Syllabus for Test 05:

1. L12 (partly) the SSP part

Crystalline and polycrystalline solids, crystallite, amorphous solids, lattice and basis, Bravais lattice, 1D, 2D and 3D Bravais lattice, non-Bravais lattice, lattice with a basis, honeycomb lattice, graphene

2. L13

Symmetry operations in lattice, translation, rotation, n-fold axis of rotation, non-existence of five-fold axis of rotation, reflection, inversion, basis vectors, classification of Bravais lattice in 2D and 3D (5 and 14 classes, respectively).
This essentially covers material from the beginning of SSP up to classification of 3D Bravais lattices.

1. Crystalline materials differ from amorphous materials by

containing different chemical elements.

having periodic spacing of atoms.

being natural rather than man-made.

having different densities.

All of the others.

Answer: having periodic spacing of atoms.

2. Number lattice points in an unit cell is

one

two

four

depends on type of Bravais lattice

six

Answer: depends on type of Bravais lattice.

3. Identify the Unit Cell:

Simple cubic (SC)

Face centered cubic (FCC)

Body centered cubic (BCC)

Hexagonal close pack (HCP)

Diamond structure

Answer: Hexagonal close pack (HCP)

4. In 3D, Bravais lattices consist of how many types of space lattices:

Five

Seven

Thirteen

Fourteen

Twelve

Answer: Fourteen. Out of 14 Bravais lattices, 7 are primitive. Remaining seven consists of 3 body centered, 2 face centered and 2 end centered unit cells. They belong to ***SEVEN CRYSTAL CLASSES***.

5. Graphite is a common form (allotrope) of Carbon. Its crystal structure is:

Cubic

Monoclinic

Orthorhombic

Hexagonal

Triclinic

Answer: Hexagonal

6. Copper has a face-centered cubic unit cell. How many copper atoms are in each conventional unit cell?

4

6

8

1

2

Answer: 4

7. Which of the following conditions are being satisfied by tetragonal crystal system?

$a = b = c$, $\alpha = \beta = \Upsilon = 90^o$

$a \neq b \neq c$, $\alpha = \beta = \Upsilon = 90^o$

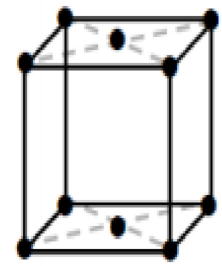
$a = b \neq c$, $\alpha = \beta = \Upsilon = 90^o$

$a = b = c$, $\alpha \neq \beta = \Upsilon = 90^o$

$a \neq b \neq c$, $\alpha \neq \beta \neq \Upsilon$

Answer: Tetragon has two sides equal and all angles equal. $a = b \neq c$, $\alpha = \beta = \Upsilon = 90°$

8. Which crystal structure does the picture show?



Body centered cubic (BCC)

Face centered cubic (FCC)

Base centered orthorhombic

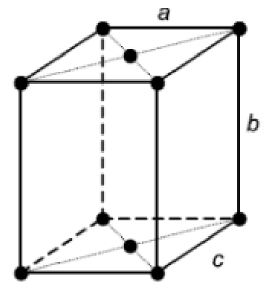
Base centered monoclinic

None of the mentioned

Answer: Base centered orthorhombic. Explanation: For base centered orthorhombic, we have:

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

But for monoclinic lattice, we have: $a \neq b \neq c$ $\alpha = \gamma = 90^o$ and $\beta \neq 90^o$ which should look like the one to the right:



9. Which of the following conditions are being satisfied by monoclinic crystal system?

$a \neq b \neq c$, $\alpha = \beta = \Upsilon = 90^o$

$a = b \neq c$, $\alpha = \beta = \Upsilon = 90^o$

$a \neq b \neq c$, $\alpha = \beta = 90^{o,}$ $\Upsilon \neq 90^o$

$a = b = c$, $\alpha \neq \beta = \Upsilon = 90^o$

$a \neq b \neq c$, $\alpha \neq \beta \neq \Upsilon$

Answer: A monoclinic unit cell has all sides unequal and two angles equal to 90° : $a \neq b \neq c$, $\alpha = \beta = 90^{o,}$ $\Upsilon \neq 90^o$

10. Which one of the following is least symmetric?

Tetragonal

Simple cubic

Triclinic

Monoclinic

Orthorhombic

Answer: Triclinic. In triclinic crystal system, we observe all the sides and angle to unequal to each other ($a \neq b \neq c$ and $\alpha \neq \beta \neq \gamma$), thus giving least symmetry (1-fold symmetry) among all 7 classes of Bravais lattices.

11. The cubic system is characterized by:

3 axes of 2 fold symmetry

4 axes of 3 fold symmetry

2 axes of 4 fold symmetry

6 axes of 4 fold symmetry

None of the others mentioned.

Answer: 4 axes of 3 fold symmetry. These four axes are along the four diagonals going through points at opposite corners.

12. An orthorhombic system is characterized by:

6 axes of 4 fold symmetry

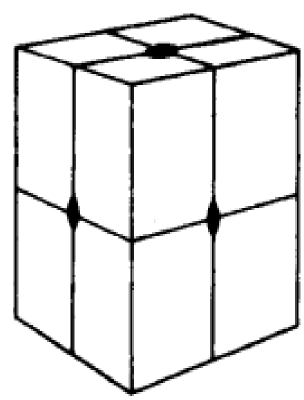
3 mirror planes parallel to the faces

4 axes of 3 fold symmetry

6 mirror planes along the diagonals of the faces

3 axes of 2 fold symmetry

Answer: 3 mirror planes parallel to the faces. Since, $a \neq b \neq c$, $\alpha = \beta = \gamma = 90^o$, we have:



4 axes are along the four diagonals going through points at opposite corners do not produce any symmetry.

Because of unequal length of the sides, the 6 mirror planes along the diagonals of the faces do not return the original unit cell. Similarly the option of 4 fold symmetry is not valid.

13. A unit cell that contains lattice points only at the corners is known as:

a primitive unit cell

a non-primitive unit cell

a conventional unit cell

a cubic unit cell

a triclinic unit cell

Answer: a primitive unit cell. Explanation: If a unit cell chosen contains lattice points only at its corners, it is called a primitive or simple unit cell. It contains only one lattice point per cell since each lattice point at the corners is ***equally*** shared by the adjacent unit cells. There are other primitive unit cells besides simple cubic unit cells.

14. Example of a non-Bravais lattice is:

Graphene

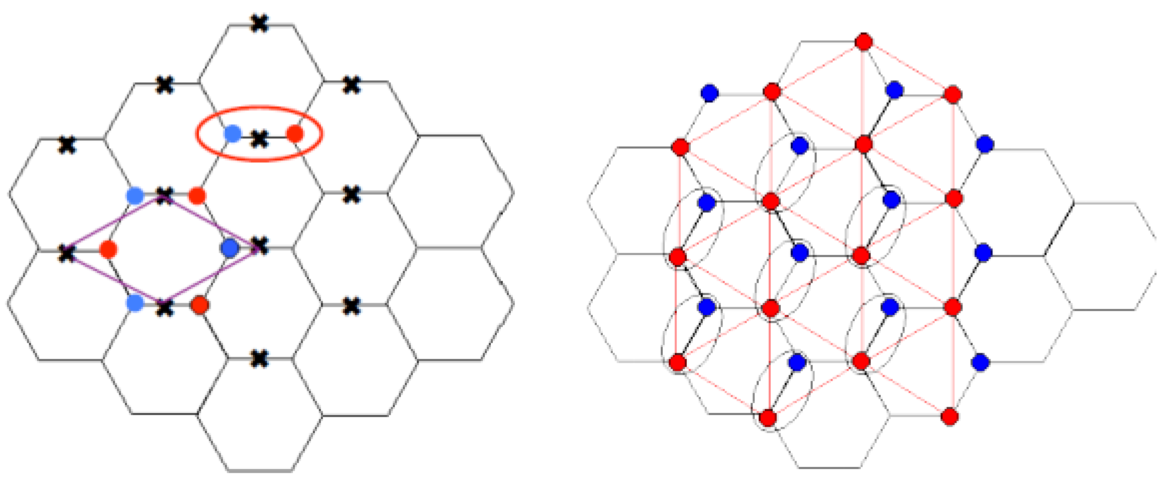
Triagonal lattice

Centered Rectangular lattice

Hexagonal lattice

Square lattice

Answer: Graphene has honey-comb lattice structure which is a non-Bravais lattice. It can be thought of as a oblique Bravais lattice with a 2-atom basis with the same atoms in the basis. Hence it sis a non-Bravais lattice (since its basis has more than one atom of the same type).



15. 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 $a \neq b \neq c$, then number of **possible** lattice points per unit cell is:

3

1

5

6

8

Answer: 1 lattice points per cell for simple orthorhombic unit cell, which is a primitive unit cell. For base-centered and body-centered orthorhombic unit cells, number of lattice points/cell is 2 while for the face-centered orthorhombic unit cell, the number of lattice points/cell is 4. Hence among the choices, only 1 is a possible value.

Suggestions:

You should **not only remember but also completely understand** the classification schemes of the crystal structures in 2D and 3D.

Here is a summary:

For reference, 7 classes of Bravais lattices are tabulated below:

Crystal System	Lengths	Angles
cubic	$a=b=c$	$\alpha=\beta=\gamma=90^\circ$
tetragonal	$a=b\neq c$	$\alpha=\beta=\gamma=90^\circ$
orthorhombic	$a\neq b\neq c$	$\alpha=\beta=\gamma=90^\circ$
trigonal	$a=b=c$	$\alpha=\beta=\gamma<120^\circ,\neq 90^\circ$
hexagonal	$a=b\neq c$	$\alpha=\beta=90^\circ$, $\gamma=120^\circ$
monoclinic	$a\neq b\neq c$	$\alpha=\beta=90^\circ\neq\gamma$
triclinic	$a\neq b\neq c$	$\alpha\neq\beta\neq\gamma$

Also, you should identify the **symmetry properties** of the lattices.