We use a novel description of the interaction between charges in two-dimensional (2D) semiconductors to investigate the binding properties of two-, three- and four-particle complexes of charge carriers (excitons, trions and biexcitons). We report binding energies and pair distribution functions calculated using diffusion quantum Monte Carlo methods, which are exact for these systems. Our results will enable the interpretation of experimental photoabsorption and photoluminescence measurements on 2D transition-metal dichalcogenide materials. We show that our data are consistent with previous binding-energy data for the limits in which the interactions between charges reduce to logarithmic and Coulomb (1/r) forms. We find that the logarithmic interaction that has previously been used to study excitons and trions in 2D semiconductors provides an inadequate description of the behaviour of systems such as molybdenum disulphide, and we provide accurate binding-energy data for excitons, trions and biexcitons in these materials.