Journey Inside the Atom

Standard difficulty · 20 questions · 40 marks · Time: 36 minutes

Name: _____ Date: _____ Score: ____ / 40

Show your working for Sections B and C. Answers are on the last page — try every question first!

Section A — Choose the correct answer — 8 × 1 = 8 marks

1. How many protons are there in an atom of $^{12}_{6}C$?

(a) 18 **(b)** 12 **(c)** 13 **(d)** 6

2. The valency of calcium (Z = 20) is:

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

3. The electron was discovered by:

(a) E. Goldstein **(b)** J. Chadwick **(c)** J. J. Thomson **(d)** E. Rutherford

4. Which pair are isotopes?

(a) $^{12}_{6}C$ and $^{13}_{6}C$ **(b)** $^{14}_{7}N$ and $^{22}_{10}Ne$
(c) $^{1}_{1}H$ and $^{14}_{6}C$ **(d)** $^{24}_{12}Mg$ and $^{40}_{18}Ar$

5. How many electrons are there in the ion Al^{3+}? (Z of Al = 13)

(a) 10 **(b)** 16 **(c)** 13 **(d)** 11

6. A sample of neon has 53% atoms of mass 20 u and 47% of mass 22 u. Its average atomic mass is:

(a) 42 u **(b)** 21 u **(c)** 21.06 u **(d)** 20.94 u

7. An atom has 3 protons, 7 neutrons and 3 electrons. Its mass number is:

(a) 10 **(b)** 13 **(c)** 3 **(d)** 7

8. Assertion (A): An atom of $^{13}_{6}C$ has 7 neutrons.
Reason (R): Mass number = number of protons + number of electrons.

(a) Both A and R are true, and R is the correct explanation of A.
(b) Both A and R are true, but R is not the correct explanation of A.
(c) A is true, but R is false.
(d) A is false, but R is true.

Section B — Short answer — 8 × 2 = 16 marks

9. Hydrogen has atomic number 1 and mass number 1. Find the numbers of protons, neutrons and electrons in its atom, and write its symbol with A and Z.

10. Write the distribution of electrons in the shells of magnesium (Z = 12). What is its valency?

11. The atom $^{40}_{20}Ca$ forms the ion Ca^{2+}. Find the numbers of protons, neutrons and electrons in the ion, and its electronic configuration.

12. What were the main conclusions of Rutherford's alpha-particle scattering experiment?

13. Silver has two isotopes of mass 107 u and 109 u. In a sample, 59% of the atoms are silver-107. Find the average atomic mass.

14. The average atomic mass of a sample of boron is 10.44 u. It contains only boron-10 and boron-11. What percentage of the atoms is boron-10?

15. Are these pairs isotopes, isobars or neither? (a) $^{15}_{7}N$ and $^{14}_{7}N$ (b) $^{14}_{7}N$ and $^{14}_{6}C$

16. An element has the electronic configuration 2, 4. What is its atomic number and name? What is its valency?

Section C — Word problems — 4 × 4 = 16 marks

17. Describe Rutherford's alpha-particle scattering experiment and its observations.

18. Complete the table for silicon ($^{28}_{14}Si$), sulphur ($^{32}_{16}S$), chlorine ($^{35}_{17}Cl$): number of protons, neutrons and electrons, electronic configuration and valency.

19. An element X has three isotopes: mass 45 u (83%), 46 u (9%) and 47 u (8%). (a) Find its average atomic mass. (b) Why is the atomic mass of an element often not a whole number? (c) Do the isotopes have the same chemical properties? Why?

20. Compare an atom of $^{14}_{7}N$ with its ion N^{3-}: (a) protons, (b) neutrons, (c) electrons, (d) electronic configuration, (e) which noble gas the ion's configuration matches, (f) the charge and why.

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Answer key

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Q	Answer	Working
1	**(d) 6**	Z = 6, A = 12
2	**(a) 2**	configuration 2, 8, 8, 2
3	**(c) J. J. Thomson**	—
4	**(a) $^{12}_{6}C$ and $^{13}_{6}C$**	same atomic number, different mass numbers
5	**(a) 10**	lost 3
6	**(d) 20.94 u**	20 × 53/100 + 22 × 47/100
7	**(a) 10**	mass number = protons + neutrons
8	**(c) A is true, but R is false.**	A is true: neutrons = 13 − 6 = 7. R is false.
9	**Protons 1, neutrons 0, electrons 1; $^{1}_{1}H$**	neutrons = A − Z
10	**2, 8, 2; valency 2**	outer shell has 2 electrons
11	**Protons 20, neutrons 20, electrons 18; 2, 8, 8**	the atom loses 2 electrons
12	**Most of the space inside the atom is empty; there is a small, dense, positively charged centre (the nucleus) where almost all the mass is; the nucleus is very small compared with the atom.**	—
13	**107.82 u**	107 × 59/100 + 109 × 41/100
14	**56% (and 44% boron-11)**	10x + 11(100 − x) = 1,044
15	**(a) isotopes; (b) isobars**	isotopes: same Z; isobars: same A, different Z
16	**Z = 6, carbon; valency 4**	total electrons = 2 + 4
17	**Fast-moving alpha particles were aimed at a very thin gold foil. Most passed straight through; some were deflected by small angles; about one in 12,000 bounced back. He concluded that the atom is mostly empty space, with a tiny, dense, positive nucleus in which almost all its mass is concentrated, and electrons revolving around it.**	—
18	**Silicon: p 14, n 14, e 14; 2, 8, 4; valency 4. Sulphur: p 16, n 16, e 16; 2, 8, 6; valency 2. Chlorine: p 17, n 18, e 17; 2, 8, 7; valency 1**	—
19	**(a) 45.25 u. (b) It is the average of the masses of its isotopes, weighted by how common each is. (c) Yes: they**	45 × 83/100 + 46 × 9/100 + 47 × 8/100

Q	Answer	Working
	have the same number of electrons and the same electronic configuration.	
20	**(a) 7 and 7. (b) 7 and 7. (c) 7 and 10. (d) 2, 5 and 2, 8. (e) neon. (f) −3: the atom gains 3 electrons, so protons and electrons no longer balance.**	—