12

Chemistry

In society

Mark Dewar

16 Objectives

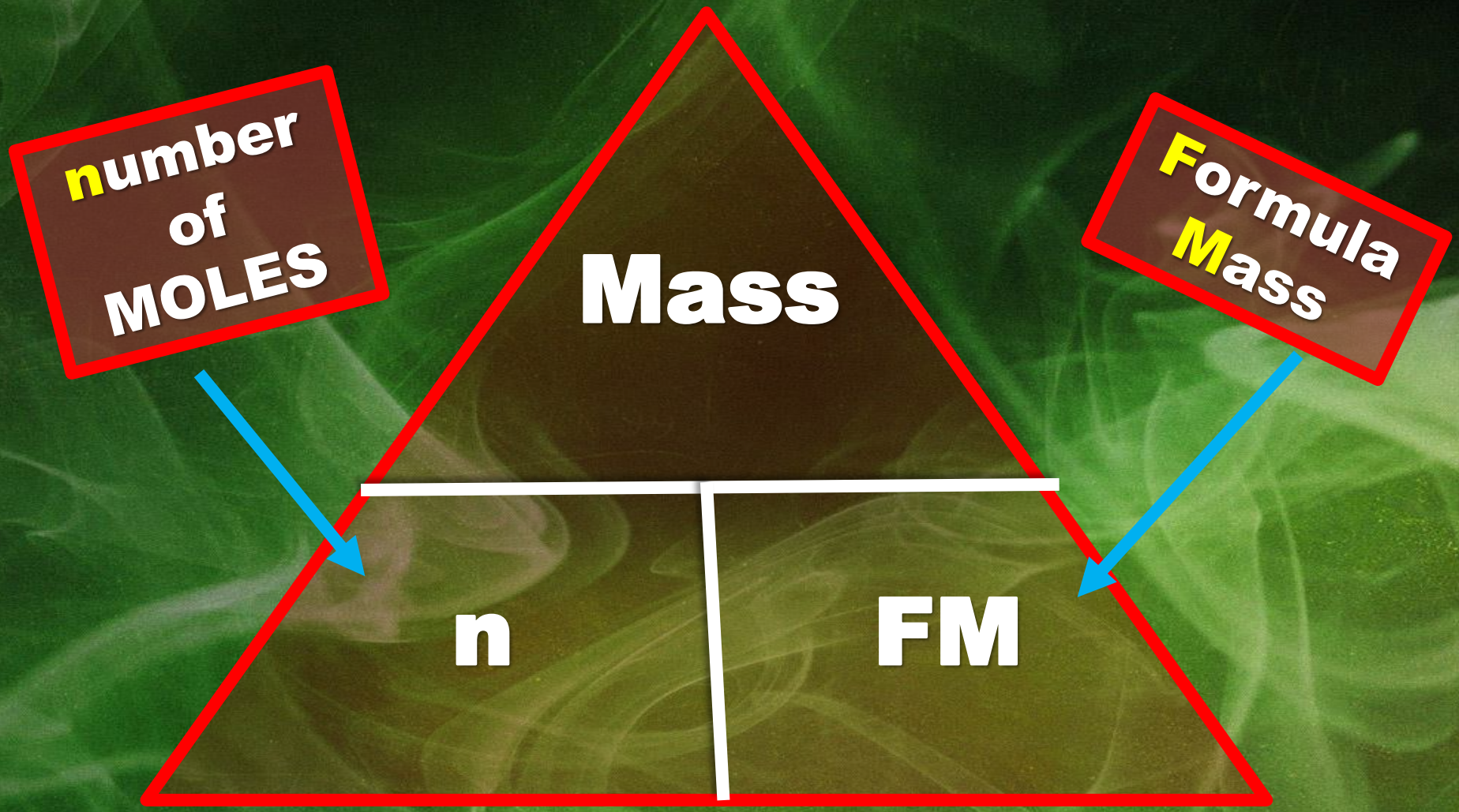
1. Stoichiometry

2. EQUILIBRIUM

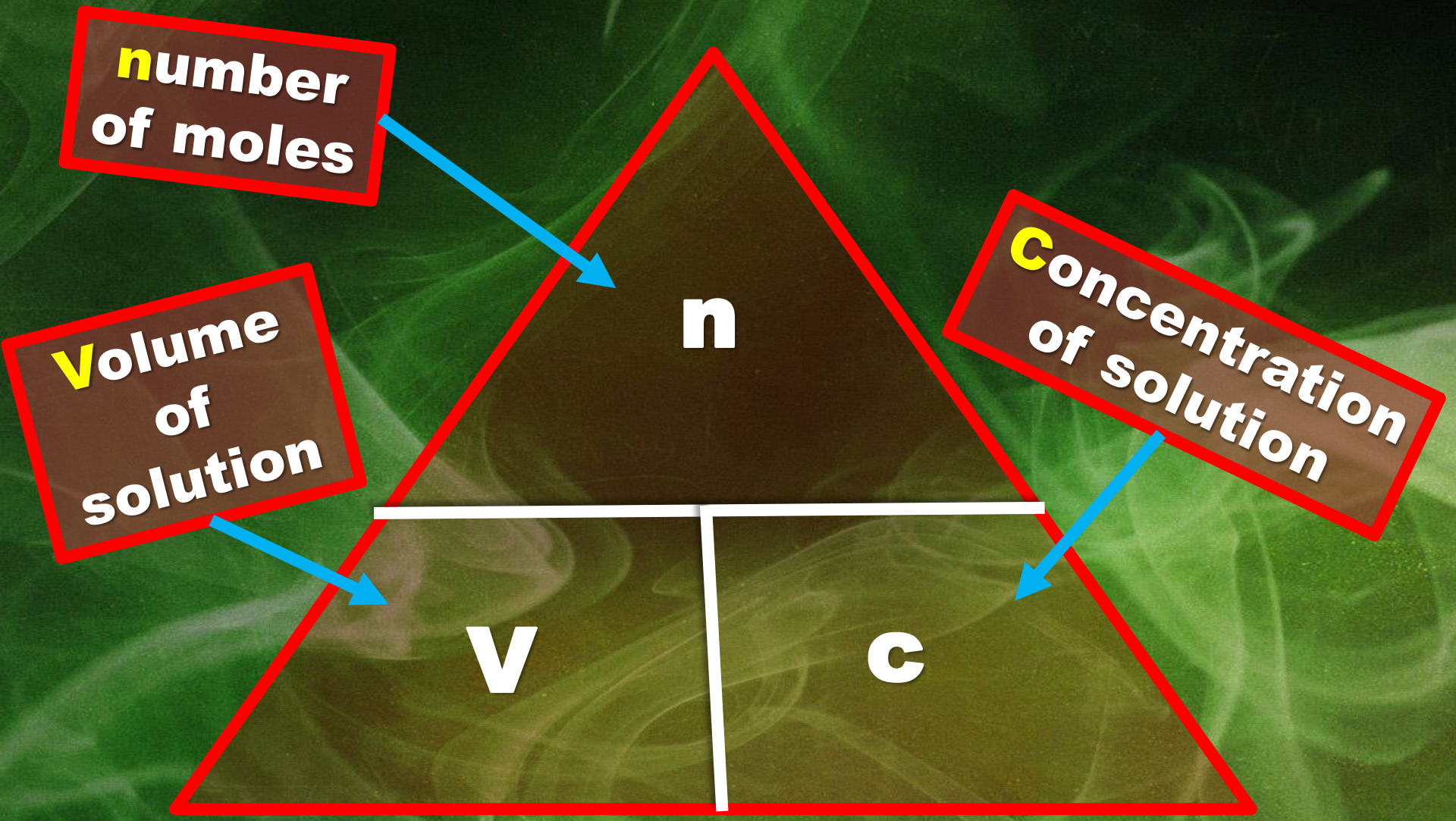
3. Le Chatelier's Principle

SOLIDS!

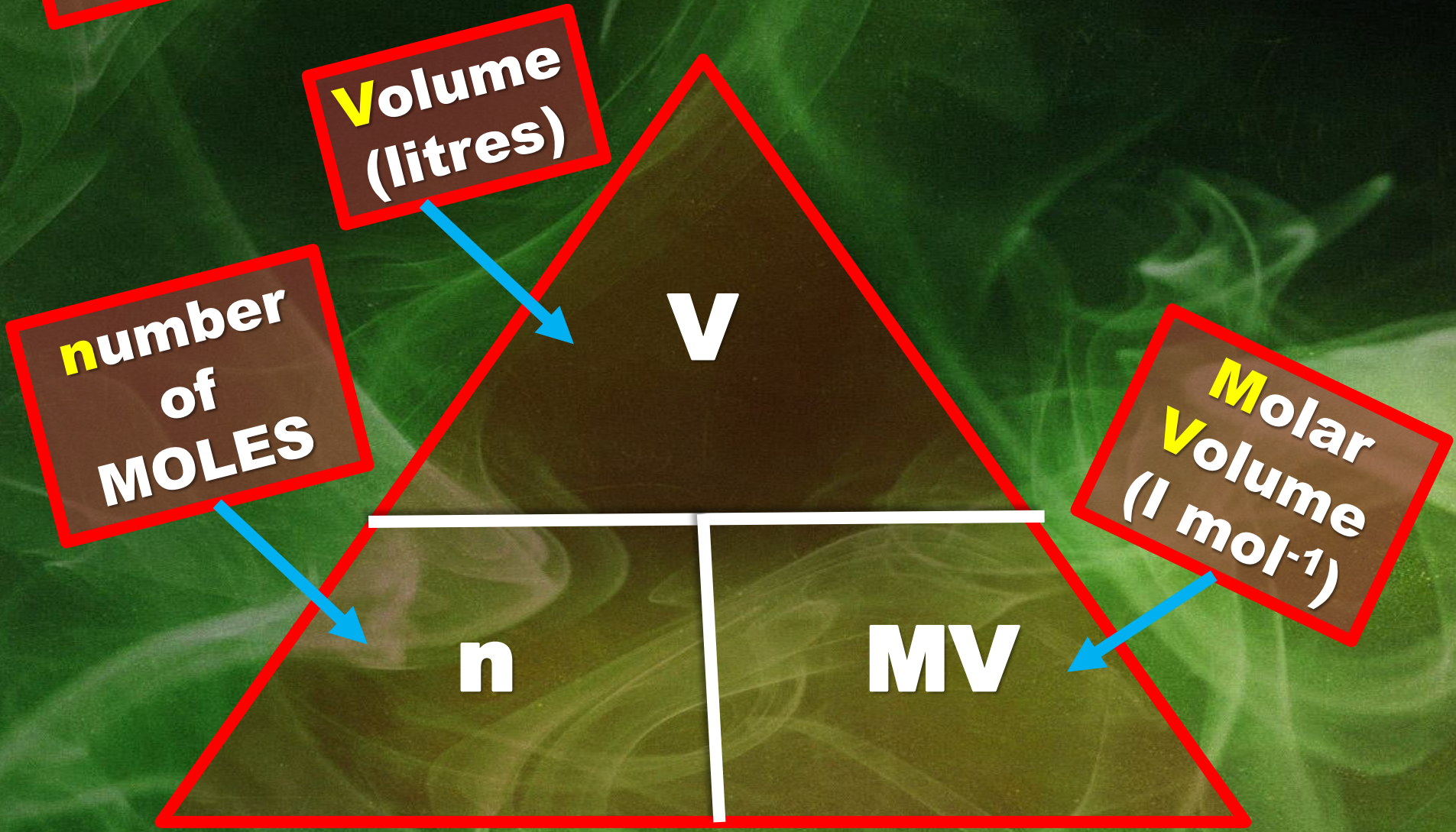
CALCULATIONS



CALCULATIONS



GAS! CALCULATIONS



CHEMICAL EQUATIONS

STOICHIOMETRY

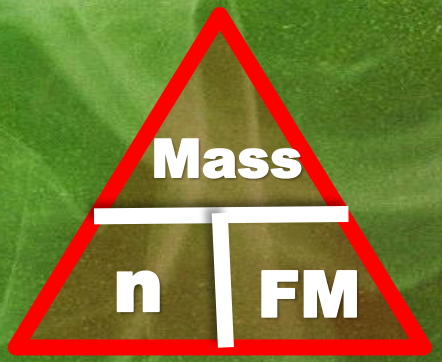
1. MEASURING CHEMICALS THAT GO INTO, AND COME OUT OF, ANY GIVEN REACTION.
2. IN GREEK, MEANS "MEASURING ELEMENTS"
3. ALLOWS US TO COUNT ATOMS AND MOLECULES BY WEIGHING THEM.

CALCULATIONS

Mass of carbon dioxide produced when 10g of $CaCO_3$ is heated?

$$CaCO_{3(s)} \rightarrow CaO_{(s)} + CO_{2(g)}$$

?



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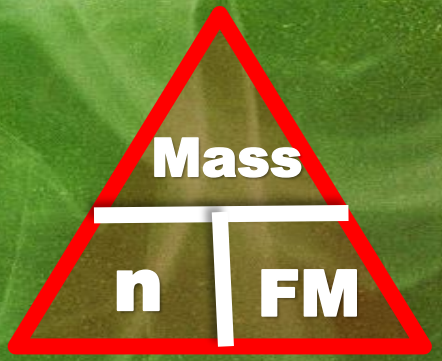
1 mole $CaCO_3$ → 1 mole $CO_{2(g)}$



CALCULATIONS

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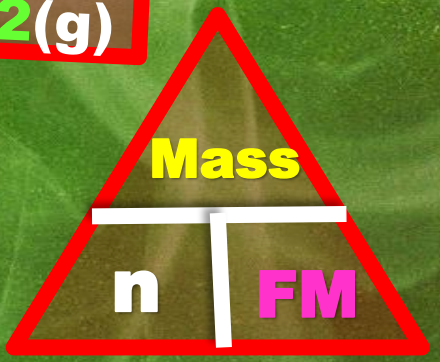
$$CaCO_{3(s)} \rightarrow CaO_{(s)} + CO_{2(g)}$$

1 mole $CaCO_3$ → 1 mole $CO_{2(g)}$

100g $CaCO_3$ → 44g $CO_{2(g)}$

n = 10g/100

= 0.1 moles of $CaCO_3$



CALCULATIONS

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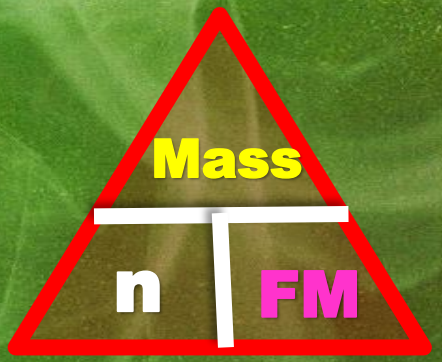
0.1 moles of $CaCO_3$ → 0.1 moles of CO_2



CALCULATIONS

Mass of carbon dioxide produced when 10g of $CaCO_3$ is heated?

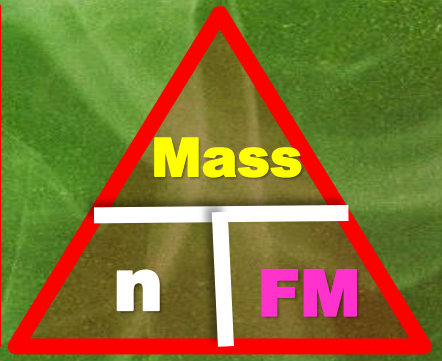
$$CaCO_{3(s)} \rightarrow CaO_{(s)} + CO_{2(g)}$$

0.1 moles of $CaCO_3$ → 0.1 moles of CO_2

100g $CaCO_3$ → 44g $CO_{2(g)}$

mass = 0.1 x 44

= **4.4g** of CO_2

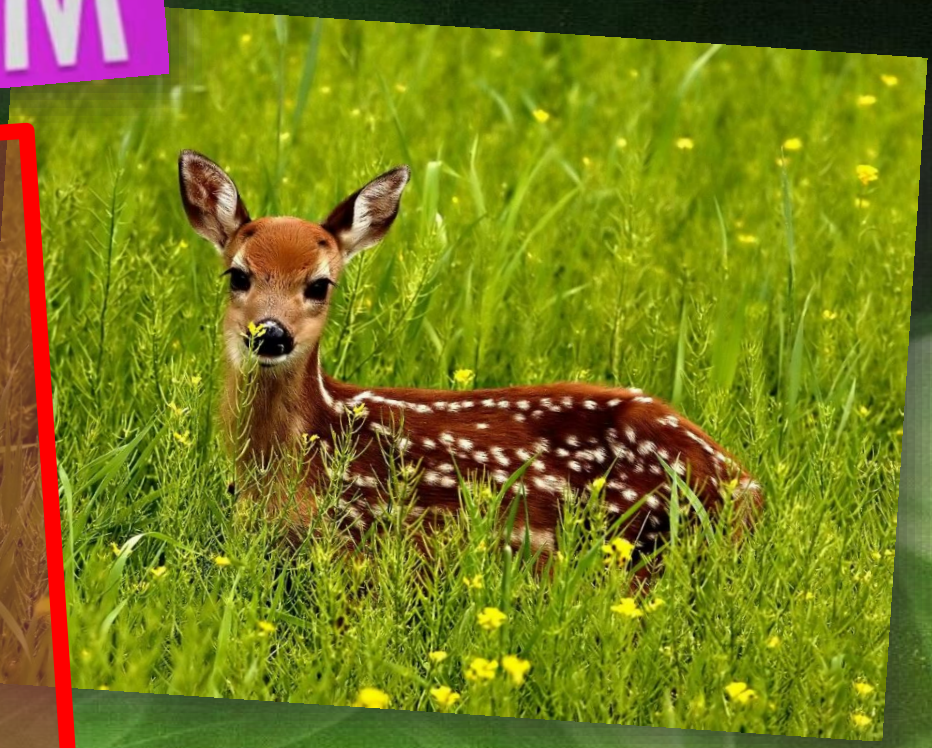


EQUILIBRIUM

EQUILIBRIUM

EQUILIBRIUM

In nature equilibrium works by finding a balance between animal population and food supplies available.



EQUILIBRIUM

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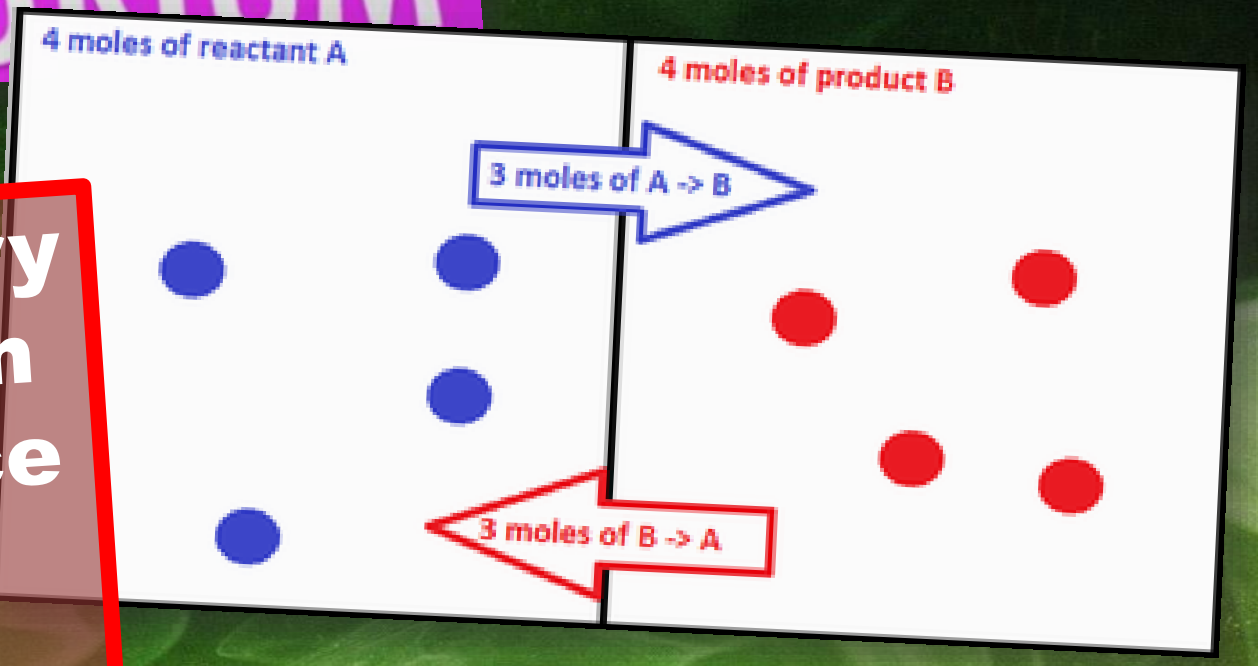


In chemistry equilibrium is a balance between products and reactants.

EQUILIBRIUM

EQUILIBRIUM

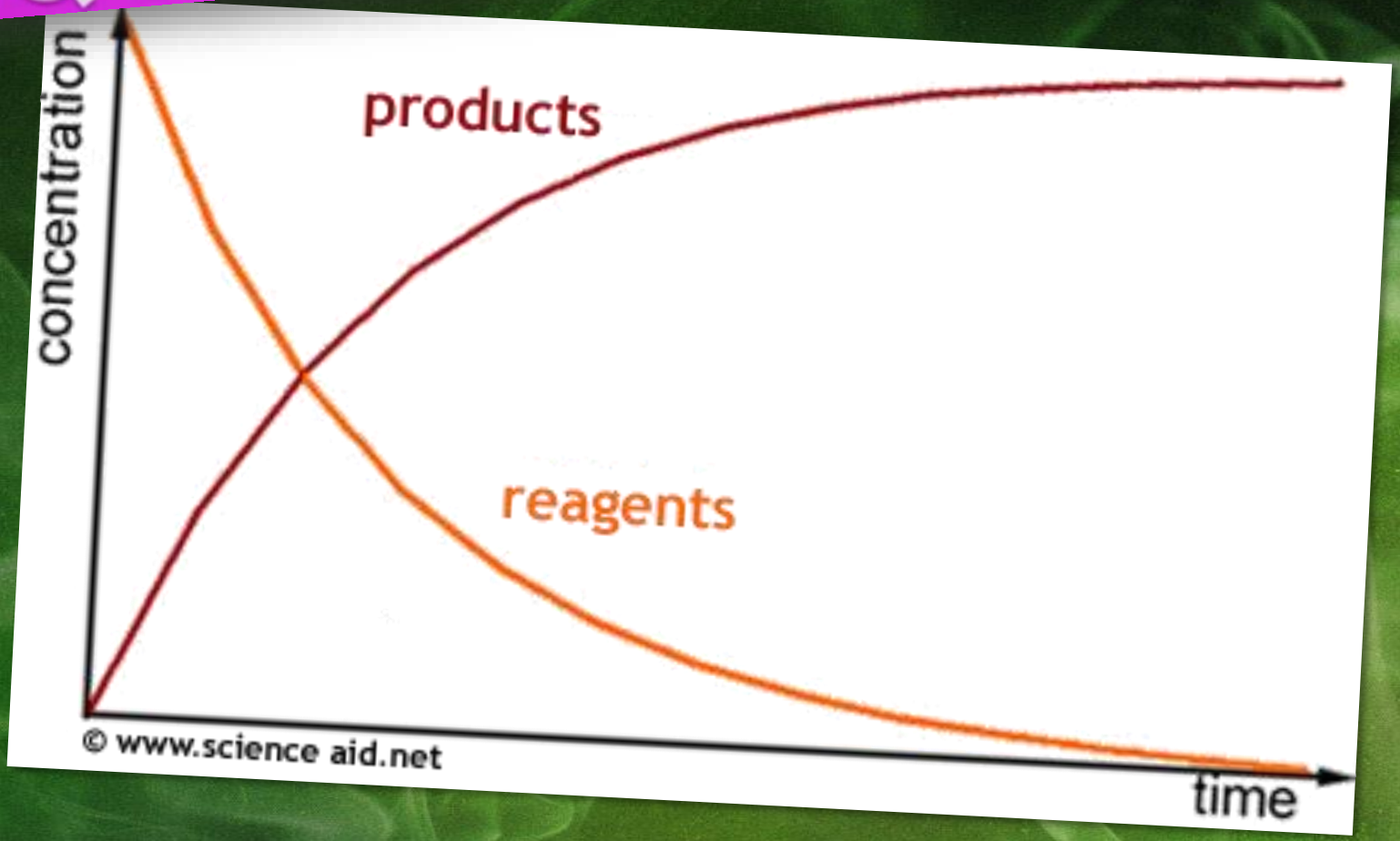
A reversible reaction:

$$HNO_2 \rightleftharpoons H^+ + NO_2^-$$

Reactions are not straight forward reactions. Many reaction NEVER finish.

EQUILIBRIUM

EQUILIBRIUM



EQUILIBRIUM

EQUILIBRIUM

FORWARD REACTION

+

REVERSE REACTION

Forward reaction → reactants turning into products

EQUILIBRIUM

EQUILIBRIUM

FORWARD REACTION

+

REVERSE REACTION

Reverse reaction → products turning into reactants

EQUILIBRIUM

EQUILIBRIUM STATE

WHEN A REACTION'S FORWARD PROGRESS (REACTANTS FORMING PRODUCTS) IS PERFECTLY BALANCED WITH THE REVERSE PROCESS (PRODUCTS CHANGING BACK INTO THE REACTANTS)

Reaction keep going back and forth till it reaches equilibrium state.

EQUILIBRIUM

EQUILIBRIUM STATE

In a **dynamic equilibrium**, the **rate** of the forward reaction is **equal** to the rate of the back reaction.

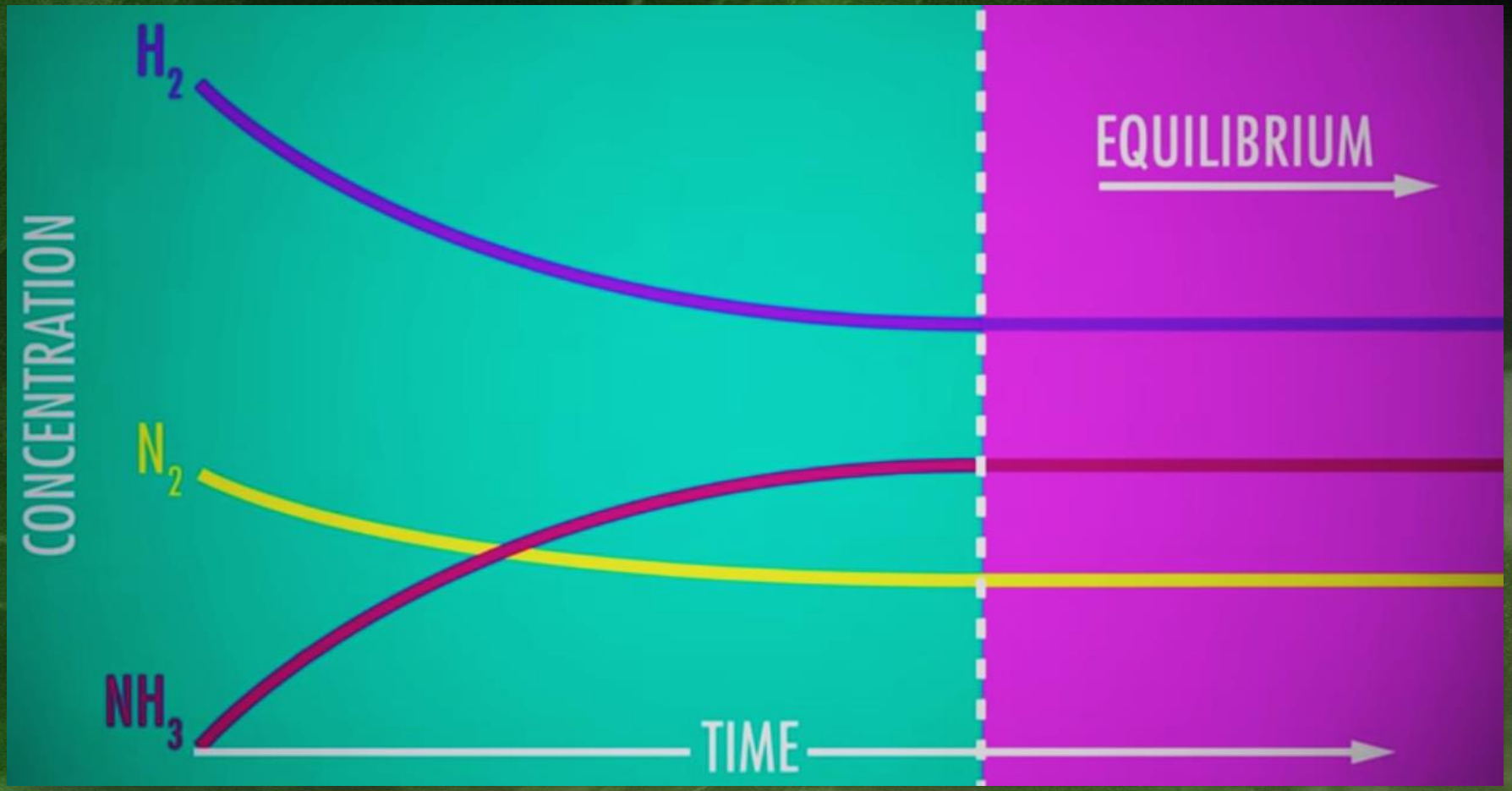
The concentration of the reactants and products remains **constant** but **not** necessarily equal.

EQUILIBRIUM

$$N_2(g) + 3\,H_2(g) \rightleftharpoons 2\,NH_3(g)$$

Haber process

EQUILIBRIUM



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

EQUILIBRIUM

LE CHATELIER'S PRINCIPLE

IF **A STRESS** IS PLACED ON A SYSTEM AT **EQUILIBRIUM**,
THE SYSTEM WILL PROCEED IN A DIRECTION THAT
MINIMIZES THE STRESS.

Henry Louis
Le Châtelier

EQUILIBRIUM

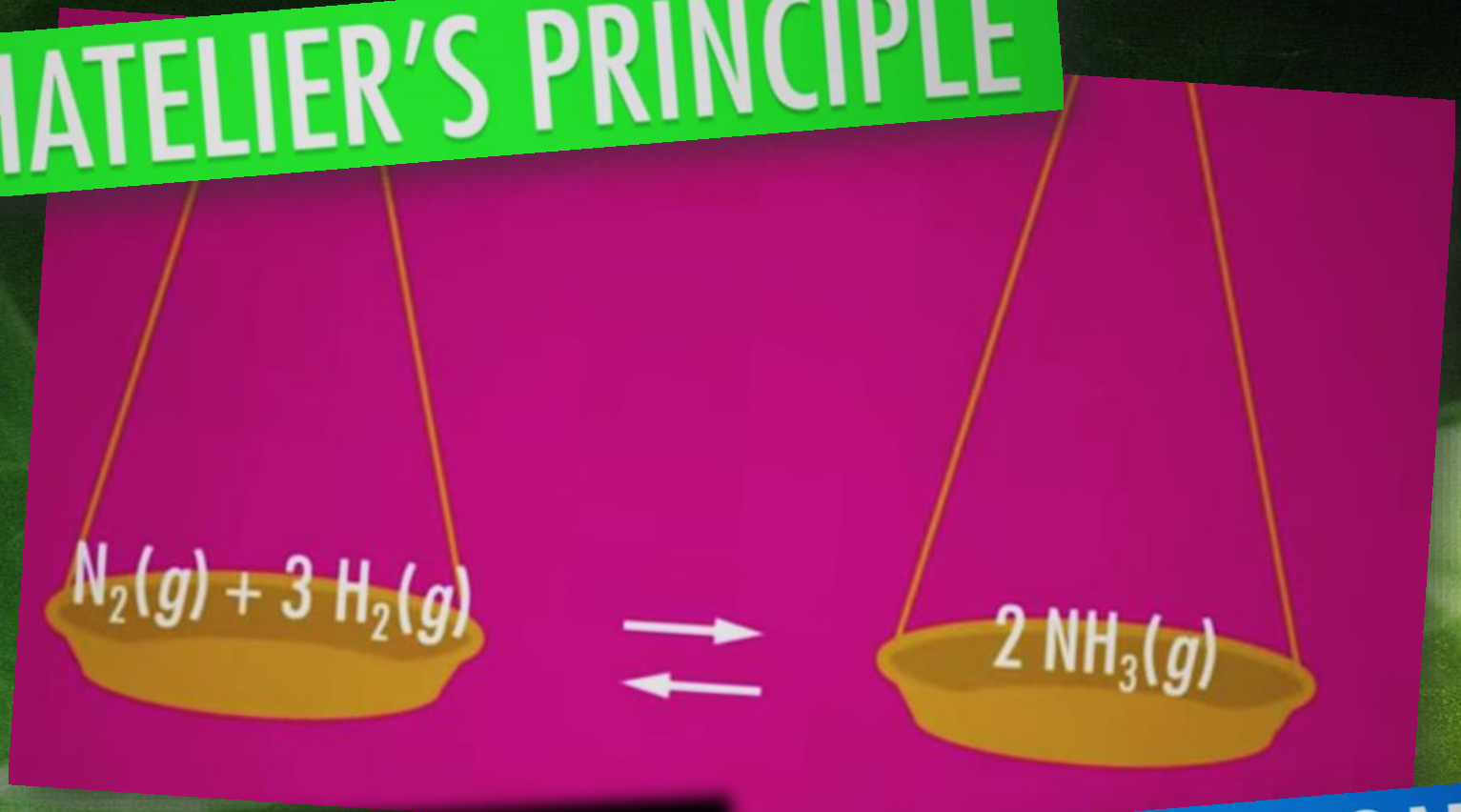
LE CHATELIER'S PRINCIPLE

How to manipulate the stress.

1. **CONCENTRATION**

EQUILIBRIUM

LE CHATELIER'S PRINCIPLE

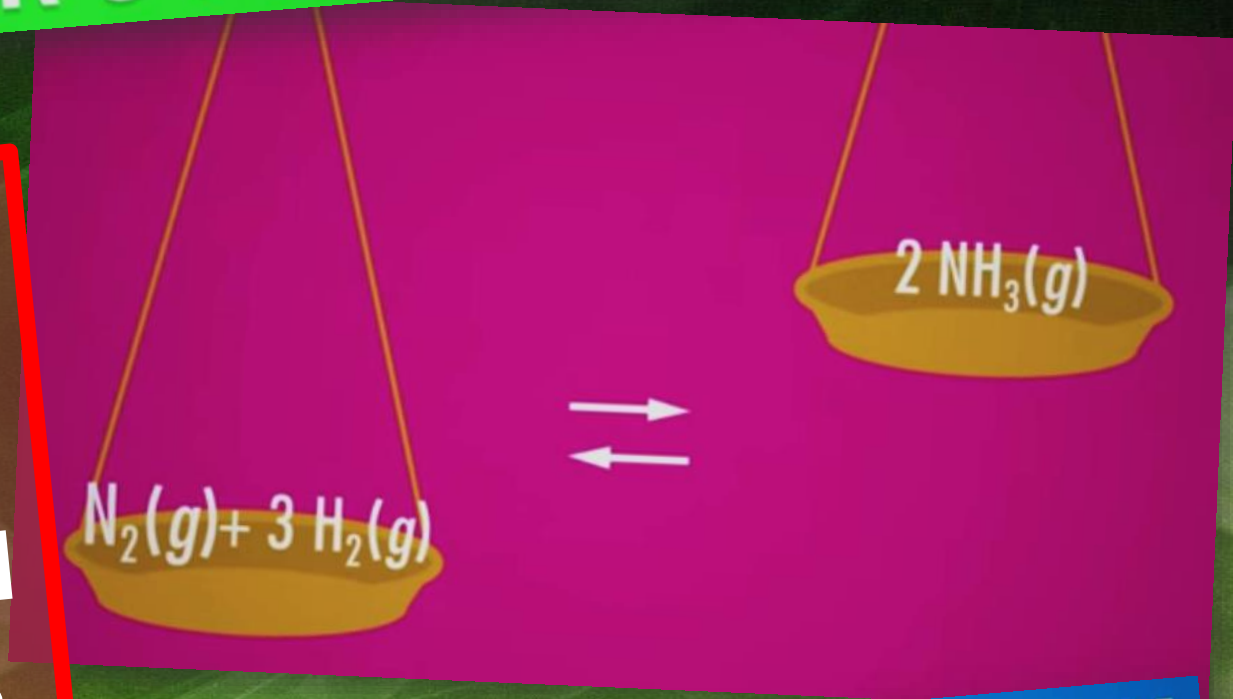


If more H_2 is added?

CONCENTRATION

EQUILIBRIUM

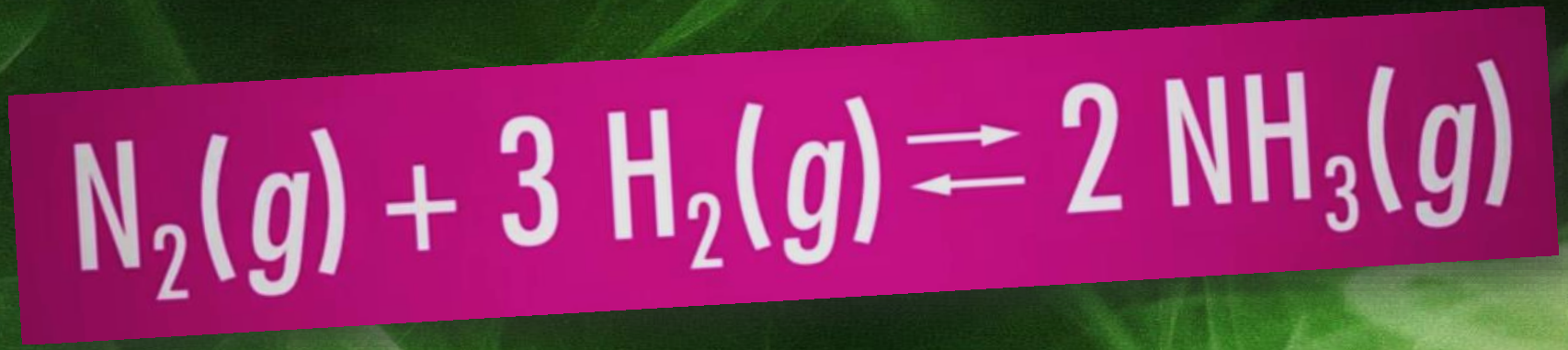
LE CHATELIER'S PRINCIPLE



With higher conc. of reactant the forward reaction is favored.

CONCENTRATION

EQUILIBRIUM



To get a high yield of product Haber continuously removed ammonia so reaction never reached equilibrium.

EQUILIBRIUM

LE CHATELIER'S PRINCIPLE

How to manipulate the stress.

2. **PRESSURE**

EQUILIBRIUM

LE CHATELIER'S PRINCIPLE

$$1\ N_2(g) + 3\ H_2(g) \rightleftharpoons 2\ NH_3(g)$$

4 moles of gas react to form two moles of gas.

EQUILIBRIUM

LE CHATELIER'S PRINCIPLE

$$1\ N_2(g) + 3\ H_2(g) \rightleftharpoons 2\ NH_3(g)$$

Forward reaction **decreases** volume:

Reverse reaction **increases** volume

EQUILIBRIUM

LE CHATELIER'S PRINCIPLE

PRESSURE

$$1\,N_2(g) + 3\,H_2(g) \rightleftharpoons 2\,NH_3(g)$$

Increasing the pressure puts more stress on the high volume reactants than the low volume products.

EQUILIBRIUM

LE CHATELIER'S PRINCIPLE

PRESSURE

Increasing the pressure pushes equilibrium to the right → more product produced.

EQUILIBRIUM

LE CHATELIER'S PRINCIPLE

PRESSURE

Decreasing the **pressure** pushes equilibrium to the left ← more reactants produced.

EQUILIBRIUM

LE CHATELIER'S PRINCIPLE

How to manipulate the stress.

3. **TEMPERATURE**

EQUILIBRIUM

LE CHATELIER'S PRINCIPLE

TEMPERATURE

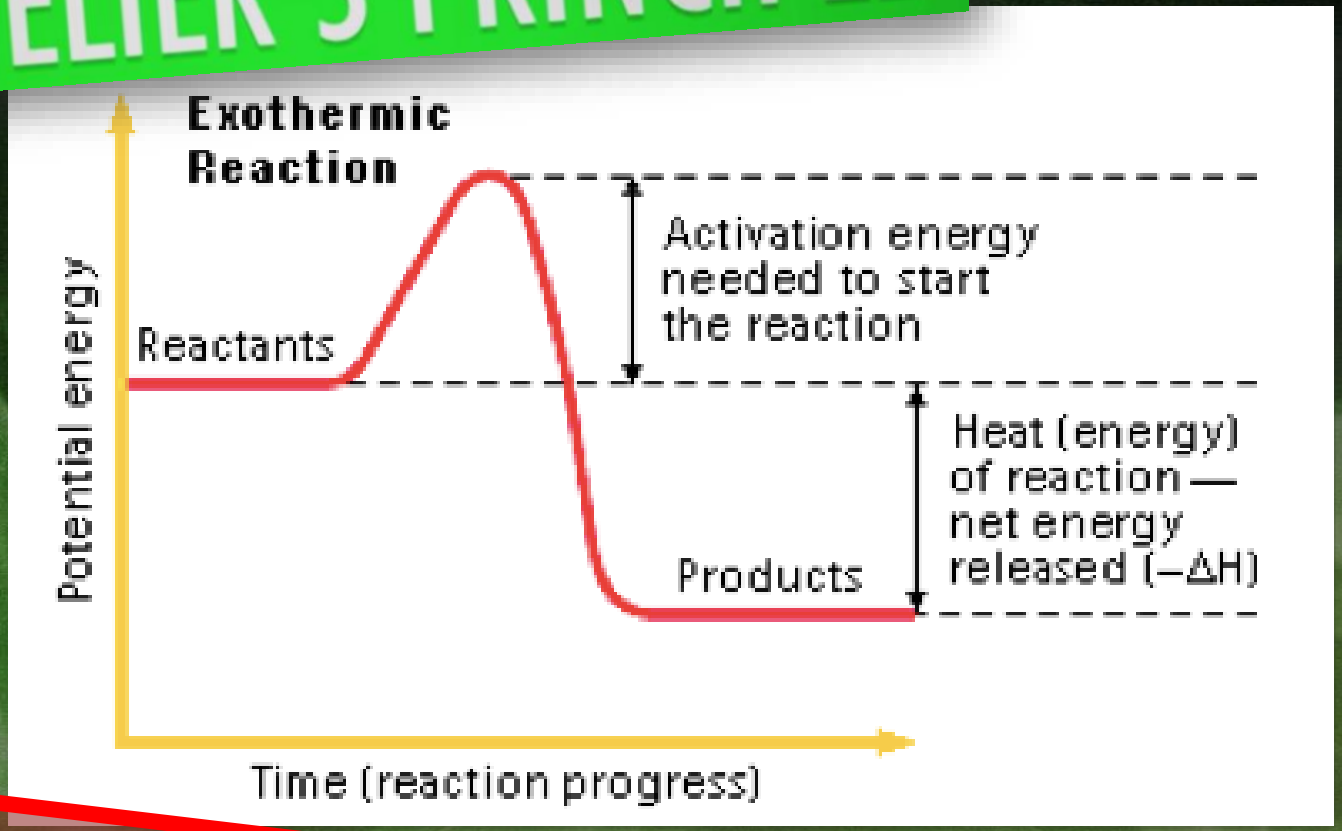
EXOTHERMIC REACTIONS

RELEASE HEAT.

Favored at lower temperatures.

EQUILIBRIUM

LE CHATELIER'S PRINCIPLE



Exothermic reaction that releases heat

EQUILIBRIUM

LE CHATELIER'S PRINCIPLE

TEMPERATURE

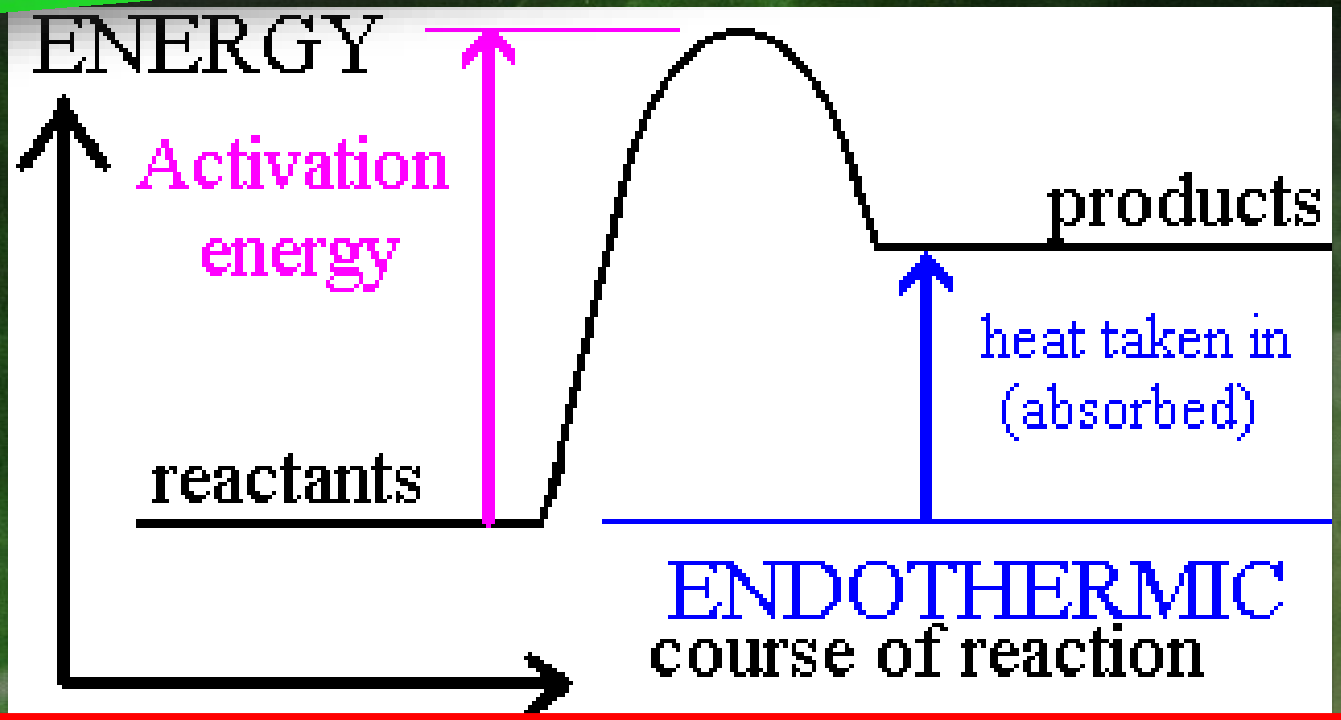
ENDOTHERMIC REACTIONS

CONSUME HEAT.

Favored if heat is added.

EQUILIBRIUM

LE CHATELIER'S PRINCIPLE



Endothermic absorbs energy from its surroundings in the form of heat.

QUESTIONS

$$SO_2\ (g) + 0.5O_2\ (g) \leftrightarrow SO_3\ (g)$$

$$\Delta H_{forward} = -94 kJmol^{-1}$$

Ideal conditions?

a) High pressure and low temperature

b) Low pressure and high temperature

c) High pressure and high temperature

d) Low pressure and low temperature

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