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[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  1



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>




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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

 8

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The essence of change

Why does a drop of ink in water disperse?
Why do salt water and fresh water mix?

 9


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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."


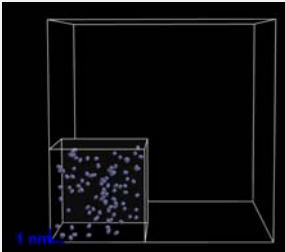
Michael Munowitz, "Principles of Chemistry," W. W. Norton, 2000



10

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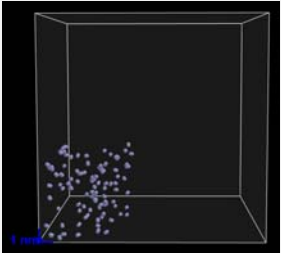
A gas **fills** its container



12

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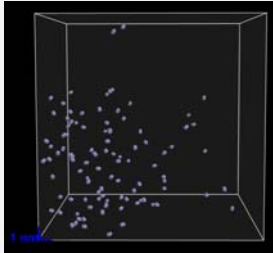
A gas **fills** its container



13

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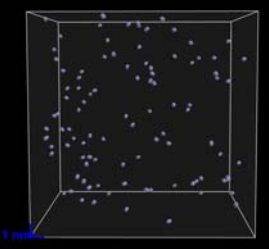
A gas **fills** its container



14

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A gas fills its container




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15

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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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17

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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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18

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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

19

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Gases **mix** evenly

permeable barrier

One gas on **left**, another on **right**

20

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Gases **mix** evenly

permeable barrier

Equal amounts throughout

21

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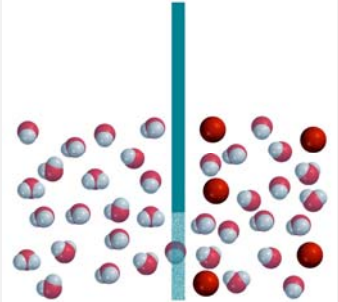
Osmotic pressure across **semipermeable** membrane

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

22

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Osmotic pressure across semipermeable membrane

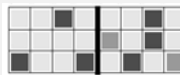


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23

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Osmotic pressure across semipermeable membrane



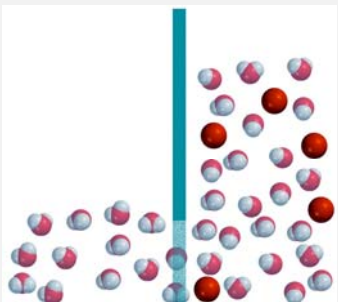
Solvent passes across membrane to right making pressure higher (n/V) on right

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24

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Osmotic pressure across semipermeable membrane



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25

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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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26

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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 **bgbggbg**?

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

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Counting **distinguishable** (unique) arrange

Say we have three girls and four boys.

For each particular arrangement, say **bgbggbg**, 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?

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



39

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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

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



40

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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

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



41

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Practice with particle dispersal

See page 3 of

<http://quantum.bu.edu/courses/ch102-spring-2017/notes/SecondLaw.pdf>



42

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[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

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0 of 0

1

44

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[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

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Response Counter

10

46

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[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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Response Counter

10

47

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The **more water**, the **more ways** ink disperses

2 ink particles in water

Waters	Ways
2	1
3	3
4	6
5	10
10	45
20	240
40	1260

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48