Principles of electronic materials

PYL-102

P. Das

Broad Research Area: Nanoscale magnetism, electronic transport fluctuations

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Course objective

- providing basic foundation/training to understand

electronic, optoelectonic and other solid state devices

Course-Content

- Energy bands in solids
- Classification of electronic materials: metals, semiconductors, insulators
- Free electron model. conductivity, concepts of Fermi surface
- Effective mass and holes
- Concepts of phonons
- Thermoelectricity
- Intrinsic, extrinsic semiconductors, degenerate semiconductors
- Metal-semiconductor junctions, p-n junctions
- Diffusion and drift transport - carrier lifetime and diffusion length
- Direct and Indirect band gaps
- Optical transitions, photon absorption, Exciton
- Photovoltaic effect
- Dielectrics and electrical polazation, depolarization field
- Piezoelectricity, Pyroelectricity and ferroelectricity
- Magnetism in metals

Suggested books

- Band theory and electronic properties of solids, by John Singleton, Oxford University Press

- Introduction to Solid State Physics, by Charles Kittel, Wiley publishers

- Solid State Physics by N. Aschcroft and N. Mermin

Course evaluation and attendance policy

Attendance:

• Full attendance required, No entry after 11:05 am.

Grading/Evaluation:

1. Minor-I: 15 points

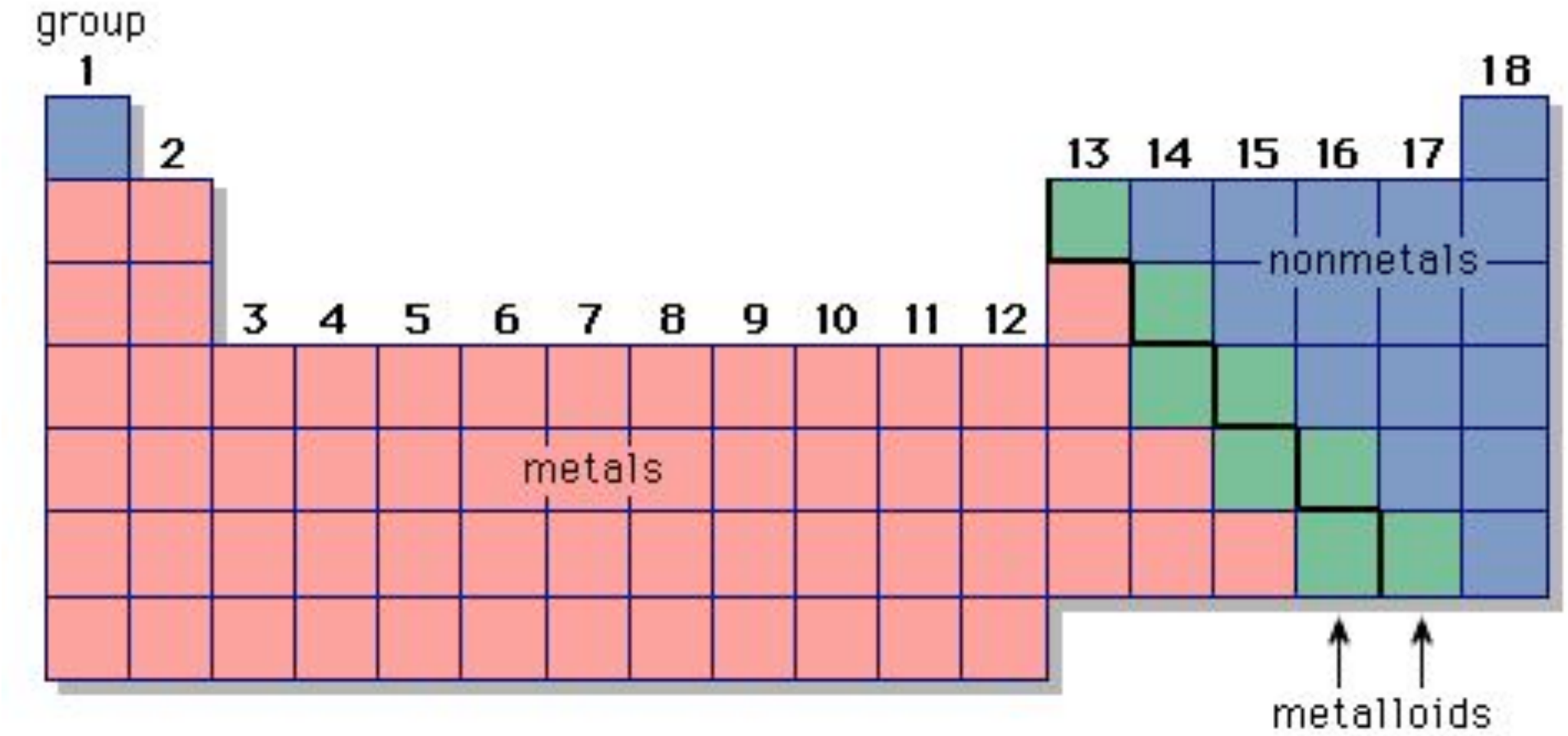
2. Minor II: 15 points

3. Major: 30 points

4. Quiz: total 40 points (every week!)

No re-minor, No re-major !

Metallic state favoured by most elements



Metals, Nonmetals, and Metalloids

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Uub	—	Uuq	—	—	—	—

Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

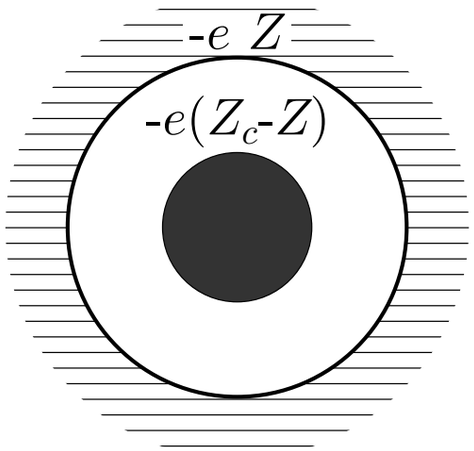
metals

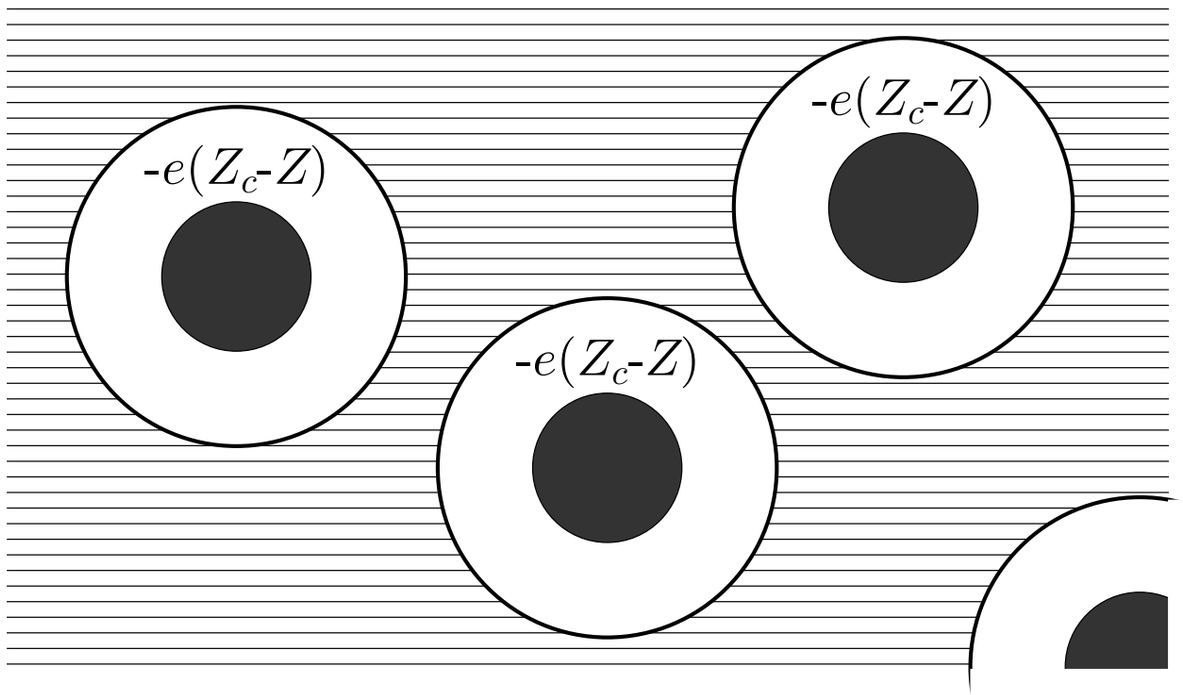
metalloids

nonmetals

Metals

- Tightly bound ion cores
- Surrounded by a more loosly-bound valence electrons
- Large no. of nearest neighbor (hcp, fcc, bcc, etc.)





Nucleus

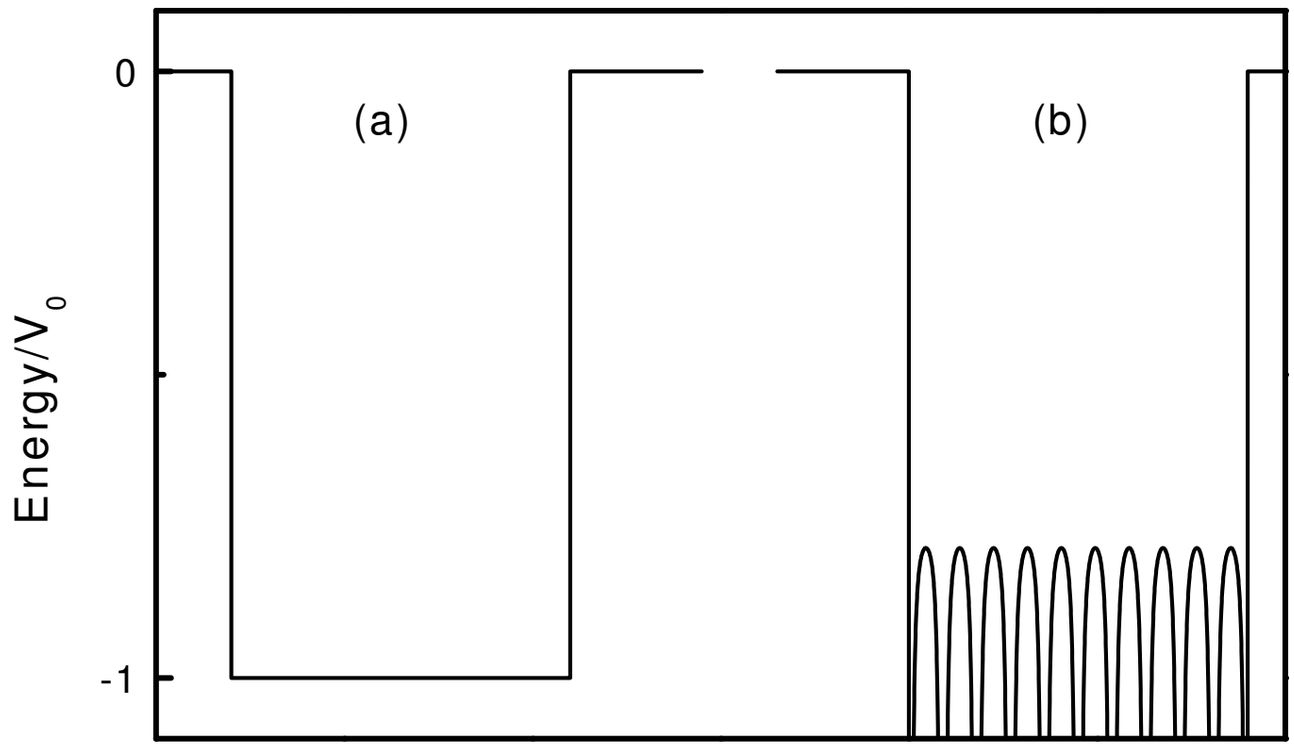
Core electrons

Valence electrons

Ion { Nucleus, Core

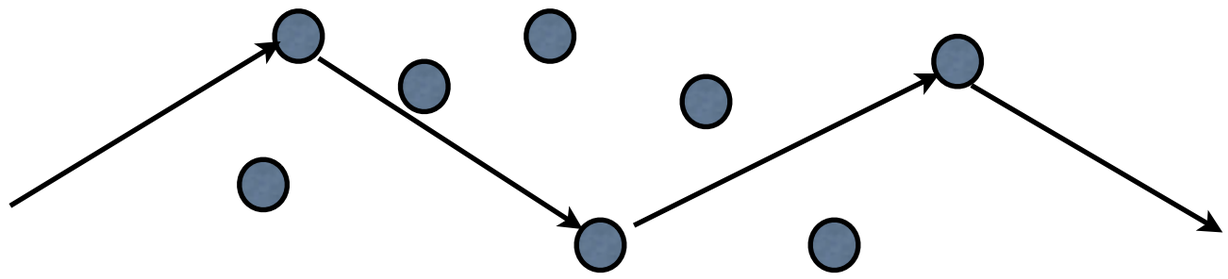
Conduction electrons

- Array of widely spaced, small ion cores
- Mobile electrons move through the volume between the cores



The Drude model

- Electrons collide only with ion cores and nothing else !



- No interaction with each other (independent electron approximation) or with ions (free electron approximation) between collisions!

- collisions are instantaneous, results in change in velocity

- Electron experiences a collision a rate τ^{-1} (scattering rate)

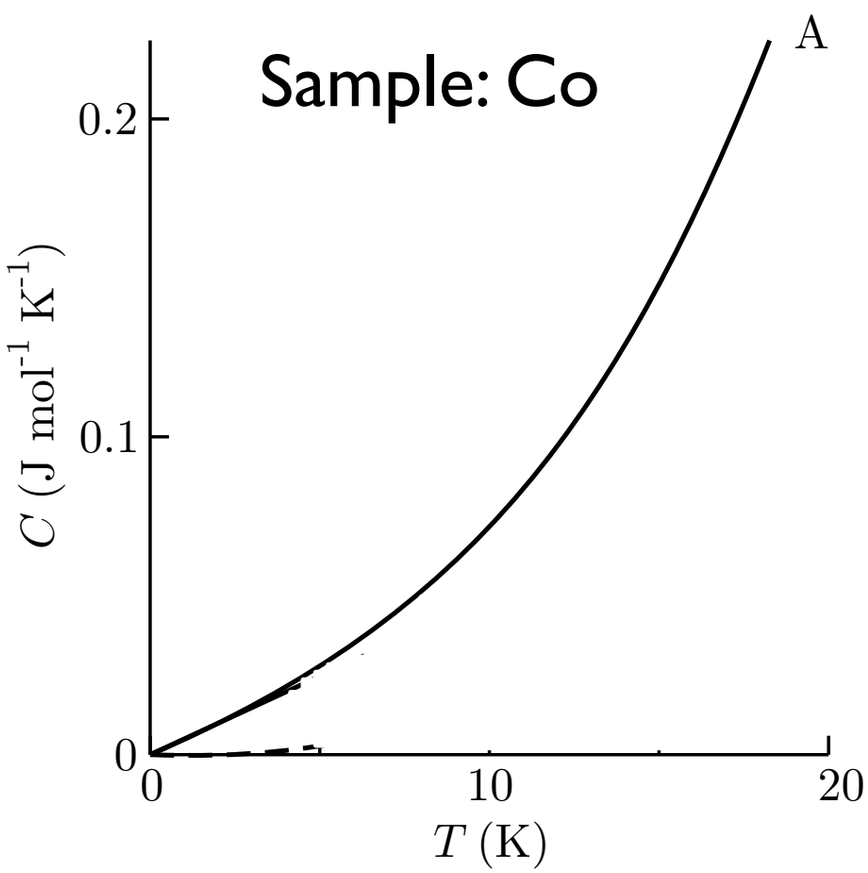
- electrons achieve thermal equilibrium with surroundings only through collisions

Failure of Drude's model

Drude's results
(equipartition of energy)

$$C = \frac{3}{2} n k_B$$

Experimental heat capacity



Ref.: G. Duyckaerts, Physica **6,** 817 (1939).