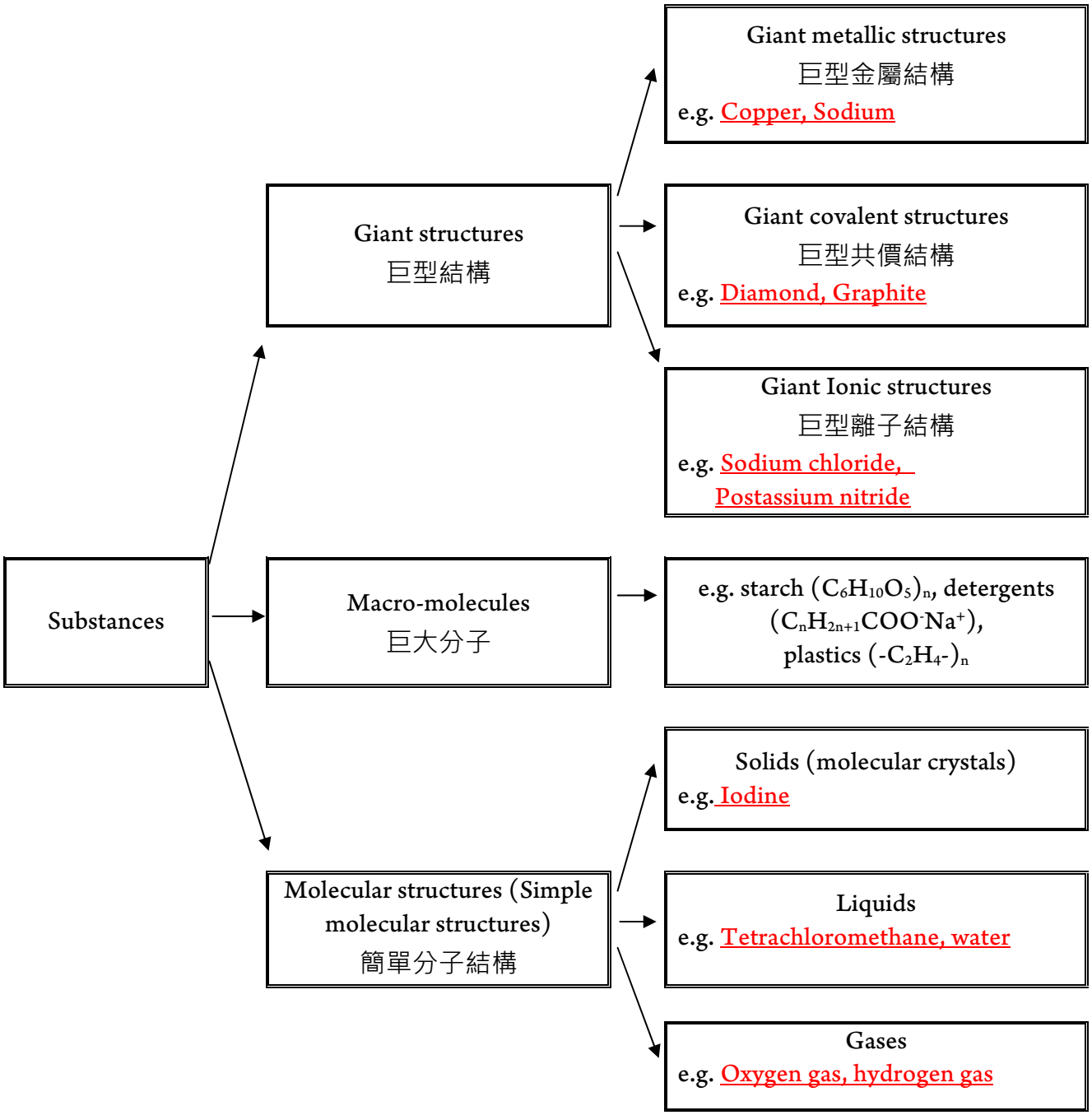
Section Two : The Microscopic World
Unit Eight: Structure, bonding and Properties

I. Introduction --- Structure of Substances

Do you think common salt, graphite, sugar and copper have the same structure?

No, because they have different properties.

According to the structure, substances can be classified as follows:



III. Properties of Ionic Compounds

B. **High melting points and boiling points**

Strong ionic bonds (or ***strong electrostatic forces***) are held between the ions in a regular structure.

V. Properties of Simple Molecular Structure

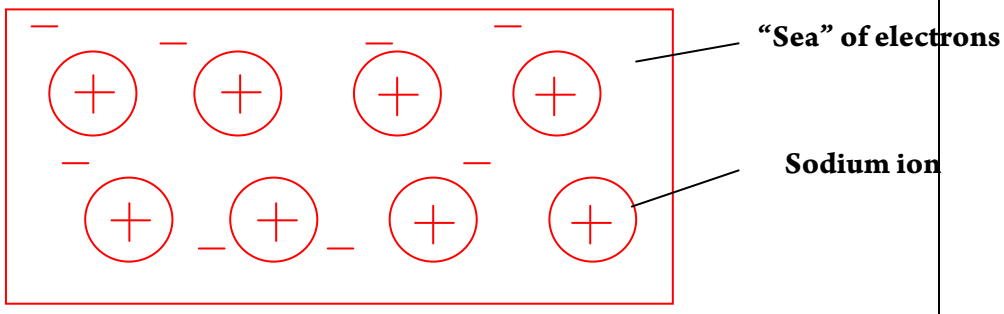
A. Weak van der Waal's force / intermolecular force is held between molecules

B. Weak van der Waal's force / intermolecular force, which requires little energy to break, is held between molecules.

C. There is **no charged particles** such as mobile electron and mobile ion.

D. **Soluble in non-aqueous solvents** such as alcohol and tetrachloromethane but **insoluble in aqueous solvents**.

VIII. Giant Metallic Structure 巨型金屬結構

	Giant Metallic Structure
Model of structure	e.g. sodium 
State at room conditions	**Solid** (except: Mercury)
Melting point and boiling point	Usually **high (except Group I)**
Electrical conductivity	**Good** conductors in **solid and liquid states**

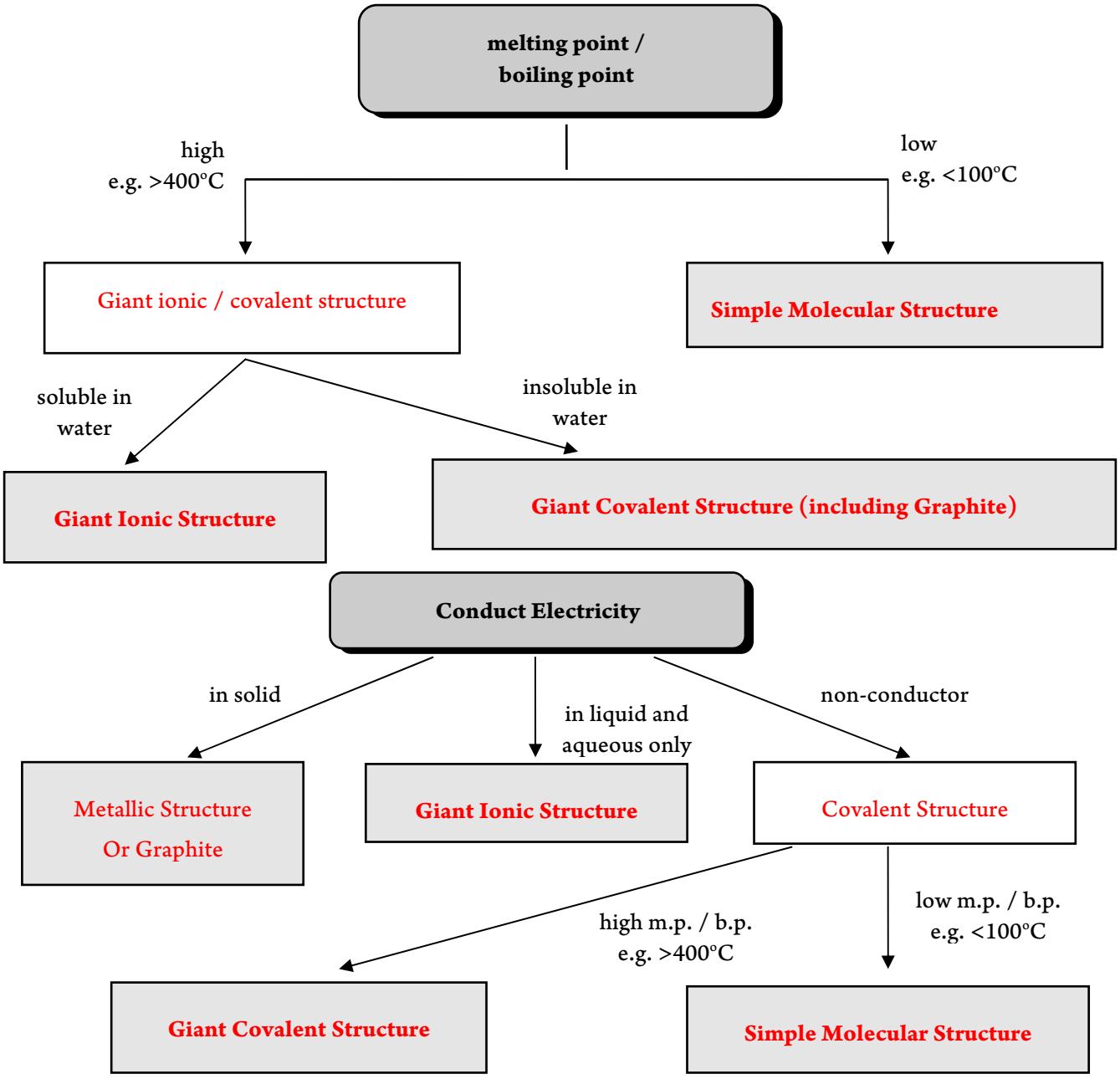
Comparison between Ionic, Covalent and Metallic Substance

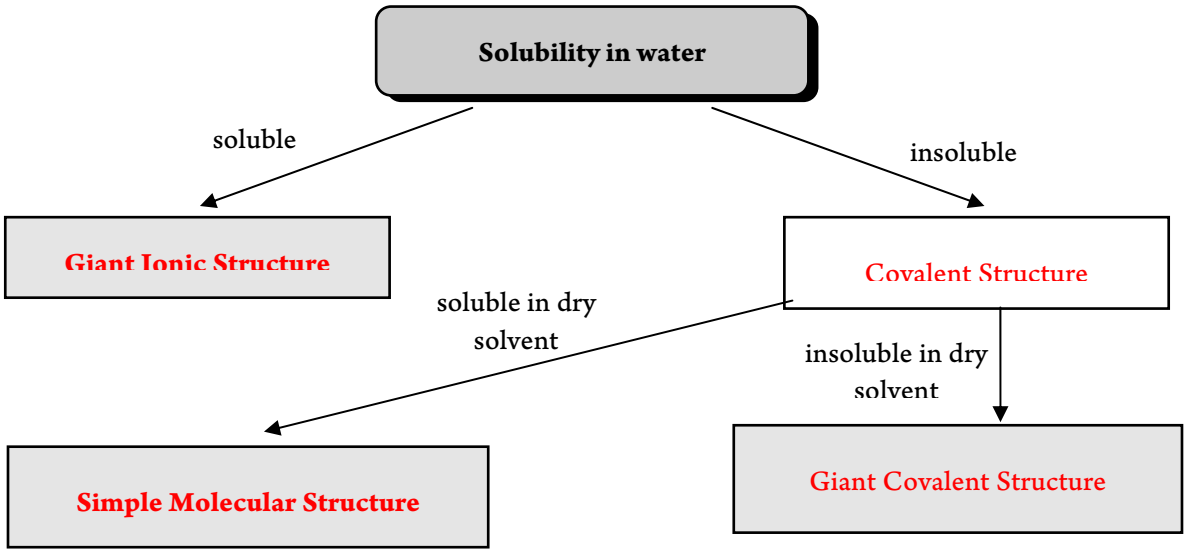
	Ionic Compounds	Covalent Compounds		Metals
		Simple Molecular	Giant Covalent	Giant Metallic
Examples	NaCl, CsCl, $MgCl_2$, CaO	CH_4, NH_3, H_2O	Diamond, Graphite, Quartz	All Metals
Particles	Ions (Cations and Anions)	Small discrete Molecules	Atoms	Metallic cations and free electrons
Constituents	Metal + Non-metal	Non-metal + Non-metal		Metal
Bonding	**Giant ionic lattice** Oppositely charged ions are attracted by strong electrostatic forces in 3-D network.	**Simple molecules** Atoms are held together by strong covalent bond to form molecules. Molecules are held together by weak intermolecular forces such as van der Waals' forces	**Giant atomic lattice** The atoms form a network and each atom is joined to others by strong covalent bonds	Giant Metallic Structures Metllic bonds links the metal ions (positively charged and the "sea" of electrons (negatively charged)
State	Solid	Usually liquid or gas (gases, volatile liquids or solid of low m.p.)	Solid	Solid
m.p. / b.p.	High	Low	Very high	Usually high
Hardness	Hard but brittle	Soft and brittle	Very Hard (Graphite is hard but brittle)	Usually Hard but flexible
Reason for m.p. / b.p. and hardness	Strong ionic bond	Weak intermolecular forces	Strong covalent bond	Strong metallic bond
Solubility **(a) in water** **(b) in CCl_4**	Soluble Insoluble	Insoluble Soluble	Insoluble Insoluble	Insoluble (may react) Insoluble
Electrical conductivity	Conduct with decomposition in molten or aqueous state only	Does not conduct electricity	Does not conduct electricity (except graphite)	Conduct with decomposition in molten or solid states
Reason for electrical conductivity	Ions are mobile in molten or aqueous states but fixed in solid state	No mobile charged particle	No mobile charged particle (Graphite have free electrons to conduct)	Free / delocalised electrons are present

Exercise

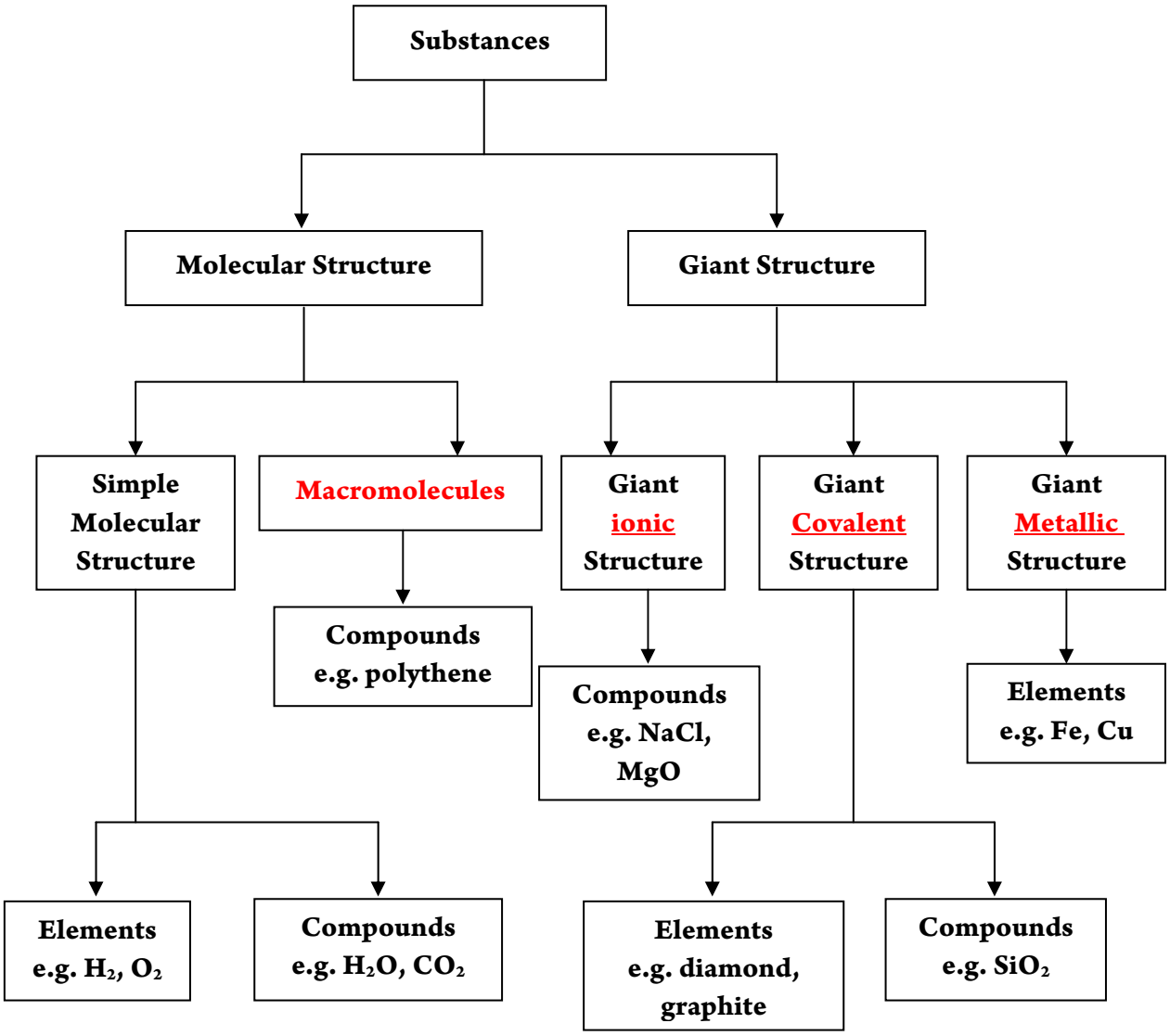
(a) A and F
(b) B
(c) C, E and I
(d) A, B and F
(e) D, G and H
(f) B

Summary




Solubility in water
soluble
insoluble
Giant Ionic Structure
Covalent Structure
soluble in dry solvent
insoluble in dry solvent
Simple Molecular Structure
Giant Covalent Structure

Concept Map


Substances
Molecular Structure
Giant Structure
Simple Molecular Structure
Macromolecules
Giant ionic Structure
Giant Covalent Structure
Giant Metallic Structure
Compounds e.g. polythene
Compounds e.g. NaCl, MgO
Elements e.g. Fe, Cu
Elements e.g. H_2, O_2
Compounds e.g. H_2O, CO_2
Elements e.g. diamond, graphite
Compounds e.g. SiO_2

Supplementary Exercise

1. (a) A, C
   (b) F
   (c) ionic, since it can conduct electricity in molten state only
   (d) metallic, since it can conduct electricity in both solid state and molten state
   (e) C will be easily liquefied since its boiling point is just lower than room temperature.
   (f) (1) same element exist in different forms is called allotropes
   (2) two, they are diamond and graphite
   (3) D
   (4) diamond since it can't conduct electricity

2. (a) Group 1 for element A
   Group 4 for element B
   Group 2 for element C
   (b) Since they are metals , therefore they possess free electrons for conducting electricity
   (c) (1) hydrogen
   (2) alkaline
   (3) it will float in water since its density is less than 1
   (d) Since the compound is ionic in nature and it possess free or mobile ions in its molten state, therefore it can conduct electricity
   (e) element B has high boiling point and melting point since it has a giant lattice structure with atoms linked together by strong covalent bond
   (f) Since element B is a non-metal and it dies not possess free electrons.
   As a result it cannot conduct electricity

3. (a) Van der Waals‘ force is present between ammonia molecules
   (b) (1) There are two bond types in ammonium chloride. They are covalent bond and ionic bond .
   (2) Ammonium chloride has a higher boiling point than ammonia since it is an ionic compound and its ions are attracted by strong electrostatic force .
   (3) It has no colour since both ammonium ion and chloride ion are colourless
   (c) An ionic can conduct electricity in molten state but not in solid state

4. (a) Sodium chloride is an ionic compound, its ions are attracted together by strong electrostatic force, therefore, it has a higher boiling point. On the other hand, methane exists in molecules are attracted together by weak van der Waals' force, therefore it has a lower boiling point.

   (b) The electronic configuration for nitrogen is 2,5. The second electron shell can only accommodate 8 electrons, therefore, NCl_5 does not exists for this compound requires 10 electrons in the second electron shell which is impossible.