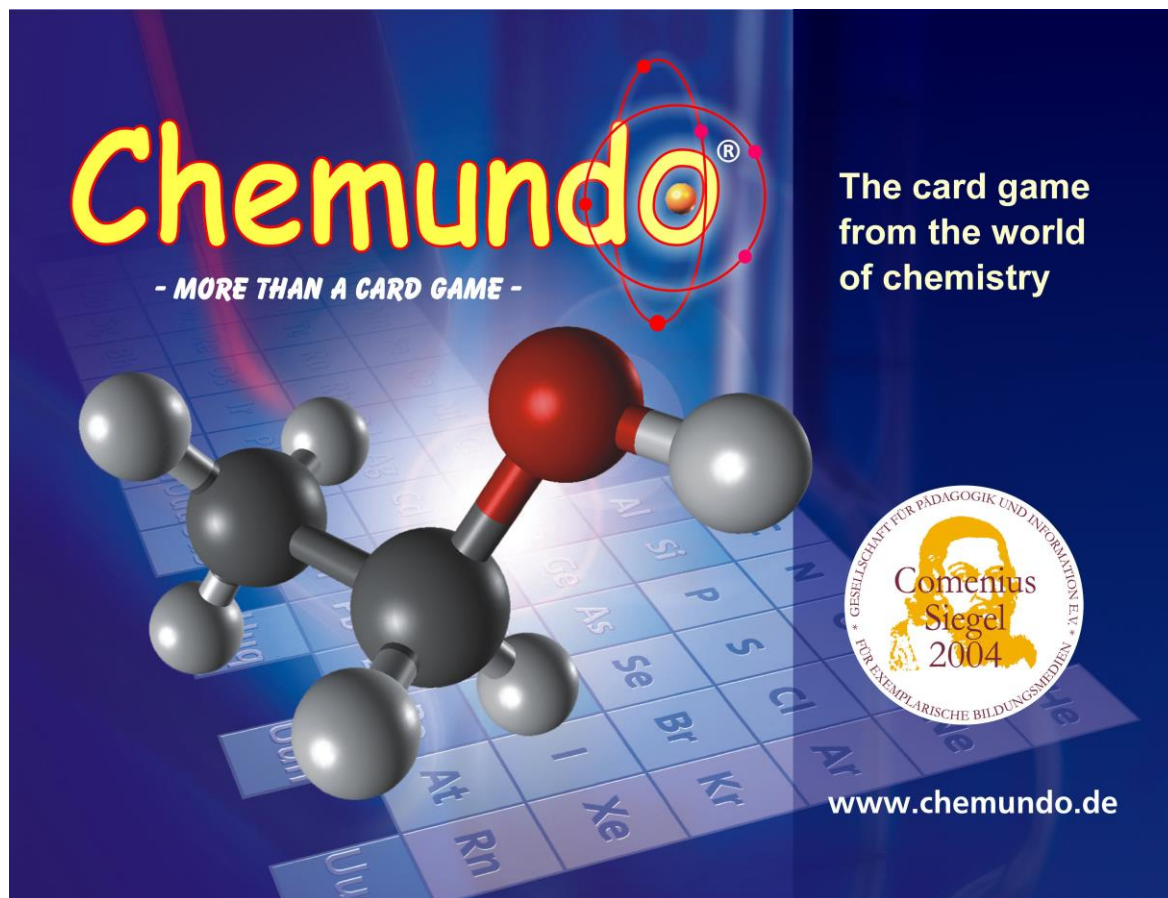


Chemundo® - Rules & Chemistry



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In June 2004, already the first edition of Chemundo®, was honored with the COMENIUS-AWARD in the category of outstanding edutainment products from the Society for Pedagogy and Information in Berlin (SPI).

Link to: www.gpi-online.de for more information.

The game Chemundo® contents:

- ◆ 40 organic chemistry cards (OC)
- ◆ 40 inorganic chemistry cards (IC)
- ◆ 21 action cards
- ◆ 6 jokers (portraits of famous pioneers of chemistry) *and a*
- ◆ booklet (25p.) about Rules & Chemistry



Image: 6th Chemundo® edition 2013 - ISBN 978-3-9815848-0-6



What can we learn by playing Chemundo®?

Basic inorganic chemistry, nomenclature and stoichiometry (i.e., the ratio of the ions), basic organic chemistry, e.g. nomenclature, molecular formula in 2- and 3D, hazard symbols (GHS pictograms) and many more things about chemistry...

I. Chemundo® – Rules of the game (basic versions)

(for more comprehensive instructions consult [or: link to] www.eduris.de)

I.1 General features

The object of this game is to be the first to go out. Chemundo® can be played using the inorganic chemistry (IC) deck or the organic chemistry (OC) deck of cards. The game can be played by two to five players.

The players choose a referee who makes sure that the players name the individual chemical compounds correctly. The tables on pages 8 and 9 may serve to assist the referee.

I.2 The game

Before shuffling remove all jokers.

After shuffling the IC or OC deck, the dealer deals seven cards to each player.

The remaining cards form the drawing pile, which is placed in the center of the table. The top card of this drawing pile is turned over, thereby creating the discard pile.

The neighbor to the left of the dealer begins by placing a matching card onto the open card of the discard pile.

He may discard a regular card, that is a chemical compound card, or an action card. These will be explained in detail.

If the player is unable to drop a card, he has to pick up a card from the drawing pile.

When discarding a card, the player has to name the compound shown loudly and clearly, and also the stoichiometry (i.e., the ratio of ions) when playing with the IC deck. Thereby, the proper suffixes (indicated by purple question marks on the individual cards) have to be identified and stated, and the player has to decide whether the purple parentheses can be omitted.

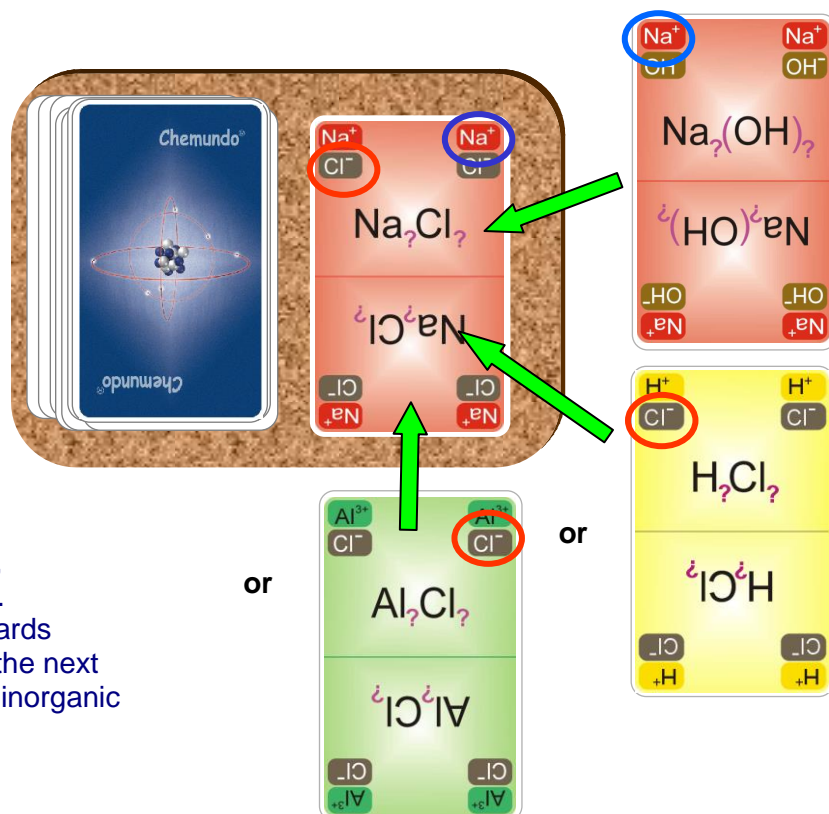
The referee may use the Listing of the proper nomenclature to check whether the compound has been named correctly (see tables on pages 8-9). The player has to pick up a penalty card from the drawing pile if he fails to name the compound correctly.

At the onset of a game the players may decide on the exact details of the naming process.

I.3. Playing with the IC (inorganic chemistry) card deck

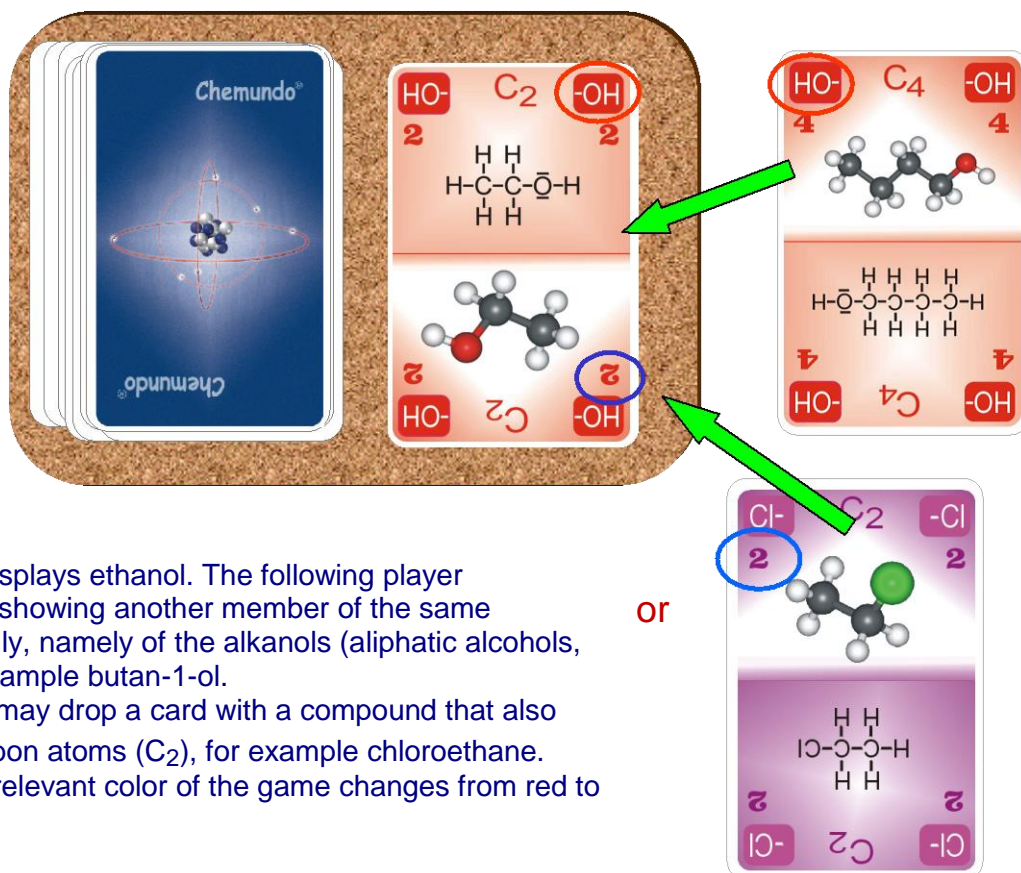
The player may only discard a card that has the same cation or anion as the card face up on the discard pile. The color of the cards is determined by the respective cations.

Example:
The top card of the discard pile is sodium chloride (red card).
Then the following player can drop a card displaying a sodium compound, e.g. sodium hydroxide (NaOH, red), onto it.
Alternatively, he may drop a card displaying the anion chloride or an IC-chloro compound, e.g. hydrochloric acid (HCl, yellow).
In the latter case, the color of the cards changes from red to yellow. Then, the next player can discard a chloride or an inorganic hydrogen compound card.



I.4. Playing with the OC- (organic chemistry) card deck

A characteristic color has been assigned to each family of homologous compounds. Therefore, only a card showing a compound homologous to the card face up on the discard pile may be discarded. Alternatively, a card from another family of homologous compounds, which contains the identical number of carbon atoms, may be dropped.



Example:

The open card displays ethanol. The following player may drop a card showing another member of the same homologous family, namely of the alkanols (aliphatic alcohols, red cards), for example butan-1-ol. Alternatively, he may drop a card with a compound that also contains two carbon atoms (C_2), for example chloroethane. In this case, the relevant color of the game changes from red to purple.

I.5. End of the game

Once a player has only one card left in his hand, he has to say "Chemundo" loudly and clearly; if he fails to do so he has to pick up a penalty card. The winner is who gets rid of all of his cards first. At this point the game is over.

I.6. The action cards

If a player drops an action card, the subsequent player has to obey the action imposed by this special card, that is unless he can undo the required action by discarding the appropriate action card.

If the discarded card displays a GHS symbol of danger or classification of hazard, its definition has to be explained correctly. Otherwise a penalty card has to be picked up.

Certain action cards may only be dropped onto cards of a certain color. In this case, no change or only a limited change of color occurs. These special cards are:



Skip (Symbol: Traffic sign; hazard symbols/GHS pictogram; 2 cards)

The following player has to skip one round.

**+1 all** (hazard symbol cards)

All players – excluding the player who leads – have to pick up one card each. The subsequent player may respond by using a © Neutralization Card.

**Equilibrium Reaction** (2 cards; limited change of color)

If the Equilibrium Reaction card is dropped, the direction of the game, and hence the sequence of the players is reversed. The test tubes depicted indicate onto which colors this card may be discarded. The player who discards this card decides which color is to follow.

**Fortune Card** (Symbol: Clover leaf, 3 'X-Cards')

Whoever drops this card, may immediately drop another card of his choice or may transfer it to a player of his choice. This is an attractive option to get rid of the 'Coal Man' (see below).

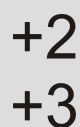
The following action cards may be discarded onto any card (common symbol: 5 test tubes):

**'Coal Man'** (Comic figure with the carbon symbol)

If a player drops this card, he receives one card from each player. He may, however, specify, in which color the game is to continue. Therefore, the best strategy is to avoid discarding this card, and to wait for a Fortune Card, upon which this malicious card may be transferred to another player.

**Change of Color**

The player who discards this card may choose a color of his choice. Try to avoid speaking of colors, instead say: sodium salts, alkanes etc.

**+2/+3-Cards** (hazard pictograms, 5 cards)

The subsequent player has to pick up two or three cards, respectively. The player decides, with which compound or in which color the game is to continue. The ensuing player can pass on the required action to the next player by adding yet another +2/+3-Card to the discard pile. Then the next player has to pick up the corresponding number of cards.

**Neutralization Card** (blue signs, 4 cards)

This card has a special function: it neutralizes the required action of almost every action card.



Example: A player drops a +3-Card. The subsequent player may respond by discarding the Neutralization Card, i.e., he does not have to pick up three cards, instead he may choose the color in which the game is to continue.

Accordingly, the Neutralization Card may also be used as a Change of Color Card, without necessarily neutralizing an action. It, however, cannot neutralize the Skip or the Coal Man card (compared to the *OLD MAID*-card of classical card games).

3 Examples: Action cards with GHS pictograms and their impact on the game:



Subsequent player has to pick up 2 cards plus option to change color.



All players pick up 1 card (excluding the player who leads)



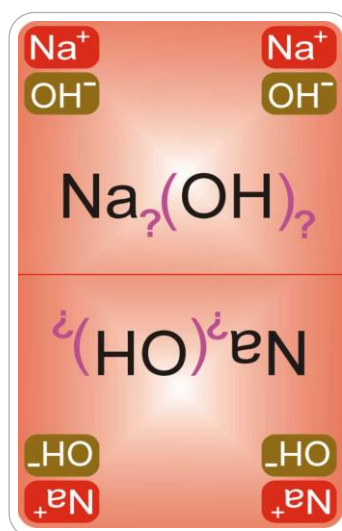
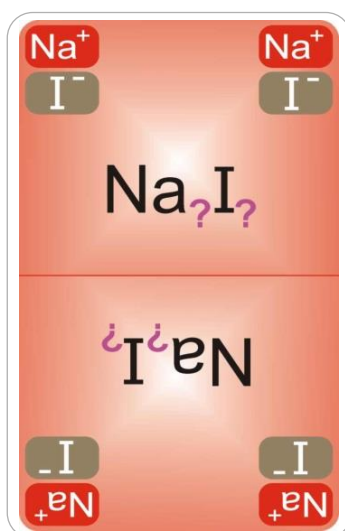
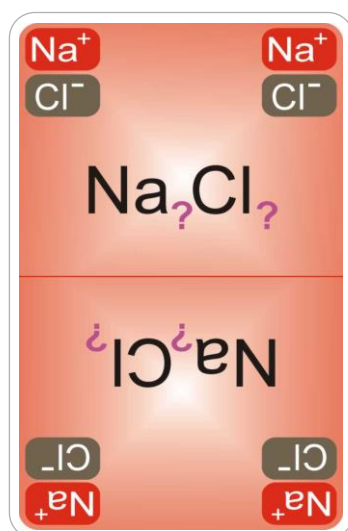
Subsequent player has to skip one round.

II. Rules for playing Chemundo®-Rummy

To play Chemundo®-Rummy, remove all the action cards except the 6 jokers.

The number of players should be between 3 and 5. Every player is dealt 11 cards - face down - the rest is placed as a drawing pile in the center of the table. The object of the game is to collect and to organize cards in sets. The first player to put down all of his cards is the winner and the game is immediately over. Sets may consist of

- # OC-cards (organic chemistry cards) displaying compounds with **the same number of carbon atoms, or of the same homologous family, for example three alkanols (alcohols),** or for
- # IC-cards (inorganic chemistry cards) containing **the same anions, e.g. three chlorides, or the same cations and respectively, anions, which end in -ide (for example: chloride, bromide, iodide or hydroxide) or in -ate (like: nitrate, sulfate, carbonate or phosphate).**
e.g.: a set of sodium chloride, sodium iodide and sodium hydroxide:



How to start:

The player to the left of the dealer starts the game by picking up one card from the drawing pile or taking the top card of the discard pile and ends his turn by discarding a card face up. A first round has to be completed before the players may put down their sets of cards. In order to be eligible to put down the first series or set, i.e., to be allowed to "open", the following requirements have to be met:

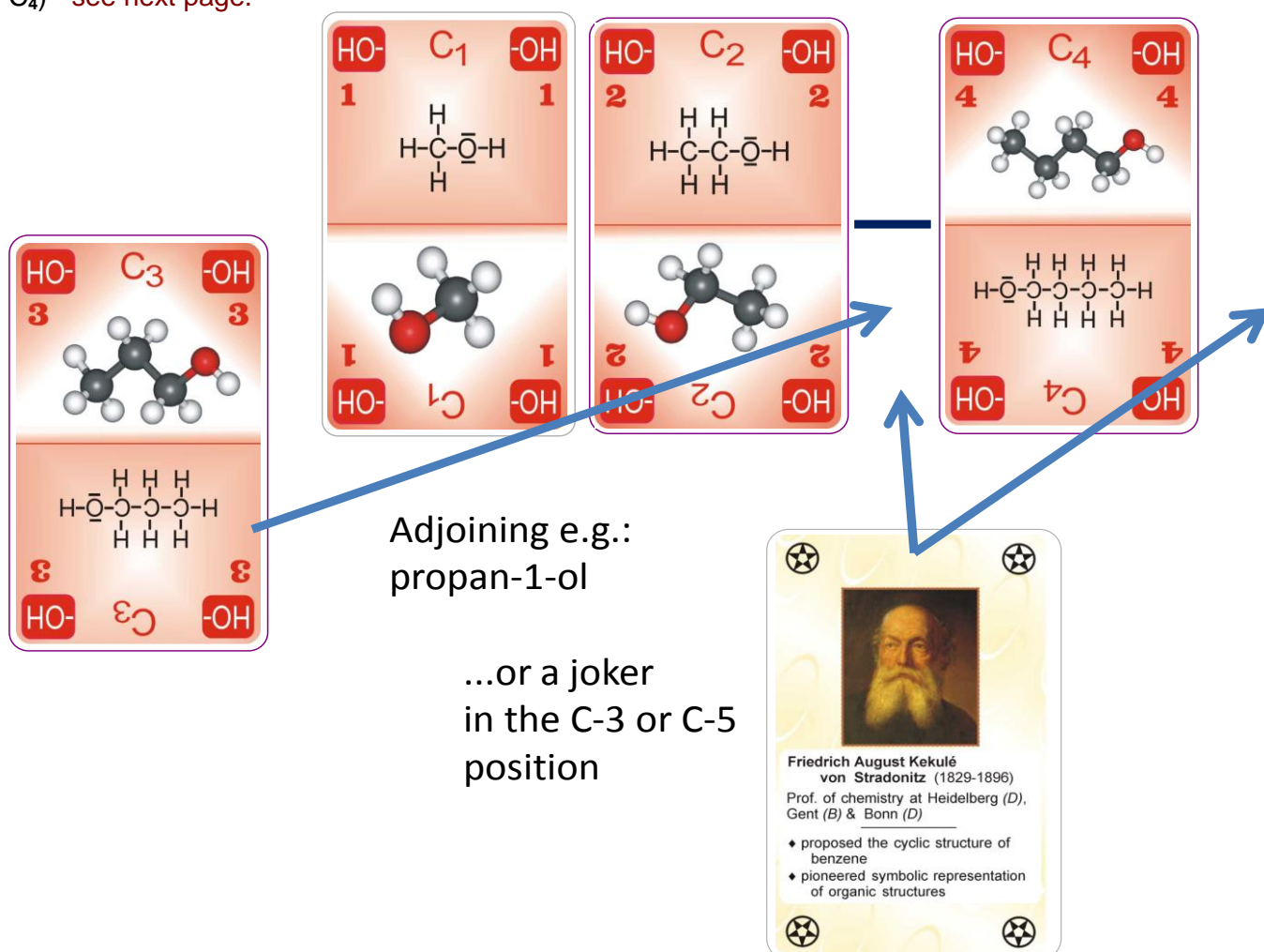
The player must put down at least:

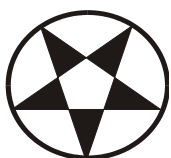
one set of at least 3 IC-cards and one set of at least 3 OC-cards

or only

one set of at least 4 IC- or 4 OC-cards

After "opening", other sets of at least 3 cards can be put down, whenever it is a player's turn. In addition, the player may add cards to already existing sets, also to those of other players'. However, single OC-cards may only be added to an adjoining card of a set, e.g.: propan-1-ol (C₃) can be added to an already discarded set of methanol-ethanol and butan-1-ol (C₁, C₂, - C₄) - see next page.



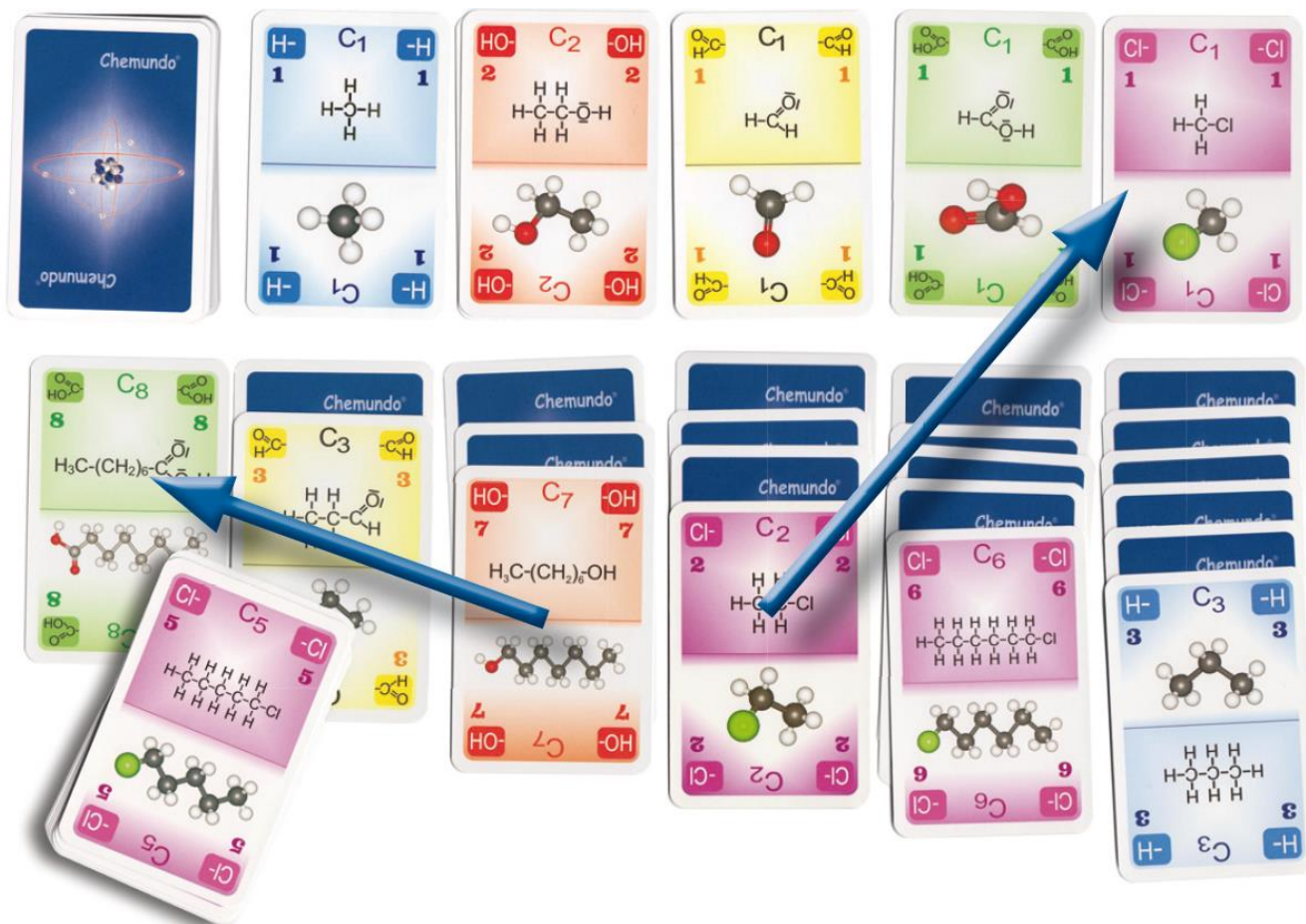


There are 6 jokers in the game (portraits of famous pioneers of chemistry). These may substitute a regular card in order to complete an IC or OC set. When using a joker, the player must clearly define which card the joker substitutes. If another player has this very card, he may use this card to replace the joker, once it is his turn.

When putting down sets, all the individual compounds have to be named correctly, e.g. sets of the OC deck or sets of salts, acids and bases of the IC deck. If a player fails to do so, or if he makes a mistake, the player has to skip the next round or pick up a penalty card.

Illa. Chemundo® Patience (Solitaire) with 5x8 OC cards

This game is similar to Solitaire. But instead of the usual seven columns, there are only six. The first card on the left faces up and the rest faces down. Five foundations are built up in sequence according to the five homologous series of the OC cards. Build tableaux in descending order and by alternating colors – for Chemundo® Patience this means alternating homologous series.



IIIb. Chemundo® Poker with the OC cards

Like in regular Poker, the aim is to compile a hand of 5 cards to the best combinations. For Chemundo® Poker, however, the use of chemistry-related Poker terms is even more fun. Typical terms from the NMR spectra, such as doublet, triplet, quartet, or e.g., 'full spectra' replace Poker terms such as Pair, 3 of a Kind, 4 of a Kind, and Full House.

The table following shows the types and ranking of hands (estimated but not calculated ranking of cards):

Ranking of Hands	Examples
(1) doublet	2 x C ₃
(2) double doublet	2 x C ₂ and 2 x C ₅
(3) triplet	3 x C
(4) carbon street	C ₁ -C ₂ -C ₃ -C ₄ -C ₅ from any homologous series
(5) full spec	triplet + doublet = 'full house' in Poker
(6) quartet	4 x C ₄
(7) spin	5 cards from only one chem. homologous series, e.g. 5 alkanes = 'flush' in Poker
(8) quintet	5 x C ₇
(9) straight/royal spin	a carbon street of only one chem. homologous series

Further priorities*: E.g.: C₈ > C₇ > C₆ etc. (first rank) or chloroalkanes* > alkanic acids > alkanals > alkanols > alkanes (sec. rank) *due to higher molecular masses.

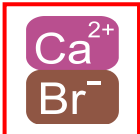
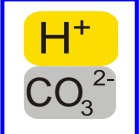


No matter, which version of Chemundo® you play – enjoy all the FUN of the world of chemistry



IV. The inorganic chemistry (IC) deck of cards

		Na⁺ sodium	Mg²⁺ magnesium	Ca²⁺ calcium	Al³⁺ aluminium
H⁺		----- bases -----			
H₂O water	OH⁻ hydroxide	NaOH	Mg(OH)₂	Ca(OH)₂	Al(OH)₃
Acids:		----- salts -----			
HCl* hydrochloric	Cl⁻ chloride	NaCl	MgCl₂	CaCl₂	AlCl₃
HBr* hydrobromic	Br⁻ bromide	NaBr	MgBr₂	CaBr₂	AlBr₃
HI* hydroiodic	I⁻ iodide	NaI	MgI₂	CaI₂	AlI₃
H₂CO₃ carbonic	CO₃²⁻ carbonate	Na₂CO₃	MgCO₃	CaCO₃	Al₂(CO₃)₃
H₃PO₄ phosphoric	PO₄³⁻ phosphate	Na₃PO₄	Mg₃(PO₄)₂	Ca₃(PO₄)₂	AlPO₄
H₂SO₄ sulfuric	SO₄²⁻ sulfate	Na₂SO₄	MgSO₄	CaSO₄	Al₂(SO₄)₃
HNO₃ nitric	NO₃⁻ nitrate	NaNO₃	Mg(NO₃)₂	Ca(NO₃)₂	Al(NO₃)₃

Examples how to name IC cards, e.g. a card depicts:

the cation:  the player has to name: **calcium bromide** or for: 
 and the anion:  with the stoichiometry*: **CaBr₂**  **carbonic acid** and **H₂CO₃**

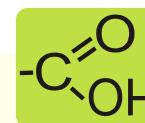
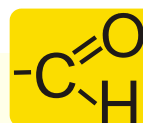
*= the ratio of ions

Notes:

*IUPAC names; *in water, commonly (nonsystematic): hydrochloric acid, hydrobromic acid, hydroiodic acid;

In water, the IC acids (mineral acids, e.g. hydrogen chloride) dissociate forming oxonium cations H₃O⁺ and their corresponding anions.

V. The OC (organic chemistry) deck of cards (IUPAC* Names)



chloroalkanes	C_x x	alkanes	alkanols (alcohols)	alkanals (aldehydes)	alkanoic acides (carboxylic acids)
chloro~	1	methan~e	~ol	~al ¹⁾	~oic acid ³⁾
chloro~	2	ethan~e	~ol	~al ²⁾	~oic acid ⁴⁾
1-chloro~	3	propan~e	...-1-ol	~al	~oic acid
1-chloro~	4	butan~e	...-1-ol	~al	~oic acid
1-chloro~	5	pentan~e	...-1-ol	~al	~oic acid
1-chloro~	6	hexan~e	...-1-ol	~al	~oic acid
1-chloro~	7	heptan~e	...-1-ol	~al	~oic acid
1-chloro~	8	octan~e	...-1-ol	~al	~oic acid
example. C_3 :					
1-chloropropane	$x=3$	propane	propan-1-ol	propanal	propanoic acid

IUPAC* preferred is: ¹⁾ formaldehyde, ²⁾ acetaldehyde ³⁾ formic acid, ⁴⁾ acetic acid

*International Union of Pure and Applied Chemistry

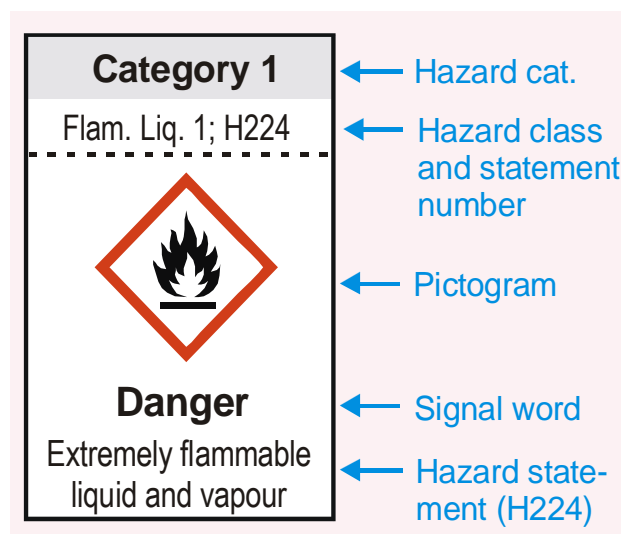
VI. Nine action cards with the new GHS hazard symbols (pictograms)

GHS background information

The Globally Harmonized System of Classification and Labeling of Chemicals (GHS), first discussed at the United Nations Rio Conference in 1992, addresses the classification of chemicals by different types of harmonized hazard elements. GHS labels are mandatory by Dec. 2010 in Europe to indicate all potentially hazardous properties of chemical substances.

Compared to former directives, GHS is more complex and more precise. All labels include hazard statements and the signal words **warning** or **danger**.

See the label with the hazard statement H224:








Announcement of GHS action cards

The following tables describe the most important hazard classes for the GHS pictograms, displayed on nine action cards. When discarding a GHS action card, the player has to name at least one dedicated hazard class (see the following tables).




If the players cannot name the card correctly, they have to draw a penalty card. However, at the onset of a game, the players may decide on the exact details of the naming process.

A) Physikalische Gefahren – Physical hazards

	Hazard class		Hazard class
	Unstable explosives Self-reactive substances and mixtures ¹⁾ Organic peroxides ¹⁾		Oxidizing gases Oxidizing liquids Oxidizing solids
	Flammable gases Flammable aerosols Flammable liquids Flammable solids Pyrophoric liquids Pyrophoric solids		Compressed gas Refrigerated liquefied gas Dissolved gas
			Corrosive to metals



¹⁾ The pictogram **Flame** is as well used for this hazard class.

B) 1. Acute health hazards

	Hazard class & cat. ²⁾ , e.g.:		Hazard class & cat. , e.g.:
	Acute toxicity (oral, dermal, inhalation, cat. 1,2,3)		Skin corrosion (cat. 1A, 1B, 1C) Serious eye damage (cat. 1)
	Acute toxicity (oral, dermal, inhalation, cat. 4) Skin irritation (cat. 2) Serious eye irritation (cat. 2) Skin sensitization (cat. 1A, 1B)		

²⁾ According to categories, 2 GHS pictograms are used for the hazard class **Acute Toxicity**.

B) 2. Further health hazards esp. CMR* and Specific Target Organ Toxicity (STOT)**



	Hazard class, e.g.:
	Respiratory tract irritation Narcotic effects
	Reproductive toxicity Carcinogenicity Germ cell mutagenicity Respiratory sensitisation (cat. 1A, 1B) Aspiration hazard Specific target organ toxicity: - single exposure - repeated exposure

* Cancerogen, mutagen, reprotoxisch;

** STOT: Gesundheitsgefahren für spezielle Zielorgane

* Cancerogen, mutagen, reprotoxic;

C) Hazardous to the environment

	Hazard classes, e.g.:
	Acute aquatic hazard Long-term aquatic hazard
	Hazardous to the ozone layer

Ref.. e.g. via:

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:353:0001:1355:EN:pdf>

VII . ANNEX

GHS Glossary - selection of French, German & English terms

Termes officiels extraits du règlement (CE) No 1272/2008	Offizielle Begriffe aus der Verordnung (EG) Nr. 1272/2008 (sogenannte CLP-Verordnung)	Official terms of the Regulation (EC) No 1272/2008 (CLP regulation)*
SGH – système général harmonisé de classification et d'étiquetage des produits chimiques	GHS – Global-harmonisiertes System zur Klassifizierung und Kennzeichnung von Chemikalien	GHS – Global Harmonized System on classification, labeling and packaging of substances
mention de danger	Gefahrenhinweis	hazard statement
conseil de prudence	Sicherheitshinweis	safety advice
pictogramme de danger	Gefahrenpiktogramm	hazard pictogram
mention d'avertissement	Signalwort	signal word
toxicité aiguë	Akute Toxizität	Acute health hazard
toxicité pour certains organes cibles	Zielorgantoxizität	Specific Target Organ Toxicity (STOT)
mutagenicité sur les cellules germinales	Keimzellmutagenität	germ cell mutagenicity
cancérogénicité	Karzinogenität	cancerogenicity
toxicité pour la reproduction	Reproduktionstoxizität	reprotoxicity
pictogramme SGH	GHS-Piktogramm	GHS pictogram
dangers pour le milieu aquatique	gewässergefährdend	hazardous to the aquatic life
cancérogène (ou cancérigène), mutagène et reprotoxique; CMR	Cancerogen (oder karzinogen), mutagen, reprotoxisch (krebserzeugend, erbgutverändernd, fortpflanzungsgefährdend, CMR)	cancerogenic (or: carcinogen), reprotoxic, mutagen (CMR)

*REGULATION (EC) No 1272/2008 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 December 2008 on classification, labeling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006: <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:353:0001:1355:en:PDF>

ACKNOWLEDGEMENTS

First of all, I would like to thank Prof. Dr. Hans Joachim Bader und his students of the Chemundo® project group at the Institute of Didactics of Chemistry at the Goethe University Frankfurt for our fruitful cooperation and for optimizing the game, making it the valuable and highly motivating way of learning chemical basics.

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Last but not least, I express my gratitude to Dr. Ursula Bünzli-Trepp, member of IUPAC's Chemical Nomenclature Advisory Subcommittee, for her support and expertise in checking the chemical nomenclature of the game.

Fußgönheim/Pfalz, June 2013

Dr. Reiner Kober
(eduris GmbH)

