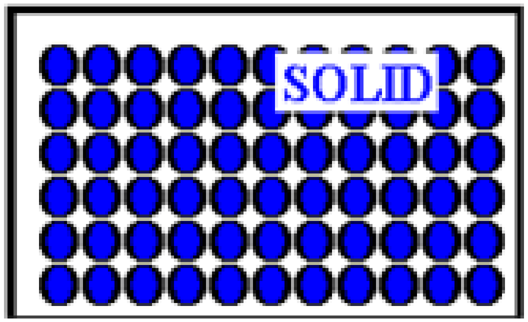
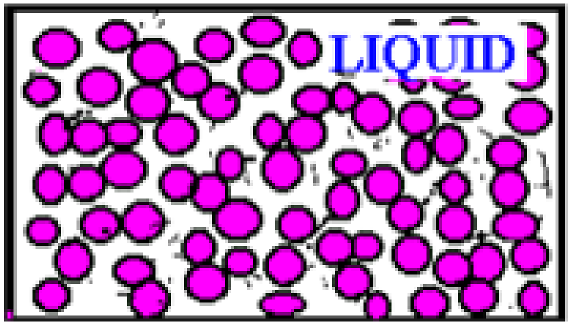
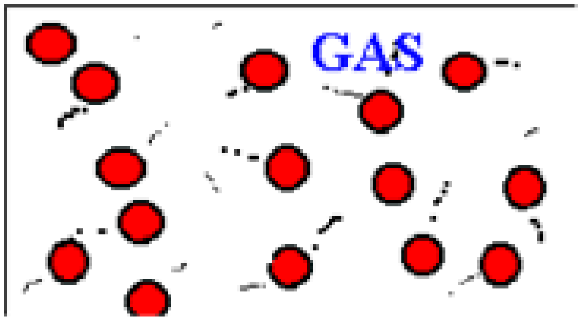
AICE chapter 5

States of Matter



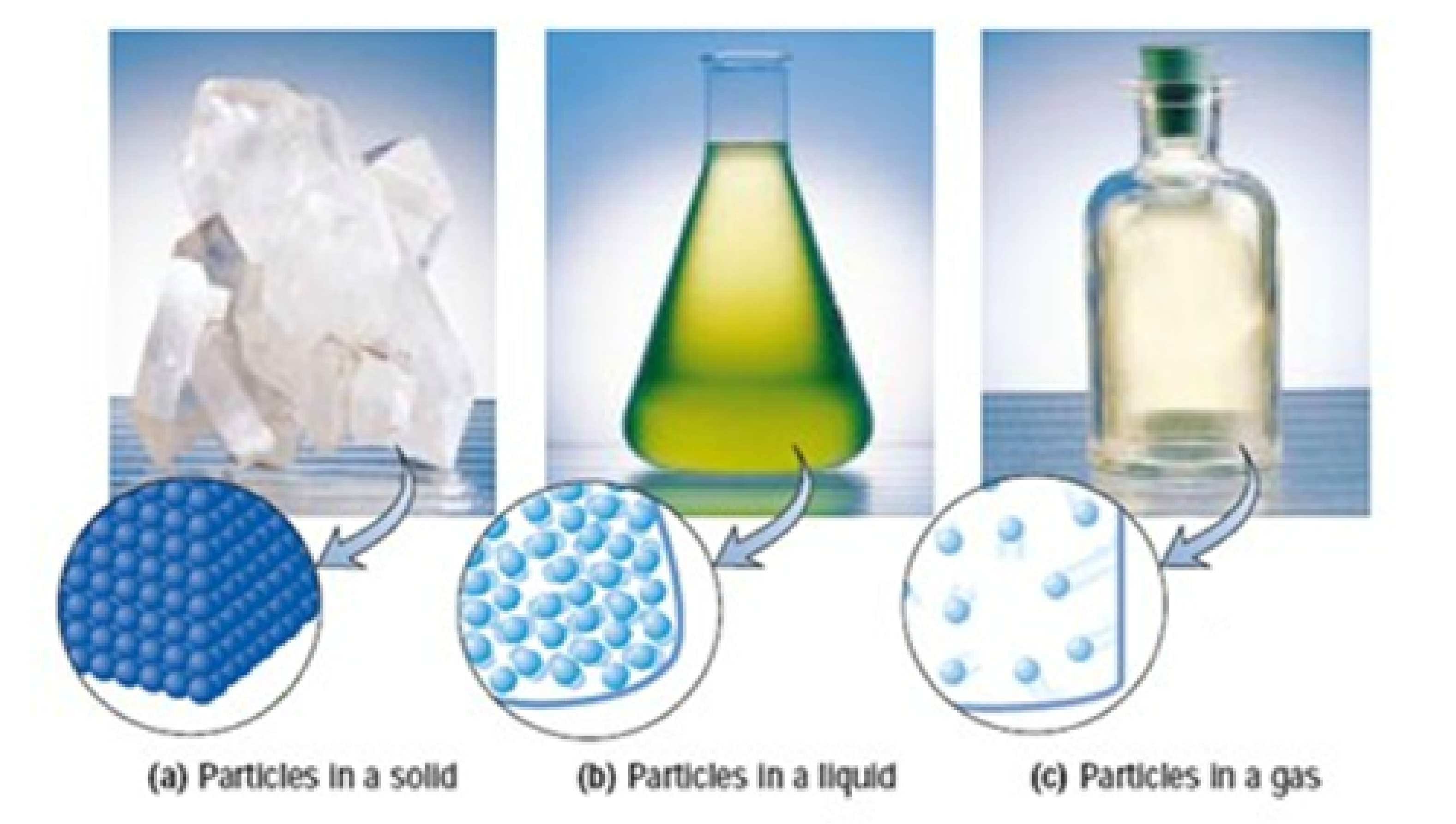




Kinetic theory - a way to describe the motion of the particles

$KE = 1/2\ mv^2$

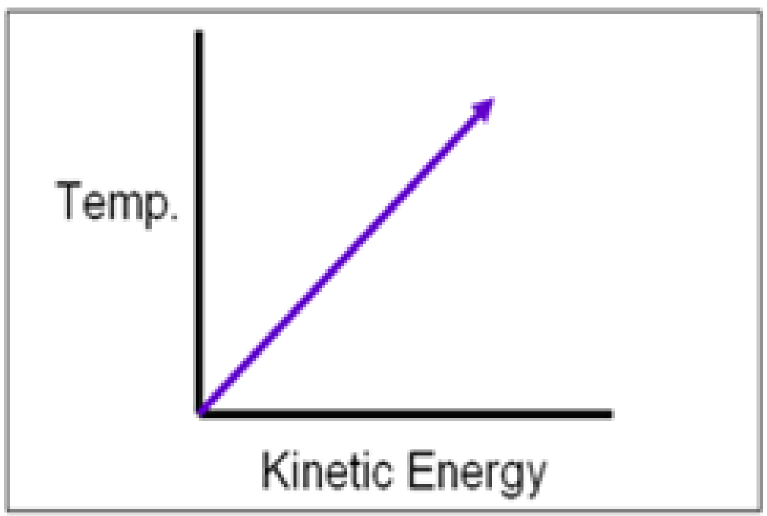
It states that particles in all forms of matter (solid, liquid or gas) are in constant motion (vibrating , swim or flying) past each other.



| | Solids | Liquids | Gases |
|---|---|---|---|
| Distance | Touching | Close | Far |
| Compress-ible | No | Slightly | Yes |
| Movement | Vibrate | Swim | Fly |

# Kinetic Theory of Gases

1. Molecules in gases are in constant movement
2. The small particles have no attraction or repulsion to each other.
3. The collisions are "elastic" and no KE is lost.
4. The temp. is related to the average KE.




As temp. ↑ so does KE

At absolute zero = 0K the KE is also 0= -273.15 degrees Celcius

A theoretical gas that fits into the Kinetic theory of gases is called an ideal gas.

When a gas particle collides with an object it creates a force. If gas particles are placed in a closed container the large amount of gas particles hitting the walls of the container create pressure.

$\downarrow V = \uparrow P$ $\quad$ $\uparrow T = \uparrow V$

The pressure is measured in Pascals

$1Pa = 1N/m^2$ & $J = n \times m$

1 atm = 760 torr = 760 mmHg = 101.3kPa

Real gases differ from ideal gases:
1. at high pressure
2. at low temperatures

they are close to each other which cause the VDW forces to pull the molecules towards each other and away from the container.

So if you want a real gas to act like an ideal gas you need high t and low p

# Ideal Gas Equation

Used to detemine quantity of an ideal gas would take up using pressure, temperature and volume.

$PV = nRT$

where P = pressure in Pa

where V = volume in $m^3 = 1000dm^3$

where n = moles=(mass / relative atomic mass)

where T = temp. in K

where R = ~~.0821 L*atm / mol *K~~ NO

8.31 $JK^{-1}mol^{-1}$

$PV = nRT$

$n = m / M_r$

$M_r = mRT/PV$

also of note: density = m/V
so you can also use the equation:
$M_r = dRT/P$

# paper 1 may/june 2003

6 Measured values of the pressure, volume and temperature of a known mass of a gaseous compound are to be substituted into the equation

$$pV = nRT$$

in order to calculate the relative molecular mass, $M_r$, of the compound.

Which conditions of pressure and temperature would give the most accurate value of $M_r$?

| | pressure | temperature |
|---|---|---|
| **A** | high | high |
| **B** | high | low |
| **C** | low | high |
| **D** | low | low |

paper 1 may/june 2006

6 Which of the following least resembles an ideal gas?

A ammonia

B helium

C hydrogen

D trichloromethane

ideal gas~nonpolar

paper 1 nov 2008

7 Which of the following would behave most like an ideal gas at room temperature?

**A** carbon dioxide

**B** helium

**C** hydrogen

**D** nitrogen

# paper 1 may/june 2010

3 Which gas closely approaches ideal behaviour at room temperature and pressure?

**A** ammonia

**B** carbon dioxide

**C** helium

**D** oxygen

paper 1 may/june 2010

9 Which mass of gas would occupy a volume of 3 $dm^3$ at 25 °C and 1 atmosphere pressure?
[1 mol of gas occupies 24 $dm^3$ at 25 °C and 1 atmosphere pressure.]

**A** 3.2 g $O_2$ gas

**B** 5.6 g $N_2$ gas

**C** 8.0 g $SO_2$ gas

**D** 11.0 g $CO_2$ gas

V=moles x 24

# paper 1 may/june 2011

**11** In which change would only van der Waals' forces have to be overcome?

| | | |
|---|---|---|
| **A** | evaporation of ethanol | $C_2H_5OH(l) \rightarrow C_2H_5OH(g)$ |
| **B** | melting of ice | $H_2O(s) \rightarrow H_2O(l)$ |
| **C** | melting of solid carbon dioxide | $CO_2(s) \rightarrow CO_2(l)$ |
| **D** | solidification of butane | $C_4H_{10}(l) \rightarrow C_4H_{10}(s)$ |

vdw=np

# paper 1 may/june 2012

6 *Use of the Data Booklet is relevant to this question.*

The gas laws can be summarised in the ideal gas equation.

$$pV = nRT$$

0.56 g of ethene gas is contained in a vessel at a pressure of 102 kPa and a temperature of 30 °C.

What is the volume of the vessel?

**A** 49 $cm^3$ **B** 494 $cm^3$ **C** 48 900 $cm^3$ **D** 494 000 $cm^3$

# paper 1 may/june 2012

**8** Under which set of conditions is a gas most likely to behave ideally?

| | temperature | pressure |
|---|---|---|
| **A** | high | high |
| **B** | high | low |
| **C** | low | high |
| **D** | low | low |

# paper 1 may/june 2013

8 Why does the rate of a gaseous reaction increase when the pressure is increased at a constant temperature?

**A** More particles have energy that exceeds the activation energy.

**B** The particles have more space in which to move.

**C** The particles move faster.

**D** There are more frequent collisions between particles.

# paper 1 may/june 2013

9 Which would behave the **least** like an ideal gas at room temperature?

**A** carbon dioxide

**B** helium

**C** hydrogen

**D** nitrogen

# paper 1 may/june 2013

**10** The general gas equation can be used to calculate the $M_r$ value of a gas.

For a sample of a gas of mass $m$ g, which expression will give the value of $M_r$?

**A** $M_r = \frac{mpV}{RT}$ **B** $M_r = \frac{pVRT}{m}$ **C** $M_r = \frac{mRT}{pV}$ **D** $M_r = \frac{pV}{mRT}$

**Cation unknowns**

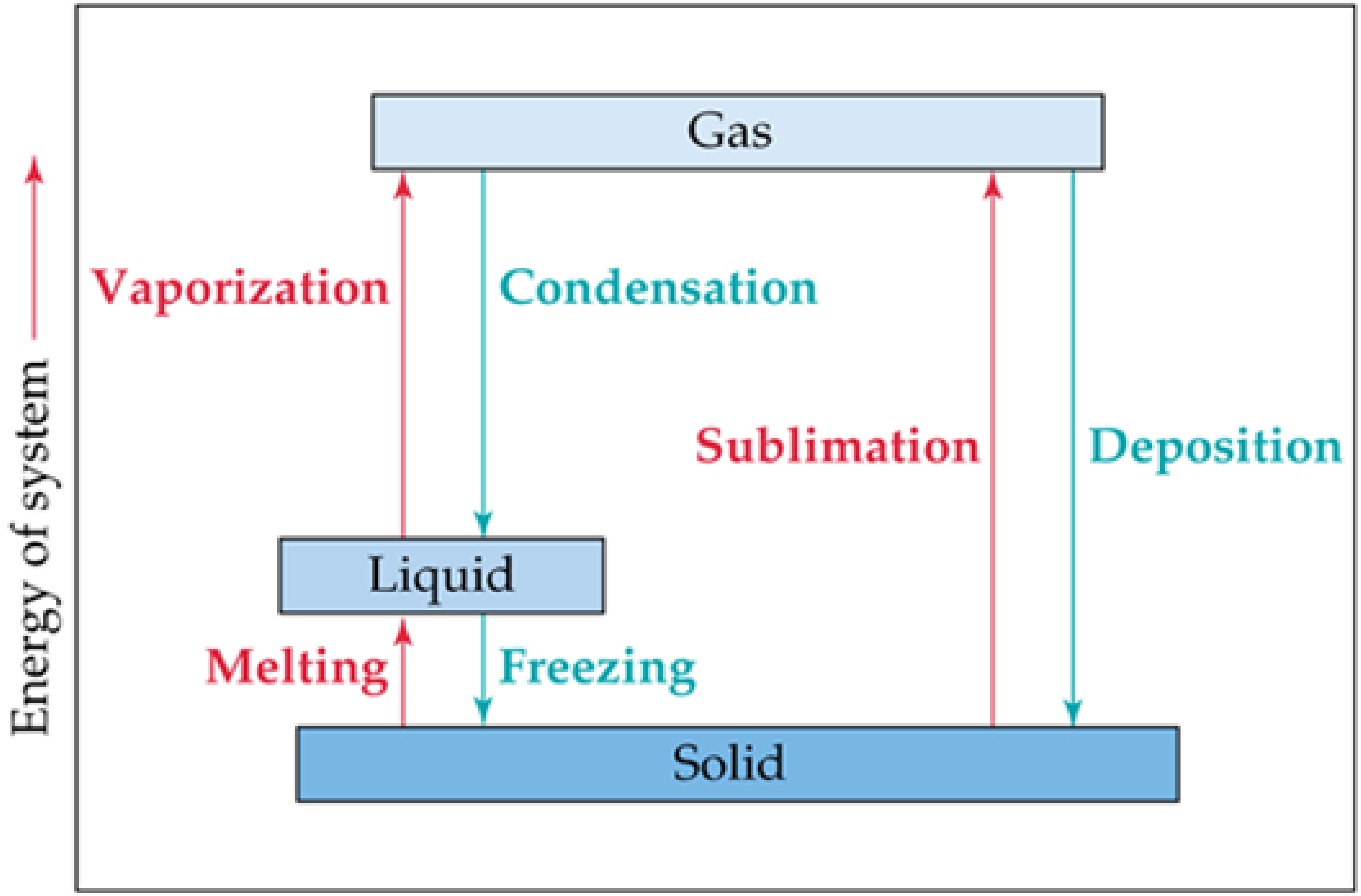
| Unknown No. | $Ag^{+}$ | $Cu^{2+}$ | $Zn^{2+}$ | $Fe^{3+}$ |
|---|---|---|---|---|
| ✓ 1 | X | X | X | |
| ✓ 2 | | X | X | X |
| ✓ 3 | X | | X | X |
| ✓ 4 | X | X | | X |
| ✓ 5 | X | | | X |
| ✓ 6 | | X | | X |
| ✓ 7 | | X | X | |
| ✓ 8 | X | X | | |
| ✓ 9 | X | | X | |
| ✓ 10 | | | X | X |
| ✓ 11 | X | X | X | X |

give a total volume of 8 mL. Stopper the test tube. A [illegible] unknowns, can be generated for the anions.

## Anion unknowns

| Unknown No. | $Cl^-$ | $CO_3^{2-}$ | $NO_3^-$ | $SO_4^{2-}$ |
|---|---|---|---|---|
| 1 | X | X | X | |
| 2 | | X | X | X |
| 3 | X | | X | X |
| 4 | X | X | | X |
| 5 | X | | | X |
| 6 | | X | | X |
| 7 | | X | X | |
| 8 | X | X | | |
| 9 | X | | X | |
| 10 | | | X | X |
| 11 | X | X | X | X |

# Phase Changes & Energy

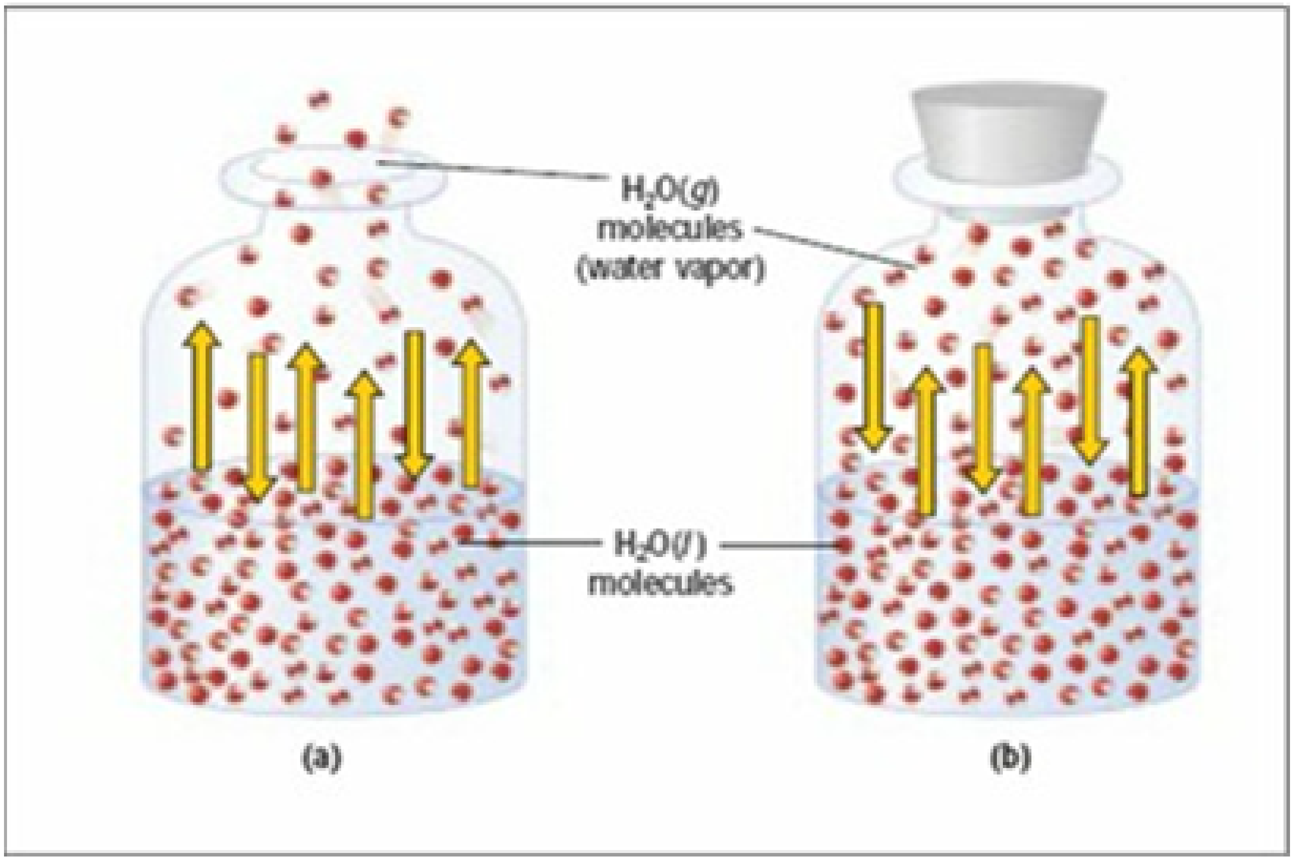



Endothermic: melting, evaporating/boiling & sublimation

Exothermic: freezing, condensation, & deposition

# Dynamic Equilibrium

Movement of an equal number of particles back and forth from one state of matter to another. The rate must be equal.



Enthalpy change of Vaporisation -
the energy required to change 1 mole of liquid to 1 mole of gas (liquid to vapour)

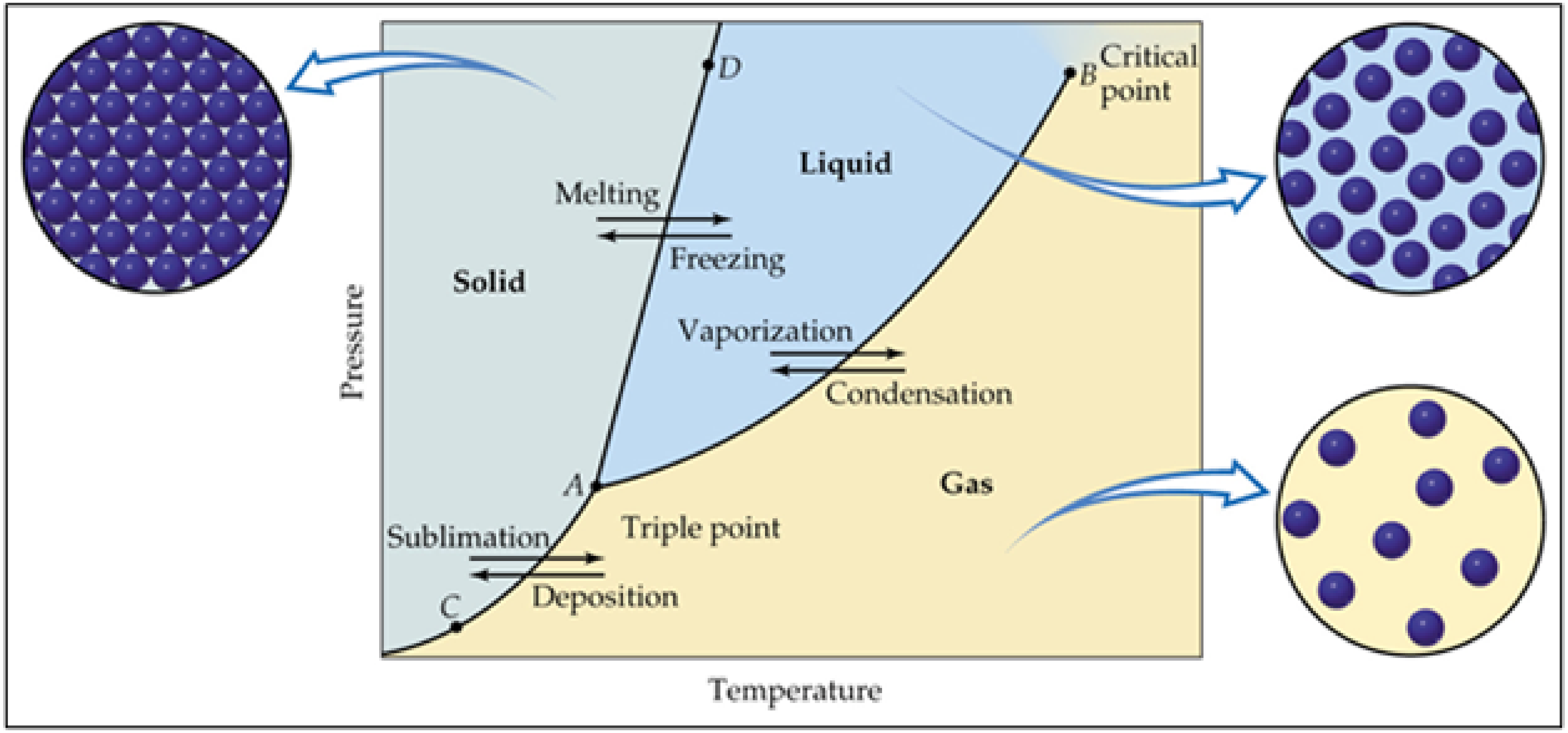
vapour pressure - the pressure exerted by a vapour in equilibrium with its liquid

As the temperature of the liquid increases the number of vapour particles increases, causing more collisions and therefore more vapour pressure.

BP - temperature at which the vapour pressure equals the atmospheric pressure.

# Phase Diagrams

- Shows the relationship between the 3 phases of matter at various temperatures and pressures.




Triple Point: All 3 phases of matter at equilibrium.

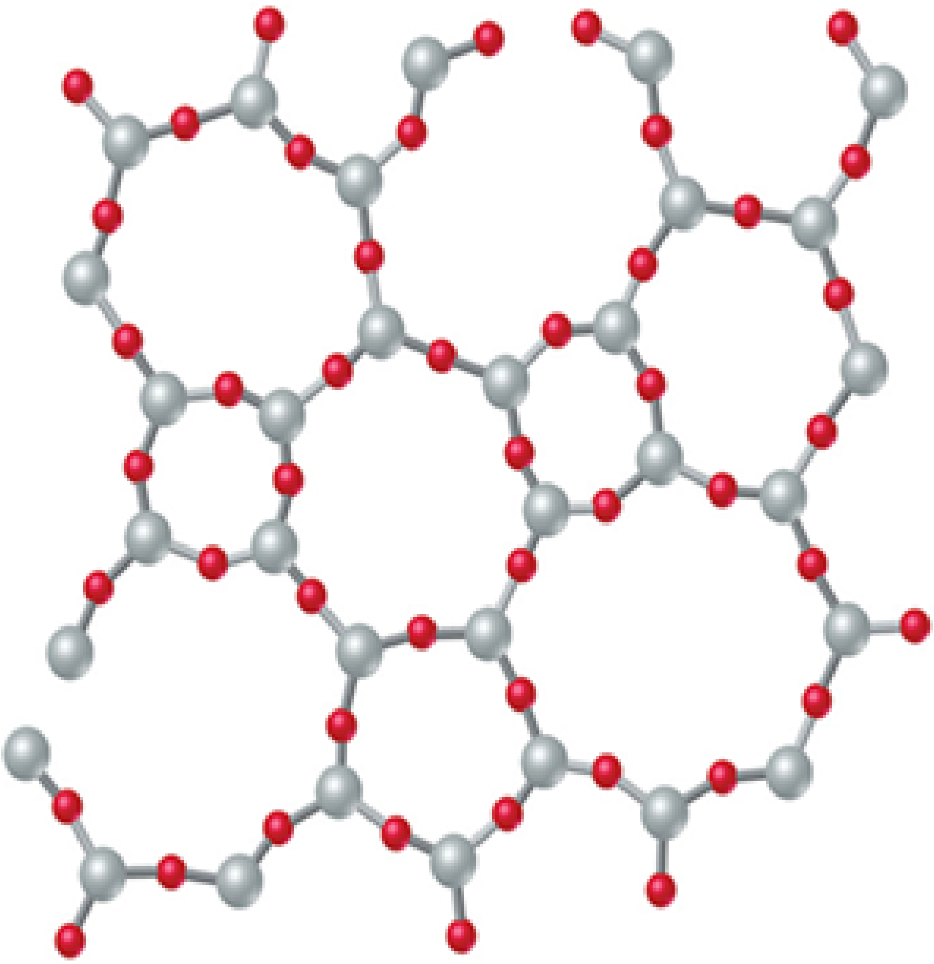
Critical Point: The highest temperature at which the liquid phase can exist.

# Characteristics of Solids

- There are 2 general classifications of solids:

  -Amorphous: No pattern to the arrangement of particles. Their melting point is over a wide range of temperatures. They just get softer and softer when heated. (Examples- glass, plastic, wax)

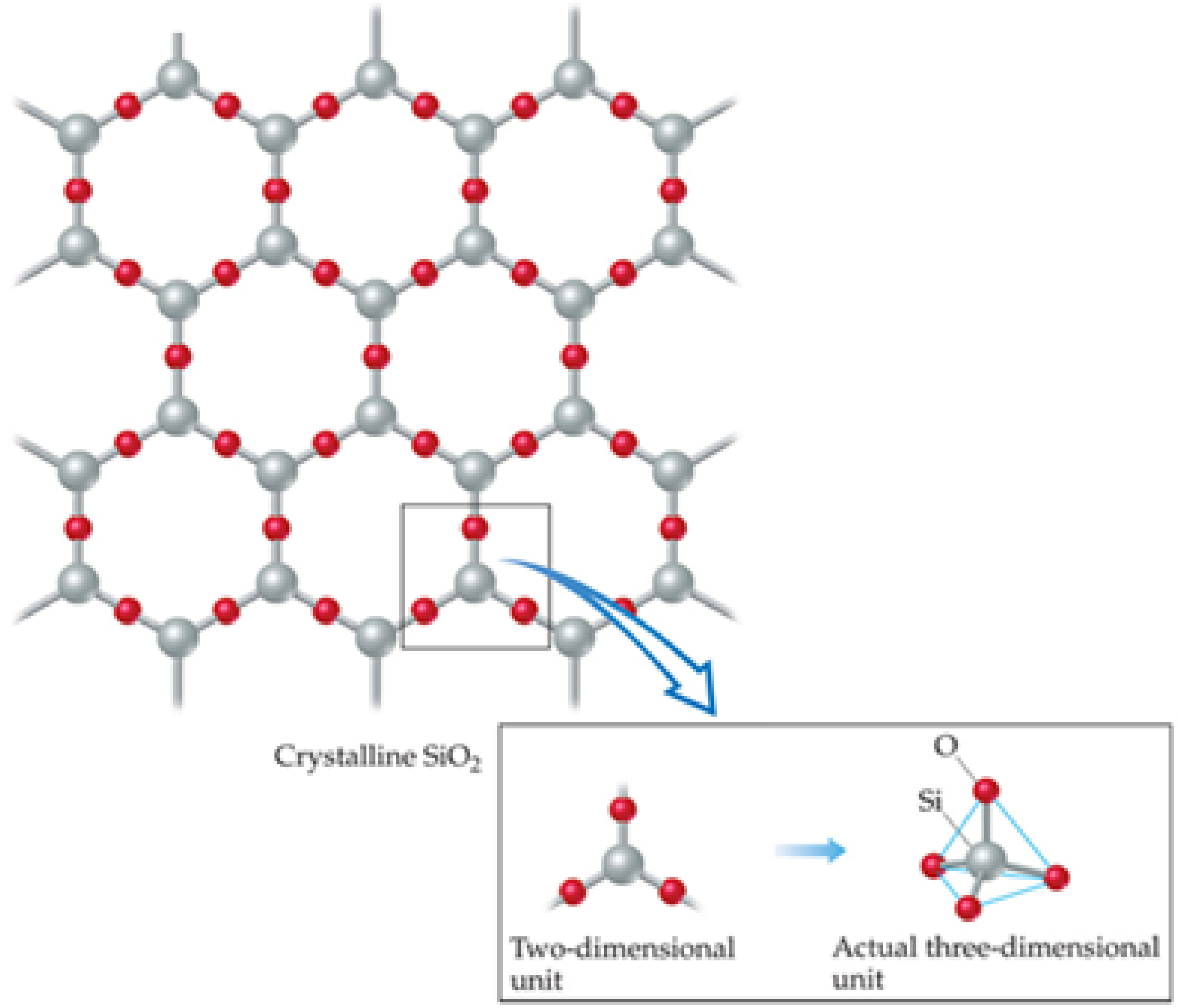
  - Crystalline: Well-ordered, definite arrangement of atoms. Crystals have a repeated structure and a melting point at a very narrow range of temperatures. (Examples- metals, $H_2O$, diamond)



Amorphous $SiO_2$

- Amorphous—no particular order in the arrangement of particles.

- Crystalline—particles are in highly ordered arrangement.



# Crystalline Solids

There are four types of crystalline solid:

- Molecular (formed from molecules) - usually soft with low melting points and poor conductivity.
- Covalent network (formed from atoms) - very hard with very high melting points and poor conductivity.
- Ionic (formed form ions) - hard, brittle, high melting points and poor conductivity.
- Metallic (formed from metal atoms) - soft or hard, high melting points, good conductivity, malleable and ductile.

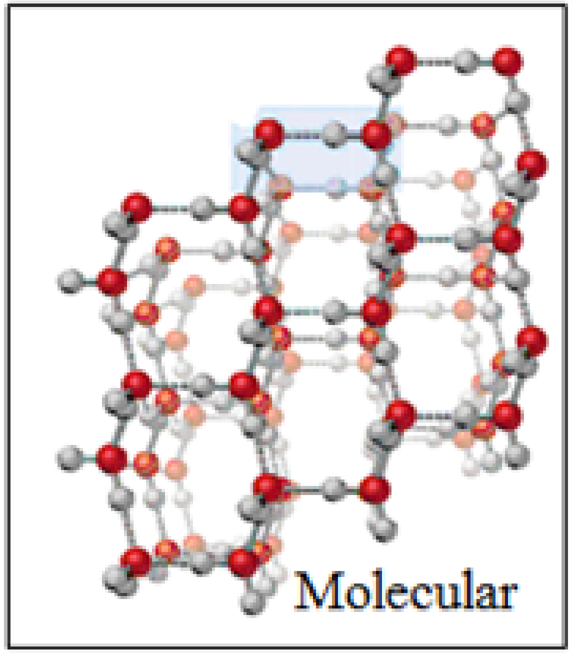
# Bonding in Crystalline Solids

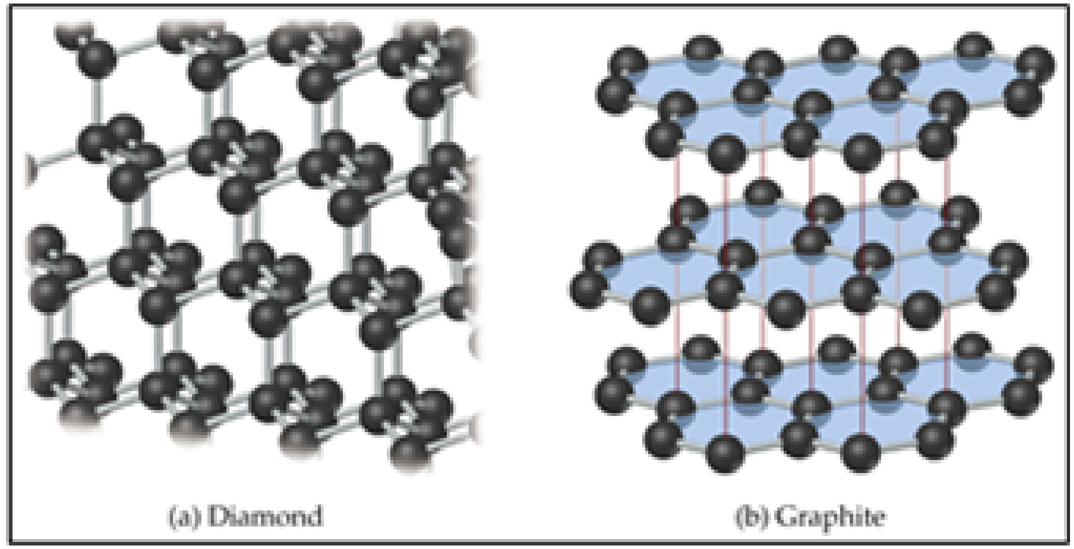
**TABLE 11.7 Types of Crystalline Solids**

| Type of Solid | Form of Unit Particles | Forces Between Particles | Properties | Examples |
|---|---|---|---|---|
| Molecular | Atoms or molecules | London dispersion, dipole-dipole forces, hydrogen bonds | Fairly soft, low to moderately high melting point, poor thermal and electrical conduction | Argon, Ar; methane, $CH_4$; sucrose, $C_{12}H_{22}O_{11}$; Dry Ice™, $CO_2$ |
| Covalent-network | Atoms connected in a network of covalent bonds | Covalent bonds | Very hard, very high melting point, often poor thermal and electrical conduction | Diamond, C; quartz, $SiO_2$ |
| Ionic | Positive and negative ions | Electrostatic attractions | Hard and brittle, high melting point, poor thermal and electrical conduction | Typical salts—for example, NaCl, $Ca(NO_3)_2$ |
| Metallic | Atoms | Metallic bonds | Soft to very hard, low to very high melting point, excellent thermal and electrical conduction, malleable and ductile | All metallic elements—for example, Cu, Fe, Al, Pt |

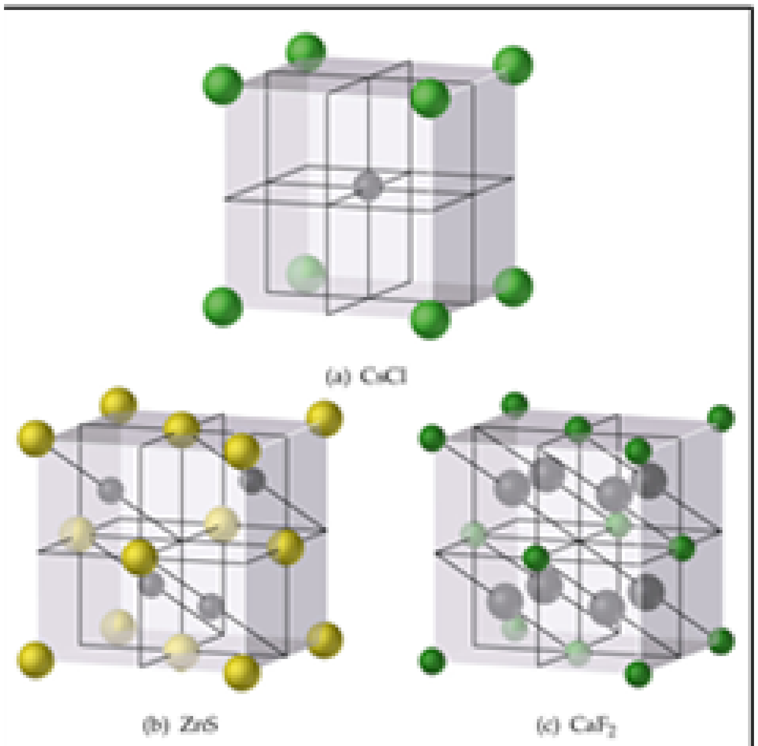
- Metallic bonds are formed from metal nuclei floating in a sea of electrons.

# Crystalline Solids

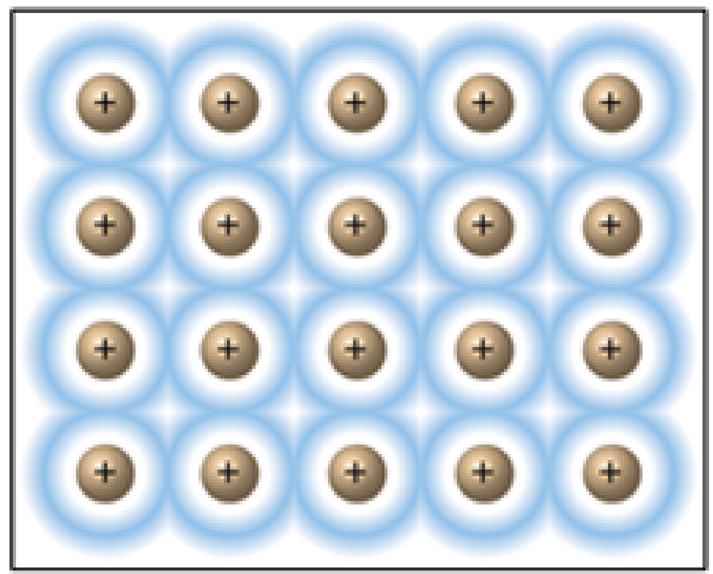



Covalent Network



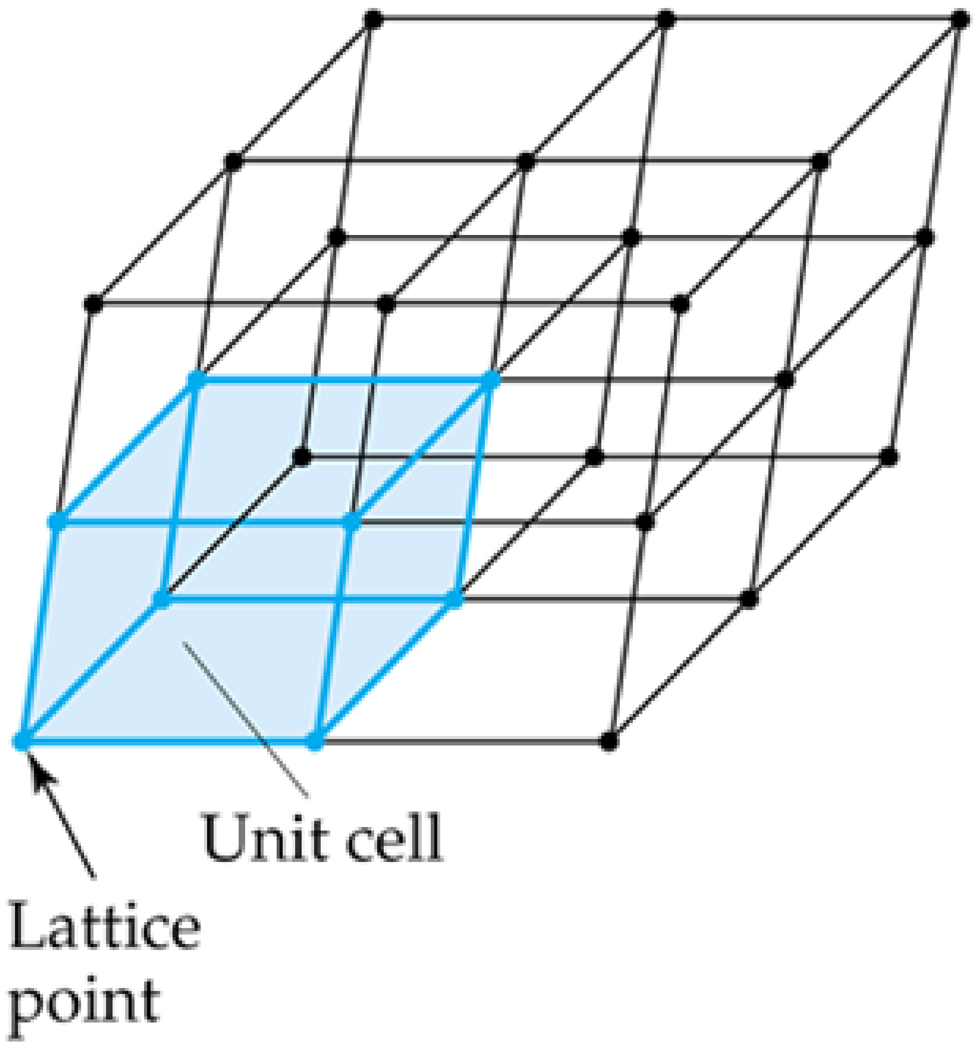

Ionic

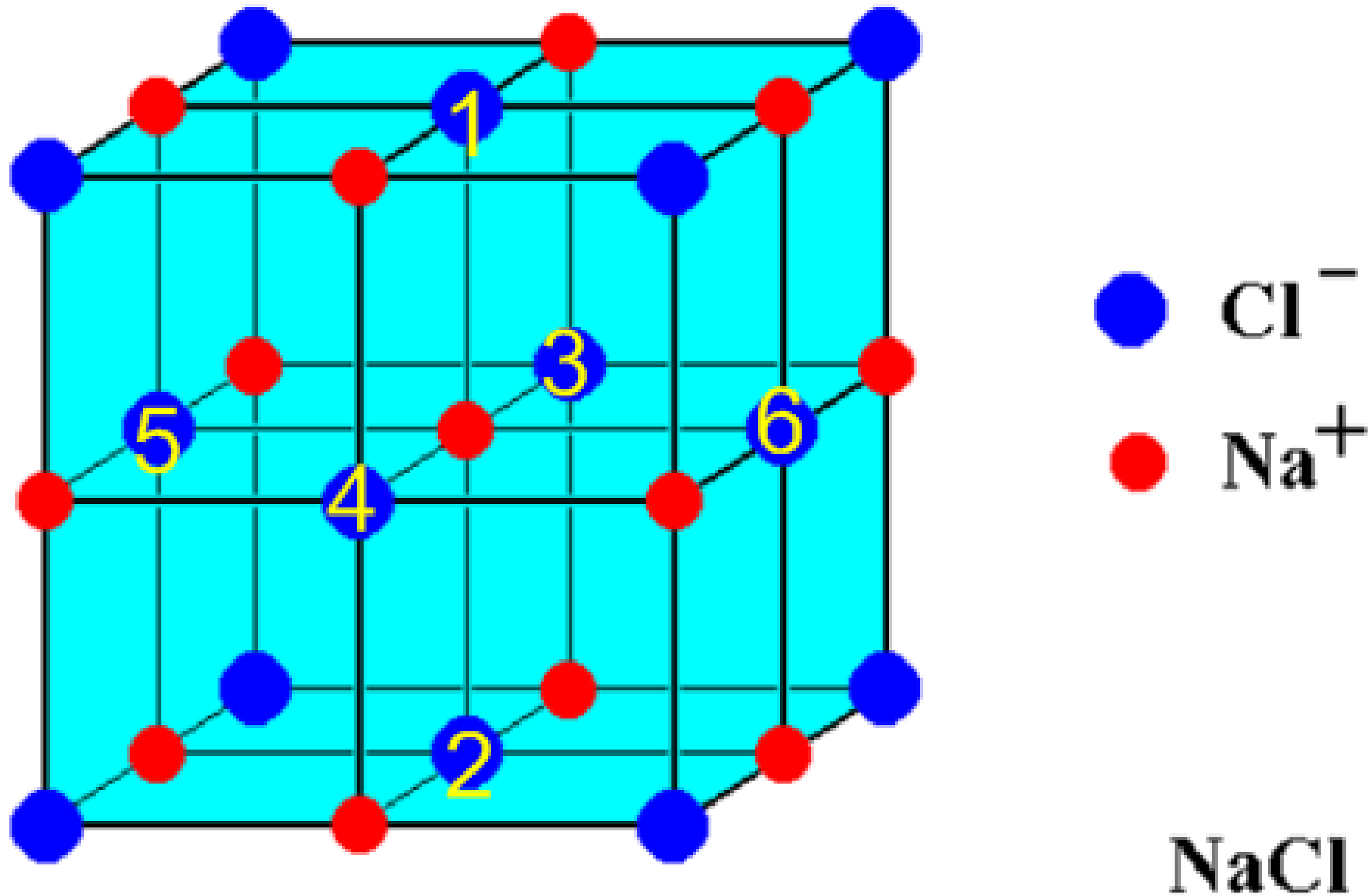


Metallic

# Structure of Solids

- Unit Cell: The smallest repeating unit in a crystal is a unit cell.
  - A unit cell is the smallest unit with all the symmetry of the entire crystal.
- Three-dimensional stacking of unit cells is the crystal lattice.





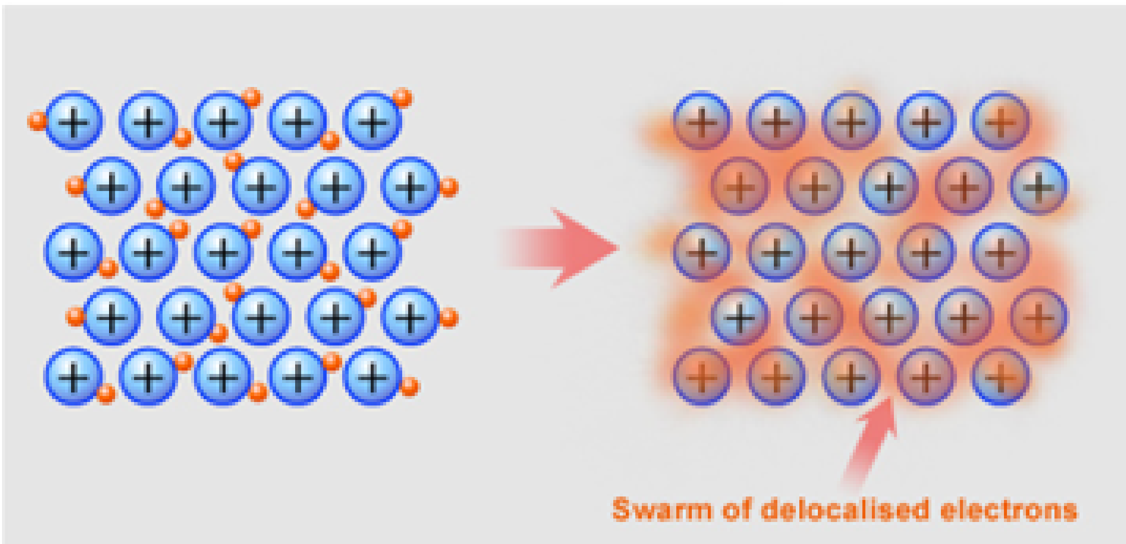

Notice each sodium is surrounded by six chlorine.

Ionic compounds

1. hard & brittle
2. only conduct when molten
3. are soluble to some degree in water
4. the higher the charge = the higher the surface area = the higher the charge density = the higher the melting point

Metallic compounds

1. sea of delocalized electrons
2. when force is applied they slide past each other.
3. are malleable, ductile and have high tensile strength



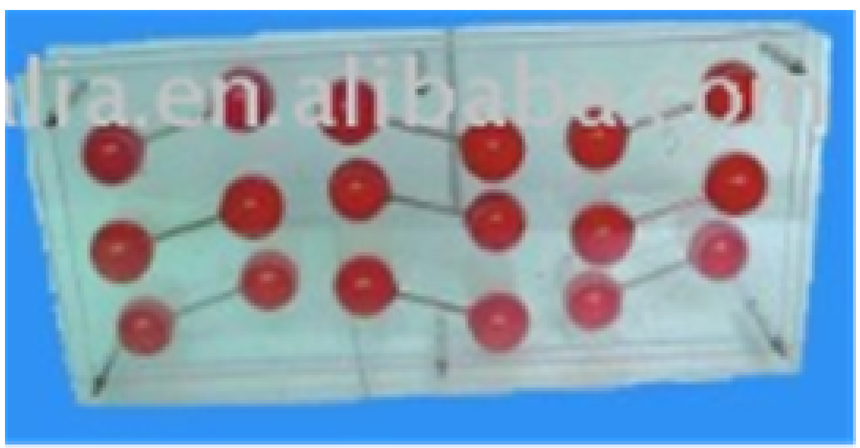
# Alloys

Mixture of 2 or more metals or metal with a non metal.

An alloy is stronger than either metal alone because the different sized atoms cause the lattice structure to be disrupted, so the layers of metal ions do not slide past each other.

Simple molecular compounds
that form crystals:

$I_2$ have weak VDW forces them but strong covalent forces within the molecules themselves. low mp. frozen water (ice)



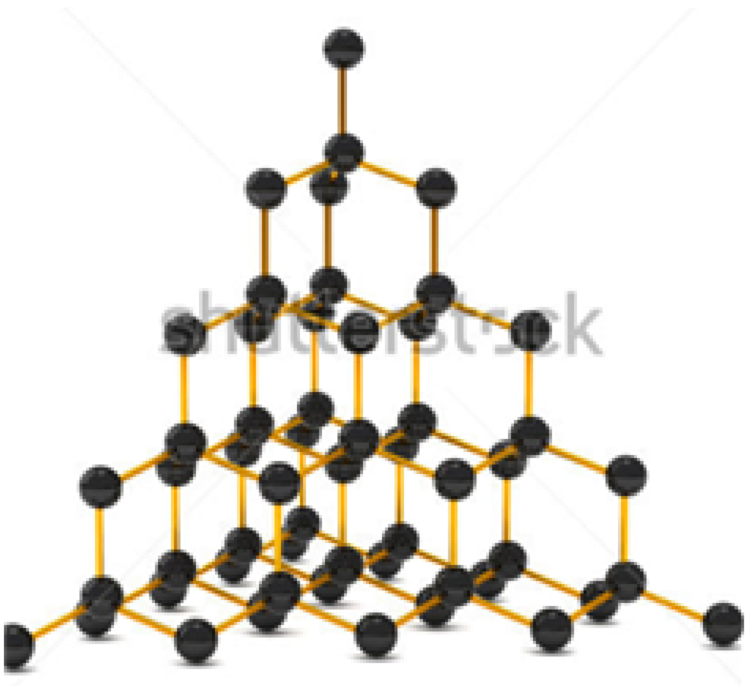
Giant molecular structures

3D network of covalent bonds

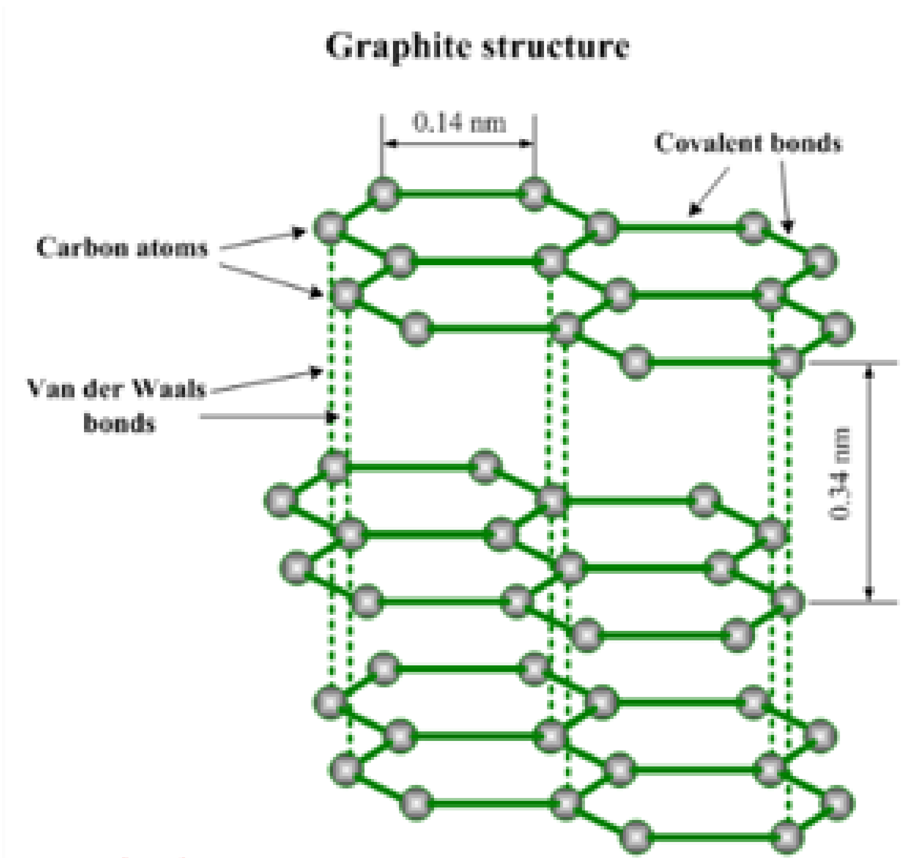
graphite, diamond (allotropes of carbon)
and silicon dioxide (sand & quartz)

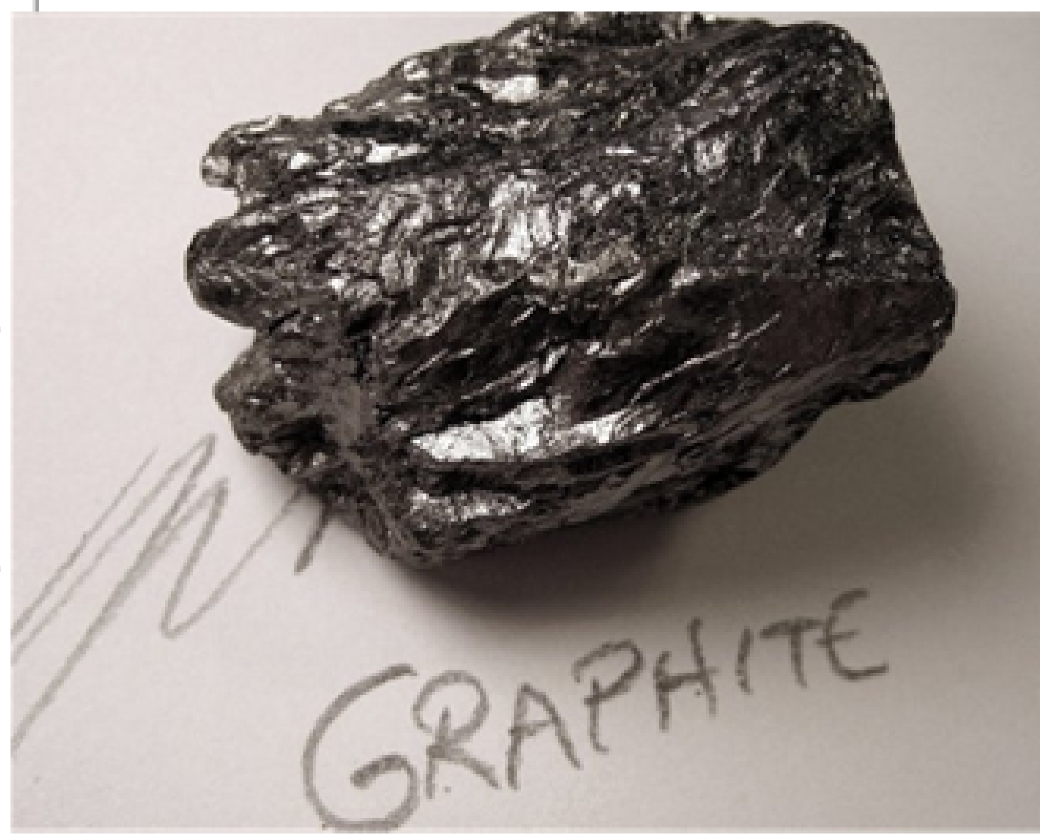
- Diamonds are an example of a covalent-network solid in which atoms are covalently bonded to each other.
  - ➢ They tend to be hard and have high melting points.

Inter




- Graphite is an example of a molecular solid in which atoms are held together with van der Waals forces.
    - They tend to be softer and have lower melting points.



Ceramics - clay containing aluminum oxide, or sand containing silicon dioxide.

1. high melting & boiling point
2. do not conduct electricity or heat
3. retain strength at high temps, 550 degrees Celcius. (refractories)
4. cannot be scratched due to 3d network of strong covalent bonds
5. chemically unreactive

Porcelain is a ceramic made by firing clay

Uses:

Magnesium oxide - electrical insulators, refractory liner in furnaces, fire-resistant wall boards.
Aluminum oxide - refractory liner in furnaces, abrasive for grinding hard materials, transparent aluminium/scandium windows for military vehicles.
Ceramics - refractory liner in furnaces, as an abrasive(sandpaper), glass manufacture.
Porcelain - high voltage insulator, plates/cups

Conserving materials:

*We have a limited supply of metal ores on earth, which cannot be replaced.
*Instead of recycling the ores are usually placed in dump sites.
*Extracting metals from ores is expensive

So we must recycle:

Recycling:

*Saves energy
*Conserves supplies
*Stops landfills from filling up
*Cheaper than ore extraction

Concerns:
* Earth's copper ores containing about 1% of available copper
* There is a 95% saving in energy if we recycle Aluminium