Structure of Atom (Advanced)

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. In a hydrogen atom, an electron jumps from level n = 4 down to n = 1. The line given out belongs to the:
(a) Lyman series **(b)** Balmer series **(c)** Pfund series **(d)** Paschen series

2. Using the Rydberg equation (R = 109,677 cm^{-1}), the wave number of the hydrogen line for a jump from n = 3 to n = 2 is about:
(a) 39,606 cm^{-1} **(b)** 18,280 cm^{-1} **(c)** 12,186 cm^{-1} **(d)** 15,233 cm^{-1}

3. Electrons in a sample of hydrogen atoms are excited to level n = 9. As they fall back, by every possible jump, as far as n = 1, how many different spectral lines can appear?
(a) 45 **(b)** 8 **(c)** 36 **(d)** 81

4. "They came out when alpha particles struck a thin sheet of beryllium." This describes:
(a) light from a sodium vapour lamp
(b) cathode rays
(c) the neutral radiation in Chadwick's experiment
(d) canal rays

5. Cathode rays bend towards the positively charged plate. This shows that they are:
(a) negatively charged **(b)** made of light
(c) positively charged **(d)** neutral

6. How many neutrons are there in one atom of magnesium-26 (atomic number 12, mass number 26)?
(a) 38 **(b)** 26 **(c)** 12 **(d)** 14

7. Canal rays were first observed in 1886 by:
(a) Eugen Goldstein **(b)** John Dalton
(c) J. J. Thomson **(d)** James Chadwick

8. Assertion (A): The hydrogen line for a jump from n = 5 to n = 2 belongs to the Balmer series.
Reason (R): Each series of hydrogen lines is named by the upper level from which the electron falls.
(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. Using R = 109,677 cm^{-1}, find the wave number of the hydrogen line for a jump from n = 7 to n = 3. Give the answer to the nearest whole number, in cm^{-1} (per cm).

10. An electron in a hydrogen atom falls from n = 5 to n = 4. Name the series of the line given out.

11. A line in the Brackett series of hydrogen comes from an electron that started at n = 9. To which level did it fall?

12. For a neutral atom of argon-40 (Z = 18, A = 40), find the number of (a) protons, (b) neutrons and (c) electrons.

13. How many electrons are there in the oxide ion, O^{2-} (atomic number of oxygen = 8)?

14. Electrons in hydrogen atoms are excited up to level n = 4. How many different lines of the Balmer series can they give out?

15. Find the ratio of the wave number of the hydrogen line n = 4 → 2 to that of the line n = 5 → 3, as a single number. (Give the answer to 2 decimal places where needed.)

16. For the Brackett series of hydrogen, find the wave number of its second line, using R = 109,677 cm^{-1}. Give it to the nearest whole number, in cm^{-1} (per cm).

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

17. Helium has two protons, yet its mass is about four times that of hydrogen. What did this suggest, and how was it settled?

18. A sample of hydrogen atoms is excited so that electrons reach level n = 7. (a) How many different lines can appear in all as they fall back to n = 1? (b) How many of them are in the Paschen series? (c) Using R = 109,677 cm^{-1}, find the wave number of the line for the jump from n = 7 straight to n = 4, to the nearest whole number, in cm^{-1} (per cm).

19. An electron in a hydrogen atom falls from n = 7 to n = 4, and then from n = 4 to n = 3. (a) Name the series of the first line. (b) Name the series of the second line. (c) Using R = 109,677 cm^{-1}, find the wave number of the single jump from n = 7 to n = 3, to the nearest whole number, in cm^{-1} (per cm). (d) Is it the sum of the two smaller jumps' wave numbers? (Yes or No)

20. Two isotopes of carbon (atomic number 6) have mass numbers 12 and 14. Find (a) the number of protons in each, (b) the neutrons in the lighter one, (c) the neutrons in the heavier one and (d) the electrons in a neutral atom of either.

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Answer key

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Q	Answer	Working
1	**(a) Lyman series**	a series is named by the lower level the electron falls to: n = 1 is Lyman
2	**(d) 15,233 cm^{-1}**	$R(1/2^2 - 1/3^2) = 109{,}677 \times 5/36$
3	**(c) 36**	levels 1 to 9 are 9 levels; any two give a line: 9 × 8 ÷ 2
4	**(c) the neutral radiation in Chadwick's experiment**	Chadwick's neutral particles were neutrons
5	**(a) negatively charged**	unlike charges attract
6	**(d) 14**	neutrons = A − Z = 26 − 12
7	**(a) Eugen Goldstein**	from the history of the subatomic particles
8	**(c) A is true, but R is false.**	A is true: the lower level is n = 2, which is the Balmer series. R is false.
9	**9,948 per cm**	$R(1/3^2 - 1/7^2) = 109{,}677 \times 40/441 = 9{,}948.03$
10	**Brackett**	the lower level, n = 4, names the series
11	**n = 4**	every Brackett line ends at n = 4
12	**(a) 18; (b) 22; (c) 18**	protons = electrons = Z; neutrons = 40 − 18
13	**10**	the atom gains 2: 8 + 2
14	**2**	Balmer lines end at n = 2 and can start at n = 3 to 4: 4 − 2
15	**2.64**	$(1/2^2 - 1/4^2) \div (1/3^2 - 1/5^2)$; R cancels
16	**3,808 per cm**	n = 6 → 4: $109{,}677 \times (1/4^2 - 1/6^2)$
17	**It suggested a neutral particle in the nucleus that adds mass. Chadwick found it in 1932: the neutron, with about the mass of a proton. Helium has 2 protons and 2 neutrons.**	marking: each point in the model answer
18	**(a) 21; (b) 4; (c) 4,617 per cm**	(a) 7 × 6 ÷ 2; (b) from n = 4 … 7 down to n = 3; (c) $109{,}677 \times (1/4^2 - 1/7^2)$
19	**(a) Brackett; (b) Paschen; (c) 9,948 per cm; (d) Yes**	(a) lower level 4; (b) lower level 3; (c) $109{,}677 \times (1/3^2 - 1/7^2)$; (d) $(1/4^2 - 1/7^2) + (1/3^2 - 1/4^2) = 1/3^2 - 1/7^2$, so energies add
20	**(a) 6; (b) 6; (c) 8; (d) 6**	isotopes share Z = 6; neutrons = A − Z: 12 − 6 and 14 − 6

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