

Net ionic equations, titration and redox

AP Chemistry · Worksheet answers

Each answer gives the method, the substitution and the result with units. For equations, check that both atoms and charges balance. Allow small differences in the last digit because of rounding of molar masses.

Level: AP Chemistry · **Curriculum:** AP Chem Unit 4

Problem 1 Soluble or insoluble

NaCl **soluble**; AgCl **insoluble**; BaSO₄ **insoluble**; K₂CO₃ **soluble** (group 1); Mg(OH)₂ **insoluble**; NH₄NO₃ **soluble**.

Problem 2 Find the spectators

1. **Ag⁺(aq) + Cl⁻(aq) → AgCl(s).**
2. **Na⁺ and NO₃⁻.**

Problem 3 Oxidation numbers

1. $x + 4(-2) = -2$, so S = **+6**.
2. $2x + 7(-2) = -2$, so Cr = **+6**.
3. $x + 4(+1) = +1$, so N = **-3**.
4. $x + 3(-2) = -1$, so Cl = **+5**.

Problem 4 Oxidised or reduced

Mg goes from 0 to +2: **Mg is oxidised** and is the reducing agent. Cu²⁺ goes from +2 to 0: **Cu²⁺ is reduced** (oxidising agent).

Problem 5 Reading a titration curve

1. About **pH 1** (0.100 M strong acid).
2. About **25 mL**, in the middle of the steep rise.
3. **pH 7**; phenolphthalein or bromothymol blue, both of which change colour within the steep part.

Problem 6 Volume added from a burette

1. $21.60 - 0.30 = \mathbf{21.30\text{ mL}}$.
2. $n(\text{NaOH}) = 0.02130 \times 0.100 = 2.130 \times 10^{-3} \text{ mol} = n(\text{HCl})$; $c = 2.130 \times 10^{-3} / 0.01000 = \mathbf{0.213\text{ mol/L}}$.

Problem 7 Three kinds of equation

1. $\text{Na}_2\text{CO}_3(\text{aq}) + \text{CaCl}_2(\text{aq}) \rightarrow \text{CaCO}_3(\text{s}) + 2\text{NaCl}(\text{aq})$
2. $2\text{Na}^+ + \text{CO}_3^{2-} + \text{Ca}^{2+} + 2\text{Cl}^- \rightarrow \text{CaCO}_3(\text{s}) + 2\text{Na}^+ + 2\text{Cl}^-$
3. **$\text{Ca}^{2+}(\text{aq}) + \text{CO}_3^{2-}(\text{aq}) \rightarrow \text{CaCO}_3(\text{s})$**

Problem 8 Neutralisation equations

1. **$\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l})$** .
2. **$\text{CH}_3\text{COOH}(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{CH}_3\text{COO}^-(\text{aq}) + \text{H}_2\text{O}(\text{l})$** ; the weak acid is not split into ions, and Na^+ is a spectator.

Problem 9 Predict the precipitate

1. **Yes, BaSO_4 .**
2. **No**, all products are soluble.
3. **Yes, $\text{Fe}(\text{OH})_3$.**
4. **Yes, ZnS .**

Problem 10 Mass of precipitate

$$n(\text{Ag}^+) = 0.0250 \times 0.200 = 5.00 \times 10^{-3} \text{ mol} = n(\text{AgCl})$$
$$m = 5.00 \times 10^{-3} \times 143.32 = \mathbf{0.717 \text{ g}}.$$

Problem 11 Limiting reagent in solution

$$n(\text{Pb}^{2+}) = 6.00 \times 10^{-3} \text{ mol}; n(\text{I}^-) = 15.0 \times 10^{-3} \text{ mol}. \text{Pb}^{2+} + 2\text{I}^- \text{ needs } 12.0 \times 10^{-3} \text{ mol of I}^-.$$

I^- is in excess, so **$\text{Pb}(\text{NO}_3)_2$ is limiting**.

$$m = 6.00 \times 10^{-3} \times 461.0 = \mathbf{2.77 \text{ g}}.$$

Problem 12 Percent yield

$$\text{Theoretical} = 2.766 \text{ g (unrounded)}. \text{Percent yield} = 2.45 / 2.766 \times 100 = \mathbf{88.6 \%}.$$

Problem 13 Sulfuric acid titration

$$n(\text{NaOH}) = 0.03050 \times 0.1000 = 3.050 \times 10^{-3} \text{ mol}$$
$$n(\text{H}_2\text{SO}_4) = 3.050 \times 10^{-3} / 2 = 1.525 \times 10^{-3} \text{ mol}$$
$$c = 1.525 \times 10^{-3} / 0.02500 = \mathbf{0.0610 \text{ mol/L}}.$$

Problem 14 Half-equations

1. Oxidation: **$\text{Zn} \rightarrow \text{Zn}^{2+} + 2\text{e}^-$** . Reduction: **$\text{Ag}^+ + \text{e}^- \rightarrow \text{Ag}$** .
2. Zn gives 2 electrons and each Ag^+ accepts only 1, so electrons balance with 2 Ag^+ .

Problem 15 Dissolving ionic compounds

In 0.10 M Na_3PO_4 : $[\text{Na}^+] = 0.30 \text{ M}$, $[\text{PO}_4^{3-}] = 0.10 \text{ M}$.

Problem 16 Concentration of vinegar

1. $n(\text{NaOH}) = 0.01820 \times 0.1000 = 1.820 \times 10^{-3} \text{ mol} = n(\text{acid})$; $c = 1.820 \times 10^{-3} / 0.02500 = 0.0728 \text{ mol/L}$.

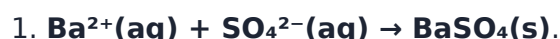
2. Dilution factor 10: **0.728 mol/L**.

3. $0.728 \times 60.05 = 43.7 \text{ g/L}$, so **4.37 g** per 100 mL.

Problem 17 Redox titration of iron

1. $n(\text{MnO}_4^-) = 0.02040 \times 0.02000 = 4.080 \times 10^{-4} \text{ mol}$; $n(\text{Fe}^{2+}) = 5 \times 4.080 \times 10^{-4} = 2.040 \times 10^{-3} \text{ mol}$; $c = 2.040 \times 10^{-3} / 0.02500 = 0.0816 \text{ mol/L}$.

2. Mn: +7 to +2 (reduced); Fe: +2 to +3 (oxidised).

Problem 18 Ions left after precipitation

2. $n = 5.00 \times 10^{-3} \text{ mol}$ of each, so $m = 5.00 \times 10^{-3} \times 233.39 = 1.17 \text{ g}$.

3. Total volume 0.1000 L. $n(\text{Na}^+) = 2 \times 5.00 \times 10^{-3} = 1.00 \times 10^{-2} \text{ mol}$; $n(\text{Cl}^-)$ the same; each concentration is **0.100 mol/L**.

Problem 19 Analyse titration data

1. Use **concordant** results (within 0.10 mL): trials 2, 3 and 4. The rough trial is discarded because the end point was overshoot.

2. Mean = $(21.60 + 21.55 + 21.65)/3 = 21.60 \text{ mL}$; $n(\text{NaOH}) = 0.02160 \times 0.1050 = 2.268 \times 10^{-3} \text{ mol}$; $c(\text{HCl}) = 2.268 \times 10^{-3} / 0.02500 = 0.0907 \text{ mol/L}$.

Problem 20 Identify four solutions

1 = **Pb(NO₃)₂** (the only one that precipitates with two others); 2 = **KI** (yellow PbI_2); 3 = **Na₂SO₄** (white PbSO_4); 4 = **NaNO₃** (no reaction).

