ChemMend: A Card Game To Introduce and Explore the Periodic Table while Engaging Students' Interest

Vicente Martí-Centelles* and Jenifer Rubio-Magnieto*

Cite this: J. Chem. Educ. 2014, 91, 6, 868–871

Publication Date:April 30, 2014

https://doi.org/10.1021/ed300733w

ChemMend: A Card Game to Introduce and Explore the Periodic Table while Engaging Student's Interest

Vicente Martí-Centelles‡* and Jenifer Rubio-Magnieto‡*

Departamento de Química Inorgánica y Orgánica, Universitat Jaume I, Avda. Sos Baynat, s/n, E-12071 Castellón (Spain). E-mail: martiv@uji.es and jrubio@uji.es.

KEYWORDS. General Public, Continuing Education, Periodicity/Periodic Table, Humor/Puzzles/Games.

In memory of Purificación Escribano

ABSTRACT: The deeply knowledge of the periodic table is one of the most important keys to understand the basic principles of Chemistry. Memorizing the elements of the groups and periods is one of the most commonly used strategies to learn the position of each element in the periodic table; nevertheless it is a hard task for most students. The use of card games can represent a useful alternative to teach some chemical aspects. Here, we present *ChemMend*, a new Chemical card game which will allow chemistry students to obtain a good ability in the periodic table. This game attracts the attention of the students, and it allows them to review mentally the period and group while playing; being the learning a consequence of the game. The *ChemMend* game will introduce and explore the periodic table in the classroom.

Introduction

Learning the periodic table is a key issue for understanding the chemical properties of the elements and it is essential to study Chemistry.[1-3] In this regard, people interested in Chemistry —in particular chemistry students— must know the position of all the elements in the periodic table, and they must be able to identify the period and the group of each element.[4,5]

One of the main drawbacks for chemistry students is to learn the periodic table by memorizing as they find it boring. Therefore the development of creative educational methodologies to engage students in interactive enjoyable learning may solve this problem. Games are a promising teaching alternative as they can be designed for teaching specific topics, and this might allow students to learn in more entertaining way compared to the traditional lecture format.[6-7] Different authors —Russell,[6,8] Denny,[9] Crute,[10] Pieroni,[11] and co-workers— are excellent promoters of chemical games for teaching purposes and they have reported amazing chemistry games with successful pedagogical results. Card games are a widely used approach for that purpose with results that confirm that they are a powerful method to stimulate the students; and in particular they have been used to teach the periodic table.[12-16] However, the main disadvantage of these card games is that they only focus on the most significant elements. These games also fail in teaching the position of elements in the periodic table as they mainly focus on the correlation between names and symbols of the elements.

Therefore, our aim was to prepare a new card game (*ChemMend*) based on the position of all the elements in the periodic table, which allows students —high school students, first-year undergraduate Chemistry students or even for anyone interested in sciences— to become familiar with the periodic table. It is important to note that the aim of this game is not to memorize the positions of elements in the table, however, one of the strengths to play *ChemMend* is that all players have to review mentally the period and group during the game; and therefore this may allow students to learn

the periodic table, being the memorization a consequence of the game. We have optimized *ChemMend* with the opinion of the students after playing it, and here we present the optimized version of *ChemMend* whose cards can be printed and cut with scissors from the Supporting Information. This novel and original approach may be a real option to use in the classroom.

Materials

The different cards necessary to play *ChemMend* are included in the Supporting Information. They can be easily printed in a conventional printer and they can be cut using a scissors. Different sample cards are shown in Figure 1.

A periodic table has also been included to be use in the basic level in order to help less experienced players in case they need it. It also can be printed from the Supporting Information.

Figure 1. Example of *ChemMend* card (front of the card, left image and back of the card, right image).

ChemMend: Exploring the periodic table

ChemMend is a card game similar to *UNO*, which can be played by 2–10 players. The main goal of this game is to improve the ability of the students in the periodic table.

Rules: There are 117 cards divided in chemical meaning cards and non-chemical meaning cards. The chemical cards (90 in total) contain the symbol of each element of the periodic table (except

lanthanides and actinides elements). The non-chemical cards (27 cards) are designed to make the play more interesting and playable, and they are distributed in 4 categories —skull (4 cards), equilibrium reaction (5 cards), Mendeleiev (8 cards), and joker electron ionization (10 cards)— whose description is detailed here:

■ *Skull*. The Skull card, when played, makes to lose the turn to the player of the right, and the next player can continue with the game. If a Skull card is turned up at the beginning of play, the same rule applies.

■ *Equilibrium reaction*. The Equilibrium reaction card (⇄) changes the playing direction from clockwise to counter-clockwise and vice versa. If this card appears at the beginning of the game, the dealer starts the game in the counter-clockwise direction.

■ *Mendeleiev*. The Mendeleiev card, when played, allows the player to choose a new period or group for the next player in the game. It can also be used at the beginning of the game. These cards are introduced to acknowledgement the creator of the periodic table, Dmitri Mendeleiev, and his face is depicted in such card.

■ *Electron ionization*. When the Electron ionization card is played the next player to the person who played the card (*i.e.* the next player in rotation) must take one or two cards accordingly to the number of electrons involved (one card for –1 or two cards for –2). If turned up at the beginning of play, the same rule applies.

The actual action in *ChemMend* takes about 5–15 minutes per game, depending on the number of players involved and their knowledge of the periodic table. If necessary there is an alternative end in case there is no enough time to finish the game (after 2 rounds or more). The game must finish at the player before the player who started the game. Then the players have to count the points of their cards (1 point for each card of first period elements, 2 points for each card of second period elements, and so on). The player with fewer points wins the game.

The only difference from the difficult level and the initial one is that in the initial level is allowed to have a look in the periodic table.

Playing the game: To start the game, each player picks one card, the person with the highest atomic number is the dealer. Non-chemical cards count as zero. The playing cards are dealt by the dealer to each player (six cards to each player in the anticlockwise direction). The remaining cards are placed face down in the middle of the table (draw pile), and finally the top card of the draw pile is turned over (reference card) and placed adjacently to the draw pile; this card is the first one of the discard pile. The player to the dealer's right starts the game and has to place one of their cards on the reference card. The card played must have the same group (chemical cards), period (chemical cards), or it must be a wild card (non-chemical cards). Every player has to follow the directions of a non-chemical card (skip a turn, draw cards...) by the preceding player. When a player has only one card left in his/her hand, he/she must say aloud "*ChemMend*". If the player forgets to say "*Chem-Mend*" and another player catches him, the player who forgot to say "*ChemMend*" must draw two cards from the draw pile. The goal of the game is to finish the cards as soon as possible, so the player who first gets rid of all his cards wins the game.If necessary, there is an alternative end for the game to be used in the case of exceeded time (see above). For example, if the game is started by a Cl chemical card as the reference card on the discard pile, the first player must put down a card that belongs to the same group of the Cl (*i.e.* F, Br, I, At, or Uus) or to the same period (*i.e.* Na, Mg, Al, Si, P, S, or Ar). Alternatively, the player can put down a non-chemical card (see the functions of action cards in rules). If the player does not have any of those cards, he/she must take a card from the draw pile. If the card he/she picked up can be played, for instance, let's assume that the player takes the Br chemical card from the draw pile, the player is free to put it down now on the discard pile or he/she can decide not to play the card and then the play moves on to the next person in turn continuing the game (right side, but considering that if any equilibrium reaction cards has been played this

can change) (Figure 2).

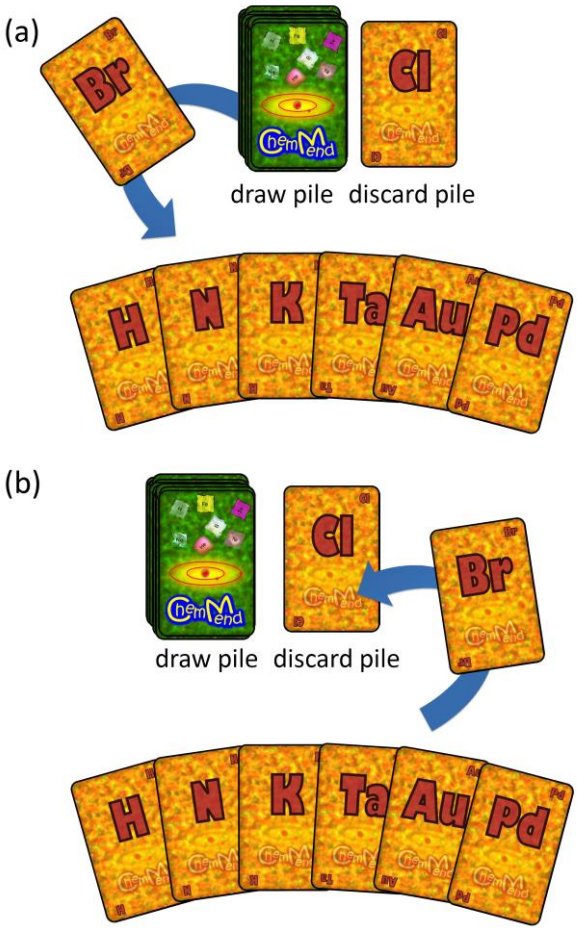


Figure 2. Example of *ChemMend* game explained in the text, in which: (a) the player does not have any of the corresponding cards to play on Cl (the 5 cards belong to different groups and periods), so the player must take a card from the draw pile (Br card); and (b) the player puts down the Br card.

Results and discussion

As described in the introduction, learning the periodic table is essential to study Chemistry, and the use of new teaching techniques can be an essential tool to motivate students to learn Chemistry in a more fun and interesting way, avoiding the initial memorization of the periodic table that was found to be a struggle for most of the high school students and for the first-year undergraduate students.

In this regard, *ChemMend* is an ideal game for the first Chemistry lessons as it teaches the period/group location of all the elements in the periodic table. In order to develop this game, an initial

version was given to a high school Physics and Chemistry class (tenth grade) where 20 students (Spanish boys and girls aged 15 and 16 years) played with the game. After that, students made a report, which allowed us to draw different conclusions. The students were satisfied with the initial version of *ChemMend* expressing in their reports positive comments such as: "The game is entertaining", "This game allows us to learn well the table", "Playing *ChemMend* makes possible to consolidate the periodic table", "*ChemMend* allows to practice placing the elements in their location and therefore our chemistry skills will improve", "I would like to buy the game to play at home", and so on. Students' suggestions and comments were analyzed in detail and allowed us to optimize the game. So, the version of the *ChemMend* game, which is presented in this paper, has the appropriate number of cards and rules for playing and for make students learn and enjoy.

We tested the optimized version of *ChemMend* with high school students of the Physics and Chemistry class (eleventh grade) in three 50 minutes sessions (29 Spanish boys (50%) and girls (50%) students of average age of 16 years old) and with first-year undergraduate Chemistry Engineering students in the Chemistry class (first year Chemistry Engineering university students) in two 45 minutes sessions (14 Spanish boys (90%) and girls (10%) students of average age of 18 years old). Students answered a quiz and a poll before and after playing the game: Seven questions and one quiz before playing the game, and six questions and one quiz after playing the game. The "before playing" poll consists in different questions that allow to find out if students are familiar with the periodic table and its elements, and if it is difficult for them to study the periodic table. The questions are: Are you familiar with the periodic table?; Do you know the position of the periodic table elements?; Do you find it tedious to study the position of the periodic table elements?. Then, there are some questions related to the instructions, design, usefulness, and first impression of the *ChemMend* game. The questions are: Do you think that the instructions for playing *ChemMend* are sufficiently clear?; After reading the instructions, do you think *ChemMend* can help you to discover

the periodic table?; Do you like the design of the game cards?. All these questions are answered using adjectives such as: much, enough, little, or useless. The last "before playing" activity is a quiz with a periodic table with 13 blanks that students have to fill with the appropriate elements. Afterwards, students played the game for several sessions in different days, and then they performed the "after playing" activities that consist in different questions and the same periodic table quiz. It must be stressed that the quiz allows evaluating the students' improvement of their knowledge of the periodic table (Figure 3). The "after playing" poll consists in questions about the *ChemMend* game rounds that students have played. Students are asked to evaluate the efficacy of the game (much, enough, little, or useless), the utility of *ChemMend* to learn the position of the elements into the periodic table; and finally if they would recommend the game. These "after playing" questions are: How many times have you played *ChemMend*?; Did you consolidate the elements of the periodic table by playing the game?; Did *ChemMend* help you to learn the relative position of the periodic table elements?; Did *ChemMend* help you to improve your level of knowledge of the periodic table?; Would you recommend the use of *ChemMend*?.

The results of the quiz before and after playing the game (the periodic table with 13 blanks described previously) show an increase of average score of the students for both groups (eleventh grade high school Physics and Chemistry class and first-year undergraduate Chemistry class); it increases from 5.7 ± 0.5 to 6.5 ± 0.5 for high school students, and from 4.7 ± 0.7 to 7.4 ± 0.4 for first-year engineering Chemistry students (the maximum score is 10). This indicates that playing *ChemMend* may improve the knowledge of the periodic table (Figure 3a). Figure 3b shows the raw data obtained from the quiz before (horizontal axis) and after playing the game (vertical axis). In this regard, the data points in the Figure 3b in the upper left half show an improvement by playing the game, *i.e.* the marks obtained after playing the game are larger than the marks obtained before playing the game. In particular 67% and 79% of the students improved their marks in the quiz by

playing the game, for high school and undergraduate students, respectively. The results of the poll indicate that students have a good first impression of the *ChemMend* game after reading the instructions; and they think that playing the game will help them to improve their knowledge of the periodic table and nobody thinks that it will be useless (16% much, 81% enough, 3% little, 0% useless, for high school; and12% much, 65% enough, 24% little, 0% useless for university). After playing the game, 94% (high school) and 89% (university) of the students think that they have learned the relative position of elements in the periodic table by playing *ChemMend*. Moreover, 69% (high school) and 78% (university) of the students consider that playing *ChemMend* has improved their knowledge of the periodic table. Interestingly, 90% (high school) and 94% (university) of students would recommend the use of *ChemMend*. Teachers also feel enthusiastic with the game, and they will use *ChemMend* in next years to introduce and to remind the periodic table. Therefore the results show that *ChemMend* is a real enjoyable alternative activity in the classroom for the first Chemistry lessons.

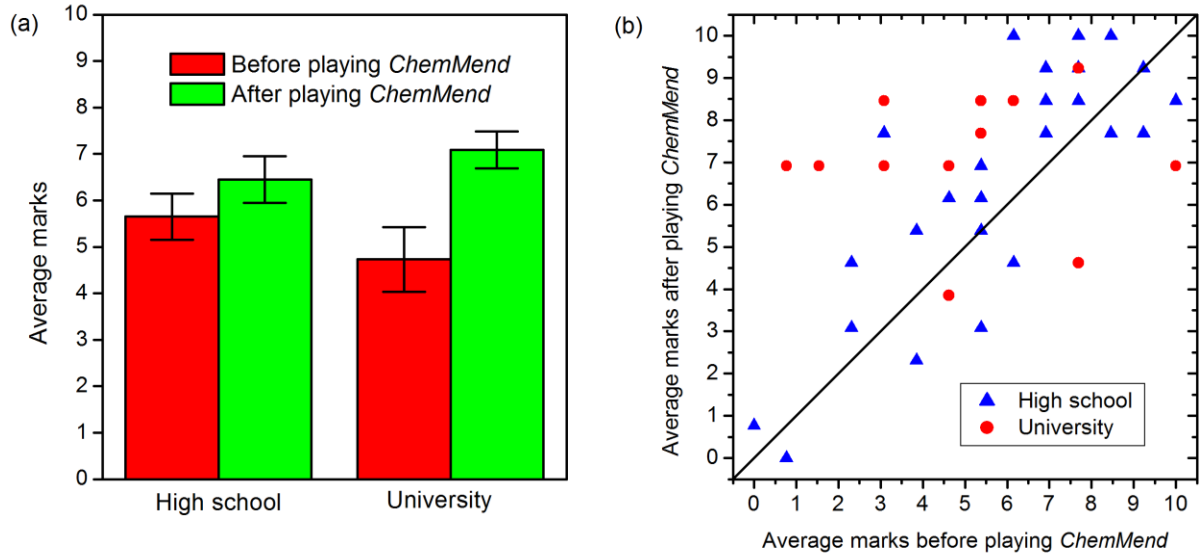


Figure 3. Results of the quiz before and after playing *ChemMend*: (a) average marks, (b) raw data.

Conclusions

ChemMend has been found to be a useful tool for teaching the periodic table in an entertaining way, as the game has been designed to attract the attention of the students. The game allows students to review mentally the period and group for each play during the game and therefore this may allow students to learn the periodic table by playing the game. Thus, the developed card game will introduce a new manner to teach the periodic table in the classroom.

ASSOCIATED CONTENT

Supporting Information. A file with card images for printing and a periodic table. This material is available free of charge via the Internet at http://pubs.acs.org

AUTHOR INFORMATION

Corresponding Authors

martiv@uji.es (V.M.-C.) and jrubio@uji.es (J.R.-M.)

Author Contributions

The manuscript was written through contributions of all authorsand all authors have given approval to the final version of the manuscript. ‡These authors contributed equally.

ACKNOWLEDGMENT

The authors would like to thank Sergio Menargues Irles for critical reading of the initial version of the manuscript and for testing with the tenth grade students (Physics and Chemistry class) from the Colegio Sagrado Corazón Hermanos Maristas (Alicante, Spain). Their helpful comments and suggestions after playing the first version of *ChemMend* are warmly acknowledged. The authors would also like to thank: Eduardo García-Verdugo Cepeda and the first year Chemistry Engineering university students (Chemistry class) at Universitat Jaume I (Castellón, Spain); and Francisco Sanchez

Tarrega and the eleventh grade students (Physics and Chemistry class) from IES Sa Colomina (Eivissa, Spain) for testing the final version of the game.

Notes

The authors declare no competing financial interest.

REFERENCES

(1) Silva, A.; Barroso, M. F.; Freitas, O.; Teixeira, S.; Morais, S.; Delerue-Matos, C. The Periodic Table: Contest and Exhibition. *J. Chem. Educ.* **2006**, *83* (4), 557−560.

(2) Rouvray, D. H. Elements in the history of the Periodic Table. *Endeavour* **2004**, *28* (2), 69−74.

(3) Kirschner, S. Chemical Periodicity. *J. Chem. Educ.* **1961**, *38* (5), 274.

(4) Mabrouk, S. T. The Periodic Table as a Mnemonic Device for Writing Electronic Configurations. *J. Chem. Educ.* **2003**, *80* (8), 894−898.

(5) von Marttens Osorio, H.; Goldschmidt, A. The electronic periodic chart of the element. *J. Chem. Educ.* **1989**, *66* (9), 758−761.

(6) Russell, J. V. Using Games to Teach Chemistry: An Annotated Bibliography. *J. Chem. Educ.* **1999**, *76* (4), 481−484.

(7) Antunes, M.; Pacheco, M. A. R.; Giovanela, M. Design and Implementation of an Educational Game for Teaching Chemistry in Higher Education. *J. Chem. Educ.* **2012**, *89* (4) 517−521.

(8) Granath, P. L.; Russell, J. V. Using Games to Teach Chemistry. 1. The Old Prof Card Game. *J. Chem. Educ.* **1999**, *76* (4), 485−486.

(9) Denny, R. A.; Lakshmi, R.; Chitra, H.; Devi, N. Elementary "Who Am I" Riddles. *J. Chem. Educ.* **2000**, *77* (4), 477−478.

(10) Crute, T. D. *J.* Classroom Nomenclature Games—BINGO. *J. Chem. Educ.* **2000**, *77* (4), 481−482.

(11) Pieroni, O. I.; Vuano, B. M.; Ciolino, A. E. Classroom innovation: games to make chemistry more interesting and fun. *Chem. Educ.* **2000**, *5* (4), 167−170.

(12) Kavak, N. ChemPoker. *J. Chem. Educ.* **2012**, *89* (4), 522−523.

(13) Franco Mariscal, A. J.; Oliva Martínez, J. M.; Bernal Márquez, S. An Educational Card Game for Learning Families of Chemical Elements. *J. Chem. Educ.* **2012**, *89* (8) 1044−1046.

(14) Alexander, S. V.; Sevcik, R. S.; Hicks, O. D.; Schultz, L. D. Elements—A Card Game of Chemical Names and Symbols. *J. Chem. Educ.* **2008**, *85* (4), 514−515.

(15) Elementeo Chemistry Card Game. http://www.elementeo.com/ (accessed Nov 2013).

(16) Chemundo Home Page. http://www.eduris.de/chemundo-neue_auflage_feb2009.htm (accessed Nov 2013).

Supporting information for:

ChemMend: A Card Game To Introduce and Explore the Periodic Table while Engaging Student's Interest

Vicente Martí-Centelles[a]* and Jenifer Rubio-Magnieto[a]*

[a] *Departamento de Química Inorgánica y Orgánica, Universitat Jaume I, Avda. Sos Baynat, s/n, E-12071 Castellón (Spain). E-mail: martiv@uji.es and jrubio@uji.es.*

H

He

Li

Be

B

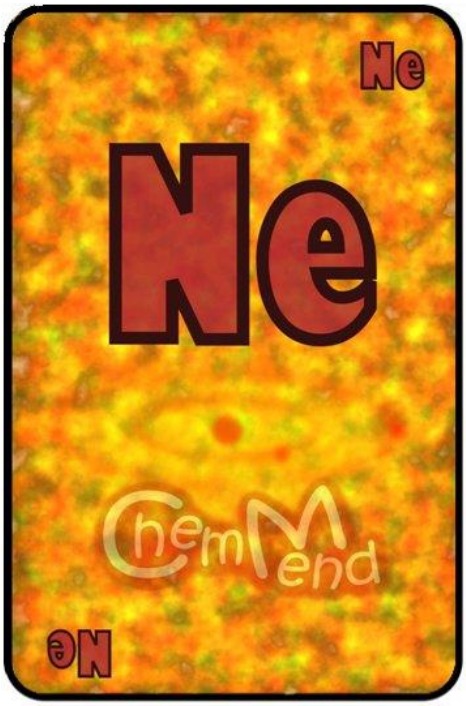
C

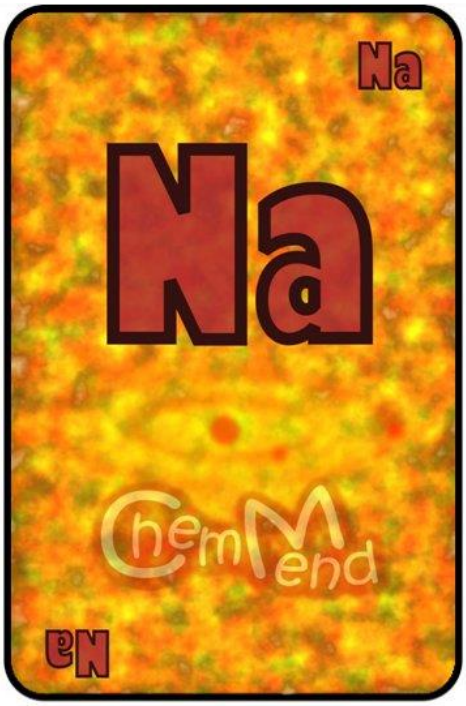
N

O

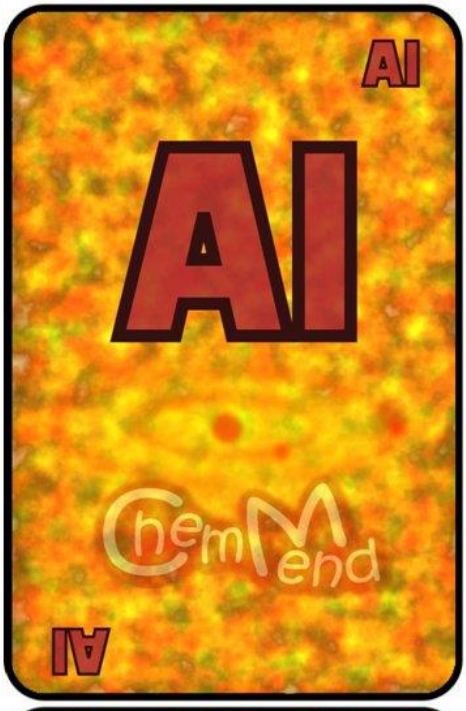
F


H
Fe
Te
B
Ne
He
Ni
ChemMend

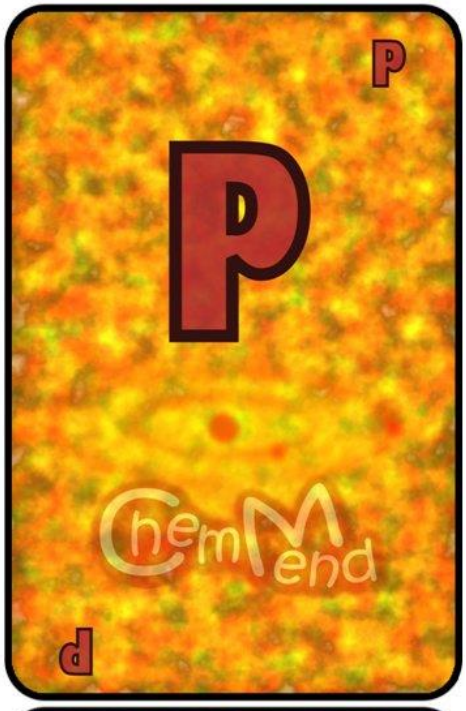

Ne
Ne
ChemMend


Na
Na
ChemMend

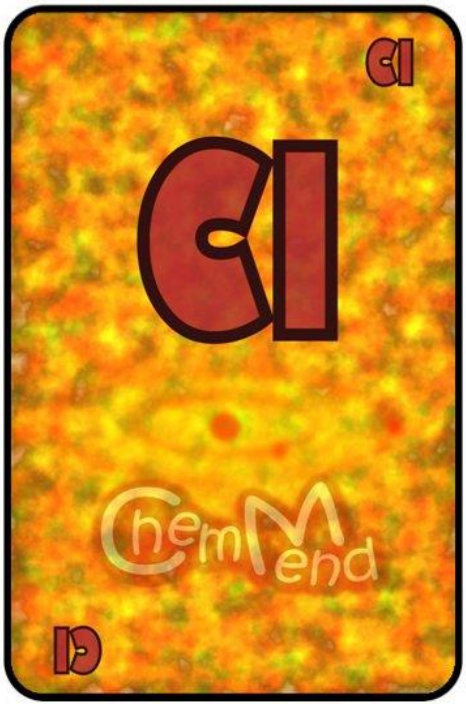

Mg
Mg
ChemMend

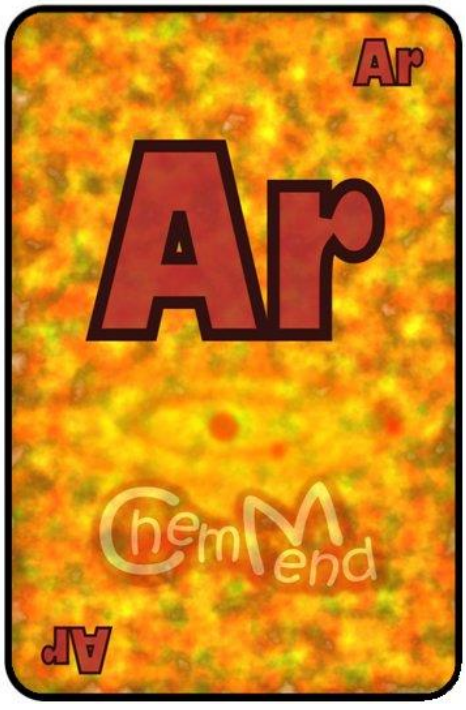

Al
Al
ChemMend


Si
Si
ChemMend


P
P
ChemMend


S
S
ChemMend


Cl
Cl
ChemMend


Ar
Ar
ChemMend


H
Fe
Te
B
Ne
He
Ni
ChemMend

K

ChemMend

Ca

ChemMend

Sc

ChemMend

Ti

ChemMend

V

ChemMend

Cr

ChemMend

Mn

ChemMend

Fe

ChemMend

Co

ChemMend


H
Fe
Te
B
Ne
He
Ni
ChemMend

Ni

Cu

Zn

Ga

Ge

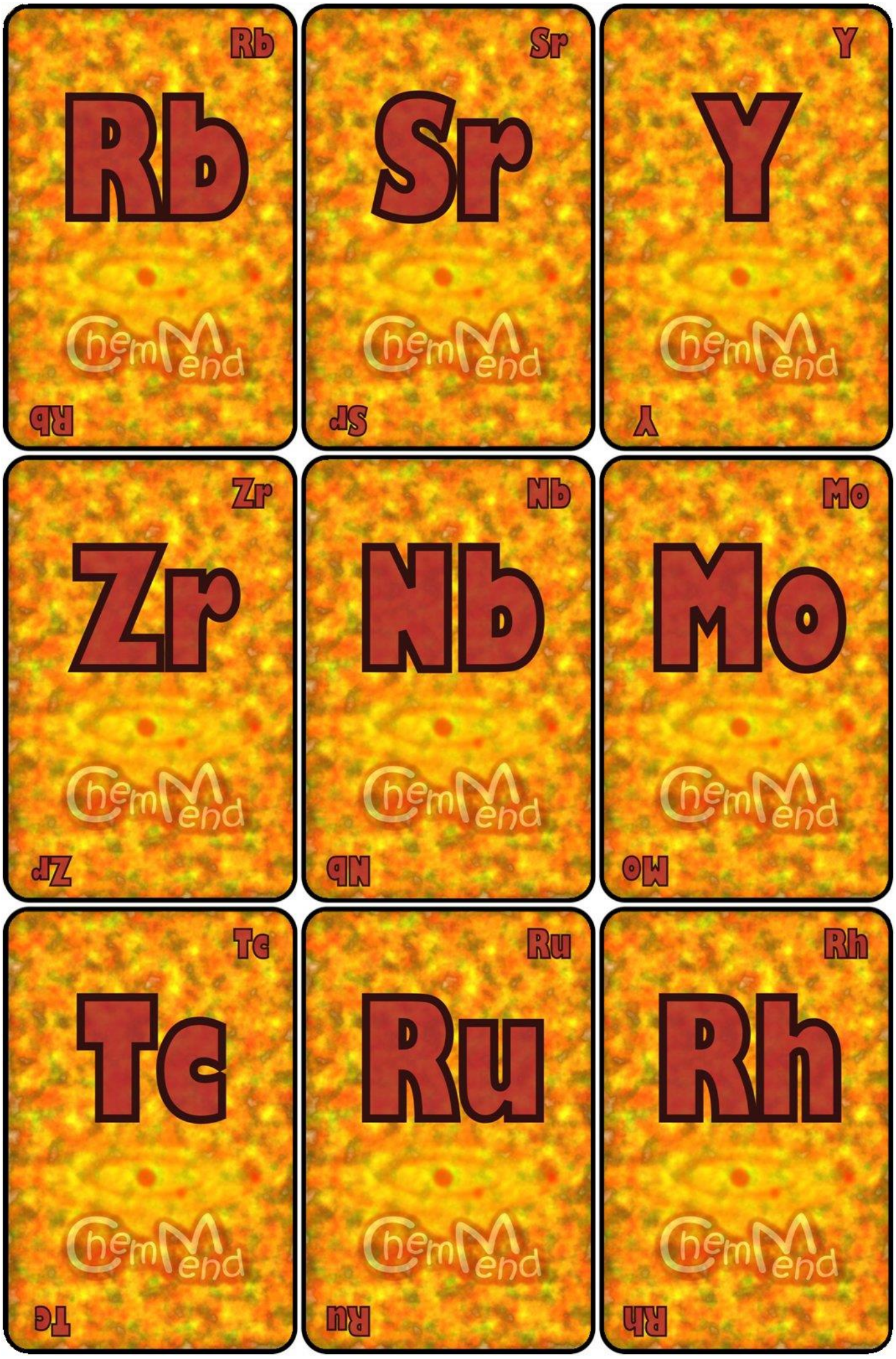
As

Se

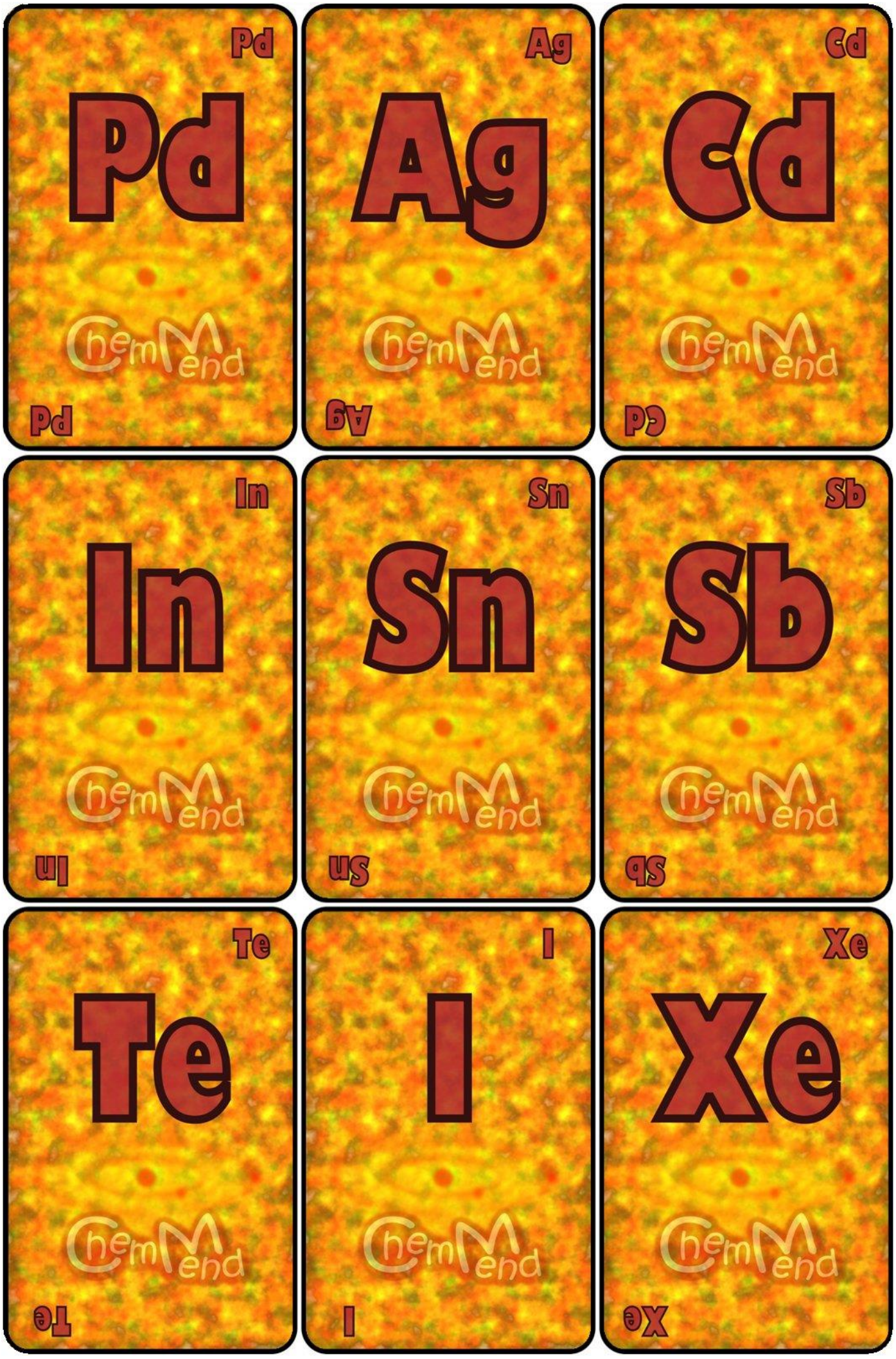
Br

Kr


H
Fe
Te
B
Ne
He
Ni
ChemMend


Rb
Rb
ChemMend
Rb
Sr
Sr
ChemMend
Sr
Y
Y
ChemMend
Y
Zr
Zr
ChemMend
Zr
Nb
Nb
ChemMend
Nb
Mo
Mo
ChemMend
Mo
Tc
Tc
ChemMend
Tc
Ru
Ru
ChemMend
Ru
Rh
Rh
ChemMend
Rh


H
Fe
Te
B
Ne
He
Ni
ChemMend


Pd
Pd
ChemMend
Pd
Ag
Ag
ChemMend
Ag
Cd
Cd
ChemMend
Cd
In
In
ChemMend
In
Sn
Sn
ChemMend
Sn
Sb
Sb
ChemMend
Sb
Te
Te
ChemMend
Te
I
I
ChemMend
I
Xe
Xe
ChemMend
Xe


H
Fe
Te
B
Ne
He
Ni
ChemMend

Cs

ChemMend

Ba

ChemMend

Lu

ChemMend

Hf

ChemMend

Ta

ChemMend

W

ChemMend

Re

ChemMend

Os

ChemMend

Ir

ChemMend


H
Fe
Te
B
Ne
He
Ni
ChemMend

Pt

Au

Hg

Tl

Pb

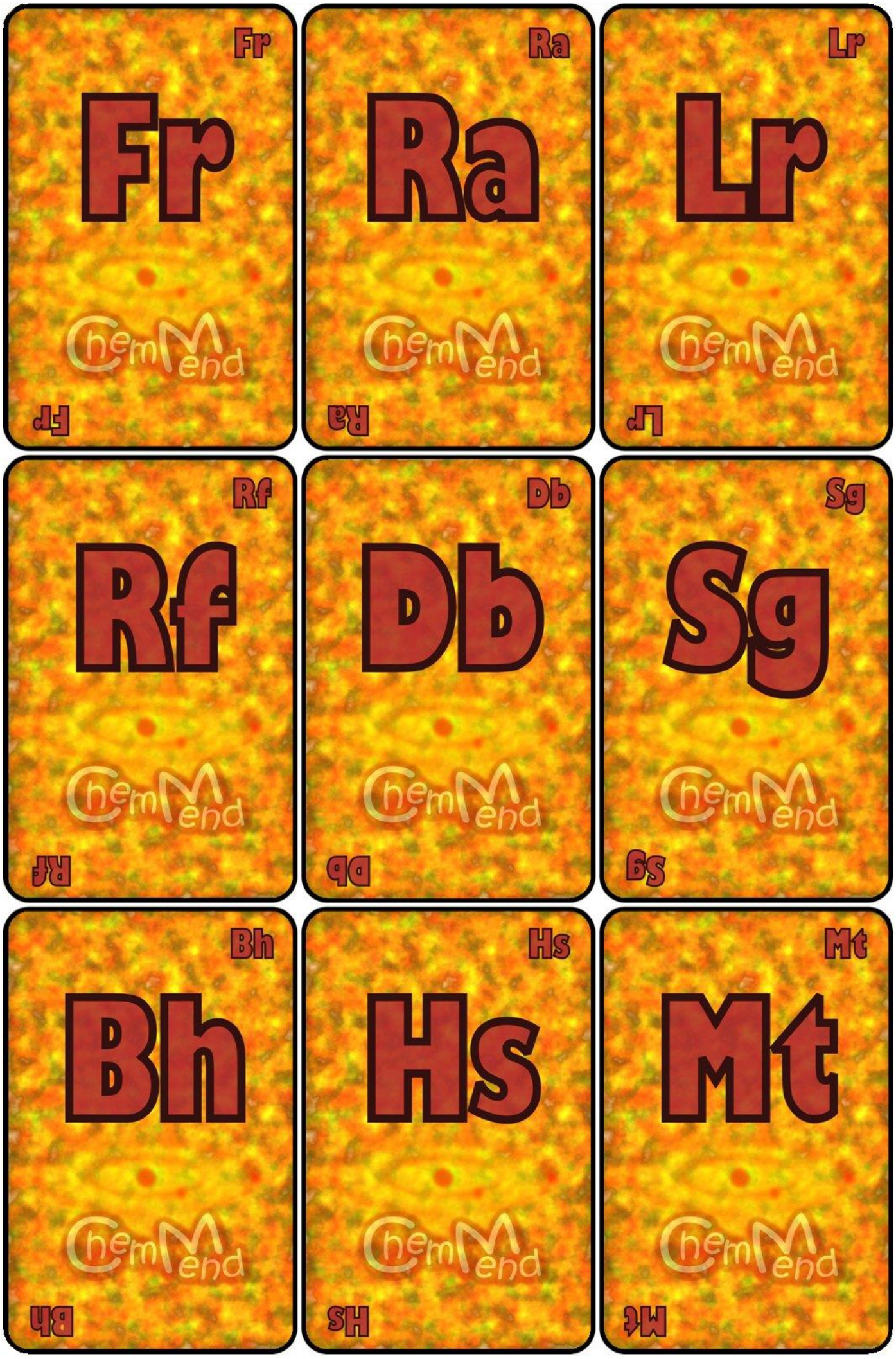
Bi

Po

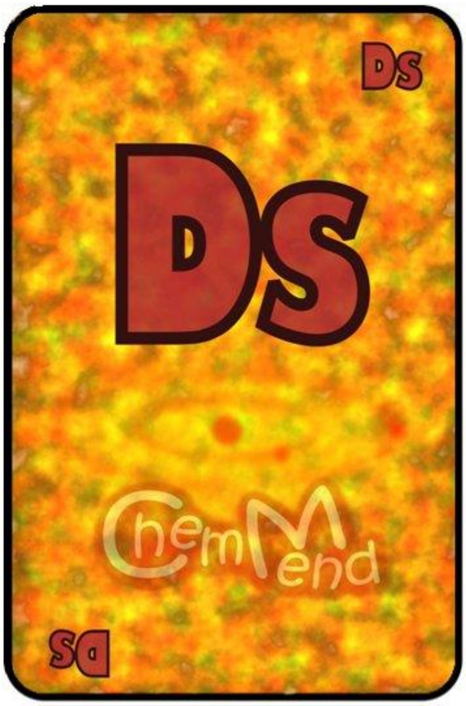
At

Rn

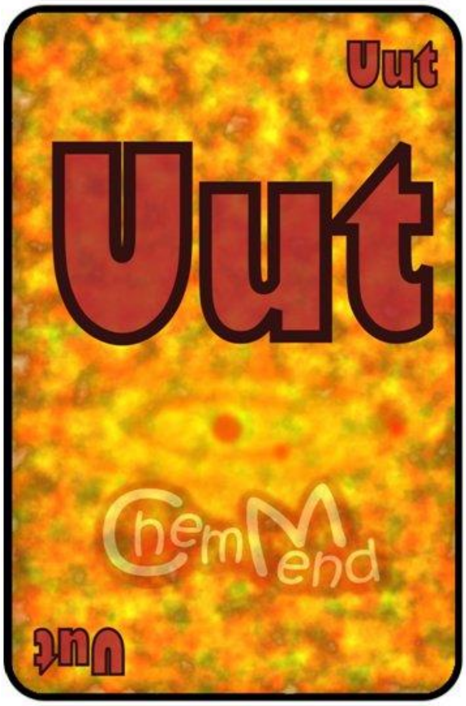

H
Fe
Te
B
Ne
He
Ni
ChemMend

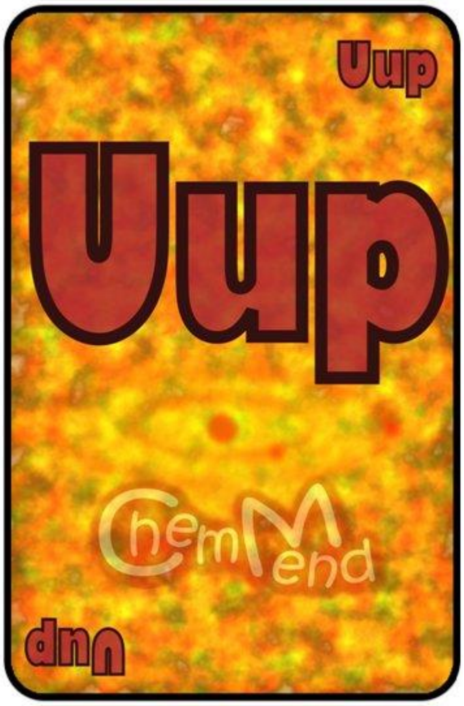

Fr
Fr
ChemMend
Fr
Ra
Ra
ChemMend
Ra
Lr
Lr
ChemMend
Lr
Rf
Rf
ChemMend
Rf
Db
Db
ChemMend
Db
Sg
Sg
ChemMend
Sg
Bh
Bh
ChemMend
Bh
Hs
Hs
ChemMend
Hs
Mt
Mt
ChemMend
Mt

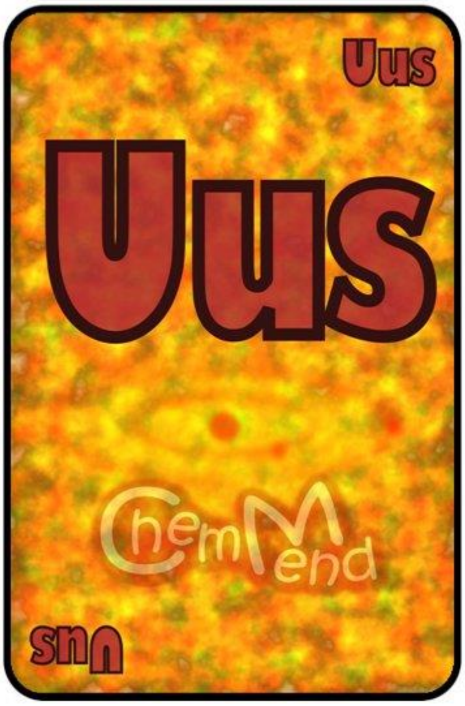
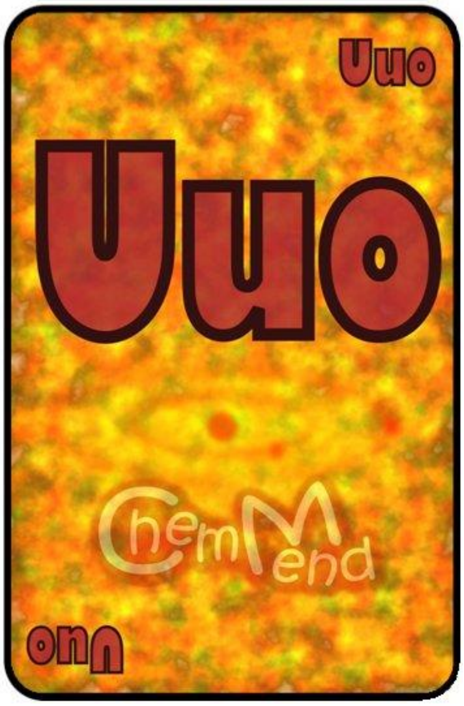

H
Fe
Te
B
Ne
He
Ni
ChemMend


Ds
Ds
ChemMend
Ds

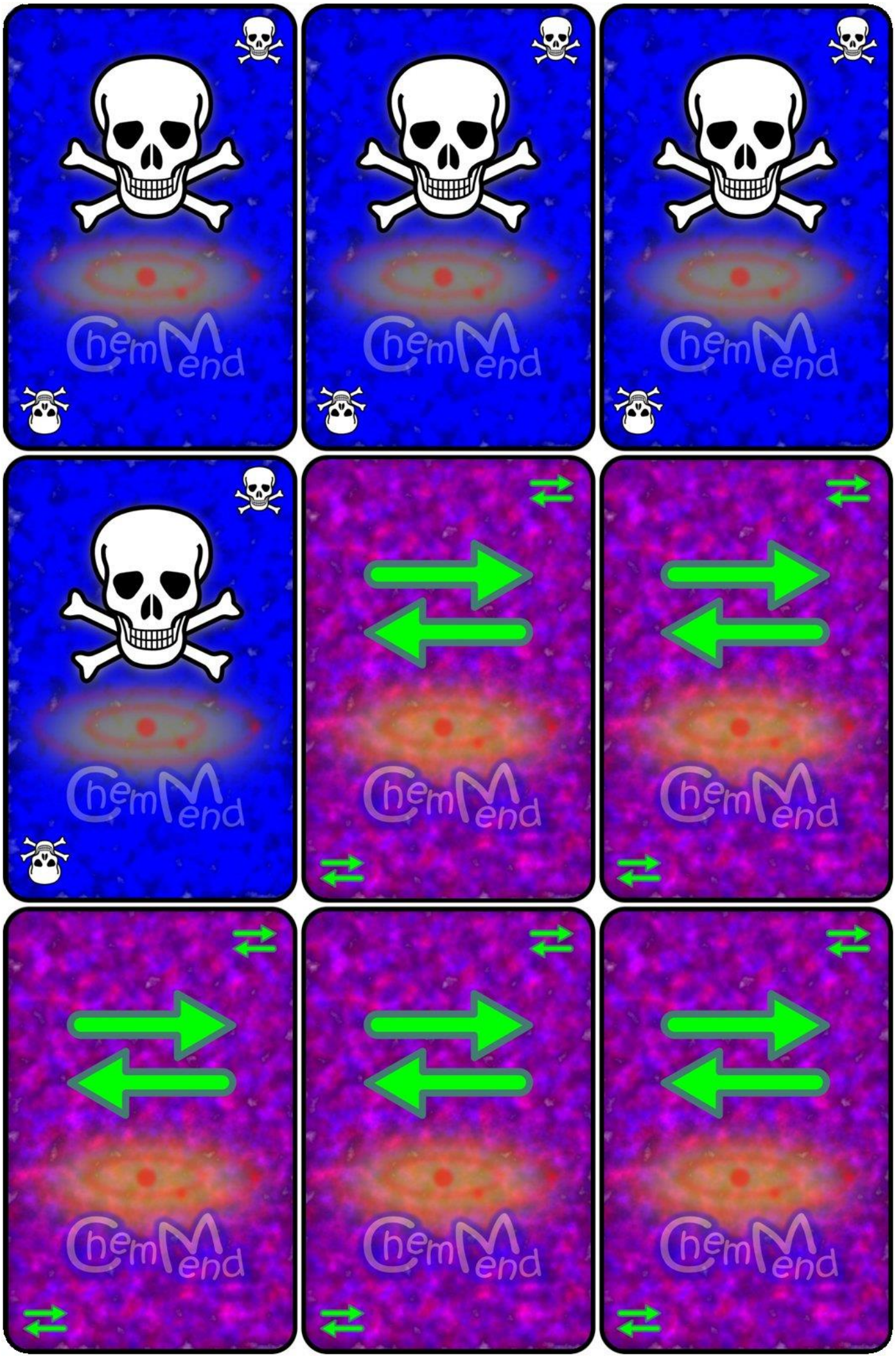
Rg
Rg
ChemMend
Rg

Cn
Cn
ChemMend
Cn

Uut
Uut
ChemMend
Uut

Fl
Fl
ChemMend
Fl

Uup
Uup
ChemMend
Uup

Lv
Lv
ChemMend
Lv

Uus
Uus
ChemMend
Uus

Uuo
Uuo
ChemMend
Uuo


H
Fe
Te
B
Ne
He
Ni
ChemMend


ChemMend

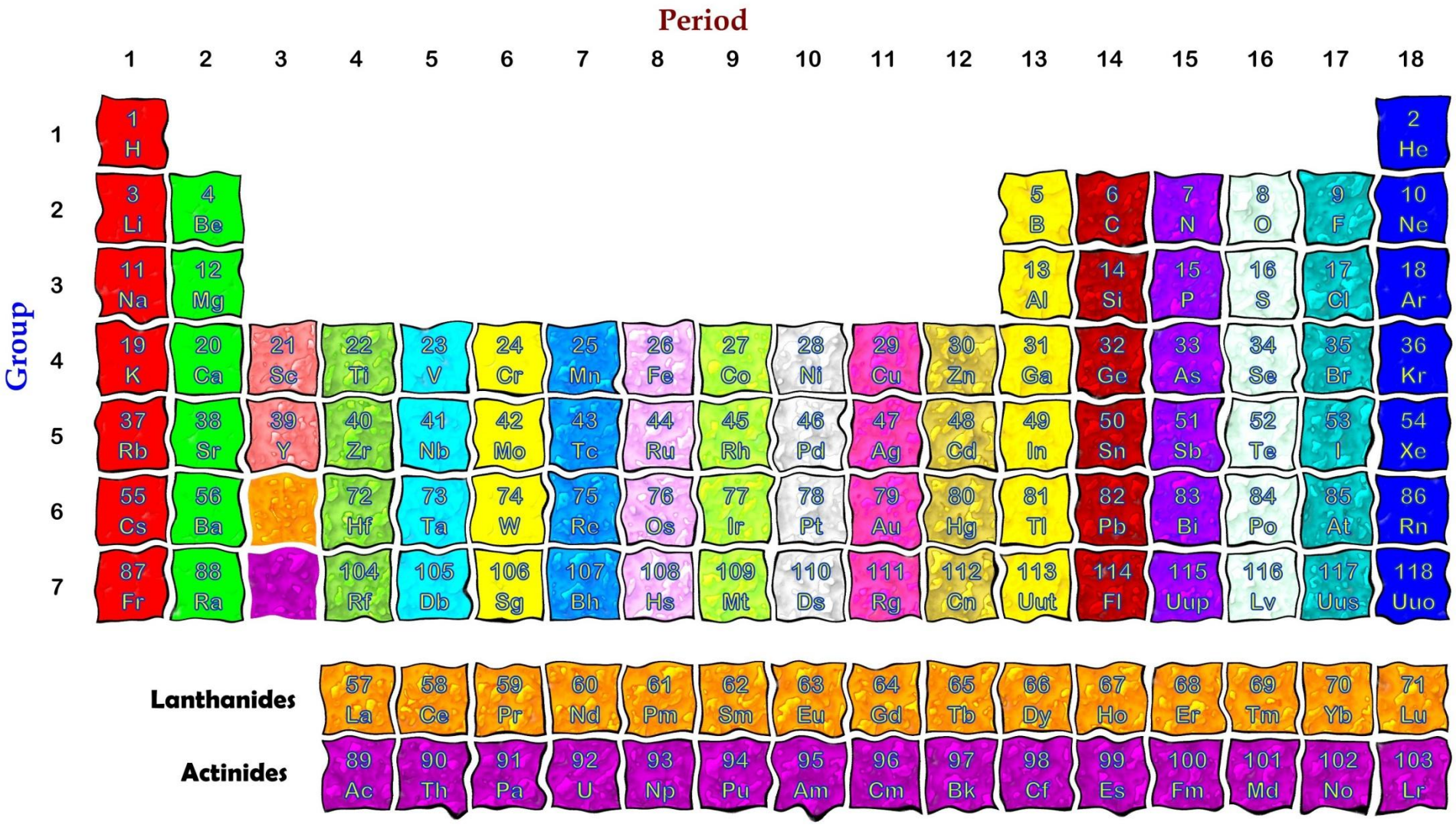

H
Fe
Te
B
Ne
He
Ni
ChemMend


ChemMend
ChemMend
ChemMend
ChemMend
ChemMend
ChemMend
ChemMend
ChemMend
-1 e-
ChemMend


H
Fe
Te
B
Ne
He
Ni
ChemMend


-1 e-
ChemMend
-1 e-
ChemMend
-1 e-
ChemMend
-1 e-
ChemMend
-1 e-
ChemMend
-1 e-
ChemMend
-1 e-
ChemMend
-2 e-
ChemMend
-2 e-
ChemMend


H
Fe
Te
B
Ne
He
Ni
ChemMend


Period
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Group
1 2 3 4 5 6 7
1 H
2 He
3 Li
4 Be
5 B
6 C
7 N
8 O
9 F
10 Ne
11 Na
12 Mg
13 Al
14 Si
15 P
16 S
17 Cl
18 Ar
19 K
20 Ca
21 Sc
22 Ti
23 V
24 Cr
25 Mn
26 Fe
27 Co
28 Ni
29 Cu
30 Zn
31 Ga
32 Ge
33 As
34 Se
35 Br
36 Kr
37 Rb
38 Sr
39 Y
40 Zr
41 Nb
42 Mo
43 Tc
44 Ru
45 Rh
46 Pd
47 Ag
48 Cd
49 In
50 Sn
51 Sb
52 Te
53 I
54 Xe
55 Cs
56 Ba
72 Hf
73 Ta
74 W
75 Re
76 Os
77 Ir
78 Pt
79 Au
80 Hg
81 Tl
82 Pb
83 Bi
84 Po
85 At
86 Rn
87 Fr
88 Ra
104 Rf
105 Db
106 Sg
107 Bh
108 Hs
109 Mt
110 Ds
111 Rg
112 Cn
113 Uut
114 Fl
115 Uup
116 Lv
117 Uus
118 Uuo
Lanthanides
57 La
58 Ce
59 Pr
60 Nd
61 Pm
62 Sm
63 Eu
64 Gd
65 Tb
66 Dy
67 Ho
68 Er
69 Tm
70 Yb
71 Lu
Actinides
89 Ac
90 Th
91 Pa
92 U
93 Np
94 Pu
95 Am
96 Cm
97 Bk
98 Cf
99 Es
100 Fm
101 Md
102 No
103 Lr