

# Atomic and Molecular Physics

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## Part B - Advanced

**Quick Note:** Atomic and Molecular Physics is not included in the Core Part A syllabus.

1. Diffuse hydrogen gas within a galaxy may be assumed to follow a Maxwell distribution at temperature  $10^6 K$ , while the temperature appropriate for the H gas in the intergalactic space, following the same distribution, may be taken to be  $10^4 K$ . The ratio of thermal broadening of the Lyman- $\alpha$  line from the H-atoms within the galaxy to that from the inter-galactic space is closest to.

(February 15, 2022)

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|--------|----------|
| A. 100 | B. 1/100 |
| C. 10  | D. 1/10  |

2. The absorption lines arising from pure rotational effects of HCl are observed at  $83.03 \text{ cm}^{-1}$ ,  $103.73 \text{ cm}^{-1}$ ,  $124.30 \text{ cm}^{-1}$ ,  $145.03 \text{ cm}^{-1}$  and  $165.51 \text{ cm}^{-1}$ . The moment of inertia of the HCl molecule is (take  $\frac{h}{2\pi c} = 5.6 \times 10^{-44} \text{ kg.m}$ )

(November 19, 2020)

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|---|---|
| A. $1.1 \times 10^{-48} \text{ kg.m}^2$ | B. $2.8 \times 10^{-47} \text{ kg.m}^2$ |
| C. $2.8 \times 10^{-48} \text{ kg.m}^2$ | D. $1.1 \times 10^{-42} \text{ kg.m}^2$ |

3. If we take the nuclear spin  $\vec{I}$  into account, the total angular momentum is  $\vec{F} = \vec{L} + \vec{S} + \vec{I}$ , where  $\vec{L}$  and  $\vec{S}$  are the orbital and spin angular momenta of the electron. The Hamiltonian of the hydrogen atom is corrected by the additional interaction  $\lambda \vec{I} \cdot (\vec{L} + \vec{S})$ , where  $\lambda > 0$  is a constant. The total angular momentum quantum number F of the p-orbital state with the lowest energy is

(November 19, 2020)

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|--------|--------|
| A. 0   | B. 1   |
| C. 1/2 | D. 3/2 |