & proton but different no. of neutron:

CORE CONCEPT AND DERIVATION

Isotopes are atoms of the same chemical element that have the same atomic number but a different mass number.

Formula: None required.

Solution:

- Because isotopes are the same element, their atomic number (Z) is identical, meaning they have the same number of protons and electrons (in a neutral state).
- The difference in their mass numbers is purely due to a different number of neutrons in the nucleus.

Why other options are incorrect: Isobars have the same mass number but different atomic numbers. Isotones have the same number of neutrons but different numbers of protons.

Question #82 Key: (D)

MDCAT 2017

Identify the correct option associated with the shape of p-orbital:

CORE CONCEPT AND DERIVATION

The azimuthal quantum number l dictates the shape of the electron probability density (orbital).

Formula:

$$l = 1 \Rightarrow \text{p-orbital}$$

Solution:

- For an s-orbital ($l = 0$), the shape is spherical.
- For a p-orbital ($l = 1$), the shape is a dumbbell (two lobes separated by a single nodal plane).
- For a d-orbital ($l = 2$), the shapes are typically double-dumbbells or a dumbbell with a collar (like d_{z^2}).
- Option D represents the classic dumbbell shape associated with p-orbitals.

Why other options are incorrect: Option A is an s-orbital. Options B and C represent d-orbitals.

Question #83 Key: (D)

MDCAT 2016

Number of neutrons in [Formula] will be:

CORE CONCEPT AND DERIVATION

The number of neutrons in an isotope is the difference between its mass number (A) and atomic number (Z).

Formula:

$$N = A - Z$$

Solution:

- From the symbol ${}^{66}_{30}\text{Zn}$, the mass number $A = 66$.
- The atomic number $Z = 30$.
- Number of neutrons $N = 66 - 30 = 36$.

Why other options are incorrect: 30 is the number of protons. 35 and 38 are mathematically incorrect subtractions.

Question #84 Key: (B)

MDCAT 2016

The maximum number of electrons in electronic configuration can be calculated by using formula:

CORE CONCEPT AND DERIVATION

The total number of electrons that can be accommodated in a principal energy level (shell) depends solely on its principal quantum number n .

Formula:

$$\text{Max Electrons per Shell} = 2n^2$$

Solution:

- For $n = 1$ (K shell): $2(1)^2 = 2$
- For $n = 2$ (L shell): $2(2)^2 = 8$
- For $n = 3$ (M shell): $2(3)^2 = 18$
- This standard formula aggregates the capacities of all subshells within the n^{th} shell.

Why other options are incorrect: $2l + 1$ calculates the number of orbitals in a subshell, not the maximum electrons in a principal shell.

Question #85 Key: (D)

KMU 2016

What are the values of principal quantum number and azimuthal quantum number for the last electron in chlorine...

CORE CONCEPT AND DERIVATION

The quantum numbers n (principal) and l (azimuthal) define the specific shell and subshell where the valence electron resides.

Formula: None required.

Solution:

- Chlorine has an atomic number $Z = 17$.
- Its electronic configuration is $1s^2, 2s^2, 2p^6, 3s^2, 3p^5$.
- The last (valence) electron enters the $3p$ orbital.
- For a $3p$ orbital, the principal quantum number $n = 3$.
- The azimuthal quantum number for a p -orbital is $l = 1$.
- Therefore, $(n, l) = (3, 1)$.

Why other options are incorrect: They do not match the quantum numbers of the $3p$ subshell.

Question #86 Key: (B)

KMU 2016

Which of the following electronic configuration is / are correct? (i) [Formula] (ii) [Formula] (iii) [Formula]...

CORE CONCEPT AND DERIVATION

Anomalous electronic configurations occur in transition metals to maximize stability via fully-filled (d^{10}) or half-filled (d^5) subshells.

Formula: None required.

Solution:

- (i) is completely missing the $2p$, $4s$, and $3d$ orbitals. It is blatantly incorrect.
- (ii) correctly shows the anomalous configuration for Copper ($Z = 29$), where an electron is promoted to achieve a stable, fully-filled $3d$ subshell: $[Ar]4s^1 3d^{10}$.
- (iii) incorrectly assigns 35 electrons to Chromium ($Z = 24$). Its correct config is $[Ar]4s^1 3d^5$.
- (iv) is the predicted (but incorrect) Aufbau configuration for Chromium.
- Hence, ONLY (ii) is correct.

Why other options are incorrect: They include structurally flawed or experimentally incorrect configurations.

Question #87 Key: (A)

MDCAT 2015

There are four orbitals [Formula] and [Formula]. Which order is correct with respect to the increasing energy...

CORE CONCEPT AND DERIVATION

For orbitals within the same principal shell (same n), energy increases as the azimuthal quantum number (l) increases.

Formula:

Energy sequence for same n : $s < p < d < f$

Solution:

- Given $n = 4$ for all options.
- The l values are: $s = 0$, $p = 1$, $d = 2$, $f = 3$.
- Applying the $n + l$ rule:
- $4s = 4 + 0 = 4$
- $4p = 4 + 1 = 5$
- $4d = 4 + 2 = 6$
- $4f = 4 + 3 = 7$
- Therefore, the increasing order is $4s < 4p < 4d < 4f$.

Why other options are incorrect: They jumble the well-established s, p, d, f subshell hierarchy.

Question #88 Key: (D)

MDCAT 2015

Which one of the following pairs has the same electronic configuration as possessed by neon (Ne-10)?

CORE CONCEPT AND DERIVATION

Isoelectronic species have the exact same number of electrons.

Formula:

Total Electrons = $Z - \text{Charge}$

Solution:

- Neon (Ne) has an atomic number $Z = 10$, meaning it has 10 electrons.
- Sodium ion (Na^+): $Z = 11$, charge = $+1 \Rightarrow 11 - 1 = 10$ electrons.
- Fluoride ion (F^-): $Z = 9$, charge = $-1 \Rightarrow 9 - (-1) = 10$ electrons.
- Since both Na^+ and F^- have 10 electrons, they are isoelectronic with Neon.

Why other options are incorrect: Cl^- and K^+ have 18 electrons (isoelectronic with Argon), and Mg^+ has 11 electrons.

Question #89 Key: (C)

MDCAT 2014

According to the number of protons, neutrons and electrons given in the table, which one of the following opti...

CORE CONCEPT AND DERIVATION

The charge of an ion is determined by the difference between its protons (positive charge) and electrons (negative charge).

Formula:

Charge = Protons – Electrons

Solution:

- For As: $33 - 30 = +3 \Rightarrow \text{As}^{+3}$
- For Ga: $31 - 28 = +3 \Rightarrow \text{Ga}^{+3}$
- For Ca: $20 - 20 = 0 \Rightarrow \text{Ca}^0$ (Neutral atom)

Why other options are incorrect: They assign incorrect charges, such as giving Calcium a charge when its protons and electrons are equal.

Question #90 Key: (C)

MDCAT 2013

Number of electrons in the outermost shell of chloride ion ([Formula]) is:

CORE CONCEPT AND DERIVATION

Formation of an anion involves the addition of electrons to the valence shell of a neutral atom to achieve a stable noble gas configuration.

Formula:

$$\text{Electrons} = Z - \text{Charge}$$

Solution:

- A neutral Chlorine (Cl) atom has atomic number $Z = 17$.
- Its electronic configuration is $1s^2, 2s^2, 2p^6, 3s^2, 3p^5$ (or 2, 8, 7).
- The outermost shell ($n = 3$) has $2 + 5 = 7$ electrons.
- When it gains 1 electron to form the chloride ion (Cl^-), the configuration becomes $3s^2, 3p^6$.
- The outermost shell now contains $2 + 6 = 8$ electrons.

Why other options are incorrect: 17 is the total number of protons. 7 is the valence electrons in a neutral Cl atom, not the ion.

Question #91 Key: (C)

MDCAT 2013

Correct order of energy in the given sub-shells is:

CORE CONCEPT AND DERIVATION

Orbital energy is governed by the $(n + l)$ rule.

Formula:

$$\text{Energy order} \propto (n + l)$$

Solution:

- Calculate $(n + l)$ for each:
- $5s : 5 + 0 = 5$
- $3d : 3 + 2 = 5$ (Lower n than $5s$, so lower energy)
- $4s : 4 + 0 = 4$
- $3p : 3 + 1 = 4$ (Lower n than $4s$, so lower energy)
- Descending order of energy: $5s > 3d > 4s > 3p$.

Why other options are incorrect: They incorrectly sequence the $n + l$ values or misapply the tie-breaking rule for identical $n + l$ sums.

Question #92 Key: (D)

MDCAT 2012

The relative energies of [Formula], [Formula] and [Formula] orbitals are in the order:

CORE CONCEPT AND DERIVATION

The energy of an orbital is directly proportional to its $(n + l)$ value (Aufbau Principle).

Formula:

$$\text{Energy} \propto (n + l)$$

Solution:

- For $4s : n = 4, l = 0 \Rightarrow n + l = 4$
- For $3d : n = 3, l = 2 \Rightarrow n + l = 5$
- For $4p : n = 4, l = 1 \Rightarrow n + l = 5$
- Since $4s$ has the lowest value, it has the lowest energy.
- For $3d$ and $4p$, both have $n + l = 5$. When $(n + l)$ values are identical, the orbital with the lower n value has lower energy. Thus, $3d < 4p$.
- Overall order: $4s < 3d < 4p$.

Why other options are incorrect: They violate the $(n + l)$ rule for filling order.

Question #93 Key: (C)

MDCAT 2012

With increase in the value of principal quantum number "[Formula]", the shape of the [Formula] orbitals rema...

CORE CONCEPT AND DERIVATION

The principal quantum number n determines the main energy level (shell) and the distance of the electron from the nucleus.

Formula:

$$\text{Size} \propto n^2$$

Solution:

- As the value of n increases (e.g., $1s \rightarrow 2s \rightarrow 3s$), the electron cloud expands outward.
- The orbital maintains its spherical shape, but its volume and radius increase significantly.

Why other options are incorrect: Size cannot decrease or remain the same because higher energy shells are physically located further from the nucleus.

Question #94 **Key: (C)**

MDCAT 2010

Which quantum number tells us about orientation of orbitals?

CORE CONCEPT AND DERIVATION

Quantum numbers describe the properties of atomic orbitals and the properties of electrons in orbitals.

Formula: None required.

Solution:

- The principal quantum number (n) describes energy and size.
- The azimuthal quantum number (l) describes the shape of the orbital.
- The magnetic quantum number (m) describes the orientation of the orbital in three-dimensional space.
- The spin quantum number (s) describes the spin of the electron.

Why other options are incorrect: Principal, spin, and azimuthal describe size/energy, spin, and shape respectively, not 3D spatial orientation.