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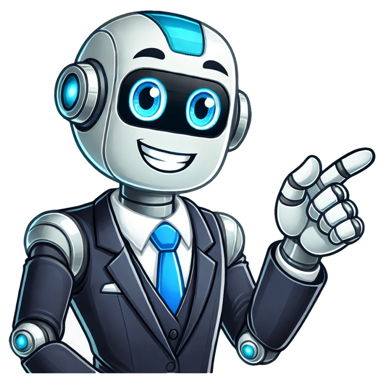

Example of ion-dipole

Ion-dipole forces or ion-dipole interactions are the forces of attraction between ions and dipoles. They are typically found in solutions containing ions. Compounds break down into ions in polar solvents and form bonds between themselves and the polar solvent. The forces are electrostatic and occur between the ions and the oppositely charged end of the polar molecule. The positive ions are attracted to the negative ends of the polar molecule, and the negative ions are to the positive ends. Ion-dipole forces are mainly responsible for the dissolution of ionic substances in water [1-8]. Ion Dipole Forces Here are some facts and characteristics of the ion-dipole forces which can be applied to determine it. The ions and dipoles are aligned closer to one another so that the forces are maximum.Their strength is proportionate to ion charge or dipole strength.They are stronger than the dipole-dipole forcesThey are weaker than the intramolecular ionic and covalent bonds. Examples of the ion-dipole forces are the forces between sodium (Na+) and chlorine (Cl–) and a polar water molecule (H2O). Here, the positively charged sodium ion is attracted to the negatively charged oxygen (Oδ-) atom, and the negatively charged chloride (Cl–) ion is attracted to the positively charged hydrogen (Hδ+) atom [1-8]. Ion Dipole Dorces Examples An ion-induced dipole force occurs when an ion interacts with a nonpolar molecule. In this case, the charge on the ion induces polarity in the nonpolar molar molecule. The two interacting species then attract one another and form a weak bond. The strength of this force will depend on the charge on the ion and the polarizability of the molecule. The phenomenon is very similar to dipole-induced dipole force [7,8]. Example: In hemoglobin, the interaction between iron (II) ions (Fe2+) and oxygen molecule (O2) is ion-induced dipole force. Fact Checked Content Last Updated: 17.02.2023 8 min reading time Content creation process designed by Content cross-checked by Content quality checked by Save Article Save Article Before we dive into ion-dipole interactions, we first need to dive further into the concept of the dipole. A dipole is present in a molecule when one side of the molecule is more electronegative than the other. This means that one side is more likely to accept an electron (more electronegative), so it has a slight negative charge, while the other side is more likely to lose an electron, so it has a slight positive charge. The trends in electronegativity are:Elements that are closer to the top-right of the periodic table (like fluorine, F) are very electronegative.Elements that are less electronegative (like francium, Fr) are closer to the bottom left.The first thing we need to remember is that not every molecule with a difference in electronegativities will have a dipole. Let's look at a comparison: Fig. 1 - CH4 is a nonpolar compound with no dipole, while NaCl is a polar compound with a dipole.Methane, CH4, does not have a dipole, and that's for two reasons. The first is that, while there is a difference in electronegativities, the difference isn't large enough. For a compound to be considered polar, the difference in electronegativity has to be greater than 0.4. Carbon has an electronegativity of 2.5, while Hydrogen has one of 2.2. The difference in electronegativity is negligible enough that the molecule isn't considered polar. The second reason is that the molecule is symmetrical. Even if the bonds were polar, the symmetry negates that. Think of it this way, if 4 people are playing tug-of-war and all of them are pulling with the same force, the center isn't going to move.For NaCl, this molecule is polar and has a dipole. The difference in electronegativity between Na and Cl is over 2, so the bond is very polar. Na has a lower electronegativity, so the "positive" side points towards it, while the "negative" side points towards Cl. The arrow is referred to as the dipole moment.The dipole moment (μ) is the measurement of the magnitude of the dipole. The formula is:$$ \mu = q * r $$Where:q = partial charge of each end of the dipole r = separation between charges (i.e. bond length)The dipole moment is important for calculating the total strength of the ion-dipole interaction. The dipole moment is directly proportional to the potential energy of the interactionThe basic interaction here is the attraction/repulsion between the ion and the dipole. Fig. 2 - The anion attracts and repels different ends of the dipole The anion (light-blue circle with a minus sign) attracts the positive end of the dipole while repelling the negative end. The colors represent electron density, with the cooler colors meaning less density, with the warmer colors meaning more density. Ion-dipole forces are contactless, so there will always be a distance separating the ion and molecule. We measure the energy of these forces using the formula for ion-dipole potential. The ion-dipole potential is the potential energy of an ion-dipole attraction. The formula is:$$ E = \frac{ -k|q_1|\mu } {r_1^2} $$Where:k = proportionality constant (Coulomb's constant)q1 = charge of the ionμ = dipole moment of the moleculer1 = the radius between the ion and the molecule (the subscript is noted as 1 to differentiate between the q and r used to calculate μ)We note that the ion-dipole potential is derived from the Coulomb's Law potential, thusly:1. Given the Coulomb Law potential:$$ E = \frac{ -k q_1 q_2 } {r_1} $$Where k is Coulomb's constant, q1 is the charge on the ion, q2 is the charge on the dipole, and r1 is the radius between the ion and the molecule.2. Next, we solve for the charge on the dipole, q2, and insert this into the Coulomb Law potential:\begin{align}& \mu = q_2 * r_1 \qquad (solving~ for~ q_2,~ we~ get) \\& q_2 = \mu / r_1\end{align}Subtituting for q2, we obtain:$$ E = \frac{ -k q_1 (\frac {\mu} {r_1}) } {r_1} = \frac { -kq_1 \mu} { r_1^2} $$ The Ion-dipole force strength is dependent on three things: The magnitude of the dipole moment, the distance between the ion and the molecule, and the size of the polar molecule. Based on the equation, we can see why these first two things are important. The size of the molecule affects the radius between the ion and the molecule, but it also affects how easily the ion will interact with it. If we have a large molecule with many bonds, it will be more difficult for an ion to approach the molecule. The Ion-dipole forces are commonly found in solutions where an ionic compound has been dissolved in a polar solvent. The most common example is salt in water. Fig. 3 - Ion-dipole forces between salt (NaCl) and water The sodium (Na+) cation attracts the partially negative oxygen (O), while the chlorine (Cl-) anion attracts the partially positive hydrogen (H).In these kinds of solutions, the ionized compound and the polar solvent form a "net". While this example only shows 1 Na+ and 2 Cl- ions, in reality, there would be a lot, and each ion would be attracted to several water molecules.Ion-dipole forces have an important role in proteins. They are typically utilized when a reaction requires high specificity or fixed geometry. For example, they act as gatekeepers in transporters and ion channels, making sure that only the appropriate ions are passing through the membrane. As another example, these interactions hold the enzymatic intermediate in a fixed position during an enzyme reaction so that it can proceed properly. There is another kind of ion-dipole force that is weaker than the one we have looked at previously. These are ion-induced dipole forces. An ion-induced dipole interaction is when an ion approaches a non-polar molecule and the electrons in the molecule "respond", creating a dipole. So, what do we mean by "respond"? Let's look at a diagram of the interaction. Fig. 4 - A cation induces a dipole in a non-polar molecule The electrons in the molecule are attracted to the cation. Since these electrons are being pulled, the electron density is shifting. Now that more electrons are on the left side than the right, a dipole is formed. If you have ever used a magnet near a paperclip, then noticed that other paperclips are attracted to it, it's the same principle!These interactions will be much weaker, since the charge of the induced dipole in a non-polar molecule is smaller than the charge of a dipole in a polar molecule. Ion-dipole forces describe the electrostatic attraction between an ion and a neutral molecule with a dipole. The ion will attract one side of the dipole and repel the other. Dipoles in polar molecules are caused by a difference in electronegativities greater than 0.4.The formula for the ion-dipole potential is: \(E = \frac{ -k |q_1| \mu } {r_1^2} \)The Ion-dipole force strength is dependent on three things: The magnitude of the dipole moment, the distance between the ion and the molecule, and the size of the polar molecule. An ion-induced dipole interaction is when an ion approaches a non-polar molecule and the electrons in the molecule "respond", creating a dipole. These interactions are much weaker than ion-dipole forces. What are ion dipole forces? Ion-dipole forces describe the electrostatic attraction between an ion and a neutral molecule with a dipole. The ion will attract one side of the dipole and repel the other. What is an example of ion dipole forces? When salt dissolves in water, the positively charged sodium will be attracted to the partially negative oxygen, while the negatively charged chlorine will be attracted to the partially positive hydrogen. What elements have ion dipole forces? An element that is an ion and not neutral can have these forces. In a molecule, the elements must have a difference in electronegativity that is greater than 0.4 to have this type of force. How do you know if it's an ion dipole? One species must be an ion, while the other must be a molecule with a present dipole. Even if a molecule is polar, if it is symmetrical, the dipoles cancel out and cannot have ion-dipole interactions. Is ion dipole the strongest intermolecular force? Ion-dipole interactions are the strongest of the intermolecular forces. Save Article Access over 700 million learning materials Study more efficiently with flashcards Get better grades with AI Sign up for free Already have an account? Log in Good job! Keep learning, you are doing great. Don't give up! Next Open in our app At StudySmarter, we have created a learning platform that serves millions of students. Meet the people who work hard to deliver fact based content as well as making sure it is verified. Lily Hulatt is a Digital Content Specialist with over three years of experience in content strategy and curriculum design. She gained her PhD in English Literature from Durham University in 2022, taught in Durham University's English Studies Department, and has contributed to a number of publications. Lily specialises in English Literature, English Language, History, and Philosophy. Get to know Lily Gabriel Freitas is an AI Engineer with a solid experience in software development, machine learning algorithms, and generative AI, including large language models' (LLMs) applications. Graduated in Electrical Engineering at the University of São Paulo, he is currently pursuing an MSc in Computer Engineering at the University of Campinas, specializing in machine learning topics. Gabriel has a strong background in software engineering and has worked on projects involving computer vision, embedded AI, and LLM applications. Get to know Gabriel Vaia is a globally recognized educational technology company, offering a holistic learning platform designed for students of all ages and educational levels. Our platform provides learning support for a wide range of subjects, including STEM, Social Sciences, and Languages and also helps students to successfully master various tests and exams worldwide, such as GCSE, A Level, SAT, ACT, Abitur, and more. We offer an extensive library of learning materials, including interactive flashcards, comprehensive textbook solutions, and detailed explanations. The cutting-edge technology and tools we provide help students create their own learning materials. StudySmarter's content is not only expert-verified but also regularly updated to ensure accuracy and relevance. Learn more This force which exists between an ion and a polar molecule, accounts for the dissolution of ionic compounds in polar solvents like waterFor example, in a solution of sodium chloride, NaCl, in water:The oxygen atom has a partial negative (δ-) chargeThe hydrogen atoms have a partial positive charge (δ+)Overall, there is a dipole moment within the water moleculeThe Na+ ion is attracted to the negative end of the dipoleThe Cl- ion is attracted to the positive end of the dipoleIon-dipole interaction between sodium and chloride ions with waterThe magnitude of ion-dipole interactions increases as either the ionic charge or the magnitude of the dipole moment increasesDid this page help you?Expertise: Chemistry Content CreatorStewart has been an enthusiastic GCSE, IGCSE, A Level and IB teacher for more than 30 years in the UK as well as overseas, and has also been an examiner for IB and A Level. As a long-standing Head of Science, Stewart brings a wealth of experience to creating Topic Questions and revision materials for Save My Exams. Stewart specialises in Chemistry, but has also taught Physics and Environmental Systems and Societies. Intermolecular forces are attractive forces between separate molecules.Intermolecular forces or IMFs are attractive and repulsive electromagnetic forces between molecules. These forces determine most of a substance's physical properties and state of matter.Intermolecular forces are attractive and repulsive forces between atoms, groups of atoms, or ions in separate molecules.The three main types of intermolecular forces are hydrogen bonding (dipole-dipole forces), ion-dipole forces (and ion-induced dipole forces), and Van der Waals forces (Debye force, London dispersion force, Keesom force).Ion-dipole forces are the strongest intermolecular forces, followed by hydrogen bonding, other dipole-dipole forces, and dispersion forces. Van der Waals forces are the weakest intermolecular forces.Intramolecular forces act within a molecule, while intermolecular forces act between separate molecules.Intermolecular forces act between molecules. In contrast, intramolecular forces are the attractive and repulsive forces within molecules that are responsible for chemical bonds and molecular structure. In both cases, forces act between atoms or groups of atoms. Intermolecular forces are weaker than intramolecular forces, but both types of forces play important roles in the shapes of molecules, their properties, and their interactions with one another. Intermolecular forces are dotted lines in diagrams, while intramolecular forces (bonds) are solid lines.Intermolecular forces can either attract (opposite electrical charges) or repel (like charges), but the main classes of intermolecular forces deal with attraction. The three types of intermolecular forces are:Dipole-dipole forces (including hydrogen bonding)Ion-dipole forces and ion-induced dipole forcesVan der Waals forces (Debye force, London dispersion force, Keesom force)So, although there are three broad categories of intermolecular forces, you can expand them from their categories to get five or six types of forces. Some sources also include ion-ion forces, for example, between aqueous ions like Na+ and Cl–.A hydrogen bond is a type of dipole-dipole bond where a hydrogen atom feels attraction to a more electronegative atom (usually oxygen, fluorine, or nitrogen) that already shares a bond with another atom. Hydrogen bonding is directional. It is similar to a covalent bond. Hydrogen bonds are stronger than Van der Waals forces, but weaker than ion-dipole or ion-induced dipole forces.A good example of hydrogen bonding is the attraction between water molecules. Hydrogen atoms on one molecule form hydrogen bonds with oxygen atoms of neighboring water molecules. A consequence of hydrogen bonding is the high boiling point of water compared to similar molecules. Hydrogen bonding also stabilizes nucleic acids, proteins, and other polymers.More generally, dipole-dipole forces occur between all polar molecules. The positive part of a molecule aligns with the negative portion of its neighbor.Ion-dipole and ion-induced dipole forces are intermolecular forces involving ions instead of polar or nonpolar molecules.An ion-dipole force arises when an ion interacts with a polar molecule. The positive portion of one group aligns with the negative portion of the other. An example of ion-dipole interaction is the hydration of metal ions in water, where the metal cations align with the oxygen atoms in neighboring water molecules. The strength of ion-dipole interactions depends on the magnitude of the dipole moment, the size and charge of the ion, and the size of the polar molecule.An ion-induced dipole force occurs when an ion and a nonpolar molecule interact. The charge of the ion distorts the electron cloud surrounding the nonpolar molecule.Van der Waals forces are the relatively weak attraction between uncharged atoms or molecules, such that all molecules feel some attraction to one another. There are multiple components to Van der Waals forces, include the Keesom force, Debye force, and London dispersion force.Keesom force (permanent dipole – permanent dipole): The Keesom force is a temperature-dependent interaction between rotating permanent dipoles. This force only occurs between two polar molecules (or other molecules with permanent dipole moments). The Keesom force is very weak.Debye force (permanent dipole – induced dipole): The Debye force is a polarization from the interactions between rotating permanent dipoles and the induced dipoles formed by polarizable atoms and molecules. Here, a molecule with a permanent dipole induces a dipole in another molecule, repelling its electrons. An example if the interaction between Ar and HCl, where the argon electrons are attracted to the H side of the molecule and repelled by the Cl side.London dispersion force (fluctuating dipole – induced dipole): This force arises from the non-zero instantaneous dipole moments of all atoms and molecules due to random fluctuations in electron density. Atoms with more electrons experience a larger London dispersion force than atoms with fewer electrons.The nature of the chemical species involved in intermolecular forces matters, so there is no hard-and-fast ranking of strongest to weakest intermolecular forces. But, ion-dipole interactions tend to be the strongest, followed by hydrogen bonding, other types of dipole-dipole bonding, and London dispersion forces.Type of Intermolecular ForceDescription/StrengthExampleIon-DipoleOccurs between ions and polar molecules; strongestNa+ and Cl– ions interacting with H2OHydrogen BondHydrogen atom is attracted to nitrogen, fluorine, or oxygen from another molecule; strongNH3 molecules interacting with each otherDipole-DipolePolar molecules attract each other; strength increases with increasing polarityCH3CN molecules interacting with each otherLondon DispersionOccurs between all molecules; weakest but increases with increasing molecular weightCH4 with itself, Br2 with itselfArunan, Elangannan; Desiraju, Gautam R.; et al. (2011). "Definition of the hydrogen bond (IUPAC Recommendations 2011)". Pure and Applied Chemistry. 83 (8): 1637–1641. doi:10.1351/PAC-REC-10-01-02Biedermann, F.; Schneider, H.J. (2016). "Experimental binding energies in supramolecular complexes". Chemical Reviews. 116 (9): 5216–5300. doi:10.1021/acs.chemrev.5b00583Cooper, M.M.; Williams, L. C.; Underwood, S.M. (2015). "Student Understanding of Intermolecular Forces: A Multimodal Study." J. Chem. Educ. 92 (8): 1288-1298. doi:10.1021/acs.jchemed.5b00169Margenau, H.; Kestner, N.R. (1969). Theory of Intermolecular Forces. International Series of Monographs in Natural Philosophy. Vol. 18 (1st ed.). Oxford: Pergamon Press. ISBN 978-0-08-016502-8.King, Matcha (1976). "Theory of the Chemical Bond". JACS. 98 (12): 3415–3420. doi:10.1021/ja00428a004Roberts, J.K.; Orr, W.J. (1938). "Induced dipoles and the heat of adsorption of argon on ionic crystals". Transactions of the Faraday Society. 34: 1346. doi:10.1039/TF9383401346Related Posts Ion-dipole forces or ion-dipole interactions are the forces of attraction between ions and dipoles. They are typically found in solutions containing ions. 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