# 9.1 From bonding models to materials

Name: _____ Class: _____ Date: _____ **Total: 25 marks**

**KEY WORDS** alloy • polymer • monomer • repeat unit • addition polymerization • condensation polymer

## Objective

Build the skills to answer exam questions on **materials** : the bonding triangle, alloys and polymers.

**You must be able to:**

- place a substance on the bonding triangle from electronegativity values and predict its properties
- explain why alloys are harder than pure metals
- draw the repeat unit of an addition polymer and identify its monomer
- describe condensation polymerization to make polyesters and polyamides

## 1 Key knowledge and worked examples

### Bonding is a continuum

The **bonding triangle** (van Arkel–Ketelaar) uses two values for a binary compound: the **difference** in electronegativity $\Delta\chi$ (up the side) and the **average** electronegativity $\bar{\chi}$ (along the base). Large $\Delta\chi$ (above about 1.8): mostly **ionic**; small $\Delta\chi$ and high $\bar{\chi}$: **covalent**; small $\Delta\chi$ and low $\bar{\chi}$: **metallic**. Most substances lie between the corners.



exercises.lol exercises.com.cn

| material | key idea |
|---|---|
| alloy | a mixture of a metal with other elements; atoms of different sizes disrupt the regular layers, so they slide less easily: **harder, stronger** |
| addition polymer | monomers with C=C join; the double bond opens; no other product |
| repeat unit | the smallest part that repeats: from $CH_2$=CHX, the repeat unit is –$CH_2$–CHX– |
| plastics | strong C–C and C–H bonds, non-polar: unreactive and not biodegradable |
| condensation polymer (HL) | two functional groups react and a small molecule ($H_2O$ or HCl) is lost each time: diol + dicarboxylic acid → polyester (ester links); diamine + dicarboxylic acid → polyamide (amide links) |

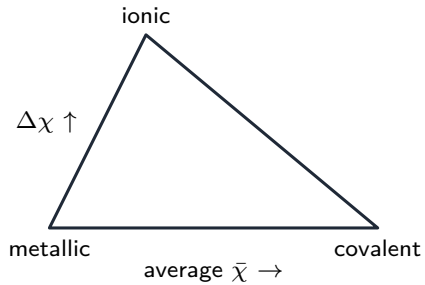
**Worked example 1: the triangle.** NaCl: $\chi$(Na) = 0.9, $\chi$(Cl) = 3.2: $\Delta\chi$ = 2.3, $\bar{\chi}$ = 2.05: **ionic**.

**Worked example 2: monomer.** The repeat unit –$CH_2$–CH(CN)– comes from **$CH_2$=CHCN**.

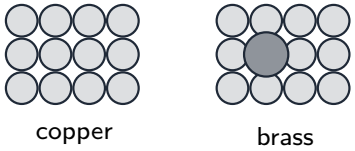
**Answer shapes:** calculate both values before using the triangle.

## 2 Practice

**2.1** Aluminium chloride: $\chi$(Al) = 1.6, $\chi$(Cl) = 3.2. Calculate $\Delta\chi$ and $\bar{\chi}$, and use the bonding triangle to classify the bonding. [2]



**2.2** Brass is an alloy of copper and zinc. Explain why brass is harder than pure copper. [3]




**2.3** Propene, $CH_2{=}CHCH_3$, forms poly(propene). Draw the repeat unit of poly(propene) and state the type of polymerization. [3]

$$H_2C=CH-CH_3$$

**2.4** Nylon-6,6 forms from hexane-1,6-diamine and hexanedioic acid. State the small molecule lost and name the link formed. [2]

$$H_2N(CH_2)_6NH_2$$

$$HOOC(CH_2)_4COOH$$



exercises.lol exercises.com.cn

## 3 Exam-style questions

**3.1** Part of a polymer chain is shown: $-CH_2-CHCl-CH_2-CHCl-$




carbon chain (H atoms not shown)

(a) Name the monomer. [1]

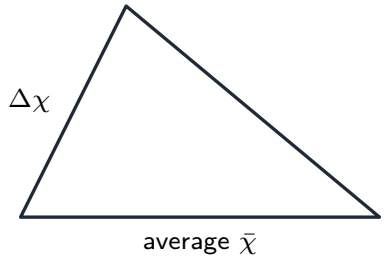
(b) Explain why polymers like poly(ethene) are unreactive and do not biodegrade. [2]

(c) PVC is more rigid than poly(ethene). Suggest why. [2]

(d) Ethane-1,2-diol, $HOCH_2CH_2OH$, and benzene-1,4-dicarboxylic acid form a polyester. Describe how the polymer forms and state the link in its repeat unit. [3]

**3.2** The table gives electronegativity values.

| element | Cs | F | Si | Cl | Cu |
|---|---|---|---|---|---|
| $\chi$ | 0.8 | 4.0 | 1.9 | 3.2 | 1.9 |




(a) State what is meant by electronegativity. [1]

(b) Use the bonding triangle to classify the bonding in caesium fluoride, CsF, and silicon tetrachloride, $SiCl_4$, and in copper. Show your values. [3]

(c) Aircraft bodies are made of aluminium alloys, not pure aluminium. Suggest two reasons. [2]

(d) State one property of polymers that makes them useful for packaging. [1]



exercises.lol exercises.com.cn