

# WORDS FROM DICE

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Word games such as Boggle consist of letters on the faces of dice. Usually one rolls the dice and tries to form a word out of the upward-facing letters. However, another game leads to interesting logological challenges: draw the dice one at a time out of a bag, the first die then turned over to yield the first letter of a word, the second die to yield the second letter, and so on.

Let us fix ideas with a simple example—three dice with 18 different letters, the objective being to form a three-letter word no matter what order the dice are drawn. Almost any assignment of letters will do:

A O N D P C   E R S L Y M   I T H U D B

yields ART if the dice are drawn 123, ATE if drawn 132, RAT if drawn 213, ETA if drawn 132, TAR if drawn 312, and TEA if drawn 321. (In fact, only the four letters AERT have been used.)

It is still easy to arrange 24 different letters on four dice so that words always can be formed:

B C G L N P   D E H I J S   A K T V W X   F M O R U Y

1234 pear	2134 spar	3124 also	4123 flit
1243 pert	2143 spot	3142 aloe	4132 opts
1324 lair	2314 sago	3214 wily	4213 melt
1342 pare	2341 harp	3241 viol	4231 meal
1423 grit	2413 hula	3412 arch	4312 face
1432 lute	2431 soap	3421 trip	4321 rasp

The six letters B D J K N X were not used.

It is a significantly more difficult logological problem to arrange 26 letters and four blank spaces on five dice so that a word can be formed no matter the order in which the dice are removed from the bag. There are 120 different words to be found, corresponding to the 120 different orders that dice may be drawn. To maximize the number of theoretically-possible words, the letters should be allocated 6,5,5,5,5 to the dice, yielding 3750 combinations.

How should the individual letters be assigned? A reasonable strategy is to ensure that the best final-letter choices such as E, S, Y, N and R are allocated to different dice. Furthermore, vowels should be spread around, not concentrated on one or two dice, to minimize the occurrence of impossible consonant clusters. It turns out that it is just barely possible to find a complete set of 120 words if one is restricted to boldface entries in either the second or third editions of the Merriam-Webster Unabridged Dictionary (or in the Merriam-Webster Collegiate Dictionary). Plurals and past tenses of words are allowed, as are single words from two-word phrases such as KOL NIDRE or MINKE WHALE. RALO (pluralized below) is found only in the Measures section, it being a Yugoslavian measure of area. It was necessary to admit HIDRO-, a hyphenated prefix, but the line was drawn at reformed spellings!

The allocation used was

EHLPV- BISTU- ADFMY- CGJNOQ KRWXZ-

12345 humor	21345 shack	31245 fetor	41235 Cesar	51234 retan
12354 hidro-	21354 spawn	31254 metro	41253 chirm	51243 reina
12435 vicar	21435 begar	31425 flour	41325 chair	51324 redip
12453 hunky	21453 showy	31452 aport	41352 chart	51342 react
12534 Lukan	21534 serac	31524 deric	41523 newsy	51423 recta
12543 pirny	21543 bergy	31542 meros	41532 ceras	51432 rends
13245 labor	23145 savor	32145 abhor	42135 gular	52134 kilan
13254 latro	23154 sapro	32154 athro	42153 query	52143 wilga
13425 Vanir	23415 saner	32415 miner	42315 nuder	52314 rumen
13452 haori	23451 smoke	32451 Minke	42351 Nidre	52341 rudge
13524 lyric	23514 syren	32514 dukhn	42513 curly	52413 winey
13542 earns	23541 sarge	32541 dirge	42531 giral	52431 Rinde
14235 lobar	24135 bolar	34125 mohur	43125 Galux	53124 rapic
14253 entry	24153 sopra	34152 acerb	43152 Capri	53142 ralos
14325 Lodur	24315 boder	34215 doser	43215 caber	53214 rasen
14352 hoars	24351 scare	34251 moire	43251 gaure	53241 waine
14523 horsy	24513 sorva	34512 acres	43512 cares	53412 races
14532 lords	24531 Torah	34521 dowse	43521 carse	53421 ranse
15234 primo	25134 skean	35124 aweto	45123 creta	54123 kohua
15243 pricy	25143 Irena	35142 Areoi	45132 Oreas	54132 wolfs
15324 Erato	25314 bravo	35214 Arulo	45213 gripy	54213 roupy
15342 exact	25341 brace	35241 azine	45231 crime	54231 koude
15423 prosy	25413 Iroha	35412 froes	45312 craps	54312 romps
15432 prods	25431 brome	35421 arose	45321 orate	54321 knash

Note that J has not been used.

What allocation of letters to six dice generates the greatest number of words? With 720 words to be found, this is an extraordinarily difficult problem, best left to the computer. It seems unlikely that a complete set of words can be found, even using computer-based sources like the Oxford English Dictionary and the United States Board of Geographic Names.

One can generalize the dice problem by allowing letters to appear more than once, with the proviso that all words must be different. For example, what set of 36 letters produces the greatest number of six-letter words? A computer can be programmed to perform a hill-climbing strategy: find the number of words corresponding to a given allocation of letters, then change a single letter and see if a larger number of words result. Unfortunately, there are a very large number of ways one can change a single letter!

One can also generalize the dice problem by asking for that allocation of letters that minimizes the number of words formed with respect to a specified dictionary. For three-letter words, one can ensure that no Websterian words are formed by excluding the five vowels plus Y, plus a couple of common consonants. For four-letter words, after excluding a couple of common vowels such as A and E, one places the six rarest consonants on one die and the remaining vowels plus two common consonants on a second die. However, it is impossible to eliminate all Websterian words, even restricted to the Pocket Dictionary.