Chem 107: Inorganic Chemistry (40720)

Professor Matt Law
e-mail: lawm@uci.edu
Office Hours: Wed 3:00-4:00p and Thurs 11-noon in NS2 2127

TAs
Juliet Khosrowabadi
e-mail: jkhosrow@uci.edu
Office Hours: Tues 2:00-3:00p, 3rd floor tables, Reines Hall

Kyle Rosenkoetter
e-mail: krosenko@uci.edu
Office Hours: Monday 4:00-5:00p, NS1 3213

Class website: http://www.chem.uci.edu/~lawm/107.html

Syllabus

Textbook

- **Miessler, G. L.; Fischer, P. J, Tarr, D. A. *Inorganic Chemistry*. 5th Edition; ISBN 0-321-81105-4.**

Lecture Slides

- **Lecture slides are posted to the course website as PDF files before or just after each lecture.**

Homework

- **Sapling Learning online homework (graded), plus suggested problems from textbook (ungraded)**

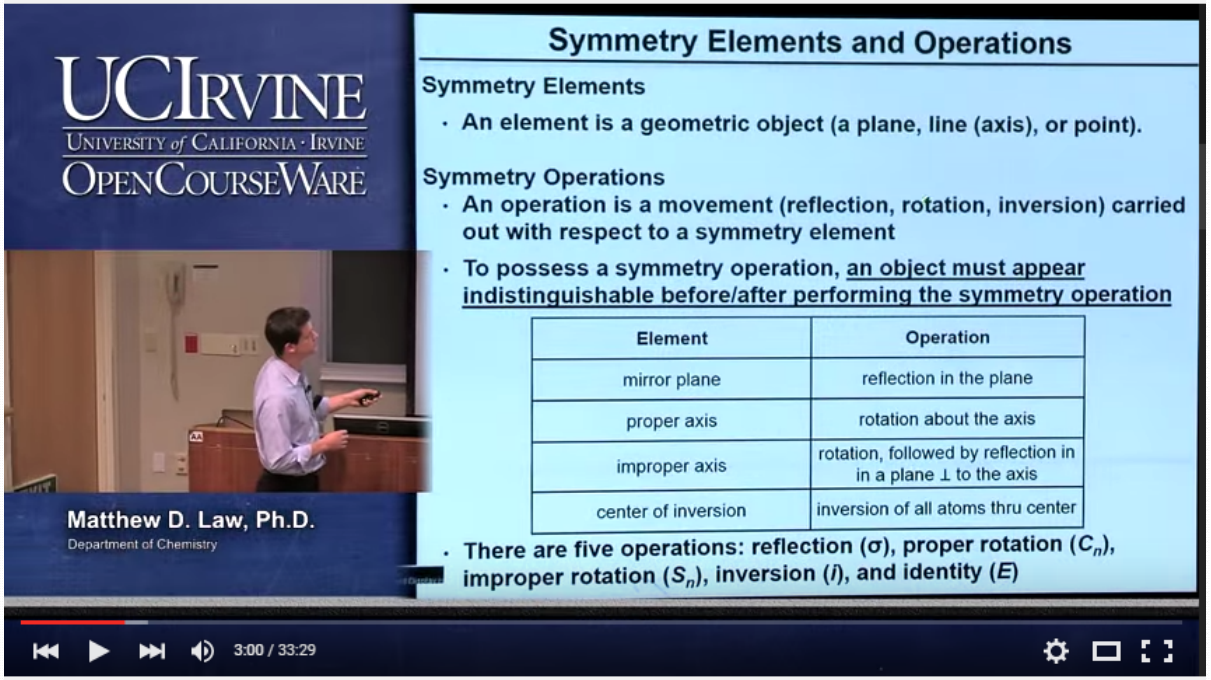
Discussion Sections

- **Will begin meeting next week (9/28/15).**
- **Discussion sessions are optional, but will give you valuable interactive practice with the course material.**

Syllabus

Video Lectures

- **Videos from last year's lectures are available on class website, courtesy of UCI Open Chemistry Initiative**
  - **Second half of the videos feature Prof. Heyduk, so will be different this year**
  - **Best used as study aid, not regular substitute for attending live lectures**

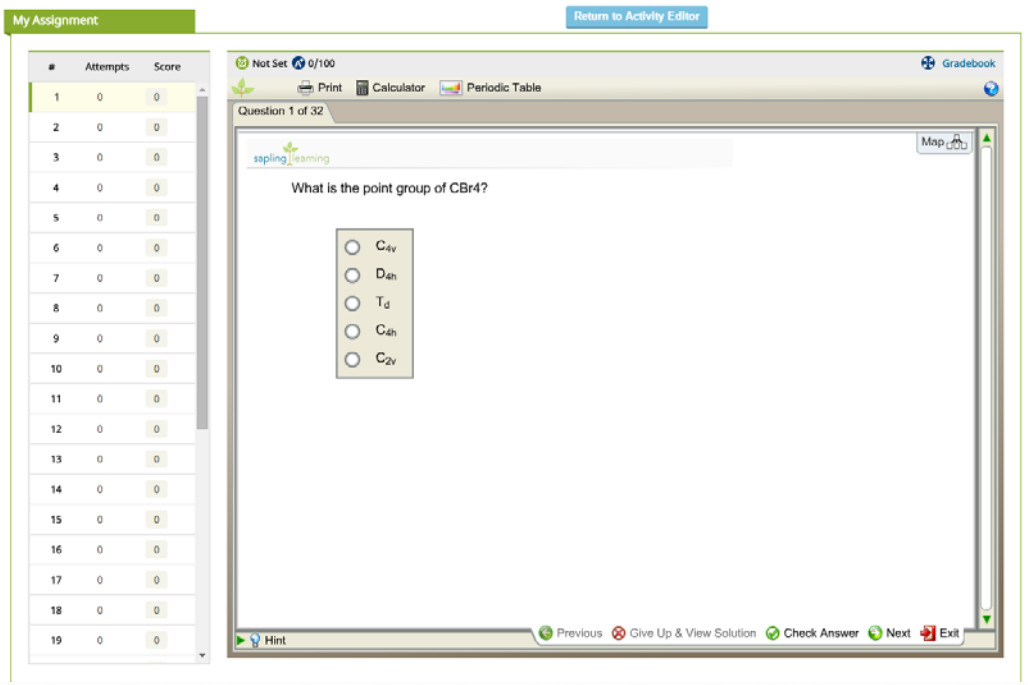


Chemistry 107. Inorganic Chemistry. Lecture 01

Syllabus

Online Homework

- **Graded online homework assignments for each chapter via Sapling Learning.**
  - **Sign up here: http://bit.ly/saplinginstructions**
  - **$30 for the quarter**
  - **10% of course grade**
  - **Technology TA: Dr. Katherine Koen, support@saplinglearning.com**
  - **First assignment available next week**



Syllabus

Lecture Schedule

- **We will cover Chapters 4-11**
  - **Midterm I (Ch. 4,5,7)**
  - **Midterm II (Ch. 6,7,8,9)**
  - **Final (Ch. 4-11)**

Week	Date	Chapter(s)	Topics
0	9/25	4	Class Intro, Symmetry Operations
1	9/28	4	Point Groups
	9/30	4	Representations and Character Tables
	10/2	4	Character Tables and One Application of Symmetry
2	10/5	4	A Second Application of Symmetry
	10/7	5	Simple MO Theory
	10/9	5	MO Theory, Part II
3	10/12	5	MO Theory, Part III
	10/14	5	MO Theory, Part IV
	10/16	7	The Crystalline Solid State
4	10/19	7	Crystal Structures
	10/21	7	Thermodynamics and Electronic Structure of Solids
	10/23	4,5, some7	***Midterm Exam I***
5	10/26	7	Semiconductors, Solar Cells, and Lasers
	10/28	6	Models of Acid-Base Reactions
	10/30	6	Acid-Base Strength
6	11/2	8	Hydrogen, Alkalis & Alkaline Earths
	11/4	8	Boron and the Carbon Groups
	11/6	8	Carbon Through Noble Gases
7	11/9	9	Coordination Chemistry I: Intro
	11/11		***Veteran's Day - No Class***
	11/13	9	Coordination Chemistry II: Geometries and Isomers
8	11/16	10	Coordination Chemistry III: Electronic Structure
	11/18	6, rest 7, 8,9	***Midterm Exam II***
	11/20	10	Ligand Field Theory
9	11/23	10	Jahn-Teller Effect, Orbital Overlap Method, Electron Counting
	11/25	11	Spectroscopy and Multielectron Atoms I
	11/27		***Thanksgiving - No Class***
10	11/30	11	Spectroscopy and Multielectron Atoms II
	12/2	11	Term Symbols and Selection Rules
	12/4	11	Tanabe-Sugano Diagrams
Finals	12/9	4-11	***Final Exam 8-10 AM***

- *You are responsible for the background material in Chapters 1-3!*

Syllabus

Exams

- **Two midterms and one final.**
- **Exams are cumulative.**
- **There are no make-up exams. If you miss a midterm for an approved reason, the value of the final will be adjusted accordingly. See course syllabus for details.**

Date	Assignment	Percentage
Friday, Oct 23rd	Midterm Exam I	20
Weds, Nov 18th	Midterm Exam II	30
Wed, Dec 9th, 8:00a	Final Exam	40
	Online Homework	10
	Total	**100**

Chem 107 on the Web

The Chem 107 website is your source for up-to-date information regarding this class.

- **http://www.chem.uci.edu/~lawm/107.html**
- **The class website is accessible through EEE, the UCI Chemistry Department website, google, etc.**
- **Detailed syllabus, lecture schedule, suggested textbook homework problems and answer keys, lecture slides, links to video lectures, readings, and announcements are available here.**

Email Contact

E-mails will only be accepted and answered for UCI email addresses

- **Please be courteous and respectful when contacting me or the TAs.**
- **Just like you, we are very busy and we have many commitments outside of this class.**
- **To email us please use the format below and we will get back to you ASAP.**

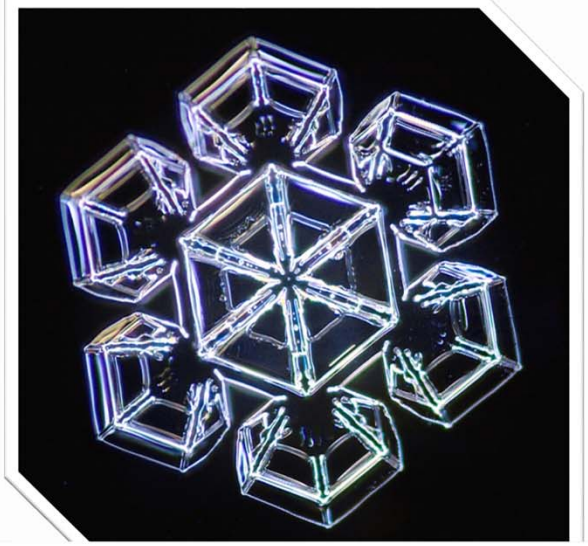
  - **Subject: Chem 107**

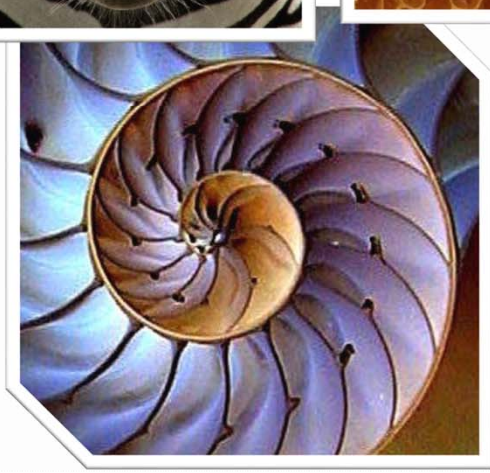
    Dear Professor Law,

    I had a question regarding something in lecture/the text/on the exam/etc. Please include as much information as possible so that we can get an answer to you ASAP.

    Thanks for your time,
    Peter/Petra Anteater
    UCI ID #

Symmetry in Nature





Symmetry from other planets

Symmetry Elements and Operations

Symmetry Elements

- **An element is a geometric object (a plane, line (axis), or point).**

Symmetry Operations

- **An operation is a movement (reflection, rotation, inversion) carried out with respect to a symmetry element**
- **To possess a symmetry operation, an object must appear indistinguishable before/after performing the symmetry operation**

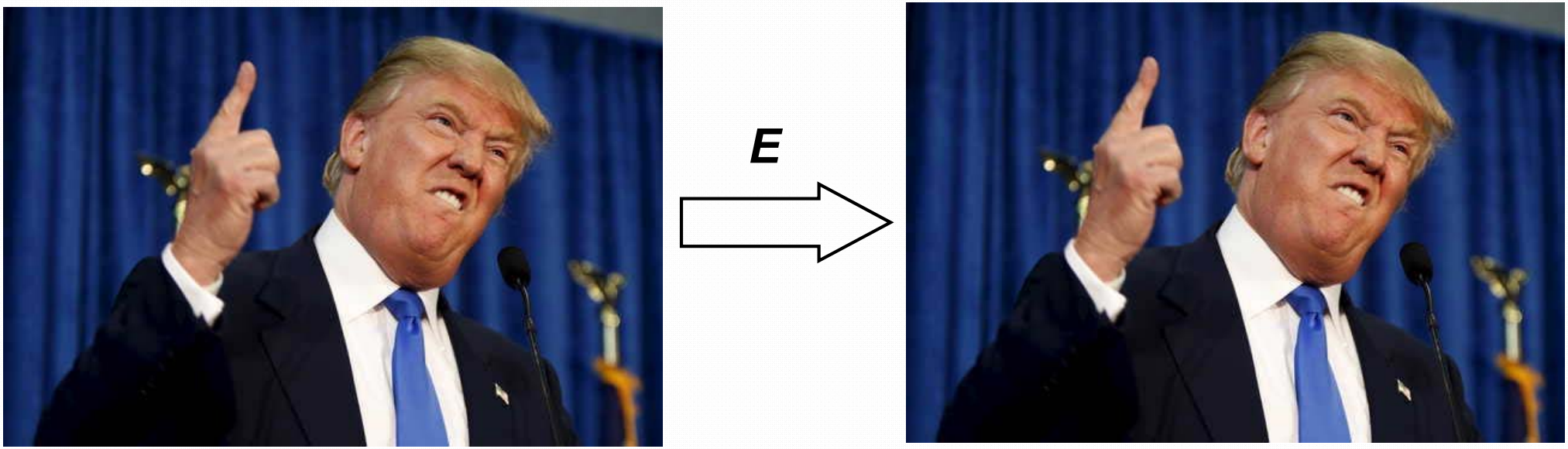
Element	Operation
mirror plane	reflection in the plane
proper axis	rotation about the axis
improper axis	rotation, followed by reflection in in a plane ⊥ to the axis
center of inversion	inversion of all atoms thru center

- **There are five operations: reflection (σ), proper rotation (C_n), improper rotation (S_n), inversion (i), and identity (E)**

The Identity

Identity Operation (*E*)

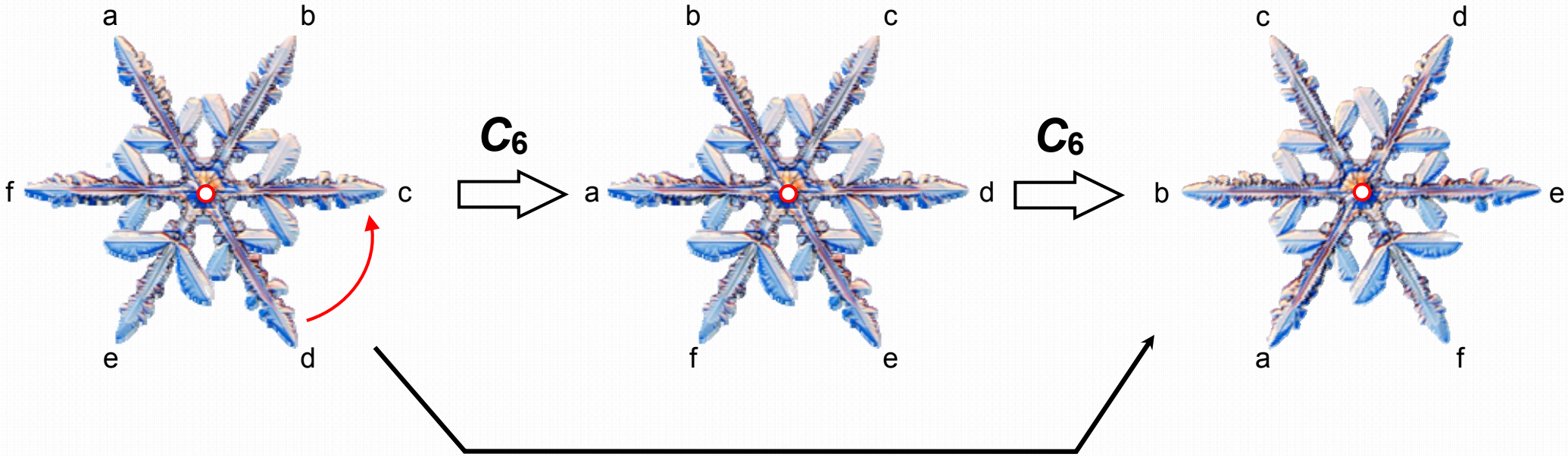
- **the "do nothing" operation (the simplest operation)**
- **mathematically equivalent to multiplying by 1**
- **all objects have *E***



Proper Rotations

Rotation Operation (C_n)

- a counter-clockwise rotation of $2\pi/n$ ($360°/n$) about an axis



$$C_6 \times C_6 = C_6^2 = C_3$$

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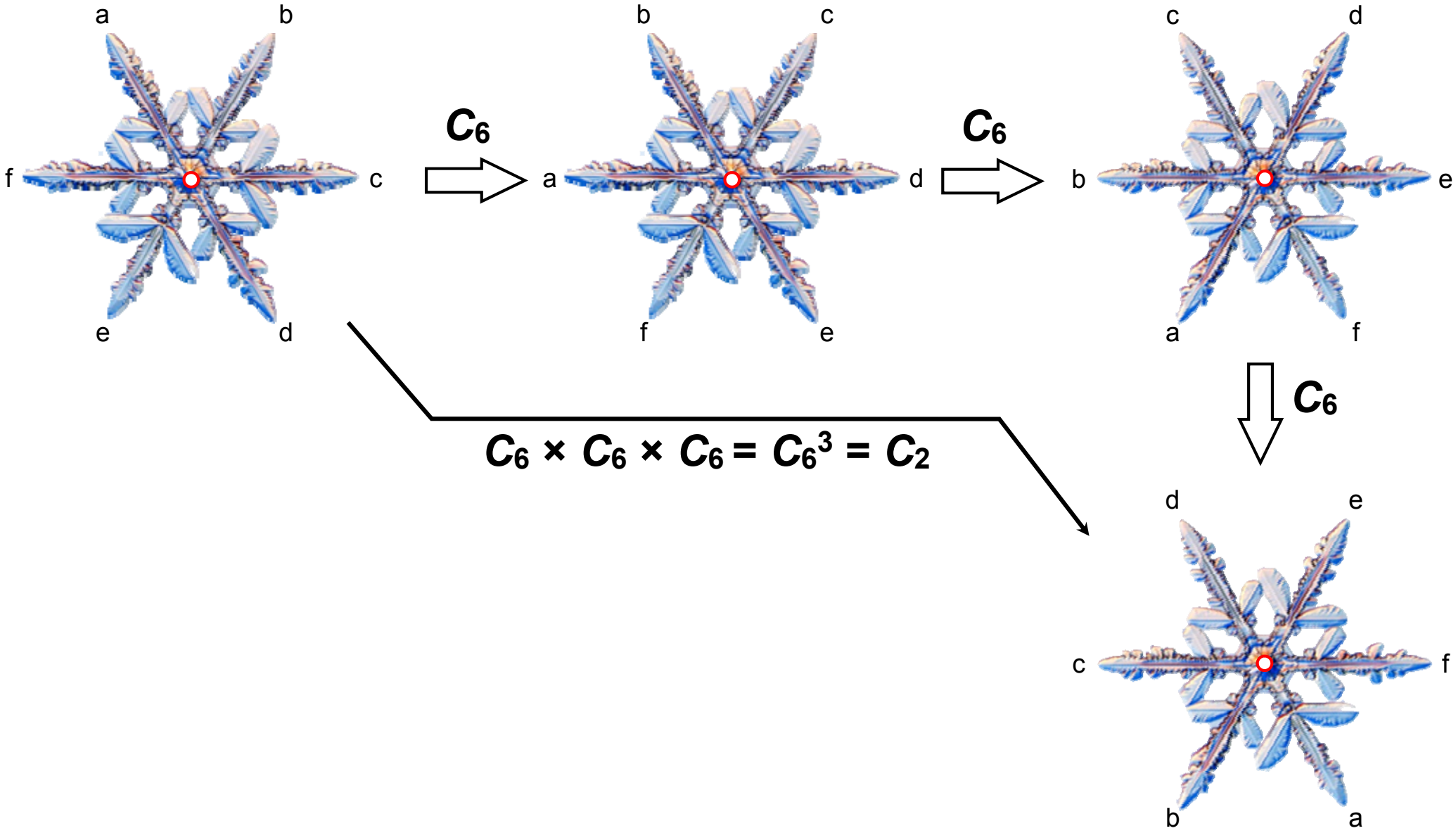

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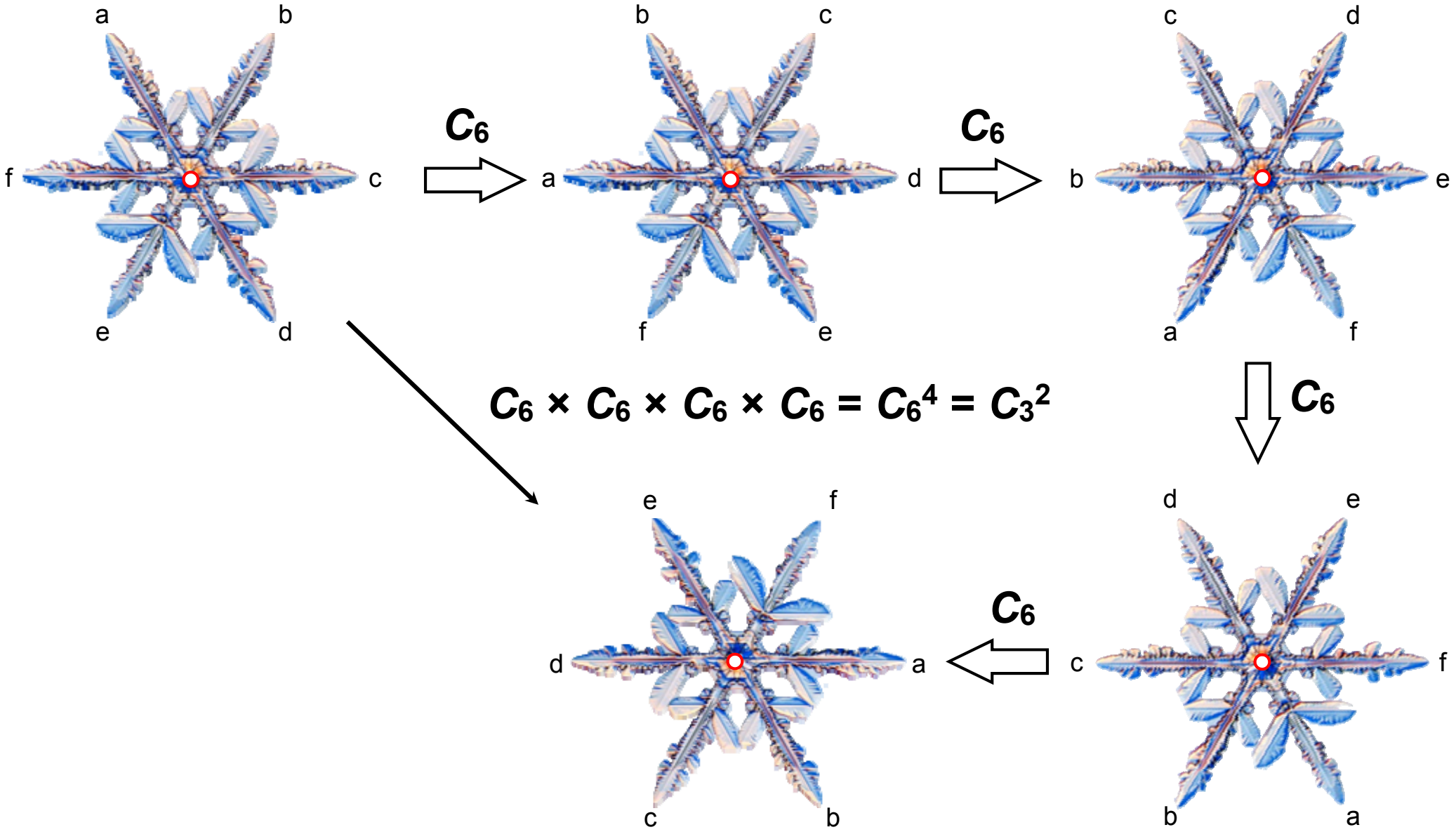

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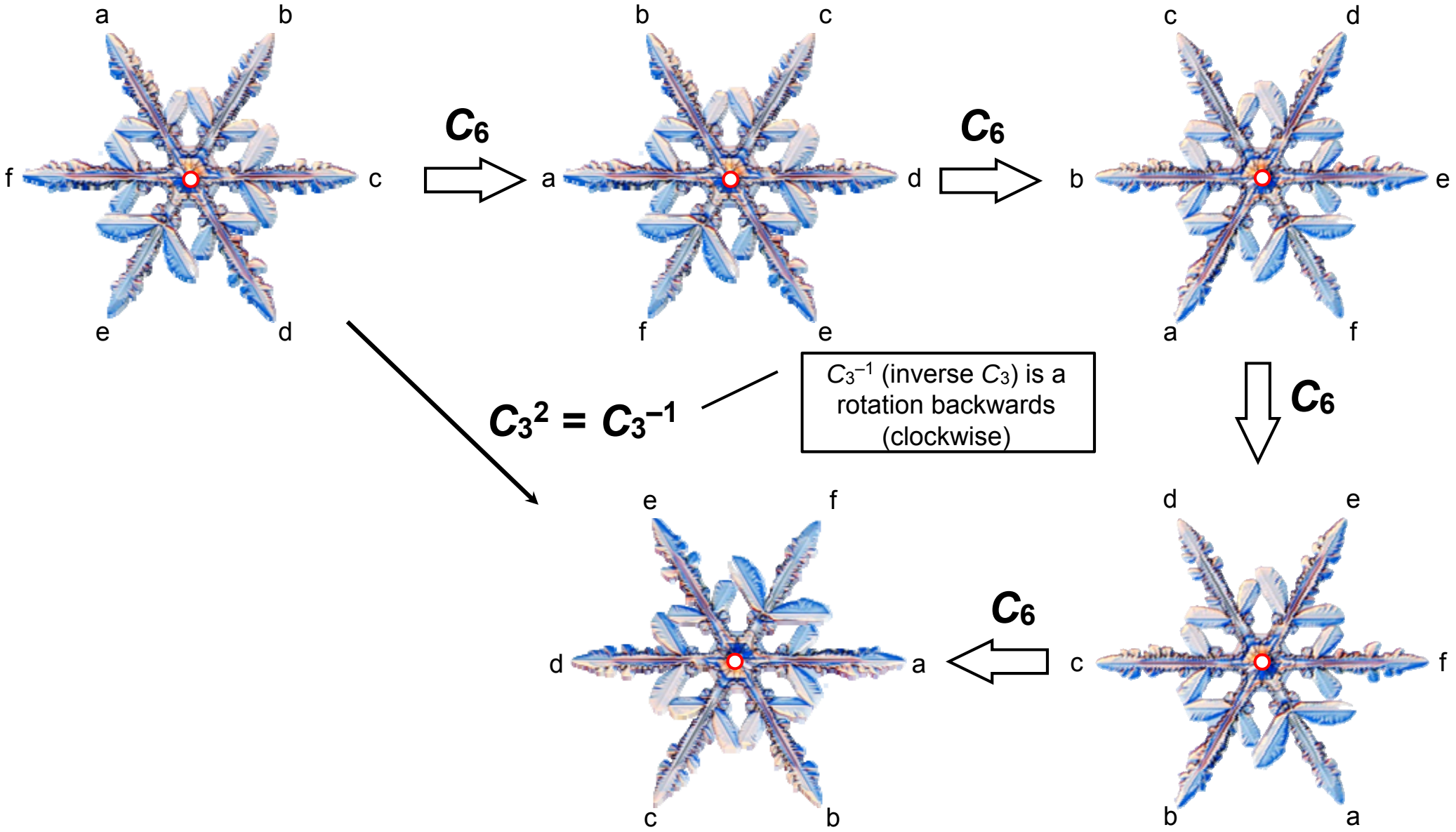

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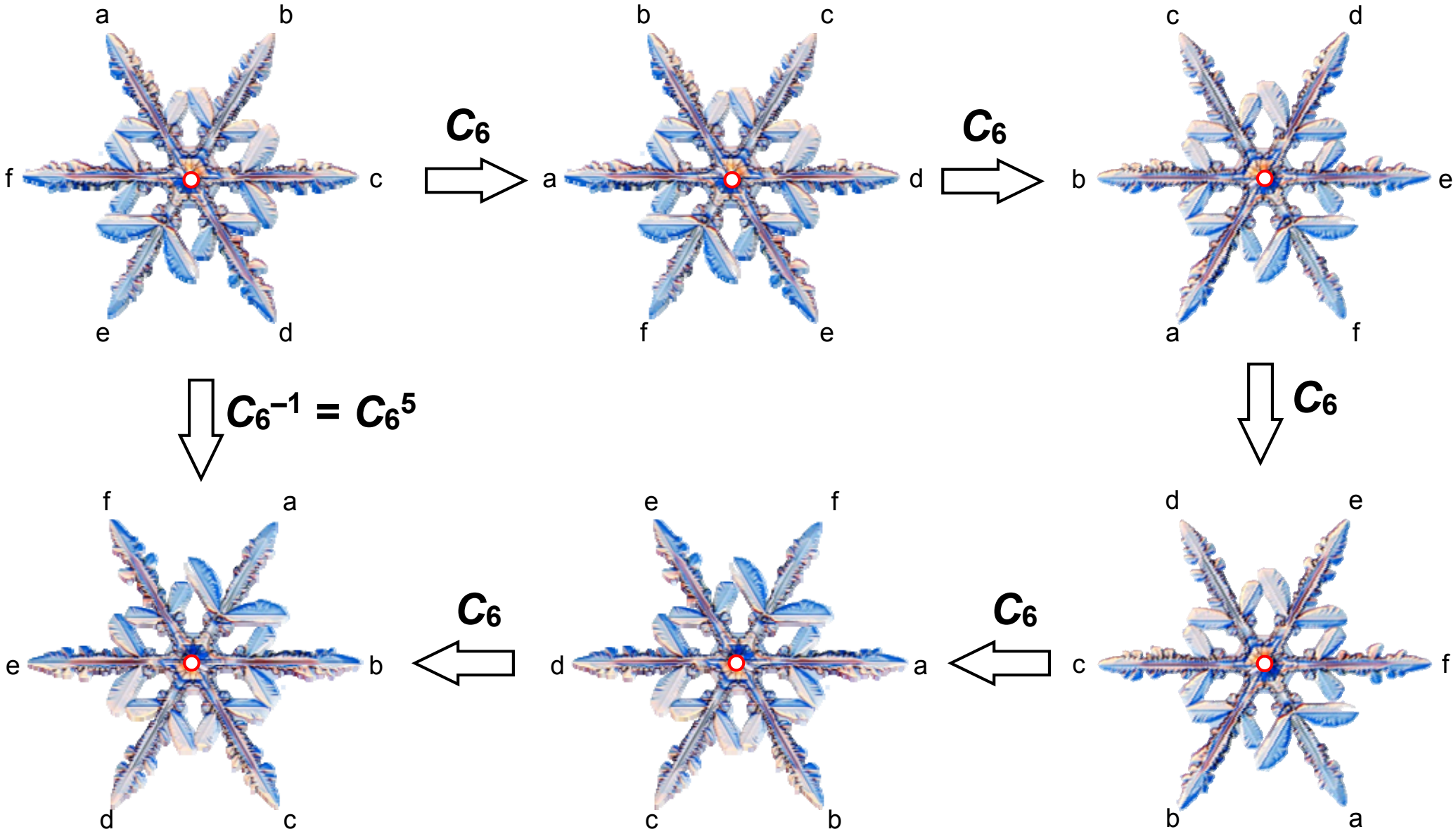

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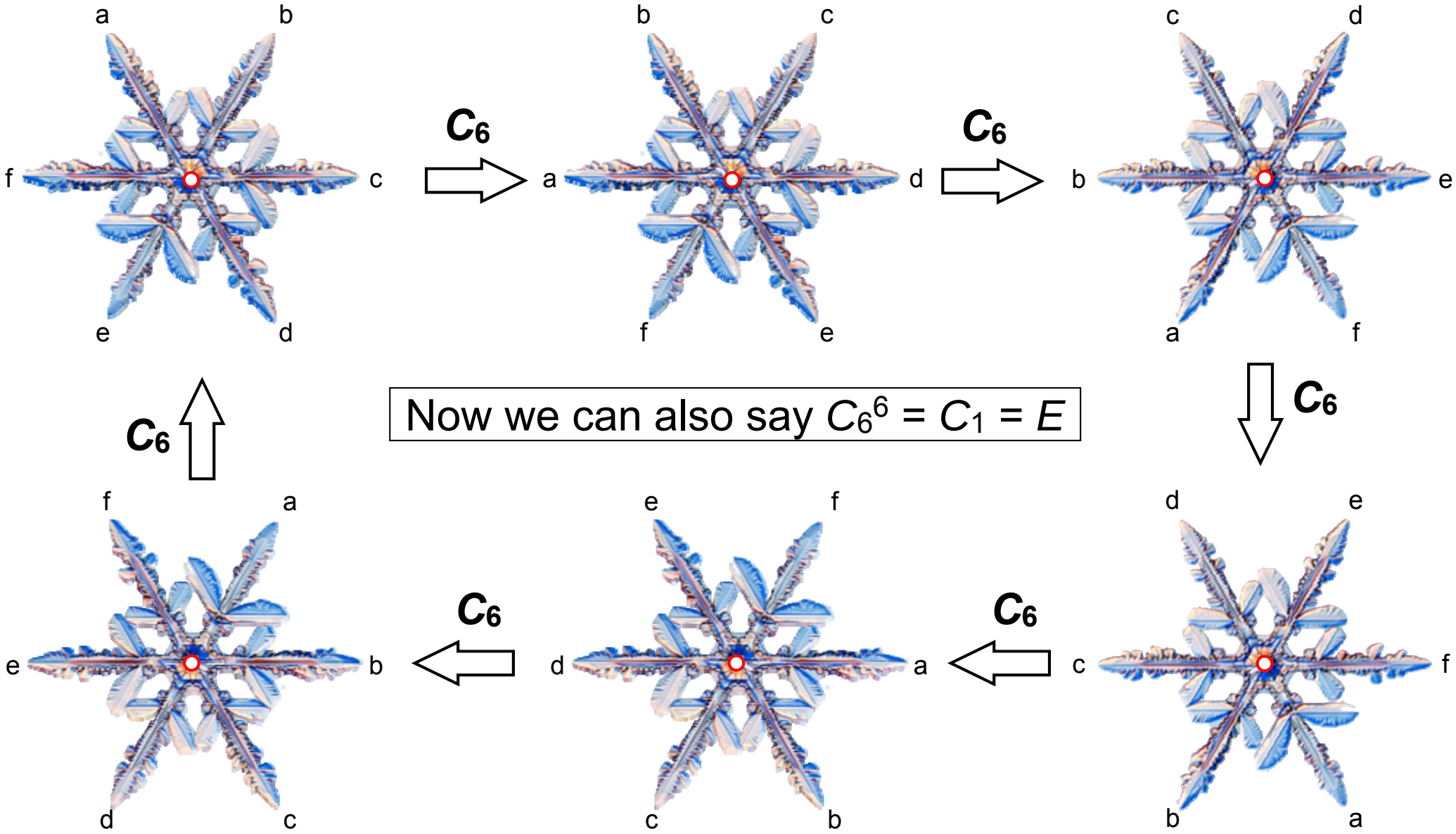
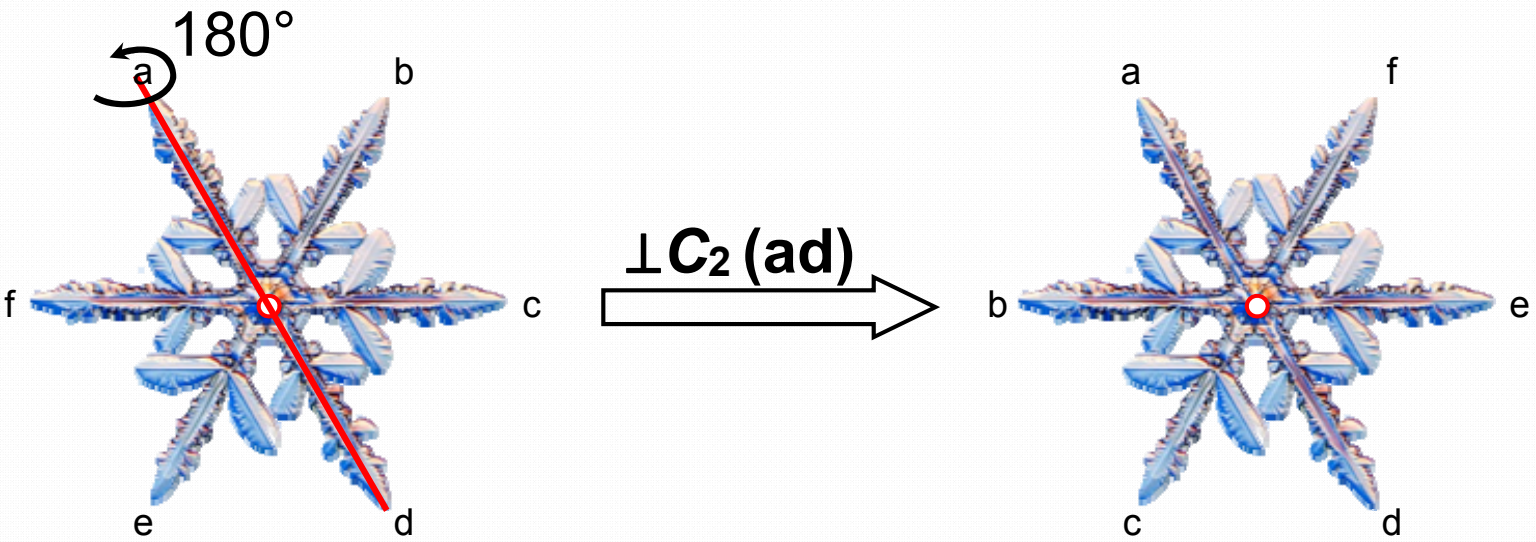


Proper Rotations

Rotation Operation (C_n)

- **a counter-clockwise rotation of $2\pi/n$ ($360°/n$) about an axis**
- **the rotation axis with the largest *n* is called the *highest order* or *principal axis* (the C_6 axis in the case of our snowflake)**
- **some objects have rotations that are perpendicular to the principal axis**



Proper Rotations

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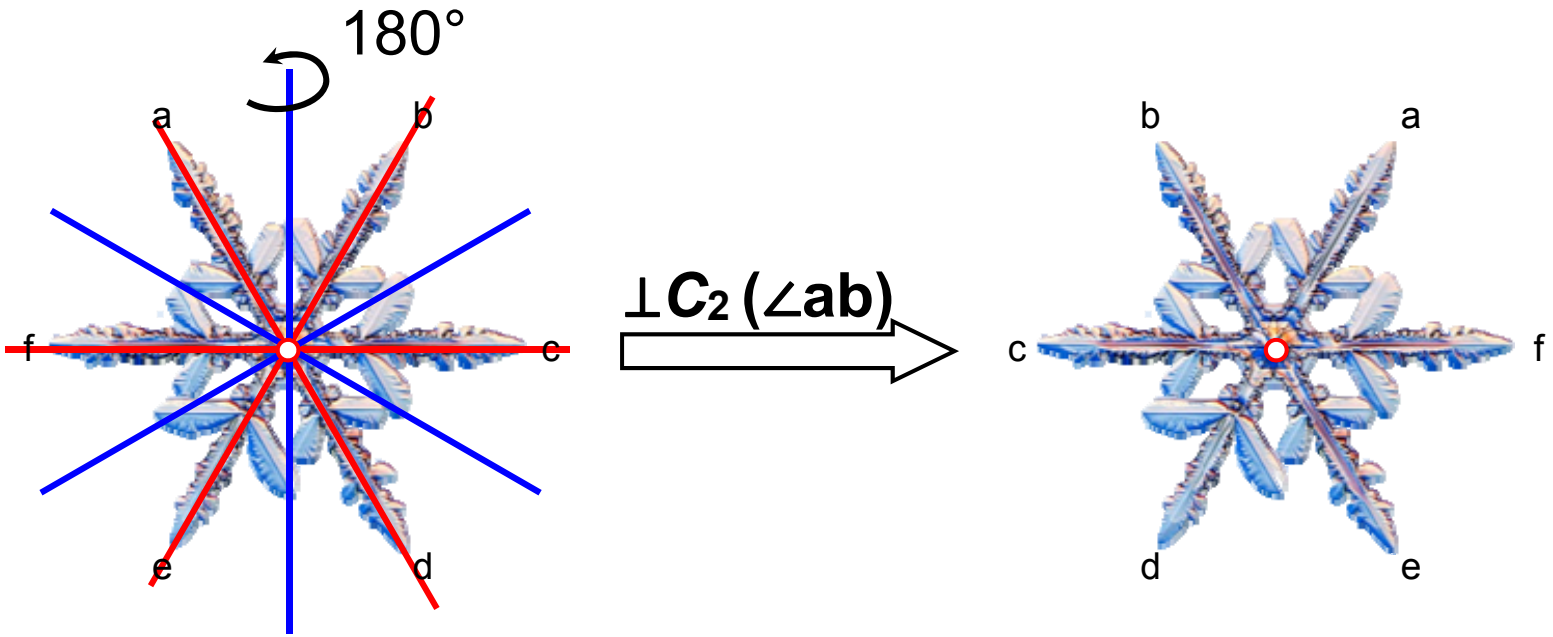
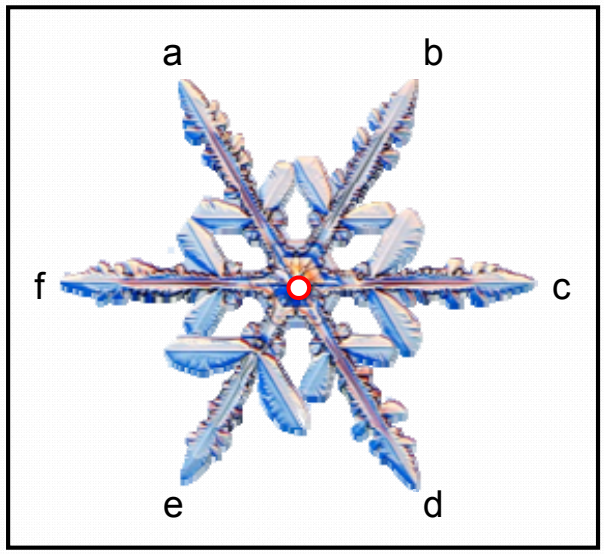
- **a counter-clockwise rotation of $2\pi/n$ ($360°/n$) about an axis**
- **the rotation axis with the largest n is called the *highest order* or *principal axis* (the C_6 axis in the case of our snowflake)**
- **some objects have rotations that are perpendicular to the principal axis**
- **an object with a C_n axis must have zero or n perpendicular C_2 axes**
- **the snowflake has coincident C_6, C_3, and C_2 axes plus six $\perp C_2$ axes**



Reflections

Reflection Operation (σ)

- **an internal reflection thru a plane of symmetry within an object**
- **a horizontal mirror plane (σ_h) is *perpendicular* to the principal axis**



$\sigma^n = E$
when n is even

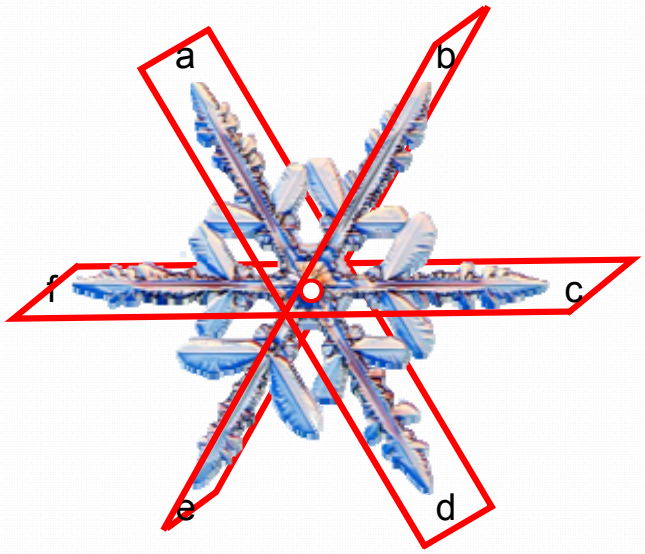
$\sigma^n = \sigma$
when n is odd

Reflections

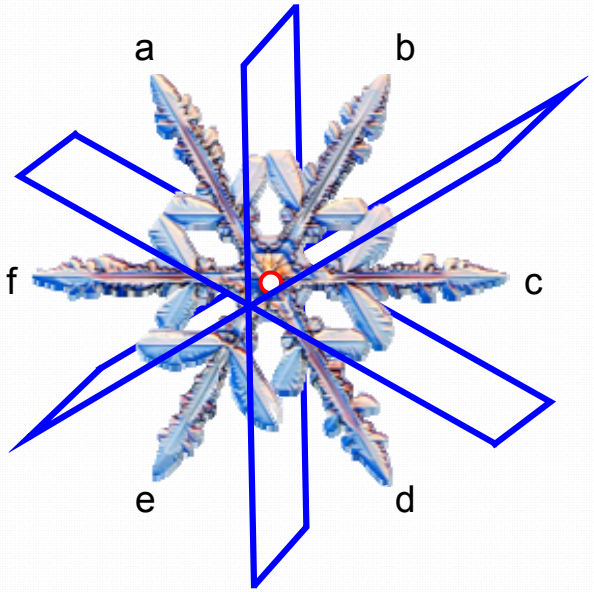
Reflection Operation (σ)

- **an internal reflection thru a plane of symmetry within an object**
- **a horizontal mirror plane (σ_h) is *perpendicular* to the principal axis**
- **vertical (σ_v) and dihedral (σ_d) mirror planes are *parallel* to the principal axis**
- **$\#\sigma_v + \#\sigma_d = 0$ or n**
- **our snowflake has one σ_h, three σ_v and three σ_d mirror planes**

σ_v



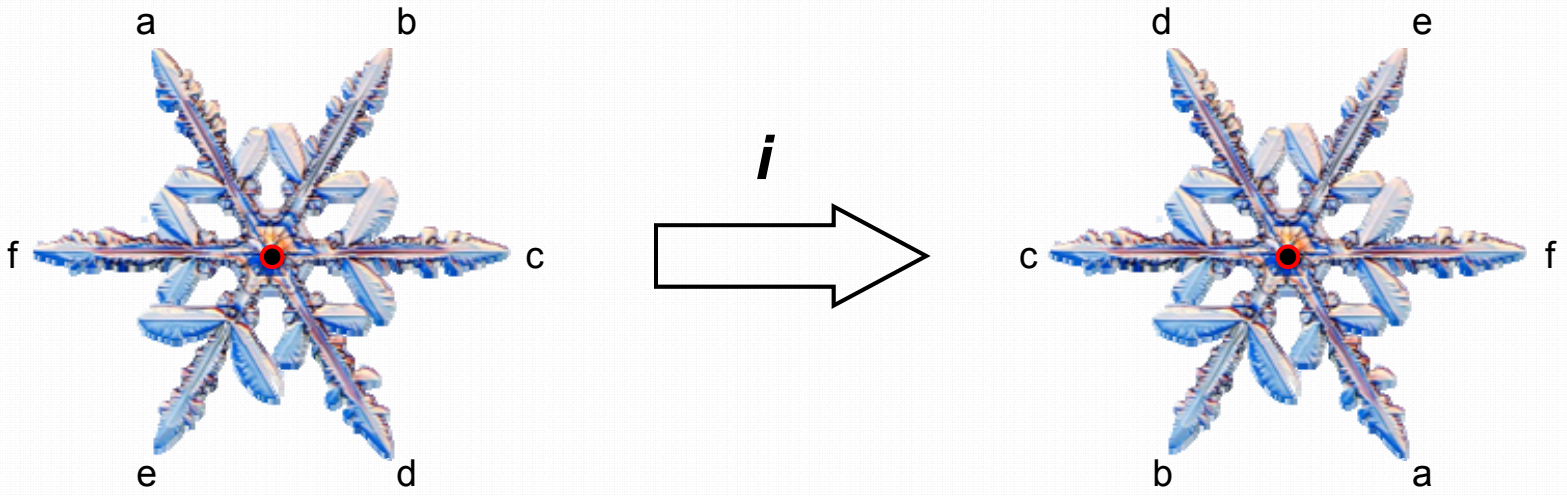
σ_d



Inversion

Inversion Operation (*i*)

- **each point is moved along a straight line through the center of the object (the *inversion center*) to a point an equal distance from the center**
- **in other words: (*x*,*y*,*z*) → (-*x*,-*y*,-*z*) for all points**
- **an object can have zero or one inversion center**
- **the snowflake has an inversion center**



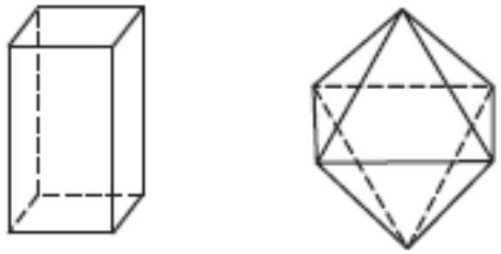
$i^n = E$ when n is even, $i^n = i$ when n is odd

Inversion

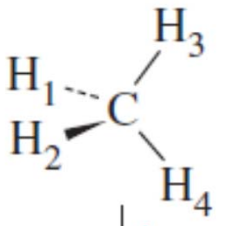
Inversion Operation (*i*)

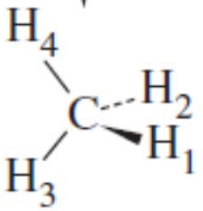
- **octahedra, boxes, squares, rectangles, and parallelograms have inversion centers, but tetrahedra, triangles, and pentagons do not**

yes inversion centers



no inversion centers





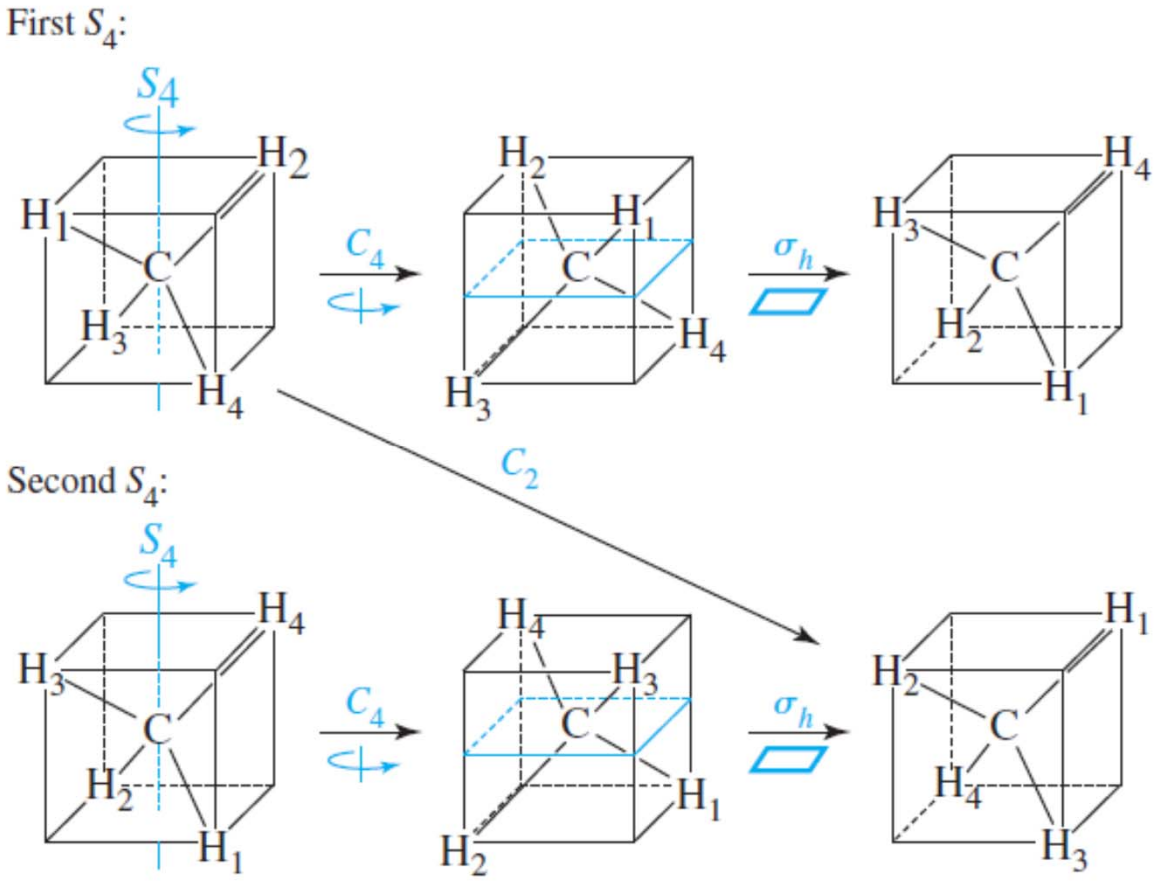
No center of inversion

Improper Rotations

Improper Rotation Operation (S_n)

- **a rotation followed by a perpendicular reflection (a *roto-reflection*)**

S_4 operation in methane



Rotation angle	*Symmetry operation*
90°	S_4
180°	C_2 $(= S_4^2)$
270°	S_4^3
360°	E $(= S_4^4)$

Also: $S_2 = i$, $S_1 = \sigma$

- **There are S_3 and S_6 operations in the snowflake, but we'll illustrate the S_n operation with an actual molecule in a minute.**