PHYSICAL CHEMISTRY

DPP

DAILY PRACTICE PROBLEMS

DPP No. 12

Total Marks : 44

Max. Time : 46 min.

Topic : Atomic Structure

Type of Questions		M.M., Min.
Single choice Objective ('–1' negative marking) Q.1,3,5	(3 marks, 3 min.)	[9, 9]
Multiple choice objective ('–1' negative marking) Q.2, 4,6	(4 marks, 4 min.)	[12, 12]
Short Subjective Questions ('–1' negative marking) Q.10,12	(3 marks, 3 min.)	[6, 6]
Comprehension ('–1' negative marking) Q.7 to 9	(3 marks, 3 min.)	[9, 9]
Match the Following (no negative marking) (2 × 4) Q.11	(8 marks, 10 min.)	[8, 10]

1. The potential energy of the electron present in the ground state of Li^{2+} ion is represented by :

(r = Radius of ground state)

(A) $+\frac{3e^2}{4\pi \epsilon_0 r}$ (B) $-\frac{3e}{4\pi \epsilon_0 r}$ (C) $-\frac{3e^2}{4\pi \epsilon_0 r^2}$ (D) $-\frac{3e^2}{4\pi \epsilon_0 r}$

2. Which of the following are isotopes :

(i) Atom, whose nucleus contains 20p + 15n (ii) Atom, whose nucleus contains 20p + 17n

(iii) Atom, whose nucleus contains 18p + 22n (iv) Atom, whose nucleus contains 18p + 21n

(A) (i) and (iii) (B) (i) and (ii) (C) (ii) and (iii) (D) (iii) and (iv)

3. Which of the following are isobars :

(i) Atom, whose nucleus contains 20p + 15n (ii) Atom, whose nucleus contains 20p + 20n

(iii) Atom, whose nucleus contains 18p + 17n (iv) Atom, whose nucleus contains 18p + 22n

(A) (i) and (iii) (B) (ii) and (iii) (C) (iii) and (iv) (D) (i) and (iv)

4. Which of the following is/are isotones :

(A) ${}^{2}_{1}H$, ${}^{3}_{1}H$ (B) ${}^{15}_{7}N$, ${}^{16}_{8}O$ (C) ${}^{40}_{18}Ar$, ${}^{40}_{20}Ca$ (D) ${}^{3}_{1}H$, ${}^{4}_{2}He$

5. Which of the following are isoelectronic :

(I) CH_3^+ (II) H_3O^+ (III) NH_3 (IV) CH_3^-

(A) I and III (B) III and IV (C) I and II (D) II, III and IV

6.* Which of the following are isoelectronic species :

(A) CO_3^{2-}, NO_3^- (B) SO_4^{2-}, PO_4^{3-} (C) CO_2, N_2O (D) N^{3-}, Al^{3+}

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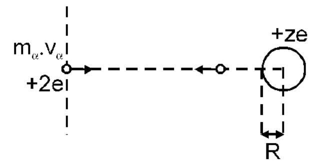
Comprehension # (Q.7 to Q.9)

The approximate size of the nucleus can be calculated by using energy conservation theorem in Rutherford's α-scattering experiment. If an α-particle is projected from infinity with speed v, towards the nucleus having z protons, then the α-particle which is reflected back or which is deflected by 180^0 must have approached closest to the nucleus. It can be approximated that α-particle collides with the nucleus and gets back. Now, if we apply the energy conservation equation at initial point and collision point, then :



$$(\text{Total Energy})_{initial} = (\text{Total Energy})_{final}$$
$$(K.E.)_i + (P.E.)_i = (K.E.)_f + (P.E.)_f$$

$(P.E.)_i = 0$, since P.E. of two charge system separated by infinite distance is zero. Finally the particle stops and then starts coming back.

$$\frac{1}{2}m_\alpha v_\alpha^2 + 0 = 0 + \frac{Kq_1q_2}{R} \Rightarrow \frac{1}{2}m_\alpha v_\alpha^2 = K\frac{2e \times ze}{R} \Rightarrow R = \frac{4Kze^2}{m_\alpha v_\alpha^2}$$

Thus the radius of nucleus can be calculated using above equation. The nucleus is so small a particle that we can't define a sharp boundary for it. Experiments show that the average radius R of a nucleus may be written as:

$$R = R_0(A)^{1/3}$$

where $R_0 = 1.2 \times 10^{-15}$ m
A – mass number of atom
R – radius of nucleus

7. If the diameter of two different nuclei are in the ratio 1:2, then their mass number are in the ratio :
(A) 1:2 (B) 8:1 (C) 1:8 (D) 1:4

8. An α-particle with speed v_0 is projected from infinity and it approaches up to r_0 distance from a nuclei. Then, the speed of α-particle which approaches upto $2r_0$ distance from the nucleus is :
(A) $\sqrt{2}\,v_0$ (B) $\frac{v_0}{\sqrt{2}}$ (C) $2v_0$ (D) $\frac{v_0}{2}$

9. Radius of a particular nucleus is calculated by the projection of α-particle from infinity at a particular speed. Let this radius is the true radius. If the radius calculation for the same nucleus is made by another α-particle with half of the earlier speed, then the percentage error involved in the radius calculation is :
(A) 75% (B) 100% (C) 300% (D) 400%

10. With what velocity should an α-particle travel towards the nucleus of a Copper atom, so as to arrive at a distance of 10^{-13} m from the nucleus of Copper atom. (At. No. of Cu = 29). (Take $\sqrt{40}$ = 6.32)

11.

	Column-I		Column-II
(A)	Frequency	(p)	Linear distance travelled by a wave per unit time.
(B)	Wavelength	(q)	Number of waves passing through a point in one second.
(C)	Time period	(r)	Linear distance between starting and end point of one complete wave.
(D)	Speed	(s)	Time taken for one complete wave to pass through a point.

12. For a wave, frequency is 10 Hz and wavelength is 2.5 m. How much linear distance will it travel in 40 seconds ?

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Answer Key

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1.	(D)	**2.***	(BD)	**3.**	(A)	**4.***	(BD)	**5.**	(D)
6.*	(ABCD)	**7.**	(C)	**8.**	(B)	**9.**	(C)		
10.	6.32×10^5 m/s.	**11.**	[A – q] ; [B – r] ; [C – s] ; [D – p].			**12.**	1000 m		

Hints & Solutions

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1. $PE = -\dfrac{KZe^2}{r}$.

2.* Isotopes have same atomic number but different mass number.

3. Isobars have same mass number.

4.* Isotones have same number of neutrons.

5. Each has 10 electrons.

In $CH_3^+ = 6 + 3 - 1 = 8$ e

In $H_3O^+ = 3 + 8 - 1 = 10$ e

6.* Isoelectronic specis have same number of electrons.

7. $\dfrac{R_1}{R_2} = \left(\dfrac{A_1}{A_2}\right)^{1/3}$

$\Rightarrow \quad \dfrac{1}{2} = \left(\dfrac{A_1}{A_2}\right)^{1/3}$

$\Rightarrow \quad \dfrac{A_1}{A_2} = \dfrac{1}{8}$

ratio of atomic mass number.

8. $r_0 = \dfrac{4KZe^2}{M_0 v_0^2}$

$\Rightarrow \quad 2r_0 = \dfrac{4KZe^2}{M_0 v'^2}$

$\Rightarrow \quad r_0 v_0^2 = 2 r_0 v'^2$

$\Rightarrow \quad v' = \dfrac{v_0}{\sqrt{2}}$

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9. Given $R = \frac{4KZe^2}{M_0 v_0^2}$

$\therefore$ $R' = \frac{4KZe^2}{M_0\left(\frac{v_0}{2}\right)^2} = 4R$

$\therefore$ % error $= \frac{4R - R}{R} \times 100 = 300\ \%$.

10. Use $R = \frac{4Kze^2}{m_\alpha {v_\alpha}^2}$.

11. Definition

12. In one second, wave can travel distance = $\nu \times \lambda = 10 \times 2.5$ m = 25 m
In 40 seconds, it will travel = 25 × 40 m = **1000 m**.

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