

Theme Round

Lexington High School

December 8, 2018

Chemistry

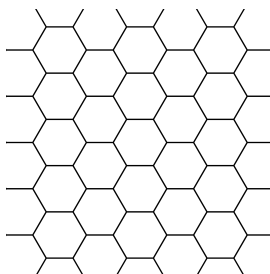
Chemistry. BOOM BOOM. Things explode, and if you're not careful, you might explode, too.

1. The half life of a radioactive isotope is the time it takes for the isotope to decay too half of its original concentration. Francium-223 decays with a half life of 22 minutes. Determine how many minutes it takes for a sample of francium-223 to decay to 25% of its original concentration.
2. Ezra is walking across the periodic table. Determine the number of ways he can walk from gallium, atomic symbol Ga, to neon, atomic symbol Ne, if he must walk through sulfur, atomic symbol S, and can only walk right or up.

5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
31 Ga 69.72	32 Ge 72.61	33 As 74.92	34 Se 78.97	35 Br 79.90	36 Kr 83.80

Periodic Table

3. In organic chemistry, molecules can be represented as polygons, where vertices are atoms and edges are bonds. A certain molecule is a finite plane of continuous hexagons, such as the one shown below. If there are 32 atoms and 41 bonds, how many hexagons are in the molecule?



Hexagons

4. Steel is an alloy of iron and carbon. Four iron atoms can be represented as mutually tangent spheres, and the carbon atom can be represented as a sphere externally tangent to all four iron atoms. If the radius of the iron atom is 12 angstroms, determine the radius of a carbon atom in angstroms.
5. Electrons in an atom are described by a set of four quantum numbers, $\{n, l, m_l, m_s\}$, according to the following restrictions: all quantum numbers must be integers except m_s , which can be either $+\frac{1}{2}$ or $-\frac{1}{2}$; $0 \leq l < n$; and $|m_l| \leq l$. Additionally, no two electrons can have the same set of four quantum numbers. Determine the number of electrons that can exist such that $n \leq 20$.

Mafia

Mafia is a game where there are two sides: The village and the Mafia. Every night, the Mafia kills a person who is sided with the village. Every day, the village tries to hunt down the Mafia through communication, and at the end of every day, they vote on who they think the mafia are.

6. Patrick wants to play a game of mafia with his friends. If he has 10 friends that might show up to play, each with probability $\frac{1}{2}$, and they need at least 5 players and a narrator to play, what is the probability that Patrick can play?
7. At least one of Kathy and Alex is always mafia. If there are 2 mafia in a game with 6 players, what is the probability that both Kathy and Alex are mafia?
8. Eric will play as mafia regardless of whether he is randomly selected to be mafia or not, and Euhan will play as the town regardless of what role he is selected as. If there are 2 mafia and 6 town, what is the expected value of the number of people playing as mafia in a random game with Eric and Euhan?
9. Ben is trying to cheat in mafia. As a mafia, he is trying to bribe his friend to help him win the game with his spare change. His friend will only help him if the change he has can be used to form at least 25 different values. What is the fewest number of coins he can have to achieve this added to the fewest possible total value of those coins? He can only use pennies, nickels, dimes, and quarters.
10. Sammy, being the very poor mafia player he is, randomly shoots another player whenever he plays as the vigilante. What is the probability that the player he shoots is also not shot by the mafia nor saved by the doctor, if they both select randomly in a game with 8 people? There are 2 mafia, and they cannot select a mafia to be killed, and the doctor can save anyone.

Music

What music do you like the best? Perhaps theme music from anime? Or maybe you like gaming theme music from YouTubing gamers on arcade games!

11. Every note in a musical phrase that is 2 measures long lasts for $\frac{1}{8}$ of the measure of $\frac{1}{4}$ of it. How many different rhythms can the phrase have if there are no rests?
 12. I play a random chord of three different notes. It is called dissonant if the distance between any two of those notes are 1, 2, 6, 10, or 11 semitones apart. Given that the longest distance between two notes is at most 12 semitones, what is the probability that the chord will be dissonant?
 13. Two distinct notes are called an interval and if they are 0, 5, or 7 semitones apart modulo 12, they are a perfect interval. (Modulo 12 means the remainder when divided by 12.) If a piano has 88 notes, and consecutive notes are 1 semitone apart, how many perfect intervals can be played?
 14. An ensemble has a violin, a viola, and a cello. A chord has 3 notes and each instrument can play 1 or 2 of them at a time. How many ways can they play the chord if every note in the chord must be played? (Octaves don't matter.)
15. 5@