A+ Academy – Online Teaching

كيمياء تحضيري جامعة القدس (أبو ديس)

Topic: Pre Chemistry

Instructor:Ammar Telfah

Chapter (4) – Part (3)

WhatsApp & Telegram (00962787124146)

Quantum Numbers

- <u>Quantum numbers</u>: A series of numbers which describe various properties of the orbital.

<u>الأعداد الكمية</u> : هي عبارة عن أعداد تصف وجود الالكترون داخل الغلاف الرئيسي والفرعي والفلك واتجاه دورانه.

- Each electron in an atom has a set with <u>4-quantum numbers</u>.

1/ <u>principal quantum number (n)</u>:

- <u>Has integral values</u>: 1, 2, 3, ...
- <u>Related</u>: Energy, size, How far the electron from nucleous.

- عندما تزداد قيمة (n)
- يصبح الفلك أكبر والالكترونات تكون ابعد عن النواة
- وتصبح طاقة الفلك اكبر، لأن جذب النواة له تصبح أقل.

(4S > 3S > 2S)

2/ <u>Angular momentum quantum number (L)</u>:

- <u>Has integral values</u>: From (0 to n-1)
- <u>related</u>: shape of orbital
- <u>Value of (L)</u>: 0 1 2 3

<u>Particular subshell</u>: S P d f

3) Magnetic quantum number (m_l):

- Has integral values: between from (l to $-l$)
- Related: orientation orbital in space.
-

subshell(l)	(m_l)	orientation
S : 0	0	S
P : 1	(-1, 0, 1)	P_x, P_y, P_z
d : 2	(-2, -1, 0, 1, 2)	$d_{xy}, d_{xz}, d_{yz}, d_{x^2-y^2}, d_{z^2}$

4) The spin quantum number (m_s):

- Has only two values: $(+\frac{1}{2}, -\frac{1}{2})$ (لاتعتمد عل ارقام الاعداد الأخرى)
- Related: spin electrons in orbital ($\uparrow\downarrow$ Pauli principle)

Rule: In a given atom no two electrons can have the same set of four quantum numbers(n, l, m_l, m_s).

قاعدة: في أي ذرة لا يوجد الكترونين يمتلكان نفس قيم الأربعة الأعداد الكمية.

Summary: Table

Name	symbol	Values	Examples
1) principal quantum number	n	positive integer	1, 2, 3, ----
2) Angular momentum number	l	integer (0 to $n-1$)	0, ------
3) Magnetic quantum number	m_l	($-l$ to $+l$)	$-l, \ldots 0 \ldots, +l$
4) spin quantum number	m_s	$(+\frac{1}{2}, -\frac{1}{2})$	$(-\frac{1}{2}, +\frac{1}{2})$

e.g/

1) He^{2} : $1s^2$

$\uparrow$ 1s : n = 1 , L = 0 , m_L = 0 , m_s = +1/2

$\downarrow$ 1s : n = 1 , L = 0 , m_L = 0 , m_s = −1/2

2) Li^{3} : $1s^2/2s^1$

$\uparrow$ 1s : n = 1, L = 0, m_L = 0, m_s = +1/2

$\downarrow$ 1s : n = 1 , L = 0, m_L = 0, m_s = −1/2

$\uparrow$ 2s : n = 2 , L = 0 , m_L = 0 , m_s = +1/2 or −1/2

Ex(1): Which one of the following sets of quantum numbers is not possible?

	n	l	m_l	m_s
A.	4	3	−2	+1/2
B.	3	0	1	−1/2
C.	3	0	0	+1/2
D.	2	1	1	−1/2
E.	2	0	0	+1/2

A) A B) B C) C D) D E) E

Ex(2): List the following sets of quantum numbers in order of increasing energy:

I. n = 4, l = 1, m_l = 1, m_s = +1/2
II. n = 3, l = 2, m_l = -1, m_s = +1/2
III. n = 4, l = 0, m_l = 0, m_s = +1/2

A) I < II < III
B) II < III < I
C) III < II < I
D) I < III < II
E) III < I < II

Ex(3): A possible set of quantum numbers to describe an electron in a 3d subshell is

A) n = 3, l = 0, m_l = 0 , m_s = +1/2
B) n = 3, l = 1, m_l = 0, m_s = - 1/2
C) n = 3, l = 2, m_l = 1, m_s = +1/2
D) n = 3, l = 3, m_l = 1, m_s = - 1/2
E) n = 2, l = 0, m_l = 0, m_s = +1/2

Ex(4) : Which quantum number distinguishes the different shapes of the orbitals?

a. n

b. m_l

c. l

d. m_s

e. any of these

Ex(5): All the following statements about the quantum numbers are true <u>except</u>

a. m_l has $2l + 1$ possible values.

b. n may take integral values from 1 to ∞.

c. m_l may take integral values of $+l$ to $-l$, including zero.

d. l may take integral values from 1 to $n - 1$.

e. m_s may take only the values of $+\frac{1}{2}$ and $-\frac{1}{2}$.

Ex(6): How many electrons can be described by the quantum numbers $n = 3$, $l = 3$, $m_l = 1$?

A) 0
B) 2
C) 6
D) 10
E) 14

Ex(7) In the ground state of an atom of silver (Ag), how many electrons will there be with the quantum number $l = 1$? (The n, m_l, and m_s quantum numbers may have any appropriate values.)

A) 9 B) 12 C) 18 D) 24 E) 36

Ex(8): Which one of the following sets of quantum numbers represents an electron with the highest energy?

A) $n = 3, l = 2, m_l = -2, m_s = +1/2$
B) $n = 4, l = 1, m_l = 0, m_s = -1/2$
C) $n = 4, l = 0, m_l = 0, m_s = +1/2$
D) $n = 5, l = 0, m_l = 0, m_s = +1/2$
E) $n = 4, l = 2, m_l = -1, m_s = -1/2$

Homework

Q1) Which of the following is *not* determined by the principal quantum number, *n*, of the electron in a hydrogen atom?

A) The energy of the electron.

B) the minimum wavelength of the light needed to remove the electron from the atom.

C) The size of the corresponding atomic orbital(s).

D) The shape of the corresponding atomic orbital(s).

E) All of the above are determined by *n*.

Q2) Which one of the following sets of quantum numbers is not possible?

	n	l	m_l	m_s
A.	4	3	−2	+1/2
B.	3	2	−3	−1/2
C.	3	0	0	+1/2
D.	4	1	1	−1/2
E.	2	0	0	+1/2

A) A   B) B   C) C   D) D   E) E

Q3) Which one of the following sets of quantum numbers represents an electron with the highest energy?

A) $n = 2, l = 1, m_l = 0, m_s = +1/2$

B) $n = 3, l = 0, m_l = 0, m_s = -1/2$

C) $n = 2, l = 0, m_l = 0, m_s = +1/2$

D) $n = 3, l = 2, m_l = 1, m_s = -1/2$

E) $n = 3, l = 1, m_l = 1, m_s = +1/2$

Q4) The angular momentum quantum number is best associated with the

a. shape of the orbital.

b. number of orbitals in a subshell.

c. energy of the orbital.

d. orientation in space of an orbital.

e. none of the above

Q5) Which of the following sets of quantum numbers (n, l, ml, m_s) refers to a 3d orbital?

a. $2\ 0\ 0\ -\frac{1}{2}$

b. $5\ 4\ 1\ -\frac{1}{2}$

c. $4\ 2\ -2\ +\frac{1}{2}$

d. $4\ 3\ 1\ -\frac{1}{2}$

e. $3\ 2\ 1\ -\frac{1}{2}$

Q6) What is the value of the angular momentum quantum number for an electron in a 1s orbital?

a. 2

b. 4

c. 3

d. 0

e. 1

Q7) A possible value of the magnetic quantum number m_l for a 5p electron is

a. 1.

b. 4.

c. –5.

d. 6.

e. –3.

Q8) How many values are there for the magnetic quantum number when the value of the angular momentum quantum number is 3?

a. 12

b. 7

c. 1

d. 4

e. 15

Q9) An orbital with the quantum numbers $n = 5$, $l = 2$, $m_l = -1$ may be found in which subshell?

a. 5f

b. 5d

c. 5p

d. 5g

e. 5s

Q10) What is the value of the principal quantum number for an electron in a 5d orbital?

a. –5

b. $+\frac{1}{2}$

c. 5

d. $-\frac{1}{2}$

e. 2

Q11) What is the value of the spin quantum number for an electron in a 4d orbital?

a. 4

b. 2

c. either $+\frac{1}{2}$ or $-\frac{1}{2}$

d. $-\frac{1}{2}$

e. $+\frac{1}{2}$

Q12) Which of the following sets of quantum numbers (n, l, ml, m_s) is <u>not</u> permissible?

a. 2 2 1 $+\frac{1}{2}$

b. 3 1 0 $-\frac{1}{2}$

c. 2 0 0 $+\frac{1}{2}$

d. 2 1 0 $+\frac{1}{2}$

e. 4 0 0 $-\frac{1}{2}$

Q13) Which of the following combinations of quantum numbers is permissible?

a. $n = 1, l = 2, ml = 0, m_s = -\frac{1}{2}$

b. $n = 3, l = 2, ml = 1, m_s = +\frac{1}{2}$

c. $n = 3, l = 3, ml = 1, m_s = +\frac{1}{2}$

d. $n = 2, l = 1, ml = -1, m_s = 0$

e. $n = 4, l = 3, ml = 4, m_s = -\frac{1}{2}$

Q14) Which of the following statements is incorrect?

a. The set of quantum numbers $n = 3, l = 2, ml = 0, m_s = -\frac{1}{2}$ is not permitted because $m_l = 0$.

b. The set of quantum numbers $n = 2, l = 2, ml = 1, m_s = -\frac{1}{2}$ is not permitted because $n = l$.

c. The set of quantum numbers $n = 3, l = 2, ml = 1, m_s = +\frac{1}{2}$ is permitted.

d. The set of quantum numbers $n = 3, l = 2, ml = 3, m_s = -\frac{1}{2}$ is not permitted because m_l exceeds l.

e. The set of quantum numbers $n = 4, l = 3, ml = -1, m_s = 0$ is not permitted because $m_s = 0$.

Q15) How many p orbitals are in the $n = 3$ shell?

a. 1
b. 6
c. 0
d. 5
e. 3

Q16) How many orbitals have the set of quantum numbers n =4 and $l = 2$?

a. 5
b. 9
c. 7
d. 1
e. 3

Q17) Which orbital or orbitals is/are specified by the set of quantum numbers n= 2 and l= 1?

a. 2p
b. 3s
c. 4d
d. 1f
e. 2d

Q18) Which of the following combinations of quantum numbers (n, l, m_l, m_s) do *not* represent permissible solutions of the Schrödinger equation for the electron in the hydrogen atom (i.e., which combination of quantum numbers is *not* allowed)?

A) 9, 8, -4, 1/2
B) 8, 2, 2, 1/2
C) 6, -5, -1, 1/2
D) 6, 5, -5, 1/2
E) All are allowed.

Q19) Which of the following sets of four quantum numbers (n, l, ml, m_s) correctly describes one of the valence electrons in a ground-state radium atom?

a. 7 1 0 $+\frac{1}{2}$

b. 6 1 0 $+\frac{1}{2}$

c. 7 2 0 $-\frac{1}{2}$

d. 7 2 0 $-\frac{1}{2}$

e. 7 0 0 $+\frac{1}{2}$

Q20) Which of the following statements is *false*?
A) An orbital can accommodate at most two electrons.
B) The electron density at a point is proportional to ψ^2 at that point.
C) The spin quantum number of an electron must be either $+\frac{1}{2}$ or $-\frac{1}{2}$.
D) A $2p$ orbital is more penetrating than a $2s$; i.e., it has a higher electron density near the nucleus and inside the charge cloud of a $1s$ orbital.
E) In the usual order of filling, the $6s$ orbital is filled before the $4f$ orbital.

Q21) The size of an atomic orbital is associated with
A) the principal quantum number (n).
B) the angular momentum quantum number (l).
C) the magnetic quantum number (m_l).
D) the spin quantum number (m_s).
E) the angular momentum and magnetic quantum numbers, together.

Q22) The shape of an atomic orbital is associated with
A) the principal quantum number (n).
B) the angular momentum quantum number (l).
C) the magnetic quantum number (m_l).
D) the spin quantum number (m_s).
E) the magnetic and spin quantum numbers, together.

Q23) Which of the following is a correct set of quantum numbers for an electron in a $5f$ orbital?
A) $n = 5, l = 3, m_l = +1$
B) $n = 5, l = 2, m_l = +3$
C) $n = 4, l = 3, m_l = 0$
D) $n = 4, l = 2, m_l = +1$
E) $n = 5, l = 4, m_l = 3$

Q24) Which one of the following sets of quantum numbers can correctly represent a $3p$ orbital?

A)	$n = 3$	$l = 1$	$m_l = 2$
B)	$n = 1$	$l = 3$	$m_l = 3$
C)	$n = 3$	$l = 2$	$m_l = 1$
D)	$n = 3$	$l = 1$	$m_l = -1$
E)	$n = 3$	$l = 0$	$m_l = 1$

Q25) Which of the subshells below do <u>not</u> exist due to the constraints upon the angular momentum quantum number?

A) 2d B) 2s C) 2p D) all of the above E) none of the above

Q26) Which of the subshells below do <u>not</u> exist due to the constraints upon the angular momentum quantum number?

A) 4f B) 4d C) 4p D) 4s E) none of the above

Q27) An electron cannot have the quantum numbers n = __________, l = __________, m_l = __________.

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

Q28) An electron cannot have the quantum numbers n = __________, l = __________, m_l = __________.

A) 6, 1, 0
B) 3, 2, 3
C) 3, 2, -2
D) 1, 0, 0
E) 3, 2, 1

Q29) The elements in the __________ period of the periodic table have a core-electron configuration that is the same as the electron configuration of neon.

A) first
B) second
C) third
D) fourth
E) fifth

Q30) List the following sets of quantum numbers in order of increasing energy:

I. $n = 4, l = 1, m_l = 1, m_s = +1/2$
II. $n = 3, l = 2, m_l = -1, m_s = +1/2$
III. $n = 4, l = 0, m_l = 0, m_s = +1/2$

A) I < II < III B) II < III < I C) III < II < I D) I < III < II E) III < I < II

Q31) The number of orbitals having a given value of l is equal to

A) $2l + 1$
B) $2n + 2$
C) $3l$
D) $l + m_l$
E) the number of lobes in each orbital

Answer Key:

Question	Answer	Question	Answer	Question	Answer
1	D	13	B	25	A
2	B	14	A	26	E
3	D	15	E	27	D
4	A	16	A	28	B
5	E	17	A	29	C
6	D	18	C	30	C
7	A	19	E	31	A
8	B	20	D		
9	B	21	A		
10	C	22	B		
11	C	23	A		
12	A	24	D		

ملاحظات:

اذا كان لديك أي استفسار أو سؤال تواصل مع الأستاذ على الواتس اب.

تنويه: الأستاذ عمار طلفاح يقدم دورات الكيمياء العامة والعضوية والتحليلية للعديد من الجامعات وأهمها الجامعات الأردنية وجامعات النجاح والأمريكية وأبو ديس في فلسطين وأي جامعة اخرى حول العالم، وبتالي يا ريت توصل للمهتمين من معارفك واقاربك والدارسين لهذه المواد والذين يجدون صعوبة فيها وبحبوا يلتحقوا بدورتنا يتواصلوا مع الأستاذ على الواتس اب التالي

00962787124146