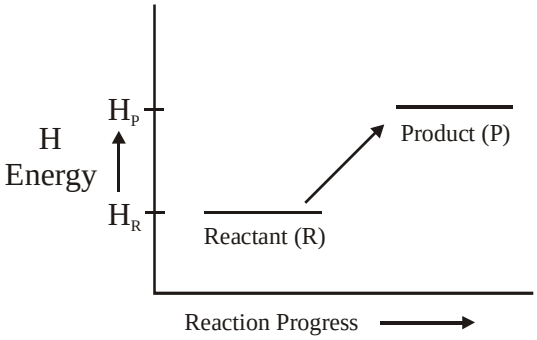
FROM ENERGY POINT OF VIEW, KEEP THE FOLLOWING THING IN MIND

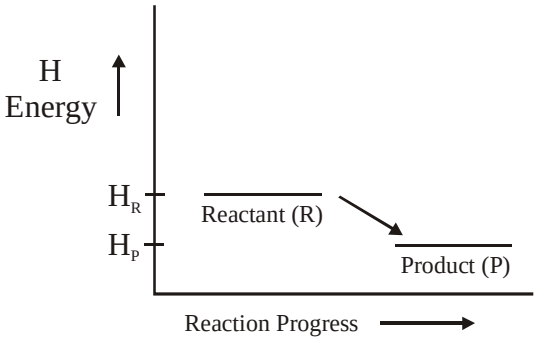
1. When energy is absorbed in reaction, it is shown with (+ve) sign. These are endothermic reactions.
2. When energy is released in reaction, is in shown with (–ve) sign. These are exothermic reaction.
3. To break bond, energy is required, that is energy is absorbed by reactant molecules. (+ve sign)
4. During bond formation, energy is released i.e. in bond formation process by atoms to form molecules is an exothermic step (–ve) sign.

For reaction $R \rightarrow P$

Reactant Product



From graph it is seen that energy of reactant is less than energy of product. Hence from energy point of view energy is provided to reactant molecule to be converted into product. Above graph is of endothermic reaction. (ΔH = +ve)



From graph it is seen that energy of reactant is less than energy of reactant. Hence from energy point of view energy is released when reactant molecule converts to product molecule. Above graph is of exothermic reaction. (ΔH = –ve)

ENTHALPY CHANGES IN CHEMICAL REACTIONS

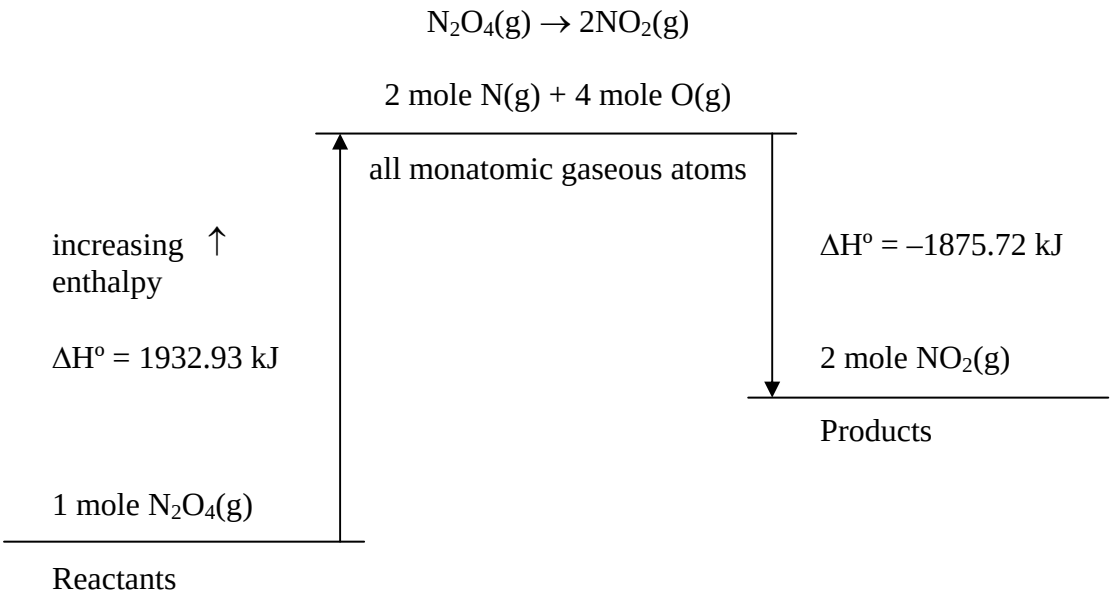
(Is Energy Released or Consumed When a Chemical Reaction Occurs)

Model 1: The Enthalpy change for a Chemical Reaction.
Table 1: Standard state enthalpies of atom combination, ΔH^{o}_{ac}

Substance	ΔH^{o}_{ac} (kJ/mol)	Substance	ΔH^{o}_{ac} (kJ/mol)
H(g)	0		
N(g)	0		
O(g)	0		
H_2(g)	–453.30	NH_3(g)	–1171.76
N_2(g)	–945.408	NO_2(g)	–937.86
O_2(g)	–498.340	N_2O_4(g)	–1932.93

To determine the overall value of ΔH^{o} for a chemical reaction, one can consider the reaction to take place by breaking apart all of the reactant molecules into their constituent atoms, and then reassembling those atoms into the product molecules. Although (in general) this is not the actual process that takes place when chemical reactions occur, thinking about the reaction in this manner is a valid way to determine the value of ΔH^{o} for the reaction.

Figure1 : The enthalpy diagram for the chemical reaction



QUESTIONS & ANSWERS

1. How much energy is required to break one mole of $N_2O_4(g)$, the reactants into gaseous atoms ?

Answer

From the given diagram :

$$N_2O_4(g) \rightarrow 2N(g) + 4O(g) \qquad \Delta H^o = 1932.93 \text{ kJ}$$
Molecule atoms atoms

∴ The energy required to break 1 mole of $N_2O_4(g)$ in gaseous atom is 1932.93.

2. Why is the ΔH^o associated with the upward arrow (left-side of Model 1) a positive number ?

Answer

The upward arrow indicate that energy increases on that axis. In otherwords energy is absorbed by the reactants. (therefore 1932.93 kJ is positive number)

3. How much energy is released when two mole of $NO_2(g)$, the products, are formed from gaseous atoms ?

Answer

From the given diagram :

$$2N(g) + 4O(g) \rightarrow 2NO_2(g) \qquad \Delta H^o = -1875.72 \text{ kJ}$$

∴ The energy released during formation of two moles of NO_2 is –1875.72 kJ. (energy released hence (–) sign . It is exothermic step)

4. Why is the ΔH^o associated with the downward arrow (Model 1) a negative number ?

Answer

The downward arrow indicated that energy decreases on that axis. In otherwords energy is given out in the process. (ΔH^o = – 1875.72 kJ, negative sign shows that energy is released)

5. For the overall reaction :
(a) is energy released or required ?

Answer

Energy is required.

(b) is the reaction endothermic or exothermic ?

Answer

Reaction is endothermic.

6. Based on the information in Figure 1, what ΔH^o for the following reaction ?

$$N_2O_4(g) \rightarrow 2NO_2(g)$$

Answer

ΔH^o = Energy involved in bond breaking + Energy involved in bond forming

= 1932.93 + (–1875.72) kJ

= + 57.21 kJ

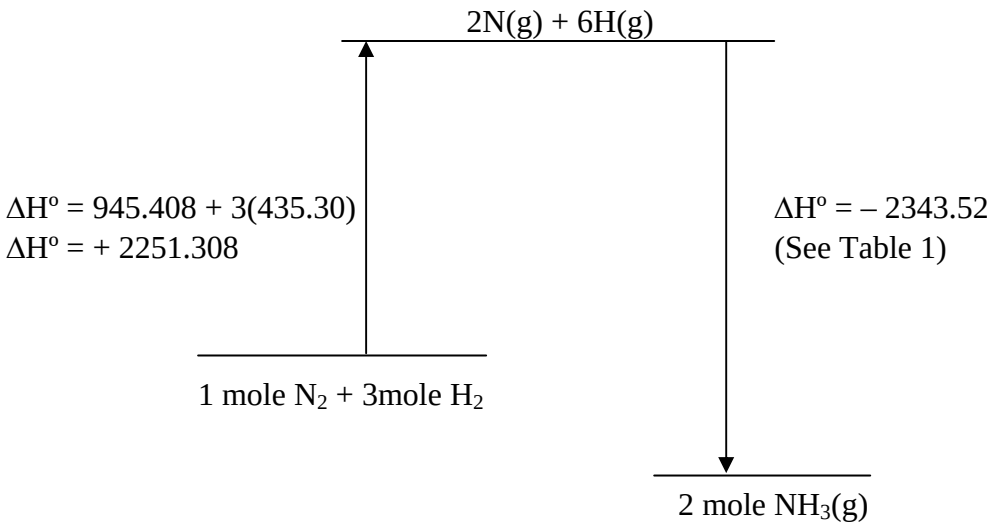
(Hence endothermic reaction)

7. For the reaction

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

(a) make a diagram similar to that in Figure 1.

Answer



Note : Use positive sign in data provided for reactants (Table 1), because energy is absorbed.

(b) Calculate ΔH^o based on your diagram.

Answer

ΔH^o = Energy involved in bond breaking + Energy involved in bond formation

= 2251.308 + (–2343.82)

= –92.212 kJ

8. Using grammatically correct sentences, describe how to calculate the ΔH^o for the reaction in CTQ7 given the ΔH^o_{ac} of the three species.

Answer

ΔH^o = [ΔH^o of 1 mole of $N_2(g)$ + 3 × ΔH^o of 1 mole $H_2(g)$] – [2 × (ΔH^o of 1 mole of $NH_3(g)$)]

ΔH^o = [Energy required for bond breaking of $N_2(g)$] + 3 × [Energy required to break $H_2(g)$] + 2 × [Energy released in bond formation of 1 mole of NH_3]
= 945.408 + 3(436.30) + 2(–1171.76)
= –92.212 kJ

9. For any given chemical reaction, in the sum of the enthalpies of atom combination for all of the reactants is more negative than the sum of the enthalpies of atom combination for all of the products, will the value of ΔH^o for the reaction be positive or negative ? Explain your reasoning.

Answer

ΔH^o for the reaction will be negative.
This is because the magnitude of energy released during atom combination is more than magnitude of energy required.

Note: Kindly provide data of ΔH^o of following molecules involved in reaction. (given in Exercise below)

Exercises

1. Calculate ΔH^o for each of the following reactions :

(a) $MgO(s) + H_2O(l) \rightarrow Mg(OH)_2(s)$

(b) $2Zn(s) + O_2(g) \rightarrow 2ZnO(s)$

(c) $TiCl_4(g) + 2H_2O(g) \rightarrow TiO_2(s) + 4HCl\ (g)$