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# DYNAMIC EQUILIBRIA

# Many chemical reactions are reversible

e.g. $CuSO_4.5H_2O \rightleftharpoons CuSO_4 + 5\,H_2O$

hydrated copper sulphate — anhydrous copper sulphate

blue — white

**Click image to see YouTube video of reaction**

# Many reversible reactions (in a closed system) can reach a state of **dynamic equilibrium**

Closed system – nothing can get in or out

e.g. $A + B \rightleftharpoons C$

at **dynamic equilibrium**

A reacts with B to make C

**simultaneously**, and at the **same rate**

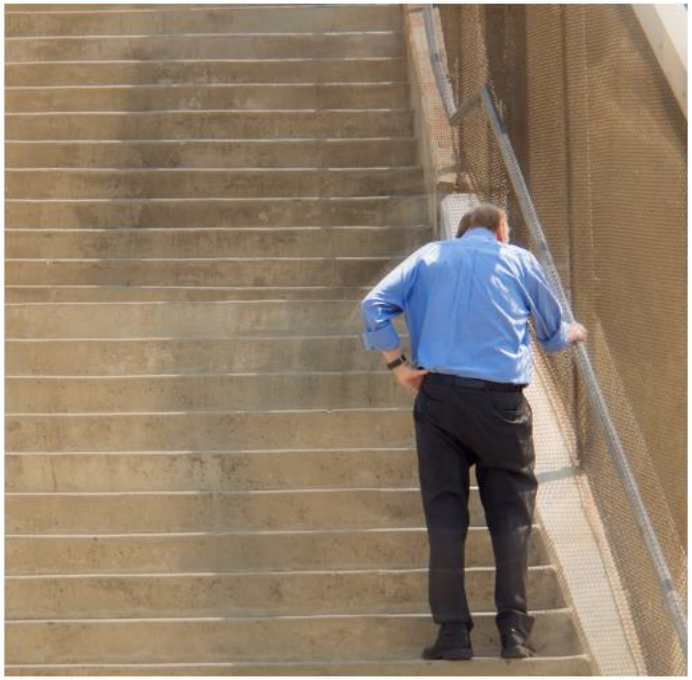
C reacts with make A and B

# @ Dynamic equilibrium

**both reactions are taking place**

- **simultaneously**,
- and at the **same rate**

# static equilibrium



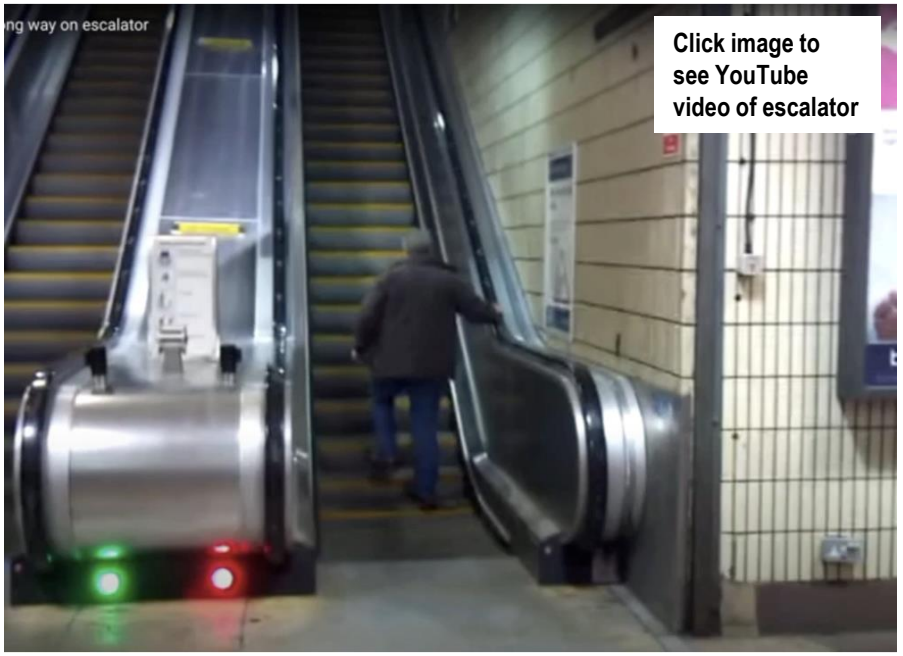
person standing still on stairs

nothing is changing

at **equilibrium**

but **STATIC**

# dynamic equilibrium

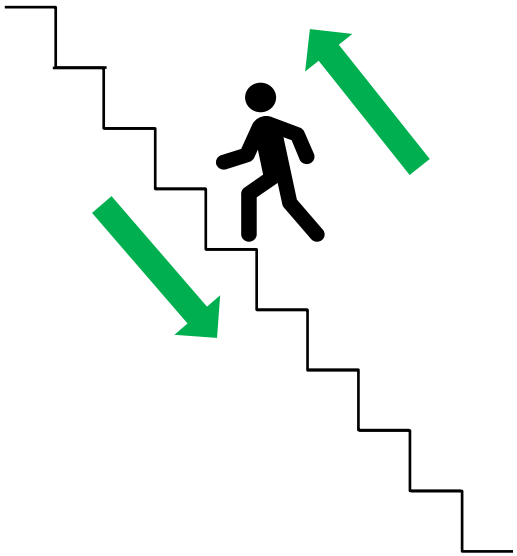



person walking up a down escalator (at same speed as escalator)

nothing is changing

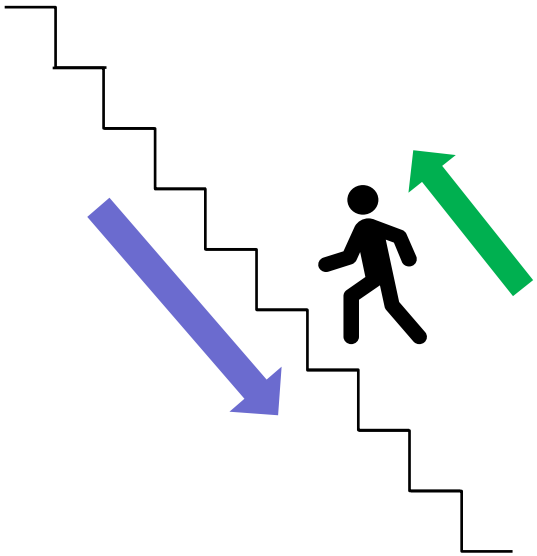
at **equilibrium**

but **DYNAMIC**



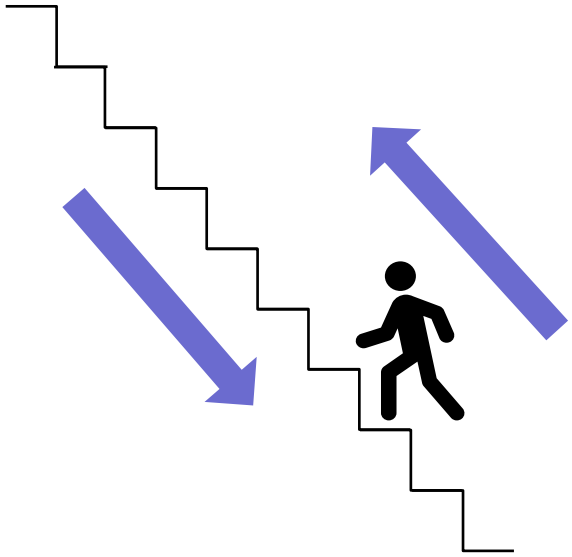
in dynamic equilibrium

**rate down = rate up**



not in equilibrium

**rate down > rate up**



new dynamic equilibrium

(in new position)

**rate down = rate up**

- if we speed up escalator we are no longer in equilibrium and person will start to move down
- but the person will walk/run faster to establish a new equilibrium – although the position of the equilibrium will have moved further to the right

# Le Chatelier's Principle

If the conditions of a system at equilibrium are changed, the position of the equilibrium moves to oppose that change

| Change | Action by equilibrium |
|---|---|
| Make it hotter | Cools it back down |
| Increase the pressure | Reduce the pressure |
| Add more of a chemical | Use it up to get rid of it |

# Le Chatelier's Principle - temperature

## Exothermic reactions

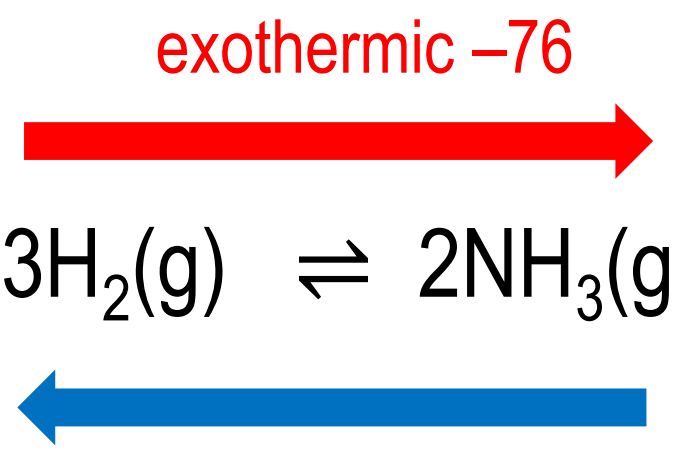
chemical energy ⟶ heat energy

makes the system **hotter**

## Endothermic reactions

heat energy ⟶ chemical energy

makes the system **colder**




$\Delta H = -76\ kJ\ mol^{-1}$

# Le Chatelier's Principle - temperature


$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -76 \text{ kJ mol}^{-1}$$

endothermic +76

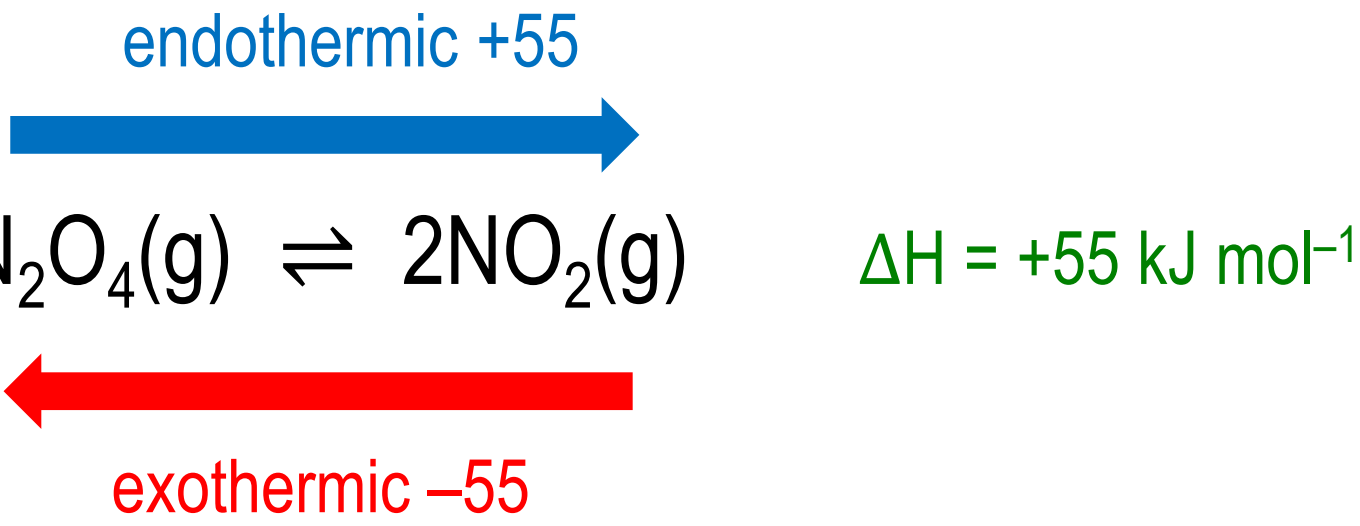
e.g. if T is increased

equilibrium position moves to oppose increase in T

by moving left in endothermic direction

decreases equilibrium yield of $NH_3$

# Le Chatelier's Principle - temperature




e.g. if T is increased

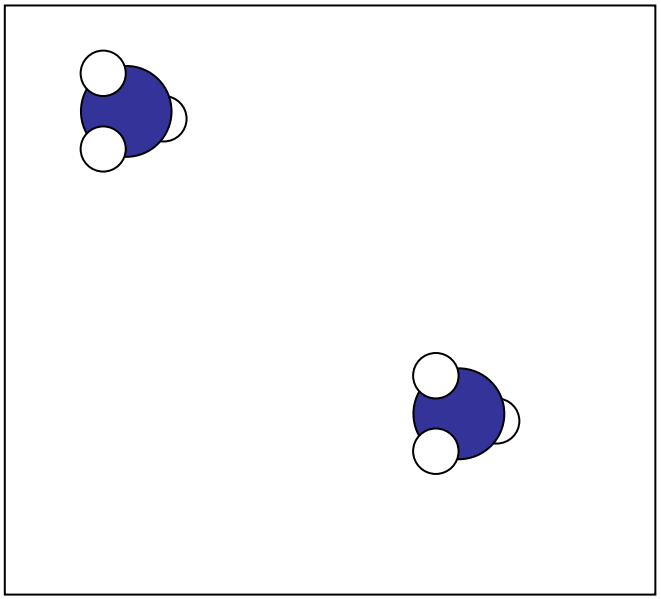
equilibrium position moves to oppose increase in T

by moving right in endothermic direction

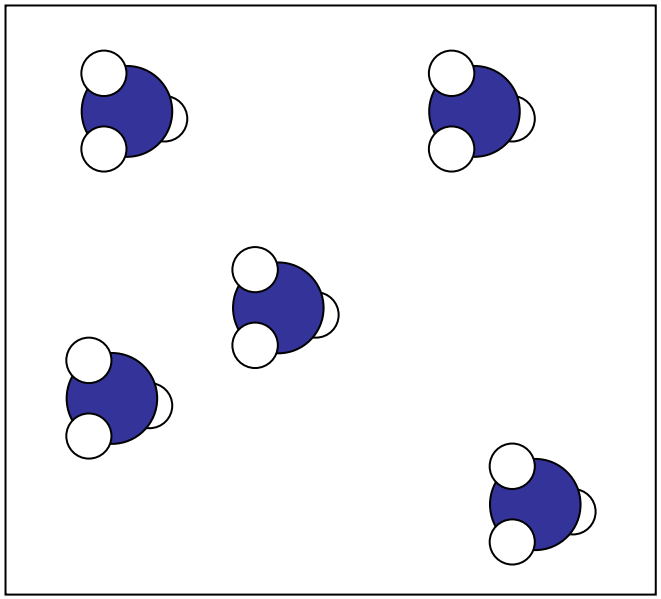
increases equilibrium yield of $NO_2$

# Le Chatelier's Principle - pressure

## More gas molecules = more pressure



lower pressure

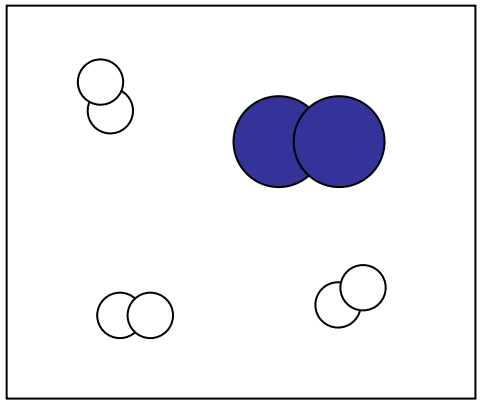


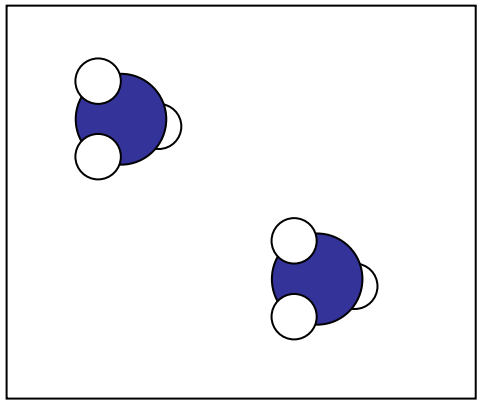
higher pressure

# Le Chatelier's Principle - pressure

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

4 molecules
more pressure





2 molecules
less pressure

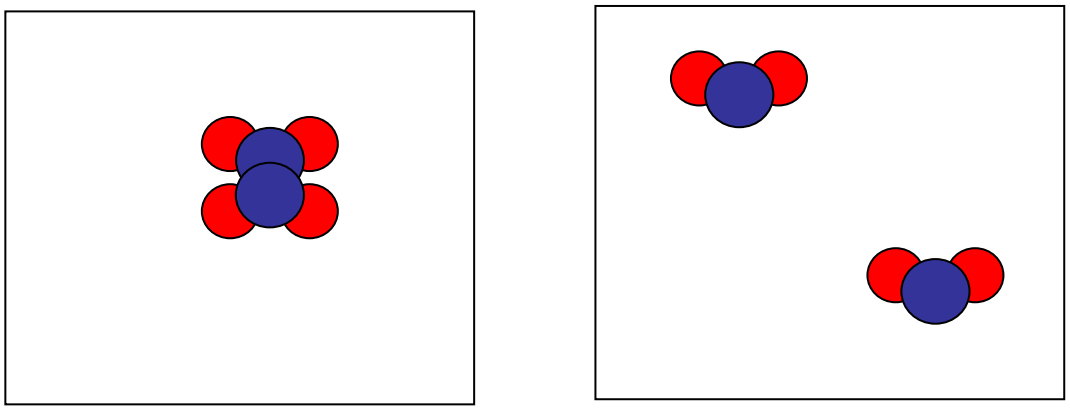
e.g. if P is increased

equilibrium position moves to oppose increase in P
by moving right to side with fewer gas molecules
increases equilibrium yield of $NH_3$

# Le Chatelier's Principle - pressure

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

1 molecule
less pressure



2 molecules
more pressure

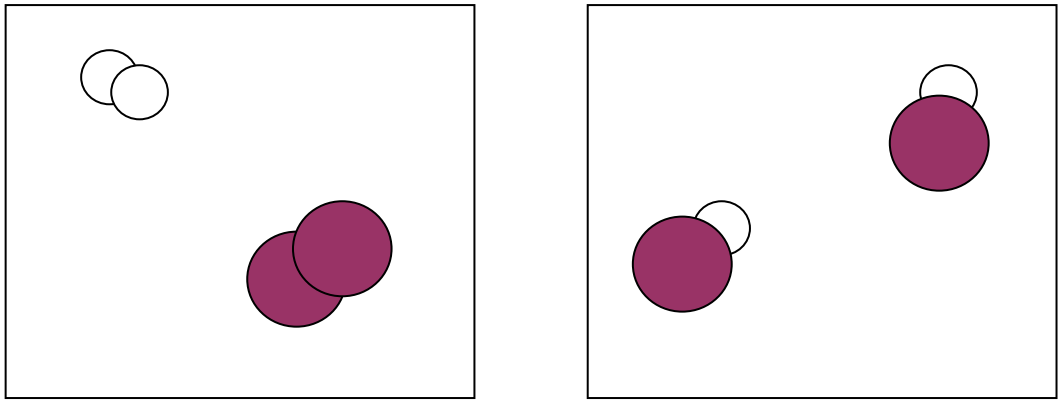
e.g. if P is increased

equilibrium position moves to oppose increase in P
by moving left to side with fewer gas molecules
decreases equilibrium yield of $NO_2$

# Le Chatelier's Principle - pressure

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

2 molecules
same pressure



2 molecules
same pressure

e.g. if P is increased

equilibrium does not move

as same number of gas molecules on each side

no effect on equilibrium yield of HI

# Le Chatelier's Principle - concentration

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

e.g. add more $N_2$

equilibrium position moves to oppose increase in $N_2$

by moving right to use it up

increases equilibrium yield of $NH_3$

# Le Chatelier's Principle - concentration

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

e.g. remove some $H_2$

equilibrium position moves to oppose decrease in $H_2$

by moving left to make more of it

decreases equilibrium yield of $NH_3$