Let V be an ℓ-dimensional Euclidean space. Let $G \subset O(V)$ be a finite irreducible orthogonal reflection group. Let $\mathcal{A}$ be the corresponding Coxeter arrangement. Let S be the algebra of polynomial functions on V. For $H \in \mathcal{A}$ choose $\alpha_H \in V^*$ such that $H = \ker(\alpha_H)$. For each nonnegative integer m, define the derivation module $\mathsf{D}^{(m)}(\mathcal{A}) = \{\theta \in \mathrm{Der}_S \mid \theta(\alpha_H) \in S\alpha_H^m\}$. The module is known to be a free S-module of rank ℓ by K. Saito (1975) for $m = 1$ and L. Solomon-H. Terao (1998) for $m = 2$. The main result of this paper is that this is the case for all m. Moreover we explicitly construct a basis for $\mathsf{D}^{(m)}(\mathcal{A})$. Their degrees are all equal to $mh/2$ (when m is even) or are equal to $((m-1)h/2) + m_i (1 \le i \le \ell)$ (when m is odd). Here $m_1 \le \cdots \le m_\ell$ are the exponents of G and $h = m_\ell + 1$ is the Coxeter number. The construction heavily uses the primitive derivation D which plays a central role in the theory of flat generators by K. Saito (or equivalently the Frobenius manifold structure for the orbit space of G.) Some new results concerning the primitive derivation D are obtained in the course of proof of the main result. Also relations to the "exponents" for the extended Shi arrangements, which are all equal to kh, and to the "exponents" for the "exponents" for the extended Catalan arrangements, which are $kh + m_i (1 \le i \le \ell)$, will be discussed.