

MLL 100

Introduction to Materials Science and Engineering

Lecture-4

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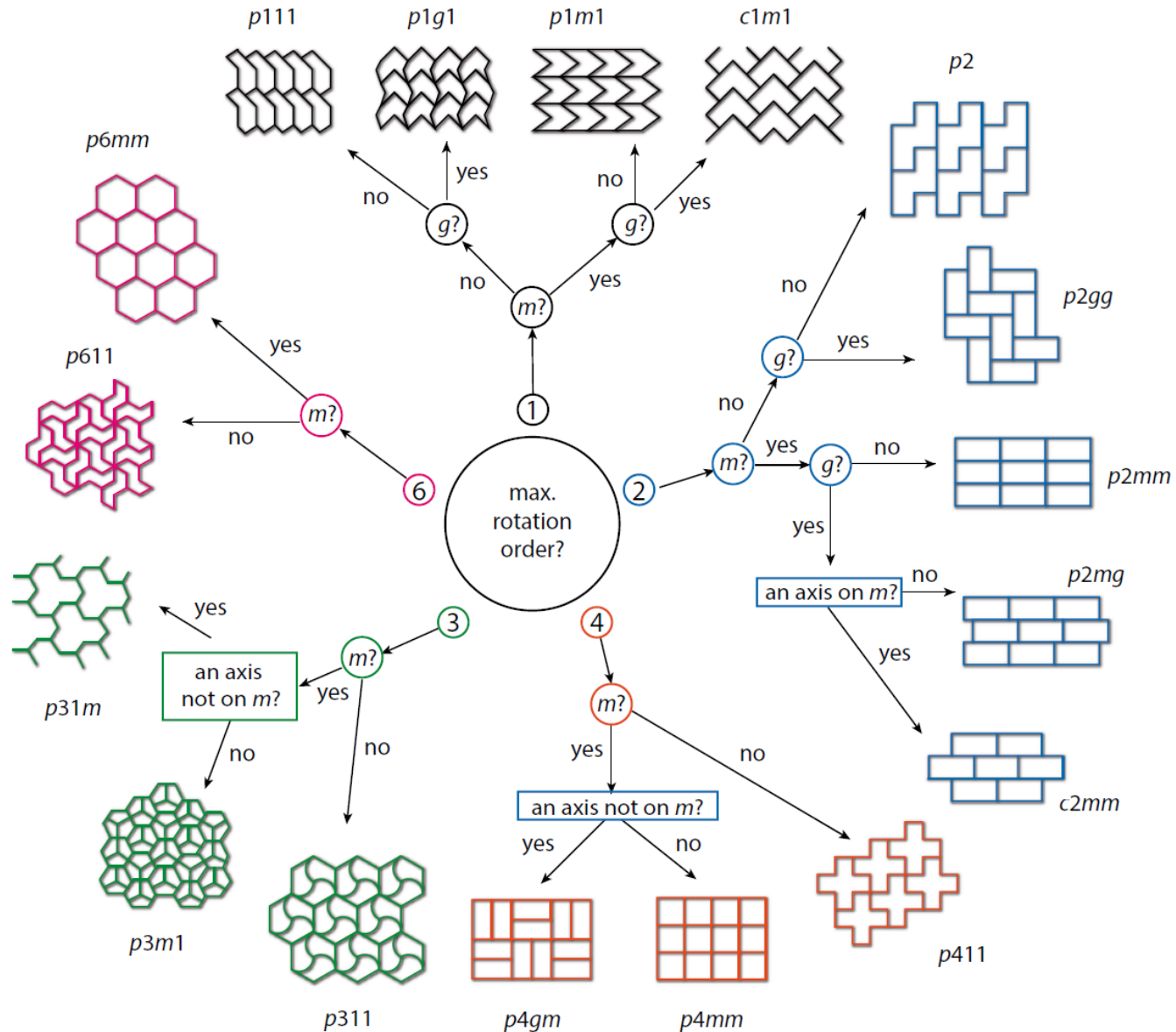
IIT Delhi
Department of Materials Science and Engineering

January 11, 2022

What we learnt in Lecture-3?

- Primitive and non-primitive unit cell
- Lattice point calculation per unit cell (2-D)
- 2-D lattices
- Plane groups

Algorithm for plane group determination

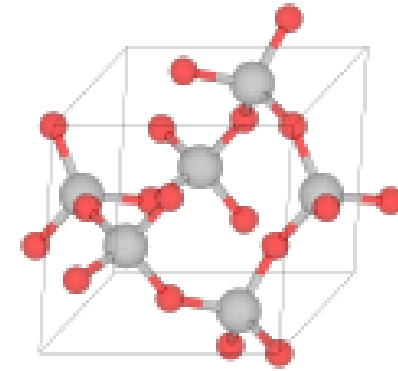


- 1) What is the rotation axis of highest order?
- 2) Is mirror plane present?
- 3) Is glide plane (g) present which does not result from any combination of rotation, translation and reflection?
- 4) Is any rotation axis of arbitrary order (not necessarily the one with the highest order) present but not on a mirror?
- 5) Is rotation axis of any order present on a mirror?

Crystal

Homogeneous, anisotropic solid states, whose building blocks are three-dimensional periodically ordered

krystallos



Homogeneous: Uniform chemical composition

Milk



Horlicks



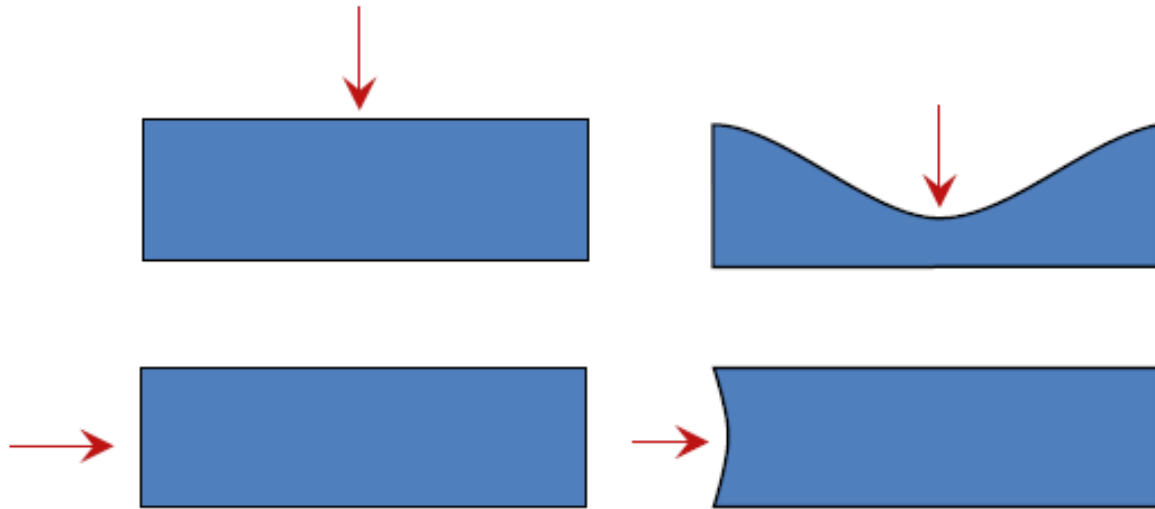
Milk with honey



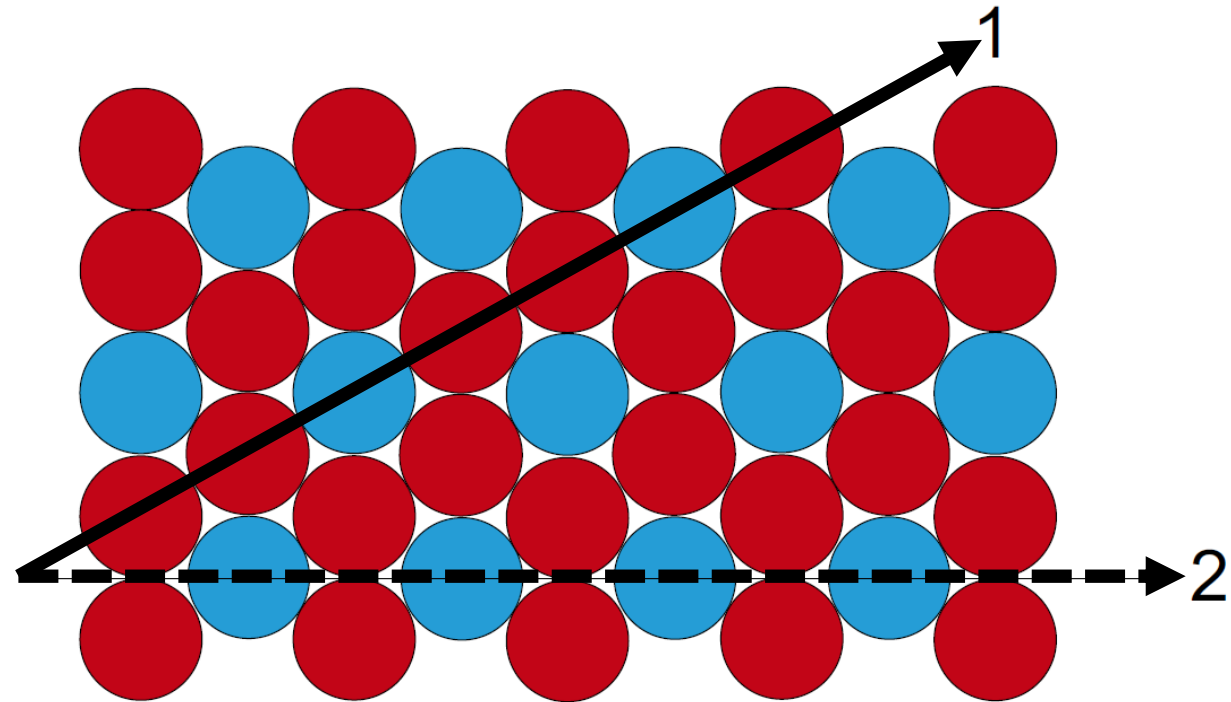
Quartz

Anisotropy

- Directional dependent properties



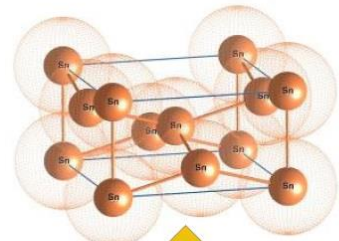
Application of pressure along different directions



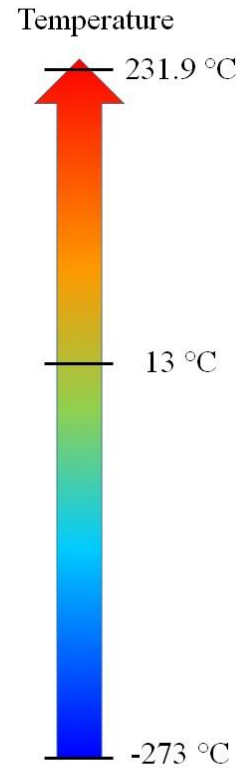
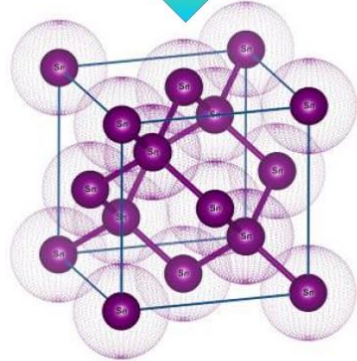
Importance of crystal systems



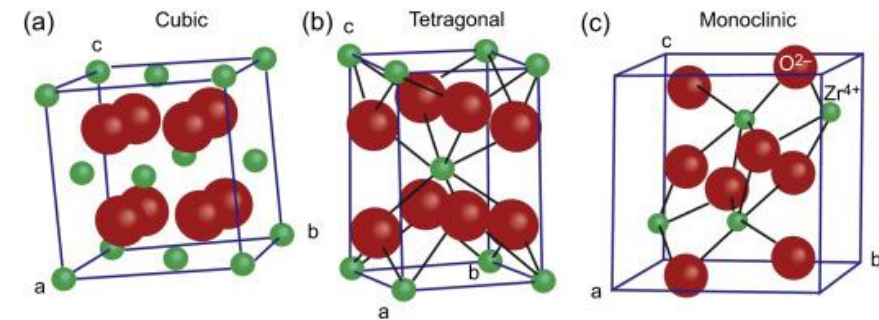
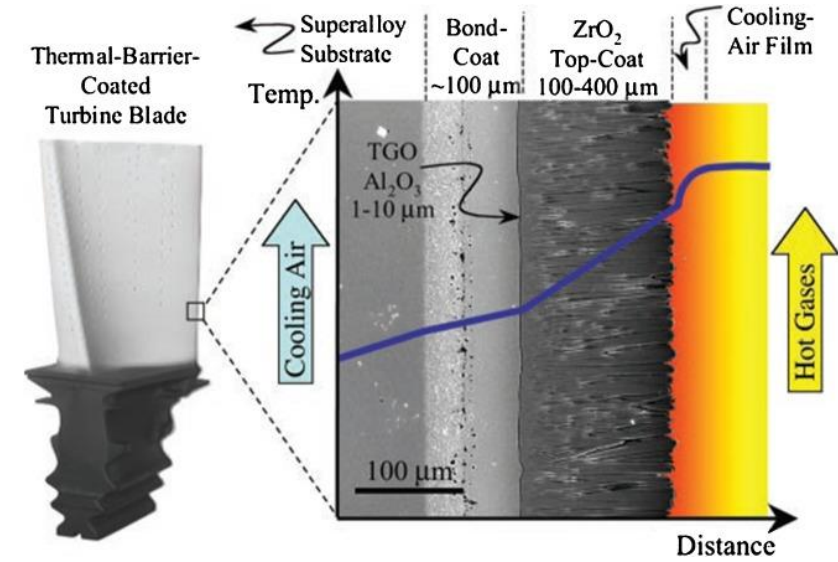
Color: White
 β -tin
 (Body Centered Tetragonal)
 $a = 5.831 \text{ \AA}$, $c = 3.181 \text{ \AA}$
 Density: 7.29 g/cm^3
 at 15°C

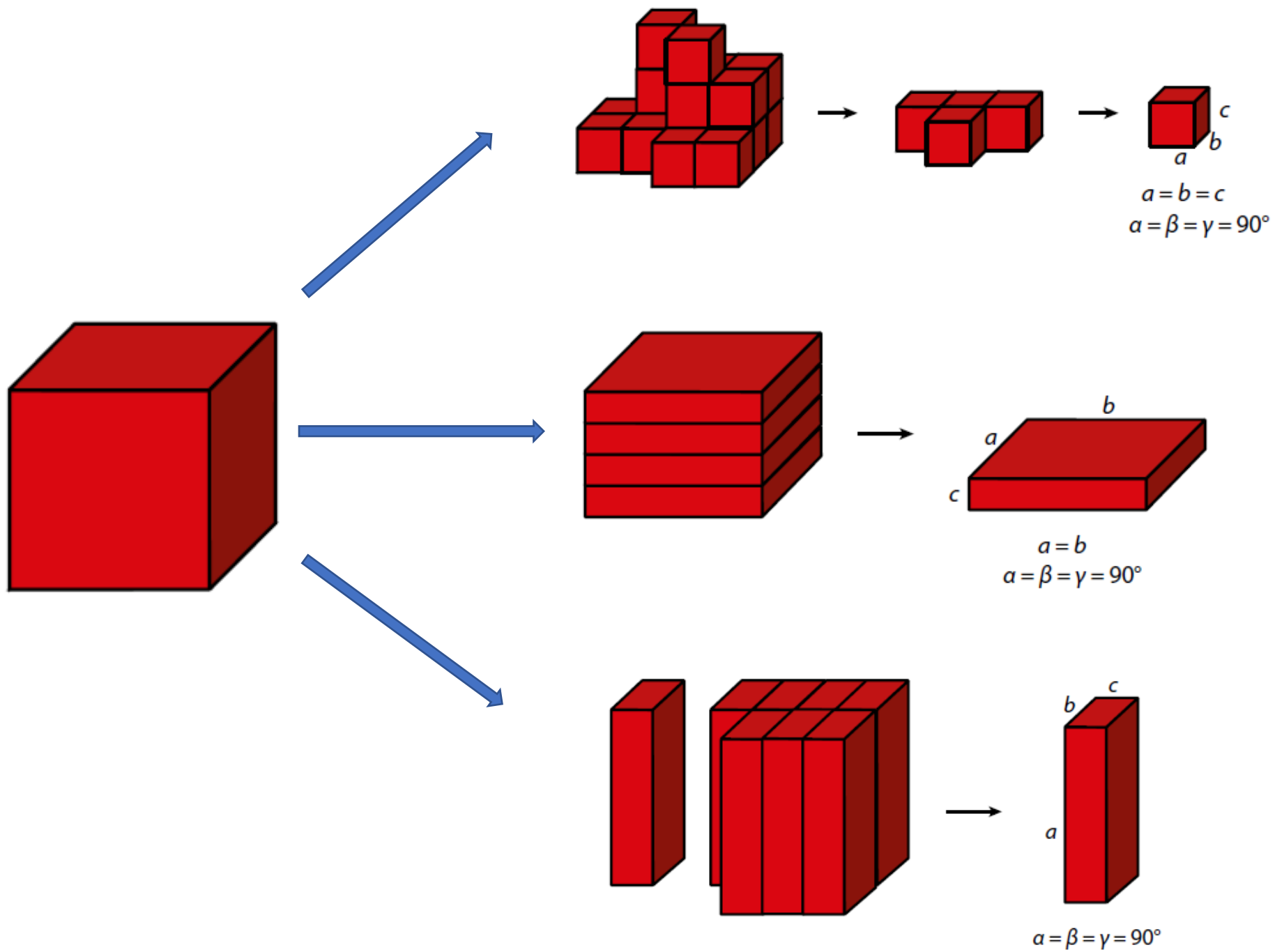


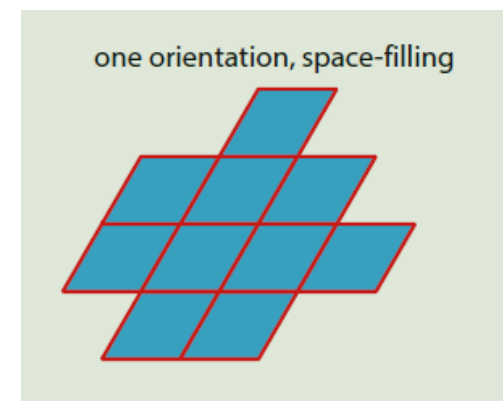
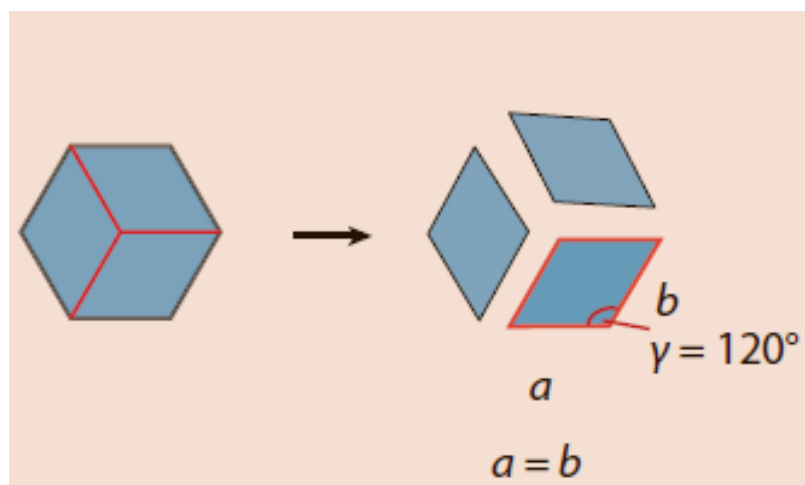
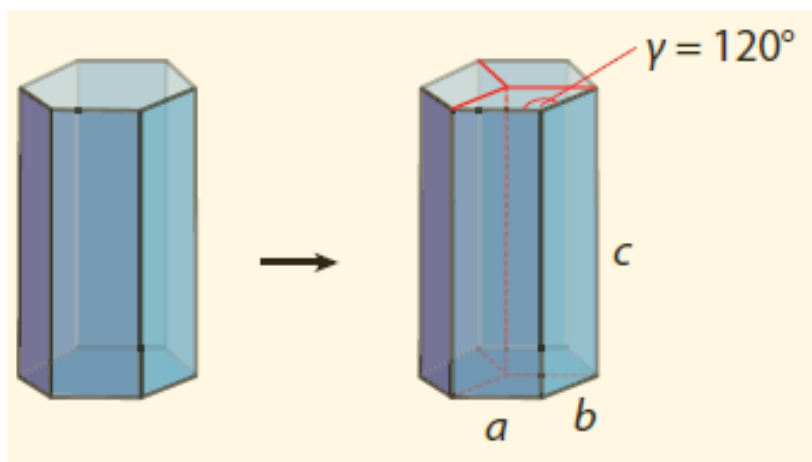
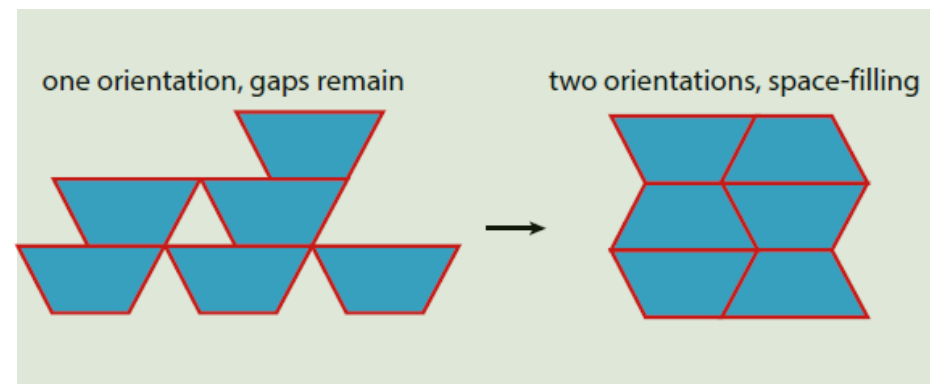
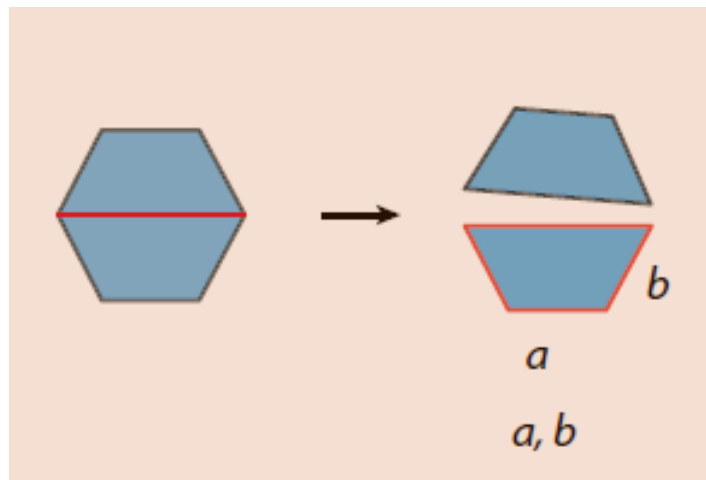
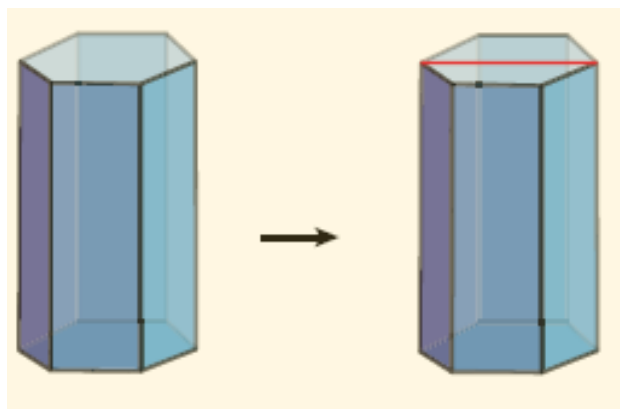
Allotropic transformation
 (27% volume change)

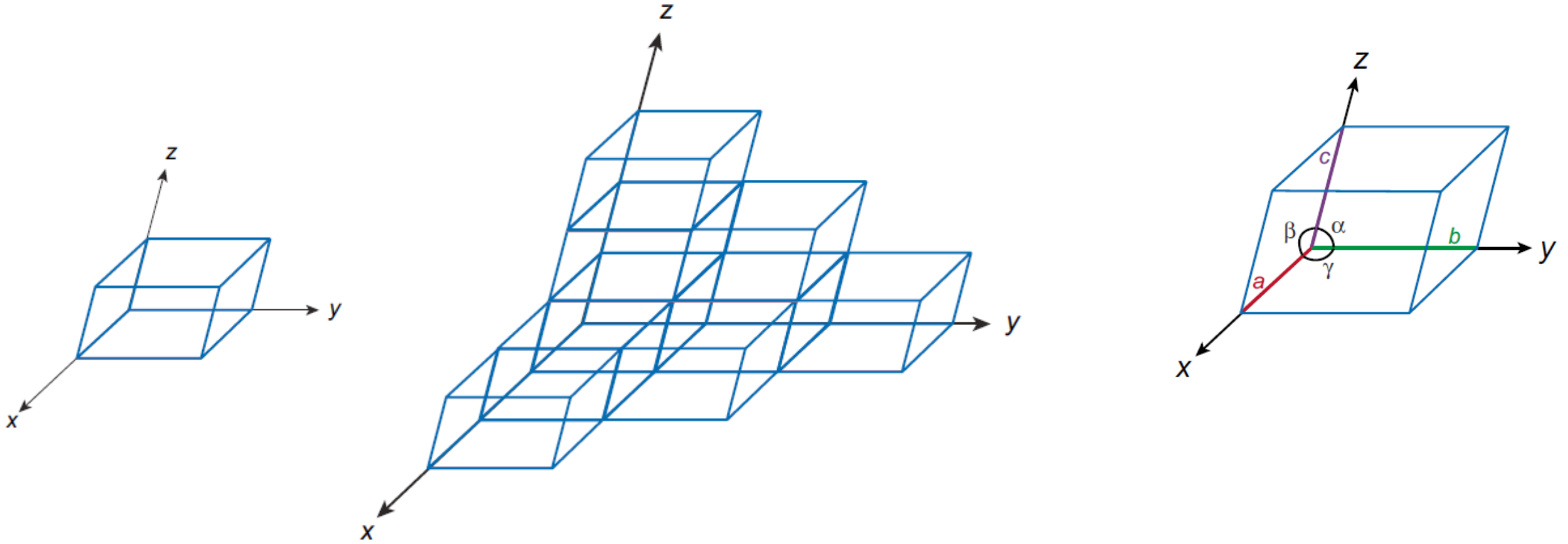


Color: Grey
 α -tin (Diamond cube)
 $a = 6.489 \text{ \AA}$
 Density: 5.77 g/cm^3
 at 13°C







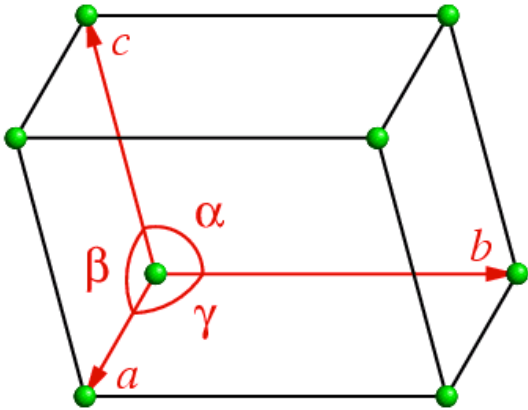


Unit cell: Smallest unit which builds up the entire crystal by repeating translations along all three spatial directions

Crystal systems

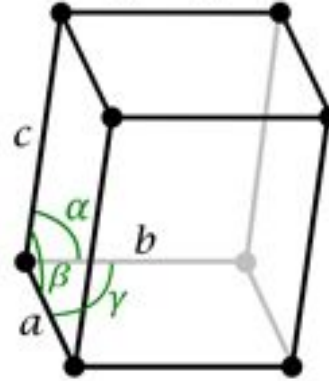
1 Triclinic

$$a \neq b \neq c; \alpha \neq \beta \neq \gamma$$



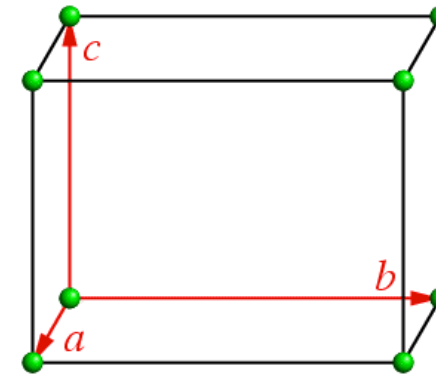
2 Monoclinic

$$a \neq b \neq c; \alpha = \gamma = 90^\circ \neq \beta$$



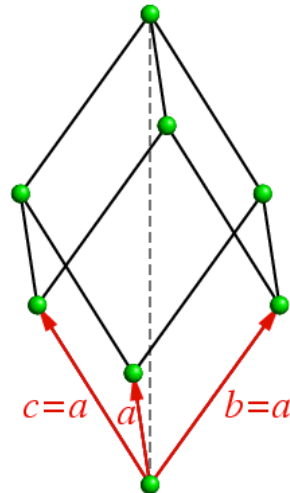
3 Orthorhombic

$$a \neq b \neq c; \alpha = \beta = \gamma = 90^\circ$$



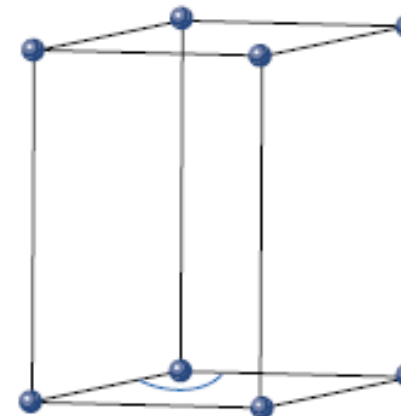
5 Trigonal

$$a = b = c; \alpha = \beta = \gamma \neq 90^\circ$$



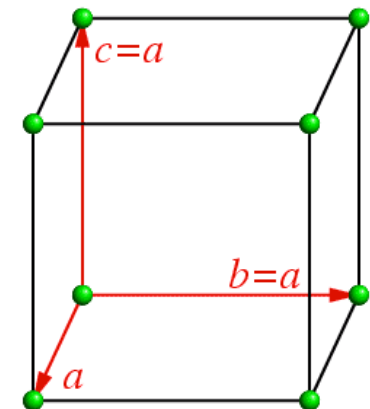
6 Hexagonal

$$a = b \neq c; \alpha = \beta = 90^\circ; \gamma = 120^\circ$$



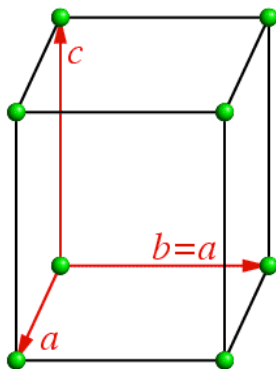
7 Cubic

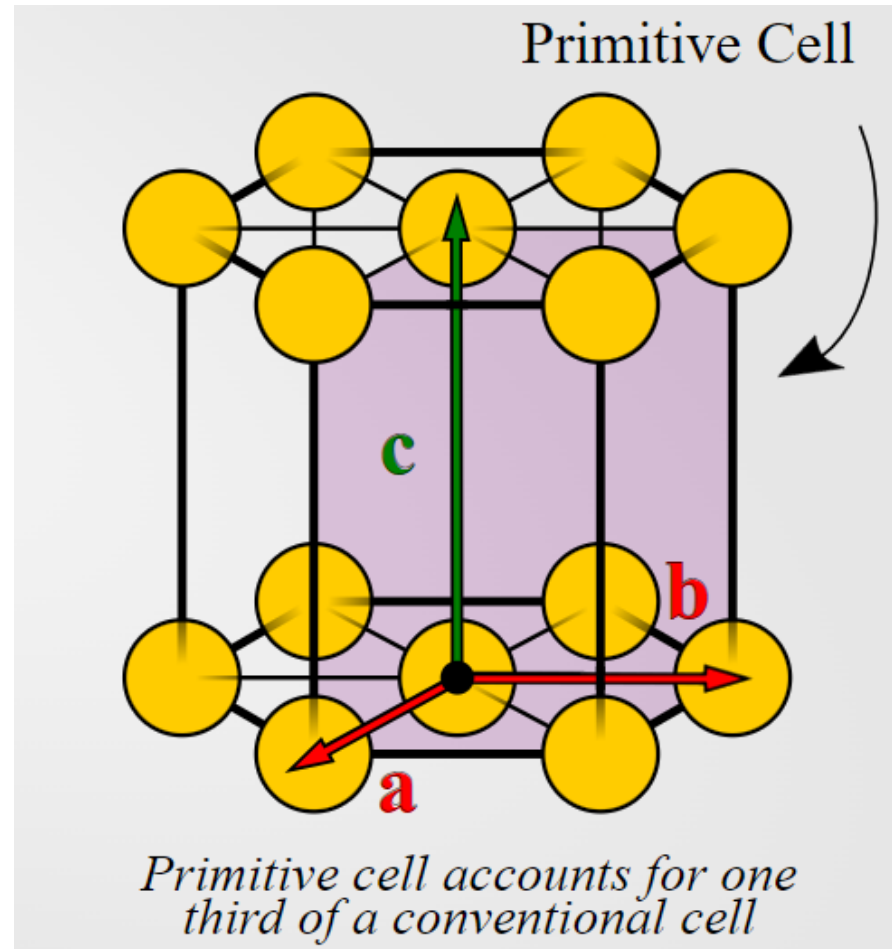
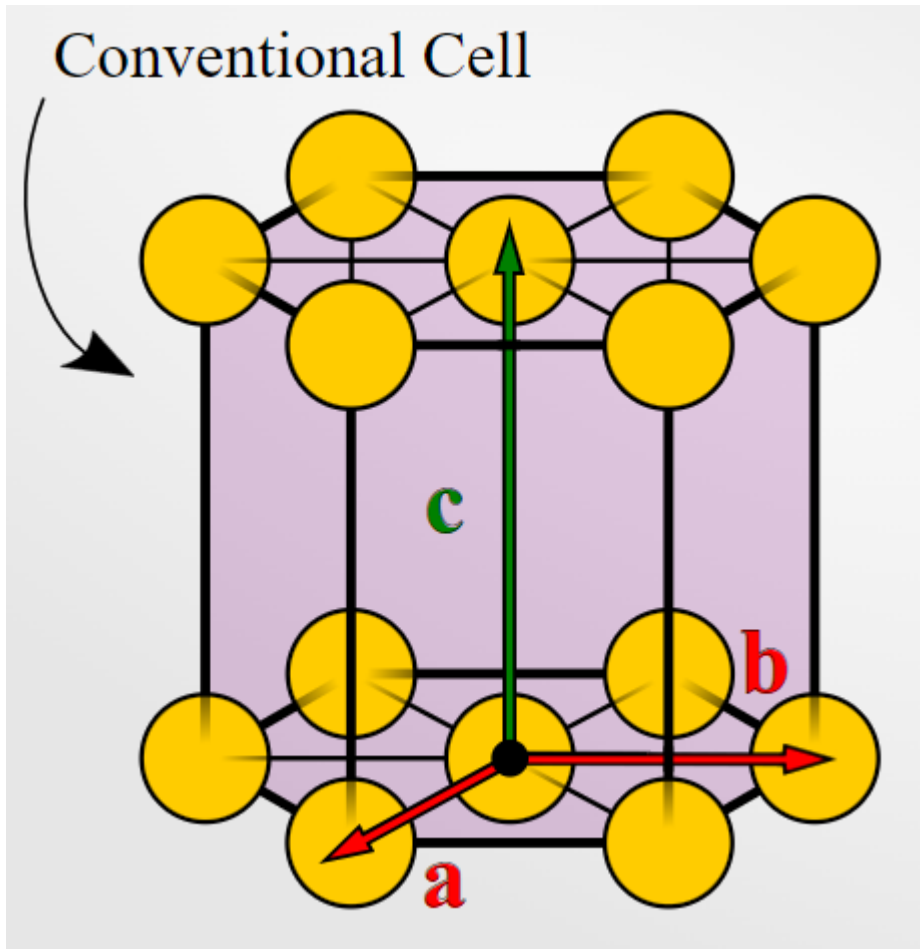
$$a = b = c; \alpha = \beta = \gamma = 90^\circ$$



4 Tetragonal

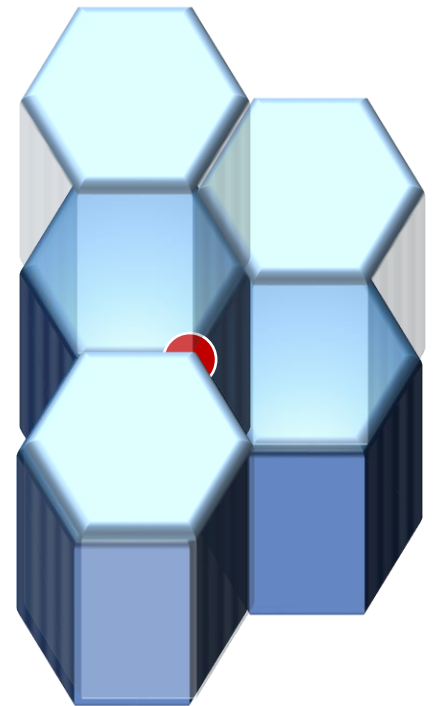
$$a = b \neq c; \alpha = \beta = \gamma = 90^\circ$$



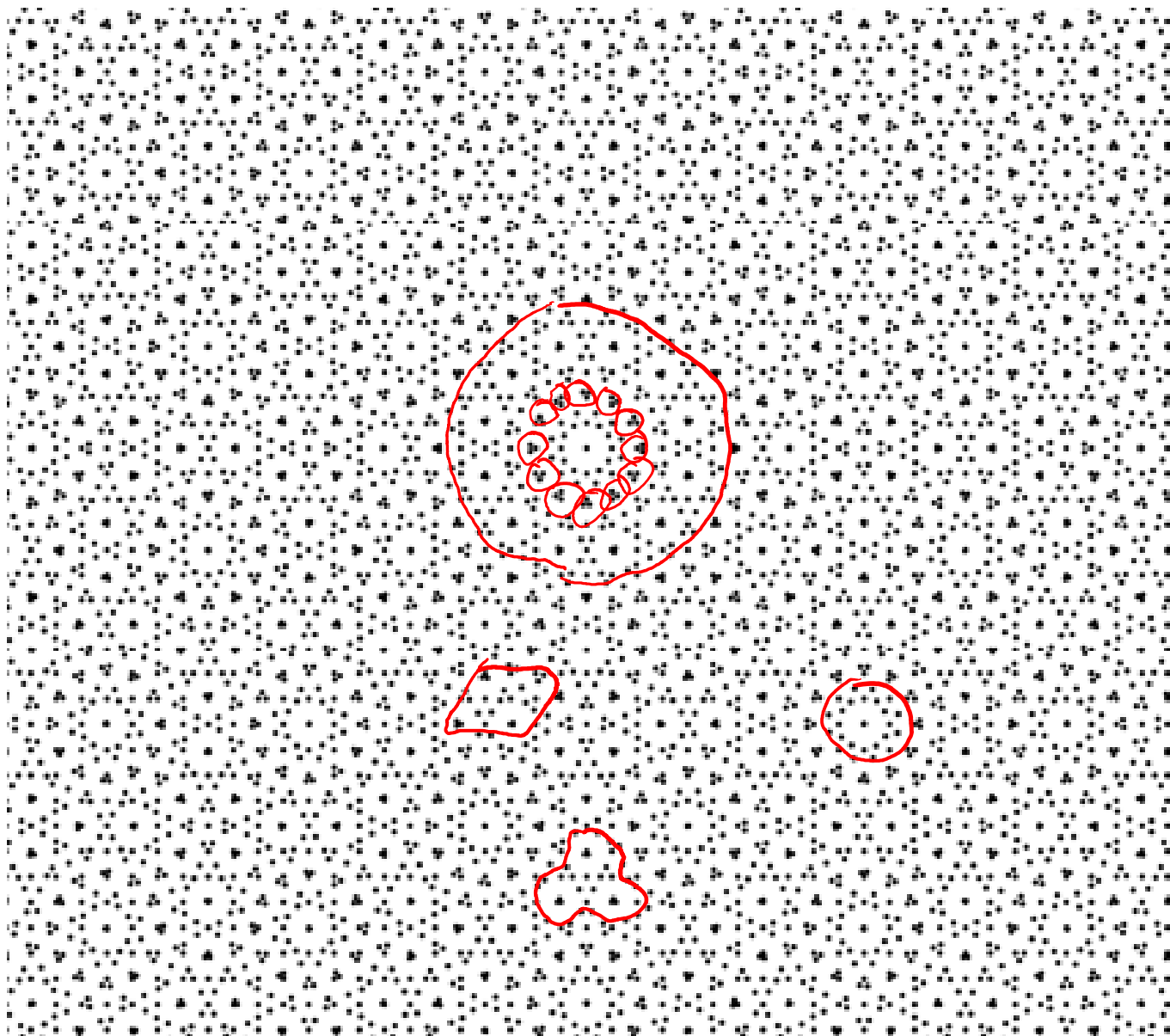


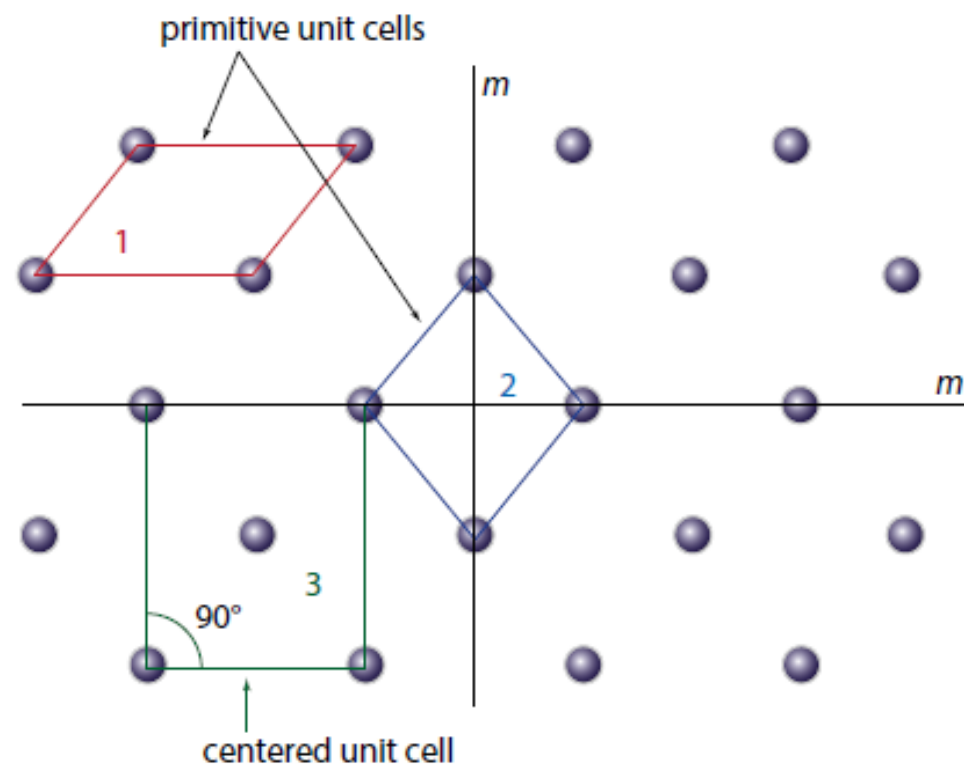
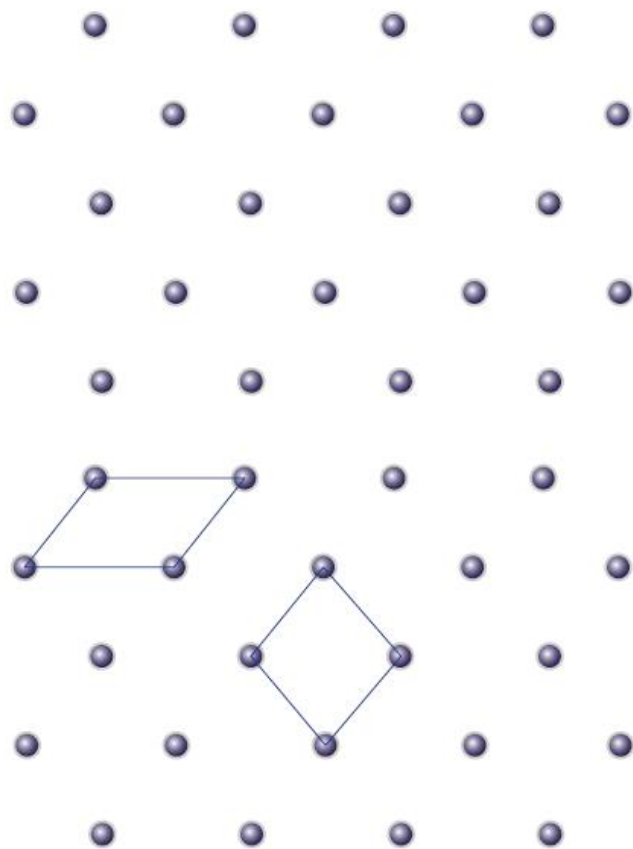
How many atoms per unit cell in a conventional cell?

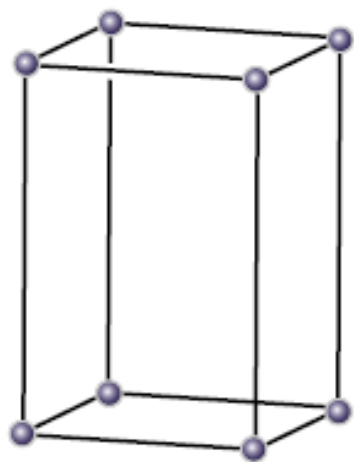
Three



Marroquin pattern

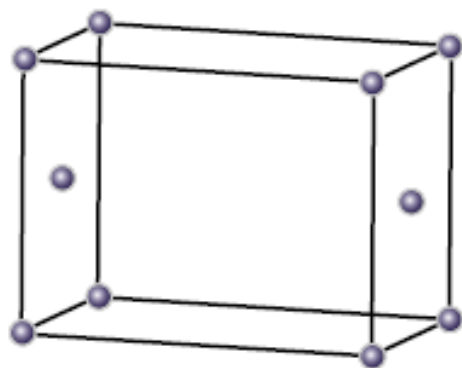






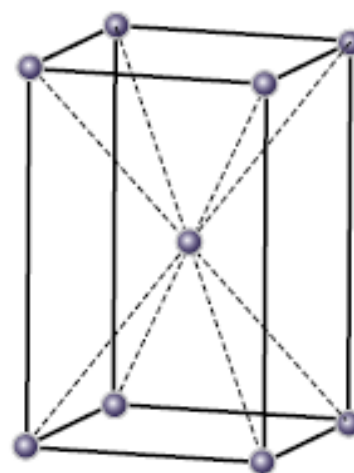
primitive

P



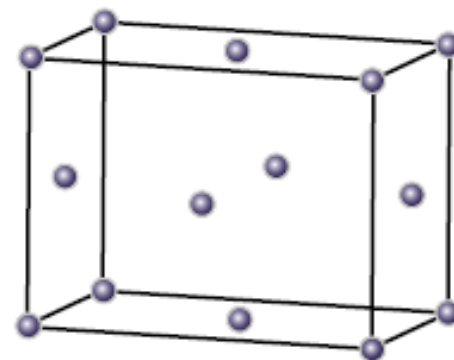
single-sided face-centered

C(AB)



body-centered

I

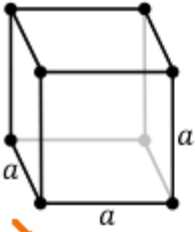
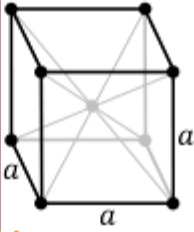
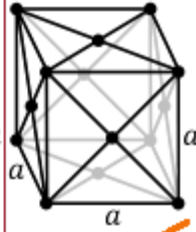
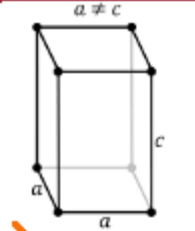
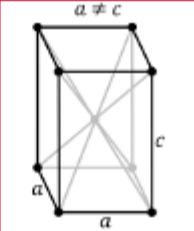
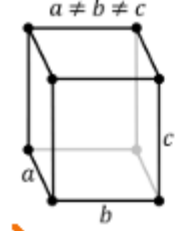
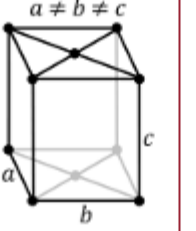
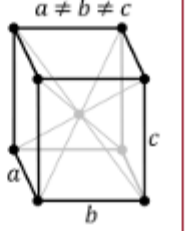
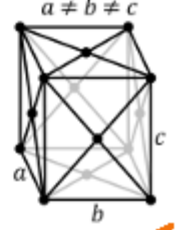
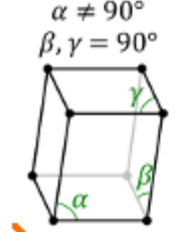
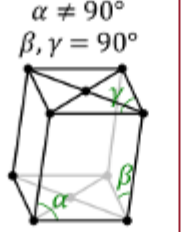
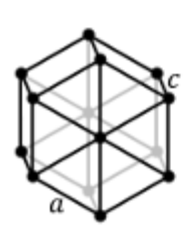
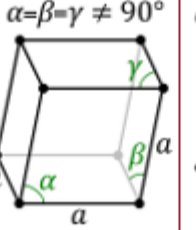
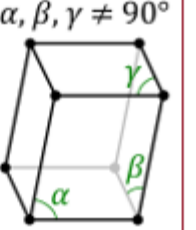


all-sided face-centered

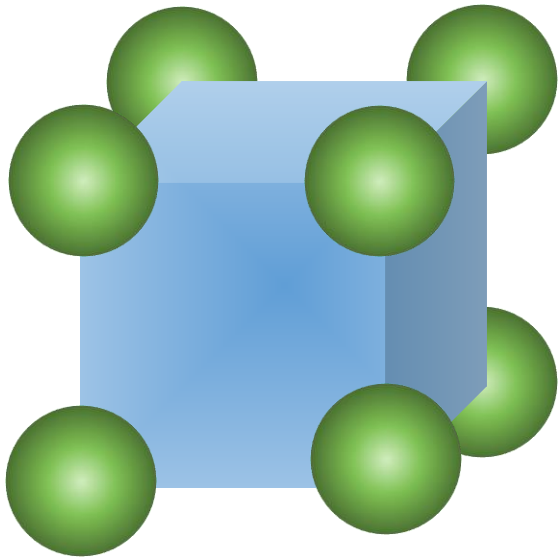
F

End-centred

14 Bravais lattices

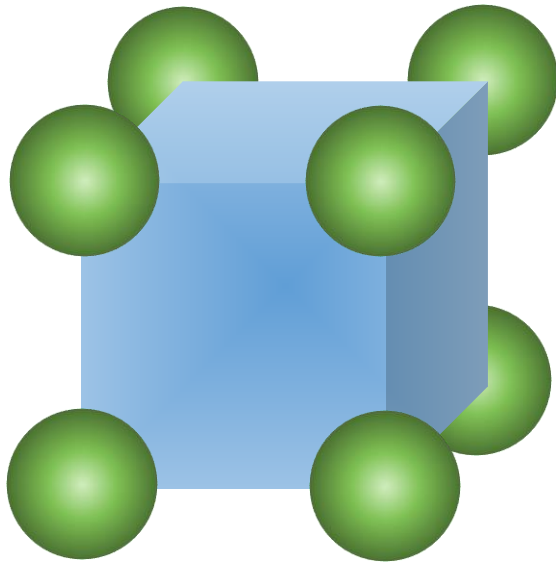
primitive	side-centred	body-centred	face-centred
			
cubic			
			
tetragonal			
			
orthorhombic			
			
monoclinic			
			
hexagonal	trigonal	triclinic	

Simple Cubic (**P**)



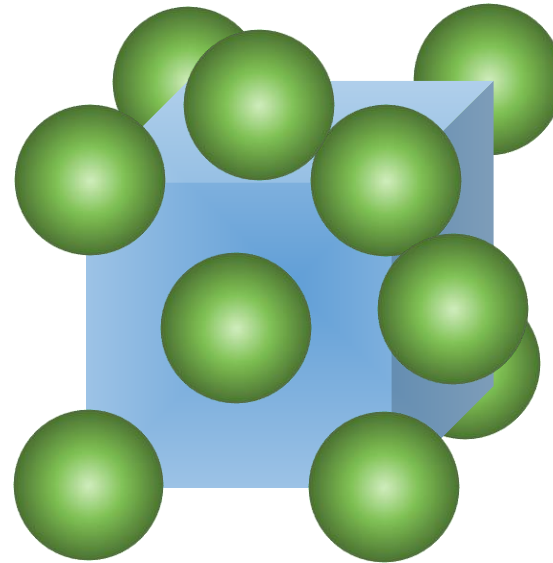
(Atoms located only at the corners of the unit cell)

Body centred Cubic (**I**)



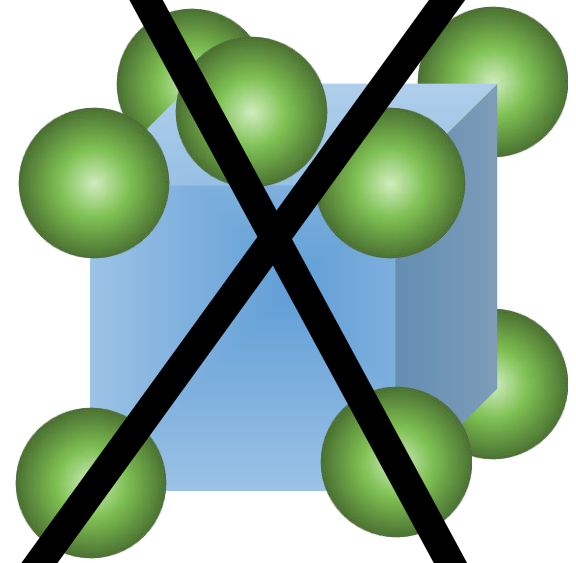
(Atoms located at the corners and centre of the unit cell)

Face centred Cubic (**F**)

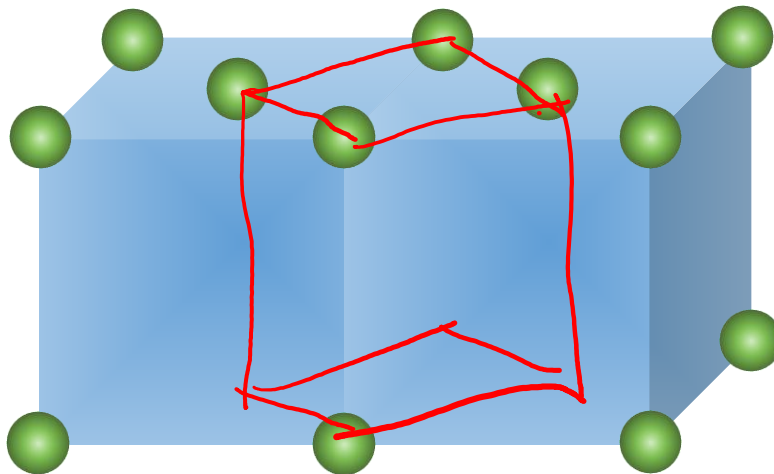


(Atoms located at the corners and faces of the unit cell)

End centred Cubic



(Atoms located at the corners and one of the opposite faces of the unit cell)



Why is there no end-centred cubic unit cell?

End-centred cubic ~ Primitive Tetragonal

- ☐ **Why is there no body-centred monoclinic Bravais lattice?**
- ☐ **Why can not a face centred cubic lattice be considered a body-centred tetragonal lattice?**