

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

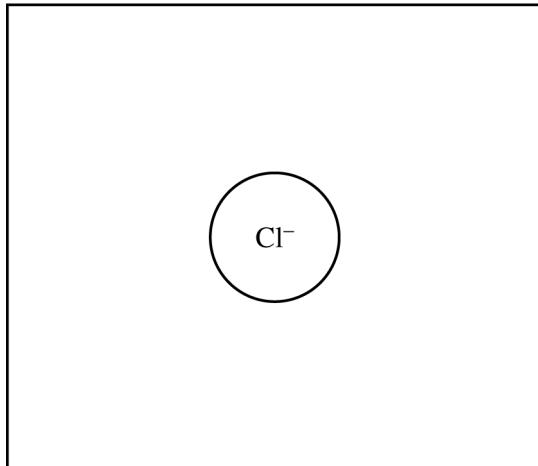
5. HCl is a molecular gas as a pure substance but acts as an acid in aqueous solution.

(a) A sample of 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 HCl(*g*) in the container.

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

(b) When HCl ionizes in aqueous solution, 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.



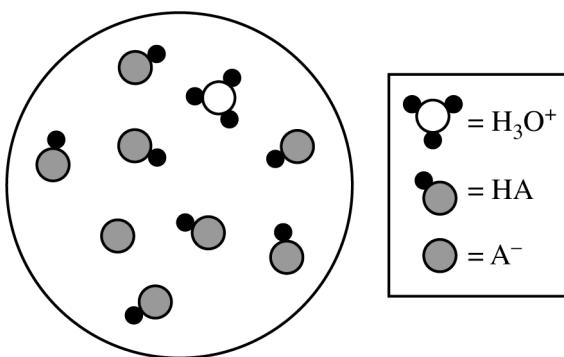
GO ON TO THE NEXT PAGE.

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

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.



GO ON TO THE NEXT PAGE.

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:

- $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

$$P_2 = \frac{(P_1)(T_2)}{T_1} = \frac{(7.45 \text{ atm})(271 \text{ K})}{296 \text{ K}} = 6.82 \text{ atm}$$

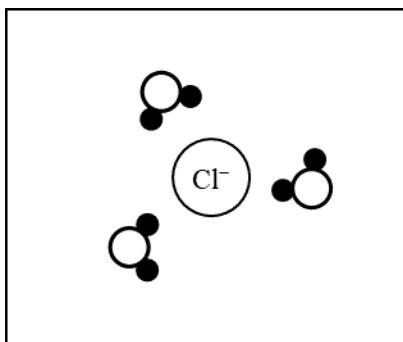
- $P = \frac{nRT}{V} = \frac{(1.84 \text{ mol})(0.08206 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}})(271 \text{ K})}{6.00 \text{ L}} = 6.82 \text{ atm}$

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

HNO₂. *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 HNO₂.*

Total for question 5 4 points