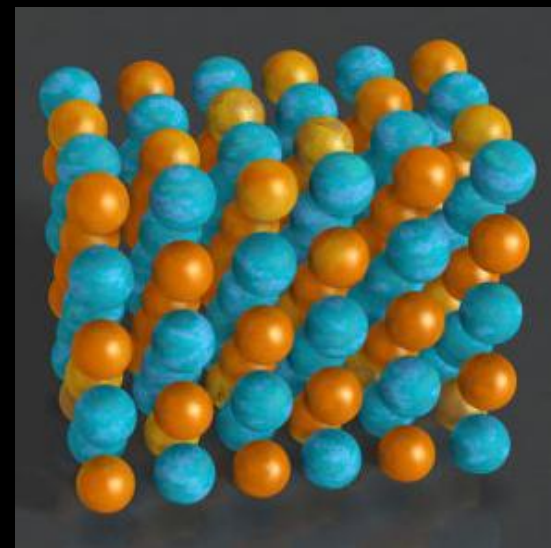
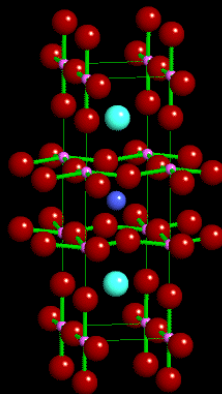
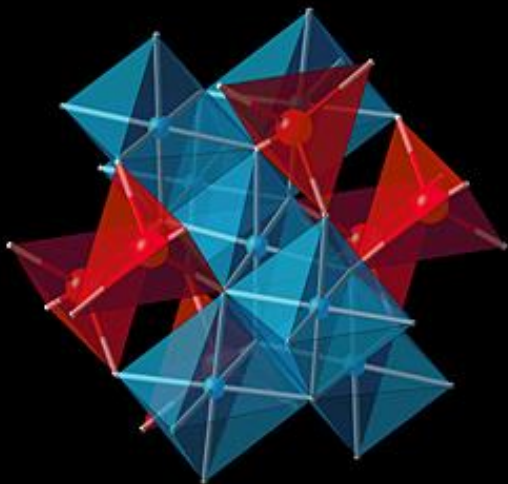


Solids



States of Matter-Solid

Form

Rigid

Compressibility

Very Low (Exam → Not Compressible)

Shape

Constant (definite)

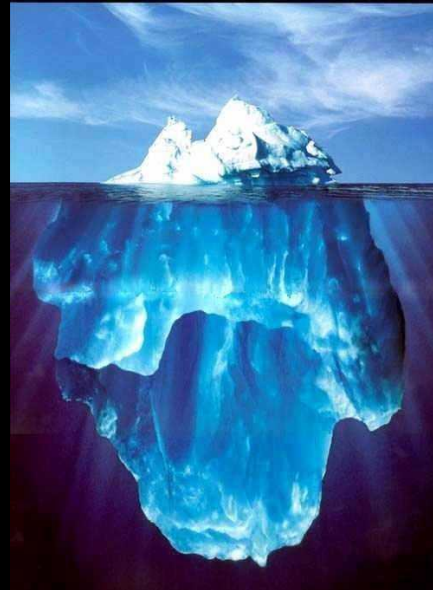
Volume

Constant (definite)

Particle Movement

Vibration in fixed position

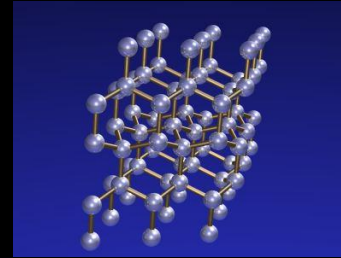
Example: Ice



Three Types of Crystalline Solids

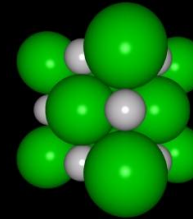
Atomic
Diamond

Atoms



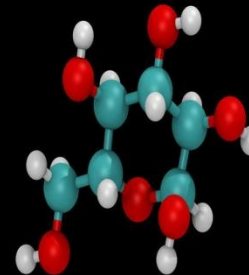
Ionic
Sodium Chloride

Ions



Molecular
Glucose

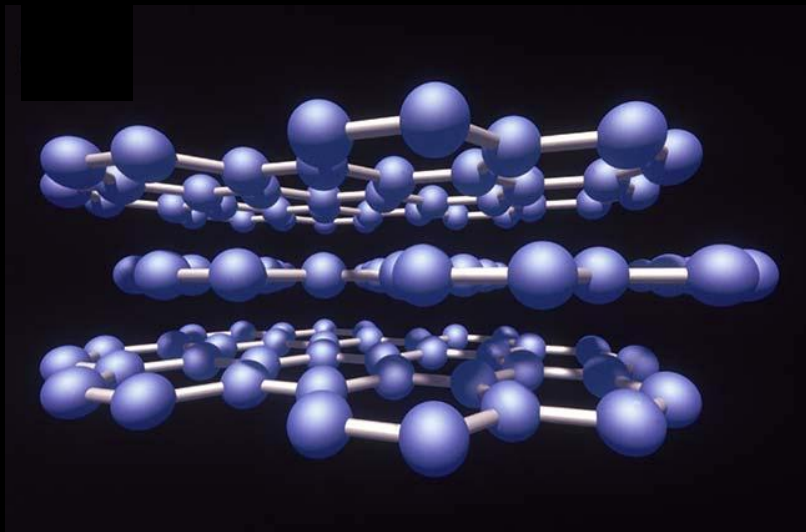
Molecules



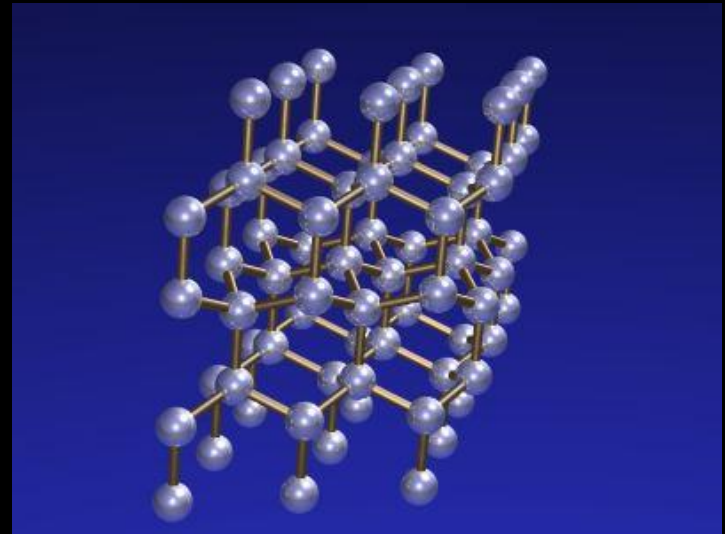
Solids: Physical Properties

Macro properties observed

Determined by atomic level geometry & forces



Graphite

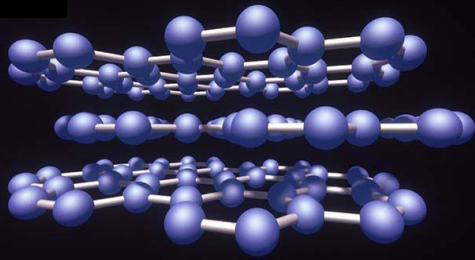


Diamond

Atomic Solids

Characteristics:

Graphite



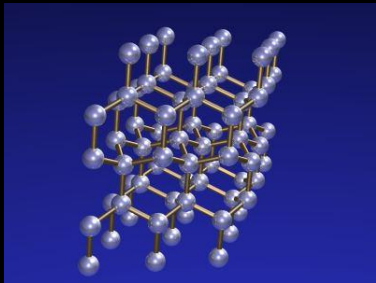
Fundamental Unit: Atom

**Shape determined by atoms packing geometry
(Atoms at every vertex of rigid geometrical shape)**

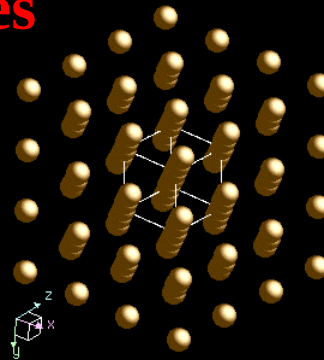
Represented by chemical formula

Variable Properties

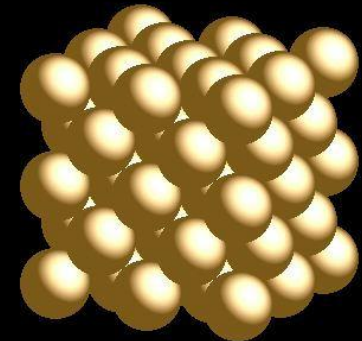
C₆₀ Bucky Ball



Diamond

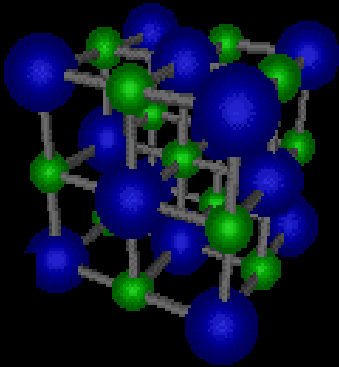


Iron



Gold

Ionic Solids



Characteristics:

Large Matrix of Charged Particles

Shape determined by ion charges and size

Represented by Formula Unit

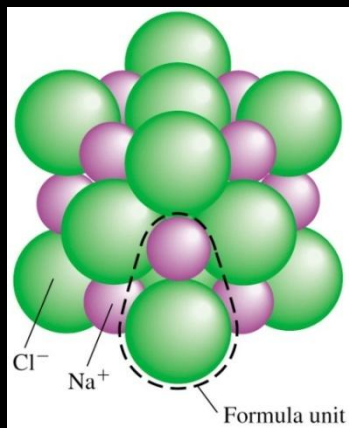
High Melting Point $\gg 200\text{ }^{\circ}\text{C}$

Brittle ... easily cleaved

Good Electrical Conductors in H_2O or melted

Strong Attractive Forces

400 – 1100 kJ / mole



Ionic Solids

Ionic Bond (Attractive force between ions governed by Coulomb

$$F \propto q_1 q_2 / r^2$$

Higher melting point:

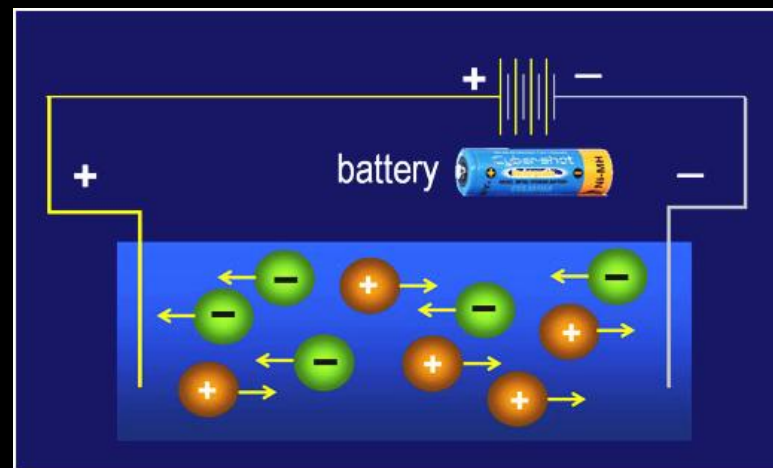
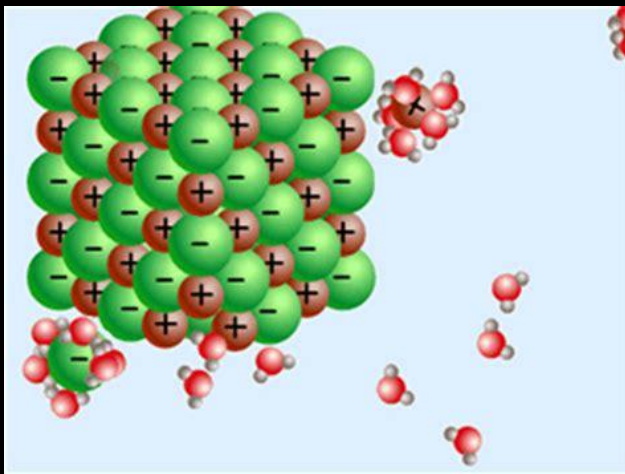
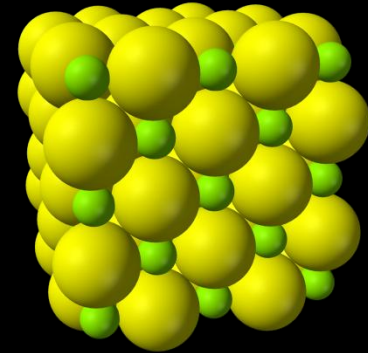
Greater charge: stronger force

Smaller ions; r^2 smaller

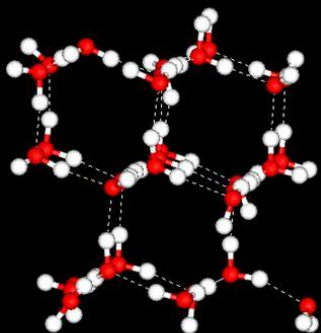
Higher boiling point

Lower vapor pressure

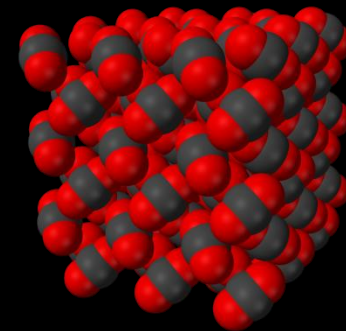
Dissolving a result of ions becoming hydrated



Molecular Solids



Solid H₂O



Solid CO₂

Characteristics:

Fundamental Unit: Molecule

Shape determined by molecular geometry

Represented by chemical formula

Low Melting Point < 200 °C

Low Attractive Forces

H-Bonds

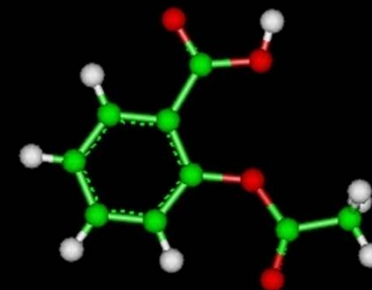
Dipole-Dipole

London Dispersion

10 – 40 kJ / mole



S₈



Aspirin

Identify the type of crystalline solid:

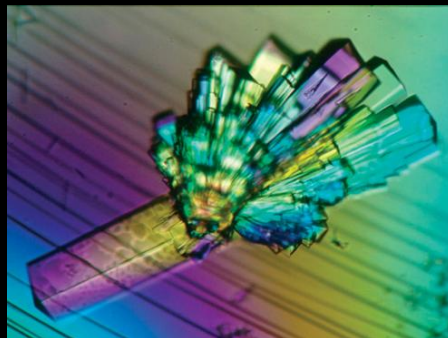
Ammonia: Molecular

Iron: Atomic

Cesium fluoride: Ionic

Argon: Atomic

White phosphorus (P_4): Molecular



Metals - Left Side Periodic Table

Metallic shine or luster

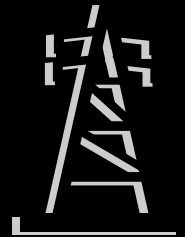
Flexible

Solids (mostly) @ room temp

Ductile - can be drawn into wires

Malleable - can be pounded into thin sheets

Conduct heat & electricity



More Metallic

Metals

Most Elements (> 80)

Beyond Iron: “Heavy Metals”

Periodic Table of the Elements

The periodic table is organized into groups (columns) and periods (rows). The groups are labeled IA through VIIA, and the periods are labeled 1 through 7. The elements are color-coded by groups: IA (green), IIA (blue), IIIA (purple), IVA (cyan), VA (magenta), VIA (yellow), VIIA (orange), and the noble gases (He, Ne, Ar, Kr, Xe, Rn) are in a separate column on the right. The lanthanide and actinide series are shown at the bottom.

Period \ Group	IA	IIA	IIIA	IVA	VA	VIA	VIIA	Noble Gases										
1	H	He																
2	Li	Be	B	C	N	O	F	Ne										
3	Na	Mg	Al	Si	P	S	Cl	Ar										
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Cu	Zn	Ga	Ge	As	Se	Br	Kr		
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
6	Cs	Ba	*La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
7	Fr	Ra	+Ac	Rf	Ha	Sg	Ns	Hs	Mt	110	111	112	113					

* Lanthanide Series
+ Actinide Series

58	59	60	61	62	63	64	65	66	67	68	69	70	71
Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
90	91	92	93	94	95	96	97	98	99	100	101	102	103
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

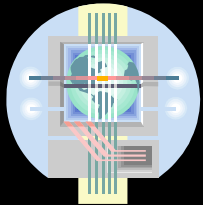
Metalloids (Semi-Metals) – “Staircase”

Properties (metallic or nonmetallic) depend on environment

Semi-conductors

good conductor at high T

poor conductor at low T



B Boron

Si Silicon

Ge Germanium

As Arsenic

Sb Antimony

Te Tellurium

Po Polonium ??

At Astatine ??

6, 7, or 8 Elements

At on some, Most consider At a halide

Staircase

Periodic Table of the Elements



1A																	0	
1	H																	2
2	Li	Be											5	6	7	8	9	10
3	Na	Mg	IIIB	IVB	VB	VIB	VII B	VII		IB	IIB	13	14	15	16	17	18	
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
6	Cs	Ba	*La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	83	84	85	86
7	Fr	Ra	+Ac	Rf	Ha	Sg	Ns	Hs	Mt	110	111	112	113					

58	59	60	61	62	63	64	65	66	67	68	69	70	71
Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
90	91	92	93	94	95	96	97	98	99	100	101	102	103
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

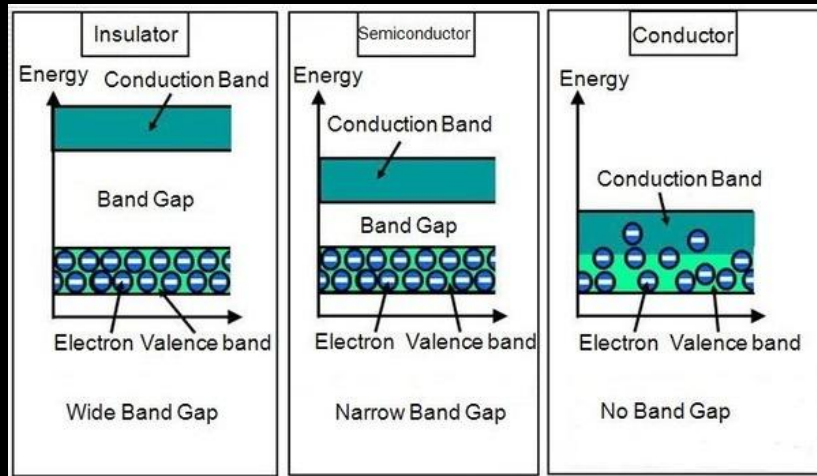
* Lanthanide Series

+ Actinide Series

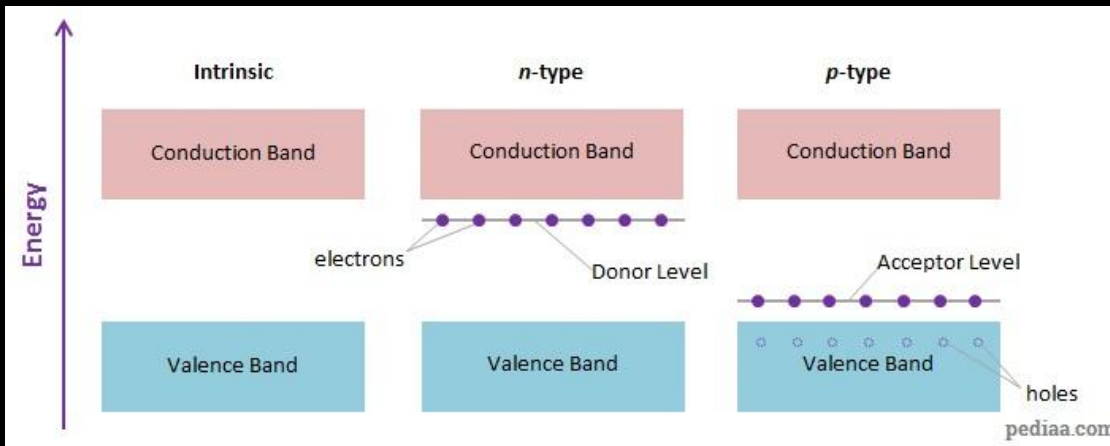
Semi-Conductors: Current Flow Depends on Energy Gap

Electrons reside in two possible energy states:

Valence and Conducance



Conductance depends on relative energy difference Between bands



Alloys: A Solid Dissolved in a Solid

More than one metal element in crystal structure

Primary Metal: **Base (Solvent)**

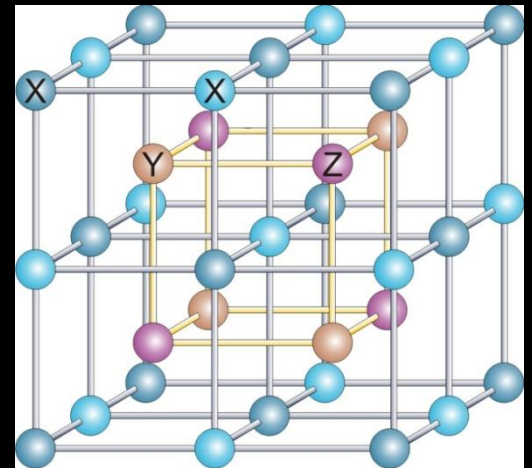
Secondary Metal: **Solute**

2 components = **Binary**

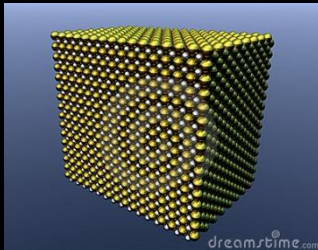
3 components = **Tertiary**

4 components = **Quaternary**

5 components = **Quinary**



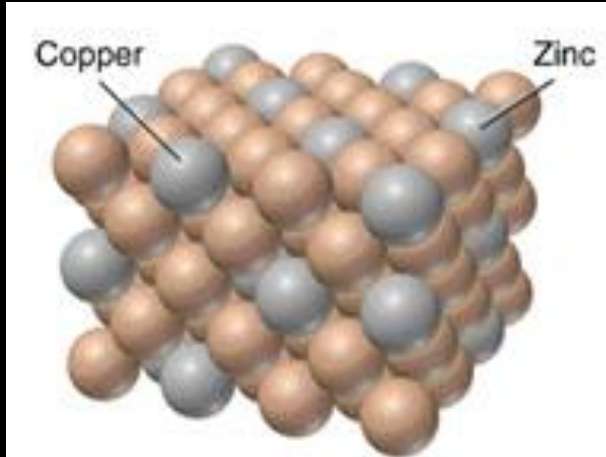
Mixture of metals: changes physical properties



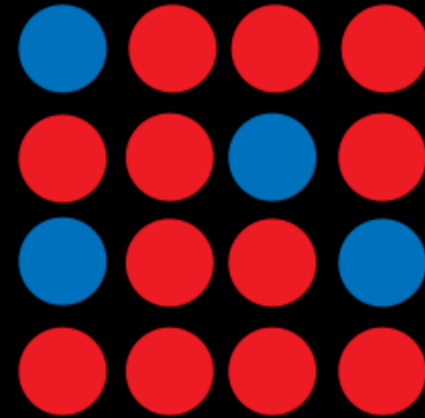


Substitutional Alloys

SOME atoms of base metal replaced



Brass



Schematic

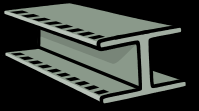
Sterling silver (93% silver, 7% copper)

Brass (67% copper, 33% zinc)

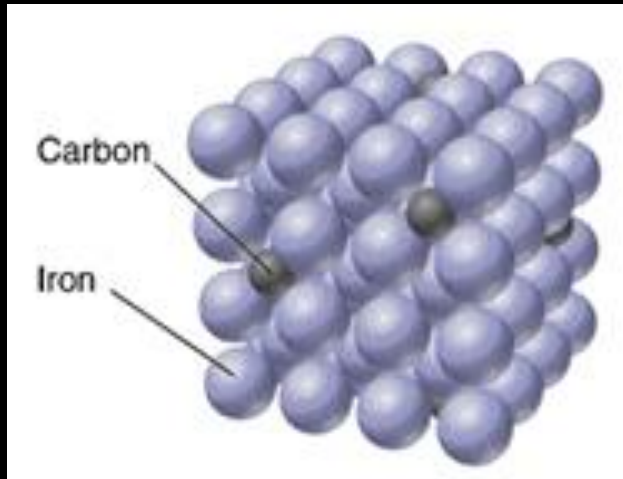
Bronze (88% copper, 12 % tin; but composition variable)

Pewter (85% tin, 7% copper, 6% bismuth, 2% antimony)

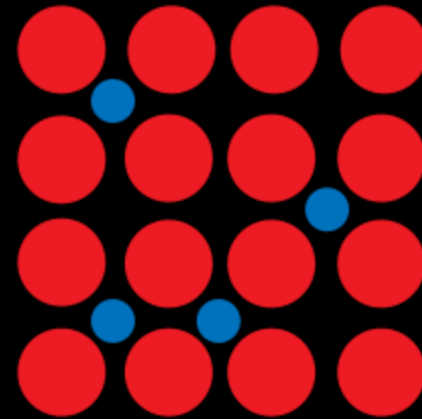
Interstitial Alloys



Smaller element atoms reside between metal atoms



Steel

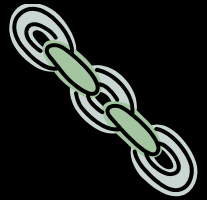


Schematic



Smaller atoms significantly alter physical properties
Provide alternate bonding network

Interstitial Alloys

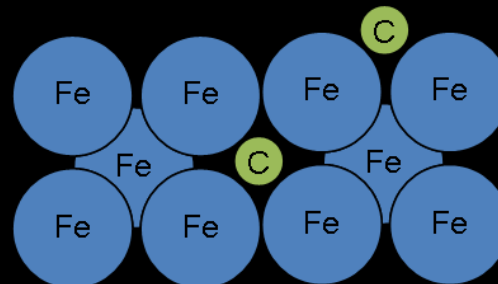
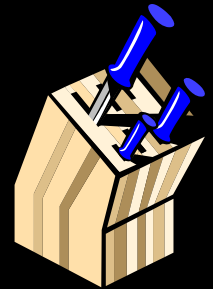
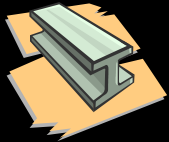


Number of interstitial atoms defines alloy properties

**Mild steels (<0.2% carbon): malleable ductile
chains, nails, and cables**

**Medium steels (0.2-0.6% carbon): harder than mild steels
rails and structural beams.**

**High-carbon steels (0.6-1.5% carbon): very hard
springs, tools, and knives**

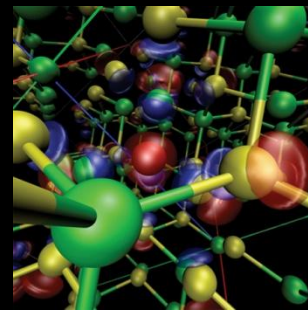
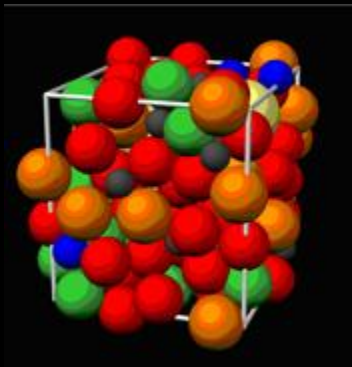


Combination Alloy: Substitutional & Interstitial

Stainless Steel

Start: Interstitial alloy of Fe & C

Substitute: Some Fe with Cr & Ni

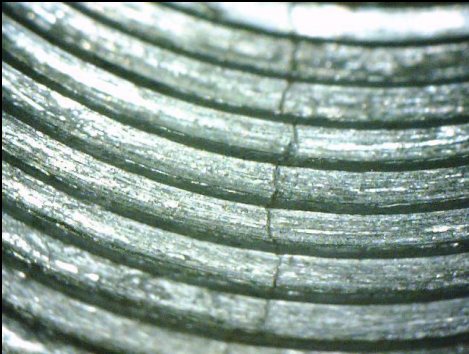


Famous Failures



Titanic:

Cheap Wrought Iron Rivets Below Waterline
Slag impurities made rivets brittle

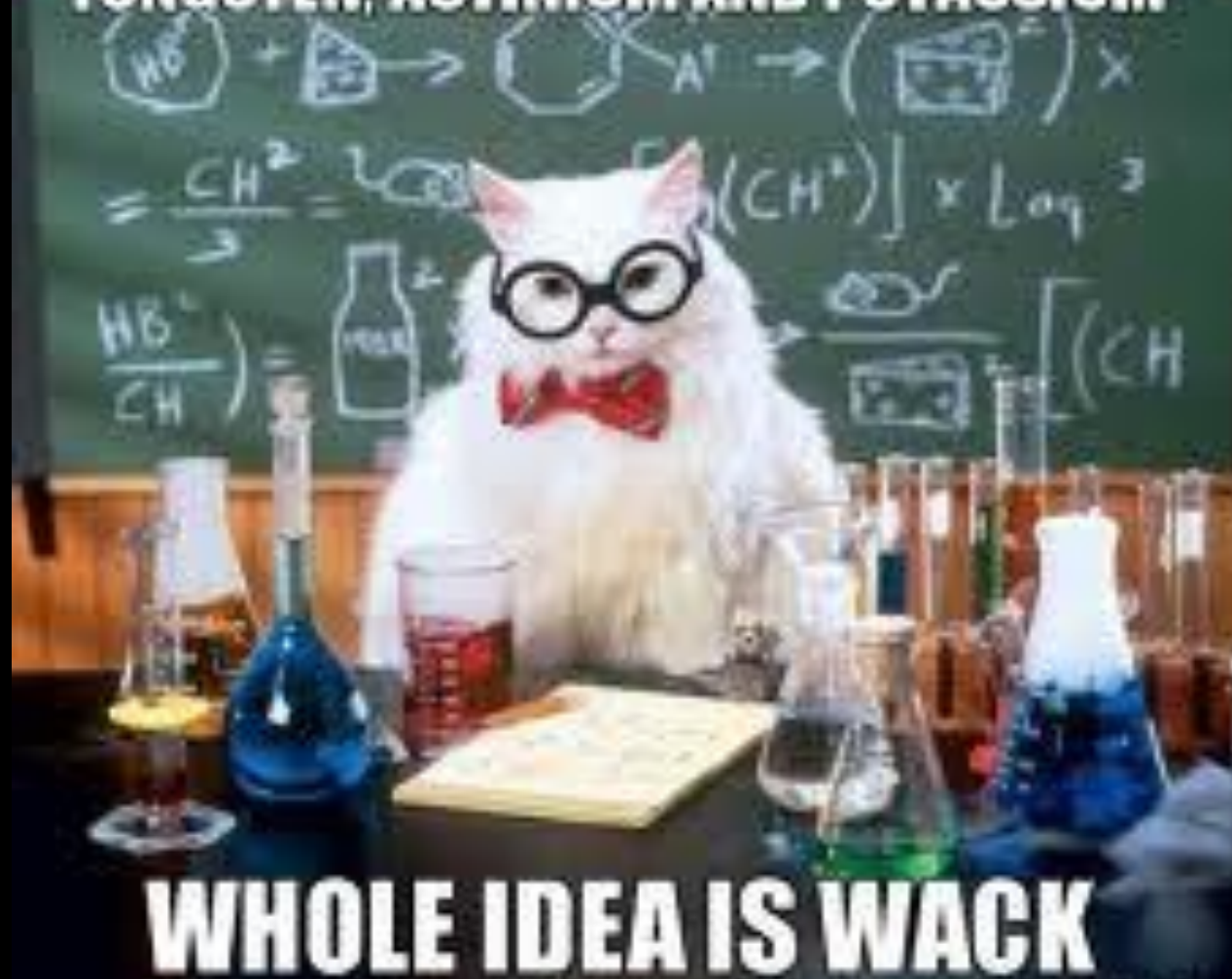


Aluminum Compressed Gas Cylinders

Cracks in head and neck of cylinder

Failures typically occur at different metal interfaces

TRYING TO DEVELOP AN ALLOY OF
TUNGSTEN, ACTINIUM AND POTASSIUM



WHOLE IDEA IS WACK

Trollme