Answer Key 00063768

Note: Draw neat diagrams where necessary.

Max. Marks 100
Duration 3 Hrs

1 a **Fill in the blanks** 10

i) The metallic bond is attraction between the positive metal cations and the cloud of negative electrons.

ii) Diamond has a covalent bond structure composed of carbon atoms which is reflected in the extreme hardness of diamond.

iii) Lusture of quartz is called as vitreous

iv) Satin-spar, a fibrous variety of gypsum show silky lusture.

v) The unit cell is the smallest unit of a three dimensional pattern which is repeated throughout the crystal.

vi) Planes of symmetry divide the crystal into two equal halves which are mirror images of each other.

vii) To measure the interfacial angle in crystals, optical goniometer is use.

viii) Triclinic is the crystal system in which three axes are unequal and none at right angles

ix) Rhomb-do-decahedron is a crystal form bounded by twelve, rhomb shaped faces.

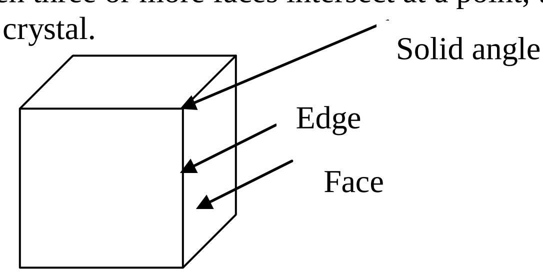
b **Define the following (all units)** 10

i) Ionic bond: Bonding between ions of opposite electrical charge. Atoms are held together by this type of bond are in the ionized state, each atom having gained or lost one or more electron, so that they have acquired a positive or negative charge. The ions are held together by the electrical attraction between oppositely charged bodies. Example-Common halite mineral NaCl and Fluorite CaF

Covalent bond: In this type of bonding, electrons are shared between two atoms, with the outermost shells of the atoms overlapping. Example- Diamond has a covalent structure composed entirely of carbon atoms.

ii) Edge: In a crystal, when two adjacent faces intersect it forms an edge of the crystal.

Solid angle: When three or more faces intersect at a point, they form the solid angle of the crystal.

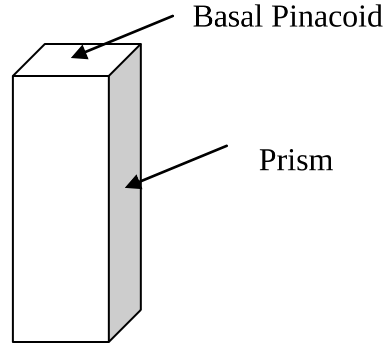


iii) Reniform habit of mineral: Kidney shaped aggregates of crystals. The rounded outer surface of massive mineral aggregates resembling those of kidneys. Example- Haematite

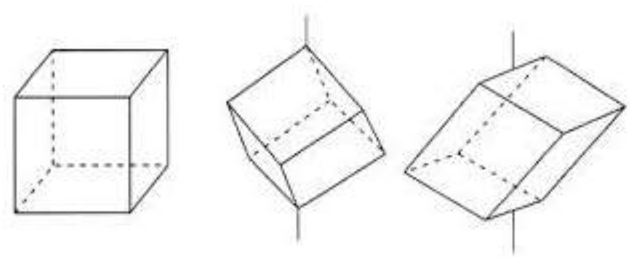
Botryoidal habit of mineral: Sperical aggregation resembling a bunch of grapes. Example- Azurite and prehnite.

iv) Basal Pinacoid: It is a form with two like-faces, parallel to the plane of the horizontal axes and cutting the c axis

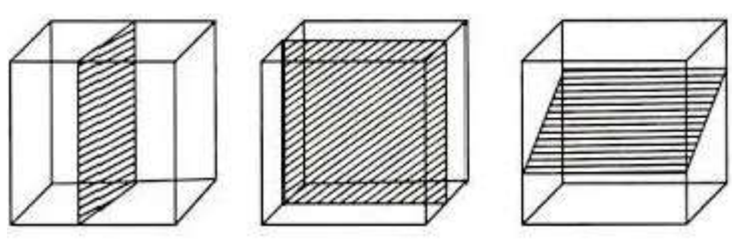
Prism: These are the forms with vertical faces and therefore parallel to the c axis and intersecting both the horizontal axes. Depending upon their orientation and lengths of intersection with horizontal axis, prisms can be classified into three types- Prism of first order, prism of second order, Ditetragonal prism.



v) Axis of symmetry: It is an imaginary line in the crystal, about which when a crystal is rotated, certain faces, edges and corners come to occupy same position in space, more than once, during complete rotation of 360°.



Plane of symmetry: It is an imaginary plane which divides a crystal into two similar and similarly placed halves such that one half is the mirror image of the other.



2 Answer any two of the following-(unit 1

a Describe the metallic bonding. Add a note on the basic atomic pattern/packing in metals. 10

- A metallic bond occurs when positive metal ions like Cu^{+2} or Fe^{+3} are surrounded by a "sea of electrons" or Cloud of electrons which are freely-moving valence electrons**.**
- The valence electrons are not bound to any particular cation, but are free to move throughout the metallic crystal.
- Crystals with this type of bonding are called metallic crystals.

- Many properties which are characteristics of metatals, are due to the presence of free electrons.
- In general there are three ways in which ions of most metals are packed together to form crystals. These are cubic close packing, body centered cubic packing and hexagonal close packing.
- Cubic close packing- metallic ions of equal size are arranged at the corners of equilateral triangles and are aligned in layers which are at right angles to the diagonal of a cube. Any one diagonal layer fits against the next so that each sphere touches three other spheres in the layers, below and above. This packing allows the metals to develop ductility and malleability. Example: Copper, Gold
  Body-centered cubic packing- The metallic ions are arranged at the centers and the corners of a series of cubes. It is not tightly packed model each sphere touches eight other ionic spheres. This arrangement is reflected in the properties, these metals are harder and more brittle. Example: Iron, Tungsten.
  Hexagonal close-packing- In this type of packing the centre of ionic spheres lie at the corners of an equilateral triangles. This ionic structure is repeated after every second layer and the repetition occurs only in one direction gliding planes are rare and hence that results in properties such as hardness and less ductility. Example: Magnesium, Titanium.

b What is isomorphism and polymorphism? Explain in detail with examples. 10

Isomorphism: Some minerals although chemically different may show similarities of more than one kind. All these minerals crystallize in the same structural pattern. Thus the minerals which have the same or similar crystal forms are said to be isomorphous and their relationship is termed as isomorphism. Example: Calcite, Rhodocrusite and siderite. All above mentioned minerals are carbonates but the only difference is cations in these three minerals are calcium, manganese and iron. All these minerals have same crystallization pattern and hence have same or similar crystal forms.

There are ions which have identical sizes and electrical charges. These ions can form similar crystal structures and also capable of interchanging their structure. Such substitution by similar ions is called isomorphous substitution. This substitution could be either partial or complete depending upon the sizes of ions and the acceptability of crystal structure. If the sunstitution is complete then it may give rise to isomorphous series. Example- Forsterite and fayalite are end members of an isomorphous series of Iron and magnesium Olivines.

Polymorphism: Compound or elements that can exist in more than one crystallographic structure are called polymorphs and the phenomenon is termed as polymorphism. Each polymorph has its own physical properties and a distinct atomic or ionic configuration. Isomorphic substances are classified as dimorphic, trimorphic etc. depending upon the number of crystalline forms developed. The same substance may form different polymorphs under differing conditions. Example- diamond and graphite are polymorphs of carbon. In diamond the carbon atoms are held together by covalent bond. It results on great hardness. On the other hand graphite has carbon atoms which are held together by covalent and van der waals bonds which results in lower hardness.

c Enlist various physical properties of minerals. Explain the habits of minerals with examples. 10

Colour
Streak
Lusture
Test, odour and feel
Form
Habit
Clevage and partings
Fracture
Hardness
Specific gravity
<u>Mineral Habit</u>

Habit	Discription	Name of Mineral
Acicular	Fine needle-like crystals	Natrolite
Bladed	Shaped like knief blade or lath-like	Kyanite
Fibrous	thin tread-like strands	Satin spar
Foilated	thin separable lamellae or leaves	Mica
Lamellar	sperable plates or leaves	wollastonite
Prismatic	Elongation of crystal in one direction	Feldspar
Reticulate	crystals in a cross mesh pattern	Rutile neddle in quartz
Scaly	small plates	Tridymite
Tabular	broad, flat, thin crystals	Barite

d Explain the physical properties of minerals that depend upon light. 10

The properties of minerals that depend upon light are

1. colour- The minerals absorb certain wavelengths of the natural light and reflects others, this is how to a human eye the mineral appears coloured. The colour is related to major atomic constitution of that mineral. Colour of mineral can also be due to presence of certain anions or anionic groups like CO_3^{-2}, Cl^{-1}etc.

Impurities in minerals can also contribute towards change in colour.

2. Steak- The streak of mineral is the colour of its powder, and may be quite different from the colour of the mineral. It is important in case of metallic minerals. Grey galena gives black streak, brass yellow pyrite gives black streak. streak is obtained by a piece of fired but unglazed porcelain called streak-plate.

3. Lusture- The lusture of mineral depends upon amount and type of reflection of light that takes place at the surface of the minerals. Following descriptive terms are used. Metallic, vitreous, resinous, pearly, silky and adamantine.

3 Answer any two of the following-

a What is a crystal? Explain concept of crystal symmetry. 10

Definition- A crystal is homogeneous solid, possessing a longrange three dimentional internal ordered atomic structure.

Concept of crystal symmetry

There is a constancy and regularity for the positions of faces, edges and corners for a crystal. This regularity of forms the symmetry of crystals and it depends upon space lattice and unit cell of that mineral

Crystals can be divided into systems and further subdivided into types. All crystals have been classified in to 6 crystal systems and 32 crystal classes. This classification is based on three fundamental elements of symmetry as follows.

Plane of symmetry

Axes of symmetry

Centre of symmetry

b State the law of rational indices. Explain the parameter system of Weiss and Index system of Miller. 10

"The indices of any crystal face are always rational numbers and are determined by dividing the intercepts of any face into the intercepts of parametric plane and clearing fractions".

Crystal faces can be defined by their intercepts on the crystallographic axes. For non-hexagonal crystals, there are three cases.

A crystal face intersects only one of the crystallographic axes.

As an example the top crystal face shown here intersects the c axis but does not intersect the a or b axes. If we assume that the face intercepts the c axis at a distance of 1 unit length, then the intercepts, sometimes called Weiss Parameters, are: ∞a, ∞b, 1c.

A crystal face intersects two of the crystallographic axes.

As an example, the darker crystal face shown here intersects the a and b axes, but not the c axis. Assuming the face intercepts the a and c axes at 1 unit cell length on each, the parameters for this face are: 1a, 1b, ∞c

A crystal face that intersects all 3 axes.

In this example the darker face is assumed to intersect the a, b, and c crystallographic axes at one unit length on each. Thus, the parameters in this example would be:

1a, 1b, 1c

Two very important points about intercepts of faces:

The intercepts or parameters are relative values, and do not indicate any actual cutting lengths.

Since they are relative, a face can be moved parallel to itself without changing its relative intercepts or parameters.

Because one does usually not know the dimensions of the unit cell, it is difficult to know what number to give the intercept of a face, unless one face is chosen arbitrarily to have intercepts of 1. Thus, the convention is to assign the largest face that intersects all 3 crystallographic axes the parameters - 1a, 1b, 1c. This face is called the unit face.

The Miller Index for a crystal face is found by

- first determining the parameters
- second inverting the parameters, and
- third clearing the fractions.

For example, if the face has the parameters 1 a, 1 b, ∞□c

inverting the parameters would be 1/1, 1/1, 1/ ∞

this would become 1, 1, 0

the Miller Index is written inside parentheses with no commas - thus (110)

c Explain the elements of symmetry, crystallographic axes and forms along with their indices for Orthorhombic System. 10

Elements of symmetry:

1. Planes of symmetry: 3 (two vertical axial planes and one horizontal)
2. Axes of symmetry: 3^2(one vertical and two horizontal)
3. Centre of symmetry: Present

Crystallographic axes

a≠b≠c

All three axes at right angles

Forms Present

1. Pinacoids
    - Basal Pinacoid (001)
    - Macro pinacoid (100)
    - Brachy Pinacoid (010)
2. Prism (110)
3. Domes
    - Macro domes (101)
    - Brachy domes (011)
4. Pyramids (111)

d Describe in detail forms of Zircon type observed in tetragonal system 10

1. Basal Pinacoid (001)
2. Prisms
    - Prisms of first order
    - Prisms of second order
    - Diteragonal Prism (hko) (210)
3. Pyramids
    - Pyramids of first order (111)
    - Pyramids of second order (101)

4 Answer any two of the following-(unit 3) 10

a Describe the basic silicate structure. Explain in detail Sorosilicates and Nesosilicates.

Silicates have tetrahedral silicon atoms having fourfold coordination with oxygen.

Sorosilicate

The silicon: oxygen ration is 2:7

Greek term Soro= group

The Si_2O_7 units are arranged on a regular pattern and linked together by other cations like Ca, Na, Al^{+3}

Example- Epidote

Nesosilicate

Name has been coined from greek Neso= island. These are constituted of individual or independent tetrahedral units.Si:O ratio is 1:4

Example: Forsterite (Olivine)

b Explain classification following structural classifications of silicates 10

1. Nesosilicates

Name has been coined from greek Neso= island. These are constituted of individual or independent tetrahedral units.Si:O ratio is 1:4

Example: Forsterite (Olivine

2. Cyclosilicates

This group consist of tetrahedral rings which have Si:O ratio 1:3

The name is from greek Cyclo= ring

c What are Tectosilicates? Explain the structure, chemical formula and minerals of tectosilicate group. 10

The tectosilicates or framework silicates have a structure wherein all of the 4 oxygens of SiO_4^{-4} tetrahedra are shared with other tetrahedra. The ratios of Si to O is thus 1:2.

Since the Si - O bonds are strong covalent bonds and since the structure is interlocking, the tectosilicate minerals tend to have a high hardness. Important minerals of tectosilicate group are

Feldspars: The feldspars are the most common minerals in the Earth's crust. They consist of three end-members:

KAlSi3O8 - Orthoclase (or), NaAlSi3O8 - Albite (ab), and CaAl2Si2O8 -Anorthite (an)

KAlSi3O8 and NaAlSi3O8 form a complete solid solution series, known as the alkali feldspars and NaAlSi3O8 and CaAl2Si2O8 form a complete solid solution series known as the plagioclase feldspars.

The feldspars have a framework structure, consisting of SiO4 tetrahedra sharing all of the corner oxygens.

Silica: It occurs in a number of forms

Crystalline- quartz, tridymite, crystobalite, coesite, stishovite

Cryptocrystalline- chalcedony, jasper, flint, opal, agate, diatomite

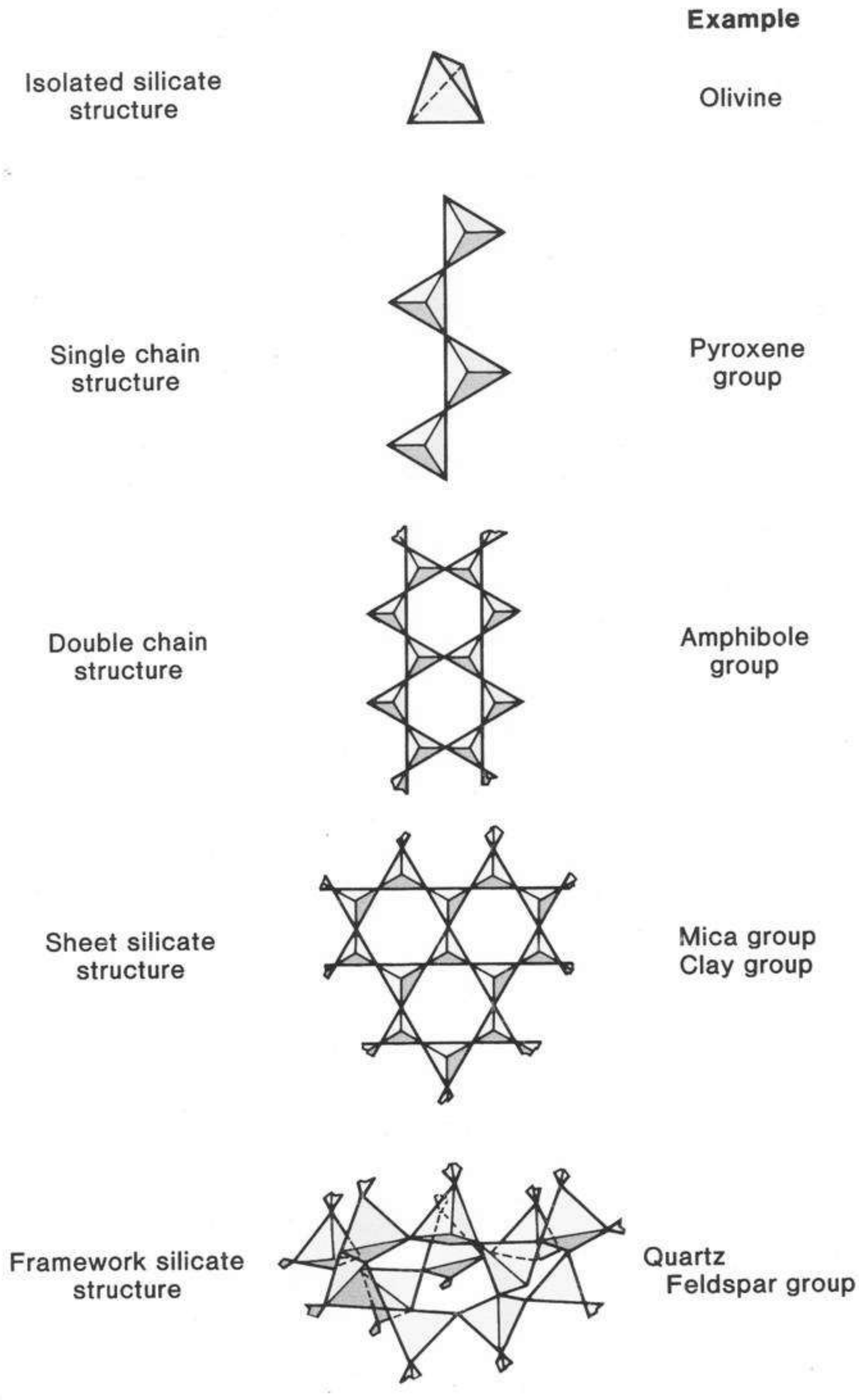
Feldspathoids: The group of minerals termed feldspathoids include those minerals which have certan similarities with feldspar. The Feldspathoids are all silica defiecient as compared to feldspar.

The main members considered are nepheline and kalsilite, leucite, the sodalite group cancrinite-vishnevite

Zeolites: The Zeoloites

$(Na_2,K_2,Ca,Ba)[(Al,Si)O_2]n.yH_2O$

d Draw neat diagrams of structures of any three silicate structures. Explain the properties of minerals of silica group. 10



Silica: It occurs in a number of forms

Crystalline- quartz, tridymite, crystobalite, coesite, stishovite

The various forms of cryptocrystalline silica can be represented on simple P-T diagram.

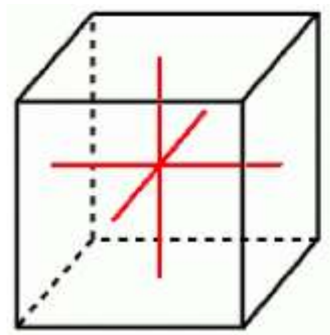
Cryptocrystalline- $SiO_2.nH_2O$

Most varieties are mixtures of cryptocrystalline silica and hydrous silica

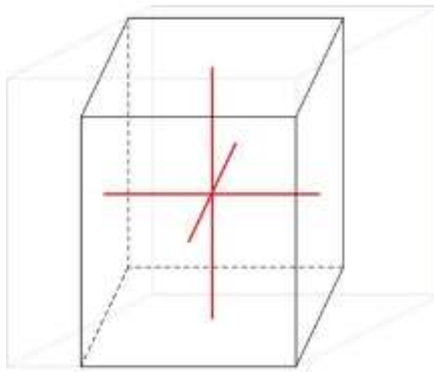
Chalcedony, jasper, flint, opal, agate, diatomite

5 **Write notes on any four of the following (all units)** 20

i) Lettering and ordering of crystallographic axes of cubic system and Monoclinic system



Cubic System



Monclinic System

ii) Contact Goniometer: A contact goniometer consists of two metal rules pivoted together at the centre of a graduated semicircle. The instrument is placed with its plane perpendicular to an edge between two faces of the crystal to be measured, and the rules are brought into contact with the faces. The angle between the rules, as read on the graduated semicircle, then gives the angle between the two faces.

iii) Fracture and Cleavage of Minerals: Cleavage is the tendency of a mineral to break along smooth planes parallel to zones of weak bonding. Calcite show Cleavage in three directions not at right angles (120o and 60o). Rhombohedral cleavage.

Fracture is the tendency of a mineral to break along curved surfaces without a definite shape. These minerals do not have planes of weakness and break irregularly. There are five basic types of fractures, concoidal (Obsidian), even (Chert), uneven, hackly (Kynite) and earthy (Chalk).

iv) Moh’s Scale of hardness.

Hardness is a measure of a mineral's resistant to abrasion. This property is easily determined and is used widely for field identification of minerals. More than a century ago. Friedrich Mohs (1773-1839), a German mineralogist, assigned arbitrary relative numbers to ten common minerals in order of their hardness.

Hardness	Mineral	Test
1	Talc	Fingernail (2.5)
2	Gypsum	
3	Calcite	Cooper coin (3)
4	Flourite	Knife

		blade (5.5)
5	Apatite	Glass plate (5.5+)
6	K-feldspar	
7	Quartz	Streak plate (7)
8	Topaz	
9	Corundum	
10	Diamond	

A simpler version of the Moho's scale can be established using three types of hardness:

Soft - Minerals that can be scratched with a fingernail

Intermediate - Minerals that cannot be scratched with a fingernail but can be scratched with a steel nail.

Hard - Minerals that cannot be scratched with a steel nail.

iv) Pinacoid form of Monoclinic system: The pinacoid form in monoclinic system consists of two like faces cutting only one axis and parallel two another two axes. Depending upon their orientation, three types of pinacoids are identified.
Basal pinacoid (001): faces are parallel to axis a and b, cuts axis c.
Ortho pinacoid (100): face cuts axis a or ortho axis and parallel to axes b and c
Clino pinacoid (010): faces cuts axis b or clino axis and reuns parallel to a and c axes.

v) Crystal form: Under favourable conditions minerals assume a definite crystal from. The following general descriptive terms are associated with crystal characters of minerals:
Crystallized- The mineral occurs as well developed crystals.
Crystalline- No definite crystals are developed
Cryptocrystalline- The mineral possesses traces of crystalline structure.
Amorphous- Complete absence of crystalline structure.

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