Chemistry

5. Energy Changes

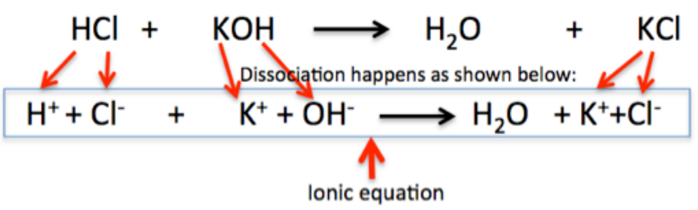
Revisiting Booklet

Name:

Contents

An exothermic reaction is a chemical reaction that releases energy by light or heat. It is the opposite of an endothermic reaction. Expressed in a chemical equation: reactants → products + energy.

Draw an energy level diagram showing an endothermic reaction



Highlight key words or phrases

Reacting two solutions, eg acid and alkali

1. **Place the polystyrene cup inside the glass beaker to make it more stable.**
2. **Measure an appropriate volume of each liquid, eg 25 cm3.**
3. **Place one of the liquids in a polystyrene cup.**
4. **Record the temperature of the solution.**
5. **Add the second solution and record the highest or lowest temperature obtained.**
6. **Change your independent variable and repeat the experiment.**

Draw an energy level diagram showing an exothermic reaction

The term endothermic process describes a process or reaction in which the system absorbs energy from its surroundings; usually, but not always, in the form of heat.

Key word	**Definition**
Reaction	
Reactants	
Products	
Energy	
Collisions	

For the practical to the left what is the Independent variable:

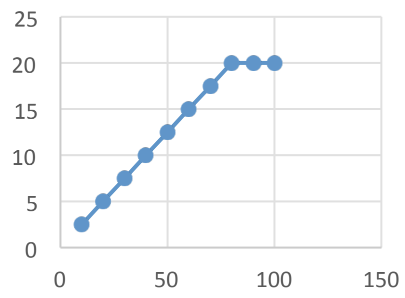
____

Dependent variable:

____

Control variables:

____



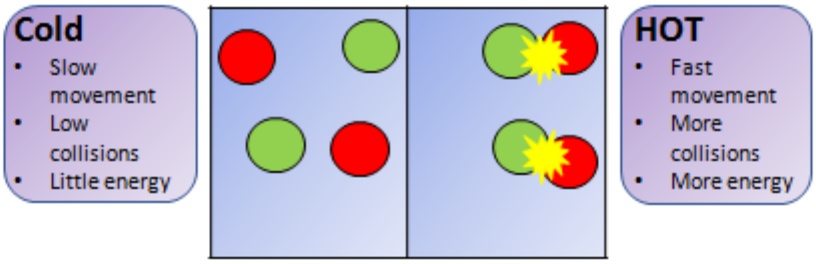
The graph to the left shows the temperature change when reacting different volumes of alkali with a set volume of acid. Describe and explain these results.

Highlight key words or phrases

Collision theory

Different reactions can happen at different rates. Reactions that occur slowly have a low rate of reaction. Reactions that happen quickly have a high rate of reaction. For example, rusting is a slow reaction: it has a low rate of reaction. Burning and explosions are very fast reactions: they have a high rate of reaction.

- For a chemical reaction to occur, the reactant particles must collide. But collisions with too little energy do not produce a reaction
- The particles must have enough energy for the collision to be successful in producing a reaction.
- The rate of reaction depends on the rate of successful collisions between reactant particles. The more successful collisions there are, the faster the rate of reaction.

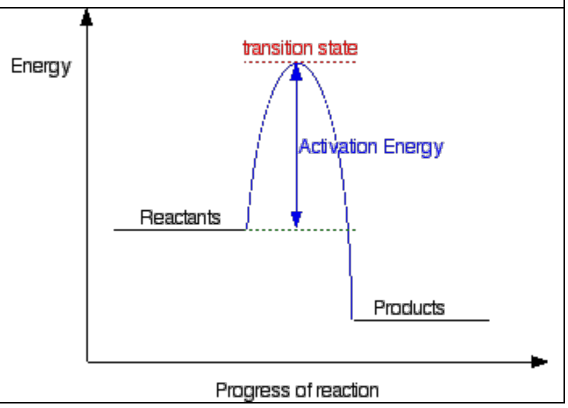


Produce a small mind map on the key points of collision theory:

A reaction profile includes the activation energy, which is the minimum energy needed by particles when they collide for a reaction to occur. The activation energy is shown as a 'hump' in the line, which:

- starts at the energy of the reactants
- is equal to the difference in energy between the top of the 'hump' and the reactant
- The overall change in energy in a reaction is the difference between the energy of the reactants and products

Describe in detail what the reaction profile to the left is showing:



During a chemical reaction:

- bonds in the reactants are broken
- new bonds are made in the products

The difference between the energy needed to break bonds and the energy released when new bonds are made determines the type of reaction.

A reaction is:
exothermic if more heat energy is released in making bonds in the products than is taken in when breaking bonds in the reactants
endothermic if less heat energy is released in making bonds in the products than is taken in when breaking bonds in the reactants

Highlight key words or phrases

Using bond energies

The energy change in a reaction can be calculated using bond energies. A bond energy is the amount of energy needed to break one mole of a particular covalent bond.
Different bonds have different bond energies. These are given when they are needed for calculations.

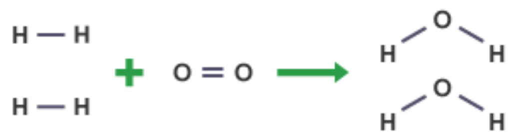
To calculate an energy change for a reaction:

- add together the bond energies for all the bonds in the reactants - this is the 'energy in'
- add together the bond energies for all the bonds in the products - this is the 'energy out'
- energy change = energy in - energy out

Bond Energy Calculation Method

1. Draw out the bonds in each of the reactants and products.
2. Calculate the energy absorbed when all of the reactant bonds are broken.
3. Calculate the energy released when all of the new bonds in the products are made.
4. Subtract the total for the new bonds from the total for the old bonds. A negative final answer means that the reaction is exothermic.

H—H	**432**	**O—H**	**467**
C—H	**413**	**C = C**	**614**
C—C	**347**	**O = O**	**495**
C—N	**305**	**C = O***	**745**
C—O	**358**	**N = O**	**607**
C—F	**485**	**N = N**	**418**
C—Cl	**339**	**N ≡ N**	**941**
N—H	**391**	**C ≡ N**	**891**
N—N	**160**	**C = N**	**615**



2 x (H-H) = 2 x 436
1 x (O=O) = 1x 498
Total energy in = 872 + 498 = 1370kJ
4 x (O-H) = 4 x 464
Total energy out = 1856 kJ
Energy change = 1370 – 1856
= **-486 kJ** (negative value - so it is exothermic)

Calculate the total bond energy for the compounds in the table below

Compound	**Bond energy**	**Compound**	**Bond energy**
CO_2		HCl	
H_2O		CH_4	
H_2		NH_3	

1. Draw out the bonds in each of the reactants and products.
2. Calculate the energy absorbed when all of the reactant bonds are broken.
3. Calculate the energy released when all of the new bonds in the products are made.
4. Subtract the total for the new bonds from the total for the old bonds. A negative final answer means that the reaction is exothermic.

$CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$

1. Draw out the bonds in each of the reactants and products.
2. Calculate the energy absorbed when all of the reactant bonds are broken.
3. Calculate the energy released when all of the new bonds in the products are made.
4. Subtract the total for the new bonds from the total for the old bonds. A negative final answer means that the reaction is exothermic.

$N_2 + 3H_2 \rightleftharpoons 2NH_3$

1. Draw out the bonds in each of the reactants and products.
2. Calculate the energy absorbed when all of the reactant bonds are broken.
3. Calculate the energy released when all of the new bonds in the products are made.
4. Subtract the total for the new bonds from the total for the old bonds. A negative final answer means that the reaction is exothermic.

$H_2 + Cl_2 \rightarrow 2HCl$

1. Draw out the bonds in each of the reactants and products.
2. Calculate the energy absorbed when all of the reactant bonds are broken.
3. Calculate the energy released when all of the new bonds in the products are made.
4. Subtract the total for the new bonds from the total for the old bonds. A negative final answer means that the reaction is exothermic.

$C_5H_{12} + 8\ O_2$ -> $5\ CO_2 + 6\ H_2O$

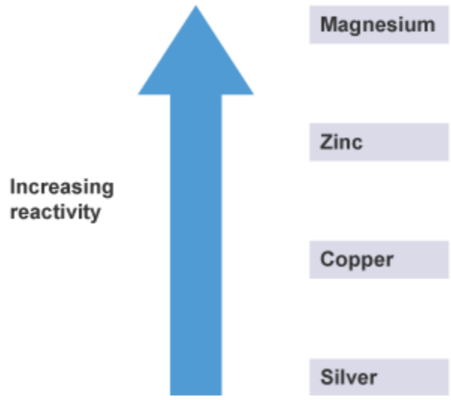
Highlight key words or phrases

Chemical cells use chemical reactions to transfer energy by electricity. The voltage of a cell depends upon a number of factors, including what the electrodes are made from, and the substance used as the electrolyte. A simple cell can be made by connecting two different metals in contact with an electrolyte. A number of cells can be connected in series to make a **battery**, which has a higher voltage than a single cell.

- In non-rechargeable cells, eg alkaline cells, a **voltage** is produced until one of the **reactants** is used up. When this happens, we say the battery 'goes flat'.
- In rechargeable cells and batteries, like the one used to power your mobile phone, the chemical reactions can be reversed when an **external circuit** is supplied.

If we connect different combinations of these metals to make a cell, we find that the voltage changes. In the below table, the positive electrodes and what they are made from are listed along the top and the negative electrodes along the side.

Here is a simple reactivity series:

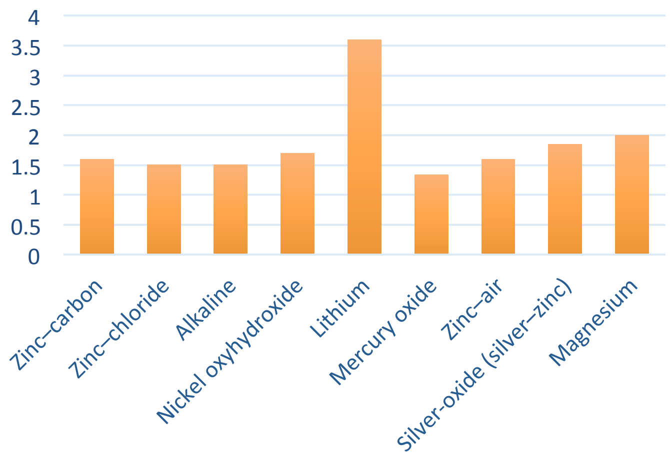


What is the reactivity series?

Metal	Chromium	Copper	Iron	Tin	Zinc
Chromium	0.0V	x	x	x	x
Copper	1.3V	0.0V	x	x	X
Iron	0.4V	0.1V	0.0V	X	X
Tin	0.6V	0.5V	0.3V	0.0V	X
Zinc	0.1V	1V	0.3V	0.7V	0.0V

The table to the left shows the voltage produced by different combinations of metals. What will be the best 2 metals to use and why?

Using the graph below which type of battery is best to use and why?



Highlight key words or phrases

Fuel cells

Fuel cells work in a different way than chemical cells.

Fuel cells produce a voltage continuously, as long as they are supplied with:

- a constant supply of a suitable fuel
- oxygen, eg from the air

The fuel is oxidised electrochemically, rather than being burned, so the reaction takes place at a lower temperature than if it was to be burned. Energy is released as electrical energy, not thermal energy (heat).

- A fuel cell combines hydrogen and oxygen to produce electricity, heat, and water.
- Hydrogen gas from a fuel tank enters one side and oxygen from the air in the other side
- The positively charged anode pulls an electron off the hydrogen atoms
- These electrons move around the circuit towards the negatively charged cathode
- Oxygen atoms accept 2 electrons from the negative cathode
- The positively charged hydrogen ions move towards the negatively charged cathode
- The negatively charged oxygen ions move towards the positively charged anode
- Both ions moth through the electrolyte where the combine and form water
- The only waste product from the hydrogen fuel cell is water
- At the cathode (negative electrode): $H_2(g) – 2e^– \rightarrow 2H^+(aq)$
- At the anode (positive electrode): $4O^-(g) + 4e^– \rightarrow 2O_2(g)$
- $4H^+(aq) + 2O^-(g) + 4e^– \rightarrow 2H_2O(g)$

Use the information above to fully annotate & explain the diagram below