


Begin your response to **QUESTION 5** on this page.

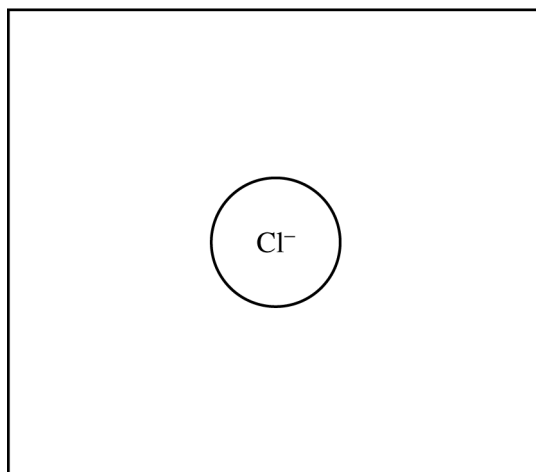
5. HCl is a molecular gas as a pure substance but acts as an acid in aqueous solution.

(a) A sample of $\text{HCl}(g)$ is stored in a rigid 6.00 L container at 7.45 atm and 296 K.

(i) Calculate the number of moles of $\text{HCl}(g)$ in the container.

(ii) The rigid 6.00 L container of $\text{HCl}(g)$ is cooled to a temperature of 271 K. Calculate the new pressure, in atm, of the $\text{HCl}(g)$.

(b) When HCl ionizes in aqueous solution, $\text{Cl}^-(aq)$ ions are formed. In the following box, draw three water molecules with proper orientation around the Cl^- ion. Use  to represent water molecules.



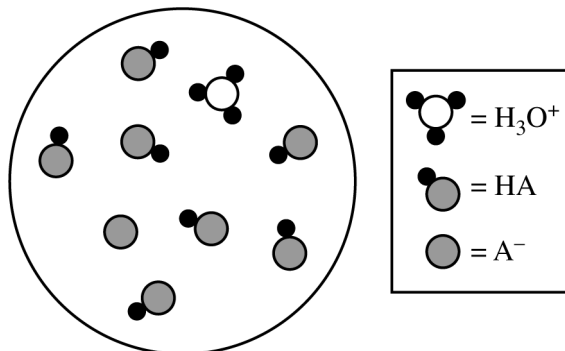
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Acid (HA)	Anion (A^-)	K_a Value
HNO_2	NO_2^-	5.6×10^{-4}
HCl	Cl^-	2.0×10^7
HClO_4	ClO_4^-	1.6×10^{15}

The K_a values for three acids are shown in the preceding table.

- (c) The following particulate diagram represents the ionization of one of the acids in the data table. Water molecules have been omitted for clarity. Which acid (HNO_2 , HCl , or HClO_4) is represented in the diagram? Justify your answer using the information in the table.

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Question 5: Short Answer

4 points

- (a) (i) For the correct calculated value: 1 point

$$n = \frac{PV}{RT} = \frac{(7.45 \text{ atm})(6.00 \text{ L})}{(0.08206 \frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}})(296 \text{ K})} = 1.84 \text{ mol}$$

- (ii) For the correct calculated value: 1 point

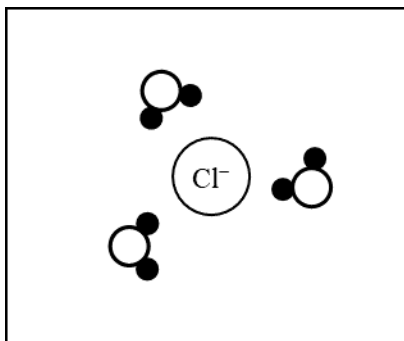
Accept one of the following:

- $\frac{P_1}{T_1} = \frac{P_2}{T_2}$
 $P_2 = \frac{(P_1)(T_2)}{T_1} = \frac{(7.45 \text{ atm})(271 \text{ K})}{296 \text{ K}} = 6.82 \text{ atm}$
- $P = \frac{nRT}{V} = \frac{(1.84 \text{ mol})(0.08206 \frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}})(271 \text{ K})}{6.00 \text{ L}} = 6.82 \text{ atm}$

Total for part (a) 2 points

- (b) For a correct drawing: 1 point

The drawing should show three water molecules with a hydrogen atom (dark circle) oriented towards the Cl^- ion.



- (c) For the correct answer and a valid justification: 1 point

HNO_2 . The diagram shows most of the molecules in their un-ionized form, indicating a weak acid with a K_a value less than 1, which is consistent with HNO_2 .

Total for question 5 4 points