

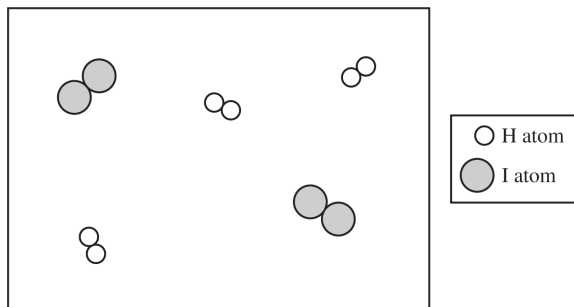
5. Hydrogen gas and iodine gas react to form hydrogen iodide at an elevated temperature, as represented by the following equation.



(a) Write the expression for the equilibrium constant, K_c , for this reaction.

(b) $\text{H}_2(g)$ and $\text{I}_2(g)$ are added to a previously evacuated container and allowed to react.

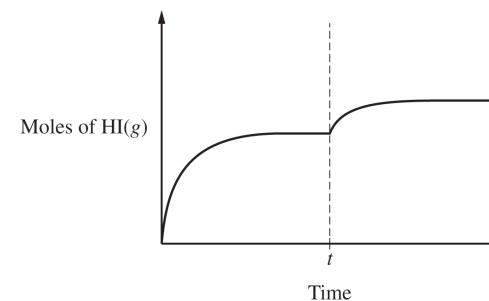
- (i) At a certain time, the value of the reaction quotient, Q , is 0.67. The following particle diagram is an incomplete representation of the system at this time. The diagram shows the relative number of $\text{H}_2(g)$ and $\text{I}_2(g)$ molecules, but the $\text{HI}(g)$ molecules are not included. Draw the number of $\text{HI}(g)$ molecules needed to complete the diagram so that it accurately represents the system.



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

- (ii) A student monitors the number of moles of $\text{HI}(g)$ over time. Hypothesize an experimental change that could have been applied to the system in the rigid container at time t to result in the change in the number of moles of $\text{HI}(g)$ shown in the graph. Assume that the student did not add more $\text{HI}(g)$ to the system.



- (iii) After equilibrium is established, the mixture is transferred to a larger container at constant temperature. As a result, would the number of moles of $\text{HI}(g)$ increase, decrease, or remain the same? Justify your answer.

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2. In the gas phase, AlCl_3 is a molecular substance. A reaction of gaseous AlCl_3 at high temperature is represented by the following balanced equation.



- (a) How many grams of $\text{Cl}(g)$ can be formed from 1.25 mol of $\text{AlCl}_3(g)$?

Additional reactions that involve Al or Cl are shown in the following table.

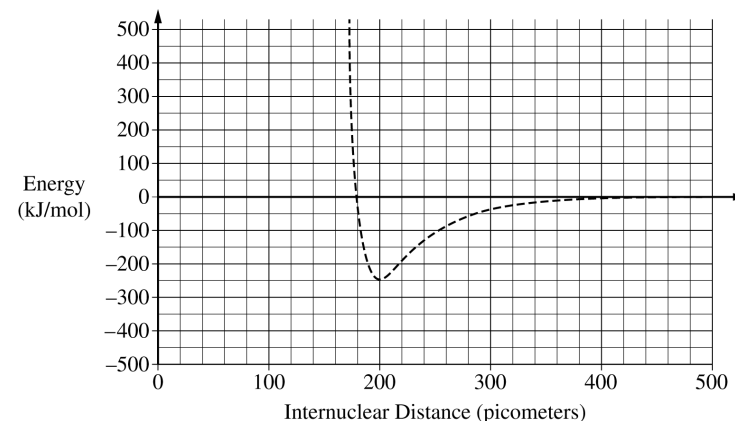
Reaction Number	Equation	ΔH_{rxn}° (kJ/mol _{rxn})
2	$\text{Al}(s) + \frac{3}{2}\text{Cl}_2(g) \rightarrow \text{AlCl}_3(g)$	-583
3	$\text{Al}(s) \rightarrow \text{Al}(g)$	+326
4	$\text{Cl}_2(g) \rightarrow 2\text{Cl}(g)$	+243

- (b) Calculate the value of ΔH_1° , in kJ/mol_{rxn}, for reaction 1 above using reactions 2, 3, and 4.

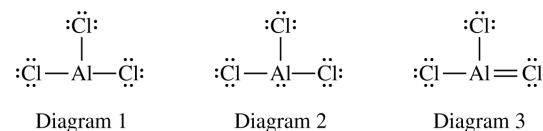
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Continue your response to QUESTION 2 on this page.

- (c) A potential energy diagram for Cl_2 is shown in the following graph.



- (i) Based on the graph, what is the bond length, in picometers, for Cl_2 ? _____
- (ii) A student finds that the average Al – Cl bond length is 220 picometers and the average bond energy is 425 kJ/mol. Draw the potential energy curve for the average Al – Cl bond on the preceding graph.
- (d) Three proposed Lewis diagrams for the $\text{AlCl}_3(g)$ molecule are shown.



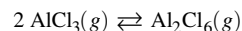
- (i) The $\text{AlCl}_3(g)$ molecule has a trigonal planar geometry. Which diagram (1, 2, or 3) can be eliminated based on geometry? Justify your choice based on VSEPR theory.

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Continue your response to **QUESTION 2** on this page.

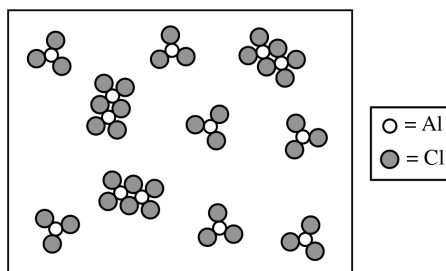
- (ii) Which of the three diagrams is the best representation for the bonding in AlCl_3 ? Justify your choice based on formal charges.

AlCl_3 is known to dimerize reversibly in the gas phase. The dimerization equilibrium is represented by the following equation.



- (e) Write the expression for the equilibrium constant, K_p , for this reaction.

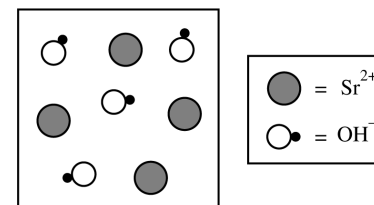
A particle-level diagram of an equilibrium mixture of $\text{AlCl}_3(g)$ and $\text{Al}_2\text{Cl}_6(g)$ at 400°C in a 25 L closed container is shown.



- (f) Using the particle-level diagram, calculate the value of K_p for the reaction if the total pressure in the container is 22.1 atm.

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Strontium hydroxide dissolves in water according to the following equation. The K_{sp} expression for strontium hydroxide is provided.



- (a) A student draws the particulate diagram shown to represent the ions present in an aqueous solution of $\text{Sr}(\text{OH})_2$. (Water molecules are intentionally omitted.) Identify the error in the student's drawing.

- (b) The student prepares a saturated solution by adding excess $\text{Sr}(\text{OH})_2(s)$ to distilled water and stirring until no more solid dissolves. The student then determines that $[\text{Sr}^{2+}] = 0.043 \text{ M}$ in the solution.

- (i) Calculate the value of $[\text{OH}^-]$ in the solution.

- (ii) Calculate the value of K_{sp} for $\text{Sr}(\text{OH})_2$.

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Continue your response to **QUESTION 7** on this page.

(c) The student prepares a second saturated solution of $\text{Sr}(\text{OH})_2$ in aqueous $0.10\text{ }M\text{ Sr}(\text{NO}_3)_2$ instead of water.

Will the value of $[\text{OH}^-]$ in the second solution be greater than, less than, or equal to the value in the first solution? Justify your answer. (Assume constant temperature.)

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END OF EXAM