1

In the tetragonal system the number of independent parameters that characterize the lattice is:

1

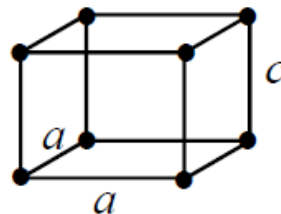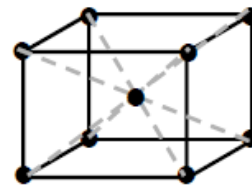2   A

3

4

6

Explanation: For a tetragonal system, a = b ≠ c, α = β = Υ = 90° i.e. a tetragon has two sides equal and all angles equal to 90 degrees, which is fixed. The independent parameters are a (or b) and c.

2. Tetragonal

c Body centred tetragonal

2

The **MINIMAL** symmetry property of rhombohedral (trigonal) system is:

1 axis of 3 fold symmetry   A

1 axis of 4 fold symmetry

2 axes of 4 fold symmetry

3 axes of 4 fold symmetry

3 axes of 2 fold symmetry

Trigonal

or Rhombohedral

Explanation: For a rhombohedral or triagonal system, we have:
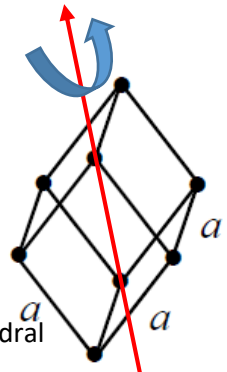
$\alpha = \beta = \gamma \neq \frac{\pi}{2}$, $\gamma < 2\pi/3$, and $a = b = c$ i.e. a=b=c   α=β=γ<120∘,≠90∘

Since, the angles between the lattice vectors is not 90 degrees there is no symmetry/rotation axis through the faces or the edges.

The only symmetry axis of rotation is *through the diagonal* which is a 3 fold axis of rotation. ALL such axis are the same (by symmetry) and each one is a 3-fold axis of rotation.

3

Most Bravais lattices in 3D have:

primitive unit cell   A

body centered unit cell

edge centered unit cell

face centered unit cell

base centered unit cell

Explanation: Out of 14 naturally occurring Bravais lattices, 7 are primitive. Remaining seven consists of 3 body centered, 2 face centered and 2 end centered unit cells.

4

In the following Bravais lattices, at least two sides of the unit cell unequal in which?

triclinic

monoclinic

orthorhombic

all of the classes mentioned   A

none of the classes mentioned

Explanation: For all three of triclinic, monoclinic and orthorhombic, we have a≠b≠c i.e. all three sides are unequal.

5

Which of the following unit cell types does **_NOT_** exist for **_BOTH_** tetragonal and monoclinic lattices?

primitive unit cell   BOTH

body centered unit cell   Tetragonal

face centered unit cell   A

base centered unit cell   Monoclinic

none of the mentioned

Explanation: For tetragonal system, we have primitive/simple and body centered unit cells. For monoclinic system, we have primitive/simple and base centered unit cells. Hence, we do not have face centered units cells for both systems.

Considering the amount of symmetry, the most symmetric crystal class in 3D is the cubic one and the least one is the triclinic system. Which one is a correct order of Bravais lattice classes in terms of symmetry among the classes mentioned? (Note: The greater than symbol ">" implies more symmetry present.)

Tetragonal > orthorhombic > rhombohedral > hexagonal   A

Orthorhombic > tetragonal > hexagonal > monoclinic

Hexagonal > tetragonal > orthorhombic > monoclinic

Rhombohedral > orthorhombic > hexagonal > tetragonal

Tetragonal > rhombohedral > orthorhombic > monoclinic

Explanation: The correct order of the symmetry among the crystal classes is: C-T-O-R-H-M-T or

Cubic > tetragonal > orthorhombic > rhombohedral > hexagonal > monoclinic > triclinic

Consider the number of parameters required for classification of the classes:

Crystal System	Lengths	Angles	Independent parameters	
cubic	a=b=c	$\alpha=\beta=\gamma=90\circ$	1	
tetragonal	a=b≠c	$\alpha=\beta=\gamma=90\circ$	2	
orthorhombic	a≠b≠c	$\alpha=\beta=\gamma=90\circ$	3	
trigonal (rhombohedral)	a=b=c	$\alpha=\beta=\gamma<120\circ,\neq90\circ$	2	
hexagonal	a=b≠c	$\alpha=\beta=90\circ, \gamma=120\circ$	2	
monoclinic	a≠b≠c	$\alpha=\beta=90\circ\neq\gamma$	4	
triclinic	a≠b≠c	$\alpha\neq\beta\neq\gamma$	6	

Clearly, after cubic, the **most symmetric is tetragonal**. The next one is orthorhombic, since all the angles are 90 degree.

Among orthorhombic and triagonal, there is no axis of symmetry or n-fold rotation through the **faces in triagonal**. The only symmetry axis for triagonal is through a diagonal (3-fold symmetry axis). Orthorhombic sustem also has these axes of rotation.

Hexagonal system does not have symmetry axes through the diagonals. Hence it has less symmetry than the triagonal or orthorhombic system.

Monoclinic and triclinic systems have increasingly less (i.e. progressively decreasing) symmetry.

7

In which of the following Bravais lattices, not all axial angles are right angles?

tetragonal

rhombohedral   A

orthorhombic

cubic

all of the mentioned

8

Which unit cell has eight particles located in the corners, has sides that are all unequal, and has angles of only 90 degrees?

tetragonal

rhombohedral

orthorhombic   A

simple cubic

triclinic

9.

If the vectors $\vec{a} = a\,\hat{x}$, $\vec{b} = b\,\hat{y}$ and $\vec{c} = c\,\hat{z}$ are the three lattice vectors with $a = b \neq c$, then number of **possible** lattice points per unit cell is:

3

2   A

4

6

8

10.

Example of a non-Bravais lattice is:

Diamond   A

Triagonal lattice

Face centered cubic lattice

Hexagonal lattice

Square lattice

11

Which crystal structure does the picture show $(\alpha = \beta = \gamma)$?

Triclinic

Monoclinic

Cubic

Triagonal   A

Orthorhombic

12

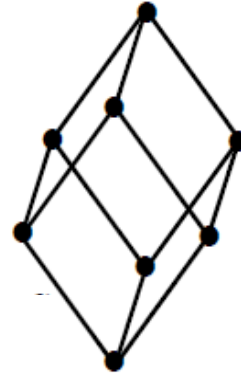In a base centered unit cell, how many atoms are in each conventional unit cell?

4

6

8

1

2   A