Checking Bond Lengths in a Carbonate Model

Base your answers on the information provided and your knowledge of chemistry. Use the 2025 Chemistry Reference Tables as needed.

A classroom display compares two bonding pictures for the carbonate ion, CO_3^{2-}. Both show the same carbon atom joined to three oxygen atoms. Picture P puts one fixed double bond at O1 and a single bond at each other oxygen. Picture Q spreads the extra bonding equally over all three carbon–oxygen connections. In the model, a fixed double bond is shorter than a single bond between the same pair of elements.

Connection	**Length in the carbonate model (pm)**
C–O1	129
C–O2	129
C–O3	129

1 Which picture is more consistent with the three carbonate measurements?

(1) P, because O1 has the shortest measured bond.

(2) P, because only one bond length is measured.

(3) Q, because all three measured lengths are equal.

(4) Q, because the three oxygen atoms have different elements.

2 Describe the bond-length pattern the display would expect if the single fixed double bond in P correctly represented the measured ion. [1]

Answer and work

The class compares an ion with one hydrogen attached to an oxygen. Its model measures C–O1 at 136 pm and C–O2 and C–O3 at 126 pm each. The formula for this second ion is HCO_3^-.

3 Use the new measurements to identify which carbon–oxygen connection is different from the other two and describe the difference. [1]

Answer and work

4 Do the element labels C and O alone establish that every C–O connection has the same length in these models? Cite one result from each ion. [1]

Answer and work