AP Chemistry Unit 4 Easier Practice Set

Chemical Reactions & Stoichiometry

Building Confidence with Reaction Types & Calculations

APChemistryRescue.com

📋 Practice Set Information

- **Total Points:** 70 points
- **Suggested Time:** 60–90 minutes
- **Questions:** 10 (scaffolded from basic mole ratios → limiting reactants → titrations)
- **Topics:** Stoichiometry, reaction types, net ionic equations, titrations, percent yield, redox
- **Skills:** Mole calculations, dimensional analysis, equation balancing, particulate representations, graph interpretation

🔬 REFERENCE DATA & MOLAR MASSES

Substance	Formula	Molar Mass (g/mol)
Water	H_2O	18.02
Carbon dioxide	CO_2	44.01
Oxygen gas	O_2	32.00
Hydrogen gas	H_2	2.02
Nitrogen gas	N_2	28.02
Ammonia	NH_3	17.03

Sodium chloride	$NaCl$	58.44
Silver nitrate	$AgNO_3$	169.87
Silver chloride	$AgCl$	143.32
Sodium nitrate	$NaNO_3$	85.00
Acetic acid	CH_3COOH	60.05
Sodium hydroxide	$NaOH$	40.00

Key Formulas:

Molarity: M = mol/L
Moles: n = mass/MM = M × V (in L)
Percent Yield: (actual/theoretical) × 100%

💡 **Stoichiometry Success Tips:**

- **Always start with a balanced equation**

  —unbalanced equations give wrong mole ratios
- **Show unit cancellation**

  at every step (g → mol → mol → g)
- **Identify the limiting reactant**

  by calculating moles of product from each reactant; smallest = limiting
- **For net ionic equations:**

  Write complete ionic first, then cancel spectator ions (same on both sides)
- **Use the stoichiometry roadmap**

  below as your guide for multi-step problems

GIVEN
Mass, Volume, Molarity, etc.

→

MOLES A
÷ MM or × M × V

→

MOLE RATIO
From balanced equation

→

MOLES B
× (mol B/mol A)

→

ANSWER
× MM, ÷ V, etc.

Question 1: Basic Mole Ratio Stoichiometry (6 points)

Consider the balanced equation for the synthesis of ammonia (Haber process):

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

(a) If you start with **2.0 moles of N_2** and excess H_2, how many **moles of NH_3** can be produced? Show your mole ratio calculation.

Work Space:

(b) If you start with **6.0 moles of H_2** and excess N_2, how many **moles of NH_3** can be produced?

Work Space:

(c) Explain the meaning of "excess" reagent in parts (a) and (b). Why do we need to specify that one reactant is in excess?

Work Space:

Question 2: Limiting Reactant with Analogy (8 points)

Sandwich Analogy: To make one sandwich, you need 2 slices of bread + 1 slice of cheese.

Analogy:

If you have 10 slices of bread and 3 slices of cheese, you can make only **3 sandwiches**

(limited by cheese), with 4 slices of bread left over.

Now consider the combustion of propane:

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$$

You have **2.0 moles of C_3H_8** and **8.0 moles of O_2**.

(a) Calculate the moles of CO_2 that can be produced from **2.0 moles of C_3H_8** (assuming excess O_2).

Work Space:

(b) Calculate the moles of CO_2 that can be produced from **8.0 moles of O_2** (assuming excess C_3H_8).

Work Space:

(c) Which reactant is the **limiting reactant**? How many moles of CO_2 are actually produced?

Work Space:

(d) How many moles of the **excess reactant** remain unreacted?

Work Space:

Question 3: Balanced Equation to Particulate Diagram (7 points)

Consider the balanced equation:

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$$

(a) Draw a particulate-level diagram showing the reaction. Use:

- = H_2 molecule (two H atoms bonded)
-  = O_2 molecule (two O atoms bonded)
-  = H_2O molecule (H–O–H bent structure)

Draw **4 H_2 molecules and 2 O_2 molecules** as reactants, then show the products. Make sure your diagram obeys the 2:1:2 ratio.

REACTANTS → **PRODUCTS**

(b) If you start with 4 H_2 molecules and 2 O_2 molecules (as shown), how many H_2O molecules are produced? Is any reactant left over?

Work Space:

Question 4: Classifying Reaction Types (7 points)

Use the flow chart below to classify each reaction. Identify the reaction type and any observable evidence (precipitate, gas, color change, etc.).

1. SYNTHESIS (Combination): A + B → AB

Example: $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$

Clue: Two or more substances combine to form one product

2. DECOMPOSITION: AB → A + B

Example: $2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$

Clue: One compound breaks into two or more products; often produces gas

3. SINGLE REPLACEMENT: A + BC → AC + B

Example: $Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$

Clue: One element replaces another; often produces gas or heat

4. DOUBLE REPLACEMENT: AB + CD → AD + CB

Example: $AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$

Clue: Two compounds exchange partners; often produces precipitate or water

5. COMBUSTION: Hydrocarbon + O_2 → CO_2 + H_2O

Example: $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$

Clue: Reaction with O_2 produces CO_2 and H_2O; releases heat/light

Classify the following reactions:

(a) $2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$

Work Space (Type + Explanation):

(b) $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

Work Space (Type + Observable evidence):

(c) $Pb(NO_3)_2(aq) + 2KI(aq) \rightarrow PbI_2(s) + 2KNO_3(aq)$

Work Space (Type + Observable evidence):

Question 5: Net Ionic Equations (8 points)

When aqueous solutions of **silver nitrate ($AgNO_3$)** and **sodium chloride (NaCl)** are mixed, a white precipitate of **silver chloride (AgCl)** forms.

Molecular Equation:

$AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$

(a) Write the **complete ionic equation** by separating all aqueous compounds into ions. (Remember: Solids, liquids, and gases do NOT dissociate.)

Work Space:

(b) Identify the **spectator ions** (ions that appear unchanged on both sides of the equation).

Work Space:

(c) Write the **net ionic equation** by canceling the spectator ions.

Work Space:

(d) Draw a particulate diagram showing the precipitation reaction. Use:

- ⊕ = Ag^+
- ⊖ = Cl^-
- ● = Na^+
- ○ = NO_3^-
- ⊕⊖ = AgCl(s) precipitate (solid cluster)

BEFORE MIXING

(Show separate Ag^+, NO_3^-, Na^+, Cl^-)

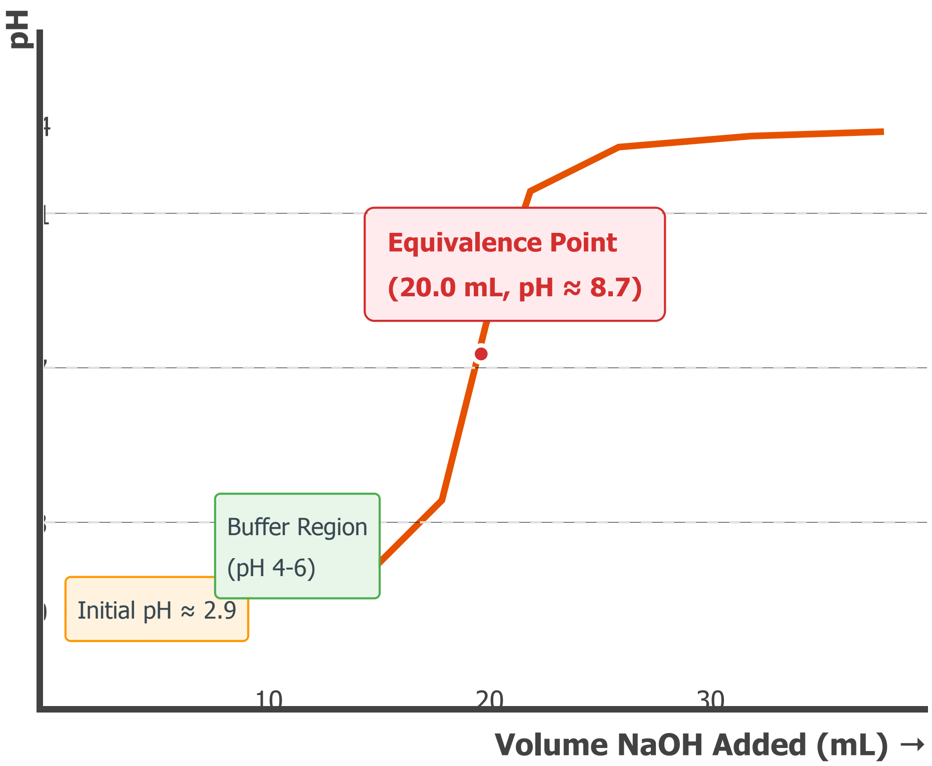
→

AFTER MIXING

(Show AgCl(s) + spectators)

Question 6: Titration Curve and Stoichiometry (9 points)

A student titrates 25.0 mL of acetic acid (CH_3COOH) with 0.100 M sodium hydroxide (NaOH). The titration curve is shown below:



Neutralization Equation:

$$CH_3COOH(aq) + NaOH(aq) \rightarrow CH_3COONa(aq) + H_2O(l)$$

(a) What volume of NaOH is required to reach the **equivalence point**? (Read from the graph.)

Work Space:

(b) Calculate the **moles of NaOH** added at the equivalence point. (Use M × V in liters.)

Work Space:

(c) Use the 1:1 mole ratio from the balanced equation to find the **moles of CH_3COOH** in the original 25.0 mL sample.

Work Space:

(d) Calculate the **molarity of the CH_3COOH** solution. (M = mol/L)

Work Space:

(e) Why is the pH at the equivalence point (8.7) **greater than 7** for this weak acid–strong base titration?

Work Space:

Question 7: Percent Yield (7 points)

In an industrial Haber process reactor, 100.0 g of N_2 reacts with excess H_2 to produce ammonia (NH_3):

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

(a) Calculate the **theoretical yield** of NH_3 (in grams) if 100.0 g of N_2 reacts completely. Show all work using the stoichiometry roadmap.

Roadmap:

g N_2 → mol N_2 → mol NH_3 (use mole ratio) → g NH_3

Work Space:

(b) If the actual yield of NH_3 is 85.0 g, calculate the **percent yield**.

Work Space:

(c) Give **two reasons** why the actual yield is often less than the theoretical yield in real reactions.

Work Space:

Question 8: Solution Stoichiometry (7 points)

A student mixes 50.0 mL of 0.200 M $AgNO_3$ with excess NaCl to produce AgCl precipitate:

$$AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$$

(a) Calculate the **moles of $AgNO_3$** in 50.0 mL of 0.200 M solution. (Use n = M × V in liters.)

Work Space:

(b) Use the 1:1 mole ratio to find the **moles of AgCl** produced.

Work Space:

(c) Calculate the **mass of AgCl precipitate** (in grams). (Use mass

= mol × MM.)

Work Space:

Question 9: Oxidation Numbers and Redox Identification (6 points)

Consider the reaction:

$$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$$

Oxidation Number Rules:

1. Free elements: oxidation number = 0 (e.g., Zn, Cu, O_2, H_2)

2. Monatomic ions: oxidation number = charge (e.g., Na^+ = +1, Cl^- = −1)

3. Oxygen: usually −2 (except in peroxides: −1)

4. Hydrogen: usually +1 (except in metal hydrides: −1)

5. Sum of oxidation numbers in a neutral compound = 0

6. Sum of oxidation numbers in a polyatomic ion = charge of ion

7. Group 1: +1; Group 2: +2; Group 17: usually −1

(a) Assign **oxidation numbers** to Zn and Cu in the reactants and products. Show your work.

Work Space:

(b) Which species is **oxidized** (loses electrons)? Which is **reduced** (gains electrons)?

Work Space:

(c) Write the **half-reactions** for oxidation and reduction.

Work Space:

Question 10: Conceptual Understanding (5 points)

Answer the following conceptual questions with clear explanations.

(a) A student says: "In a balanced equation, the **coefficients** tell us the mass ratio of reactants to products." Is this correct? Explain what the coefficients actually represent.

Work Space:

(b) Why must we **balance chemical equations** before performing stoichiometry calculations? What law does balancing equations obey?

Work Space:

(c) Explain the difference between a **complete ionic equation** and a **net ionic equation**. Why is the net ionic equation more useful for understanding precipitation reactions?

Work Space:

END OF PRACTICE SET

Total: 70 points | Answer key begins on next page

📘 COMPLETE ANSWER KEY & SCORING GUIDE

Question 1: Basic Mole Ratio Stoichiometry (6 points)

(a) Moles of NH_3 from 2.0 mol N_2 (2 points):

From the balanced equation: 1 mol N_2 produces 2 mol NH_3 (mole ratio 1:2)

$$\text{Moles NH}_3 = 2.0 \text{ mol N}_2 \times \frac{2 \text{ mol NH}_3}{1 \text{ mol N}_2} = 4.0 \text{ mol NH}_3$$

(1 pt for correct mole ratio; 1 pt for calculation and answer)

(b) Moles of NH_3 from 6.0 mol H_2 (2 points):

From the balanced equation: 3 mol H_2 produces 2 mol NH_3 (mole ratio 3:2)

$$\text{Moles NH}_3 = 6.0 \text{ mol H}_2 \times \frac{2 \text{ mol NH}_3}{3 \text{ mol H}_2} = 4.0 \text{ mol NH}_3$$

(1 pt for correct mole ratio; 1 pt for calculation)

(c) Meaning of "excess" (2 points):

"Excess" means there is **more than enough** of that reactant to completely react with the other reactant. (1 pt) We specify "excess" because in real reactions, we often don't have perfect stoichiometric amounts—one reactant runs out first (limiting reactant) and determines how much product forms. The excess reactant is left over unreacted. (1 pt for explanation of limiting reactant concept)

Scoring: (a) 2 pts; (b) 2 pts; (c) 2 pts

Question 2: Limiting Reactant with Analogy (8 points)

(a) CO_2 from 2.0 mol C_3H_8 (2 points):

Mole ratio from equation: 1 mol C_3H_8 produces 3 mol CO_2

$$\text{Moles CO}_2 = 2.0 \text{ mol C}_3\text{H}_8 \times \frac{3 \text{ mol CO}_2}{1 \text{ mol C}_3\text{H}_8} = 6.0 \text{ mol CO}_2$$

(1 pt for setup; 1 pt for answer)

(b) CO_2 from 8.0 mol O_2 (2 points):

Mole ratio: 5 mol O_2 produces 3 mol CO_2

$$\text{Moles CO}_2 = 8.0 \text{ mol O}_2 \times \frac{3 \text{ mol CO}_2}{5 \text{ mol O}_2} = 4.8 \text{ mol CO}_2$$

(1 pt for setup; 1 pt for answer)

(c) Limiting reactant (2 points):

O_2 is the limiting reactant because it produces fewer moles of CO_2 (4.8 mol vs. 6.0 mol). (1 pt) The actual amount of CO_2 produced is **4.8 mol** (limited by O_2). (1 pt)

(d) Excess C_3H_8 remaining (2 points):

First, find how much C_3H_8 reacts:

$$\text{C}_3\text{H}_8 \text{ used} = 8.0 \text{ mol O}_2 \times \frac{1 \text{ mol C}_3\text{H}_8}{5 \text{ mol O}_2} = 1.6 \text{ mol C}_3\text{H}_8$$

$$\text{C}_3\text{H}_8 \text{ remaining} = 2.0 - 1.6 = 0.4 \text{ mol}$$

(1 pt for calculating C_3H_8 used; 1 pt for excess remaining)

Scoring: (a) 2 pts; (b) 2 pts; (c) 2 pts; (d) 2 pts

Question 3: Balanced Equation to Particulate Diagram (7 points)

(a) Particulate diagram (5 points):

Reactants side: Draw 4 H_2 molecules (⚪⚪) and 2 O_2 molecules (⚫⚫). (2 pts for correct number and representation)

Products side: Draw 4 H_2O molecules (⚪⚫⚪ in bent geometry). (2 pts for correct number; 1 pt for showing bent structure)

Key check: 4 H_2 + 2 O_2 → 4 H_2O obeys the 2:1:2 ratio (multiply by 2: 4:2:4).

(b) H_2O produced and leftover (2 points):

4 H_2O molecules are produced. (1 pt) **No reactant is left over**—all 4 H_2 and 2 O_2 react completely in the correct 2:1 ratio. (1 pt) (Note: If students drew 4 H_2 + 2 O_2, they're in perfect stoichiometric ratio; if they drew 4 H_2 + 3 O_2, then 1 O_2 would be left over—adjust scoring accordingly.)

Scoring: (a) 5 pts (reactants 2, products 3); (b) 2 pts

Question 4: Classifying Reaction Types (7 points)

(a) $2Na + Cl_2 \rightarrow 2NaCl$:

Type: Synthesis (Combination). (1.5 pts) Two elements combine to form one compound. Observable: Heat/light released; formation of white solid NaCl. (0.5 pt for evidence)

(b) $CaCO_3 \rightarrow CaO + CO_2$:

Type: Decomposition. (1.5 pts) One compound breaks into two products. Observable: Gas (CO_2) evolution; requires heat (endothermic). (0.5 pt for evidence; 1 pt total = 2 pts)

(c) $Pb(NO_3)_2 + 2KI \rightarrow PbI_2 + 2KNO_3$:

Type: Double Replacement. (1.5 pts) Two compounds exchange partners (cations swap). Observable: Formation of yellow precipitate $PbI_2(s)$. (0.5 pt for precipitate; 1 pt total = 2 pts)

Scoring: (a) 2 pts; (b) 2 pts; (c) 2 pts; +1 overall clarity = 7 pts total

Question 5: Net Ionic Equations (8 points)

(a) Complete ionic equation (2 points):

$$\text{Ag}^+(aq) + \text{NO}_3^-(aq) + \text{Na}^+(aq) + \text{Cl}^-(aq) \rightarrow \text{AgCl}(s) + \text{Na}^+(aq) + \text{NO}_3^-(aq)$$

(1 pt for dissociating aqueous compounds; 1 pt for keeping AgCl(s) intact)

(b) Spectator ions (1 point):

Na^+ and NO_3^- are spectator ions—they appear unchanged on both sides. (1 pt)

(c) Net ionic equation (2 points):

Cancel spectator ions (Na^+ and NO_3^-):

$$\text{Ag}^+(aq) + \text{Cl}^-(aq) \rightarrow \text{AgCl}(s)$$

(1 pt for canceling spectators; 1 pt for correct net ionic equation)

(d) Particulate diagram (3 points):

Before mixing: Show separate Ag^+ (⊕), NO_3^- (○), Na^+ (●), Cl^- (⊖) dispersed in solution. (1 pt)

After mixing: Show AgCl(s) precipitate as clustered ⊕⊖ pairs (solid), with Na^+ (●) and NO_3^- (○) still dispersed (spectators remain in solution). (2 pts: 1 pt for precipitate; 1 pt for spectators remaining)

Scoring: (a) 2 pts; (b) 1 pt; (c) 2 pts; (d) 3 pts

Question 6: Titration Curve and Stoichiometry (9 points)

(a) Volume at equivalence point (1 point):

From the graph, the equivalence point occurs at **20.0 mL** of NaOH added. (1 pt)

(b) Moles of NaOH (2 points):

$$n = M \times V = 0.100 \text{ M} \times 0.0200 \text{ L} = 0.00200 \text{ mol} = 2.00 \times 10^{-3} \text{ mol}$$

(1 pt for formula and conversion to L; 1 pt for answer)

(c) Moles of CH_3COOH (2 points):

From the balanced equation, mole ratio is 1:1 (1 CH_3COOH : 1 NaOH). (1 pt)

$$\text{Moles CH}_3\text{COOH} = 2.00 \times 10^{-3} \text{ mol NaOH} \times \frac{1 \text{ mol CH}_3\text{COOH}}{1 \text{ mol NaOH}} = 2.00 \times 10^{-3} \text{ mol}$$

(1 pt for calculation)

(d) Molarity of CH_3COOH (2 points):

$$M = \frac{n}{V} = \frac{2.00 \times 10^{-3} \text{ mol}}{0.0250 \text{ L}} = 0.0800 \text{ M}$$

(1 pt for formula; 1 pt for answer)

(e) pH > 7 at equivalence point (2 points):

At the equivalence point, all CH_3COOH (weak acid) has reacted with NaOH (strong base) to form **CH_3COONa** (sodium acetate). The acetate ion (CH_3COO^-) is the conjugate base of a weak acid and undergoes **hydrolysis** (reaction with water):

$$\text{CH}_3\text{COO}^-(aq) + \text{H}_2\text{O}(l) \rightarrow \text{CH}_3\text{COOH}(aq) + \text{OH}^-(aq)$$

This produces OH^- ions, making the solution **basic (pH > 7)**. (1 pt for acetate hydrolysis; 1 pt for OH^- production)

Scoring: (a) 1 pt; (b) 2 pts; (c) 2 pts; (d) 2 pts; (e) 2 pts

Question 7: Percent Yield (7 points)

(a) Theoretical yield of NH_3 (4 points):

Step 1: Convert g N_2 to mol N_2:

$$n_{\text{N}_2} = \frac{100.0 \text{ g}}{28.02 \text{ g/mol}} = 3.569 \text{ mol N}_2$$

(1 pt)

Step 2: Use mole ratio (1 N_2 : 2 NH_3):

$$n_{\text{NH}_3} = 3.569 \text{ mol N}_2 \times \frac{2 \text{ mol NH}_3}{1 \text{ mol N}_2} = 7.138 \text{ mol NH}_3$$

(1 pt)

Step 3: Convert mol NH_3 to g NH_3:

$$\text{mass NH}_3 = 7.138 \text{ mol} \times 17.03 \text{ g/mol} = 121.5 \text{ g}$$

(1 pt for calculation; 1 pt for final answer with units)

(b) Percent yield (2 points):

$$\text{Percent Yield} = \frac{\text{actual}}{\text{theoretical}} \times 100\% = \frac{85.0 \text{ g}}{121.5 \text{ g}} \times 100\% = 69.96\% \approx 70.0\%$$

(1 pt for formula; 1 pt for answer)

(c) Reasons for lower actual yield (1 point):

Two reasons (0.5 pt each):

- **Incomplete reaction:** Not all reactants may convert to products (equilibrium, side reactions)
- **Product loss during collection/purification:** NH_3 may escape as gas, adhere to container walls, or be lost during filtration/transfer
- (Other valid: impure reactants, measurement errors, competing side reactions)

Scoring: (a) 4 pts (steps 1, 2, 3, final); (b) 2 pts; (c) 1 pt

Question 8: Solution Stoichiometry (7 points)

(a) Moles of $AgNO_3$ (2 points):

$$n = M \times V = 0.200 \text{ M} \times 0.0500 \text{ L} = 0.0100 \text{ mol}$$

(1 pt for conversion to L; 1 pt for answer)

(b) Moles of AgCl (2 points):

From the equation, mole ratio is 1:1 (1 $AgNO_3$: 1 AgCl). (1 pt)

$$\text{Moles AgCl} = 0.0100 \text{ mol AgNO}_3 \times \frac{1 \text{ mol AgCl}}{1 \text{ mol AgNO}_3} = 0.0100 \text{ mol}$$

(1 pt)

(c) Mass of AgCl (3 points):

$$\text{mass} = n \times \text{MM} = 0.0100 \text{ mol} \times 143.32 \text{ g/mol} = 1.433 \text{ g} \approx 1.43 \text{ g}$$

(1 pt for formula; 1 pt for calculation; 1 pt for answer with units)

Scoring: (a) 2 pts; (b) 2 pts; (c) 3 pts

Question 9: Oxidation Numbers and Redox (6 points)

(a) Oxidation numbers (2 points):

- **$Zn(s)$:** 0 (free element, rule 1)
- **$Cu^{2+}(aq)$:** +2 (monatomic ion = charge, rule 2)
- **$Zn^{2+}(aq)$:** +2
- **$Cu(s)$:** 0

(1 pt for all reactants; 1 pt for all products)

(b) Oxidation and reduction (2 points):

Oxidized: Zn (oxidation number increases from 0 → +2; loses $2e^-$). (1 pt)

Reduced: Cu^{2+} (oxidation number decreases from +2 → 0; gains $2e^-$). (1 pt)

(c) Half-reactions (2 points):

Oxidation: $Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$ (1 pt)

Reduction: $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$ (1 pt)

Scoring: (a) 2 pts; (b) 2 pts; (c) 2 pts

Question 10: Conceptual Understanding (5 points)

(a) Coefficients represent moles, not mass (2 points):

Incorrect. (0.5 pt) Coefficients represent the **mole ratio** (or molecule/atom ratio) of reactants and products, **not** the mass ratio. (1 pt) For example, in $2H_2 + O_2 \rightarrow 2H_2O$, the coefficients mean 2 moles H_2 : 1 mole O_2 : 2 moles H_2O. Because different substances have different molar masses, the mass ratio is not the same as the mole ratio (4 g H_2 : 32 g O_2 : 36 g H_2O ≠ 2:1:2). (0.5 pt for mass ratio clarification)

(b) Why balance equations (2 points):

We balance equations to obey the **Law of Conservation of Mass**: matter cannot be created or destroyed in a chemical reaction. (1 pt) A balanced equation ensures that the number of atoms of each element is the same on both sides, reflecting that atoms are rearranged but not lost or gained. Without balancing, stoichiometry calculations would give incorrect mole ratios and product amounts. (1 pt for stoichiometry connection)

(c) Complete vs. net ionic equations (1 point):

A **complete ionic equation** shows all aqueous compounds dissociated into ions, including spectator ions. A **net ionic equation** removes spectator ions and shows only the species that actually participate in the reaction. (0.5 pt) The net ionic equation is more useful because it highlights the **essence** of the reaction (e.g., $Ag^+ + Cl^- \rightarrow AgCl$) and shows what's chemically changing, making it easier to understand precipitation, acid-base, and redox reactions. (0.5 pt)

Scoring: (a) 2 pts; (b) 2 pts; (c) 1 pt