Unit 14 – AP Review **Name _____**

2023 FRQ #2 **Period _____**

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:

Reaction 1: $AlCl_{3(g)} \rightarrow Al_{(g)} + 3\ Cl_{(g)}$ $\Delta H^0_1 = ?$

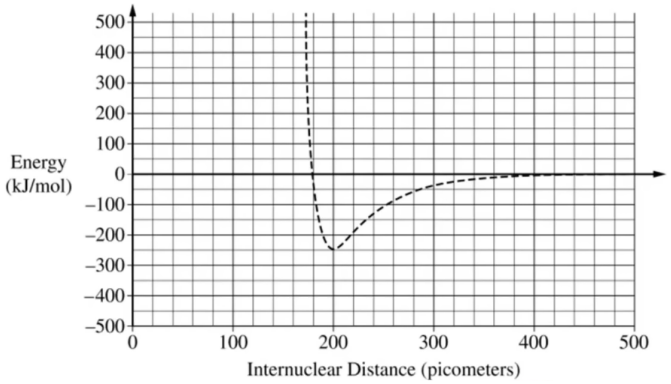
a) How many grams of $Cl_{(g)}$ can be formed from 1.25 mol of $AlCl_{3(g)}$?

Additional reactions that involve Al or Cl are shown in the following table. Reaction 1: $AlCl_3(g) \rightarrow Al(g) + 3\,Cl(g) \quad \Delta H_1^\circ = ?$

Reaction Number	Equation	ΔH°_{rxn} (kJ/mol$_{rxn}$)
2	$Al(s) + \frac{3}{2} Cl_2(g) \rightarrow AlCl_3(g)$	−583
3	$Al(s) \rightarrow Al(g)$	+326
4	$Cl_2(g) \rightarrow 2\,Cl(g)$	+243

b) Calculate the value of ΔH^0_1, in kJ/mol$_{rxn}$, for reaction 1 above using reactions 2, 3, and 4.

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 $AlCl_{3(g)}$ molecule are shown.

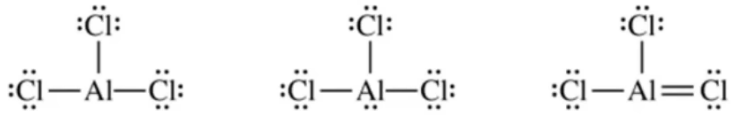


Diagram 1 Diagram 2 Diagram 3

(i) The $AlCl_{3(g)}$ 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.

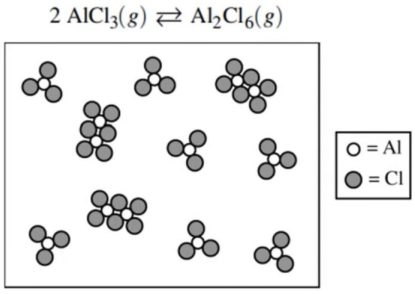
(ii) Which of the three diagrams is the best representation for the bonding in $AlCl_3$? Justify your choice based on formal charges.

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

$$2\ AlCl_3(g) \rightleftarrows Al_2Cl_6(g)$$

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

A particle-level diagram of an equilibrium mixture of $AlCl_{3(g)}$ and $Al_2Cl_{6(g)}$ at 400^0C in a 25 L closed container is shown.



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