[TP] How many distinguishable ways can 5 water molecules and 2 ink molecules be arranged?

0% 1. 14
0% 2. 21
0% 3. 240
0% 4. 5040
0% 5. None of these

Response Counter

10

Lecture 30 CH102 A1 (MWF 9:05 am)

Monday, April 10, 2017

Begin ch 17: Spontaneous change: How far?

- The essence of change
- Counting particle dispersal
- Practice with particle dispersal

Next lecture: Maximum particle dispersal = uniform pressure. Arrangements ⟶ Entropy. Counting energy dispersal. Heat (energy) flow → entropy change.

Notes: Spontaneity: Second law of thermodynamics

http://quantum.bu.edu/courses/ch102-spring-2017/handouts.html

Spontaneous change: How Far?

Mahaffy et al., ch 17 and
http://quantum.bu.edu/courses/ch102-spring-2017/handouts.html

Notes: Spontaneity: Second law of thermodynamics
PDF, 14 pages

The essence of change

Why does a drop of ink in water disperse?

Why do salt water and fresh water mix?

The essence of change

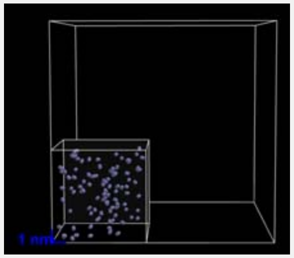
all complexity is an illusion ...

things happen simply because they can happen
and because they are statistically
most likely to happen."

Michael Munowitz, "Principles of Chemistry," W. W. Norton, 2000

10

A gas fills its container



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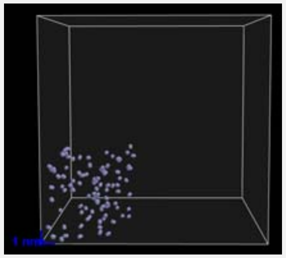
A gas fills its container



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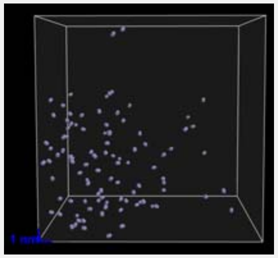
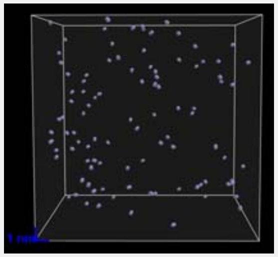
A gas fills its container



14

A gas fills its container



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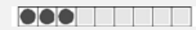
A gas fills its container



Gas all on left of container

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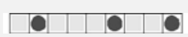
A gas fills its container



Gas evenly distributed throughout container

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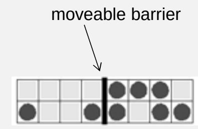
Pressure in a gas is uniform



P proportional to n/V (“lattice gas”)
P higher on the right

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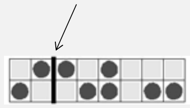
Pressure in a gas is uniform

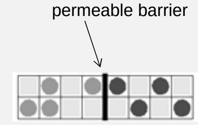
moveable barrier



P proportional to *n*/*V* (“lattice gas”)
P the same on the left and right

Gases mix evenly

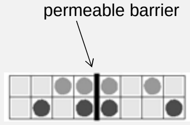
permeable barrier



One gas on left, another on right

Gases mix evenly

permeable barrier



Equal amounts throughout

Osmotic pressure across semipermeable membrane

Pressure equal (n/V) on both sides of membrane,
but solute (light grey) cannot pass across membrane to left

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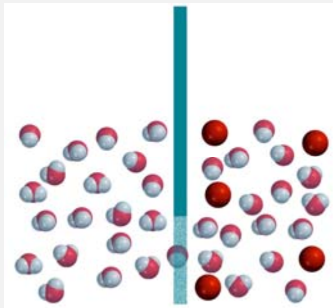
Osmotic pressure across semipermeable membrane



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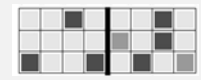
Osmotic pressure across semipermeable membrane



Solvent passes across membrane to right making pressure higher (n/V) on right

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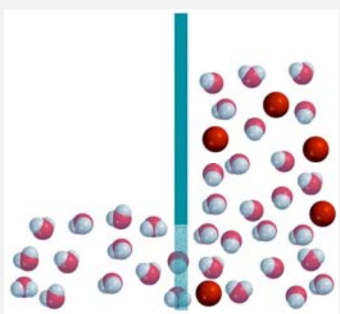
Osmotic pressure across semipermeable membrane



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Blind chance & dumb luck

Everything—absolutely everything—that happens, happens solely because of blind chance and dumb luck.

To quantify this ...

1. Learn to count the ways
2. Search for greatest number of ways

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Counting distinguishable (unique) arrangements

The goal: The number of distinguishable arrangements of
j identical objects of one kind and
k identical objects of another kind is ...

$$W(j,k) = \frac{(j+k)!}{j! \times k!}$$

For example 3 ink molecules and 4 water molecules can be uniquely arranged in

$$W(3,4) = \frac{7!}{3! \times 4!} = 35 \text{ ways}$$

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Counting distinguishable (unique) arrange

Say we have three girls and four boys.

What is the probability of calling them into line in the order $gggbbbb$?

$$\frac{3}{7} \times \frac{2}{6} \times \frac{1}{5} \times \frac{4}{4} \times \frac{3}{3} \times \frac{2}{2} \times \frac{1}{1} = \frac{1}{35}$$

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Counting distinguishable (unique) arrange

Say we have three girls and four boys.

What is the probability of calling them into line in the order $bgbgbgb$?

$$\frac{4}{7} \times \frac{3}{6} \times \frac{3}{5} \times \frac{2}{4} \times \frac{2}{3} \times \frac{1}{2} \times \frac{1}{1} = \frac{1}{35}$$

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Counting distinguishable (unique) arrange

Say we have three girls and four boys.

For each particular arrangement, say $bgbgbgb$, how many ways can it come about?

$$3!\,4! = 144$$

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Counting distinguishable (unique) arrange

Say we have three girls and four boys.

If we ignore whether a child is boy or girl, what is the total number of arrangements?

$7 \times 6 \times 5 \times 4 \times 3 \times 2 \times 1 = 7! = 5040$

Counting distinguishable (unique) arrange

Say we have three girls and four boys.

This means the total number of arrangements can be expressed as the number, W, of distinguishable arrangements times the number of ways a particular distinguishable arrangement can come about,

$7! = 5040 = W \times 3!\,4! = W \times 144$

Therefore, the number of distinguishable arrangements is

$W = 7! / (3!\,4!) = 5040/144 = 35$

Counting distinguishable (unique) arrange

More generally, say we have j objects of one kind (say, girls) and k objects of another kind (say, boys).

The number of unique arrangements of j objects of one kind and k objects of another kind is

$W(j, k) = (j + k)! / (j! \times k!)$

Practice with particle dispersal

See page 3 of
http://quantum.bu.edu/courses/ch102-spring-2017/notes/SecondLaw.pdf

[TP] How many distinguishable ways can 3 water molecules and 2 ink molecules be arranged?

20% 1. 8
20% 2. 10
20% 3. 12
20% 4. 120
20% 5. None of these

BOSTON UNIVERSITY 0 of 0 1 44

[TP] How many distinguishable ways can 5 water molecules and 2 ink molecules be arranged?

0% 1. 14
0% 2. 21
0% 3. 240
0% 4. 5040
0% 5. None of these

BOSTON UNIVERSITY Response Counter 10 46

[Quiz] How many distinguishable ways can 2 ink molecules be arranged among 12 water molecules?

0% 1. 36
0% 2. 240
0% 3. 455
0% 4. 720
0% 5. None of these

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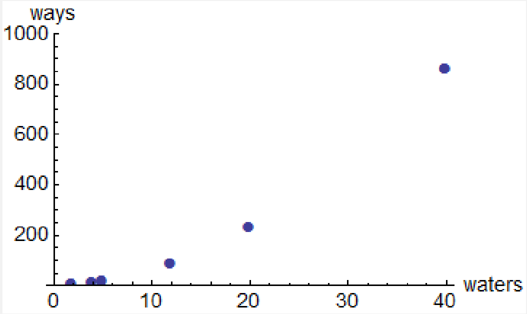
The more water, the more ways ink disperses

2 ink particles in water



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