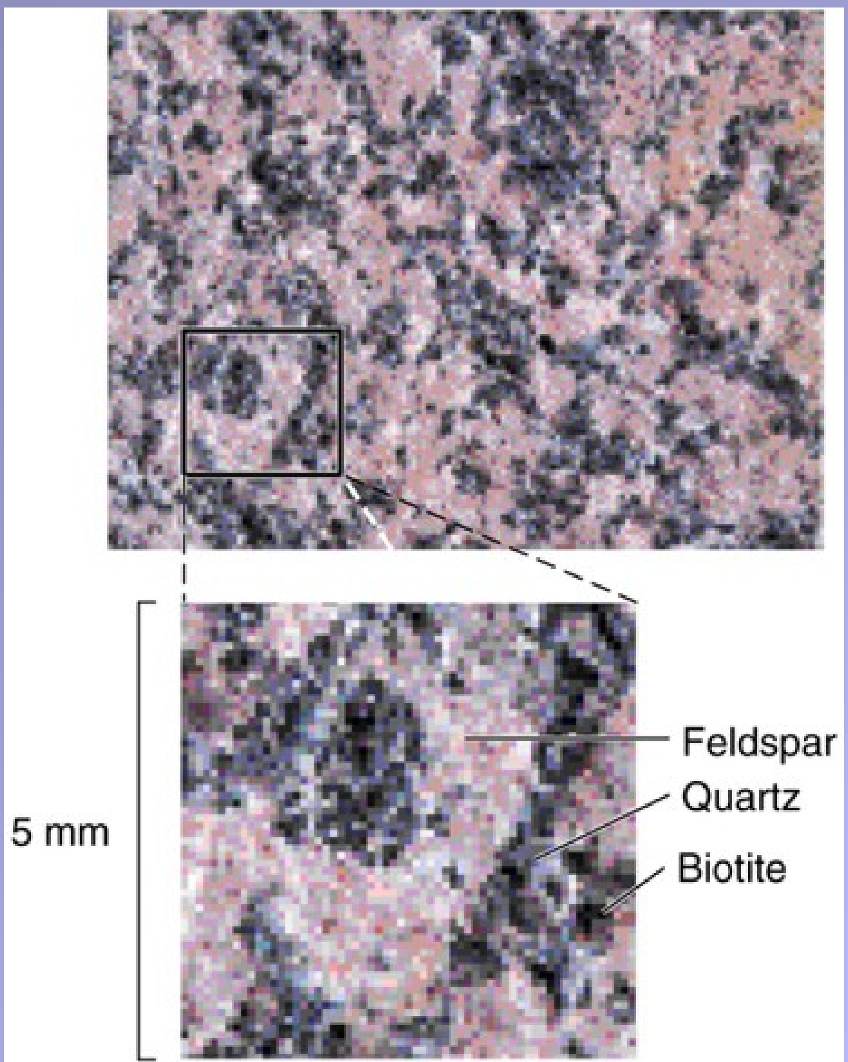
Minerals in granite

The igneous rock granite is composed of many separate grains of several main minerals



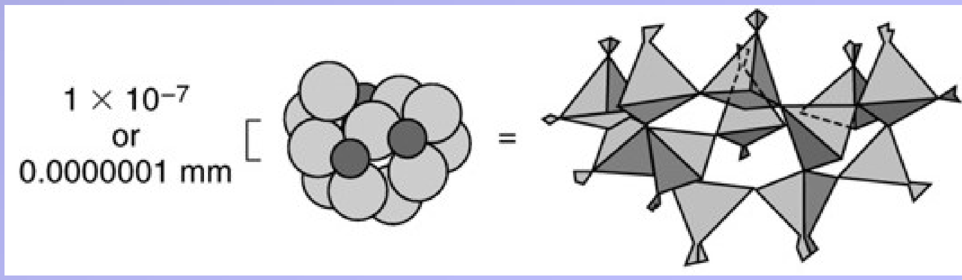


Figure 2.1

What is a *mineral*?

Naturally occurring solid

Specific chemical composition

Crystal structure
(regularly repeating units
in 3 dimensions)

Structure of halite

Mineral composed of Na Cl

Sodium Na^+ →

Chloride Cl^- →

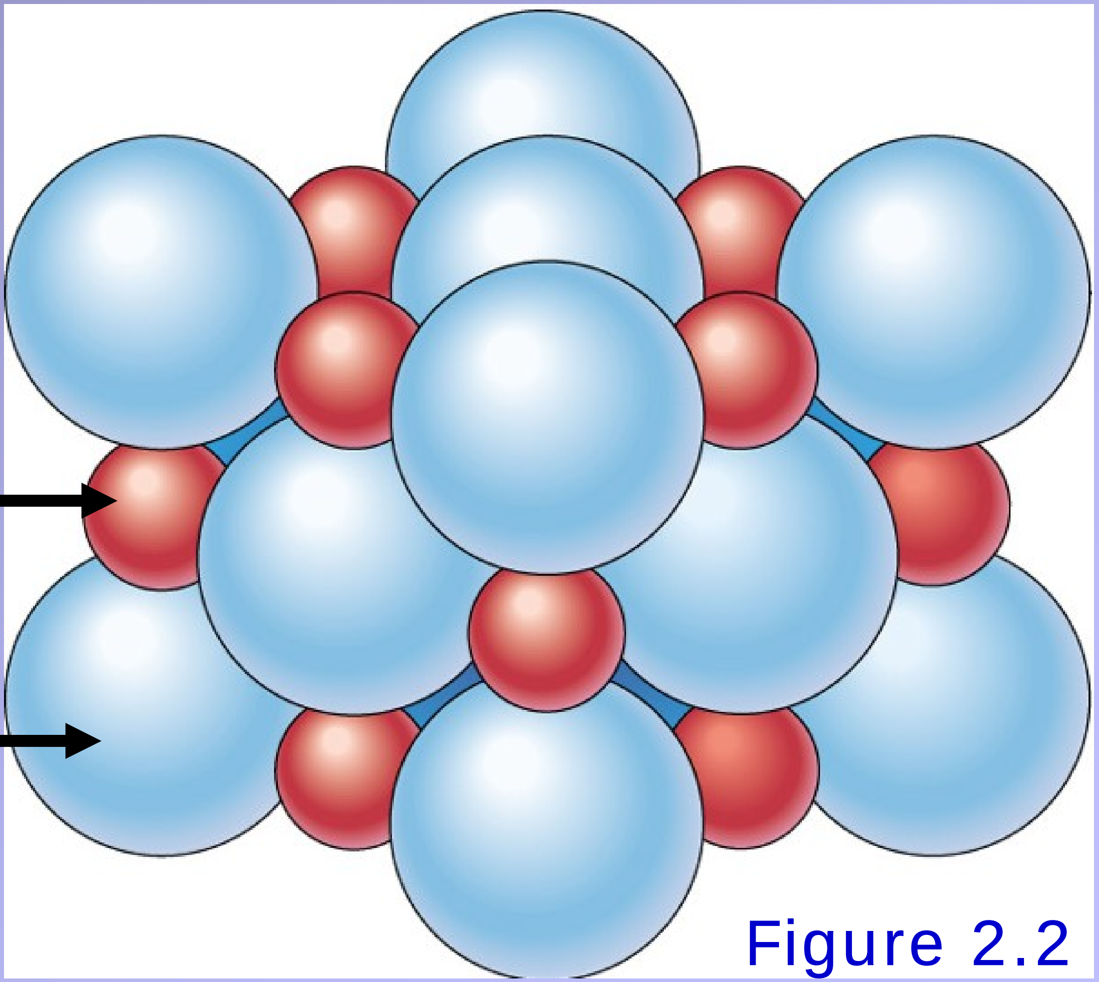


Figure 2.2

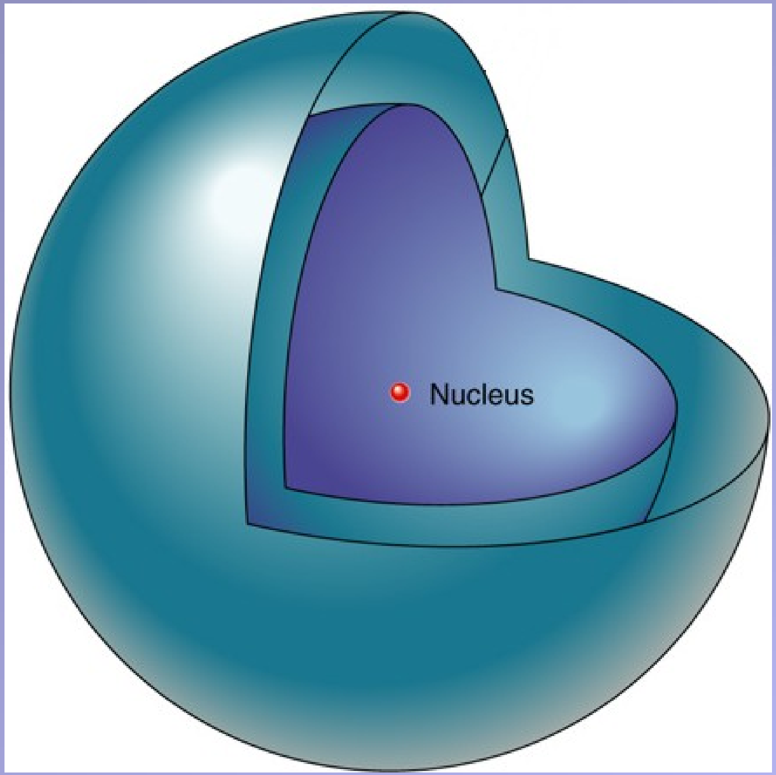
What is a *rock*?

Naturally occurring solid aggregate

- Made of one or more minerals
  - *Granite, basalt, rock salt, limestone*
- Consolidated aggregate of rock particles
  - *Sandstone, shale*
- Solid mass of rock-like materials
  - *Coal, obsidian (a volcanic glass)*

Electron shells of an atom

Nucleus is a small part of the total volume



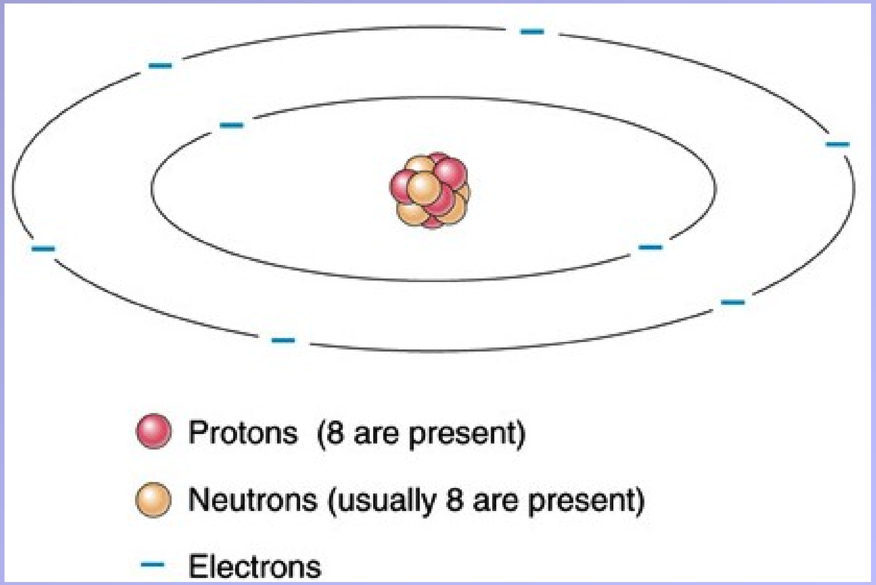
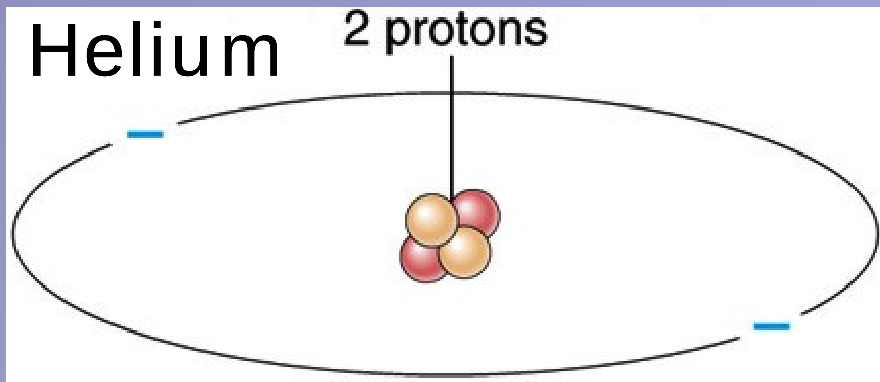


Figure 2.3

Nucleus – made of protons and neutrons
Electrons orbiting the nucleus

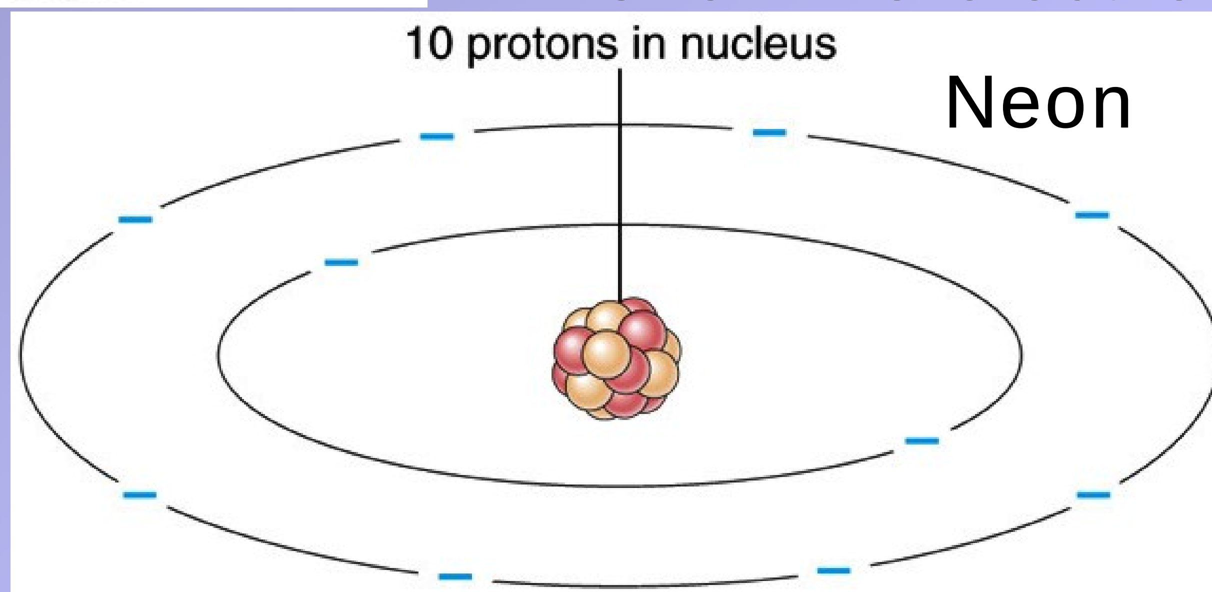
Filling electron shells

First shell – 2 electrons



		-3	-2	-1	He
B	C	N	O	F	Ne
Al	Si	P	S	Cl	Ar
Ga	Ge	As	Se	Br	Kr
In	Sn	Sb	Te	I	Xe
Tl	Pb	Bi	Po	At	Rn

2^{nd} shell – 8 electrons



Noble gases

Figure 2.4

Filling shells – Na and Cl

Na has only 1 electron in the outer (3rd) shell

Cl needs 1 more electron in the outer (3rd) shell

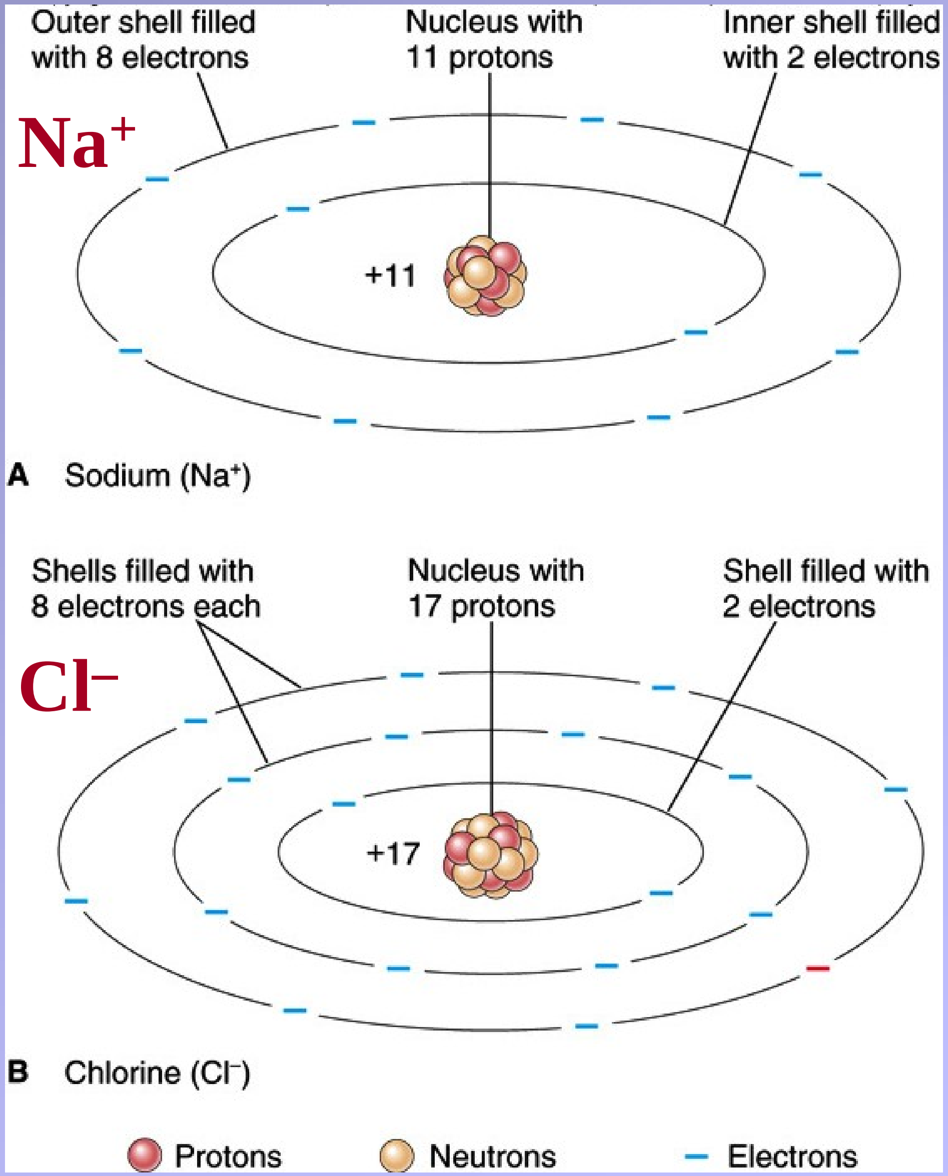


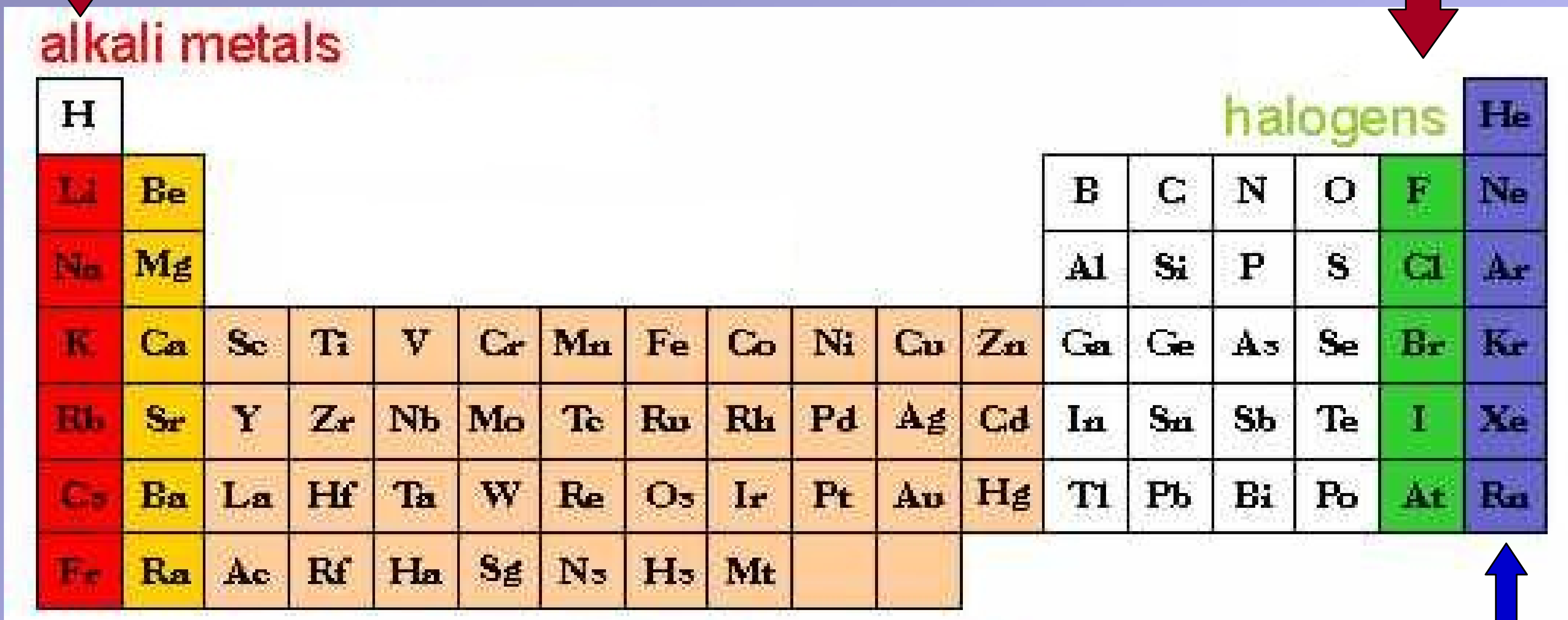
Figure 2.5

Alkali metals and halogens react

Transfer of an electron

+1

–1

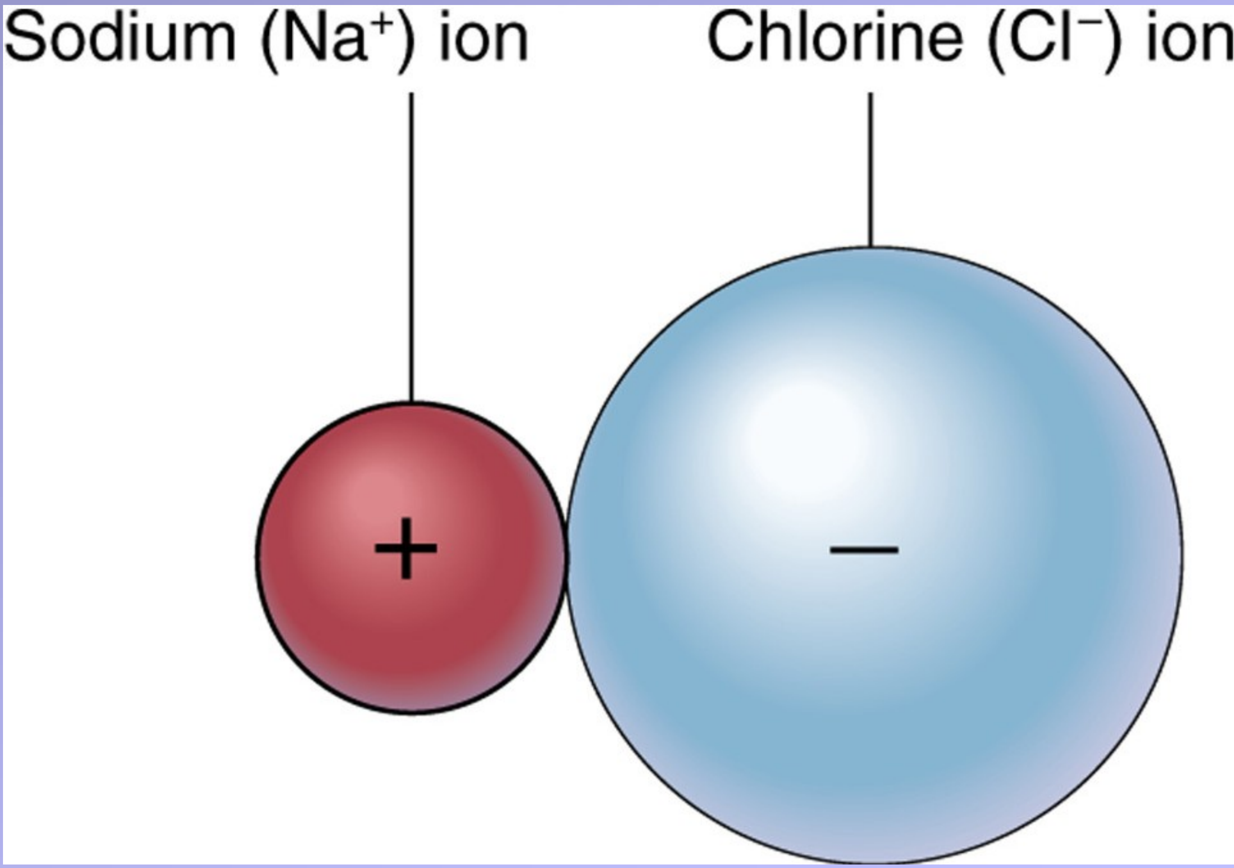


Noble gases

The result: two ions

Each ion is much more stable than the neutral atoms

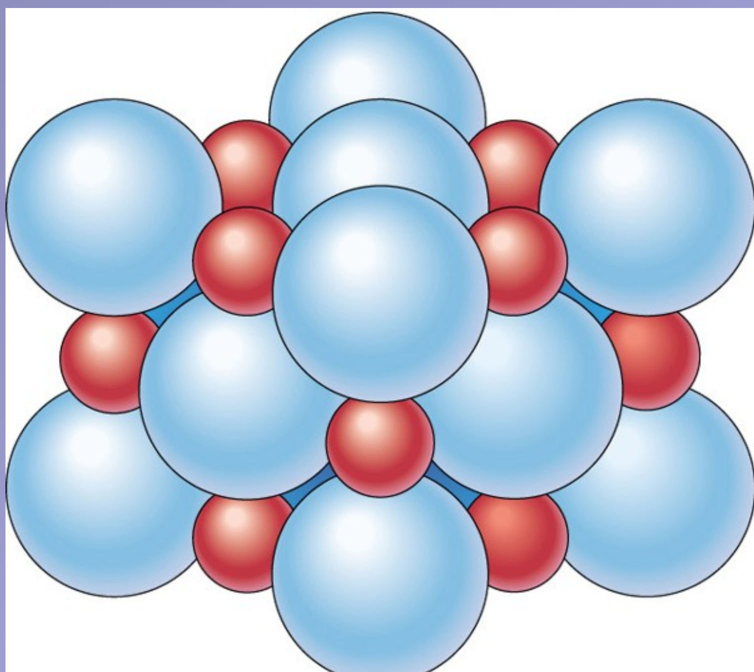
The two ions are attracted to each other by the electrical charge (similar to magnets)



Box 2.2

Ionic bonds hold together NaCl

The 3-D repeating structure is a crystal, and forms the mineral *halite*



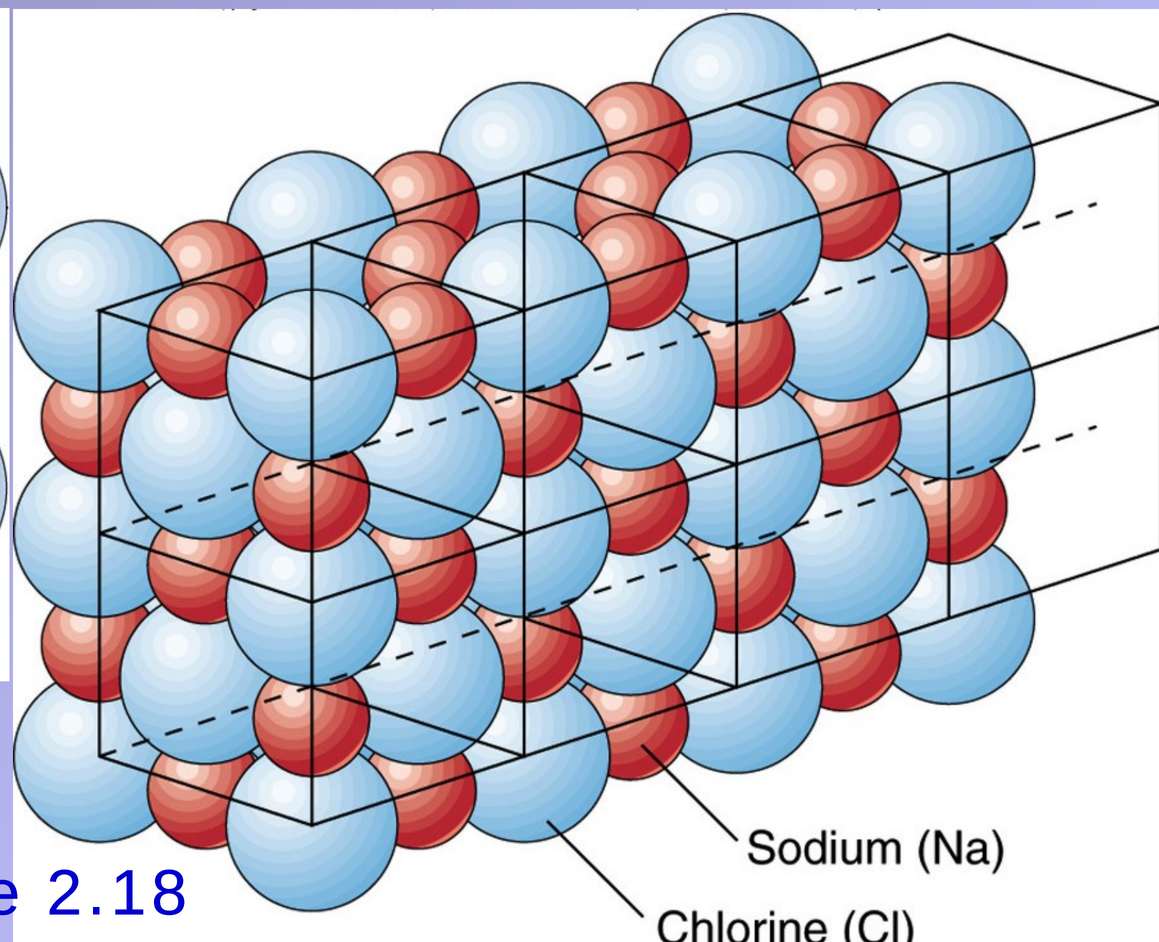
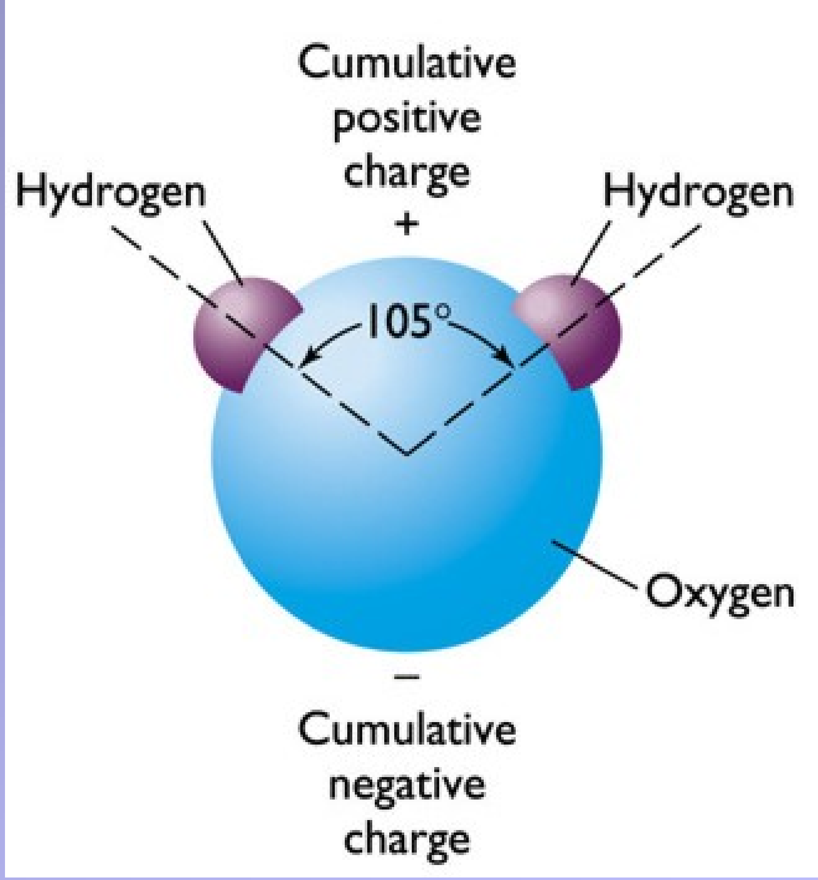


Figure 2.18

Covalent bonding of water

The hydrogen atoms and the oxygen ***share*** two electrons in the outer electron shell

Forms a ***covalent bond***



Bonds between atoms & molecules

Strong *Covalent bonds* – the electrons are shared between the atoms, keeping the nuclei close together

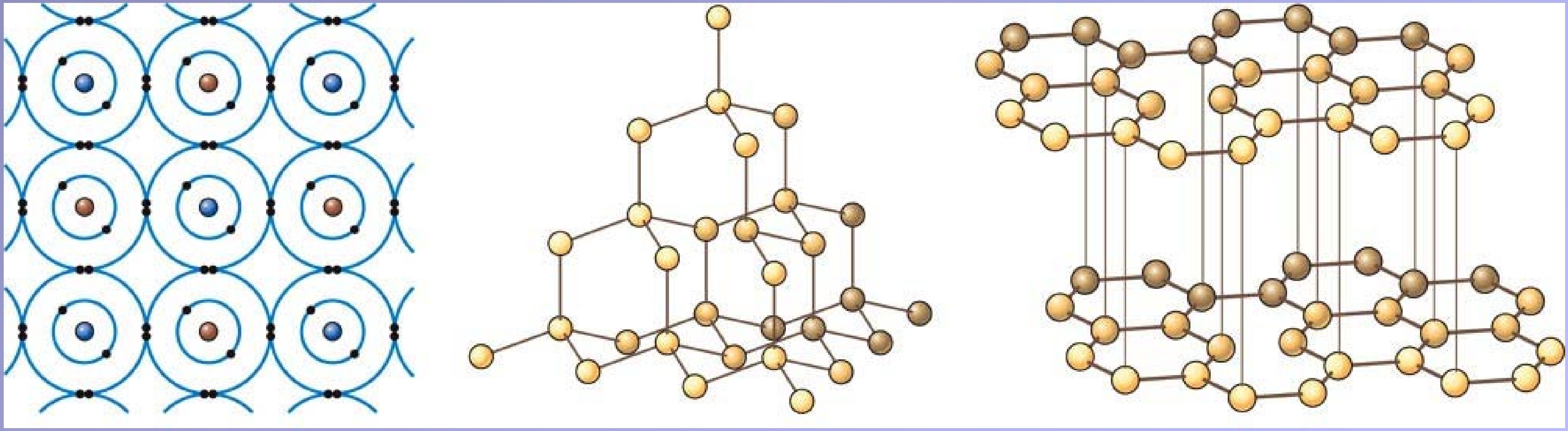
Metallic bonds – nuclei stay close together, but the electrons are free to flow along a group of atoms

Ionic bonds – electrons stay on one atom, creating positive and negative ions

Weak *Hydrogen bonding* (between molecules)

Crystals of carbon

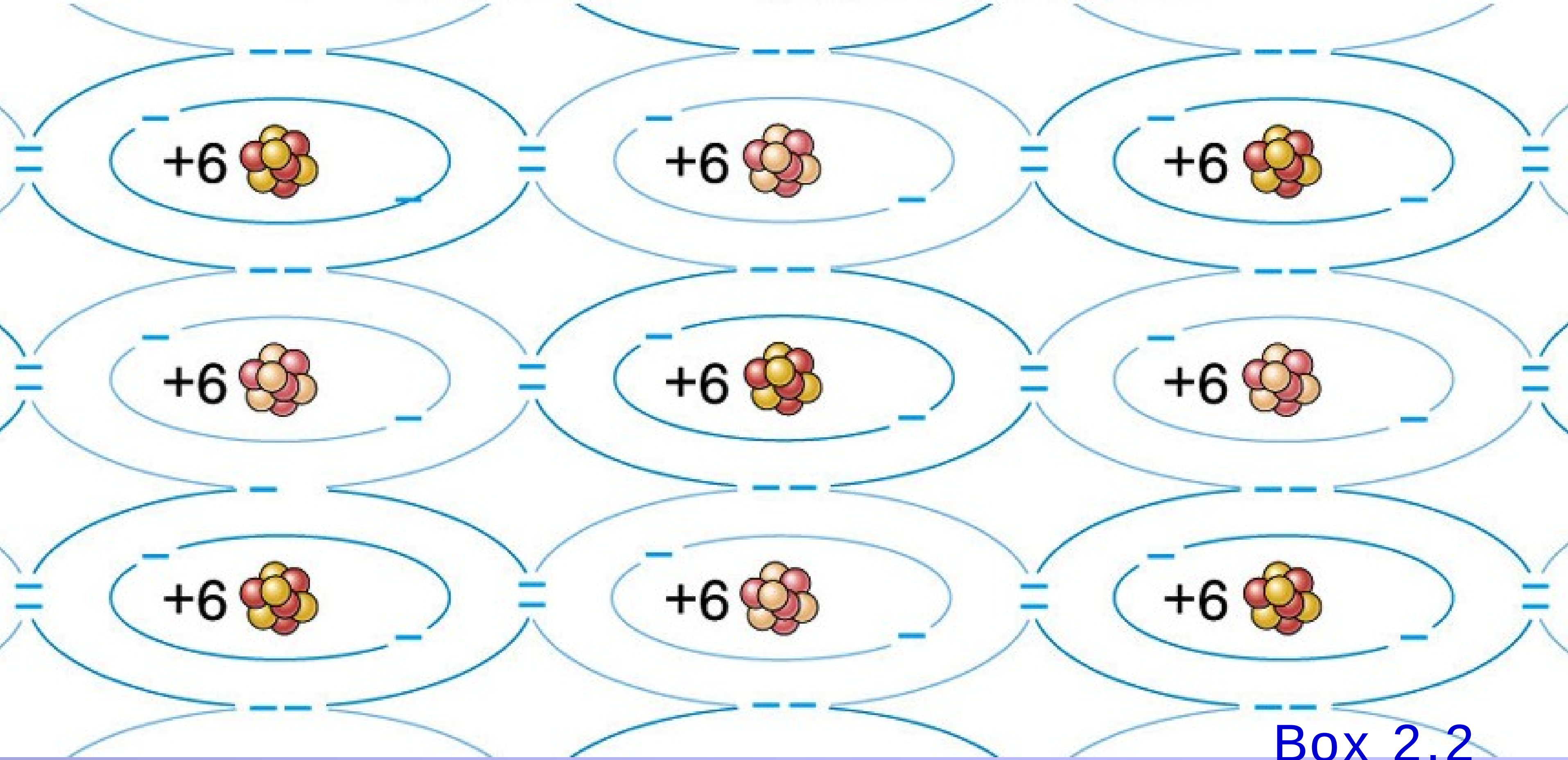
Different configurations of covalent bonds



Diamond *Graphite*

Covalent bonds are generally strongest

Examples from the textbook:
graphite and diamond



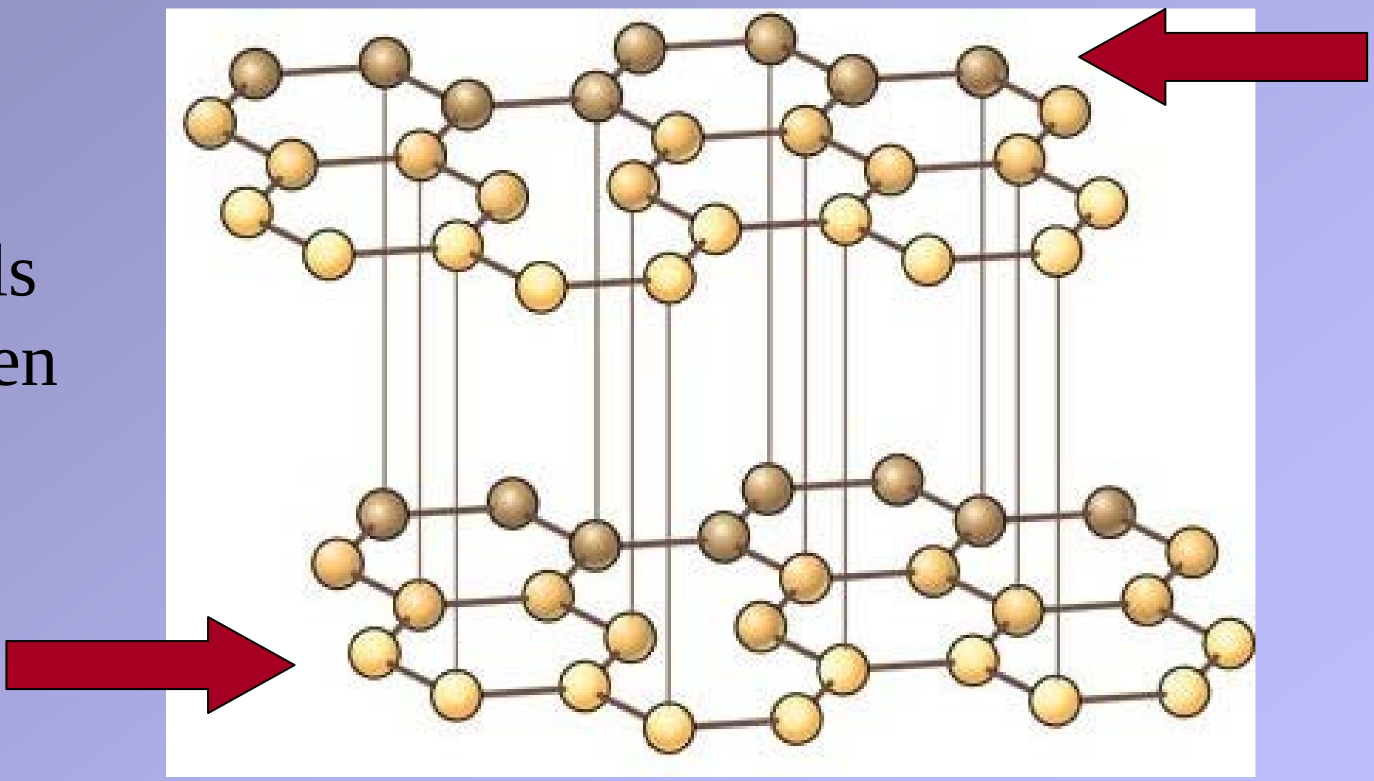
Box 2.2

Graphite – 2-D bonding

Sheets of C with strong covalent bonds

Van der Waals
bonds between
the sheets

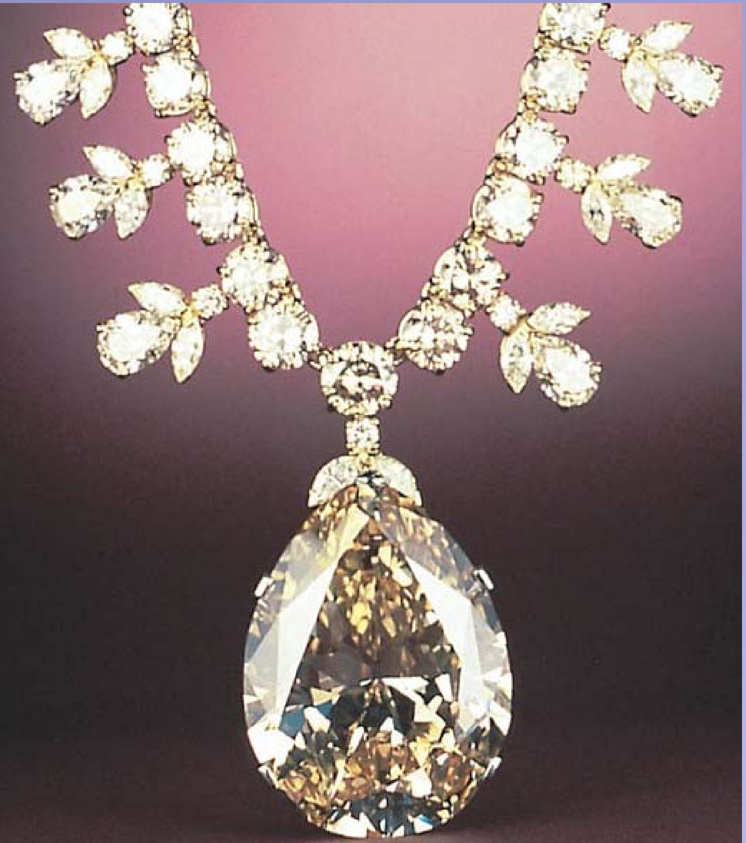
** Weak **

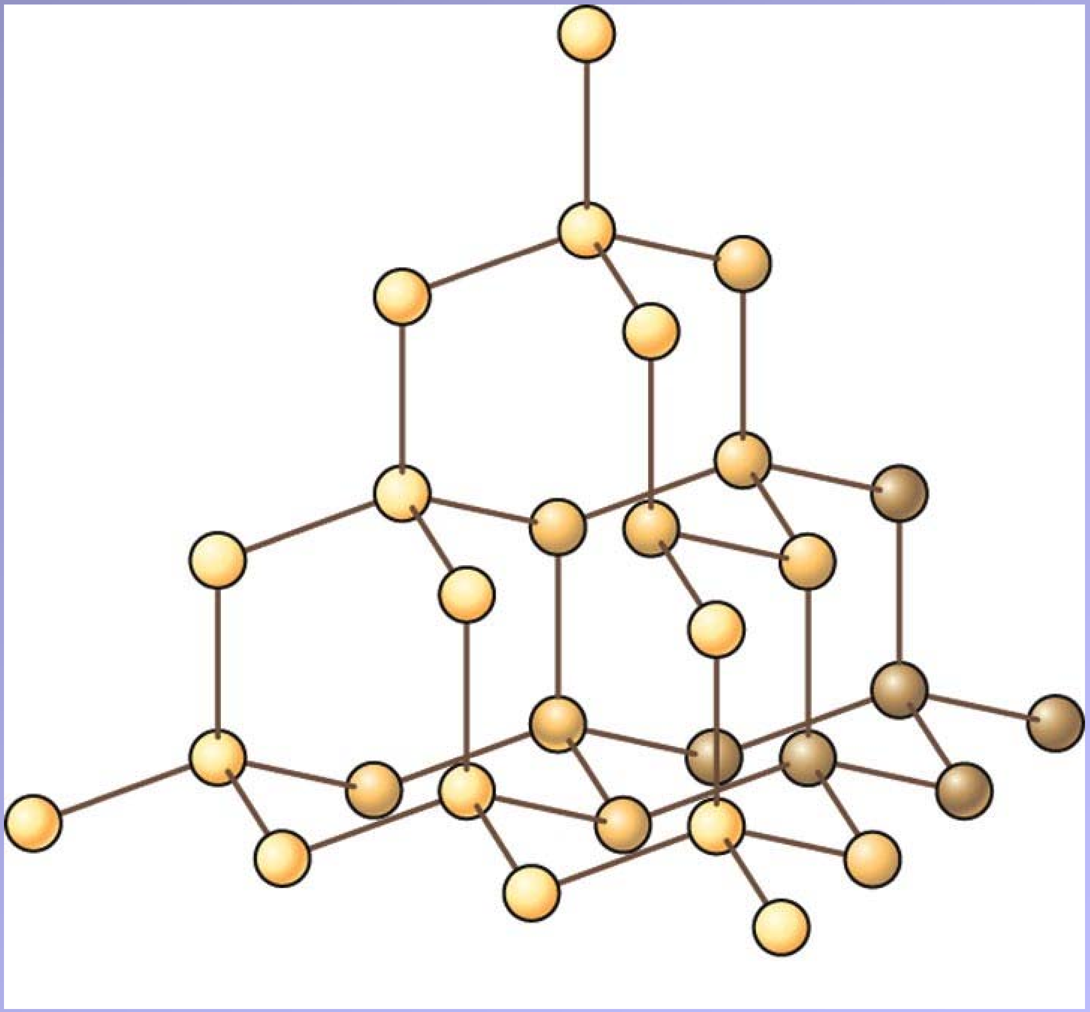


Can’t withstand shearing force

Diamond

Interlocked 3-D framework





Mineral groups

Table 3.3 in the textbook

Mineral Group	Negatively Charged Ion or Radical	Examples	Composition
Carbonate	$(CO_3)^{-2}$	Calcite	$CaCO_3$
		Dolomite	$CaMg(CO_3)_2$
Halide	Cl^{-1}, F^{-1}	Halite	$NaCl$
		Fluorite	CaF_2
Native element	—	Gold	Au
		Silver	Ag
		Diamond	C
		Graphite	C
Oxide	O^{-2}	Hematite	Fe_2O_3
		Magnetite	Fe_3O_4
Silicate	$(SiO_4)^{-4}$	Quartz	SiO_2
		Potassium feldspar	$KAlSi_3O_8$
		Olivine	$(Mg,Fe)_2SiO_4$
Sulfate	$(SO_4)^{-2}$	Anhydrite	$CaSO_4$
		Gypsum	$CaSO_4 \cdot 2H_2O$
Sulfide	S^{-2}	Galena	PbS
		Pyrite	FeS_2

Carbonates

Basic polyatomic ion – CO_3^{-2}

Most common forms:

$Ca^{+2}\ CO_3^{-2}$ calcite and aragonite

$(Ca^{+2}, Mg^{+2})\ CO_3^{-2}$ dolomite

** These minerals make up limestone, **
and stalactites in caves

Halides (from *halogen*) – salts

Fluorite – CaF_2

Halite – NaCl

Native metals

Native gold in quartz
hydrothermal

Native gold

Oxides – metals combined with oxygen

Commonly with water *(oxyhydroxides)*

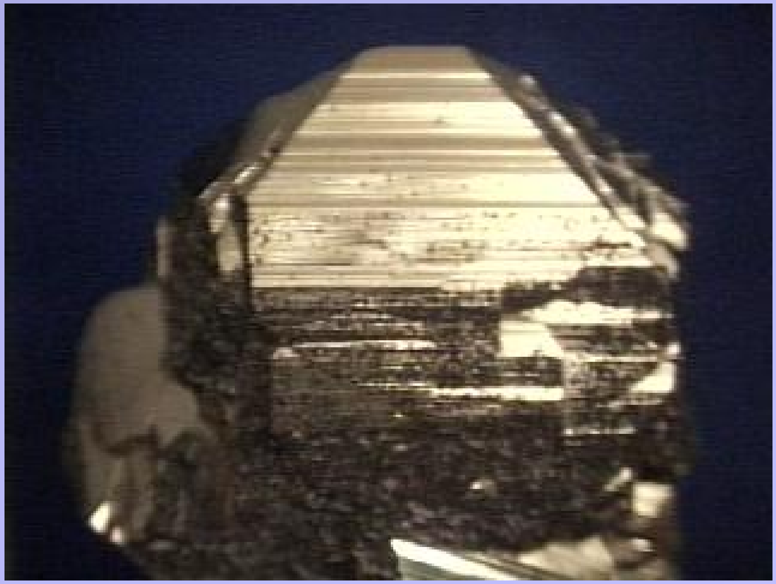
Limonite – iron oxyhydroxide

The sulfides – sulfur with no oxygen

Galena – PbS_2 lead sulfide

Common hydrothermal minerals

Pyrite – FeS_2 iron sulfide



Sulfates – sulfur with oxygen

Basic polyatomic ion – SO_4^{-2}

<u>Some common forms</u>:

$Ca^{+2}\ SO_4^{-2} * H_2O$ gypsum

Desert Rose

Calcanthite

$CuSO_4 * 5H_2O$

Hydrated Copper Sulfate

The silicates – most of the planet

Basic polyatomic ion – SiO_4^{-4}

<u>Most common forms</u>:

Olivine (Fe,Mg) SiO_4

Feldspar (*X* Al Si_3O_8) X = Ca, Na, K

Quartz SiO_2

Two major groups of silicates:

Ferromagnesian

Fe Mg SiO_4– iron & magnesium silicates

** most common minerals on Earth **

make up most of the mantle

and oceanic lithosphere

Non-ferromagnesian

X SiO_4– silicates without Fe & Mg

typically substitute Ca, Na, K

** most common minerals of continents **

make up most of granite

Telling them apart

Ferromagnesian dark, black or greenish

Telling them apart

Non-ferromagnesian light, white, or clear

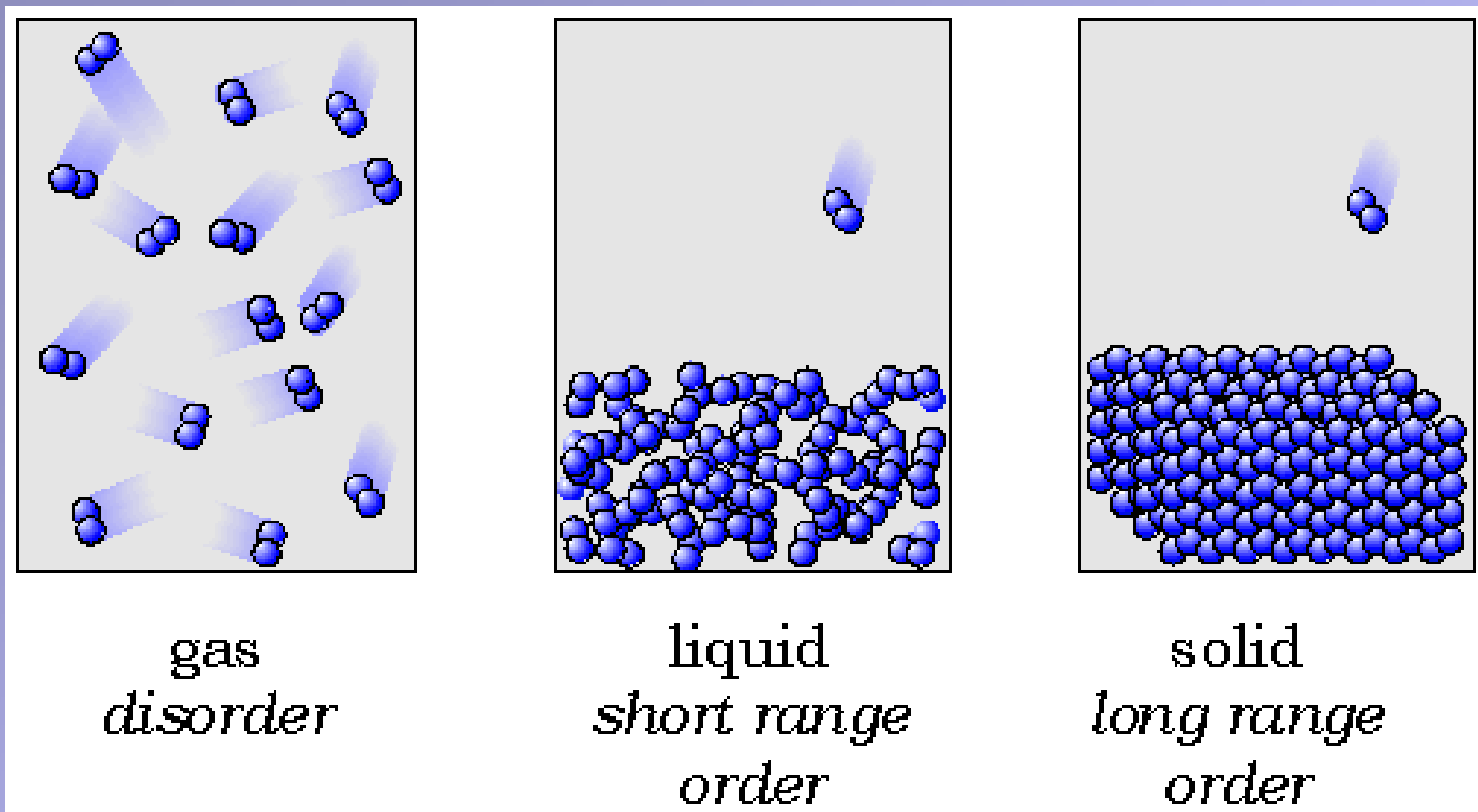
Minerals and igneous rock types

Granite – Diorite – Gabbro

A quick review: Phases of matter

States (or Phases) of Matter

GAS LIQUID SOLID



What Is Heat?

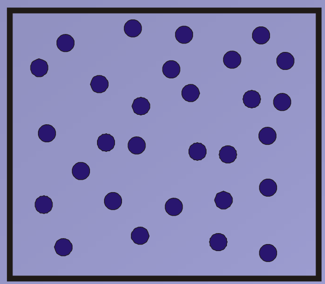
Heat results from the **vibrations** of atoms – this is **kinetic energy**

Heat is transferred along a **gradient**
conductive – particle to particle
radiative – by electromagnetic radiation infra-red radiation

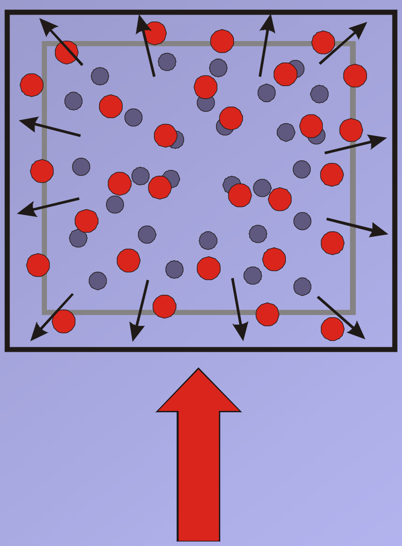
Heat is measured with a thermometer
BUT, how does a thermometer work?

The effect of heat on **density** of matter

Density = mass per unit volume

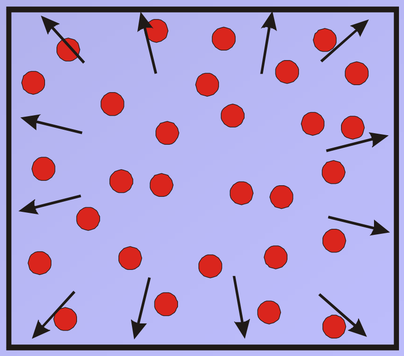


Cool rock



Expands

ADD HEAT



Hot rock

What changed?

Mass

Volume

Density

The effect of heat on **density** of matter

As temperature increases:

atoms (or molecules) vibrate faster and with greater amplitude

these vibrations "push" the atoms farther apart

which lowers the density of the material

So... *how does a thermometer work?*

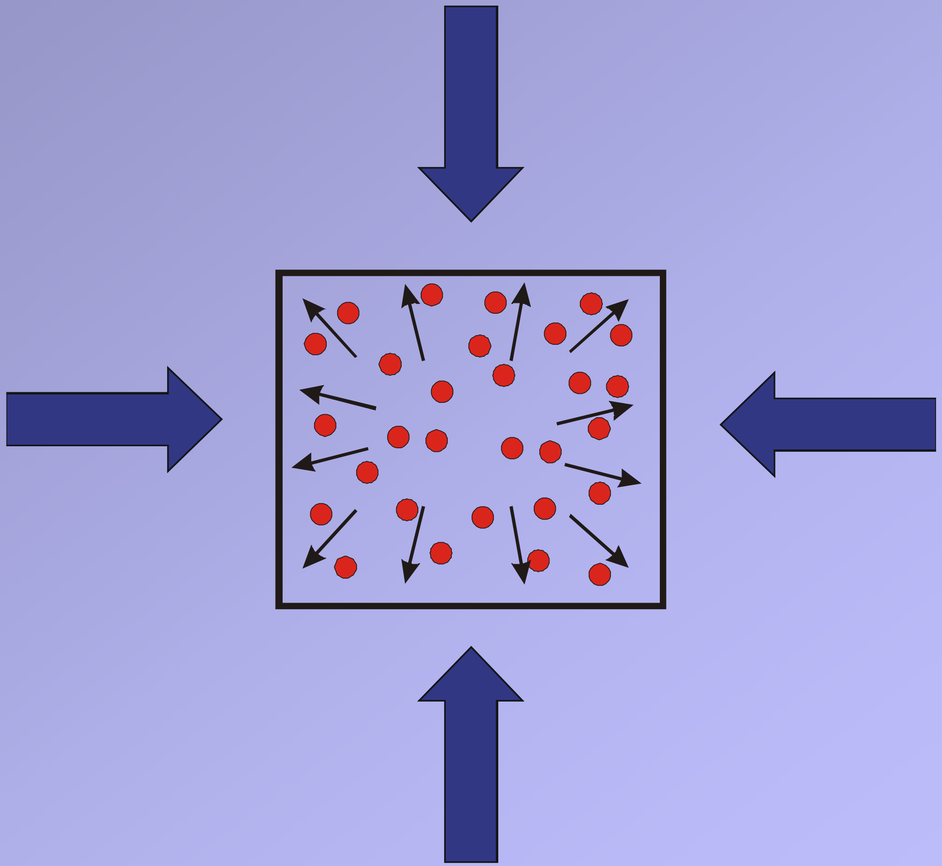
Phase Transitions

Melting is the transition from solid to liquid
freezing is the reverse

Evaporation (vaporization) is the transition from liquid to gas
condensation is the reverse

Controls on phase transitions

Phase transitions are controlled by:
- **heat** (energy available – outward force)
- **pressure** (constraining force)

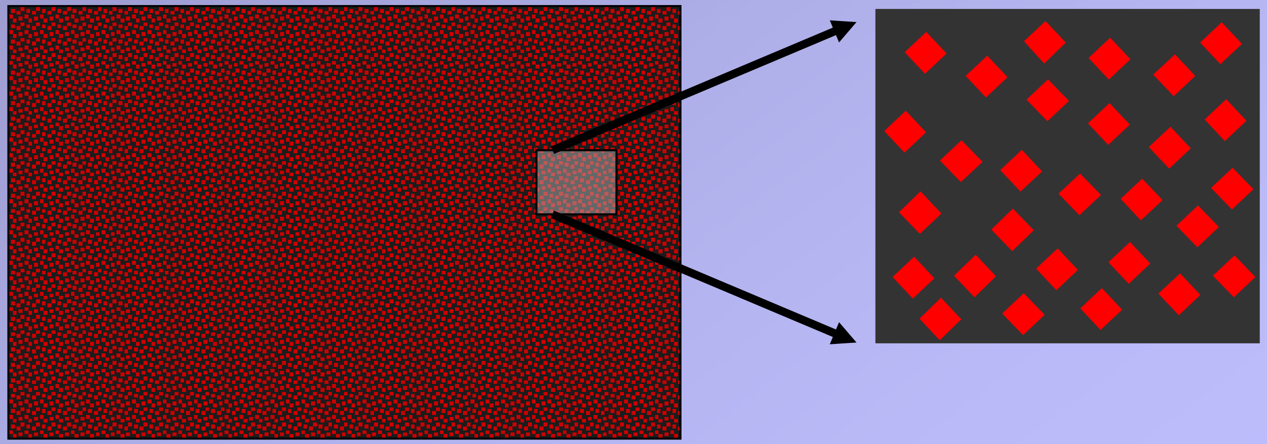


Phase transitions and rocks

Most rocks are made of more than one mineral.

Each mineral melts at a different temperature.

So, a rock can be ***partially molten*** – with liquid in between solid crystals



Phase transitions and rocks

Can a rock in the upper mantle melt without an increase in temperature?