Quantum Theory and the Electronic Structure of Atoms

# Test bank chapter (7)

Choose the most correct answer

1. The lowest energy state of an atom is referred to as its
   a) bottom state.
   **b) ground state.**
   c) fundamental state.
   d) original state.

2. All s orbitals are
   a) shaped like four-leaf clovers.
   b) dumbbell-shaped.
   c) spherical.
   d) triangular.

3. $[He]2s^2 2p^2$ is the electron configuration of which element?
   a) Beryllium Be
   b) Boron B
   c) carbon C
   d) nitrogen N

4. What are the valence electrons of vanadium (V)?
   a) $4s^2$
   b) $3d^3$
   c) $4s^2 3d^3$
   d) $3d^5$

5. What are the valence electrons of gallium Ga?
   a) $4s^2$
   b) $3d^3$
   c) $4s^2 4p^1$
   d) $3d^5$

6. The electron configuration of a neutral atom is [Ne] $3s^2 3p^1$. The four quantum numbers of the last electron are:

   a) (2, 1, -1, +1/2)
   b) (3, 3, -1 , +1/2)
   c) (3, 0, -1, +1/2)
   d) (3, 1, -1, +1/2 )

7. How many unpaired electrons does chromium (Cr) have?
   a) 0
   b) 2
   c) 4
   d) **6**

8. How many unpaired electrons does selenium (Se) have?
   a) 0
   b) **2**
   c) 4
   d) 6

**9.** What is the maximum number of orbitals described by the quantum numbers: $n = 3$ $l = 2$
a) 1
b) 3
c) **5**
d) 9

**10.** What is the maximum number of orbitals described by the quantum numbers: $n = 4$
a) 7
b) 14
**c)** **16**
d) 48

11.The maximum number of electrons that can occupy an energy level described by the principal quantum number, *n*, is
a) $n + 1$
*b)* $2n$
c) $2n^2$
d) $n^2$

12. A possible set of quantum numbers for the last electron added to complete an atom of sodium Na in its ground state is

a) $n = 3$ , $l = 1$ , $m_l = 0$ , $m_s = ½$
b) $n = 3$ , $l = 0$ , $m_l = 0$ , $m_s = ½$
c) $n = 2$ , $l = 1$ , $m_l = -1$ , $m_s = ½$
d) $n = 2$ , $l = 0$ , $m_l = -1$ , $m_s = ½$

13. The ground-state electron configuration of a calcium Ca atom is

a) $[Ne]3s^2$
b) $[Ne]3s^23p^6$
c) $[Ar]4s^13d^1$
d) $[Ar]4s^2$

14.Which one of the following sets of quantum numbers is not possible?

| | n | $l$ | $m_l$ | $m_s$ |
|---|---|---|---|---|
| Row 1 | 4 | 3 | −2 | +1/2 |
| Row 2 | 3 | 2 | −3 | −1/2 |
| Row 3 | 3 | 0 | 0 | +1/2 |
| Row 4 | 4 | 1 | 1 | −1/2 |
| Row 5 | 2 | 0 | 0 | +1/2 |

a) Row 1
b) Row 2
c) Row 3
d) Row 4

15. The number of orbitals in a *d* subshell is

a) 1
b) 3
c) **5**
d) 7

16. Which ground-state atom has an electron configuration described by the following *orbital diagram*?

| | 4s | 3d | | | | | 4p | | |
|---|---|---|---|---|---|---|---|---|---|
| [Ar] | ↑↓ | ↑↓ | ↑↓ | ↑↓ | ↑↓ | ↑↓ | ↑↓ | ↑ | ↑ |

a) phosphorus
b) germanium
c) selenium
d) tellurium

17. A ground-state atom of nickel has____unpaired electrons and is______.

a) 0, diamagnetic
b) 6, diamagnetic
c) 3, paramagnetic
d) 2, paramagnetic

**18.** What is the frequency ($s^{-1}$) of electromagnetic radiation that has a wavelength of 0.53 m?

a) **5.7 x $10^8$**
b) 1.8 x $10^{-9}$
c) 1.6 x $10^8$
d) 1.3 x $10^{-33}$

**Explanation:** The frequency and wavelength of electromagnetic radiation are related by the equation c = λv, where c is the speed of light (=3.00 x $10^8$ m/s ), λ is the wavelength in m and ν is the frequency is $s^{-1}$ or Hz. The frequency can be calculated by rearranging the above formula to get $\nu = c/\lambda = 3 \times 10^8 / 0.53 = 5.7 \times 10^8\ s^{-1}$

19. The energy of a photon of light is_____proportional to its frequency and_______proportional to its wavelength.

a) directly, directly
b) inversely, inversely
c) inversely, directly
d) directly, inversely

20. The wavelength of a photon of energy 5.25 x $10^{-19}$ J is____________m.

a) 2.64 x $10^6$
b) **3.79 x $10^{-7}$**
c) 2.38 x $10^{23}$
d) 4.21 x $10^{-24}$

**Explanation:** The wavelength and energy are related by the formula E = hc/λ, where h (6.626 x $10^{-34}$ Js) is Planck's constant, c is the speed of light (3.00 x $10^8$ m/s) and λ is the wavelength in meters. The wavelength can then be calculated by rearranging the above formula as follows: $\lambda = hc/E = 6.63\times10^{-34} \times 3\times10^8 / 5.25\times10^{-19} = 3.79 \times 10^{-7}$ m

21. What is the frequency ($s^{-1}$) of a photon of energy $4.38 \times 10^{-18}$J?

a) 438
b) $1.45 \times 10^{-16}$
c) **$6.61 \times 10^{15}$**
d) $2.30 \times 10^{7}$

**Explanation:** The frequency ν of this photon can be calculated by rearranging the equation E = h ν where E is the energy, h = Planck's constant and ν = frequency in $s^{-1}$. $\nu = E/h = 4.38 \times 10^{-18} / 6.63 \times 10^{-34} = 6.61 \times 10^{15}$

22. An electron is a Bohr hydrogen atom has energy of $-1.362 \times 10^{-19}$J. The value of n for this electron is___________.

a) 1
b) 2
c) 3
d) **4**

**Explanation:** The energy of an electron in a particular energy state in the hydrogen atom can be calculated by using the formula $E = -R_H/n^2 = (-2.18 \times 10^{-18}\ J)/n^2$, where n is the principal quantum number for the energy state. The value of n can be found by rearranging the above formula as follows:

$$n = \sqrt{\frac{-2.18 \times 10^{-18}\ J}{-1.362 \times 10^{-19}\ J}} = 4$$

19. The n = 2 to n = 6 transition in the Bohr hydrogen atom corresponds to the___of a photon with a wavelength of___nm.

a) emission, 411
**b) absorption, 411**
c) absorption, 657
d) emission, 389

**Explanation:** There are 2 parts to this question. Since the electron is moving from a smaller value of n ($n_i$) to a larger value of n ($n_f$), it must be absorbing energy. The wavelength responsible for this transition can be calculated by using the formula: $E = R_H (1/n_i^2 - 1/n_f^2)$ & $E = hc/\lambda$, $R_H$ is (Rydberg constant) = $2.18 \times 10^{-18}$J

20. How many quantum numbers are necessary to designate a particular electron in an atom___________?

a) 3
b) **4**
c) 2
d) 1

21. The___________quantum number defines the shape of an orbital.

a) spin
b) magnetic
c) principal
**d) angular**

22. There are__________orbitals in the third shell

a) 25
b) 4
c) **9**
d) 16

**Explanation:** The number of orbitals in a shell is easily calculated by the formula # of orbitals = $n^2$ where n = principal quantum number, which is 3 in this case.

23. The angular quantum number is 2 in__________orbitals.

a) s
b) p
c) **d**
d) f

24. The n = 1 shell contains__________p orbitals. All the other shells contain__________p orbitals.

a) 3, 6
b) **0, 3**
c) 6, 2
d) 3, 3

Explanation: If n = 1, then the only possible value of $\ell$ is 0 which means that n = 1 can contain only s orbitals. When n > 1, the value of $\ell = 1$ is possible making the existence of 3 p orbitals possible.

25. The principal quantum number of the first d subshell is__________.

a) 1
b) 2
c) **3**
d) 4

26. The total number of orbitals in a shell is given by__________.

a) $L^2$
**b)** $\mathbf{n^2}$
c) 2n
d) 2n + 1

28. Each p-subshell can accommodate a maximum of__________electrons.

a) **6**
b) 2
c) 10
d) 3

**Explanation**: There are 3 different p orbitals: $p_x$, $p_y$ and $p_z$. Each of these can contain 2 electrons leading to the maximum number of electrons as 6.

29. Each p-subshell can accommodate a maximum of___________electrons.

a) **6**
b) 2
c) 10
d) 3

**Explanation:** There are 3 different p orbitals: $p_x$, $p_y$ and $p_z$. Each of these can contain 2 electrons leading to the maximum number of electrons as 6.

30. The 3p subshell in the ground state of atomic xenon contains____________electrons.

a) 2
b) **6**
c) 36
d) 10

**Explanation:** Since Xe is a noble gas, its subshells will be completely filled regardless of their principal quantum number. Thus, the 3p subshell will contain 6 electrons.

31. $[Ar]4s^2 3d^{10} 4p^3$ is the electron configuration of a(n)___________atom.

a) **As**
b) V
c) P
d) Sb

**Explanation:** The easiest way to answer this question is to count the total number of electrons and find which element that number corresponds to. The total number of electrons is = 18 (for the Ar) + 2 +10 + 3 = 33 which corresponds to As.

32. The principal quantum number for the outermost electrons in a Br atom in the ground state is___________.

a) 2
b) 3
c) **4**
d) 5

**Explanation:** The electronic configuration of bromine is $[Ar]3d^{10}4s^2 4p^5$ shows that the outermost electrons are in the s and p orbitals in the $4^{th}$ energy level making the principal quantum number = 4.

33. All of the___________have a valence shell electron configuration $ns^1$.

a) noble gases
b) halogens
c) chalcogens
d) **alkali metals**

34. Which one of the following is correct?

a) $\nu + \lambda = c$
b) $\nu/\lambda = c$
c) $\lambda = c\nu$
d) **$\nu \lambda = c$**

35. In the Bohr model of the atom,___________.

a) electrons travel in circular paths called orbitals
b) electrons can have any energy
c) **electron energies are quantized**
d) electron paths are controlled by probability

36. Which one of the following is not a valid value for the magnetic quantum number of an electron in a 5d subshell?

a) 2
b) **3**
c) 0
d) 1

**Explanation:** For an electron in the 5d subshell the value of $\ell = 2$ and the magnetic quantum number $m_\ell$ can have values from –l,…0,…+l, meaning $m\ell$ could not have a value = 3.

37. Which of the subshells below do not exist due to the constraints upon the angular quantum number?

a) 2s
b) **2d**
c) 2p
d) none of the above

**Explanation:** The values of the azimuthal quantum number "l" are decided by the values of the principal quantum number "n". The values of l will only be from 0…n – 1. Thus, for n = 2, only the values of 0 and 1 will be possible for $\ell$, which means that only the 2s and 2p orbitals will be possible.

38. An electron cannot have the quantum numbers n =__________, $\ell$ =__________, $m_\ell$ =___________.

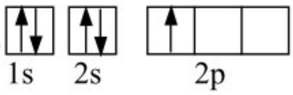
a) 2, 0, 0
b) 2, 1, -1
c) 3, 1, -1
d) **1, 1, 1**

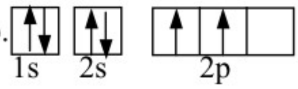
**Explanation:** The values of 1, 1, 1 would be impossible since if n = 1, the only value of $\ell$ would be = 0.

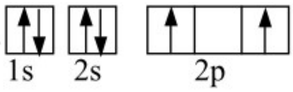
39. Which quantum number determines the energy of an electron in a hydrogen atom?

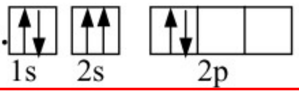
a) **n**
b) n and $\ell$
c) $m_\ell$
d) $\ell$

39. Which electron configuration represents a violation of the Pauli exclusion principle?

(a). 


(b). 


(c). 


**(d).** 


**Explanation:** According to the Pauli Exclusion Principle no two electrons in an atom cannot have the same 4 quantum numbers. The2 electrons in the 2s orbital have the same value for their $m_s$ which is not allowed. **(d)**

**40.** Which of the following is a valid set of four quantum numbers? (n, ℓ, $m_\ell$, $m_s$)

a) **2, 0, 0, + ½**
b) 2, 2, 1, - ½
c) 1, 0, 1, + ½
d) 2, 1, +2, + ½

**Explanation:** Here is why only option (a) is the correct answer: In option (b), ℓ =2 which is not allowed, in (c) mℓ ≠ 1 since l = 0 and in (d) m ℓ > l which are all not allowed.

41. Which of the following is not a valid set of four quantum numbers? (n, ℓ, $m_\ell$, $m_s$)

a) 2, 0, 0, + ½
b) 2, 1, 0, - ½
**c) 1, 1, 0, + ½**
d) 1, 0, 0, + ½

**Explanation:** Since n can never be equal to ℓ, option c is the only set that is not valid