

Concentration, separation and absorbance

AP Chemistry · Worksheet answers

Every answer shows the relationship used, the substitution and the final result with units. When a problem asks for an explanation, the main points are given in sentences. Rounding differences in the last significant figure are acceptable.

Level: AP Chemistry · **Curriculum:** AP Chem Unit 3

Problem 1 Molarity of salt solution

$$n = 11.7 / 58.44 = 0.2002 \text{ mol}$$

$$M = 0.2002 / 0.5000 = \mathbf{0.400 \text{ mol/L.}}$$

Problem 2 Mass for a solution

$$n = 0.100 \times 0.2500 = 0.0250 \text{ mol}$$

$$m = 0.0250 \times 74.55 = \mathbf{1.86 \text{ g.}}$$

Problem 3 Simple dilution

$$M_2 = M_1 V_1 / V_2 = 1.00 \times 25.0 / 250.0 = \mathbf{0.100 \text{ mol/L.}}$$

Problem 4 Calculate R_f values

1. X 2.0 cm, Y 4.4 cm, Z 6.0 cm; front 8.0 cm.
2. $R_f(X) = 2.0/8.0 = \mathbf{0.25}$; $R_f(Y) = 4.4/8.0 = \mathbf{0.55}$; $R_f(Z) = 6.0/8.0 = \mathbf{0.75}$.
3. **X**, the spot that moved least.

Problem 5 Transmittance and absorbance

1. $A = -\log 0.50 = \mathbf{0.301}$.
2. $T = 10^{-1.000} = 0.100$, which is **10 percent**.

Problem 6 Choose a separation method

1. **Filtration**.
2. **Simple distillation** (the water evaporates and is condensed).
3. **Chromatography**.
4. **Fractional distillation**, using the difference in boiling points.

Problem 7 Ion concentrations

1. $[\text{Ca}^{2+}] = \mathbf{0.30\text{ M}}$; $[\text{Cl}^-] = 2 \times 0.30 = \mathbf{0.60\text{ M}}$.
2. $[\text{Al}^{3+}] = 2 \times 0.20 = \mathbf{0.40\text{ M}}$; $[\text{SO}_4^{2-}] = 3 \times 0.20 = \mathbf{0.60\text{ M}}$.

Problem 8 Lead in drinking water

1. $0.0210 / 1.50 = \mathbf{0.0140\text{ mg/L}}$.
2. $0.0140\text{ mg/L} = \mathbf{14.0\text{ }\mu\text{g/L}}$.

Problem 9 Make a copper sulfate solution

$n = 0.250 \times 0.1000 = 0.0250\text{ mol}$; $m = 0.0250 \times 249.70 = \mathbf{6.24\text{ g}}$.

Weigh the solid, dissolve it in a beaker with a little water, transfer to a 100.0 mL volumetric flask, rinse the beaker into the flask, and fill to the mark; invert to mix.

Problem 10 A dilution series

$V_1 = M_2 \times 50.0 / 0.500$:

0.100 M: **10.0 mL**; 0.0500 M: **5.00 mL**; 0.0250 M: **2.50 mL**; 0.0100 M: **1.00 mL**.

Problem 11 Find a concentration with Beer-Lambert

$c = A/(\epsilon b) = 0.450 / (9.0 \times 10^3 \times 1.00) = \mathbf{5.0 \times 10^{-5}\text{ mol/L}}$.

Problem 12 Change the path length

1. A is proportional to b: **0.600** and **0.150**.
2. $T = 10^{-0.300} = 0.501$, so **50.1 percent**.

Problem 13 Use a calibration graph

1. About **$3.0 \times 10^{-5}\text{ mol/L}$** .
2. Gradient = $0.72 / (6.0 \times 10^{-5}\text{ mol/L}) = 1.2 \times 10^4\text{ L/mol}$; since $b = 1.00\text{ cm}$, $\epsilon = \mathbf{1.2 \times 10^4\text{ L/(mol}\cdot\text{cm)}}$.
3. With no dye there is no absorption, and the blank is set to zero.

Problem 14 Why chromatography separates

The **nonpolar dye** has the larger R_f .

Polar silica attracts the polar dye strongly, so it spends most time on the stationary phase and moves little. The nonpolar dye is more soluble in the nonpolar solvent and is carried further.

Problem 15 Mixing two solutions

$$n = 0.0500 \times 0.200 + 0.1500 \times 0.100 = 0.0100 + 0.0150 = 0.0250 \text{ mol}$$

$$M = 0.0250 / 0.2000 = \mathbf{0.125 \text{ mol/L.}}$$

Problem 16 Volume for a titration-style reaction

$$n(\text{Cl}^-) = 0.0250 \times 0.100 = 2.50 \times 10^{-3} \text{ mol} = n(\text{Ag}^+)$$

$$V = n/M = 2.50 \times 10^{-3} / 0.150 = 0.01667 \text{ L} = \mathbf{16.7 \text{ mL.}}$$

Problem 17 When Beer's law fails

1. $A/c = 0.12, 0.12, 0.12, 0.119, 0.113, 0.081$ (units 10^5 L/mol).
2. The data are linear up to about $\mathbf{8 \times 10^{-5} \text{ mol/L}}$ ($A = 0.95$); beyond it A/c falls.
3. The reading is outside the linear range. **Dilute the sample by a known factor** to bring A within the range, remeasure and multiply by the dilution factor.

Problem 18 Absorbance from percent transmittance

$$A = -\log 0.180 = \mathbf{0.745.}$$

$$c = 0.745 / (1.5 \times 10^4 \times 1.00) = \mathbf{4.96 \times 10^{-5} \text{ mol/L.}}$$

Problem 19 Diluted sample

1. $c = 0.480 / (1.20 \times 10^4 \times 1.00) = \mathbf{4.00 \times 10^{-5} \text{ mol/L.}}$
2. Dilution factor $100.0/10.00 = 10$, so original = $\mathbf{4.00 \times 10^{-4} \text{ mol/L.}}$
3. It selects a single wavelength (λ_{max}) from the source so that ϵ is constant and the measurement is most sensitive.

Problem 20 Design a colorimetric analysis

Plan: make a set of at least five standards of known concentration by dilution; run a scan of the most concentrated standard to find λ_{max} (the light absorbed by a blue solution is orange-red); zero the instrument with a blank; measure A for each standard and the unknown; plot A against c and draw a best-fit line through the origin; read the unknown from the line.

Error: air bubbles, fingerprints on the cuvette, or an unknown outside the range of standards.