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.

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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)

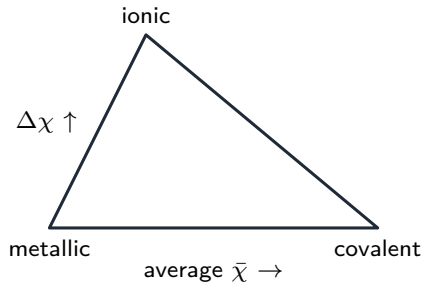
Worked example 1: the triangle. NaCl: χ(Na) = 0.9, χ(Cl) = 3.2: $\Delta\chi$ = 2.3, $\bar{\chi}$ = 2.05: **ionic**.

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

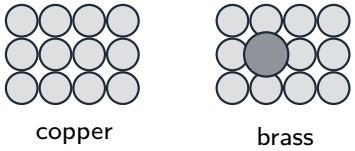
Answer shapes: calculate both values before using the triangle.

2 Practice

2.1 Aluminium chloride: χ(Al) = 1.6, χ(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]

$$H_2N(CH_2)_6NH_2$$

$$HOOC(CH_2)_4COOH$$

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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]

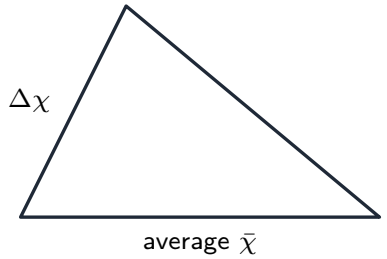
(b) Explain why polymers like poly(ethene) are unreactive and do not biodegrade. [2]

(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
χ	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]

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Solutions

Marking: **M1** a correct method, **A1** the correct answer, **B1** an independent mark.

Each answer shows the steps, then the **result**.

2.1

$\Delta\chi = 1.6$, $\bar{\chi} = 2.4$; polar covalent (between ionic and covalent)

2.2

in pure copper the layers of identical cations slide easily; zinc atoms have a different size and disrupt the regular layers; the layers cannot slide as easily, so brass is harder

2.3

–CH_2–$CH(CH_3)$– with the CH_3 on a side branch; with extension bonds at both ends / in brackets with n; addition polymerization

2.4

water; amide link (–CONH–)

3.1

(a) chloroethene (vinyl chloride), CH_2=CHCl

(b) the chains contain only strong C–C and C–H bonds; they are non-polar, so there is nothing for reagents or microorganisms to attack

(c) C–Cl bonds are polar, so there are dipole–dipole forces between chains; these are stronger than the London forces between poly(ethene) chains, so the chains slide less

(d) each –OH reacts with a –COOH (condensation); a water molecule is lost each time; an ester link, –COO–, joins the monomers

3.2

(a) the ability of an atom to attract a shared pair of electrons in a covalent bond

(b) CsF: $\Delta\chi = 3.2$, ionic; $SiCl_4$: $\Delta\chi = 1.3$, $\bar{\chi} = 2.55$, polar covalent; Cu: $\Delta\chi = 0$, $\bar{\chi} = 1.9$, metallic

(c) alloys are harder / stronger; still low density / resist corrosion

(d) any one: low density; can be shaped; unreactive; waterproof; cheap

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