Name:________________________Gen Chem I Prof. Golestaneh
Consulted with (names):___________________________ SHOW ALL YOUR WORK!

The Exploding Can

Topics: First Law of Thermodynamics, Work, Enthalpy, Gas Stoichiometry and mixtures, Hess's Law.
Problem: Calculate the maximum height (feet) the lid travels upon explosion in open environment.
Reported Result:

The lid will travel a absolute maximum distance of __________ feet.

Background Information

The exploding can demonstrates a system which does pressure-volume work on its surroundings.
The methane combustion reaction at explosion is:

$$CH_4\,(g) + 2\,O_2\,(g) \rightarrow CO_2\,(g) + 2\,H_2O\,(g) \qquad \text{(Reaction 1)}$$

We are interested in the initial and state of the reacting system. You can use a simplified approach to calculate the maximum height of the lid. A though experiment: Imagine the gas (system) trapped inside a cylinder with a frictionless piston (the lid) with some weight resting on the gas. The piston expands upon methane explosion to a maximum height that you will be calculating. Perhaps a more realistic picture would consider the impact force of explosion on the lid and the lid's resistance to this force, but we are simplifying the problem and approaching it from the gas expansion. The cylinder-piston analogy approach provides meaningful results within the scope of our simplifying assumptions. In this context, it is assumed that the heat energy generated within the system expands the volume of the gas to a level marked by the maximum height of the floating lid (the floating "piston").

Assumptions and Data Needed:

- Assume that all energy released is converted to pressure-volume expansion work, therefore we can assume that all energy released from the reaction does work on the surroundings without changing the temperature or internal energy of the system, therefore the system goes through and isothermal expansion and $\Delta U=0$. We are assuming negligible energy (heat, etc.) loss to the surroundings. In reality, recall that system work is a path dependent function and work value depends on the manner in which work is performed. If work is performed slowly it tends to become more efficient in energy conversion but slow is considered inefficient in real-world. Our assumptions help us calculate the absolute maximum limit of work one can extract from the system. There is another energy reduction factor we are not considering which is entropy and is the topic of Gen Chem II. It is not a large factor in this case.
- Assume that the lid travels directly upward with little air flow resistance.
- Assume that methane gas combustion reaction enthalpy is based on standard states of 1 atm and 298 K ($\Delta H°$) so we can use Hess' law to arrive at the enthalpy value.
- Assume that air entering into the can is at 25 °C and has a mole % composition of 78% N_2 and 21%O_2.
- Assume an atmospheric pressure of 745 torr.
- Assume a lid mass of 57.7 g
- Assume that the can has a cross sectional area = lid area = 156 cm^2
- Assume that the can's volume is 3.72 L.
- Assume that at the moment of explosion we have mole balance between CH_4 and O_2 according to the reaction.
- Can we assume that the pressure caused by mass of the lid over the gas is negligible? You should calculate it to verify the assumption.

- Use Hess's law to get the heat of reaction (kJ/mol CH_4) and the moles of methane calculated from the above to find the amount of heat generated in this exploding can.

The diagrams on the next page are intended to help you visualize the combustion process.

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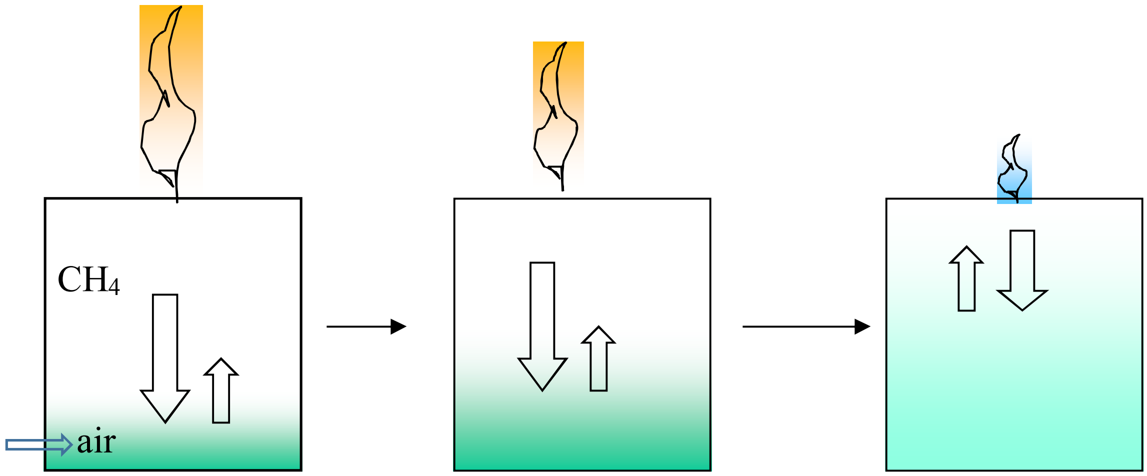
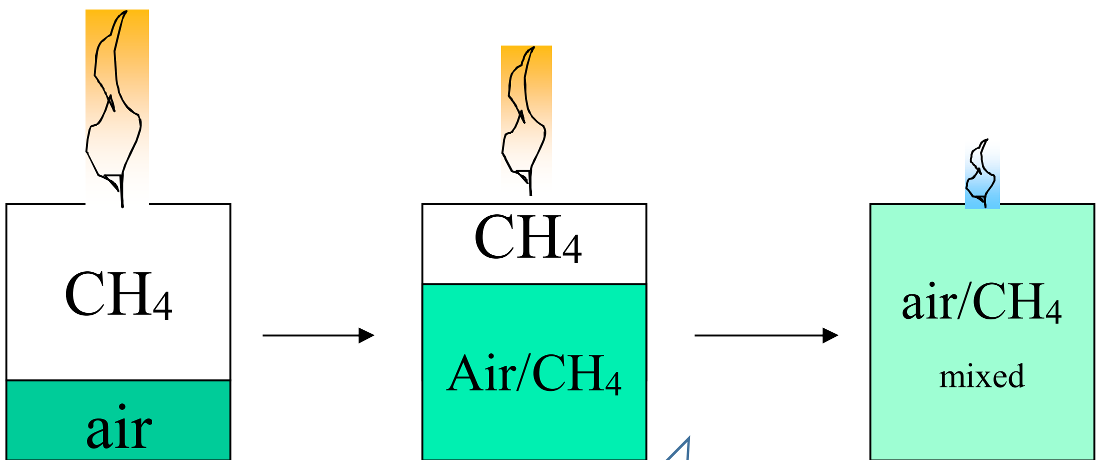


Gases diffuse into each other with time! Boom!



Can Explodes !