

Amines, amino acids and condensation polymers in action

Chemistry grades 11-12 (A Level · IB · Class 11-12) · Worksheet

Name: _____ Date: _____ Class: _____

These 20 problems train the A Level topics of amines, amino acids, condensation polymers and DNA. They move from naming and classifying to pH, titration, yield and structure calculations.

Use a calculator and the data given in each problem. Show every step, because method marks matter in A Level, IB and senior secondary exams.

Level: Chemistry grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** A Level 3.3.11-3.3.13

Problem 1 Classifying four amines (easy)

Wanjiru in Nairobi labels four reagent bottles: $\text{CH}_3\text{CH}_2\text{NH}_2$, $(\text{CH}_3)_2\text{NH}$, $(\text{CH}_3)_3\text{N}$ and $\text{C}_6\text{H}_5\text{NH}_2$.

1. Classify each amine as primary, secondary or tertiary.
2. Name the first and the last bottle.

Problem 2 Why an amine accepts a proton (easy)

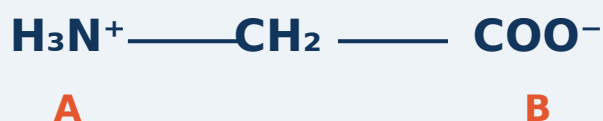
Methylamine reacts with hydrochloric acid.

1. State which part of the nitrogen atom accepts the proton.
2. Write the ionic equation for methylamine with H^+ .
3. Name the salt that forms with HCl .

Problem 3 Glycine in a sports drink (easy)

Kofi in Accra reads that glycine, $\text{H}_2\text{NCH}_2\text{COOH}$, is added to a sports drink. In water it forms the zwitterion shown.

1. Identify the groups labelled A and B.
2. Calculate the relative formula mass of glycine ($\text{C} = 12.0$, $\text{H} = 1.0$, $\text{N} = 14.0$, $\text{O} = 16.0$).
3. State the overall charge of the zwitterion.



Glycine in a neutral solution.

Problem 4 Addition or condensation (easy)

Mei in Singapore sorts three plastics: poly(propene), nylon-6,6 and PET.

1. State which two are condensation polymers.
2. Name the small molecule lost when PET forms from its diol and diacid.
3. Name the link in each condensation polymer.

Problem 5 Reading base pairs (easy)

Bilal in Lahore studies the drawing of DNA base pairs.

1. State the numbers of hydrogen bonds shown at X and Y when drawn correctly.
2. Find the error in the drawing at Y.
3. Give the complementary strand for ATGCCGTA and count its hydrogen bonds with the original strand.



Base pairs, drawn with dotted hydrogen bonds. The drawing of Y has an error that you must find in Problem 5.

Problem 6 Ranking four bases (medium)

Data at 25 °C: dimethylamine pK_b 3.27, methylamine 3.34, ammonia 4.75, phenylamine 9.13.

1. Put the four compounds in order from strongest to weakest base.
2. Calculate K_b for phenylamine.
3. Explain why phenylamine is the weakest.

Problem 7 pH of a methylamine solution (medium)

Chiamaka in Lagos prepares 0.20 mol/dm³ methylamine, $K_b = 4.6 \times 10^{-4}$ mol/dm³, at 25 °C.

1. Write the expression for K_b .
2. Calculate $[OH^-]$.
3. Calculate the pH.

Problem 8 Titrating propylamine (medium)

A 25.0 cm³ sample of aqueous propylamine, C₃H₇NH₂, needs 18.4 cm³ of 0.100 mol/dm³ HCl for neutralisation.

1. Calculate the amount of HCl used.

2. Calculate the concentration of the propylamine in mol/dm³.
3. Calculate its mass concentration in g/dm³ (Mr = 59.0).

Problem 9 Making ethylamine from bromoethane (medium)

Diego in Texas reacts bromoethane with a large excess of ammonia in ethanol.

1. Write a balanced equation.
2. Name the type of mechanism.
3. Explain why a large excess of ammonia is used.

Problem 10 Forms of alanine (medium)

Alanine is CH₃CH(NH₂)COOH.

1. Draw the species present in strongly acidic solution.
2. Draw the species present in strongly alkaline solution.
3. State the direction in which each species moves towards an electrode in an electric field.

Problem 11 Two possible dipeptides (medium)

Glycine (Mr = 75) and alanine (Mr = 89) can join in two ways.

1. Draw the link that forms between them and name it.
2. State how many different dipeptides are possible, and why.
3. Calculate the Mr of either dipeptide.

Problem 12 Cutting nylon into monomers (medium)

A repeat unit of nylon-6,6 is -NH(CH₂)₆NHCO(CH₂)₄CO-.

1. Circle the amide link by writing its atoms.
2. Give the formula of the diamine and the diacid formed by hydrolysis.
3. State what happens if the polymer is heated with aqueous HCl.

Problem 13 Bottles from ethane-1,2-diol (medium)

PET forms from benzene-1,4-dicarboxylic acid (Mr = 166) and ethane-1,2-diol (Mr = 62). The repeat unit has Mr = 192.

1. Show that 192 is correct.
2. Calculate the mass of diol needed for 1.00 kg of PET.
3. Calculate the mass of water produced.

Problem 14 Breaking down polymers (medium)

Aarav in Pune wants to recycle polymers by hydrolysis.

1. Name the products when a polyester is hydrolysed by hot aqueous NaOH.
2. Explain why poly(ethene) cannot be recycled this way.
3. Suggest one advantage of a polymer that can be hydrolysed.

Problem 15 Why Kevlar is so strong (medium)

Kevlar is made from benzene-1,4-diamine and benzene-1,4-dioyl dichloride.

1. Name the link and the small molecule lost.
2. Compare its intermolecular forces with those of poly(ethene).
3. Explain why its rigid rings add strength.

Problem 16 Identifying an amino acid (hard)

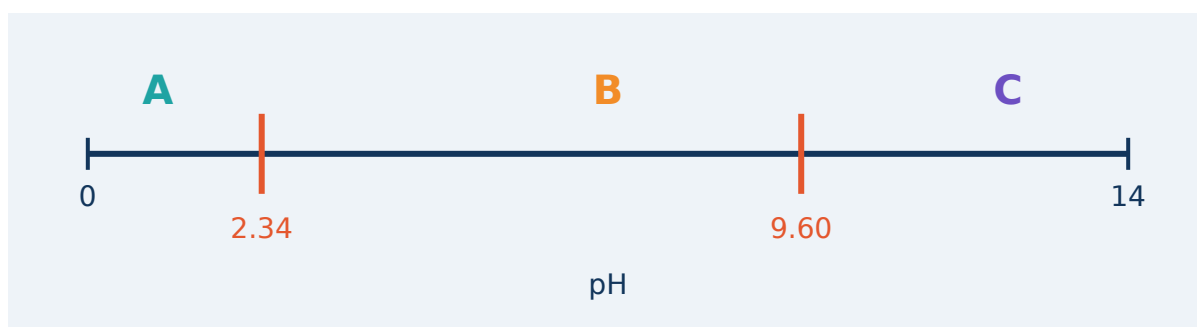
An amino acid contains 40.4 % C, 7.9 % H, 15.7 % N by mass, and the rest is oxygen. Its Mr is 89.

1. Calculate the percentage of oxygen.
2. Calculate the empirical formula ($C = 12.0$, $H = 1.0$, $N = 14.0$, $O = 16.0$).
3. Give the molecular formula and name the acid.

Problem 17 Glycine across the pH range (hard)

For glycine, $pK_{a1} = 2.34$ ($-\text{COOH}$) and $pK_{a2} = 9.60$ ($-\text{NH}_3^+$). The diagram splits the pH scale.

1. Identify the species in regions A, B and C.
2. Calculate the isoelectric point.
3. Predict where glycine moves during electrophoresis at pH 12.



Regions of pH for glycine, split by the two pK_a values.

Problem 18 Yield of nylon-6,6 (hard)

Mei reacts 8.70 g of hexane-1,6-diamine ($M_r = 116$) with excess hexanedioyl dichloride and isolates 14.1 g of dry nylon-6,6 (repeat unit $M_r = 226$).

1. Calculate the theoretical mass of nylon.
2. Calculate the percentage yield.
3. Calculate the volume of HCl gas produced at room temperature if the molar volume is $24.0 \text{ dm}^3/\text{mol}$.

Problem 19 Counting bonds in DNA (hard)

A synthetic DNA fragment has 600 base pairs (1200 nucleotides), and 30.0 % of its nucleotides are adenine.

1. Calculate the numbers of A, T, G and C.

2. Calculate the total number of hydrogen bonds between strands.
3. Explain why DNA rich in G and C melts at a higher temperature.

Problem 20 Four amines with one formula (hard)

Four isomers share the formula C_3H_9N , with boiling points of about 3 °C, 32 °C, 37 °C and 48 °C.

1. Draw and name the four isomers and classify each.
2. Identify the isomer with the lowest boiling point and explain why.
3. Compare the boiling points of the two primary amines and suggest why they differ.