ANSWER KEY.

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Solutions Virtual Lab

Chemistry | ANSWER KEY

Open activities.zornscience.org/solutions-lab/ and follow each step. Record values exactly as the lab shows them, with their units.

Objective

Use the Solutions Lab to make solutions of a known molarity with a volumetric flask, dilute a stock solution and check $M_1V_1 = M_2V_2$, and use solubility curves to predict when crystals form.

NGSS alignment

HS-PS1-3 (structure of substances and electrical forces between particles) and HS-PS1-7 (using mathematical representations of moles and mass). Practices: planning and carrying out investigations, analyzing and interpreting data, using mathematics. Crosscutting concept: scale, proportion, and quantity.

Meet the simulation

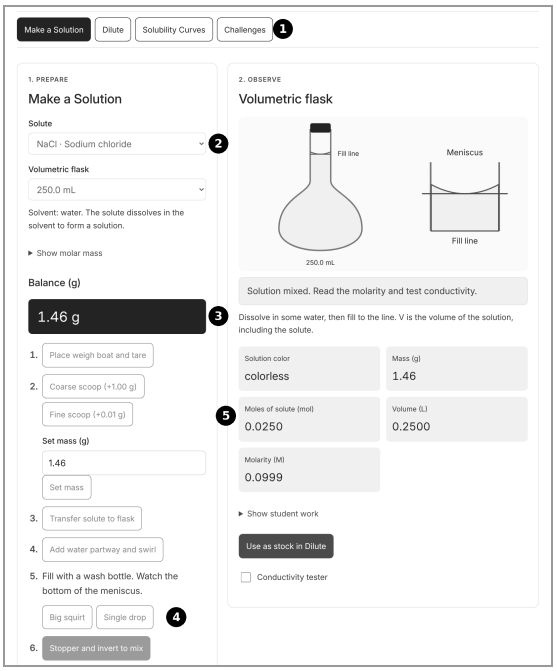


Figure 1. Make a Solution. (1) Mode tabs: Make a Solution, Dilute, Solubility Curves, Challenges. (2) Solute and volumetric flask. (3) The balance and the numbered steps: tare, weigh, transfer, and dissolve. (4) The wash bottle. Use Big squirt, then Single drop until the bottom of the meniscus sits on the fill line, then stopper and invert. (5) The readouts: mass, moles, volume, and molarity.

Pre-lab

1. Name the solute and the solvent in salt water. Write the formula for molarity, with units.

Solute: NaCl (salt). Solvent: water. Molarity (M) = moles of solute ÷ liters of solution, in mol/L.

2. How many grams of NaCl (58.44 g/mol) do you need to make 250.0 mL of 0.100 M NaCl?

0.2500 L × 0.100 mol/L = 0.0250 mol
0.0250 mol × 58.44 g/mol = 1.46 g

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Part A. Make a Solution

3. Choose Make a Solution and check Conductivity tester. For each row, pick the solute and flask, then follow steps 1 to 6 (type the mass and press Set mass). Record the moles, the molarity, and the bulb. Why does the NaCl solution read 0.0999 M and not exactly 0.100 M?

Solute	Mass (g)	Flask (mL)	Moles of solute (mol)	Molarity (M)	Bulb
NaCl	1.46	250.0	**0.0250**	**0.0999**	**bright**
KNO_3	5.06	100.0	**0.0500**	**0.500**	**bright**
$CuSO_4 \cdot 5H_2O$	6.24	250.0	**0.0250**	**0.100**	**bright**
$C_{12}H_{22}O_{11}$ (sucrose)	8.56	250.0	**0.0250**	**0.100**	**off**

The balance reads to 0.01 g, so 1.461 g rounds to 1.46 g. That is 0.02498 mol, and 0.02498 mol ÷ 0.2500 L = 0.0999 M (3 sig figs from 1.46 g).

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4. The $CuSO_4$ and sucrose solutions are both 0.100 M. Why does only one of them light the bulb? Classify each as a strong electrolyte or a nonelectrolyte.

$CuSO_4$ is ionic. It dissociates into Cu^{2+} and SO_4^{2-} ions that carry charge, so it is a strong electrolyte. Sucrose is molecular. It dissolves as neutral molecules, so it is a nonelectrolyte.

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5. Choose NaCl and the 1000. mL flask. Check Measure 1.00 L of water instead, weigh 58.44 g, and follow the steps. Record the volume and molarity. Then press Start over, uncheck the box, and make it again by filling to the line. Explain the difference.

Measuring 1.00 L of water: 1.0200 L of solution and 0.9804 M. Filling to the line: 1.000 L and 1.000 M. The dissolved salt takes up space, so adding 1.00 L of water makes more than 1.00 L of solution and lowers the molarity. Molarity uses liters of solution, so dissolve the solid in some water and then fill to the line.

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Part B. Dilute

6. Choose Dilute and the 1.00 M $CuSO_4$ stock. For each row, pick the pipet (V_1) and flask (V_2), transfer, fill to the line, and mix. Record M_2 and the water added. Which two rows give the same M_2, and why?

V_1 (mL)	V_2 (mL)	M_2 (M)	Water added (mL)
10.00	100.0	**0.100**	**90.0**
25.00	250.0	**0.100**	**225.0**
5.00	100.0	**0.0500**	**95.0**
25.00	100.0	**0.250**	**75.0**

Rows 1 and 2 both give 0.100 M. In both, V_2 is 10 times V_1, so the stock is diluted 10 times. Check: 1.00 M × 25.00 mL = M_2 × 250.0 mL, so M_2 = 0.100 M.

7. Choose the 2.00 M NaCl stock. Dilute 10.00 mL to 100.0 mL, press Use as the new stock, and repeat. Record M_2 after each step. How many times more dilute is the final solution?

Step 1: 0.200 M. Step 2: 0.0200 M. Each step dilutes 10 times, so the final solution is 100 times more dilute than the stock.

8. Check Particle view. Compare the stock aliquot and the diluted solution. What stays the same? What changes?

The number of solute particles (moles) stays the same. The volume gets bigger, so the concentration goes down and the blue color gets lighter.

Part C. Solubility Curves

9. Choose Solubility Curves and KNO_3. Leave Cool gently unchecked. Set the temperature to 70 °C, press Start over, and add 100 g (Add 10 g ten times). Lower the temperature to each value and record the results.

Temperature (°C)	Solubility (g per 100 g H_2O)	Dissolved (g)	Crystals formed (g)	Solution state
70	**138.0**	**100.0**	**0.0**	**unsaturated**
50	**85.0**	**85.0**	**15.0**	**saturated**
30	**46.0**	**46.0**	**54.0**	**saturated**
10	**21.0**	**21.0**	**79.0**	**saturated**

At 70 °C all 100 g dissolves. Below about 57 °C the solution reaches the curve, and the extra crystallizes. Crystals formed = 100 g − solubility.

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10. Press Start over at 70 °C and add 100 g KNO_3 again. Check Cool gently and cool to 30 °C. Record the dissolved mass and the solution state. Then press Drop in a seed crystal and record what happens. How does this explain a hand warmer?

Cooled gently: 100.0 g dissolved, supersaturated (above the curve, 46.0 g). After the seed crystal: 46.0 g dissolved and 54.0 g of crystals, saturated. A supersaturated solution is unstable, so one crystal makes all the extra solute crystallize at once, which releases heat in a hand warmer.

11. Choose NH_3 (a gas). At 0 °C, add 80 g, then warm to 30 °C. Record the dissolved mass and gas escaped. Cool back to 0 °C. Why doesn't the gas come back, and why does warm soda go flat?

At 30 °C: 44.0 g dissolved and 36.0 g of gas escaped. Back at 0 °C it stays at 44.0 g, because the escaped gas left the beaker. Gases are less soluble in warm water, so warm soda loses its CO_2.

Analysis

12. Calculate the mass of NaCl needed for 500.0 mL of 0.250 M NaCl. Then make it in the lab and record the molarity it shows.

0.5000 L × 0.250 mol/L = 0.125 mol
0.125 mol × 58.44 g/mol = 7.31 g
The lab reads 0.250 M.

13. Plan how to make 250.0 mL of 0.100 M $CuSO_4$ from the 1.00 M stock. Which pipet and flask do you use, and how much water is added? Test your plan in the lab.

V_1 = (0.100 M × 250.0 mL) ÷ 1.00 M = 25.0 mL. Use the 25.00 mL pipet and the 250.0 mL flask. Water added: 225.0 mL. The lab gives 0.100 M.

14. Name two sources of error if you made these solutions in a real school lab.

Any two: filling past the line or reading the top of the meniscus instead of the bottom; leaving solid behind in the weigh boat (not rinsing it into the flask); not mixing after filling; the balance not tared; wet glassware or a pipet not rinsed with the stock; the temperature not matching the curve or flask calibration.

Conclusion

15. Write a claim, evidence, and reasoning: what does molarity measure, and how do dilution and temperature change how much solute is in a solution?

Claim: molarity is moles of solute per liter of solution. Dilution lowers the molarity without changing the moles, and temperature sets the most solute that can stay dissolved. Evidence: diluting 10.00 mL of 1.00 M $CuSO_4$ to 100.0 mL gave 0.100 M with 0.0100 mol before and after; cooling 100 g KNO_3 from 70 °C to 30 °C left 46.0 g dissolved and 54.0 g of crystals. Reasoning: adding water spreads the same particles through more volume, so $M_1V_1 = M_2V_2$. For most solids, colder water dissolves less, so the extra comes out as crystals; gases do the opposite.

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