a place of mind

FACULTY OF EDUCATION

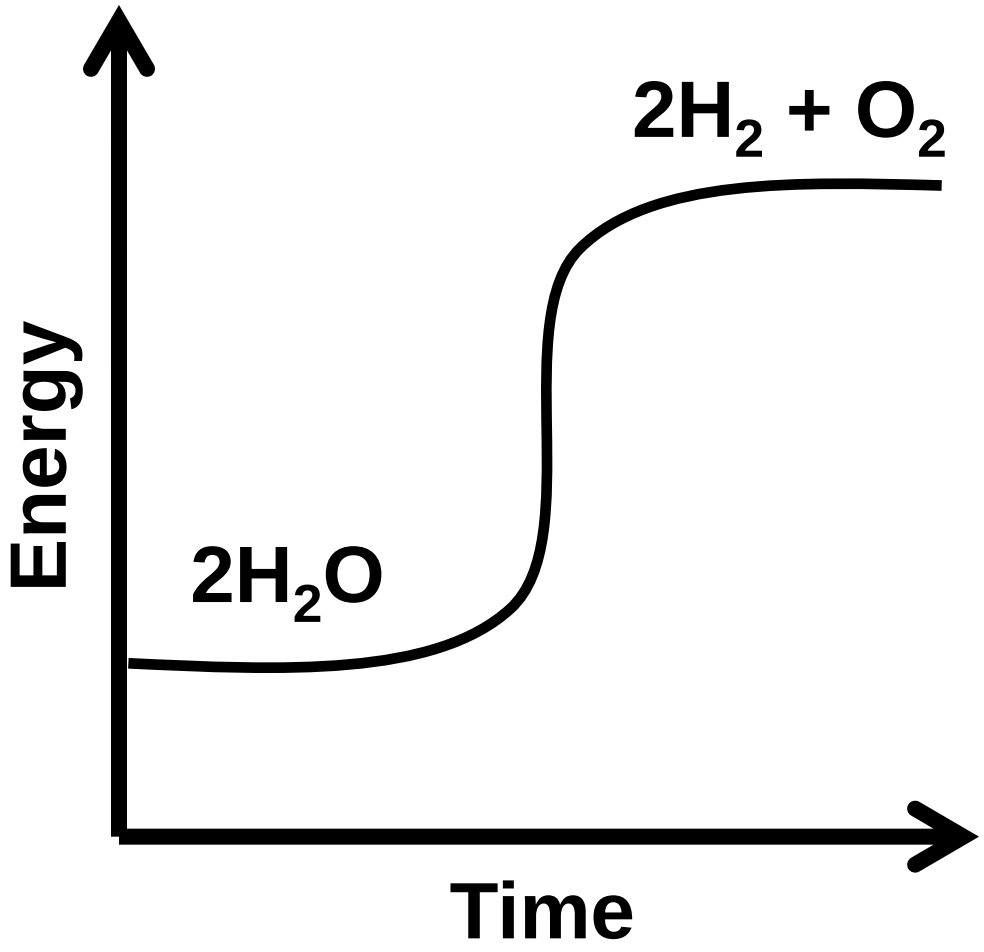
Department of
Curriculum and Pedagogy

Chemistry
Chemical Reactions:
Exothermic and Endothermic

Science and Mathematics
Education Research Group

Supported by UBC Teaching and Learning Enhancement Fund 2012-2013

Endo/Exothermic Reactions



Endo/Exothermic Reactions I

Which of the answers correctly completes the following statement?

_____ chemical bonds requires energy and _____ chemical bonds releases energy.

A. Forming / Forming
B. Forming / Breaking
C. Breaking / Breaking
D. Breaking / Forming
E. None of the above

Solution

Answer: D

Justification: The complete statement is:

Breaking chemical bonds requires energy and forming chemical bonds releases energy.

To understand this statement, think about 2 magnets. A chemical bond is like when they are stuck together. To pull 2 magnets apart you have to apply force (putting in energy). To put 2 magnets together (positive side to negative side), you don't have to do anything. In fact, a clapping sound is made when the magnets hit each other (energy released).

Endo/Exothermic Reactions II

Which of the following statements is true?

A. An endothermic reaction occurs when bonds are formed.
B. An exothermic reaction occurs when bonds are formed
C. Energy is released in an endothermic reaction.
D. Energy is absorbed in an exothermic reaction.
E. B and C

Solution

Answer: B

Justification: The definitions of endo/exothermic reactions are:

Exothermic reaction → energy is released

Endothermic reaction → energy is absorbed

Thus, neither C nor D are correct

From last question we know that:

Breaking bonds → requires energy

Forming bonds → releases energy

Thus, an exothermic reaction is the result of bonds forming and an endothermic reaction is the result of bonds breaking.

Endo/Exothermic Reactions III

$$2K + S \rightarrow K_2S$$

What type of reaction is the above chemical reaction, and would it be endothermic or exothermic?

A. Synthesis / endothermic
B. Decomposition / exothermic
C. Synthesis / exothermic
D. Synthesis / neither (no energy change would occur)
E. Decomposition / neither (no energy change would occur)

Solution

Answer: C

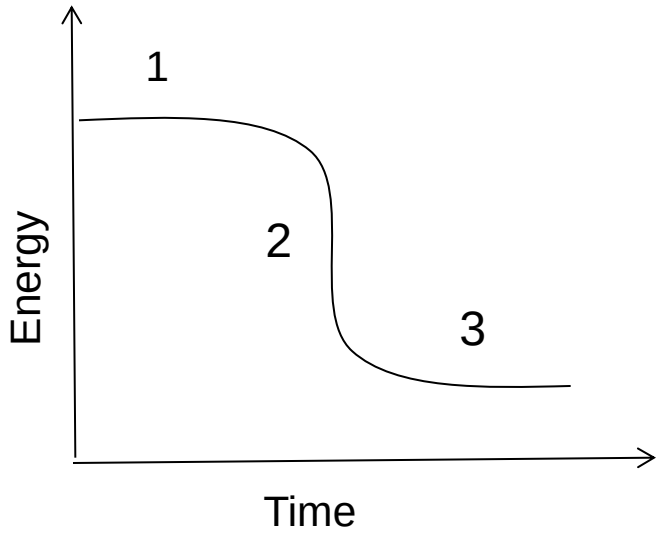
Justification: $2K + S \rightarrow K_2S$ is a synthesis reaction because 2 compounds are reacting to form 1 new compound.

Energy changes will always occur when bonds are broken and formed, thus D and E are incorrect.

Because this is a synthesis reaction, new bonds are being formed. Thus, this reaction is exothermic.

Endo/Exothermic Reactions IV

Which statement best describes what the different section of the curve in the following graph represents?



A. Part 1 represents the chemical potential energy that the reactants have.

B. Part 3 represents the lower chemical potential energy that the reactants have after they've reacted.

C. Part 2 represents the loss of energy as the reaction moved from products to reactants.

D. Part 2 represents the absorption of energy as the reaction moved from reactants to products.

E. More than one of the above

Solution

Answer: A

Justification: The curve tells you how much potential energy the system has at a moment in time.

Part 1 is early on in the reaction when the reactants are still present. Thus, it represents the chemical potential energy that the reactants have.

Part 3 represents the chemical potential energy that the system has later on when only the products are present. Thus, it represents how much chemical potential energy the products have. Answer B is incorrect because the reactants are no longer present at this point in time.

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Solution

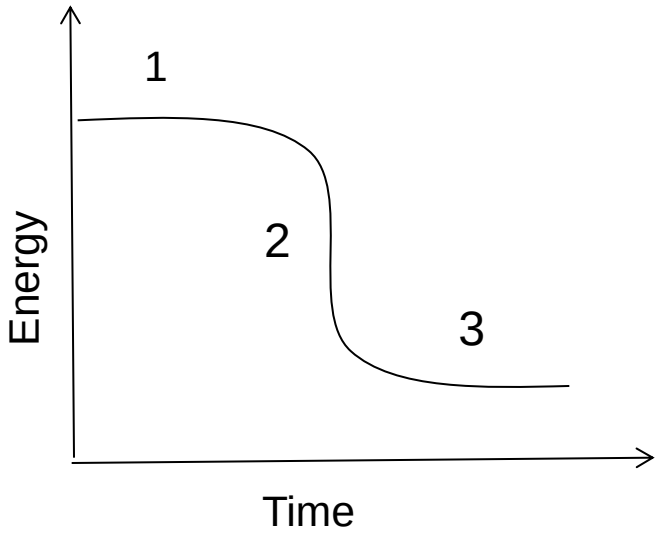
Answer: A

Justification: Part 2 shows the middle of the reaction when the reactants are turning into products. Thus, it shows the amount of potential energy changing as the reaction proceeds from the reactants to the products.

The way that the curve is drawn indicates that the amount of energy is decreasing. This means that energy is leaving (or being released from) the system. This then means that the reaction is exothermic and energy is being lost.

Endo/Exothermic Reactions V

Which statement best describes what the curve in the following graph represents?



A. The curve shows the change in the chemical potential energy of the whole system as time progresses.

B. The curve shows the total energy in the system when the reactants are first combined.

C. The curve conveys that the products have a lower chemical potential energy than the reactants.

D. The curve conveys that the reactants have a lower chemical potential energy than the products.

E. A and C

Solution

Answer: E

Justification: The curve does show the change in potential energy of the whole system as time progresses and the reaction occurs.

B is not correct because only the beginning section of the graph (part 1) shows the total energy when the reactants are first mixed.

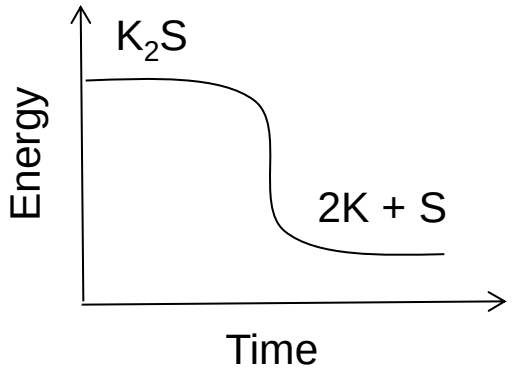
We know that part 1 of the graph represents the reactants and part 3 represents the products. Thus, because part 1 is higher up on the energy scale than part 3, we know that the reactants have a higher chemical potential energy then the products. Thus, C and D are both incorrect.

Endo/Exothermic Reactions VI

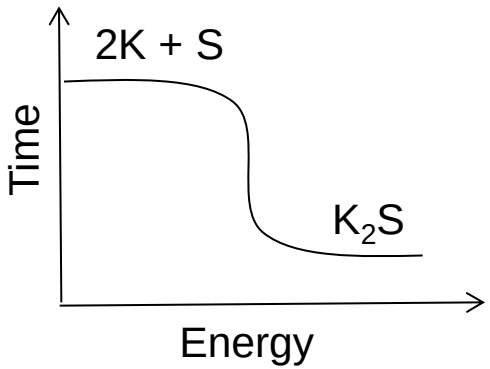
$2K + S \rightarrow K_2S$

Which graph would best describe the change in energy in the above reaction?

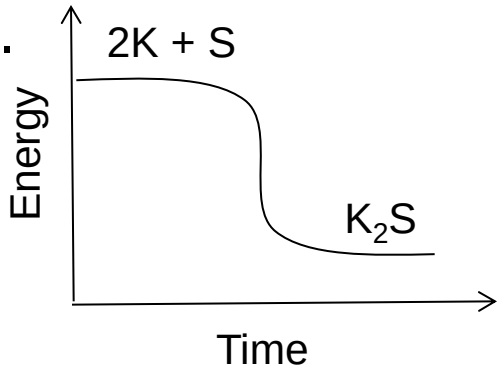
A.



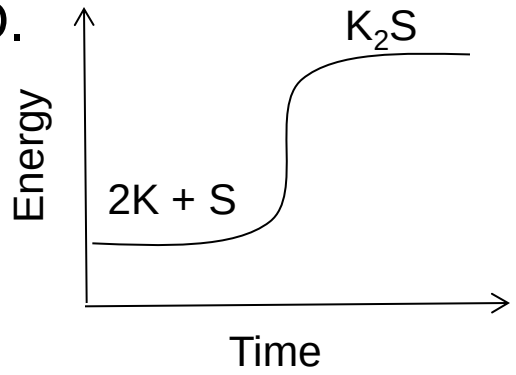
B.



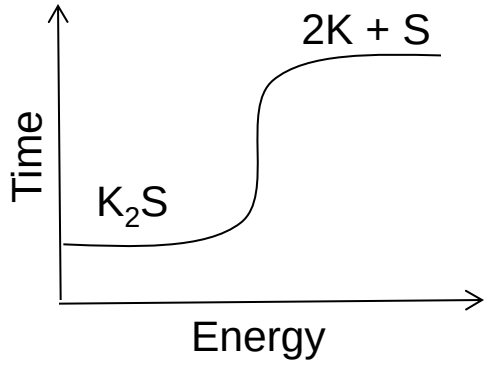
C.



D.



E.



Solution

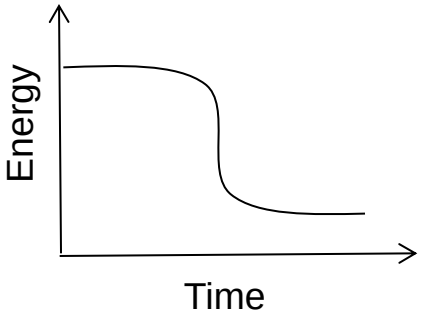
Answer: C

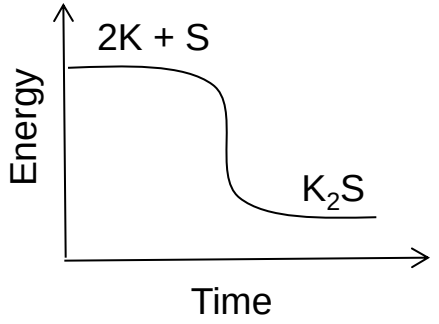
Justification: $2K + S \rightarrow K_2S$ is a synthesis reaction. Bonds are being formed, thus the reaction is exothermic.

Therefore the energy graph needs to show a release of energy as the reaction proceeds forward in time.

Note that the vertical axis represents energy and the horizontal axis represents time.

We also know that the energy is released as the reaction goes from the reactants to the products.



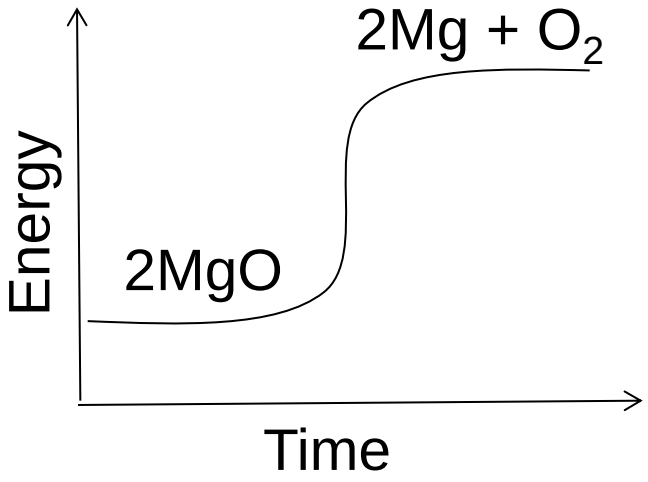


Endo/Exothermic Reactions VII

The following graph shows a reversible chemical reaction.

Which chemical equation(s) best represent the graph?

1) $2MgO + Energy \rightarrow 2Mg + O_2$
2) $2MgO \rightarrow 2Mg + O_2 + Energy$
3) $2Mg + O_2 + Energy \rightarrow 2MgO$
4) $2Mg + O_2 \rightarrow 2MgO + Energy$



A. 2 and 4
B. 2 and 3
C. 1 and 3
D. 1 and 2
E. 1 and 4

Solution

Answer: E

Justification: The reaction is: $2MgO \rightarrow 2Mg + O_2$
The graph shows that energy is absorbed into the reaction as it proceeds (an increase in energy) which means it is endothermic.

When writing the balanced equation out, you need to show that energy has been added to the system. To do this you have write the equation with energy on the reactant side. This indicates that energy went into the reaction to make it proceed.

$$2MgO + Energy \rightarrow 2Mg + O_2$$

If the energy term is written on the product side, that indicates that energy is released (like an additional product) from the reaction.

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Solution

Answer: E

Justification: The answer could also be D because it represents the same reaction except in reverse (the synthesis of MgO as opposed to the decomposition of MgO). For synthesis-decomposition pairs, the reactions are reversible and the amount of energy released or absorbed is the same.

$$2Mg + O_2 \rightarrow 2MgO + Energy$$

Note that not all reactions are reversible. You can only presume that the decomposition-synthesis pairs are reversible.

Endo/Exothermic Reactions VIII

Which of the following statements defines enthalpy?

A. The change in energy during a reaction
B. The amount of heat energy contained in a system
C. The energy of movement contained in a system
D. The total amount of energy contained in a system
E. None of the above

Solution

Answer: B

Justification: The definition of enthalpy is the amount of heat energy contained in a system. It is denoted by the symbol ‘H’.

Other forms of energy do exist, such as kinetic (movement) energy, thus enthalpy is not the total energy in a chemical system.

Enthalpy is also not the change in heat energy. That is a different value denoted as ΔH.

Endo/Exothermic Reactions IX

Using the information in the graph below, what is the ΔH for the below reaction?

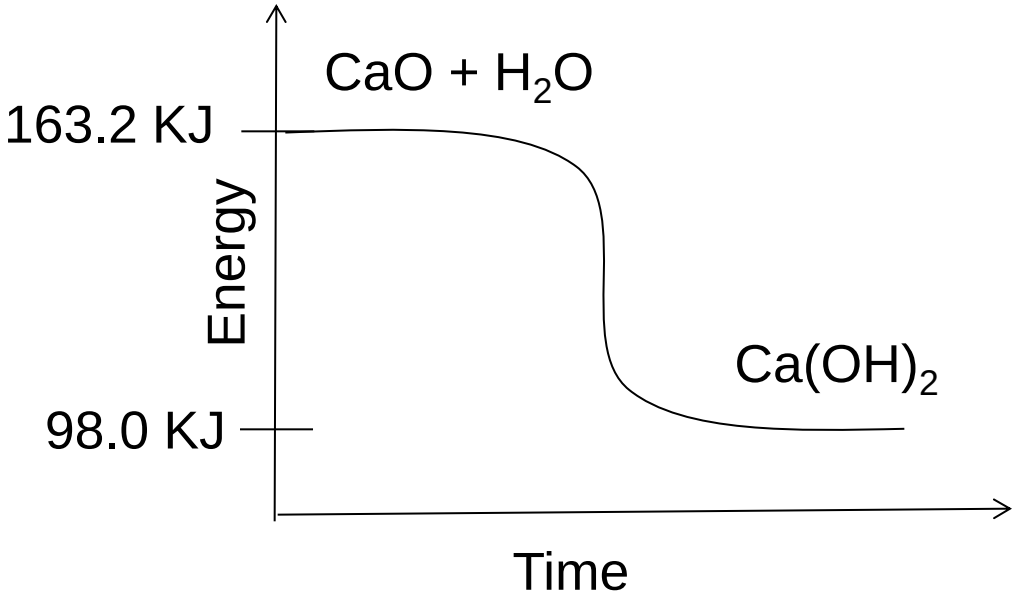
A. -65.2 KJ

B. 65.2 KJ

C. -261.2 KJ

D. 261.2 KJ

E. None of the above



Solution

Answer: A

Justification: ΔH is the change in enthalpy during a reaction. It is calculated using the equation: $\Delta H = H_{product} - H_{reactant}$

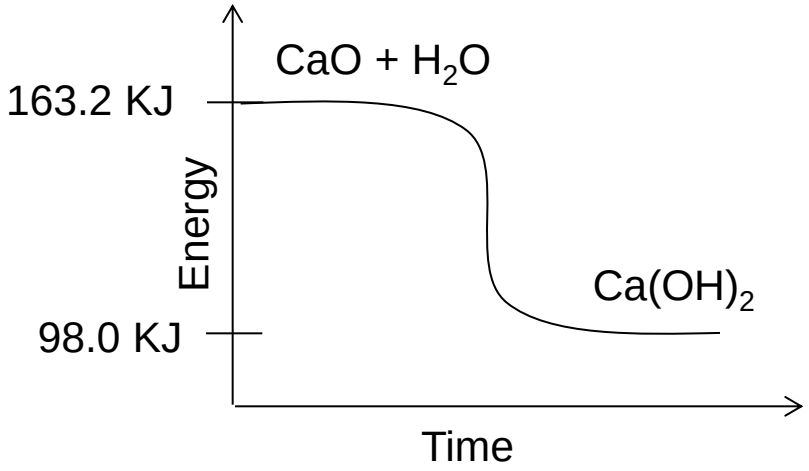
In this case, it would be: ΔH = 98.0 KJ – 163.2 KJ

It is possible to have a negative ΔH. This negative sign indicates the direction of the energy change. If it is negative that means energy is released from the system (exothermic), and if it is positive then energy is absorbed into the system (endothermic).

C and D are incorrect because ΔH is not the total enthalpy in a system, thus you should not add the enthalpies together.

Endo/Exothermic Reactions X

How would you write out the chemical equation to show the ΔH for the following reaction?



A. $CaO + H_2O \rightarrow Ca(OH)_2$ $\Delta H = 65.2$ KJ

B. $CaO + H_2O \rightarrow Ca(OH)_2$ $\Delta H = -65.2$ KJ

C. $CaO + H_2O + 65.2\ KJ \rightarrow Ca(OH)_2$

D. $CaO + H_2O \rightarrow Ca(OH)_2 - 65.2$ KJ

E. B and D

Solution

Answer: B

Justification: There are 2 ways of showing the change in enthalpy in a chemical reaction. The 2 correct equations for this question are:

1) $CaO + H_2O \rightarrow Ca(OH)_2 \quad \Delta H = -65.2$ KJ

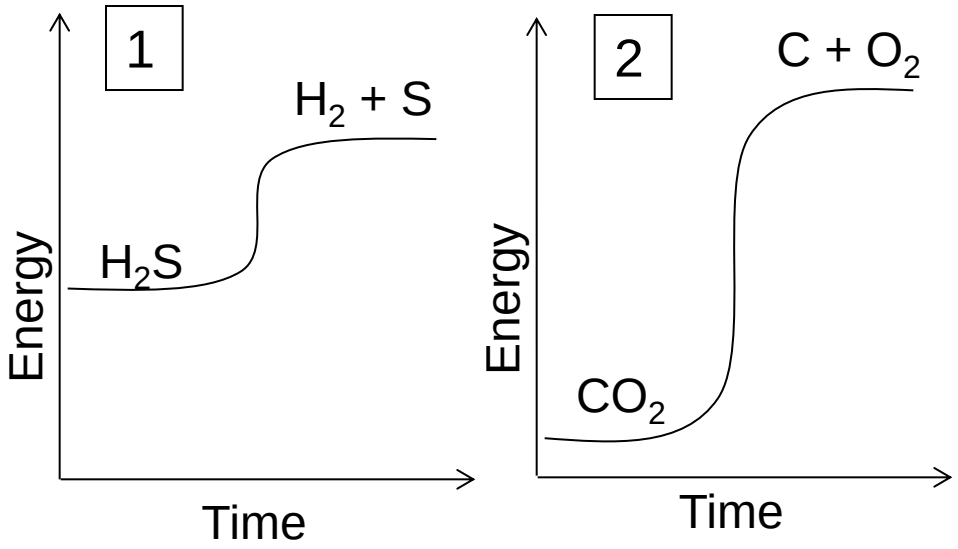
2) $CaO + H_2O \rightarrow Ca(OH)_2 + 65.2$ KJ

Answer C is very similar to number 2 above, except that the ΔH value was written on the reactant side. This is incorrect as that would indicate that the reaction is absorbing the energy, not releasing it.

Answer D is incorrect because by writing the ΔH value in the equation as a product, you are already describing the direction of the energy change. The negative sign is not needed.

Endo/Exothermic Reactions XI

Compare the two reactions. Which of the following statements does NOT correctly describe the differences and/or similarities between the two?



A. 2 has a greater ΔH than 1

B. 2 is more endothermic than 1

C. H_2S has a higher potential energy than CO_2

D. 1 requires more energy than 2 to make the reaction proceed

E. All of the above are correct

Solution

Answer: D

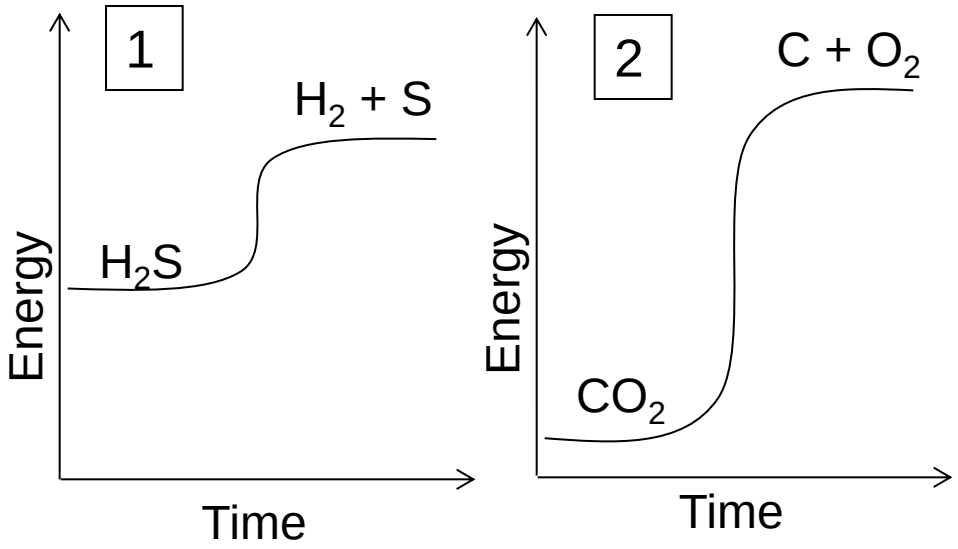
Justification: Both of the graphs show an endothermic reaction, except reaction 2 has a much larger change in enthalpy, thus more energy is needed for the reaction to occur and it is considered to be more endothermic.

The graphs do show that H_2S has a higher potential energy than CO_2.

Having a higher potential energy (H) does not mean than more energy is required to make the reaction proceed. Only the change in potential energy (ΔH) tells you how much energy is needed. Thus, D is the incorrect statement.

Endo/Exothermic Reactions XII

CO_2 and H_2S are common by-products of many industrial processes. H_2S is extremely toxic and excessive CO_2 can have negative impacts on the environment (global warming).



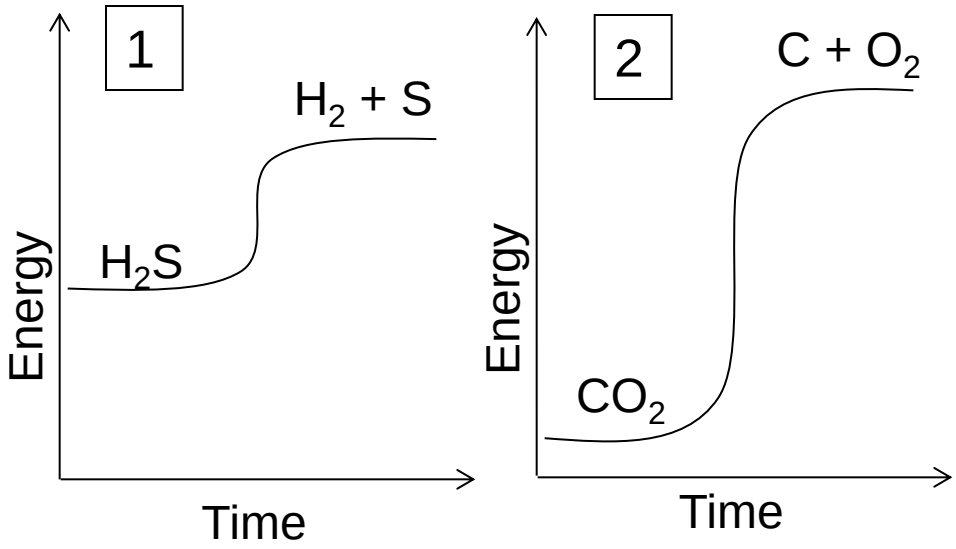
To deal with such by-products, industries will try to perform chemical reactions with the gases to form a different, less toxic and/or more useful compound.

Industries easily react H_2S to form different compounds, but there is no easy way to react CO_2.

Question on next slide…

Endo/Exothermic Reactions XII

Using the two graphs, choose which statement best explains why it is easy to react H_2S and hard to react CO_2.



A. Reacting CO_2 requires much more energy than reacting H_2S.

B. H_2S has a higher potential energy which makes it easier to react than CO_2

C. It is more difficult to create the large amount of energy required to react CO_2 as opposed to the little amount of energy for H_2S.

D. A and C

E. All of the above

Solution

Answer: D

Justification: The graphs show that reacting CO_2 has a larger ΔH and thus requires much more energy than reacting H_2S. This would make the reaction of CO_2 much more difficult to perform.

While H_2S does have a higher potential energy than CO_2, this does not affect how easy or difficult it is for the reaction to occur. Only the magnitude of ΔH determines this.

The energy that a reaction requires has to come from somewhere. On small scale experiments, the energy can usually just come from the surroundings. However, for large scale industrial processes, energy has to be put into the system in the form of electricity, heat, etc. The best way to produce a LOT of energy is through burning coal, which just creates more CO_2. This is a problem if we are trying to get rid of CO_2 in the first place.

Endo/Exothermic Reactions XIII

$$2H_2O \rightarrow 2H_2 + O_2$$

Hydrogen fuelled cars are seen as a more environmentally friendly alternative to cars fuelled by gasoline because they do not produce CO_2 (which is a cause of global warming).

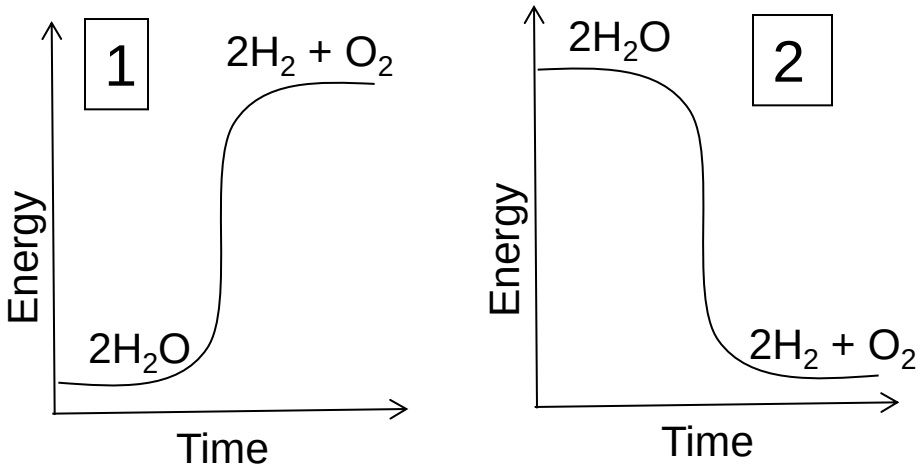
Large amounts of hydrogen are produced by the electrolysis of water (running electricity through water to decompose the water into hydrogen and oxygen) according the above equation.

Question on next slide…

Endo/Exothermic Reactions XIII

$2H_2O \rightarrow 2H_2 + O_2$

Which graph and explanation shows why hydrogen fuelled cars may not be as environmentally friendly as many people think they are.



A. 1 and i
B. 1 and ii
C. 1 and iii
D. 2 and i
E. 2 and ii
F. 2 and iii

i. The reaction produces a lot of energy which is also harmful to the environment

ii. The reaction requires a lot of energy which would likely come from burning fossil fuels

iii. The hydrogen produced has a very high chemical potential energy which can be dangerous to the environment.

Solution

Answer: B

Justification: The reaction is endothermic since bonds are being broken. Thus, energy is required to be put into the reaction to make it proceed. Graph 1 shows this reaction.

Explanation i is incorrect because energy is not produced in this reaction.

Explanation iii is incorrect because while it is true that the hydrogen produced has a high chemical potential energy, this hydrogen would not be harmful to the environment. The high potential energy could be dangerous for humans though because it makes hydrogen gas very flammable and combustible.

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Solution

Answer: B

Justification: Explanation ii is correct because a lot of energy is required to make this reaction occur. Thus lots of electricity is needed to provide the huge amount of energy needed to create enough hydrogen to power millions of cars .

The easiest method of generating that much electricity would be burning fossil fuels.

Burning fossil fuels however causes more CO_2 to be produced which is not good for the environment.

Industry Application

Many companies and researchers work hard on overcoming the problems associated with getting rid of CO_2 and creating viable ways to make Hydrogen fuelled cars.

For more information about the development of methods to reduce CO_2 emissions in industry see:

http://www.dnv.com/binaries/dnv-position_paper_co2_utilization_tcm4-445820.pdf

For more information about the problems associated with the development of hydrogen cars see:

http://www.howstuffworks.com/fuel-efficiency/hybrid-technology/hydrogen-cars3.htm