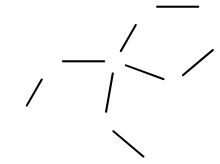
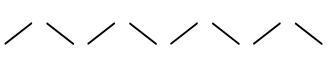
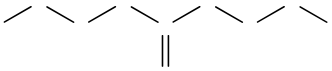
Lesson 6 For Book 1

Review Exercise --- Comparison of boiling point

Compare the boiling points of the following organic compounds, order their values in ascending order.

a) 

b) 



Skills = 1) Let them be compound 1, 2, 3 e.t.c.

2) Define how we can determine boiling point --- B.P. depends on the strength of I_____ force.

For a) Straight chain compound has a l_____ surface area → stronger interM force

* b) Going ____ the group, there is a l_____ number of electron shells of the halogen atoms → Larger electron c_____ → **higher polar**_____ → greater chance of fluctuation of the electron cloud → H_____ boiling point.

Metallic Bond

Apart from ionic bond (c_____ attraction) and covalent bond (sharing of electron→ o_____ of atomic orbitals), we have metallic bond to be studied.

- *Electron Sea Model*

→ Metal atoms lose their _____ electron to form an **electron sea**.

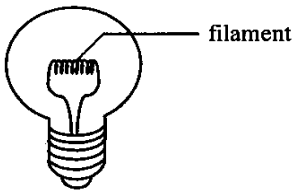
→ The metal c____ build up the **3-D / giant metal lattice** while the free / delocalized electrons flow within the metal l_____ .

→ The coulumbic attraction between the free _____ and the metal c_____ forms the metallic bond.

→ The more the valence electrons in the sea, the s_____ the metallic bond.

Exercise 1 Extra Knowledge of Tungsten

The simplified diagram below shows a tungsten light bulb. The filament inside is made of tungsten metal (atomic number = 74). The filament can emit light by passing an electric current until it reaches an extremely high temperature. Under vacuum condition, the filament would emit tungsten particles under extremely high temperature and blacken the light bulb. To avoid this from happening, the light bulb should be filled up with gas.



(a) **Describe the structure and bonding in tungsten metal with the help of a diagram.**

(3 marks)

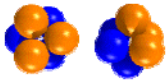
(b) **Apart from the property that tungsten can emit light at extremely high temperature, suggest another physical property that can render it suitable for making filament. Explain why it has this property.**

(2 marks)

**Metallic Lattice --- Learning from the essay 1996

Some important terms

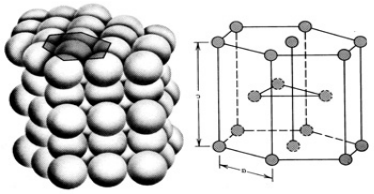
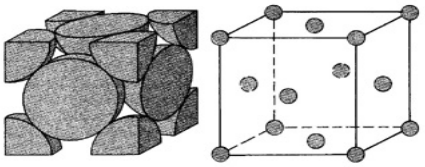
1. **Crystal/ Lattice** = A crystal is a **repeating** array. In describing this structure we must distinguish between the pattern of repetition (the lattice type) and what is repeated (the unit cell). → Use to describe SOLID only.
2. **Unit Cell =** the **simplest/smallest** portion of the lattice, which repeatedly sticks together in _____ dimension can generate the whole lattice.
3. **Close structure** = Every metal c____ are contacting with each other without many spacings. → higher / lower packing efficiency ?
4. **Open structure** = There are some spaces between every metal cations. → higher / lower packing efficiency.
5. **Octahedral Hole** = is formed bewteen two layers of three atoms.
6. **Tetrahedral Hole =** is formed when one atom/ cation is sitted on the depression formed by three atoms/cations.

7. **Coordination number =** The number of atoms/cations that an atom/cation is contacting with.

Actually, almost all of the metals crystallize in one of the following structures.

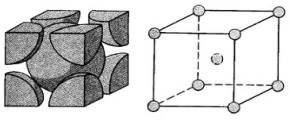
a) *Hexagonal closed packed (h.c.p.) lattice* b) *Face centred cubic lattice (f.c.c)*

Each face has one !

Features = 1. They are both _____ structure with high efficiency.
2. The coordination numbers are both _____

c) *Body centred Cubic (b.c.c.)*



Features =1. It is an _____ structure with lower packing efficiency.
2. The coordination number is _____(by considering the central one)

Extra Information

→ The different cells leads to **different physical properties** of metals.

FCC metals --- Cu, Au, Ag, are usually soft and 'ductile', which means they can be bent and shaped easily. **BCC metals** --- iron, are less ductile but stronger;
HCP metals --- are usually brittle. Zinc is HCP and is difficult to bend without breaking. Many other features depend upon the crystal structure of metals, such as **density, deformation processes, alloying behavior.**

Calculation of the no. of atoms/cations of a unit cell

1. The **face-centered cubic** system (F) has lattice points on the **faces** of the cube, that each gives exactly **1/2** contribution, in addition to the **corner** lattice points, that each gives exactly **1/8** contribution.

→ Total = __ atoms/cations ($\frac{1}{8} \times 8$ from the corners plus $\frac{1}{2} \times 6$ from the faces).

2. The **body-centered cubic** system (B) has **one** lattice point in the **center** of the unit cell in addition to the eight **corner** points.

→ Total = ___ atoms/cations per unit cell ($\frac{1}{8} \times 8 + 1$).

Skills = Centre has +1 ; face has +1/2 ; Edge has _____ ; Corner has +1/8

Exercise 2 More about Iron

Noted that Iron has two lattice structures under different thermal condition, i.e. temperature. The alpha form of iron is in b.c.c (below 906℃) while the gama form of iron is in f.c.c.(at 906℃).

a) Please draw the two forms of iron's lattice.

b) State and explain the change of volume of iron, starting from 25℃ to 1000℃.

→ 25℃ to 906℃, the volume will increase just due to t_____ expansion (熱漲)

→ at 906℃, the volume will decrease as there is a phase transition from ____ form to _____ form. And, you should realise that as gama form (f.c.c) is close structure while alpha form is open structure, the density of gama-iron has a _____ density and hence smaller volume.

→ Reaching 1000℃, the volume will increase just due to t_____ expansion again.

Ionic Bond

Ionic Model

In the ionic model, two assumptions are made:

→ Ions are perfect spheres with uniform charge distribution.

→ The cations and anions are just in contact with each other.

But, there is almost **no perfect** ionic compound due to the p_____ of ions.

Ionic Lattice

Ionic lattices consist of cations and anions which are in contact. The ions are arranged symmetrically so as to m_____ cation-cation and anion-anion repulsion. The cations and the anions are bound by **non-d**_____ electrostatic ionic bond.

Ionic compounds form crystals or lattices only in _____ state. Such continuous three-dimensional arrangement of ions makes the crystals have defintie **geometric structures**.

Review --- Can ionic compound conduct **electricity**?

→ We should bear in mind that ionic compound can conduct electricity in m_____ state only. In solid state, there is no mobile electrons/ions ?? .

Rules to form ionic crystals

As a matter of fact, in most ionic compounds, the a_____ are much larger than the c_____, and it is the anions which form the crystal array. The smaller cations reside in the holes between the anions. (T/ O holes)

Basic Concepts

1) Ions are assumed to be charged, incompressible, nonpolarizable spheres.

2) Ions try to surround themselves with as many ions of opposite charge as closely as possible. Usually in the packing arrangement, the cation is just large enough to allow the anions to surround it without touching one another.

3) The No $_{cation}$ to No $_{anion}$ ratio **must reflect** the stoichiometry of the compound. For $MgCl_2$, the lattice must be an array of chloride anions with only h_____ that number of magnesium ion.

→ in a unit cell of $MgCl_2$, there is more ____ ions.

4) The packing arrangement adopted by an ionic compound is determined by the comparative sizes of the ions → **r+/r- ratio.

Radius/Ratio	Preferred Coordination Number	Name
0.732	8	Cubic
0.414 to 0.732	6	Octahedral
0.225 to 0.414	4	Tetrahedral

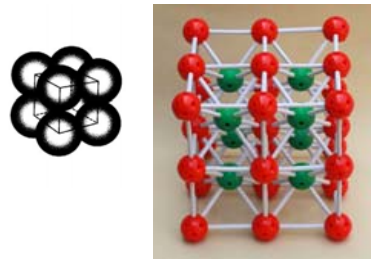
Two terms

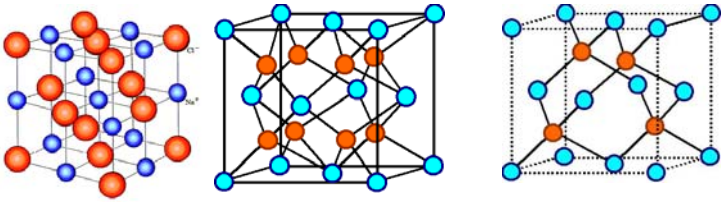
→ fluorite structure = 1:2 cation to anion ratio e.g. CaF_2

→ antifluorite structure = the cation to anion ratio is 2:1 e.g. Li_2O

Types of structure

a) *Simple Cubic e.g. CsCl* *b) Face-centred cubic e.g. NaCl / CaF_2 and ZnS*





→ 8: 8 coordinated → 6:6 8:6 4:4

→ there is a single Cs^+ ion in the middle and (8 x $^1/_8$) = 1 Cl^- ions at the corners

→ they are in close structure with higher packing efficiency.

→ interpenetrating pattern

→ is **not** the same as B.C.C.

Remark = You need to learn to draw the unit cell. Be careful, the types of lattice of metals and ionic compounds are **different**!