Chemistry Grade 9

Short Questions & Answers

Based on FBISE Pattern (3-Mark Questions)

SLO: C-09-B-75 (Knowledge Level)

Define Bronsted-Lowry acids as proton donors and Bronsted-Lowry bases as proton acceptors.

Question 1: What is a Bronsted-Lowry acid? Explain with an example.

A Bronsted-Lowry acid is a substance that donates protons (H^+ ions) to another substance during a chemical reaction. The proton is simply a hydrogen atom that has lost its electron. For example, when hydrochloric acid (HCl) reacts with water, it donates a proton to the water molecule. The equation shows this clearly: $HCl + H_2O \rightarrow H_3O^+ + Cl^-$. Here, HCl acts as the acid because it gives up a proton (H^+). Acids are very important in chemistry because they can react with metals, bases, and carbonates.

Question 2: What is a Bronsted-Lowry base? How does it differ from an acid?

A Bronsted-Lowry base is a substance that accepts protons (H^+ ions) from another substance. This is the opposite of what an acid does. While acids give away protons, bases receive protons during chemical reactions. For example, ammonia (NH_3) is a Bronsted-Lowry base because it can accept protons: $NH_3 + H_2O \rightarrow NH_4^+ + OH^-$. In this reaction, ammonia accepts a proton from the water molecule. The main difference is that acids are proton donors and bases are proton acceptors - they have completely opposite roles in chemistry.

Question 3: What is a proton? Why is it important in acid-base chemistry?

A proton is a hydrogen ion, written as H^+. It is a hydrogen atom that has lost its electron, so it only contains the nucleus with one positive charge. In acid-base chemistry, the proton is extremely important because the entire Bronsted-Lowry theory is based on the transfer of protons between acids and bases. When an acid releases a proton, that proton is accepted by a base. This transfer of protons is what causes acid-base reactions to happen. Understanding protons helps us understand why acids and bases react the way they do, and why they can neutralize each other.

SLO: C-09-B-76 (Knowledge Level)

Recognize that aqueous solutions of acids contain H^+ ions and aqueous solutions of bases contain OH^- ions.

Question 1: What ions are present in an acidic solution? Explain their role.

In an acidic solution, H^+ ions (hydrogen ions) are present in large quantities. These H^+ ions are the reason why the solution is acidic. When an acid like HCl dissolves in water, it breaks apart and releases H^+ ions: $HCl \rightarrow H^+ + Cl^-$. The more H^+ ions present in the solution, the stronger the acid is. These H^+ ions are very reactive and are responsible for the acidic properties of the solution, such as its ability to react with metals and bases. The H^+ ions give acids their characteristic sour taste and corrosive properties.

Question 2: What ions are present in a basic solution? Write an example.

In a basic solution, OH^- ions (hydroxide ions) are present in large quantities. These ions make the solution basic or alkaline. When a base like sodium hydroxide (NaOH) dissolves in water, it releases OH^- ions: $NaOH \rightarrow Na^+ + OH^-$. The more OH^- ions present in the solution, the stronger the base is. These hydroxide ions give basic solutions their characteristic properties like a bitter taste and slippery feeling. The OH^- ions are responsible for the basic nature of the solution and allow it to react with acids. When acids and bases meet, the H^+ ions from the acid react with the OH^- ions from the base.

Question 3: How can you identify whether a solution is acidic or basic using ions? Explain.

You can identify whether a solution is acidic or basic by looking at which ions are present in larger amounts. If the solution contains more H^+ ions than OH^- ions, then the solution is acidic. If the solution contains more OH^- ions than H^+ ions, then the solution is basic. If the amounts of H^+ and OH^- ions are equal, then the solution is neutral. This is the fundamental principle behind understanding acidity and basicity. Pure water is neutral because it contains equal numbers of H^+ and OH^- ions. You can test this practically using litmus paper – red litmus turns blue in basic solutions (due to OH^- ions) and blue litmus turns red in acidic solutions (due to H^+ ions).

SLO: C-09-B-77 (Knowledge Level)

Define a strong acid and base as an acid or base that completely dissociates in aqueous solution and weak acid and base as an acid or base that partially dissociates in aqueous solution.

Question 1: What is the difference between a strong acid and a weak acid?

A strong acid is one that completely dissociates (breaks apart) in water. This means that ALL of the acid molecules break down into ions. When hydrochloric acid (HCl) dissolves in water, all of the HCl molecules break apart: $HCl \rightarrow H^+ + Cl^-$. A weak acid, on the other hand, only partially dissociates in water. This means that only SOME of the acid molecules break down into ions, while others remain as molecules. For example, acetic acid (CH_3COOH) found in vinegar only partially breaks apart: $CH_3COOH \rightleftharpoons CH_3COO^- + H^+$. The double arrow shows that the reaction is reversible and doesn't go to completion. As a result, strong acids are more corrosive and reactive, while weak acids are much milder.

Question 2: Give examples of strong acids and weak acids. Explain what 'dissociate completely' means.

Strong acids include hydrochloric acid (HCl), sulfuric acid (H_2SO_4), and nitric acid (HNO_3). These acids are very corrosive and dangerous. Weak acids include acetic acid

(CH_3COOH) found in vinegar, citric acid found in lemons, and carbonic acid found in carbonated drinks. When an acid 'dissociates completely,' it means that all the molecules of the acid break apart into ions in water. For a strong acid like HCl, if you dissolve 100 molecules of HCl in water, all 100 molecules will break apart to form H^+ and Cl^- ions. In contrast, for a weak acid like acetic acid, if you dissolve 100 molecules, only a small number (maybe 1-2 molecules) will break apart, while the rest remain as complete molecules in the solution.

Question 3: What does 'partial dissociation' mean? Why do some acids only partially dissociate?

Partial dissociation means that only some of the molecules of a substance break apart into ions in water, while others remain as complete molecules. Weak acids partially dissociate because the bond between the hydrogen and the rest of the molecule is quite strong, so not all molecules have enough energy to break apart. When weak acid molecules dissolve in water, a reversible reaction occurs: $HA \rightleftharpoons H^+ + A^-$. The forward arrow shows some molecules breaking apart, and the reverse arrow shows some ions combining back into molecules. This equilibrium is reached when some molecules have broken apart and some remain whole. The reason strong acids completely dissociate is that the bonds in these molecules are much weaker and break apart easily in water. This difference in dissociation is why strong acids are dangerous and must be handled carefully, while weak acids like vinegar can be safely handled and even used in cooking.

SLO: C-09-B-78 (Application Level)

Formulate dissociation equations for an acid or base in aqueous solution.

Question 1: Write the dissociation equation for HCl and H_2SO_4. Explain the difference.

For hydrochloric acid (HCl), the dissociation equation is: $HCl \rightarrow H^+ + Cl^-$. This shows that one molecule of HCl breaks apart to form one H^+ ion and one Cl^- ion. For sulfuric acid (H_2SO_4), the dissociation equation is: $H_2SO_4 \rightarrow 2H^+ + SO_4^{2-}$. This shows that one molecule of H_2SO_4 breaks apart to form TWO H^+ ions and one sulfate ion (SO_4^{2-}) with a -2 charge. The difference is that sulfuric acid is diprotic, meaning each molecule can donate two protons, while hydrochloric acid is monoprotic, meaning each molecule donates only one proton. This is why sulfuric acid is stronger and more corrosive than hydrochloric acid of the same concentration. Both equations show complete dissociation, indicated by the single arrow, because both are strong acids.

Question 2: Write dissociation equations for NaOH and $Ca(OH)_2$. Why are the equations different?

For sodium hydroxide (NaOH), the dissociation equation is: $NaOH \rightarrow Na^+ + OH^-$. This shows that one molecule of NaOH breaks apart to form one sodium ion and one hydroxide ion. For calcium hydroxide ($Ca(OH)_2$), the dissociation equation is: $Ca(OH)_2 \rightarrow Ca^{2+} + 2OH^-$. This shows that one molecule of $Ca(OH)_2$ breaks apart to form one calcium ion (with +2 charge) and TWO hydroxide ions. The equations are different because they have different chemical formulas and contain different numbers of hydroxide groups. NaOH has only one OH group, while $Ca(OH)_2$ has two OH groups. This means that calcium hydroxide produces twice as many OH^- ions as sodium hydroxide of the same concentration, making it a stronger base. When writing these equations, it is important to balance the charges - the positive charges must equal the negative charges.

Question 3: What does the arrow (→) mean in a dissociation equation? How would you write an equation for a weak acid?

In a dissociation equation, the single arrow (→) means that the reaction goes to completion and does not reverse. It is used for strong acids and bases that completely dissociate. For example: $HCl \rightarrow H^+ + Cl^-$ shows that HCl completely breaks apart. For a weak acid, you would use a double arrow (⇌) instead, which means the reaction is reversible and an equilibrium is reached. For example, acetic acid would be written as: $CH_3COOH \rightleftharpoons CH_3COO^- + H^+$. The double arrow shows that some molecules break apart while others recombine, and the forward and reverse reactions happen at the same rate. This is a very important distinction because it shows the difference between strong acids (which completely dissociate) and weak acids (which only partially dissociate). When writing any dissociation equation, you must make sure that atoms and charges are balanced on both sides.

SLO: C-09-B-79 (Knowledge Level)

Recognize that bases are oxides or hydroxides of metals and that alkalis are water-soluble bases.

Question 1: What are metal oxides and metal hydroxides? Give examples of each.

Metal oxides are compounds made of a metal element combined with oxygen. Examples include calcium oxide (CaO), also called quicklime, and sodium oxide (Na_2O). These are basic compounds that can react with acids. Metal hydroxides are compounds made of a metal element combined with hydroxide ions (OH^-). Examples include sodium hydroxide ($NaOH$), also called caustic soda, and calcium hydroxide ($Ca(OH)_2$), also called slaked lime. Both metal oxides and hydroxides are bases, meaning they can accept protons and react with acids. The key difference is that oxides contain oxygen atoms bonded to the metal, while hydroxides contain OH^- groups bonded to the metal. When metal oxides react with water, they often form hydroxides. For example: $CaO + H_2O \rightarrow Ca(OH)_2$. Both types of bases are important in industry and in everyday life.

Question 2: What is an alkali? How are alkalis different from all bases?

An alkali is a base that dissolves easily in water to form a solution. The key feature of an alkali is that it is soluble in water - it can mix with water completely. Common examples of alkalis are sodium hydroxide (NaOH), potassium hydroxide (KOH), and ammonia solution (NH_3). These can all dissolve in water to form clear solutions. Not all bases are alkalis, however. For example, copper oxide (CuO) is a base because it reacts with acids, but it is not an alkali because it does not dissolve in water. The relationship is: all alkalis are bases, but not all bases are alkalis. Alkalis are very useful in industries like making soap and glass, and they are also used for cleaning because they dissolve well in water. When we test a substance with litmus paper, a blue color indicates the presence of an alkali or other base, while a red color indicates an acid.

Question 3: Explain the difference between metal oxide bases and alkalis. Why is this distinction important?

Metal oxide bases are oxides of metals that are basic in nature but do NOT dissolve in water. For example, magnesium oxide (MgO) and zinc oxide (ZnO) are bases that can react with acids, but they do not dissolve to form clear solutions. Alkalis, on the other hand, are hydroxides of metals that ARE soluble in water and form clear solutions. For example, NaOH and KOH dissolve completely in water. This distinction is important for several reasons. First, alkalis can be used in aqueous solutions for practical purposes, while metal oxide bases cannot. Second, when testing with litmus paper, alkalis will show a color change immediately because they dissolve, while metal oxides may not show the same effect. Third, in industry, alkalis are preferred for many applications like manufacturing because they can be handled as solutions. Understanding this difference helps us predict which bases are useful in water-based processes and which ones must be handled differently.

SLO: C-09-B-80 (Understanding Level)

Describe the characteristic properties of acids in terms of their reactions with metals, bases, and carbonates.

Question 1: Describe what happens when an acid reacts with a metal. Write a chemical equation and explain.

When an acid reacts with a metal, a chemical reaction occurs that produces a salt and hydrogen gas. For example, when zinc reacts with dilute hydrochloric acid: $Zn + 2HCl \rightarrow ZnCl_2 + H_2\uparrow$. The $\uparrow$ symbol shows that hydrogen gas is produced. In this reaction, the acid donates protons (H^+ ions) to the metal, causing the metal atoms to lose electrons and form positive ions. These positive metal ions combine with the negative ions from the acid to form a salt. The hydrogen ions are reduced to hydrogen atoms, which combine to form hydrogen gas molecules that escape as bubbles. You can test for hydrogen gas using a burning splint near the mouth of the test tube - if hydrogen is present, you will hear a characteristic 'pop' sound as the hydrogen ignites. Not all metals react with acids - only metals above hydrogen in the reactivity series will react. More reactive metals like zinc and iron react quickly and vigorously, while less reactive metals like copper do not react with dilute acids.

Question 2: What happens when an acid reacts with a base? Explain the concept of neutralization.

When an acid reacts with a base, a neutralization reaction occurs. The products are a salt and water. For example: $HCl + NaOH \rightarrow NaCl + H_2O$. In this reaction, the H^+ ions from the acid react with the OH^- ions from the base to form water molecules: $H^+ + OH^- \rightarrow H_2O$. At the same time, the positive ions from the base (Na^+) combine with the negative ions from the acid (Cl^-) to form the salt ($NaCl$). Neutralization is called this because the acidic and basic properties of both substances cancel each other out. The salt formed is neutral – it is neither acidic nor basic. This is a very important reaction in chemistry and has many practical applications. For example, if you accidentally spill an acid, you can safely neutralize it by adding a base like baking soda. In industry, neutralization reactions are used to treat acidic waste and make it safe for disposal. The strength of the acid and base used determines how much of each is needed for complete neutralization.

Question 3: What is the reaction between an acid and a carbonate? Why is this reaction important?

When an acid reacts with a carbonate or bicarbonate, three products are formed: a salt, water, and carbon dioxide gas. For example: $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2\uparrow$. The carbon dioxide gas is produced as bubbles and can be detected using limewater, which turns milky white when exposed to CO_2. In this reaction, the acid provides H^+ ions that react with the carbonate (CO_3^{2-}) to form water and carbon dioxide. This reaction is important for several reasons. First, it allows us to identify carbonates in the laboratory - if a white precipitate forms when carbon dioxide is bubbled through limewater, we know a carbonate was present. Second, this reaction is very common in nature - acid rain reacts with limestone buildings and stone statues, slowly dissolving them, which shows how powerful this reaction is. Third, in the digestive system, the acid in our stomach reacts with baking soda (a base) to produce water and carbon dioxide, which is why we sometimes feel bloated after eating. Understanding this reaction helps us appreciate both the dangers of strong acids and their useful applications.

SLO: C-09-B-81 (Understanding Level)

Identify the characteristic properties of bases in terms of their reactions with acids and ammonium salts.

Question 1: Describe the reaction between a base and an acid. What products are formed?

When a base reacts with an acid, a neutralization reaction occurs that produces a salt and water. For example: $NaOH + HCl \rightarrow NaCl + H_2O$. In this reaction, the OH^- ions from the base react with the H^+ ions from the acid to form water molecules: $H^+ + OH^- \rightarrow H_2O$. The remaining positive ion from the base (Na^+) combines with the remaining negative ion from the acid (Cl^-) to form a salt (NaCl). The reaction shows one of the key properties of bases - they can neutralize acids and make them harmless. This is why bases are used in many practical applications. For example, if you get burned by an acid, a weak base like baking soda can be applied to neutralize the acid and prevent further damage. In factories, bases are used to treat acidic waste products before they are disposed of into the environment. The complete neutralization occurs when exactly the right amounts of acid and base are mixed together. If too much base is added, the solution becomes basic, and if too much acid is added, the solution remains acidic.

Question 2: What are ammonium salts? What happens when a base reacts with an ammonium salt?

Ammonium salts are compounds that contain the ammonium ion (NH_4^+) bonded to a negative ion. Common examples include ammonium chloride (NH_4Cl) and ammonium sulfate ($(NH_4)_2SO_4$). These salts are often used as fertilizers in agriculture. When a base reacts with an ammonium salt, ammonia gas is produced along with a salt and water. For example: $NaOH + NH_4Cl \rightarrow NaCl + NH_3\uparrow + H_2O$. The base ($NaOH$) accepts a proton from the ammonium ion (NH_4^+), forming ammonia gas (NH_3) which escapes as a pungent-smelling gas. The OH^- ion from the base reacts with H^+ from the ammonium ion to form water. The remaining Na^+ and Cl^- ions form sodium chloride salt. This is a characteristic reaction of bases with ammonium salts, and it is very useful in the laboratory for identifying ammonium salts and for preparing ammonia gas. The pungent smell of ammonia is very distinctive, making this test easy to perform and recognize.

Question 3: How do you detect ammonia gas in the laboratory? Explain the properties that make this detection possible.

Ammonia gas can be detected in the laboratory using two main methods. First, you can use your sense of smell to detect the pungent (sharp, distinctive) odor of ammonia. This is a very reliable method because ammonia has a very strong and characteristic smell that is unmistakable. However, care must be taken not to inhale it directly as it can irritate the respiratory system. Second, you can use damp red litmus paper held near the source of ammonia gas. The litmus paper will turn blue because ammonia is alkaline and basic in nature. This color change happens because ammonia is a base and causes the litmus dye to change color. The OH^- ions in ammonia solution react with the litmus dye and cause this change. Both detection methods work because of the basic nature of ammonia - its strong smell comes from the volatile nature of ammonia molecules, while the color change of litmus comes from its ability to accept protons and form OH^- ions. In the laboratory, the litmus paper test is often preferred because it provides visible evidence that can be observed and recorded.

SLO: C-09-B-82 (Knowledge Level)

Define acid rain.

Question 1: What is acid rain? What causes it to form?

Acid rain is rain that is more acidic than normal rain due to the presence of strong acids like sulfuric acid (H_2SO_4) and nitric acid (HNO_3). Normal rainwater is slightly acidic with a pH of about 5.6 due to dissolved carbon dioxide forming carbonic acid. However, acid rain has a much lower pH, sometimes as low as 3 or even lower. Acid rain forms when certain gases released by human activities dissolve in water droplets in the atmosphere. When fossil fuels like coal and petroleum are burned in factories, power plants, and cars, they release sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) gases into the atmosphere. These gases react with water vapor and oxygen in the clouds to form sulfuric acid and nitric acid: $2SO_2 + O_2 \rightarrow 2SO_3$; $SO_3 + H_2O \rightarrow H_2SO_4$. Similar reactions form nitric acid. These acids dissolve in rainwater droplets, and when the rain falls, it brings these acids down to Earth. This is why acid rain is considered a major environmental problem in industrial areas.

Question 2: Name the main acids in acid rain and identify their sources. Why is acid rain dangerous?

The two main acids found in acid rain are sulfuric acid (H_2SO_4) and nitric acid (HNO_3). Sulfuric acid comes from sulfur dioxide (SO_2) released when coal and petroleum are burned in factories and power plants. Nitrogen oxides come from the combustion of fuels in car engines and from industrial processes. When these gases are released into the atmosphere, they are converted into acids by chemical reactions with water and oxygen. Acid rain is dangerous for many reasons. First, it damages stone and marble buildings and statues by reacting with carbonates in the stone, slowly dissolving them. Historical monuments and archaeological sites are particularly at risk. Second, acid rain pollutes soil and water bodies, making them unsuitable for plants and aquatic animals. Fish and other aquatic organisms cannot survive in acidic water, leading to the death of entire ecosystems. Third, acid rain damages plant leaves and roots, preventing plants from growing properly and reducing crop yields. Fourth, acid rain makes drinking water contaminated with harmful acids. Finally, acidic soil releases toxic metals like aluminum into water, which can poison both plants and animals. The effects of acid rain are long-term and cumulative, affecting multiple ecosystems and food chains.

Question 3: What are the environmental impacts of acid rain? What solutions exist to prevent acid rain?

Acid rain has severe environmental impacts on both living and non-living things. Living organisms are affected as aquatic ecosystems become too acidic for fish to survive.

Forests are damaged, with trees losing their leaves and dying. Soil becomes acidic, releasing toxic metals that poison plants. Non-living things are also damaged - stone buildings and statues dissolve, metal structures corrode, and paint on cars peels off. Entire ecosystems can be destroyed by acid rain's continuous effects. To prevent acid rain, several solutions have been developed. First, we must reduce the burning of fossil fuels by using renewable energy sources like solar, wind, and hydroelectric power. Second, factories can install 'scrubbers' in their smokestacks that remove SO_2 and NO_2 before they are released into the atmosphere. Third, we can use cleaner fuels with lower sulfur content. Fourth, cars can use catalytic converters to reduce nitrogen oxide emissions. Fifth, we can treat acidic soil and water bodies by adding bases like limestone ($CaCO_3$) to neutralize the acid. Finally, international cooperation is needed to reduce pollution across borders, as acid rain formed in one country can fall in another. Individuals can also help by using public transportation, recycling, and supporting environmental protection policies.

SLO: C-09-B-83 (Application Level)

Discuss effects of acid rain and relate them with properties of acids.

Question 1: How does acid rain damage stone buildings? Explain using the property of acids reacting with carbonates.

Stone buildings, especially those made of marble, limestone, and granite, contain carbonates like calcium carbonate ($CaCO_3$). One of the characteristic properties of acids is their ability to react with carbonates to produce carbon dioxide gas, water, and a salt. When acid rain falls on these buildings, the sulfuric acid and nitric acid in the rain react with the calcium carbonate in the stone according to this equation: $CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + H_2O + CO_2\uparrow$. The same reaction occurs with nitric acid. As this reaction continues over many years, the stone is gradually dissolved and worn away. You can see this damage on historic buildings and statues that have been exposed to acid rain for long periods - their surfaces become pitted, carved details become blurred, and entire sections can crumble away. The Taj Mahal in India, the Statue of Liberty in America, and many ancient temples around the world have all suffered damage from acid rain. The damage is permanent and cannot be reversed because once the stone is dissolved, it cannot be restored to its original state. This shows how the acid property of reacting with carbonates becomes a destructive force when acid rain falls on our cultural heritage and important structures.

Question 2: How does acid rain damage aquatic ecosystems? Relate this to the properties of acids.

Acid rain damages aquatic ecosystems in several ways related to the properties of acids. First, when acid rain falls into lakes and rivers, it increases the acidity of the water far beyond normal levels. The water becomes so acidic (pH as low as 3) that most aquatic organisms cannot survive. Fish, which are sensitive to pH changes, cannot live in water that is too acidic. Amphibians like frogs cannot reproduce in acidic water, so their populations decline and disappear. Second, acids in water can react with metals in the soil and rocks, releasing toxic metals like aluminum, mercury, and lead. These metals dissolve in the acidic water and are toxic to aquatic life - they damage the gills of fish and make it impossible for them to absorb oxygen. Third, acid rain damages the eggs and larvae of fish before they can develop. The acidic conditions prevent normal development, resulting in deformed or dead offspring. Fourth, aquatic plants struggle to grow in acidic water, reducing the food sources available to fish and other animals. This creates a cascade effect where the loss of plants leads to the loss of herbivores, which leads to the loss of carnivores. Entire food chains collapse. This shows how the acidic property of being able to dissolve and react with minerals and organisms becomes destructive in natural aquatic environments.

Question 3: How do the properties of acids explain why acid rain damages metals and soil? What can be done to reverse this damage?

The property of acids reacting with metals explains the damage to metal structures from acid rain. Acids react with metals to produce hydrogen gas and a salt, according to this general equation: Metal + Acid → Salt + Hydrogen gas. When acid rain contacts metal structures like bridges, cars, and iron railings, it follows this reaction pattern. The acid dissolves the metal surface, creating rust (iron oxide), pitting, and corrosion. Over time, the metal becomes weakened and may break or fail. This is particularly dangerous for bridges and buildings where structural failure could cause accidents. For soil damage, acids in rainwater react with minerals in the soil, altering its chemical composition. The acidic conditions cause nutrient minerals like calcium and magnesium to dissolve and wash away, leaving the soil depleted of essential nutrients that plants need to grow. Additionally, acids can release toxic metals like aluminum from soil minerals, which poison plants. To reverse the damage caused by acid rain, scientists and environmental engineers add bases to neutralized the acid. Limestone ($CaCO_3$), which is a base, is added to acidified lakes and soils. The reaction is: $CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + H_2O + CO_2$. This neutralizes the acid and restores the pH to safer levels. Crushed limestone is spread on acidic soil to restore its pH and nutrient content. Metal structures can be protected by painting them with protective coatings before acid rain can reach them. However, the best solution is prevention - reducing emissions of SO_2 and NO_2 at the source.

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