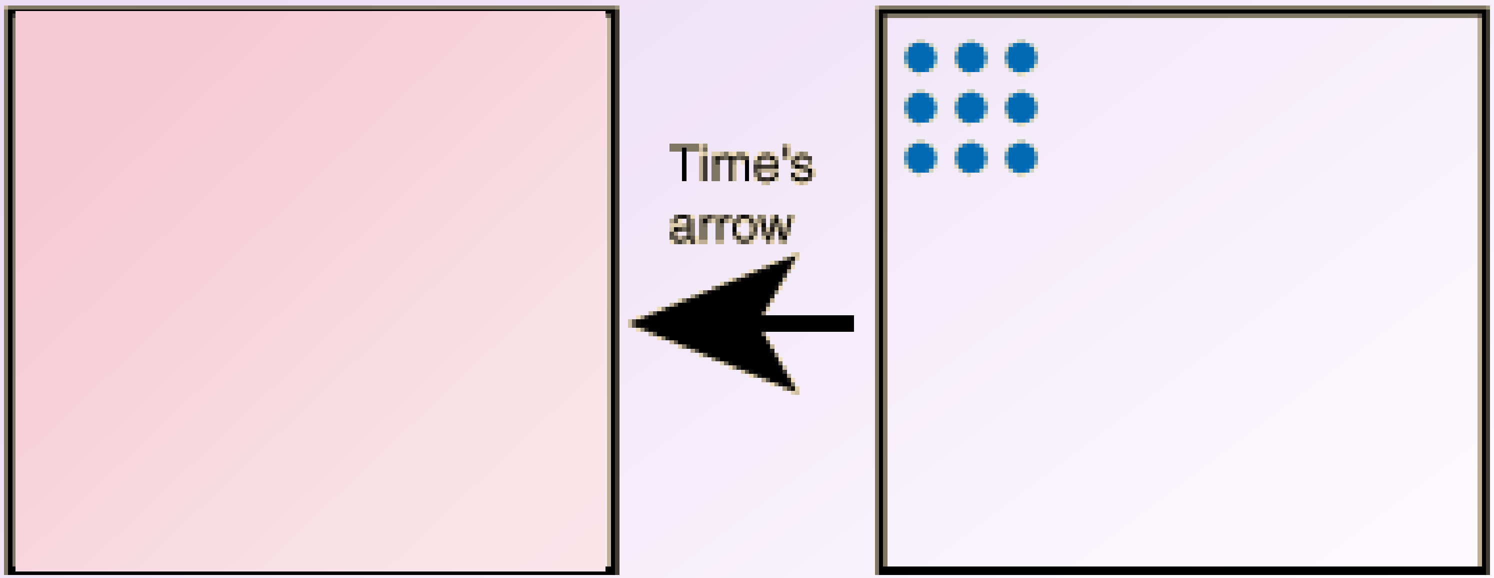
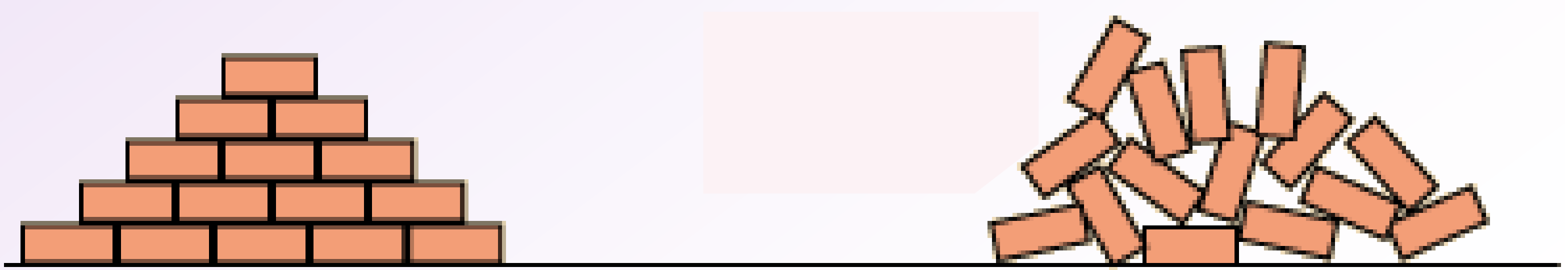
ENTROPY

ENTROPY

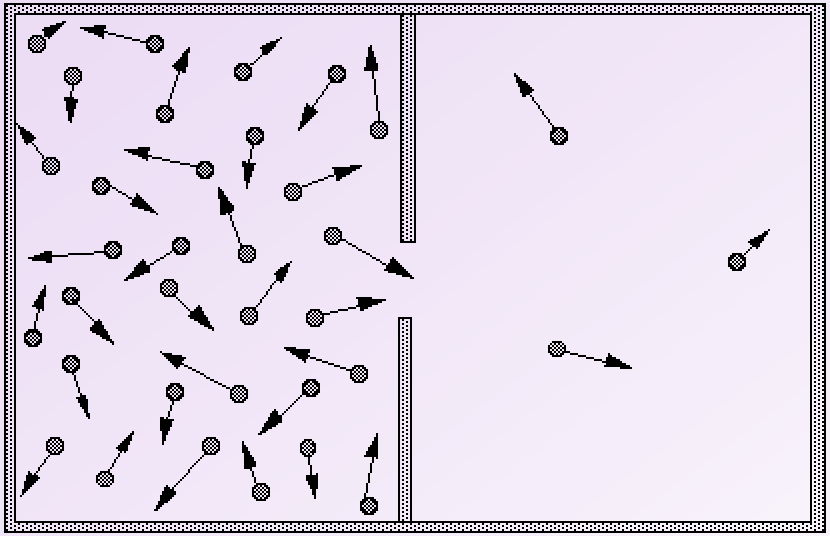
If the particles represent gas molecules at normal temperatures inside a closed container, which of the illustrated configurations came first?



If you tossed bricks off a truck, which kind of pile of bricks would you more likely produce?



ENTROPY



entropy (ΔS)- a measure of disorder or randomness

↑entropy = ↑ disorder

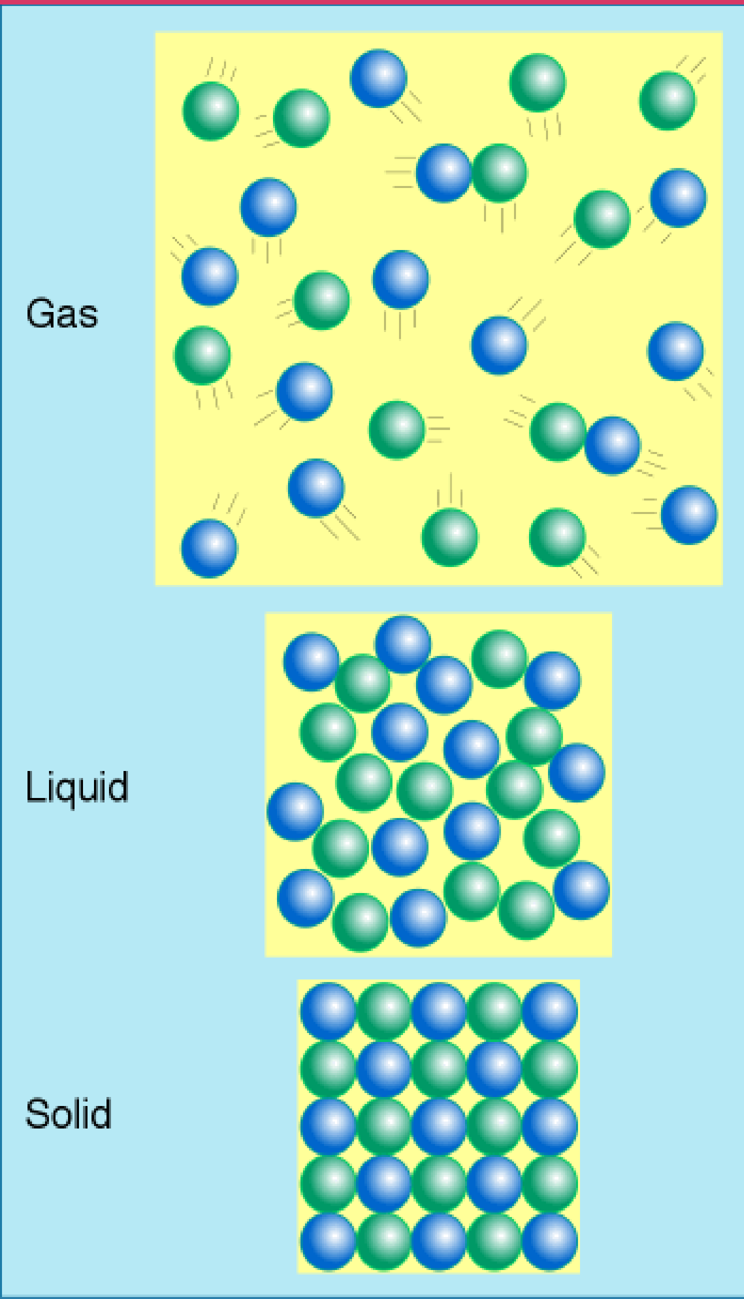
The units for entropy are **J/mol·K** or **J/K**

ENTROPY

SECOND LAW OF THERMODYNAMICS

the entropy of the universe is constantly increasing

ENTROPY

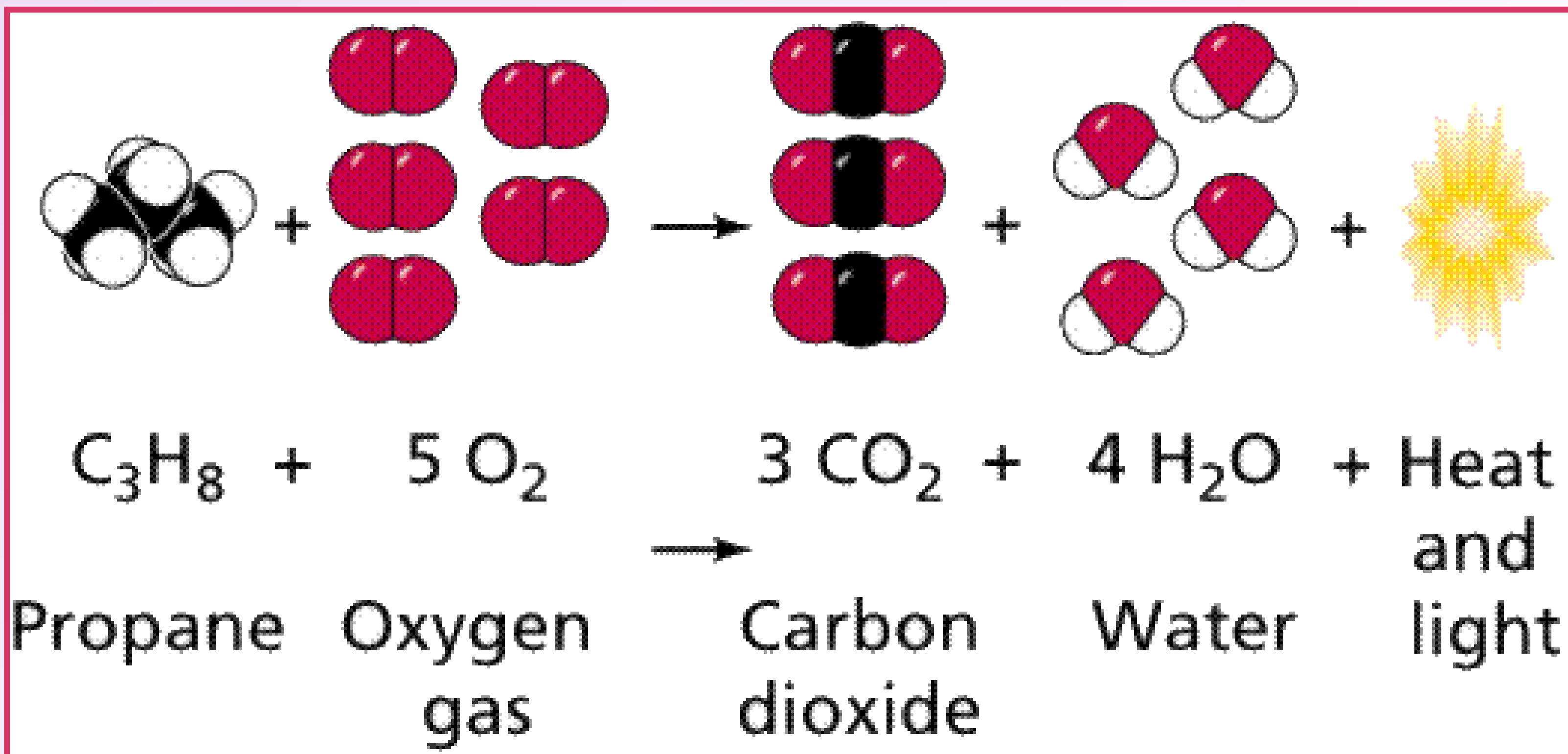


ΔS solid $\square$ ΔS liquid $\square$ ΔS gas

ENTROPY

$$\Delta S = S_{products} - S_{reactants}$$

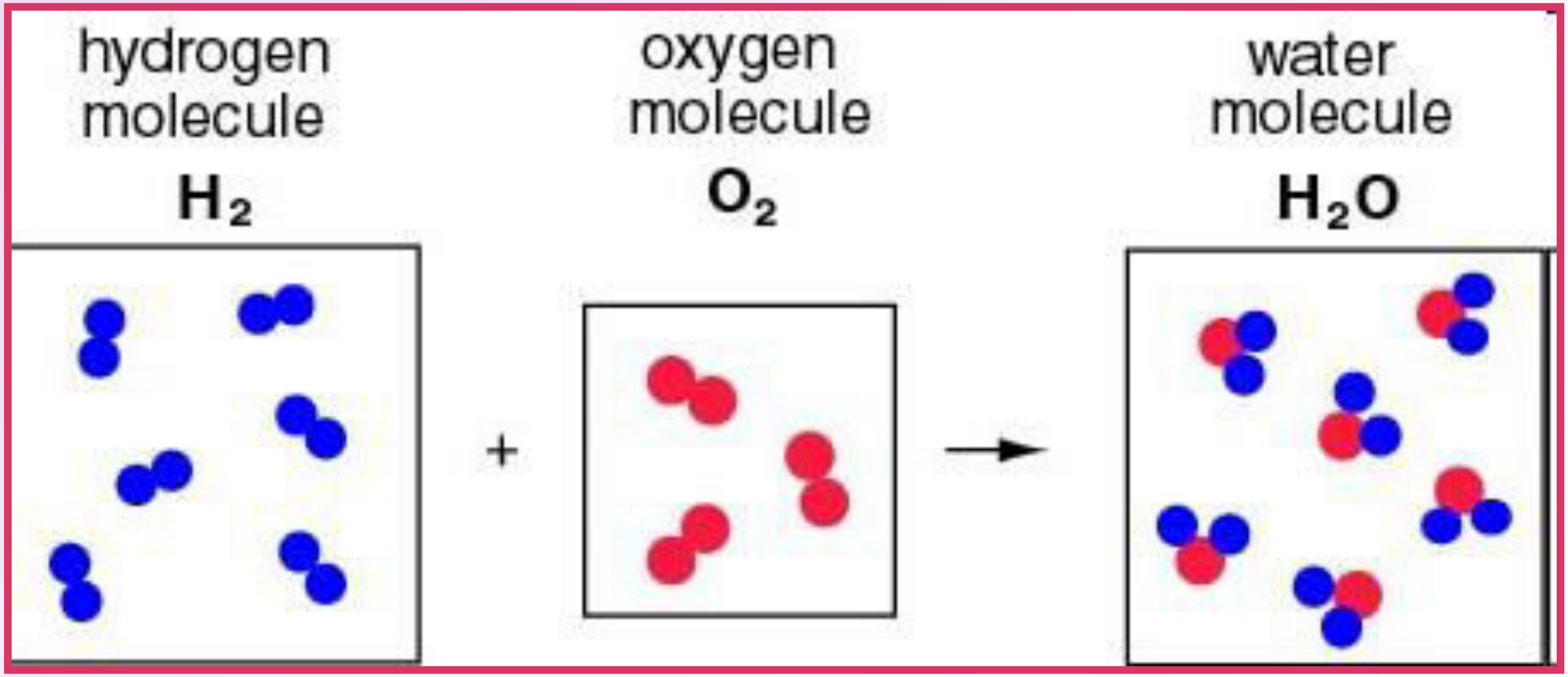
When $S_{products} > S_{reactants}$, ΔS $\boxed{}$



ENTROPY

$$\Delta S = S_{products} - S_{reactants}$$

When $S_{products} < S_{reactants}$, ΔS $\boxed{}$



ENTROPY

Predict the sign of ΔS for the following reactions:

$H_{2(g)} \rightarrow 2\ H_{(g)}$

$2\ H_{2(g)} + O_{2(g)} \rightarrow 2\ H_2O_{(l)}$

$2\ NO_{2(g)} \rightarrow N_2O_{4(g)}$

$C_3H_{8(g)} + 5O_{2(g)} \rightarrow 3CO_{2(g)} + 4H_2O_{(g)}$

condensation of steam to liquid

ENTROPY

Predict the sign of ΔS for the following reactions:

sublimation of dry ice

$2\ NH_{3(g)} \rightarrow N_{2(g)} + 3\ H_{2(g)}$

$C_6H_{12}O_{6(s)} + 6O_{2(g)} \rightarrow 6CO_{2(g)} + 6H_2O_{(g)}$

$2\ H_2O_{(l)} \rightarrow 2\ H_{2(g)} + O_{2(g)}$

$NaCl_{(s)} \rightarrow NaCl_{(aq)}$

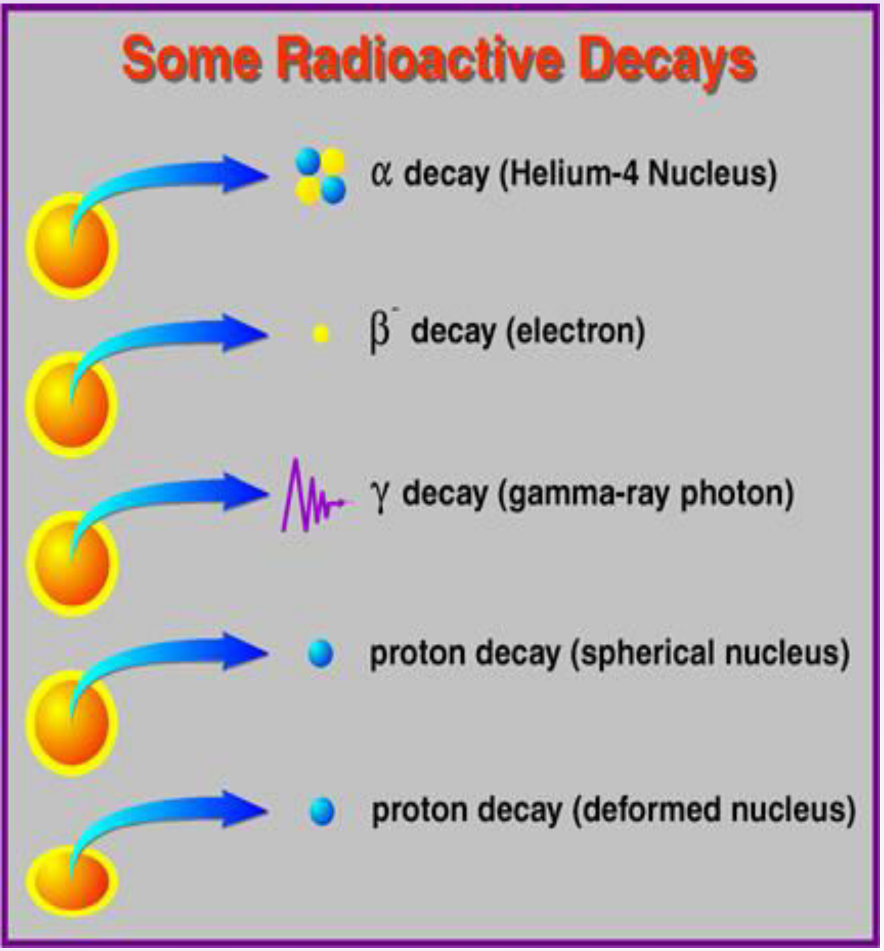
NUCLEAR REACTIONS

NUCLEAR REACTIONS

Nuclear reactions release a lot of energy.

The energy released can be measured as a change in enthalpy.

NUCLEAR REACTIONS



Radioactive decay

(4 types)

- alpha decay: emitting an alpha particle (a helium nucleus)

  α particle = ${}^{4}_{2}He$

- beta decay: emitting an electron (an electron particle from the nucleus)

  β particle = ${}^{0}_{-1}e$

- gamma decay: emitting electromagnetic radiation

  γ particle = ${}^{0}_{0}\gamma$

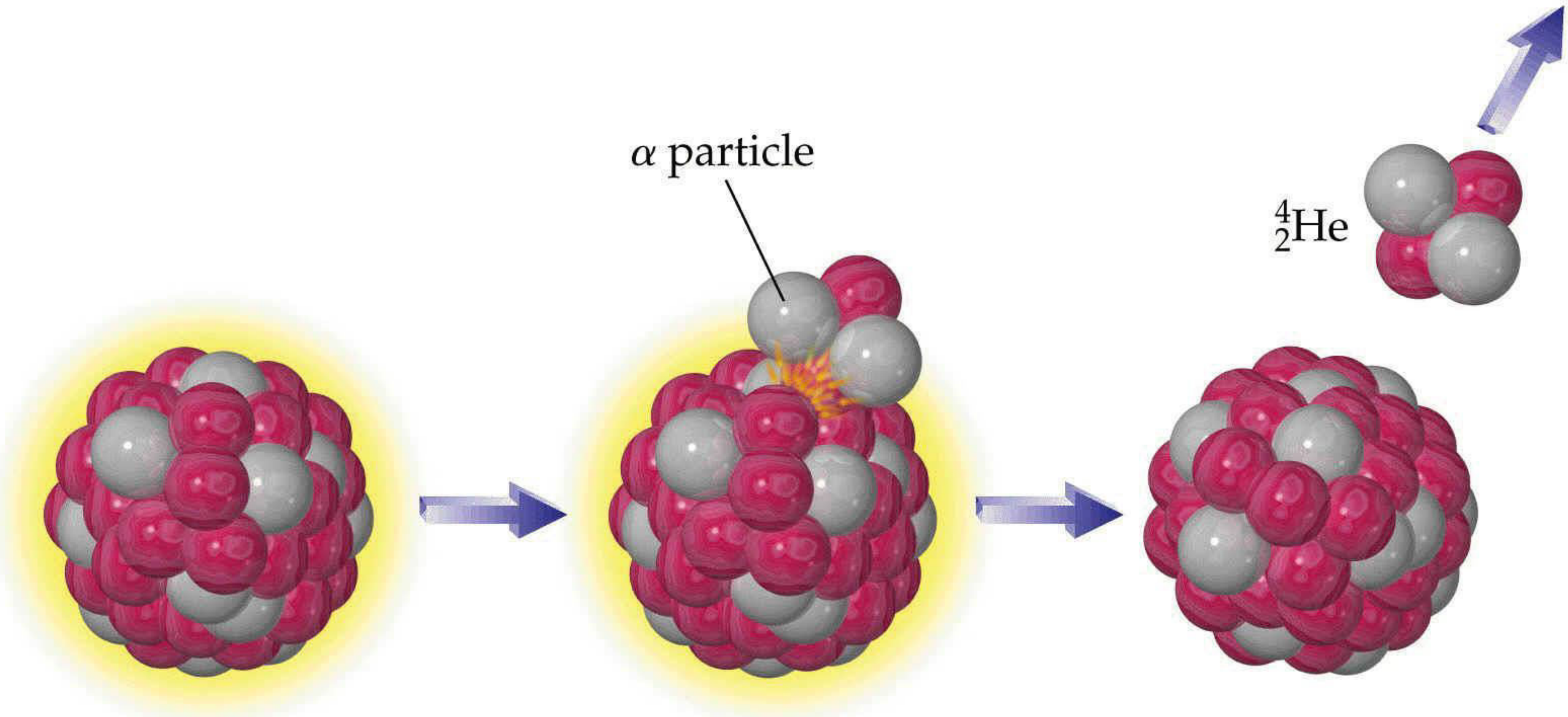
(another type is emitting a neutron)

NUCLEAR REACTIONS

Property	Alpha (α)	Beta (β)	Gamma (ɣ)	neutron (n)
nature of radiation	$^{4}_{2}He$ nucleus	$^{0}_{-1}e$ electron	high energy radiation	$^{1}_{0}n$
charge	2+	1-	0	0
mass	4 u	0	0	1 u
penetrating ability	stopped by 4 cm of air or a sheet of paper	stopped by 12 cm of air or several mm of paper	intensity decreases by 10% by 3 cm of lead	

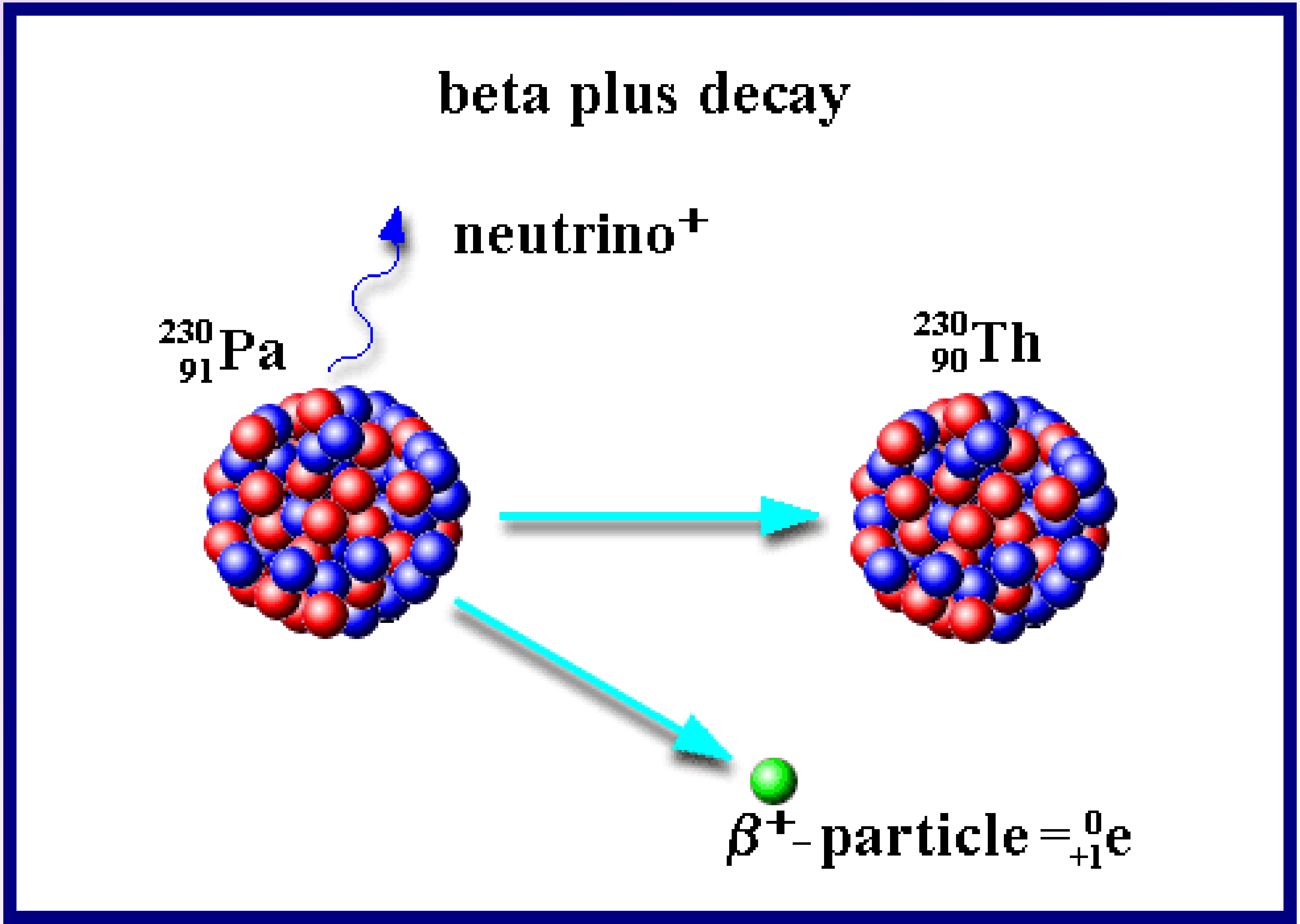
NUCLEAR REACTIONS

Alpha decay



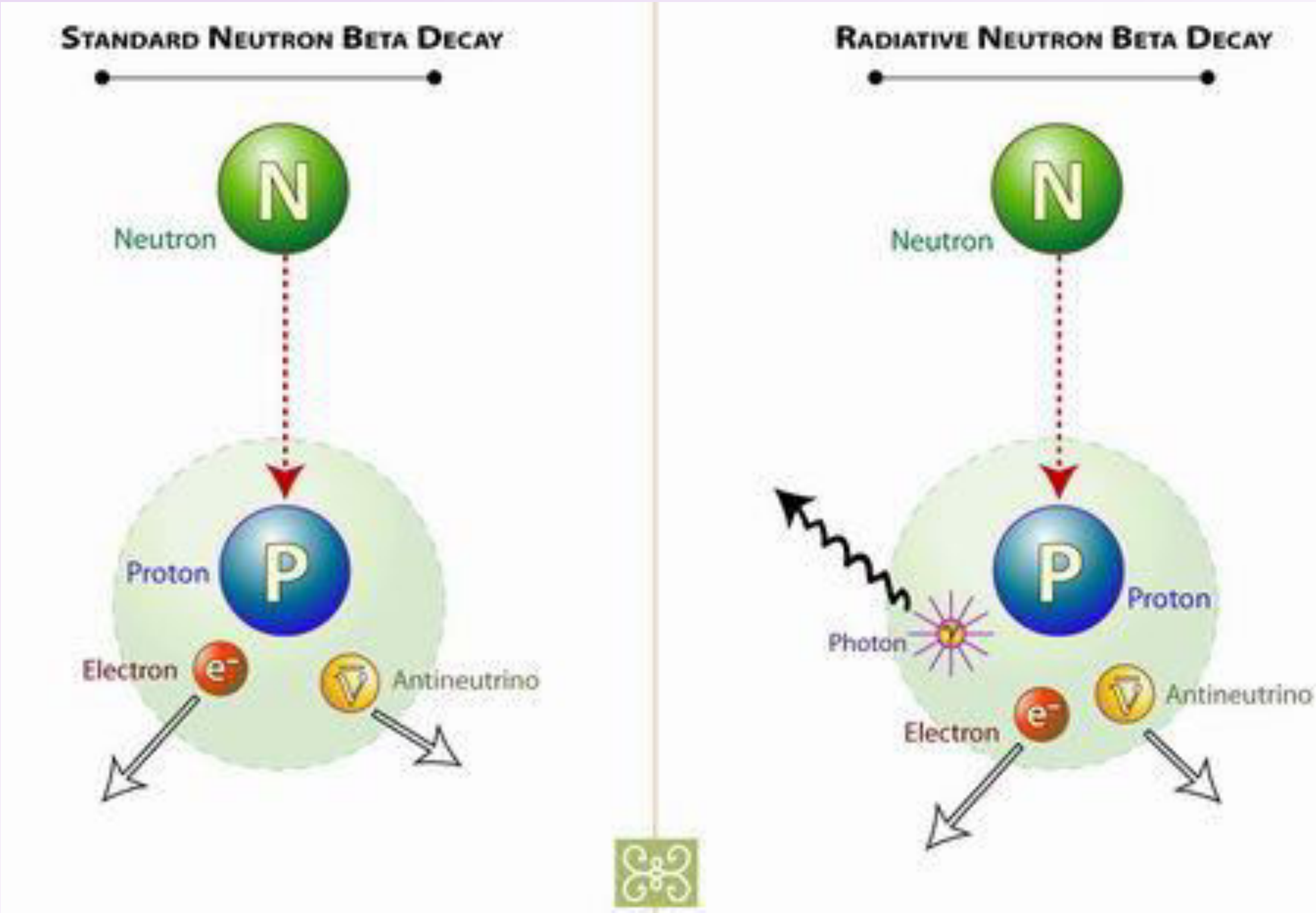
NUCLEAR REACTIONS

Beta decay



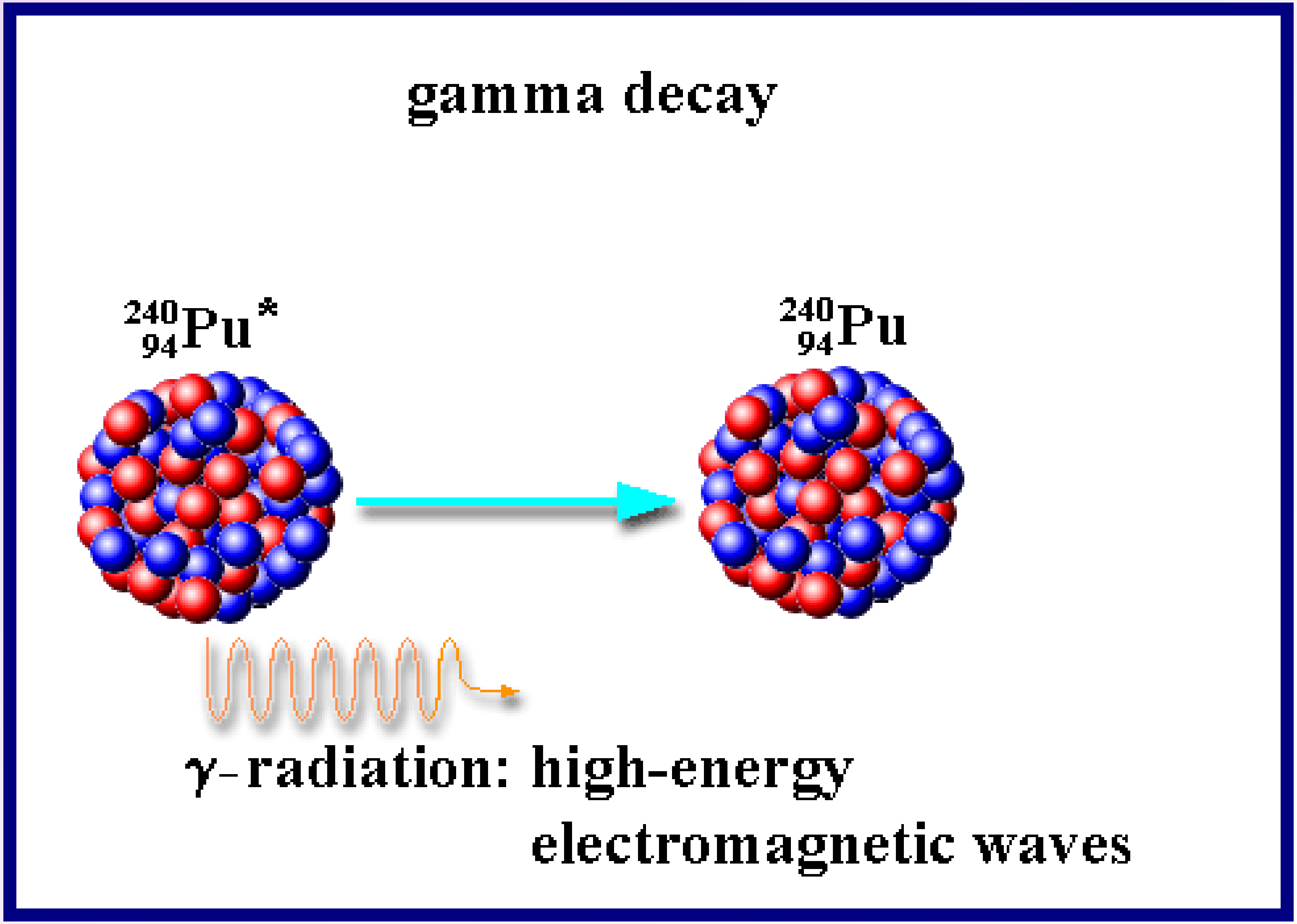
NUCLEAR REACTIONS

Beta decay



NUCLEAR REACTIONS

Gamma decay



NUCLEAR REACTIONS

Balancing Nuclear Reactions

The sums of the **atomic numbers** on both sides of the equation must be equal **(92 = 90 + 2)**

The sums of the **mass numbers** on both sides of an equation must be equal **(238 = 234 + 4)**

$$^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}He$$

NUCLEAR REACTIONS

Write an equation for the emission of an alpha particle from $^{226}_{88}Ra$

$$^{226}_{88}Ra \rightarrow$$

NUCLEAR REACTIONS

$$^{234}_{90}Th \rightarrow \mathbf{^{234}_{91}Pa} + \boxed{}$$

This is possible because

$$\mathbf{^{1}_{0}n \rightarrow \, ^{1}_{1}p + \, ^{0}_{-1}e}$$

NUCLEAR REACTIONS

Write an equation for the emission of a beta particle from $^{214}_{82}Pb$

$$^{214}_{82}Pb \rightarrow$$

NUCLEAR REACTIONS

Artificial Transmutation

Alchemists never did turn lead into gold, but along the way made many other discoveries about elements and compounds. This was the origin of the science of chemistry!

In artificial transmutation, a nucleus is hit by a small nuclear particle moving at very high speed. This can produce atoms with a desired number of protons and neutrons.

$$^{27}{}_{13}\mathrm{Al} + {}^{4}{}_{2}\mathrm{He} \rightarrow \boldsymbol{{}^{30}{}_{15}\mathrm{P} + {}^{1}{}_{0}\mathrm{n}}$$

We can now turn lead into gold!

NUCLEAR REACTIONS

Chernobyl Disaster of 1986

Abandoned city of Pripyat

NUCLEAR REACTIONS

nuclear fission - large nuclei are broken in to smaller nuclei by bombardment with a low energy neutron

- often triggers a chain reaction of events
- large amounts of energy released

(e.g. $\Delta H° = -1.9 \times 10^{10}$ kJ/mol)

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{139}_{56}Ba + ^{94}_{36}Kr + 3\,^{1}_{0}n$$

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{146}_{57}La + ^{87}_{35}Br + 2\,^{1}_{0}n$$

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{144}_{55}Cs + ^{90}_{37}Rb + 2\,^{1}_{0}n$$

NUCLEAR REACTIONS

$$^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{139}_{56}Ba + {}^{94}_{36}Kr + 3\ {}^{1}_{0}n$$

Describe the reaction with respect to:

1. spontaneity
2. organization of particles (beginning vs. end of rxn)

Spontaneous and becomes highly disorganized.

NUCLEAR REACTIONS

nuclear fusion - joining smaller nuclei together to form larger nuclei

– produces a lot of energy

Stars produce heavier atoms from the fusion of many hydrogen atoms.

$^{2}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}He + ^{1}_{0}n$ $\Delta H° = -1.7 \times 10^{9}$ kJ/mol

NUCLEAR REACTIONS

$$^{2}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}He + ^{1}_{0}n \qquad \Delta H^\circ = -1.7 \times 10^{9}\ kJ/mol$$

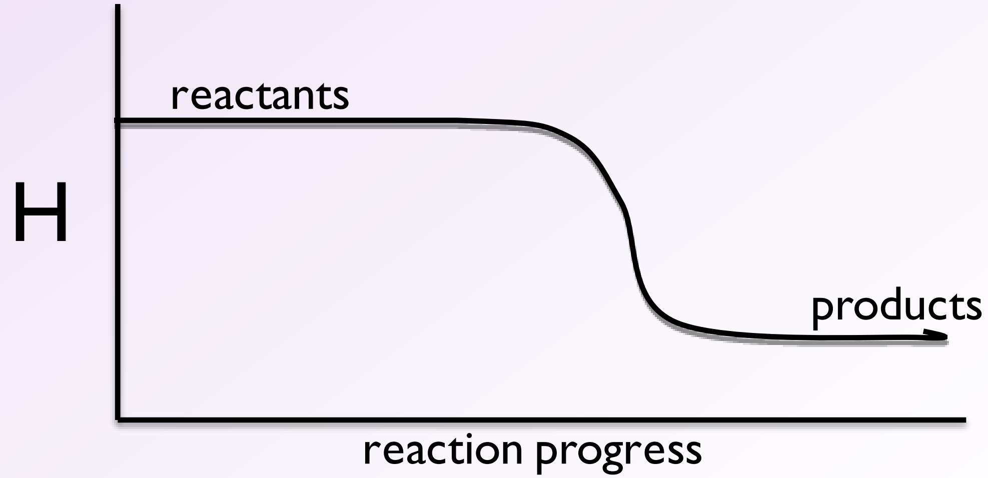
Describe the reaction with respect to:

1. spontaneity
2. organization of particles (beginning vs. end of rxn)

Not spontaneous and becomes more organized.

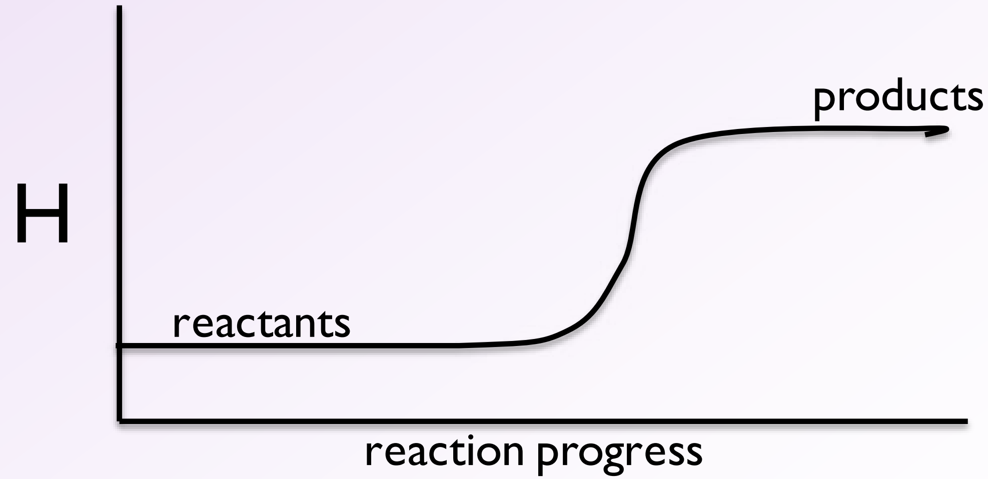
Reaction Spontaneity and Enthalpy

Chemical and nuclear reactions tend to spontaneously occur when the products are lower in energy than the reactants.



Reaction Spontaneity and Enthalpy

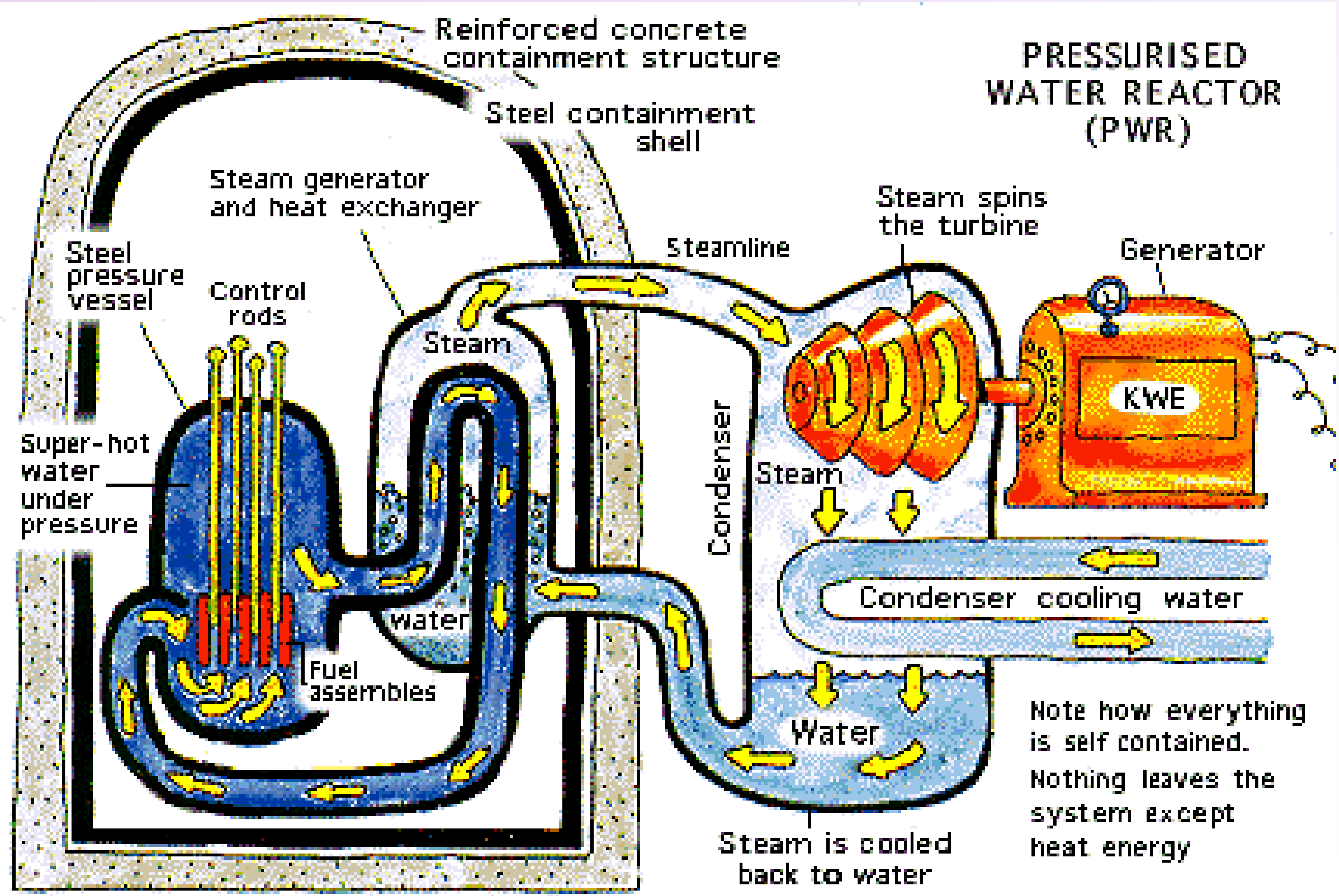
Chemical and nuclear reactions tend <u>not</u> to spontaneously occur when the products are <u>higher</u> in energy than the reactants.



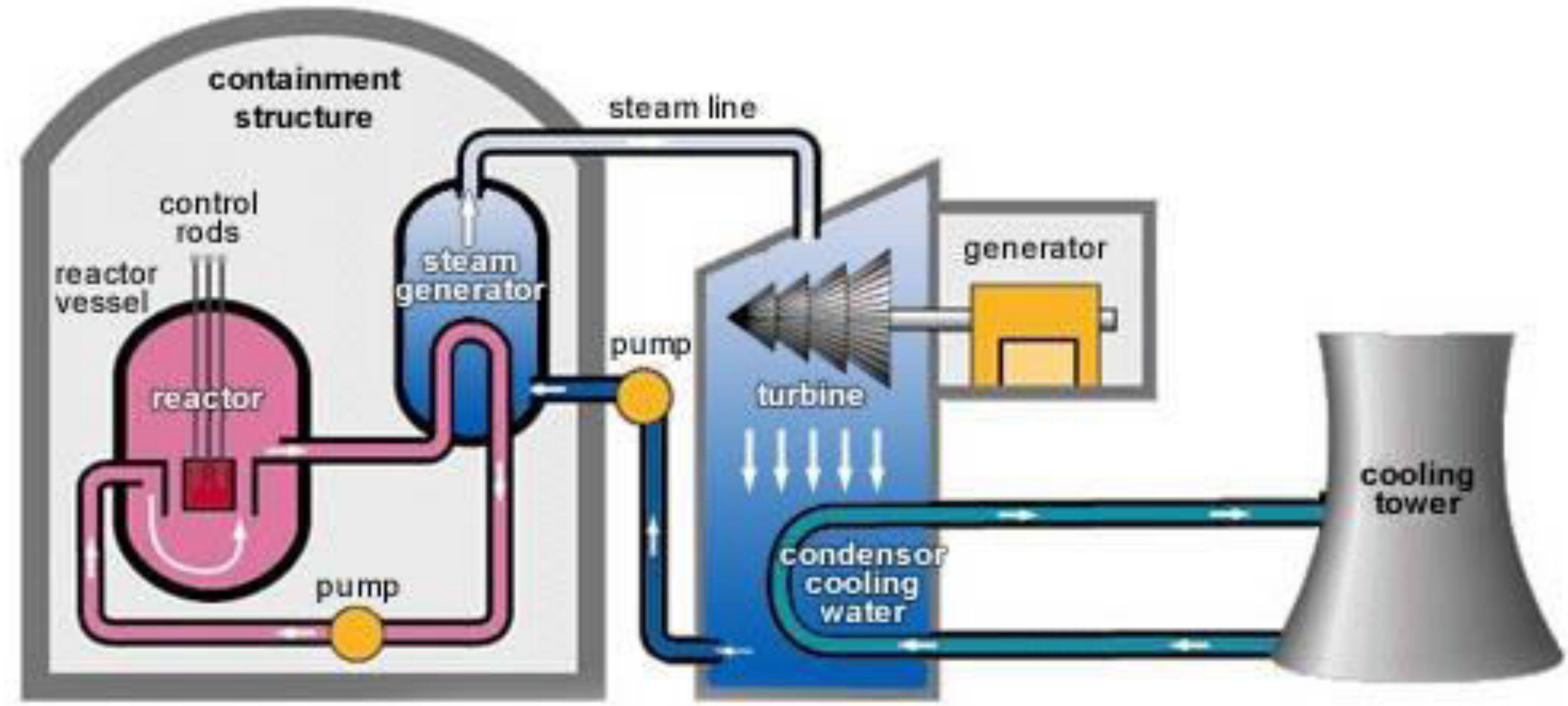
NUCLEAR REACTIONS

Nuclear reactors convert the enormous energy released from fission to electrical energy.

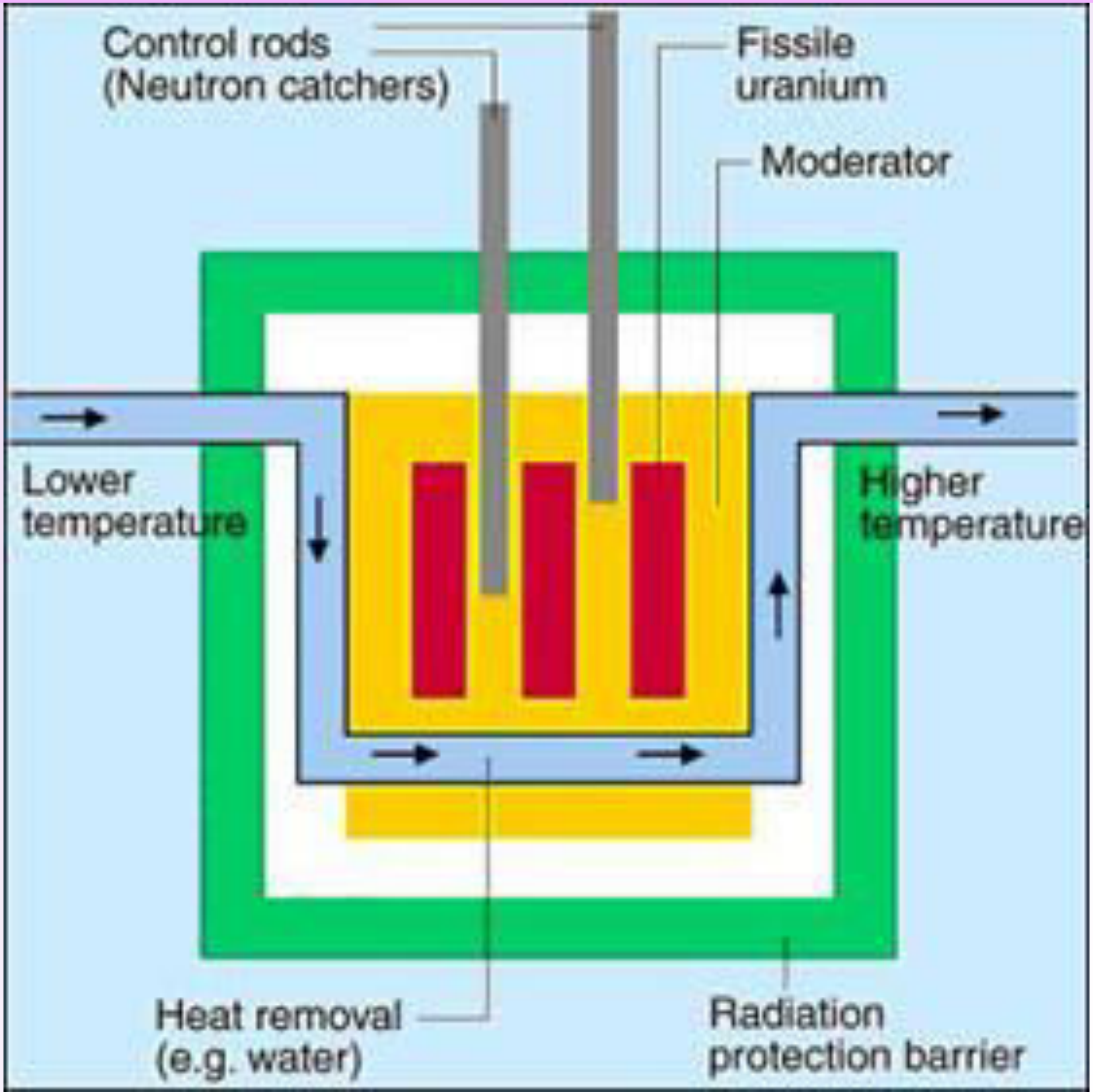
NUCLEAR REACTIONS



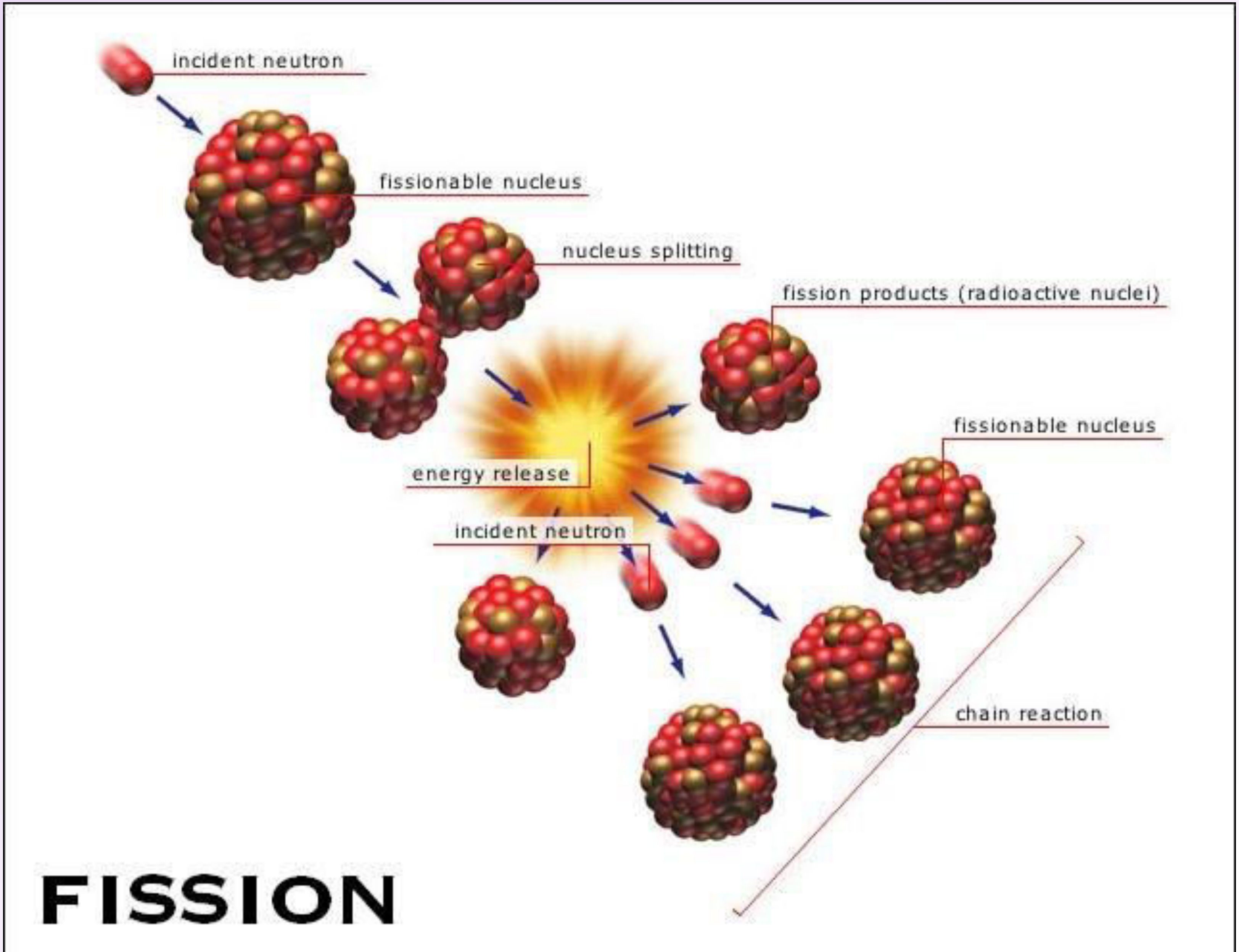
NUCLEAR REACTIONS



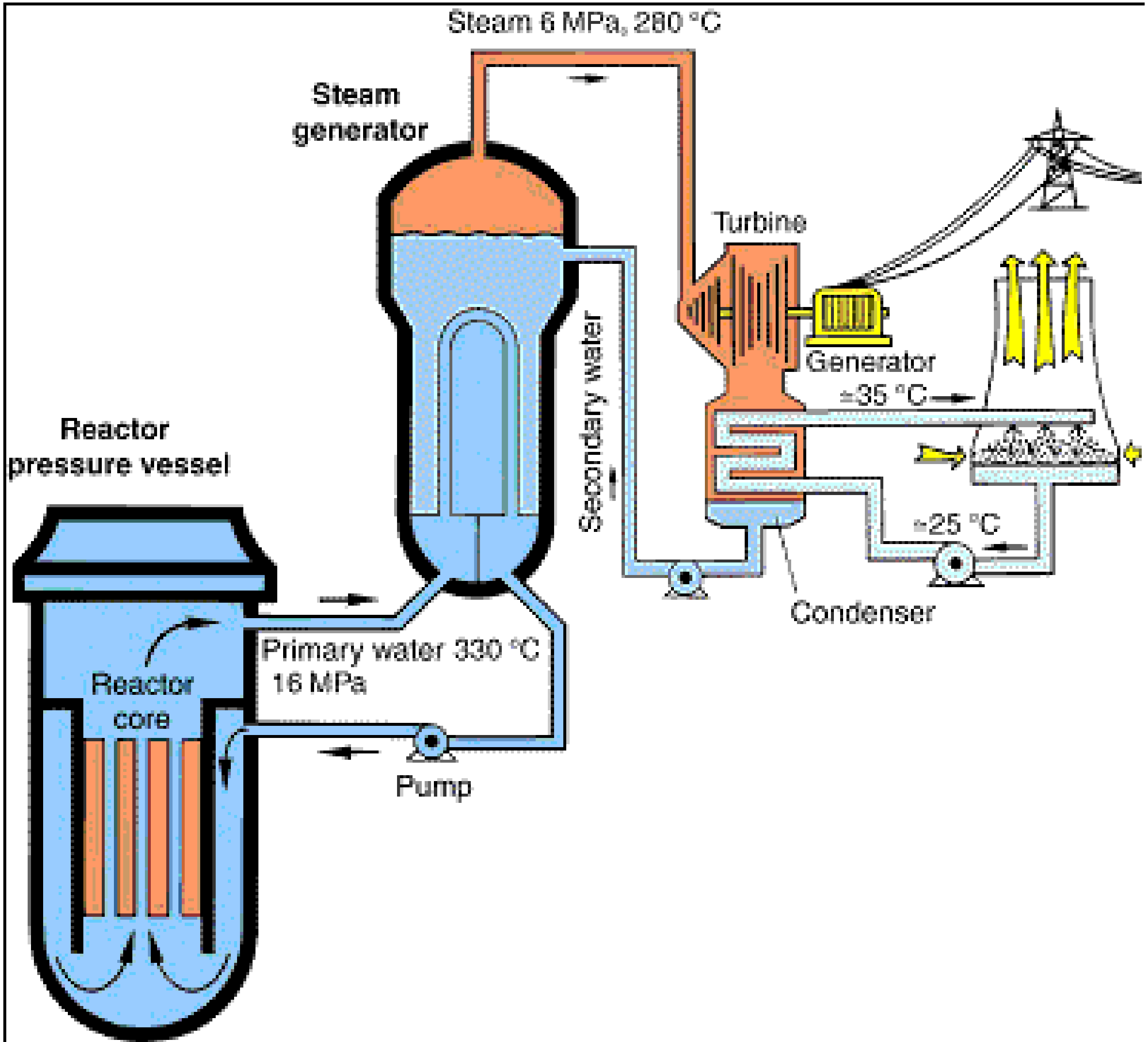
NUCLEAR REACTIONS



NUCLEAR REACTIONS



NUCLEAR REACTIONS



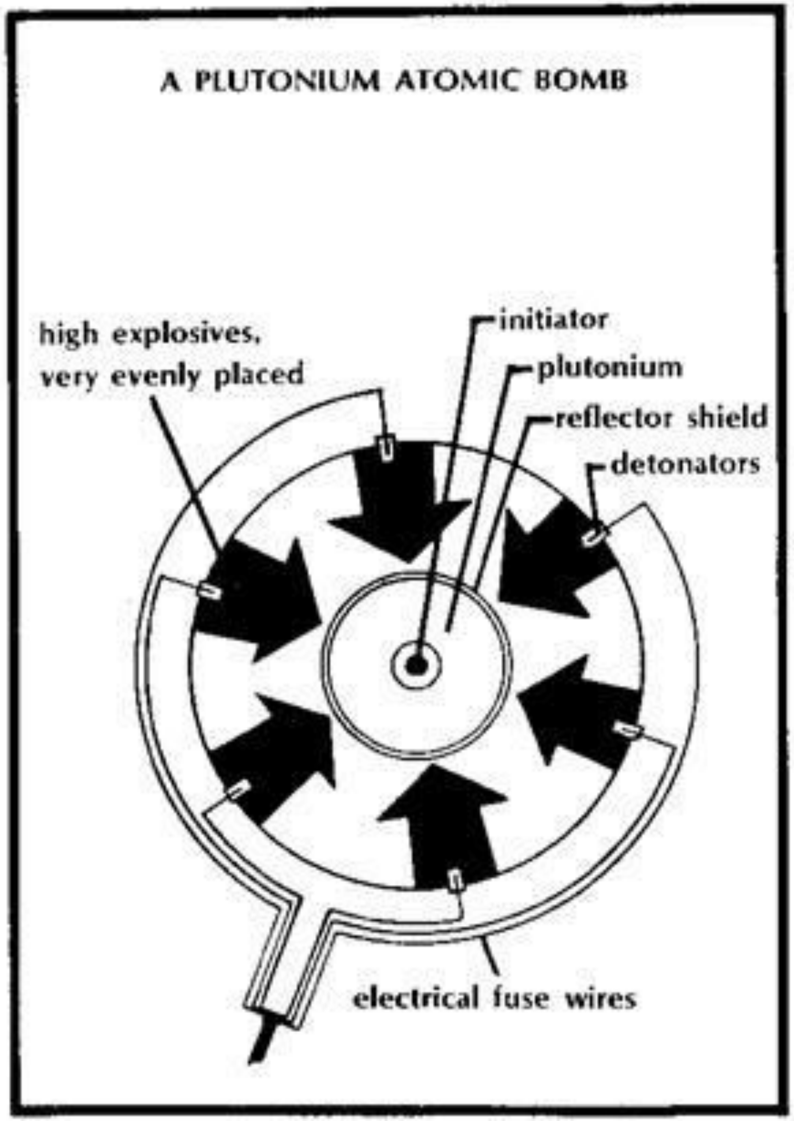
NUCLEAR REACTIONS

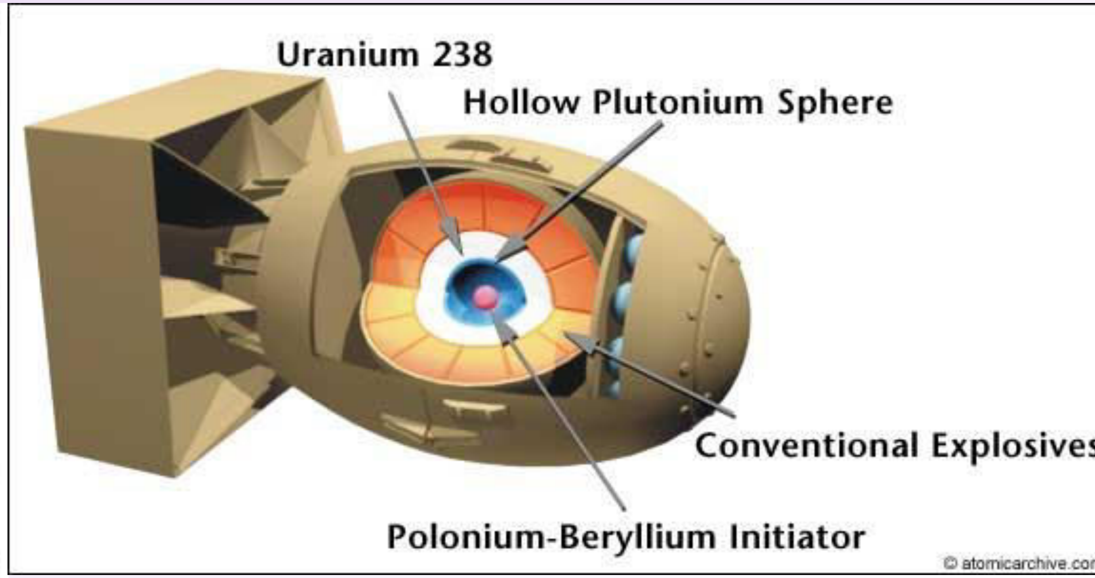
8.9-scale earthquake threatens safety of nuclear power plants in Japan (March 2011)

The earthquake and tsunami knocked out cooling systems and fuel rods began overheating

NUCLEAR REACTIONS

Hydrogen bomb vs. Nuclear Bomb

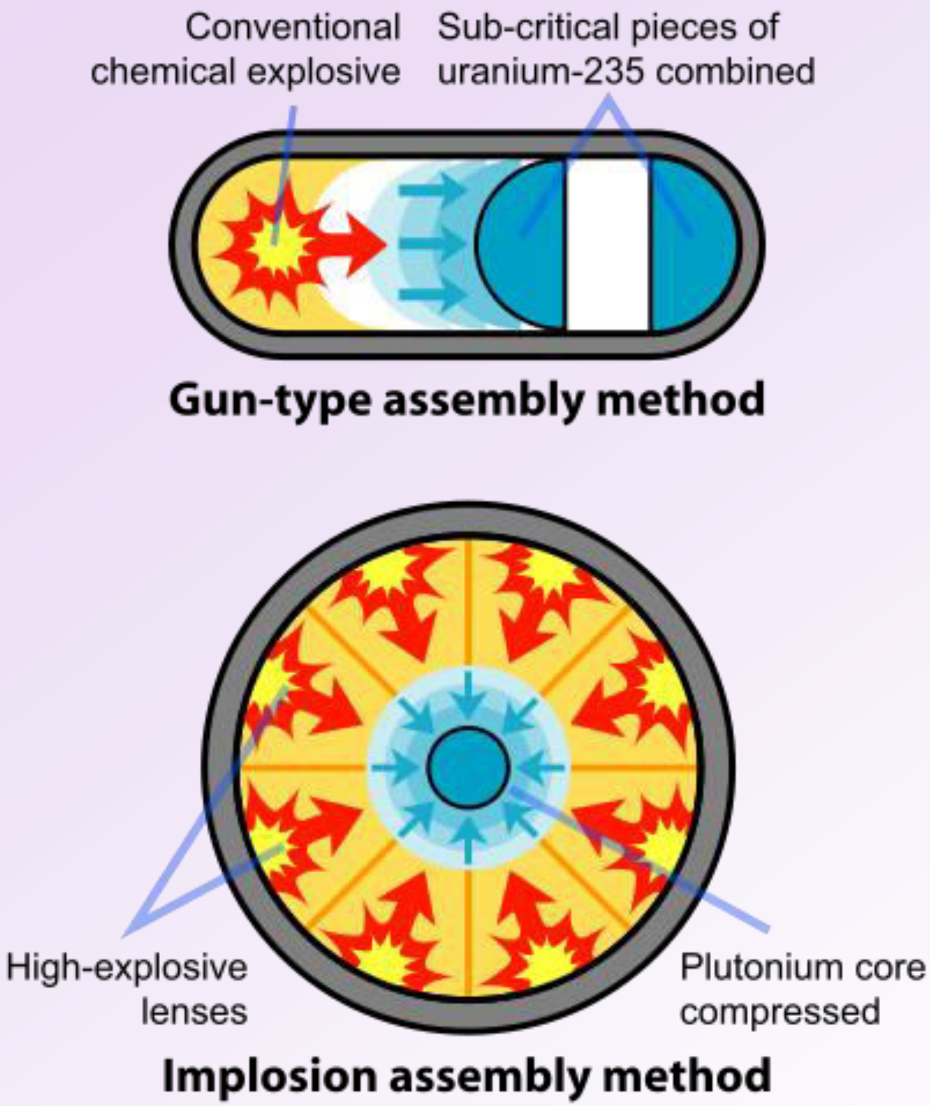




Nuclear bomb = fission

NUCLEAR REACTIONS

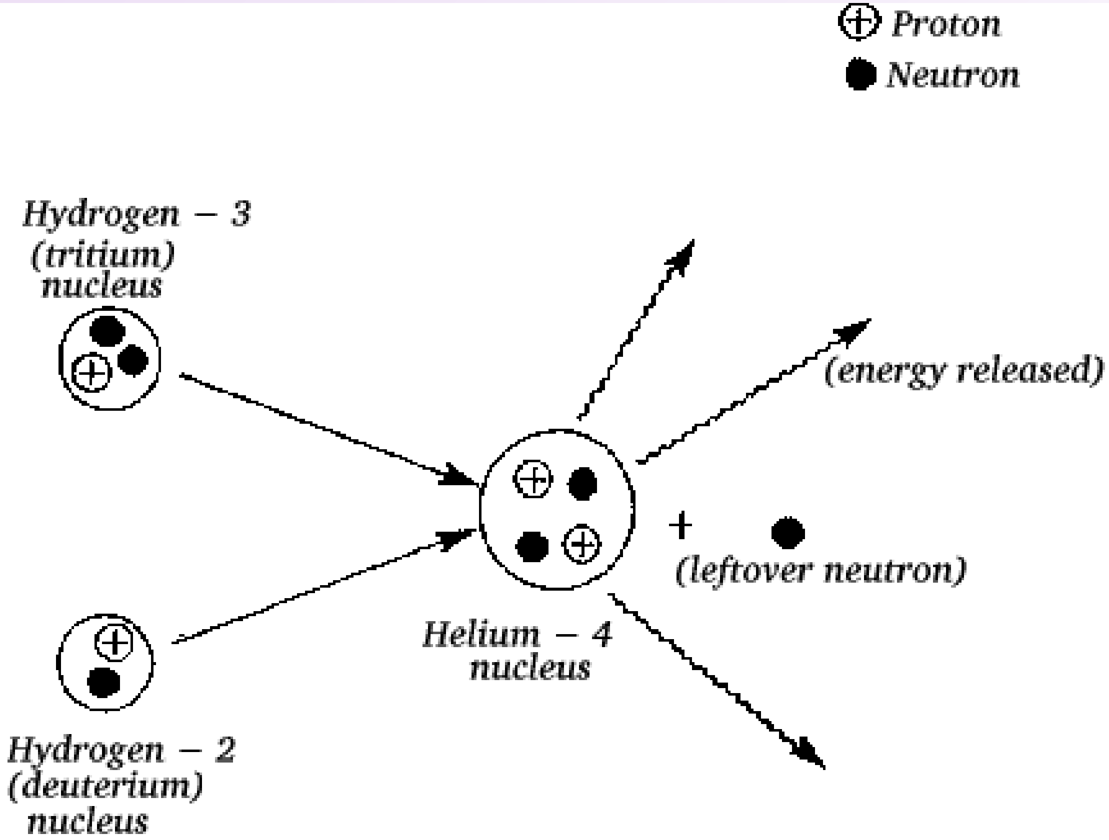
Hydrogen bomb vs. Nuclear Bomb



Nuclear bomb = fission

NUCLEAR REACTIONS

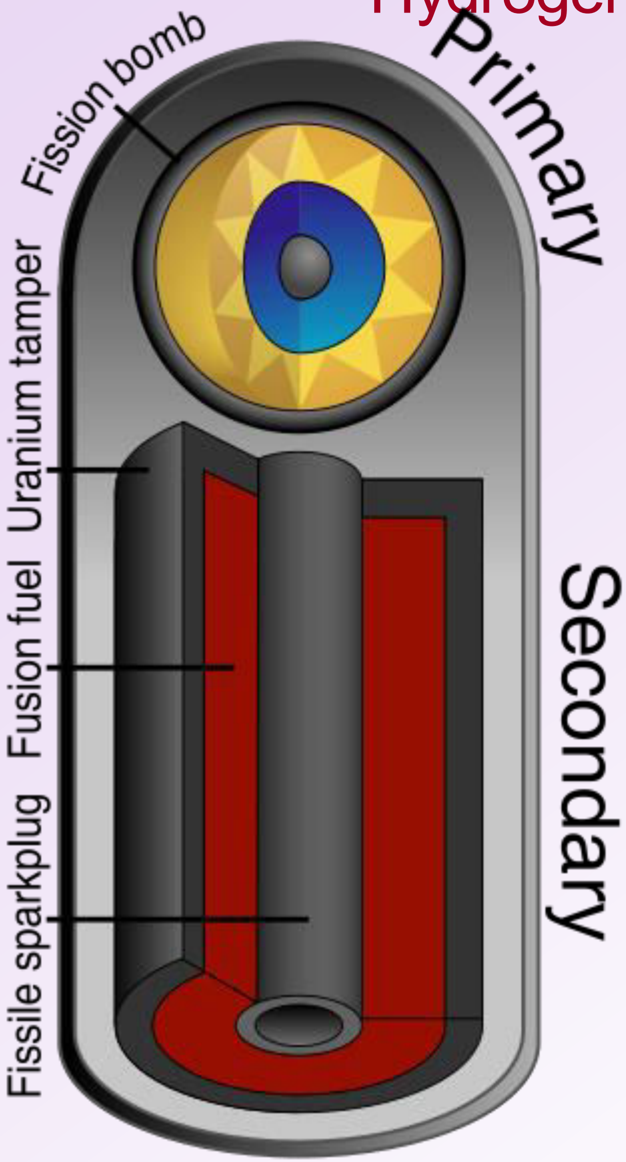
Hydrogen bomb vs. Nuclear Bomb



Hydrogen bomb = fusion

NUCLEAR REACTIONS

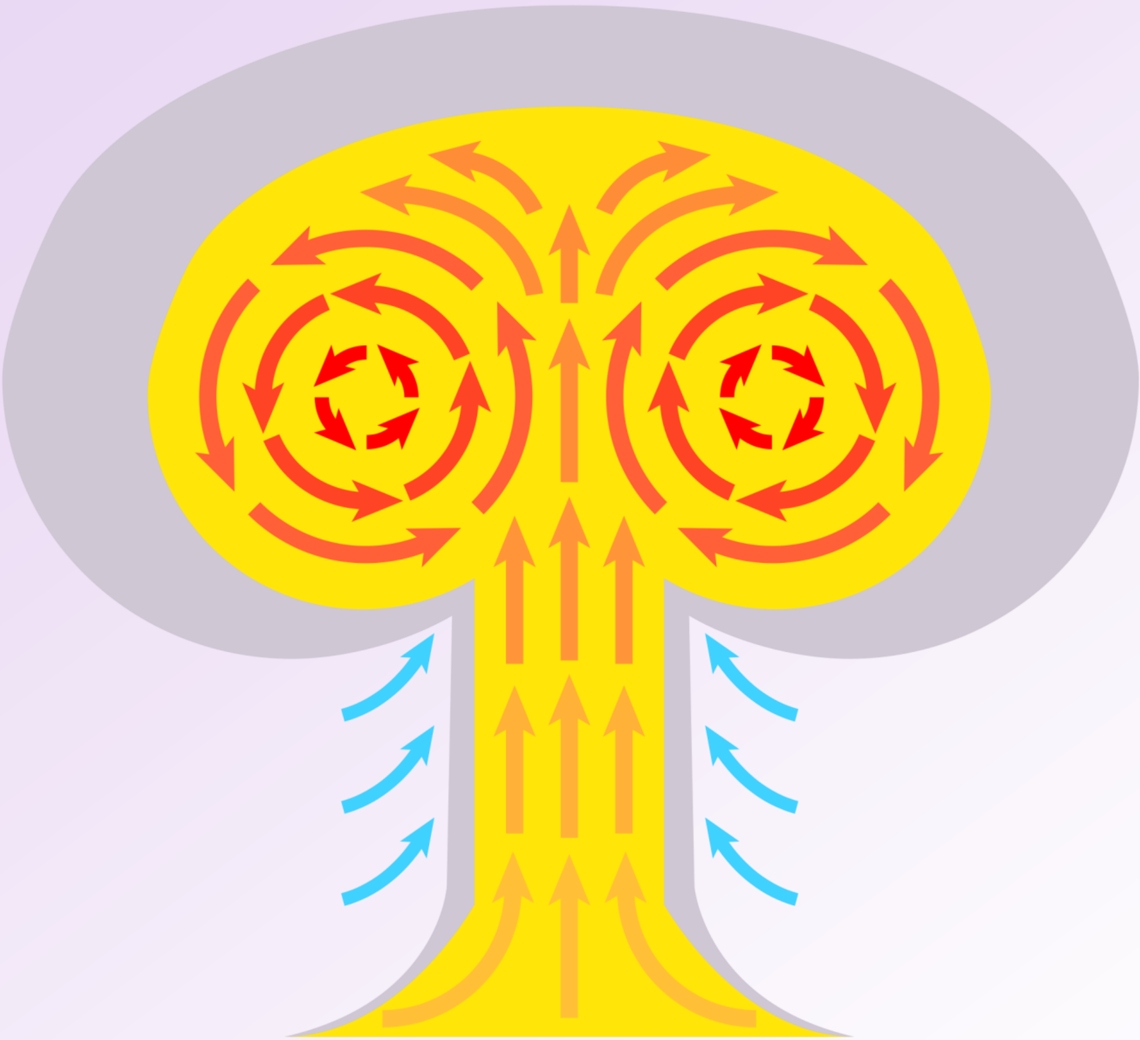
Hydrogen bomb vs. Nuclear Bomb



Hydrogen bomb = fusion

NUCLEAR REACTIONS

mushroom cloud anatomy:



Hot air rises, and cool air is drawn in to replace it.

The rising hot air mass creates a vortex within, giving the characteristic "mushroom" shape.