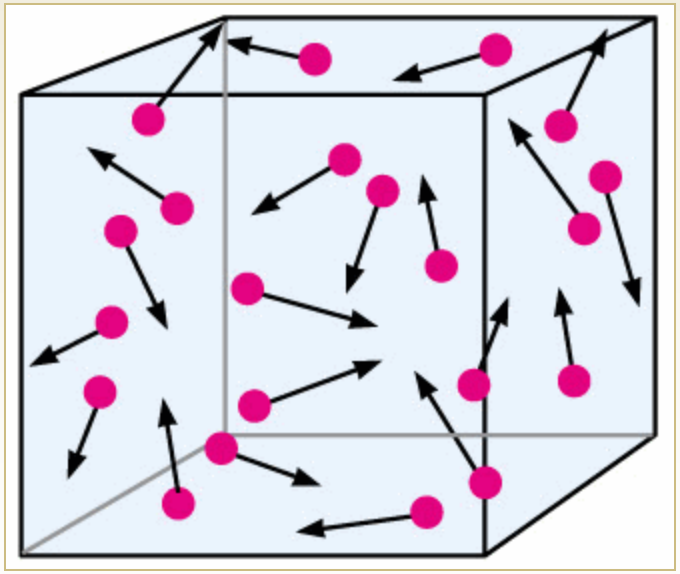
REVERSIBLE REACTIONS

REVERSIBLE REACTIONS

What happens to gas when temperature changes?



↑ T α ↑ V

↑ T α ↑ P

REVERSIBLE REACTIONS

1) When the system is heated:

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

2) When the system is cooled:

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

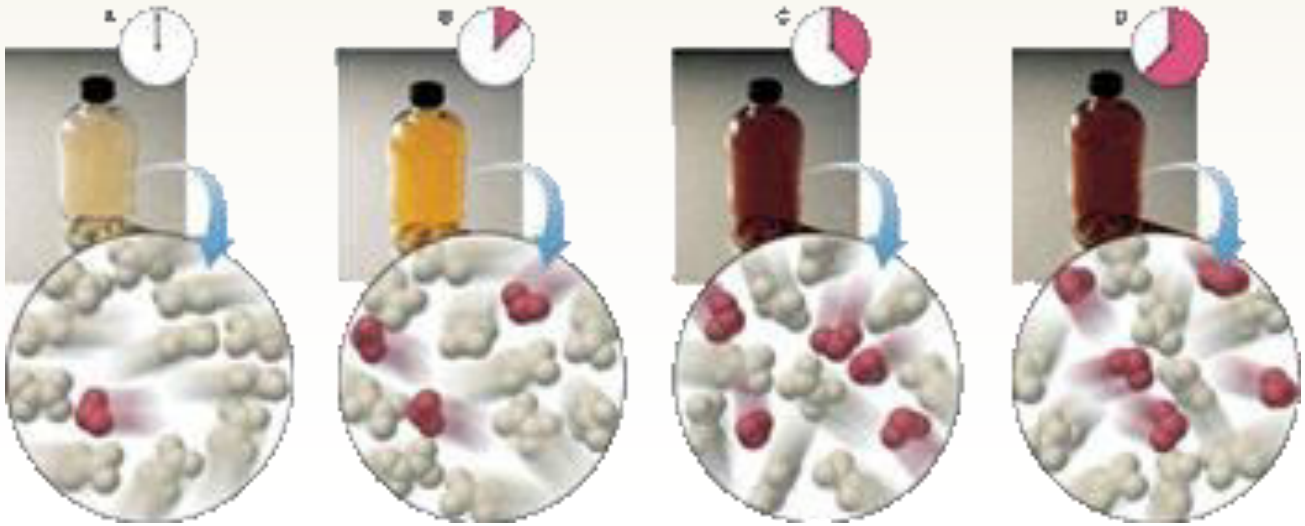
- brown gas = NO_2
- colourless gas = N_2O_4

REVERSIBLE REACTIONS

Both reactions are occurring simultaneously in a closed system at all times.

The reaction:

$N_2O_{4(g)}$ + energy <==> 2 $NO_{2(g)}$ is described as reversible.



REVERSIBLE REACTIONS

Only when both reactions are occurring at the same rate and no changes can be observed, a chemical equilibrium has been reached.

REVERSIBLE REACTIONS

Factors to Reach Equilibrium

1. closed system
2. simultaneous opposing reactions occurring at the same rate
3. equilibrium was reached by starting with reactants or products
4. temperature is constant

REVERSIBLE REACTIONS

Describe what is happening when the temperature is changed?

$$2\ NO_{2(g)} \text{ <==> } N_2O_{4(g)} + \text{energy}$$

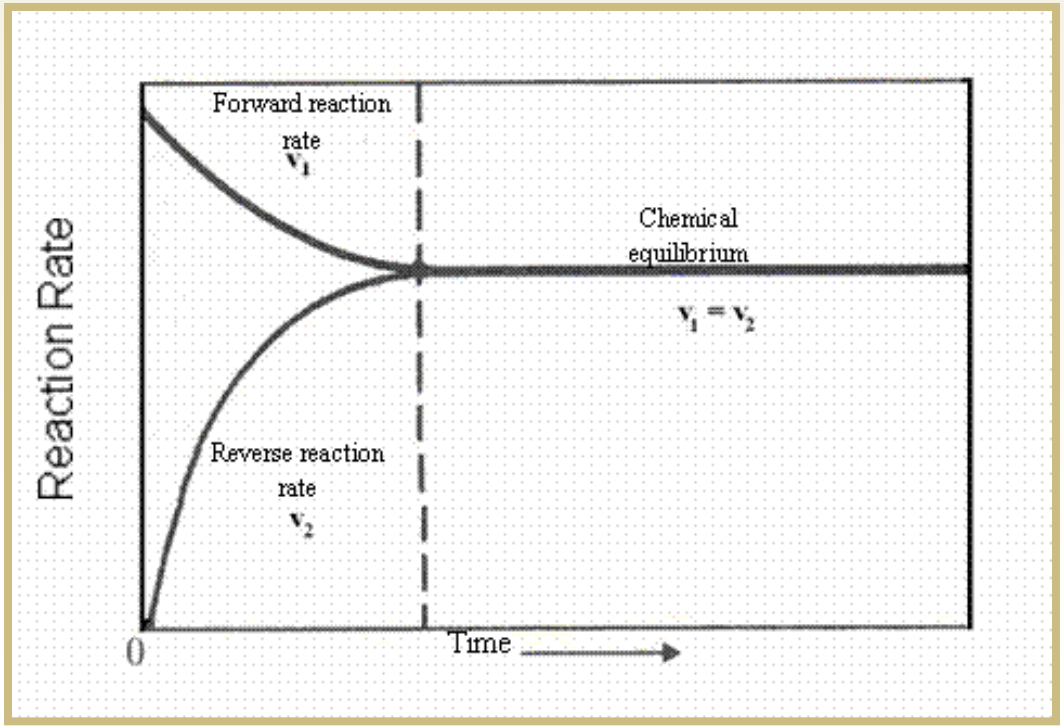
REVERSIBLE REACTIONS

Equilibrium **DOES NOT** mean the same concentrations of products and reactants.

- only that the rxn rates are equal

Reaction rates change because of temperature change.

- equilibrium rxn rates are different at different temperatures



REVERSIBLE REACTIONS

When chemicals are reacted, there are 3 possible outcomes:

1. reaction goes to completion

2. reaction does not occur at all

3. reaction achieves equilibrium

REVERSIBLE REACTIONS

Factors Determining Rxn Occurrence

1. Rxns favour energy release ($-\Delta H$)

2. Rxns favour a result of increased entropy ($+\Delta S$)

When both of these statements are true, the reaction tends to completion.

REVERSIBLE REACTIONS

Predicting Reaction Occurrence

Example #1

$$Zn_{(s)} + 2\ HCl_{(aq)} \rightarrow ZnCl_{2(aq)} + H_{2(g)} \qquad \Delta H = -152\ kJ$$

Enthalpy?	
Entropy?	
Prediction?	

REVERSIBLE REACTIONS

Predicting Reaction Occurrence

Example #2

$$3\ C_{(s)} + 3\ H_{2(g)} \rightarrow C_3H_{6(g)} \qquad \Delta H = +20.4\ kJ$$

Enthalpy?	
Entropy?	
Prediction?	

REVERSIBLE REACTIONS

Predicting Reaction Occurrence

Example #3

$2Pb(NO_3)_{2(s)} \rightarrow 2PbO_{(s)} + 4NO_{2(g)} + O_{2(g)}$ $\Delta H = +597$ kJ

Enthalpy?	
Entropy?	
Prediction?	

REVERSIBLE REACTIONS

Predicting Reaction Occurrence

Example #4

The following reaction achieves equilibrium.

$$3\ H_{2(g)} + N_{2(g)} \text{ <===> } 2\ NH_{3(g)} \quad + \text{ heat}$$

ΔH = positive or negative?

negative

REVERSIBLE REACTIONS

Predicting Reaction Occurrence

Example #5

heat + $PCl_{5(g)}$ <====> $PCl_{3(g)} + Cl_{2(g)}$

ΔH = positive or negative?

positive

REVERSIBLE REACTIONS

Predicting Reaction Occurrence

Recall, some reactions require very large E_A values.

Therefore another factor in determining reaction occurrence.

If no information on E_A is given, assume sufficient energy is available.

REVERSIBLE REACTIONS

Types of Equilibrium:

Solubility Equilibrium

Dynamic equilibrium between a solute and a solvent in a saturated solution

Phase Equilibrium

Dynamic equilibrium between different states of a pure substance in a closed system

Chemical Reaction Equilibrium

Dynamic equilibrium between reactants & products of a chemical reaction

REVERSIBLE REACTIONS

Types of Chemical Reaction Equilibrium:

- Two types:
  - **Homogeneous equilibrium:** reactants & products are all in the same phase

  - **Heterogeneous equilibrium:** reactants & products are not all in the same phase