Structure of Atom

1. The atomic number of Ni and Cu are 28 and 29 respectively. The electronic configuration $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}$ represents
(a) Cu^+ (b) Cu^{2+}
(c) Ni^{2+} (d) Ni (2006)

2. A body of mass 10 mg is moving with a velocity of 100 m s^{-1}. The wavelength of de Broglie wave associated with it would be ($h = 6.63 \times 10^{-34}$ Js)
(a) 6.63×10^{-35} m (b) 6.63×10^{-34} m
(c) 6.63×10^{-31} m (d) 6.63×10^{-37} m.
(2007)

3. Mg^{2+} is isoelectronic with
(a) Cu^{2+} (b) Zn^{2+}
(c) Na^+ (d) Ca^{2+} *(2007)*

4. The electronic configuration of Cr^{3+} is
(a) [Ar] $3d^4\ 4s^2$ (b) [Ar] $3d^3\ 4s^0$
(c) [Ar] $3d^2\ 4s^1$ (d) [Ar] $3d^5\ 4s^1$
(2007)

5. When the azimuthal quantum number has the value of 2, the number of orbitals possible are
(a) 3 (b) 0 (c) 7 (d) 5 *(2008)*

6. The correct set of four quantum numbers for outermost electron of potassium (Z = 19) is
(a) $3, 1, 0, \frac{1}{2}$ (b) $4, 0, 0, \frac{1}{2}$
(c) $3, 0, 0, \frac{1}{2}$ (d) $4, 1, 0, \frac{1}{2}$
(2009)

7. A body of mass x kg is moving with a velocity of 100 m s^{-1}. Its de Broglie wavelength is 6.62×10^{-35} m. Hence x is ($h = 6.62 \times 10^{-34}$ Js)
(a) 0.25 kg (b) 0.15 kg
(c) 0.2 kg (d) 0.1 kg *(2009)*

8. The wave number of the spectral line in the emission spectrum of hydrogen will be equal to $\frac{8}{9}$ times the Rydberg's constant if the electron jumps from
(a) $n = 3$ to $n = 1$ (b) $n = 10$ to $n = 1$
(c) $n = 9$ to $n = 1$ (d) $n = 2$ to $n = 1$
(2010)

9. The set of quantum numbers for the outermost electron for copper in its ground state is
(a) 4, 1, 1, +1/2 (b) 3, 2, 2, +1/2
(c) 4, 0, 0, +1/2 (d) 4, 2, 2, +1/2
(2010)

10. Which one of the following sets of quantum numbers represents the highest energy level in an atom?
(a) $n = 4, l = 0, m = 0, s = +\frac{1}{2}$
(b) $n = 3, l = 1, m = 1, s = +\frac{1}{2}$
(c) $n = 3, l = 2, m = -2, s = +\frac{1}{2}$
(d) $n = 3, l = 0, m = 0, s = +\frac{1}{2}$ *(2011)*

11. If the energies of the two photons are in the ratio of 3 : 2, their wavelengths will be the ratio of
(a) 9 : 4 (b) 2 : 3
(c) 1 : 2 (d) 3 : 2 *(2011)*

12. The correct set of four quantum numbers for the outermost electron of sodium ($Z = 11$) is
(a) 3, 1, 0, 1/2 (b) 3, 1, 1, 1/2
(c) 3, 2, 1, 1/2 (d) 3, 0, 0, 1/2 (2012)

13. Impossible orbital among the following is
(a) 2s (b) 3f (c) 2p (d) 4d *(2012)*

14. The electronic configuration of Cu^{2+} ion is
(a) [Ar] $3d^8\ 4s^1$ (b) [Ar] $3d^9\ 4s^0$
(c) [Ar] $3d^7\ 4s^2$ (d) [Ar] $3d^8\ 4s^0$
(2013)

15. Which one of the following sets of ions represents the collection of isoelectronic species?
(a) $K^+, Cl^-, Mg^{2+}, Sc^{3+}$
(b) $Na^+, Ca^{2+}, Sc^{3+}, F^-$
(c) $K^+, Ca^{2+}, Sc^{3+}, Cl^-$
(d) $Na^+, Mg^{2+}, Al^{3+}, Cl^-$ *(2013)*

16. Among the elements from atomic number 1 to 36, the number of elements which have an unpaired electron in their *s*-subshell is
(a) 4 (b) 7
(c) 6 (d) 9 *(2014)*

17. The statement that is not correct is
(a) angular quantum number signifies the shape of the orbital
(b) energies of stationary states in hydrogen like atoms is inversely proportional to the square of the principal quantum number
(c) total number of nodes for 3*s* orbital is three
(d) the radius of the first orbit of He^+ is half that of the first orbit of hydrogen atom. *(2014)*

18. The two electrons have the following sets of quantum numbers :

$$P = 3,\ 2, -2, +\frac{1}{2};\ Q = 3,\ 0, 0, +\frac{1}{2}$$

Which of the following statements is true?
(a) *P* has greater energy than *Q*.
(b) *P* and *Q* represent same electron.
(c) *P* and *Q* have same energy.
(d) *P* has lesser energy than *Q*. *(2015)*

19. The energy of electron in the n^{th} Bohr orbit of H-atom is
(a) $\frac{-13.6}{n^2}$eV (b) $\frac{-13.6}{n}$eV
(c) $\frac{-13.6}{n^4}$eV (d) $\frac{-13.6}{n^3}$eV *(2016)*

20. Consider the following sets of quantum numbers :
Which of the below setting is not permissible arrangement of electrons in an atom?

	n	*l*	*m*	*s*
(a)	4	0	0	$-\frac{1}{2}$
(b)	5	3	0	$+\frac{1}{2}$
(c)	3	2	−2	$-\frac{1}{2}$
(d)	3	2	−3	$+\frac{1}{2}$

(2016)

21. The correct set of quantum numbers for the unpaired electron of chlorine atom is
(a) $2, 0, 0, +\frac{1}{2}$ (b) $3, 0, 0, \pm\frac{1}{2}$
(c) $2, 1, -1, +\frac{1}{2}$ (d) $3, 1, 1, \pm\frac{1}{2}$ *(2017)*

22. Two particles *A* and *B* are in motion. If the wavelength associated with '*A*' is 33.33 nm, the wavelength associated with '*B*' whose momentum is 1/3rd of '*A*' is
(a) 1.0×10^{-8} m (b) 2.5×10^{-8} m
(c) 1.25×10^{-7} m (d) 1.0×10^{-7} m *(2019)*

ANSWER KEY

1.	(a)	**2.**	(c)	**3.**	(c)	**4.**	(b)	**5.**	(d)	**6.**	(b)	**7.**	(d)	**8.**	(a)
9.	(c)	**10.**	(c)	**11.**	(b)	**12.**	(d)	**13.**	(b)	**14.**	(b)	**15.**	(c)	**16.**	(c)
17.	(c)	**18.**	(a)	**19.**	(a)	**20.**	(d)	**21.**	(d)	**22.**	(d)				

EXPLANATIONS

1. **(a)** : Electronic configurations of :

Ni - [Ar] $3d^8\,4s^2$; Ni^{2+} - [Ar] $3d^8$

Cu - [Ar] $3d^{10}\,4s^1$; Cu^+ - [Ar] $3d^{10}$; Cu^{2+} - [Ar] $3d^9$

2. **(c)** : $m = 10\text{ mg} = 10 \times 10^{-3}\text{ g}$

$= 10 \times 10^{-6}\text{ kg} = 10^{-5}\text{ kg}$

$v = 100\text{ m s}^{-1}$, de Broglie, $\lambda = ?$, $h = 6.63 \times 10^{-34}\text{ Js}^{-1}$

de Broglie relation, $\lambda = \dfrac{h}{mv}$

$$\lambda = \frac{6.63\times10^{-34}\text{ Js}^{-1}}{10^{-5}\times100} = \frac{6.63\times10^{-34}}{10^{-3}} = 6.63\times10^{-31}\text{ m}$$

3. **(c)** : Mg^{2+} electronic configuration : $1s^2\,2s^2\,2p^6$

Na^+ electronic configuration : $1s^2\,2s^2\,2p^6$

as both possess same number of electrons *i.e.*, isoelectronic effect .

4. **(b)** : Cr ($Z = 24$) : [Ar]$3d^5\,4s^1$

Electronic configuration of Cr^{3+} : [Ar] $3d^3\,4s^0$.

5. **(d)** : Total values of $m = (2l + 1)$ = no. of orbitals in subshell.

where m = Magnetic quantum number

l = Azimuthal quantum number

where $l = 2$ represents 'd' subshell and d subshell has five orbitals. (d_{xy}, d_{yz}, d_{zx}, $d_{x^2-y^2}$, d_{z^2}).

6. **(b)** : The electronic configuration of K ($Z = 19$) is $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$.

Thus, the outermost configuration is $4s^1$, the four quantum numbers for this e^- are :

$n = 4$, $l = 0$, $m = 0$ and $s = 1/2$.

7. **(d)** : According to de Broglie's equation,

$$\lambda = \frac{h}{mv}$$

Given, $\lambda = 6.62 \times 10^{-35}$ m, $v = 100\text{ m s}^{-1}$

$h = 6.62 \times 10{-}34$ Js and $m = x$ kg

$$\therefore\quad 6.62 \times 10^{-35} = \frac{6.62\times10^{-34}}{x\times100} \Rightarrow x = 0.1\text{ kg}$$

8. **(a)** : According to Rydberg's formula,

$$\bar{\upsilon} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]Z^2$$

If $\bar{\upsilon} = \dfrac{8}{9}R$, then n_1 should be equal to 1 and n_2 should be equal to 3 *i.e.*,

$$\bar{\upsilon} = R\left[\frac{1}{1^2} - \frac{1}{3^2}\right](1)^2 = R\left[\frac{9-1}{9}\right] = \frac{8}{9}R$$

9. **(c)** : Electronic configuration of Cu

$_{29}Cu$: $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^1$

Outermost electron is in $4s$ sub-shell

For $4s$: $n = 4$, $l = 0$, $m = 0$, $s = +1/2$ or $-1/2$.

10. **(c)** : The orbital with highest $(n + l)$ value will have the highest energy. In the given sets $n = 3$, $l = 2$, $m = -2$, $s = +1/2$ have $n + l = 5$ *i.e.*, $3d$ orbital has the highest energy.

11. **(b)** : The energies of two photons are in the ratio 3 : 2, their wavelengths will be in the ratio of 2 : 3, because $E \propto \dfrac{1}{\lambda}$ (according to Planck's quantum theory).

$$\therefore\quad \frac{E_1}{E_2} = \frac{\lambda_2}{\lambda_1}$$

So, $\lambda_1 : \lambda_2 = 2 : 3$

12. **(d)** : E.C. of Na ($Z = 11$) = $1s^2\,2s^2\,2p^6\,3s^1$

Outermost electron occupies $3s$ orbital.

$\therefore\quad n = 3, l = 0, m = 0, s = 1/2$

13. **(b)** : $3f$ is impossible since for $n = 3$

Possible values of $l = 0$ to $(n - 1)$

i.e., $l = 0, 1, 2$

So only $3s$, $3p$ and $3d$ are possible.

14. **(b)** : $_{29}Cu$ = [Ar]$3d^{10}4s^1$

$\therefore\quad Cu^{2+}$ = [Ar]$3d^9\,4s^0$

15. **(c)** :

Species	$_{19}K^+$	$_{20}Ca^{2+}$	$_{21}Sc^{3+}$	$_{17}Cl^-$
No. of e^-	18	18	18	18

16. **(c)** : $_1H = 1s^1$; $_3Li = 2s^1$; $_{11}Na = 3s^1$;
$_{19}K = [Ar]\ 4s^1$; $_{24}Cr = [Ar]\ 3d^5\ 4s^1$
$_{29}Cu = [Ar]\ 3d^{10}\ 4s^1$

17. **(c)** : No. of nodes for any orbital = $n - l - 1$
For 3*s*-orbital, $n = 3$ and $l = 0$
Hence, no. of nodes for 3*s*-orbital = 3 – 1 = 2

18. **(a)** : From the given quantum numbers, it can be inferred that :
P electron belongs to 3*d* orbital.
Q electron belongs to 3*s* orbital.
Hence, *P* has greater energy than *Q*.

19. **(a)**

20. **(d)** : For a given value of '*l*' the permissible values of '*m*' are $-l,-(l-1)....0....(l-1), l$
Thus, for $l = 2$, *m* cannot have a value of –3.

21. **(d)** : Electronic configuration of Cl ($Z = 17$) atom : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$
So, the unpaired electron of Cl atom is in 3*p*-orbital.
Hence, quantum numbers for unpaired electron ;
$n = 3$, $l = 1$ (for *p*-orbital),
$m = +1, 0, -1$ and $s = \pm 1/2$
Thus, only possible set is 3, 1, 1, ± 1/2.

22. **(d)** : $\lambda_A = 33.3\ nm = 33.33 \times 10^{-9}\ m$

$$\lambda_A = h/p_A \quad ...(i)$$

$$\lambda_B = \frac{h}{p_A/3} = \frac{3h}{p_A} \quad ...(ii)$$

From eq. (i) and (ii), we get, $\frac{\lambda_A}{\lambda_B} = \frac{1}{3}$

$\Rightarrow \lambda_B = 33.33 \times 10^{-9} \times 3 = 99.99 \times 10^{-9} m$
$\approx 1.0 \times 10^{-7}\ m$