

ME211

# Materials Science and Engineering

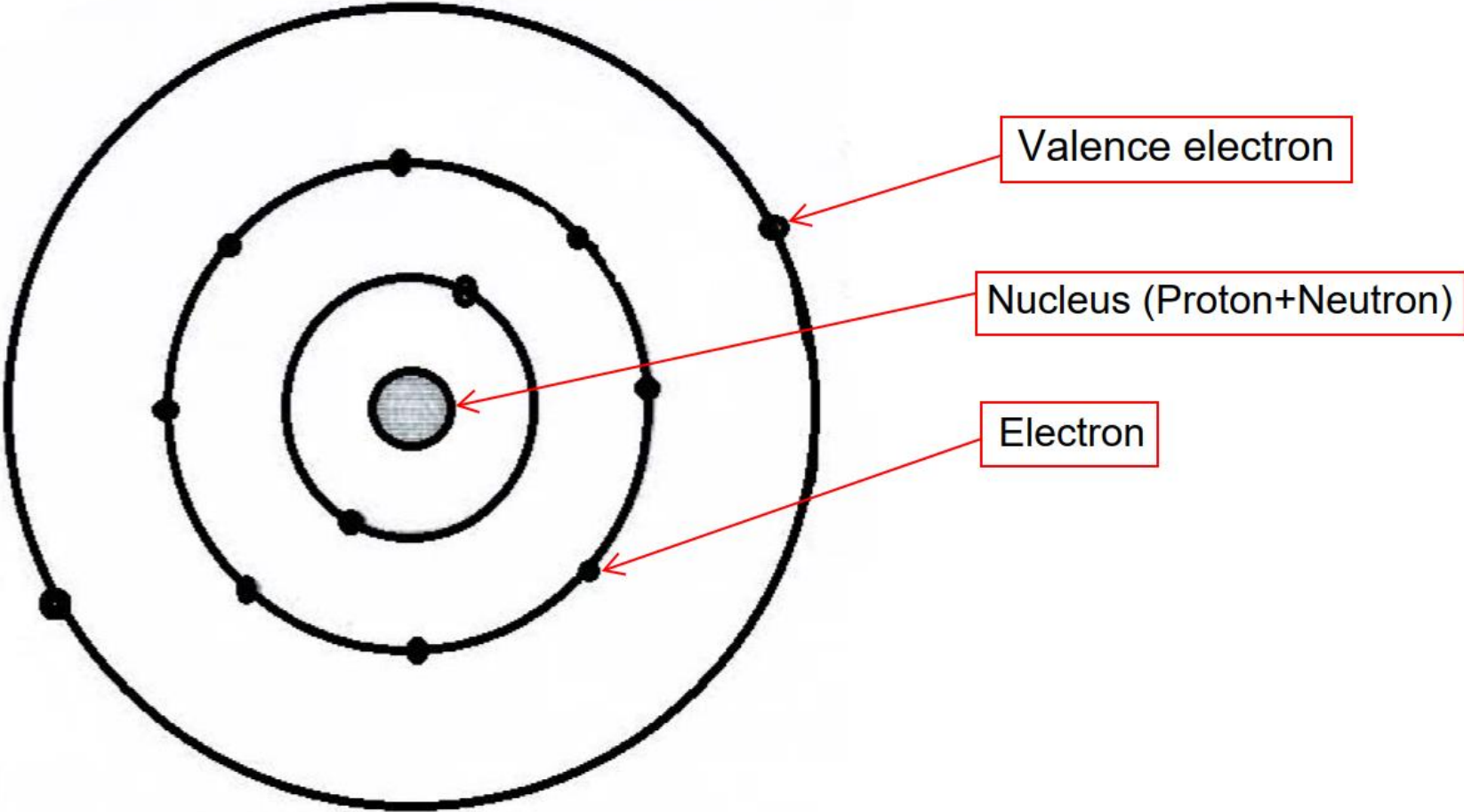
Chapter 2

Atomic Structure and Atomic Bonding

# Atomic Structure

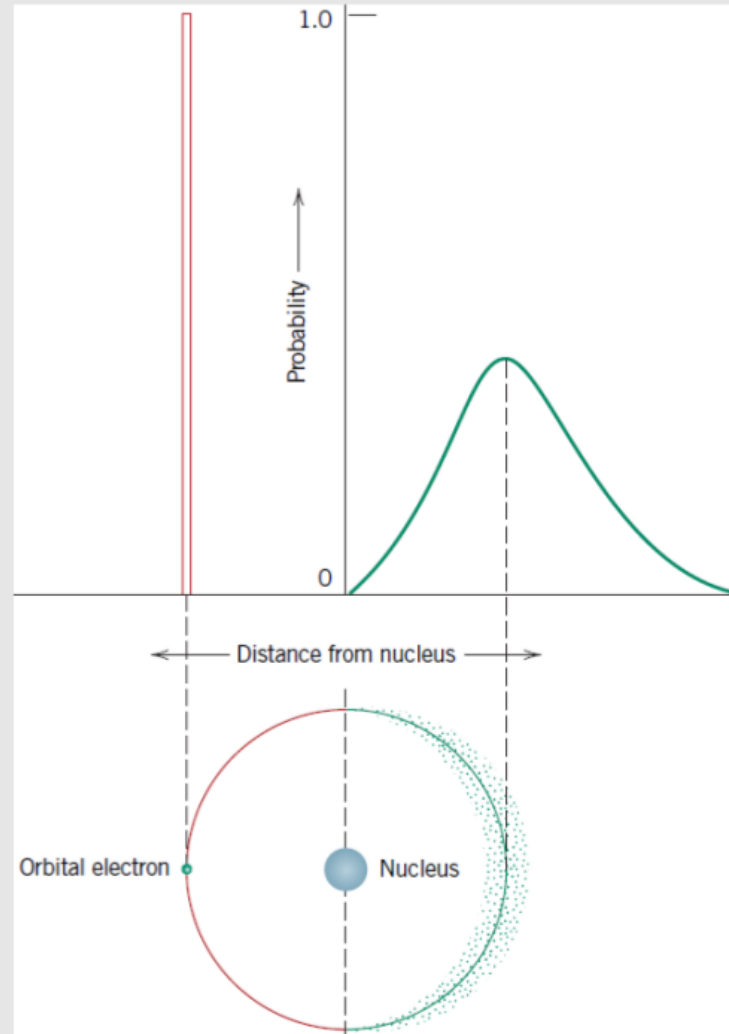
## Bohr atomic model

electrons are assumed to revolve around the atomic nucleus in discrete orbitals.



# Comparison of Bohr and Wave Mechanical Model

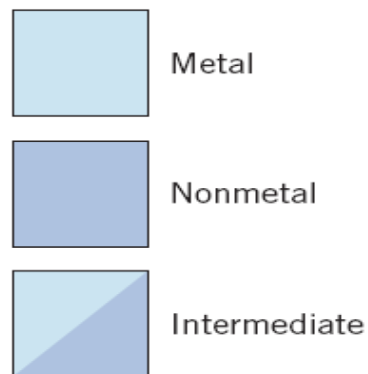
Comparison of the Bohr (left), and (b) wave mechanical atom models in terms of electron distribution (right).



IA		IIA		VIII									IIIA	IVA	VA	VIA	VIIA	0
1 H 1.0080		3 Li 6.941	4 Be 9.0122										5 B 10.811	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.180
11 Na 22.990	12 Mg 24.305	IIIB	IVB	VB	VIB	VIIB	26 Fe 55.845	27 Co 58.933	28 Ni 58.69	29 Cu 63.54	30 Zn 65.41	31 Ga 69.72	32 Ge 72.64	33 As 74.922	34 Se 78.96	35 Br 79.904	36 Kr 83.80	
19 K 39.098	20 Ca 40.08	21 Sc 44.956	22 Ti 47.87	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.845	27 Co 58.933	28 Ni 58.69	29 Cu 63.54	30 Zn 65.41	31 Ga 69.72	32 Ge 72.64	33 As 74.922	34 Se 78.96	35 Br 79.904	36 Kr 83.80	
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.4	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.30	
55 Cs 132.91	56 Ba 137.34	Rare earth series	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.2	76 Os 190.23	77 Ir 192.2	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.19	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)	
87 Fr (223)	88 Ra (226)	Actinide series	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (264)	108 Hs (277)	109 Mt (268)	110 Ds (281)									

Key

29	← Atomic number
Cu	← Symbol
63.54	← Atomic weight



Rare earth series

57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.35	63 Eu 151.96	64 Gd 157.25	65 Tb 158.92	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
--------------------	--------------------	--------------------	--------------------	-------------------	--------------------	--------------------	--------------------	--------------------	--------------------	--------------------	--------------------	--------------------	--------------------	--------------------

Actinide series

89 Ac (227)	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)
-------------------	--------------------	--------------------	-------------------	-------------------	-------------------	-------------------	-------------------	-------------------	-------------------	-------------------	--------------------	--------------------	--------------------	--------------------

## Electropositive elements: العناصر الموجبة كهربيا

Elements are capable of giving up their few valence electrons to become positively charged ions (left side of the table).

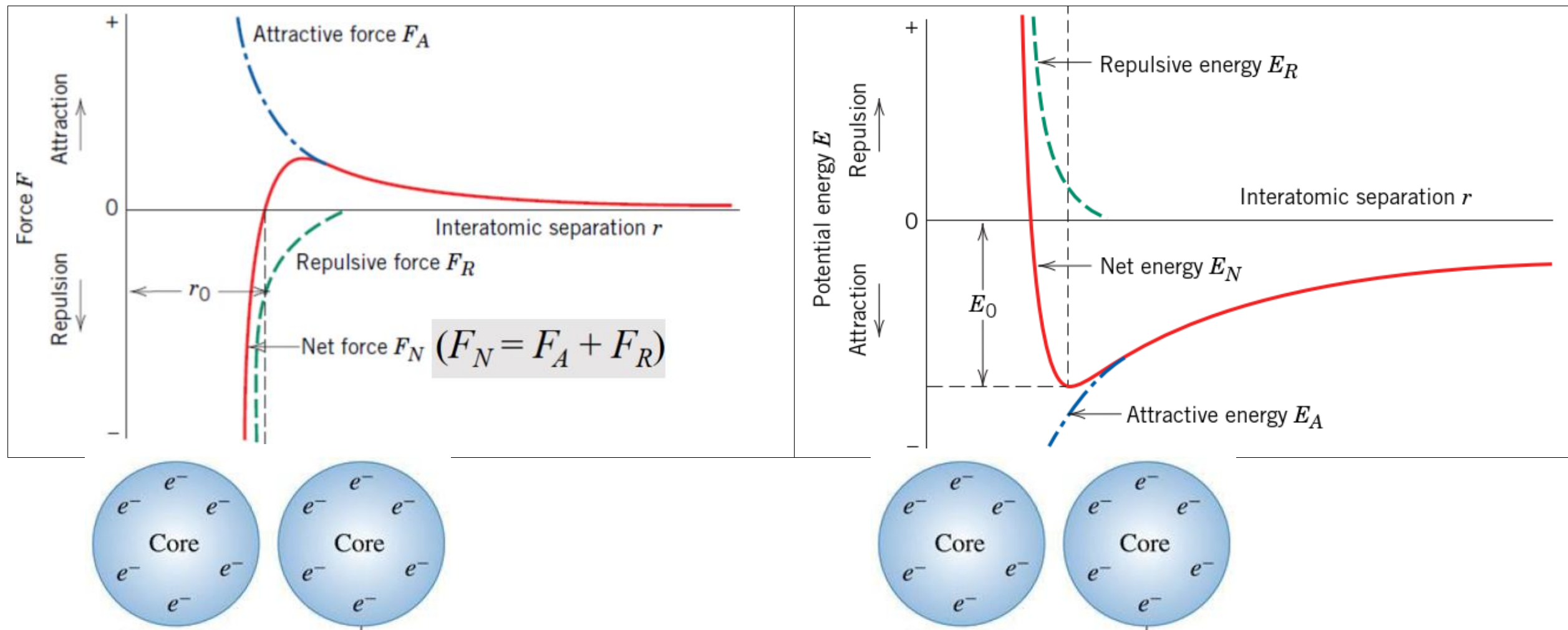
العناصر التي لها القدرة على فقد الكترونات التكافؤ الخاصة بها لتتحول الي أيونات موجبة

## Electronegative elements: العناصر السالبة كهربيا

Elements that is ready to accept electrons to form negatively charged ions or share electrons with other atoms (right side of the table).

العناصر التي لها القدرة على اكتساب الكترونات لتتحول الي أيونات سالبة.

## Bonding forces and energies



$E_0$ , it represents the energy required to separate these two atoms to an infinite separation

# Atomic Bonding in Solids

## Primary bonds

Stronger and exists in solid materials.

1. Ionic Bonding
2. Covalent Bonding
3. Metallic Bonding

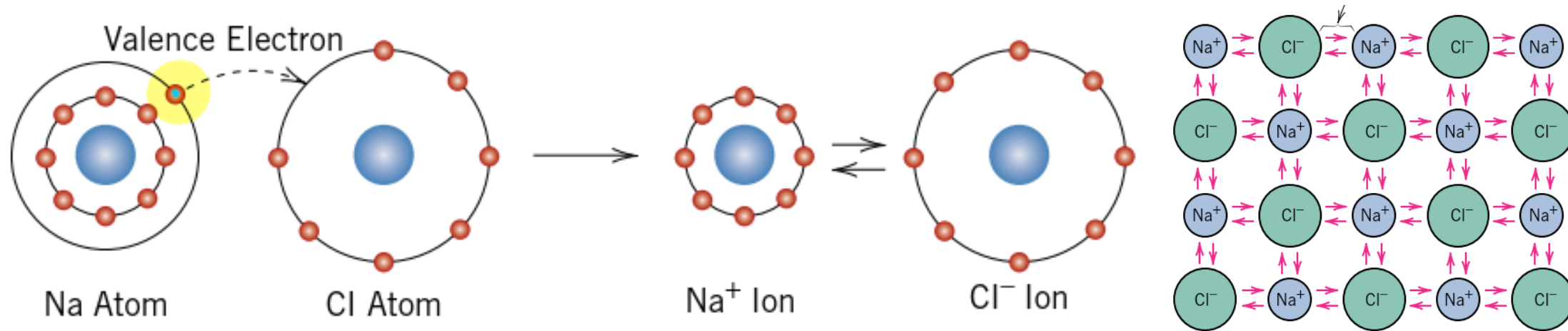
## Secondary bonds

Weak like Van der Waals bond

## Ionic Bonding الرابطة الايونية

Metallic element easily gives up their valence electrons to the nonmetallic atoms.

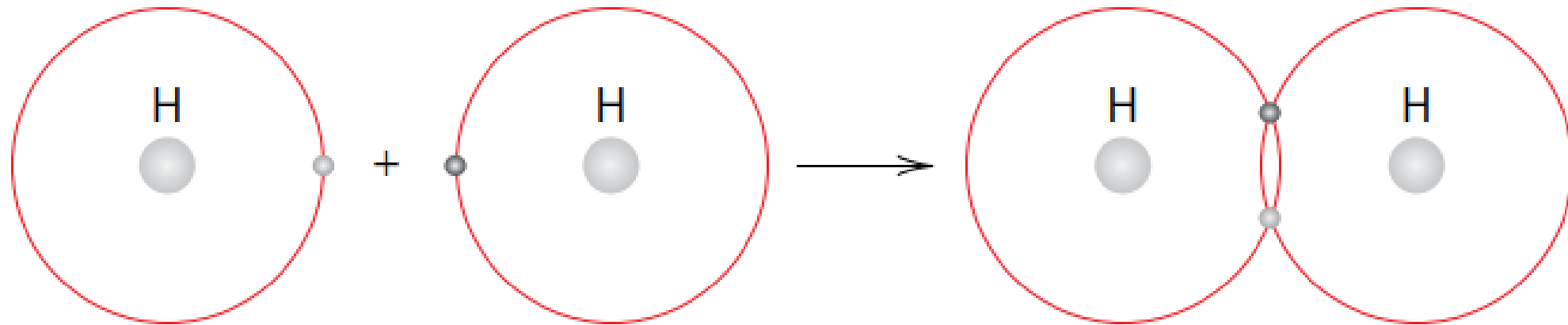
تنتقل الالكترونات التكافؤ من العنصر الفلز الي العنصر اللا فلز





## Covalent Bonding الرابطة التساهمية

Sharing the electrons between bonding atoms مشاركة الالكترونات بين الذرات المشاركة في الرابطة

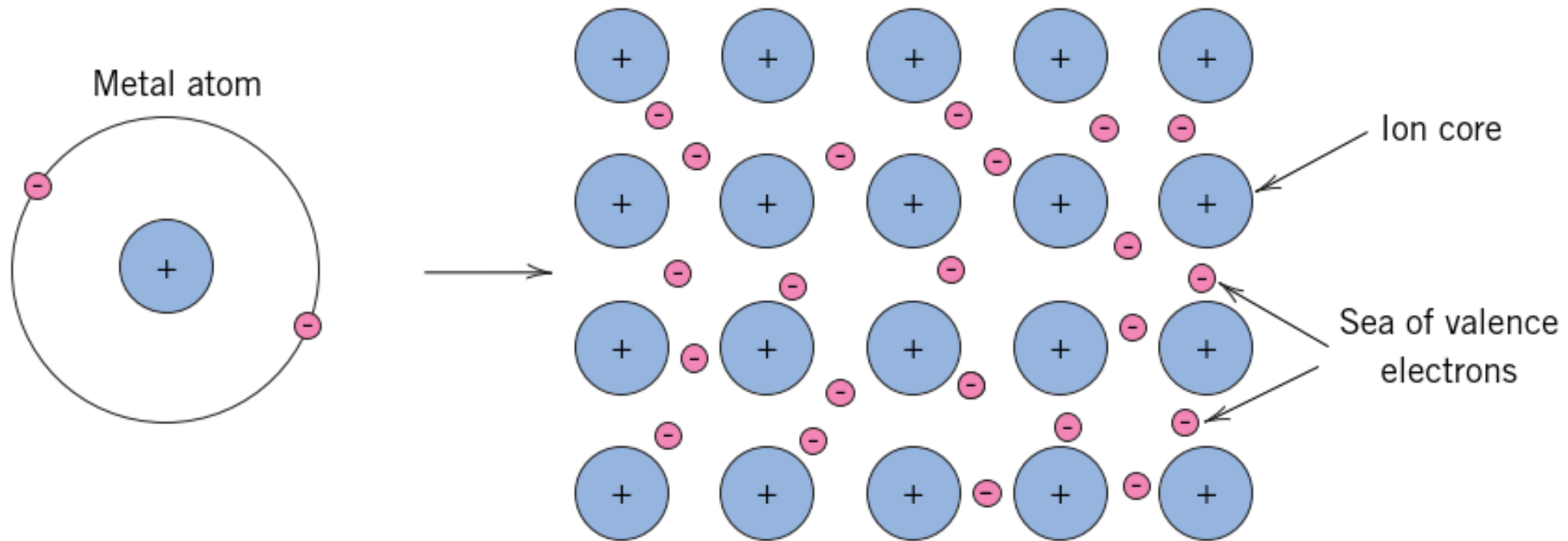


Such as  $\text{CH}_4$ ,  $\text{H}_2\text{O}$

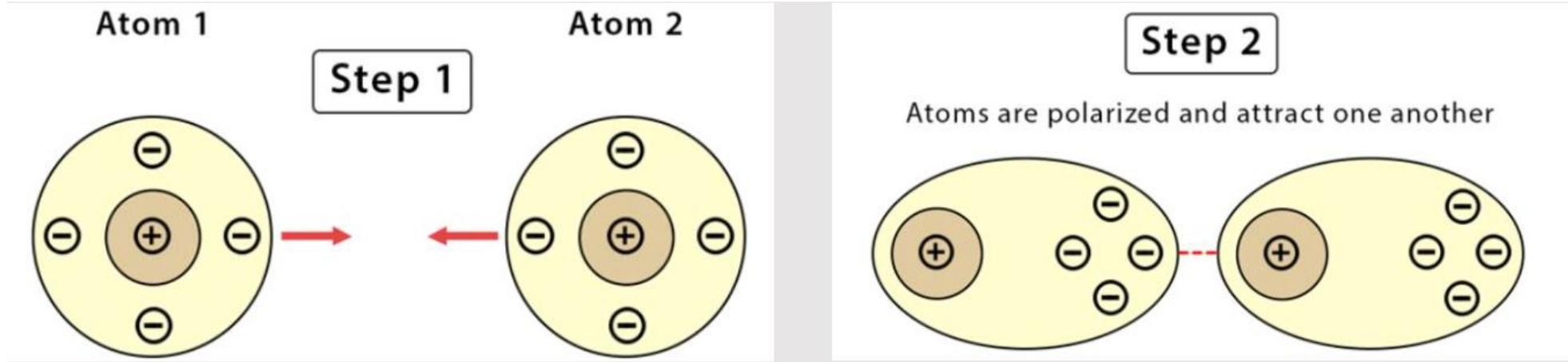
## Metallic Bonding الرابطة الفلزية

Found in metals and their alloys.

Valence electrons are not bound to any atom in the solid and forming a “sea of electrons”



## Secondary Bonding or Van Der Waals Bonding



Q6.

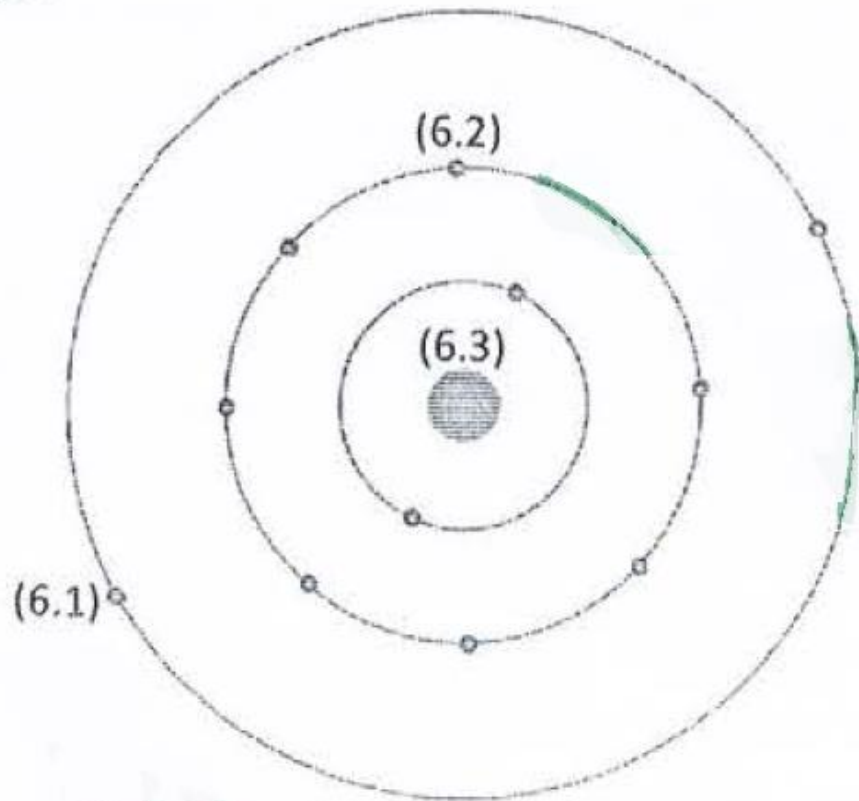


Fig. 2 Model of the Bohr atom.

Choose the correct label (A, B, C, ... or I):

~~6.1~~ \_\_\_\_\_

~~6.2~~ \_\_\_\_\_

6.3 \_\_\_\_\_

A. Proton

B. Electron

C. Orbital proton

D. Nucleus  
(Neutron+Electron)

E. Nucleus  
(Proton+Electron)

F. Nucleus  
(Proton+Neutron)

<sup>2</sup>  
G. Valence electron

H. Valence proton

I. Valence neutron

Q7. Electropositive elements are capable of:

- A. Giving up their few valence electrons to become positively charged ions ✓
- B. Giving up their few valence protons to become positively charged ions
- C. Giving up their few valence electrons to become negatively charged ions
- D. Giving up their few valence protons to become negatively charged ions
- E. Receiving few protons to become positively charged ions
- F. Receiving few electrons to become negatively charged ions

---

Q8. Electronegative elements are capable of:

- A. Giving up their few valence electrons to become positively charged ions
- B. Giving up their few valence protons to become positively charged ions
- C. Giving up their few valence electrons to become negatively charged ions ✓
- D. Giving up their few valence protons to become negatively charged ions
- E. Receiving few protons to become positively charged ions
- F. Receiving few electrons to become negatively charged ions ✓



Q9. List three primary interatomic bonds:

9.1	<u>D</u>	A. Ceramic Bonding	1 <u>D. Ionic Bonding</u>	G. Share Bonding
9.2	<u>B</u>	2 <u>B. Covalent Bonding</u>	3 <u>E. Metallic Bonding</u>	H. Transfer Bonding
9.3	<u>F</u>	C. Hybrid Bonding	F. Polymeric Bonding	I. van der Waals Bonding

Q10.

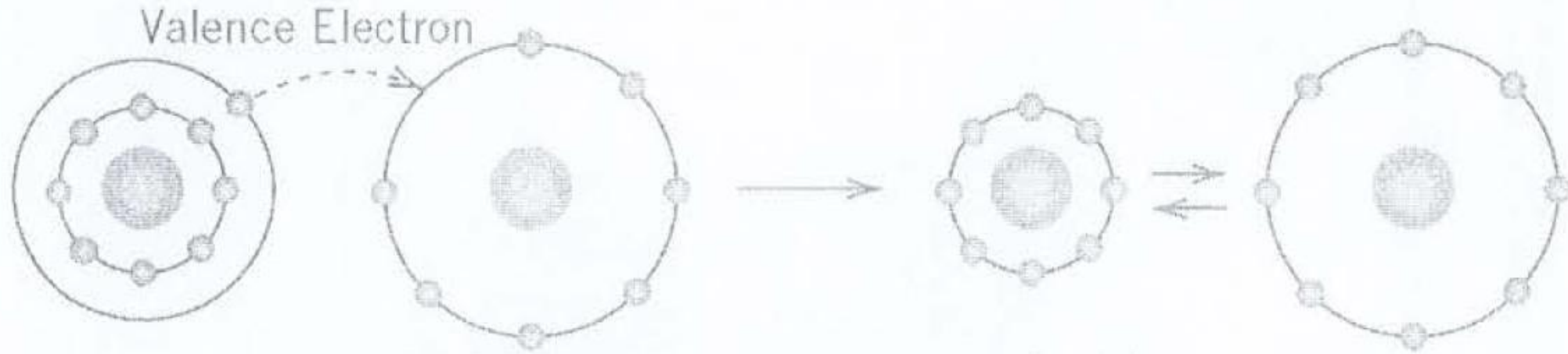


Fig. 3 Schematic representation of bonding.

What is the type of bonding shown in Fig. Circle the correct answer (A, B, C, ... or J):

- |                     |   |                          |
|---------------------|---|--------------------------|
| A. Ceramic Bonding  | <input checked="" type="radio"/> D. Ionic Bonding | G. Share Bonding         |
| B. Covalent Bonding | E. Metallic Bonding                               | H. Transfer Bonding      |
| C. Hybrid Bonding   | F. Polymeric Bonding                              | I. van der Waals Bonding |

