ExamFitter

examfitter.com · Free AP Chemistry quizzes, revision notes and worksheets

Topic 3.8: Representations of Solutions

Worksheet · AP Chemistry

UNIT 3 · PROPERTIES OF SUBSTANCES AND MIXTURES

On ExamFitter.com: Topic 3.8 Revision Notes · Topic 3.8 Quiz · Previous Worksheet: Topic 3.7 · Next Worksheet: Topic 3.9 · Unit 3: All Topics · AP Chemistry Home

How to Use This Worksheet

Work in order. Section A checks how you read a particulate diagram: key, counts, hydration shells and spacing. Section B turns counts into molarities and back. Section C combines diagrams and calculations in exam style.

Every diagram is described completely in words, so each question can be answered from the text alone. Compared boxes share one key and scale unless a question says otherwise.

Do not look at the answer key until you have attempted every question. The key gives full working, so compare your reasoning, not just answers.

Section A: Recall and Concepts

A1. A box represents aqueous sodium chloride. The key shows a filled circle for Na^+ and an open circle for Cl^-. Water is present but not counted. The box contains 4 filled and 4 open circles, all separate and spread evenly. (a) State the Na^+ to Cl^- ratio in the box. (b) Calculate the total dissolved solute particles shown. (c) Explain why the ions are drawn separate and evenly spread, not as 4 joined NaCl pairs in one corner. (d) State the total positive and total negative charge shown.

© 2026 ExamFitter.com · Free AP Chemistry worksheets

A2. A diagram shows one Na^+ ion with 4 waters around it, each oxygen end pointing toward the Na^+ ion. It also shows one Cl^- ion with 4 waters around it, but there too the oxygen ends point inward. (a) Name the attraction holding each shell together. (b) State which shell is correct, and what is wrong with the other. (c) Describe the correct water orientation around the incorrectly drawn ion, using partial charges. (d) A second student draws a Cl^- ion with 9 water molecules all touching it at once in a single ring. State why this is not possible for a small ion. (e) Four ions, K^+, Na^+, Ca^{2+} and Mg^{2+}, are each drawn with a hydration shell. Which ion holds its shell most tightly, and why?

A3. Three boxes share one key (one symbol per glucose molecule) and one scale. Box P has the standard volume and 6 molecules, Box Q the same volume and 9, and Box R twice the volume and 12. All are spread evenly, and water is not counted. (a) Rank the three by concentration, showing particles per standard volume for each. (b) State which two boxes have the same concentration, and why the raw counts 6 and 12 do not settle it alone. (c) Box Q represents a 0.90 M solution. Calculate the concentration represented by Box P and by Box R.

A4. A box representing 100 mL of potassium chloride solution contains 8 K^+ and 8 Cl^- ions, evenly spread and hydrated. The key and scale stay fixed. (a) The solution is diluted to 200 mL. State the counts the new box must show, its relative size, and the change in average spacing. (b) Instead, evaporation halves the volume to 50 mL. State the counts the new box must show, and the change in spacing and molarity. (c) State which quantity stays the same in both changes, and which moves oppositely. (d) A student redraws the diluted solution from part (a) with only 4 K^+ and 4 Cl^- ions in the doubled box. State what that drawing describes, and why it is not dilution.

© 2026 ExamFitter.com · Free AP Chemistry worksheets

A5. Three boxes of equal volume share one scale. Box 1 shows K^+ and NO_3^- ions, all separate and hydrated. Box 2 shows intact sucrose molecules only. Box 3 shows 5 intact HF molecules with 1 H^+ and 1 F^- ion. (a) Classify each box as a strong electrolyte, a weak electrolyte or a non-electrolyte, with particle evidence. (b) Rank the three by conductivity, assuming the same formula unit scale, justifying it from the mobile charged particles. (c) In Box 3, calculate the fraction of HF units dissociated, as a simple fraction. (d) State what Box 1 would show if the KNO_3 had not dissolved.

Section B: Core Practice

B1. Two boxes of equal volume share one key and scale. The first represents 0.30 M NaCl and shows 3 Na^+ and 3 Cl^- ions. The second shows 2 Mg^{2+} and 4 Cl^- ions. (a) State what molarity 1 drawn formula unit represents. (b) Calculate the $MgCl_2$ molarity in the second box. (c) Calculate the Mg^{2+} and Cl^- concentrations in the second box. (d) Calculate each box's total particle concentration, and state which conducts better, with a reason.

B2. A student draws two boxes of equal volume at one scale for $CaCl_2$ solutions. The first box, for 0.20 M, has 2 Ca^{2+} and 4 Cl^- ions. (a) State the Ca^{2+} to Cl^- ratio in the first box, and confirm it matches the formula. (b) Calculate the counts the second box must show for 0.50 M at the same volume and scale. (c) Calculate the total particles in each box, and the factor by which the count rises. (d) State two features besides count that must match between the drawings for a valid comparison.

© 2026 ExamFitter.com · Free AP Chemistry worksheets

B3. A box shows 2 Al^{3+} and 3 SO_4^{2-} ions, all separate, evenly spread and hydrated, and no other solute particles. (a) Write the simplest Al^{3+} to SO_4^{2-} ratio shown. (b) Deduce the solute formula. (c) Show that the box's charges balance. (d) A second box of the same volume and scale shows this solute at twice the concentration. State its ion counts.

B4. A box representing 100 mL of 0.80 M KCl shows 8 K^+ and 8 Cl^- ions. The solution is diluted to 400 mL. (a) Calculate the original moles of KCl. (b) Calculate the new molarity after dilution. (c) State the counts in a box for the full 400 mL at the same scale, and describe the spacing change. (d) A 100 mL sample is poured off. State the counts its box shows at the same scale, explaining them from the new molarity.

B5. A box representing the full 250 mL of 0.40 M $NaNO_3$ shows 10 Na^+ and 10 NO_3^- ions. Water evaporates until the volume is 100 mL. No solute is lost. (a) Calculate the moles of $NaNO_3$ before evaporation, and state them after. (b) Calculate the new molarity. (c) State the counts in a box for the 100 mL after evaporation, and describe two changes in the drawing.

B6. 100 mL of 0.30 M NaCl is mixed with 100 mL of 0.30 M KBr. Volumes add and both salts dissociate completely. Before mixing, boxes of each full portion at one scale show 3 Na^+ and 3 Cl^- ions, and 3 K^+ and 3 Br^- ions. (a) Calculate the moles of each ion supplied. (b) Calculate each ion's concentration in the mixture. (c) Calculate the total particle concentration in the mixture, and compare it with a starting solution. (d) Describe the combined box at the same scale: its relative size and each ion count. (e) A second pair of solutions, $AgNO_3$(aq) and NaCl(aq), is mixed, each starting box showing 3 of each ion at the same scale. Describe the final box: which ions form a solid block, which stay mobile, and how many of each.

© 2026 ExamFitter.com · Free AP Chemistry worksheets

Section C: Exam Style

C1. Two boxes of equal volume share one key and scale. Box A shows 4 Ca^{2+} and 8 Cl^{-} ions, evenly spread and hydrated. Box B shows 5 Na^{+} and 5 Cl^{-} ions and represents 0.50 M NaCl. (a) Calculate the molarity of the $CaCl_2$ solution in Box A. (b) Calculate each ion concentration in Box A. (c) Calculate the total particle concentration in each box, and state which is larger. (d) Predict which solution conducts better, justifying it from part (c). (e) A student claims Box A is more concentrated in every sense because it shows 12 particles against 10. Evaluate the claim using parts (a) and (c).

C2. Excess solid NaCl is stirred with water and left to settle. In the liquid region of the diagram, 5 Na^{+} and 5 Cl^{-} ions are spread evenly and hydrated. At the bottom sits a block of joined ions in a regular lattice, not surrounded by water. (a) State whether the system is homogeneous or heterogeneous, and identify each region. (b) A sample of the clear liquid is poured off. State its Na^{+} to Cl^{-} ratio, and why the block contributes nothing to its count. (c) More water is added and stirred. Some of the block disappears, while the liquid keeps the same ion spacing. Explain both at particle level, stating what the liquid's concentration does while solid remains. (d) State the one diagram change showing all the solid dissolved, and what further water does to spacing and concentration.

© 2026 ExamFitter.com · Free AP Chemistry worksheets

C3. A student must represent 200 mL of 0.50 M K_2SO_4, then the same solution diluted to 500 mL. The student picks a scale on which the first box, for the 200 mL, shows 5 formula units. (a) Calculate the moles of K_2SO_4, and of each ion it produces. (b) Calculate the K^+ and SO_4^{2-} concentrations in the original solution. (c) State the first box's K^+ and SO_4^{2-} counts, and verify charges balance. (d) Calculate the K_2SO_4 molarity and each ion concentration after dilution. (e) Describe the second box fully: relative size, ion counts, spacing against the first box, and water orientation around a K^+ ion and a SO_4^{2-} ion.

© 2026 ExamFitter.com · Free AP Chemistry worksheets

Answer Key

A1. (a) 4 to 4, or 1 to 1, matching NaCl: one Na^+ and one Cl^- per formula unit. (b) Total solute particles = 4 + 4 = 8. Water is the solvent and never counts as solute. (c) Dissolved NaCl exists as separate, moving, hydrated ions, so joined pairs would show undissociated units. A solution is homogeneous, so particles spread evenly; a corner cluster shows an undissolved solid. (d) Positive charge = 4 × 1 = 4 units. Negative charge = 4 × 1 = 4 units. The totals are equal, as in any solution.

A2. (a) Ion-dipole attraction, between each ion's full charge and water's partial charges. (b) The Na^+ shell is correct: δ- oxygen is attracted to the positive ion. The Cl^- shell is wrong: it puts δ- oxygen ends next to a negative ion, where like charges repel. (c) Around Cl^- the δ+ hydrogen ends point inward, with oxygen ends outward, the reverse of the cation shell. (d) Only as many waters fit around an ion as can touch its surface at once. A small ion has little surface, so 9 waters cannot all touch it in one ring. (e) Mg^{2+}. It has a +2 charge and the smallest radius of the four, so its ion-dipole attractions are strongest and its shell is the most tightly held and ordered.

A3. (a) Particles per standard volume: P 6, Q 9, R 12 ÷ 2 = 6. Increasing concentration: P and R tied, then Q. (b) P and R are equal: counts must be divided by volume first, and R spreads through twice the space. (c) Nine per volume stands for 0.90 M, so 1 per volume stands for 0.90 ÷ 9 = 0.10 M. P: 6 × 0.10 = 0.60 M. R: 6 per volume × 0.10 = 0.60 M.

A4. (a) The new box still shows 8 K^+ and 8 Cl^-: dilution adds water only. In a box twice the size, the same ions spread through twice the space, so spacing increases. (b) The box still shows 8 K^+ and 8 Cl^-, now in a box half the size. Spacing decreases and molarity doubles, because the same solute occupies half the volume. (c) Solute count, and so moles of KCl, stays the same in both. Volume and spacing rise on dilution and fall on evaporation; molarity moves the opposite way. (d) It describes removing half the solute as well as diluting, giving a quarter of the original concentration. True dilution removes no particles; water only spreads the original 8 and 8 further apart.

A5. (a) Box 1 is a strong electrolyte: KNO_3 dissociates completely, with no intact formula units left. Box 2 is a non-electrolyte: sucrose dissolves as intact neutral molecules, producing no ions. Box 3 is a weak electrolyte: most HF stays intact, and only a small fraction dissociates. (b) Conductivity needs mobile charged particles. Box 1 holds only ions and conducts best, Box 3 a few ions and weakly, Box 2 none. Order: Box 1, then Box 3, then Box 2. (c) Total HF units = 5 intact + 1 dissociated = 6. Fraction dissociated = 1 ÷ 6 = 1/6. (d) Ions locked together in a solid lattice block, with no separated hydrated ions in the water.

B1. (a) Three formula units stand for 0.30 M, so 1 drawn formula unit stands for 0.30 ÷ 3 = 0.10 M. (b) The second box shows 2 formula units, so $MgCl_2$ = 2 × 0.10 = 0.20 M. (c) Mg^{2+} = 0.20 M. Cl^- = 4 ×

© 2026 ExamFitter.com · Free AP Chemistry worksheets

0.10 = 0.40 M. (d) Each box: 6 particles × 0.10 = 0.60 M. Equal ion concentrations, so the two conduct about equally, despite different formula unit molarities.

B2. (a) 2 to 4, or 1 to 2, matching $CaCl_2$. (b) Count scales with molarity at fixed volume: factor = 0.50 ÷ 0.20 = 2.5. Ca^{2+} = 2 × 2.5 = 5 ions. Cl^- = 4 × 2.5 = 10 ions. (c) First box: 6 particles. Second box: 15 particles. Factor = 15 ÷ 6 = 2.5, matching the molarity factor at fixed volume. (d) Equal box volume, so counts compare per unit volume, and one key and scale, so one drawn particle means the same real number in both.

B3. (a) 2 to 3. (b) Al^{3+} and SO_4^{2-} in a 2 to 3 ratio give $Al_2(SO_4)_3$. (c) Positive charge = 2 × 3 = 6 units. Negative charge = 3 × 2 = 6 units. The box is neutral overall, as a solution must be. (d) Twice the concentration at the same volume and scale doubles counts: 4 Al^{3+} and 6 SO_4^{2-}, keeping the ratio and charge balance.

B4. (a) n = M × V = 0.80 × 0.100 = 0.080 mol. (b) Moles stay at 0.080 mol, so new molarity = 0.080 ÷ 0.400 = 0.20 M. (c) The box still shows 8 K^+ and 8 Cl^-: no solute was added or removed. The ions sit further apart, with four times the volume per ion. (d) Molarity fell by a factor of 4, so a 100 mL sample shows 8 ÷ 4 = 2 K^+ and 2 Cl^- ions. The sample holds 0.20 × 0.100 = 0.020 mol, one quarter of 0.080 mol.

B5. (a) Moles before = 0.40 × 0.250 = 0.100 mol. Evaporation removes water only, so moles after = 0.100 mol. (b) New molarity = 0.100 ÷ 0.100 = 1.0 M. (c) The box still shows 10 Na^+ and 10 NO_3^-. The box shrinks to 40% of its size, and the ions sit much closer together.

B6. (a) Each portion is 0.100 L, so each ion is supplied at 0.100 × 0.30 = 0.030 mol. (b) Mixture volume = 0.200 L. Each ion: 0.030 ÷ 0.200 = 0.15 M. (c) Total = 0.15 + 0.15 + 0.15 + 0.15 = 0.60 M. Each starting solution also held 0.30 + 0.30 = 0.60 M of ions, so the total is unchanged: each solution diluted the other, and the second salt replaced the lost concentration. (d) The combined box is twice either starting box and shows all the particles from both: 3 Na^+, 3 Cl^-, 3 K^+ and 3 Br^-, 12 in total, evenly spread and hydrated. (e) Ag^+ and Cl^- lock into an AgCl lattice block, 3 of each, unhydrated and immobile. The spectator ions Na^+ and NO_3^- stay mobile and hydrated in the liquid, 3 of each.

C1. (a) Box B sets the scale: 5 units stand for 0.50 M, so 1 unit stands for 0.10 M. Box A shows 4 $CaCl_2$ units, so it is 4 × 0.10 = 0.40 M. (b) Ca^{2+} = 0.40 M. Cl^- = 8 × 0.10 = 0.80 M. (c) Box A total = 0.40 + 0.80 = 1.20 M. Box B total = 0.50 + 0.50 = 1.00 M. Box A is larger. (d) Box A conducts better: conductivity rises with total mobile ion concentration, 1.20 M against 1.00 M. (e) Only partly right. For particles, Box A leads, 1.20 M against 1.00 M. For formula units, Box A is lower: 0.40 M against 0.50 M. Each $CaCl_2$ unit gives 3 ions against NaCl's 2, so the rankings oppose, and count alone cannot settle the claim.

C2. (a) Heterogeneous: two distinct regions. The liquid is a solution of dissolved, hydrated ions. The block is undissolved solid NaCl, its ions locked in a lattice. (b) The ratio is 5 to 5, or 1 to 1: only dissolved ions are in the liquid. The block is a separate phase and stays behind on pouring. (c)

© 2026 ExamFitter.com · Free AP Chemistry worksheets

Added water hydrates and separates more lattice ions, so part of the block dissolves. While solid remains, the liquid holds as much NaCl as it can, so new ions fill the added space and spacing is unchanged: concentration constant, liquid saturated. (d) The block disappears, leaving only evenly spread, hydrated ions. Further water is then dilution: counts fixed, spacing up, concentration down.

C3. (a) Moles of K_2SO_4 = 0.50 × 0.200 = 0.100 mol. K^+ = 2 × 0.100 = 0.200 mol and SO_4^{2-} = 0.100 mol. (b) K^+ = 0.200 ÷ 0.200 = 1.0 M. SO_4^{2-} = 0.100 ÷ 0.200 = 0.50 M. (c) Five units give K^+ = 5 × 2 = 10 ions and SO_4^{2-} = 5 ions. Charges: positive = 10 × 1 = 10 units; negative = 5 × 2 = 10 units. They balance. (d) Moles stay at 0.100 mol in 0.500 L, so K_2SO_4 = 0.20 M, K^+ = 0.40 M and SO_4^{2-} = 0.20 M. (e) The second box is two and a half times the size of the first, 500 mL against 200 mL, with the same counts, 10 K^+ and 5 SO_4^{2-}: dilution removes no solute, but the ions sit further apart. Around K^+ the oxygen ends of water point inward; around SO_4^{2-} the hydrogen ends point inward.

Continue Revising

Topic 3.8 Revision Notes

Topic 3.8 Quiz

Previous Worksheet: Topic 3.7

Next Worksheet: Topic 3.9

Unit 3: All Topics

AP Chemistry Home

© 2026 ExamFitter.com · Free AP Chemistry worksheets