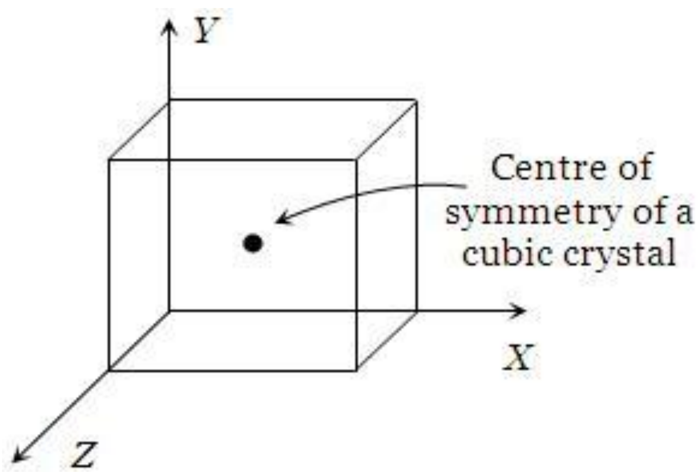
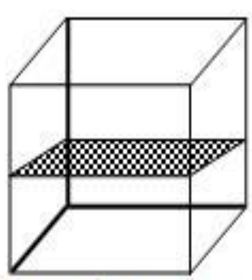
Lecture -3-

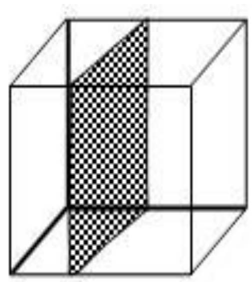
1.7 Fundamentaltype of lattice

Crystal lattice can be carried into themselves by the lattice translations (T)andby other symmetry operations [Rotation about an **axis** (1, 2, 3, 4, and 6-fold), Reflection at a plane, and Inversion through a **point**].

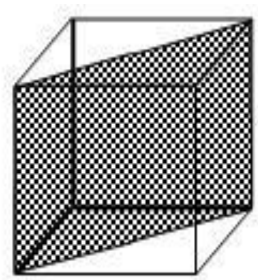




Plane of symmetry

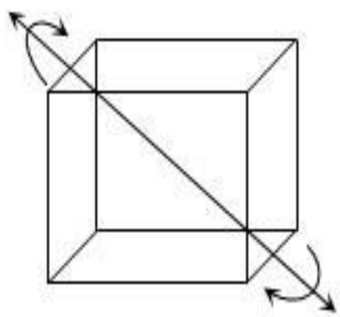


Rectangular plane of symmetry

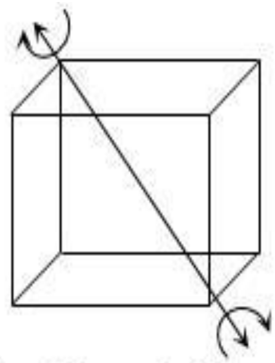


Diagonal plane of symmetry

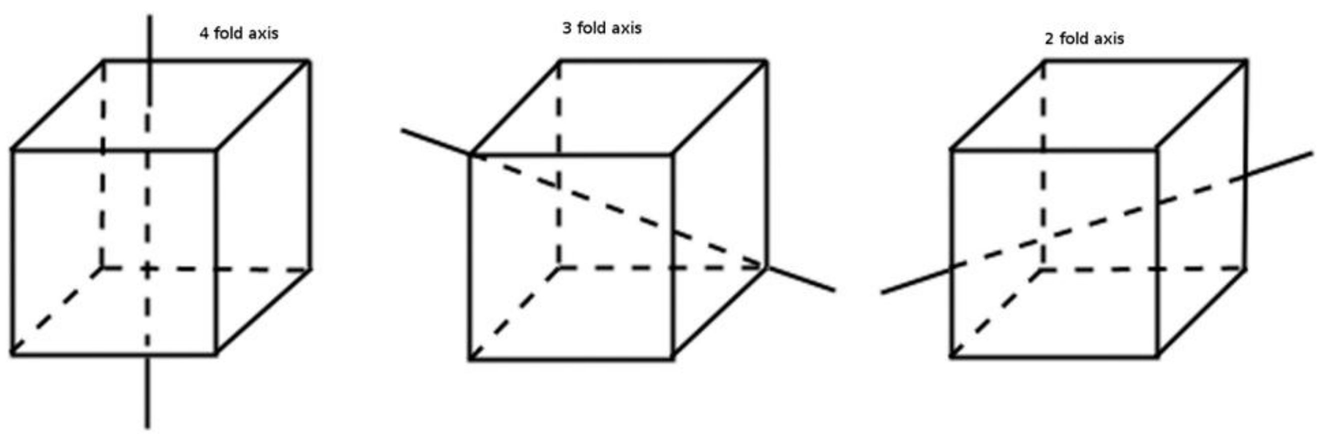
We say that a crystal has n-fold axis of rotation if rotation through an angle (Ø=2π/n) carry the lattice into itself. Lattice can be found such that 1, 2, 3, 4, and 6-fold rotation axes carry the lattice into itself, corresponding to rotations by Ø=2π, 2π/2, 2π/3, 2π/4,and2π/6 radians.



Axis of two fold symmetry

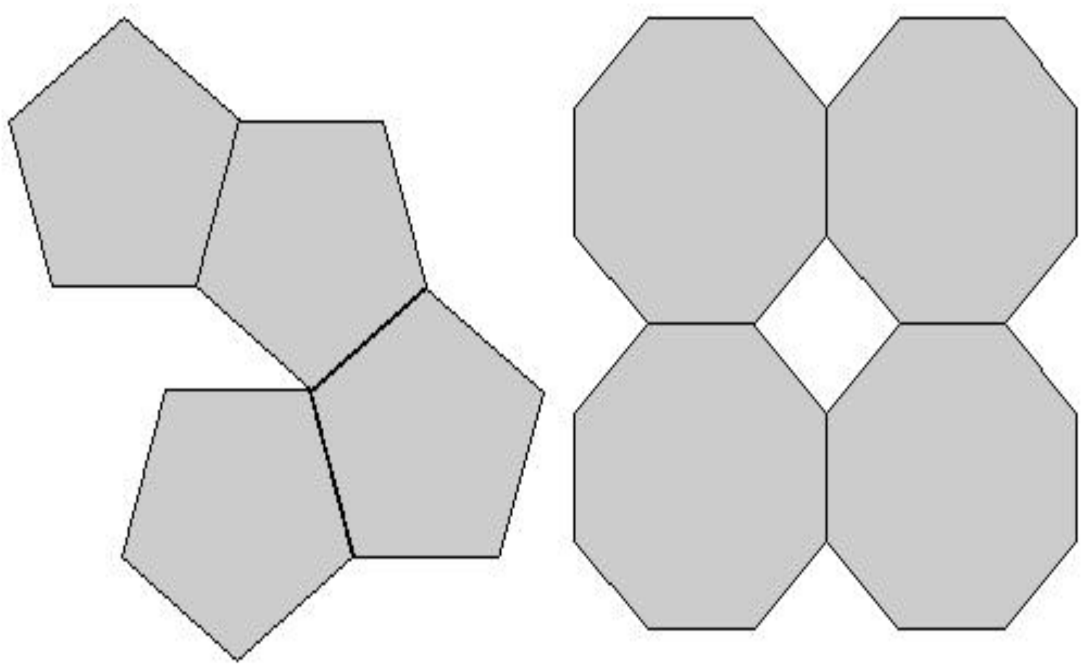


Axis of three f old symmetry



Q/Find all the possible elements symmetry for the SC.We cannot find a lattice that goes into itself under other rotation, such as 2π/7, 2π/5.This means that a 5- fold axis cannot exist in a periodic lattice. Explain why?.

As shown in Fig.(6), a fivefold axis cannot exist in a periodic lattice because it is not possible to fill the area of a plane with a connected group of pentagons (five).



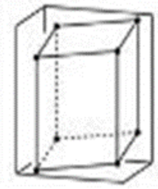
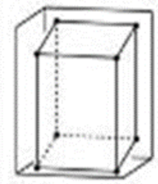
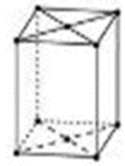
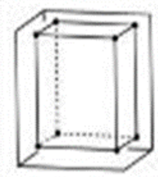
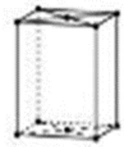
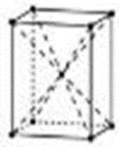
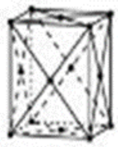
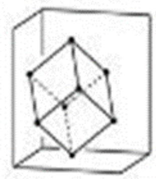
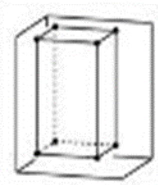
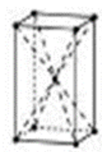
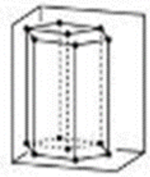
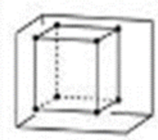
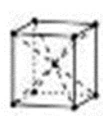
ab

Fig.6a- Fivefold ,b-Eightfold

Q/ Check for 7-fold.

1.8 Three- dimensional lattice type

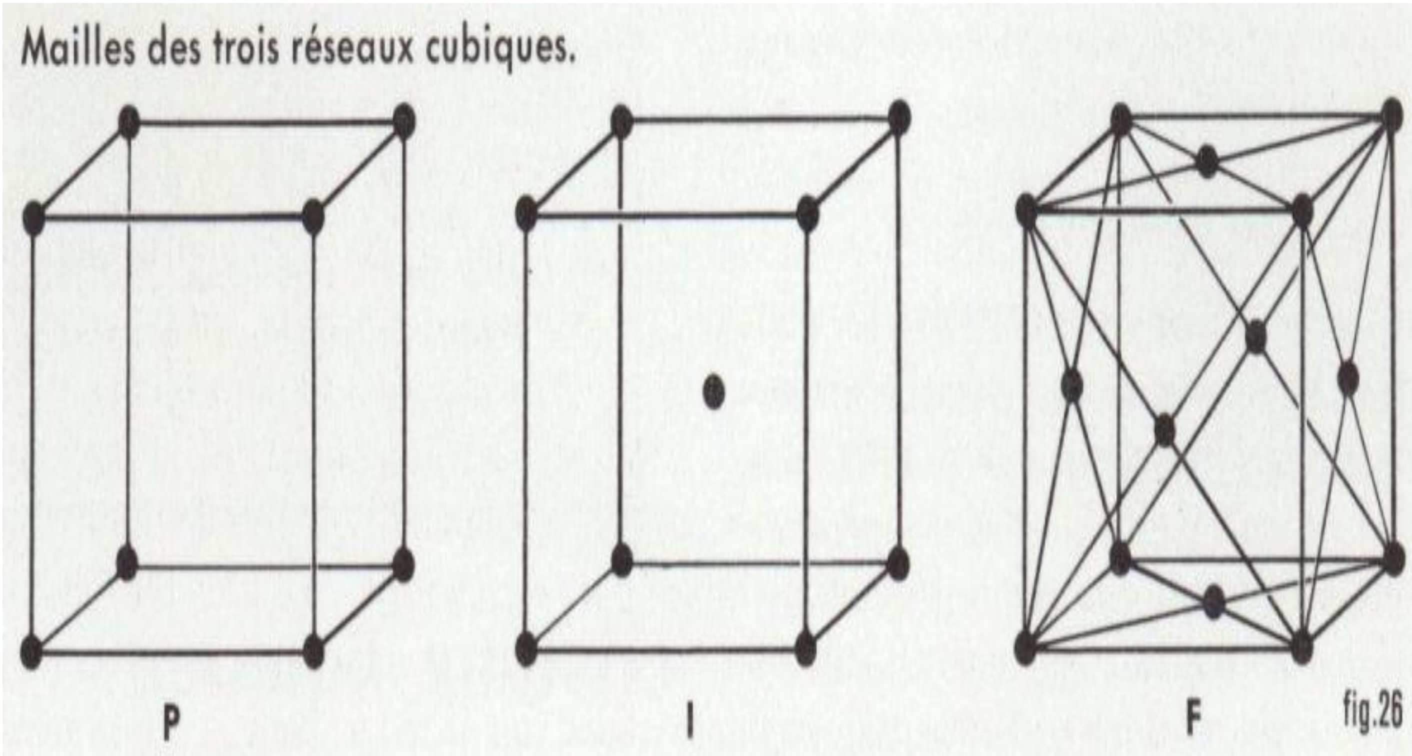
The 14 possible 3-D Bravais lattice listed in Table (1). The general lattice is triclinic and 13 special lattice. Fig.(7) shows the cubic space lattices.The characteristics of cubic lattices listed in Table (2).

النظام البلوري System	شبكات بسيطة Primitive (p)	شبكات ممركزة القاعدتين Base-centred (C)	شبكات ممركزة الجسم Body-centred (I)	شبكات ممركزة الوجوه Face-centred (F)	امثلة فلزية
ثلاثي الميل Triclinic $a \neq b \neq c$ $\alpha \neq \beta \neq \gamma \neq 90^{\circ}$					اكسنيت Axinite $Cu\,SO_4 \,.\, 5H_2O$
الوحيد الميل Monoclinic $a \neq b \neq c$ $\alpha = \gamma = 90^{\circ} \neq \beta$					امفيبول Amphibale $Na_2\,Co_3$
المعيني القائم Orthorhombic $a \neq b \neq c$ $\alpha = \beta = \gamma = 90^{\circ}$					اوليفين Olivine Barytes $AgNo_3$
الثلاثي Trigonal Rhombohedral $a = b = c$ $\alpha = \beta = \gamma \neq 90^{\circ}$					كالسيت Calcite As
الرباعي Tetragonal $a = b \neq c$ $\alpha = \beta = \gamma = 90^{\circ}$					زركون Zircon KH_3PO_4
السداسي Hexagonal $a = b \neq c$ $\alpha = \beta = 90^{\circ}$ $\gamma = 120^{\circ}$					اباتيت Apatite كوارتز Quartz Zn
المكعب Cubic $a = b = c$ $\alpha = \beta = \gamma = 90^{\circ}$					غارنت Garnet ماغنتيت Magnetite

الجدول (1) شبكات برافية

Table (2) Characteristics of cubic lattices.

	bCC I	SC p	FCC F
Volume unit cell	a^3	a^3	a^3
Number of lattice points per unit cell	2	1	4
Number of lattice points per volume	$\frac{2}{a^3}$	$\frac{1}{a^3}$	$\frac{4}{a^3}$
Number of points neighboring first class	8	6	12
Distance between adjacent points of first class	$\frac{\sqrt{3}}{2}a$	a	$\frac{1}{\sqrt{2}}a$
Number of points neighboring second-class	6	12	6
Distance between adjacent points of first class	a	$\sqrt{2}a$	a
Filling factor	0.68	0.52	0.74



Cubic simple Body centered cubic Face centered cubic

CS BCC FCC

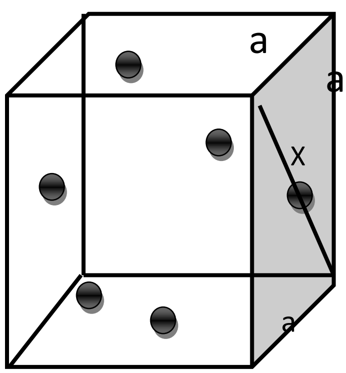
8x⅛=1 atom 2x1=2atom 6x ½=3atomS

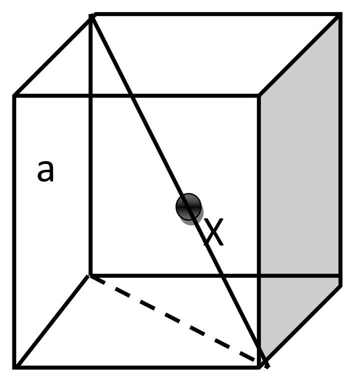
Fig.7 Cubic space lattices.

Exercise:

prove that the distance between adjacent points of first class in FCC and BCC cells is equal $\frac{1}{\sqrt{2}}$ a and $\frac{\sqrt{3}}{2}$ a respectively.

Solution:





x $=\sqrt{a^2+a^2}=\sqrt{2}$ a

x $=\sqrt{a^2+2a^2}=\sqrt{3}$ a

$\frac{x}{2}=\frac{\sqrt{2}}{2}$a $=\frac{a}{\sqrt{2}}$=d $\frac{x}{2}=\frac{\sqrt{3}}{2}$a =d