

BRIGHT SCHOLARS

AP+ EXAM PREP WORKBOOKS

CHEMISTRY

REVIEW WORKBOOK

2026-27 Aligned to the current AP Chemistry course and exam

Understand Matter. Solve Reactions. Think Like a Chemist.

Concept Review • Calculation Practice • Lab Skills • FRQ Strategy • Full-Length Exam

THIS BOOK BELONGS TO

Student Name _____

School / Class _____

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Diagnostic Test

This diagnostic samples all nine units so you can identify strengths and weaknesses before you start unit review. Work at a steady pace. Show all calculation work. When finished, turn to the Complete Worked Answer Key and Score Tracker to plan your first two weeks of study.

Part A: Multiple Choice (30 questions)

- 1 An atom of chlorine-37 contains 17 protons. How many neutrons does it contain?
(A) 17 (B) 18 (C) 20 (D) 37
-
- 2 Which quantity is best described as the weighted average mass of all naturally occurring isotopes of an element?
(A) Mass number (B) Atomic number
(C) Molar volume (D) Average atomic mass
-
- 3 A photoelectron spectrum shows two peaks of equal height at high binding energy and one peak at low binding energy, in a 2:2:1 ratio. This pattern is most consistent with which element?
(A) Boron (B) Nitrogen (C) Fluorine (D) Neon
-
- 4 Which trend correctly describes atomic radius across Period 3, left to right?
(A) Increases due to more shielding (B) Increases due to more energy levels
(C) Stays constant (D) Decreases due to increasing Z_{eff}
-
- 5 Which best explains why first ionization energy of aluminum is slightly lower than magnesium?
(A) Al's valence electron is in a higher-energy 3p subshell, easier to remove than a 3s electron
(B) Al has a larger atomic radius
(C) Al has fewer protons
(D) Mg is a metal and Al is not
-
- 6 Which molecule has the largest dipole moment based on electronegativity difference and molecular geometry?
(A) CO_2 (B) CH_4 (C) CCl_4 (D) H_2O
-
- 7 Which best describes the geometry around a central atom with 3 bonding domains and 1 lone pair?
(A) Tetrahedral (B) Trigonal pyramidal
(C) Trigonal planar (D) Bent
-
- 8 In a Lewis structure, formal charge is used to
(A) identify the most reasonable resonance structure
(B) determine molar mass
(C) calculate bond length
(D) predict boiling point
-

UNIT

1

Atomic Structure and Properties

EXAM WEIGHTING: 7–9%

BIG IDEA

Connect atomic structure to measurable evidence: isotopes, electron configurations, photoelectron spectra, and periodic trends all reflect how electrons are arranged and attracted to the nucleus.

**WHAT YOU WILL MASTER**

- Calculate moles, molar mass, percent composition, and weighted average atomic mass
- Interpret electron configurations and photoelectron spectra
- Explain periodic trends using effective nuclear charge and shielding

**KEY SKILLS / CALCULATIONS**

Mole conversions • isotope averages • electron configuration • PES interpretation • Z_{eff} reasoning

**COMMON AP TRAPS**

Mass number $\neq$ average atomic mass; remove 4s electrons before 3d for transition-metal cations; PES peak height reflects electron count, not binding energy.

Quick Review: Atoms, Isotopes, and Moles

**KNOW IT**

An atom's identity is set by its number of protons (atomic number, Z). Isotopes of an element share the same Z but differ in neutron number, giving different mass numbers (A).

Average atomic mass on the periodic table is a weighted average of all naturally occurring isotopes, weighted by their relative abundance; it is almost never a whole number.

Term	Meaning
Atomic number (Z)	Number of protons; defines the element
Mass number (A)	Protons + neutrons in one specific atom
Isotope	Atoms of the same element with different neutron counts
Mole	6.022×10^{23} particles (Avogadro's number)
Molar mass	Mass in grams of one mole of a substance (g/mol)

A mole is a counting unit, exactly like "a dozen"; it just counts an enormous number of particles so that lab-scale masses connect to particle-scale ratios.

Calculate It: Mole Conversions & % Composition

 CALCULATE IT

Example: Find the mass of 2.50 mol of CO_2 .

G (Given): 2.50 mol CO₂; molar mass CO₂ = 12.01 + 2(16.00) = 44.01 g/mol

U (Units): mol $\rightarrow$ g, using g/mol as the conversion factor

M (Model): mass = moles $\times$ molar mass

S (Solve): $2.50 \text{ mol} \times 44.01 \text{ g/mol} = 110. \text{ g CO}_2$. This is the mass of roughly 1.5×10^{24} CO_2 molecules.

Your turn:

1 Calculate the number of moles in 75.0 g of NaOH.

- 2 Calculate the percent composition by mass of nitrogen in NH_4NO_3 .

Grid area for calculation.

Data Check: Mass Spectrum & Average Atomic Mass

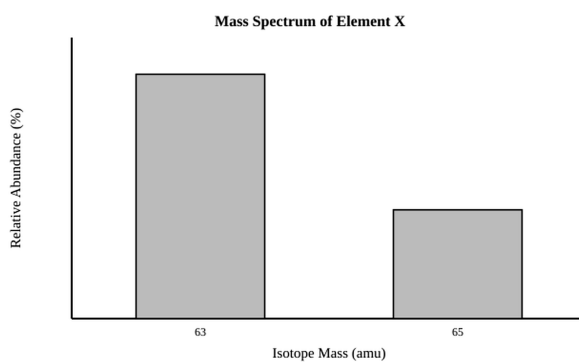


Figure 1.1. Mass spectrum data for Element X. Relative abundances: isotope of mass 63 = 69.2%; isotope of mass 65 = 30.8%.

For CO_2 and H_2O : sketch each shape, draw bond dipole arrows, and state whether the overall molecule is polar. Explain why CO_2 's bond dipoles cancel but H_2O 's do not.

[illegible]

Hybridization Practice

Electron Domains	Hybridization
2	sp
3	sp ²
4	sp ³

Identify the hybridization of the central atom in each: BeCl_2 , BF_3 , CH_4 , NH_3 , H_2O .

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	8												

Justify It: Bonding & Properties

Claim: NaCl has a much higher melting point than CH₄.

Evidence:

Reasoning (compare bond/IMF strength):

[illegible]

COMPLETE WORKED ANSWER KEY

DIAGNOSTIC TEST: WORKED ANSWERS

Part B: Calculations

1. Mass of 3.50 mol CaCO_3

Relationship: mass = moles $\times$ molar mass

Molar mass: $\text{CaCO}_3 = 40.08 + 12.01 + 3(16.00) = 100.09 \text{ g/mol}$

Substitution: $3.50 \text{ mol} \times 100.09 \text{ g/mol} = 350.3 \text{ g}$

Final answer: 350 g CaCO_3 (3 significant figures)

2. Percent composition of oxygen in $\text{Al}_2(\text{SO}_4)_3$

Molar mass: $2(26.98) + 3(32.06) + 12(16.00) = 342.14 \text{ g/mol}$

Oxygen mass: $12(16.00) = 192.00 \text{ g/mol}$

Percent oxygen: $(192.00 / 342.14) \times 100 = 56.12\%$

Final answer: 56.1% oxygen by mass

3. Combined gas law

Relationship: $P_1V_1/T_1 = P_2V_2/T_2$

Substitution: $V_2 = (1.10 \text{ atm})(4.20 \text{ L})(350 \text{ K}) / [(1.50 \text{ atm})(298 \text{ K})]$

Final answer: 3.62 L

4. Molarity of NaCl solution

Moles NaCl: $14.6 \text{ g} / 58.44 \text{ g/mol} = 0.2498 \text{ mol}$

Molarity: $0.2498 \text{ mol} / 0.5000 \text{ L} = 0.4996 \text{ M}$

Final answer: 0.500 M NaCl

5. Dilution of HCl

Relationship: $M_1V_1 = M_2V_2$

Substitution: $V_1 = (0.50 \text{ M})(250.0 \text{ mL}) / 6.0 \text{ M} = 20.83 \text{ mL}$

Final answer: 21 mL of 6.0 M HCl (2 significant figures)

6. Stoichiometry of ammonia formation

Mole ratio: 1 mol N_2 produces 2 mol NH_3

Substitution: $5.00 \text{ mol } \text{N}_2 \times (2 \text{ mol } \text{NH}_3 / 1 \text{ mol } \text{N}_2)$

Final answer: 10.0 mol NH_3

7. Experimental specific heat

Relationship: $c = q / (m \Delta T)$

Substitution: $c = 418 \text{ J} / [(25.0 \text{ g})(4.00^\circ\text{C})]$

Final answer: 4.18 J/(g $\cdot$ °C), matching the accepted value for liquid water

8. pH from hydronium concentration

Relationship: $\text{pH} = -\log[\text{H}_3\text{O}^+]$

Substitution: $\text{pH} = -\log(2.5 \times 10^{-4})$

Final answer: pH = 3.60

9. First-order half-life

Relationship: $t_{1/2} = 0.693/k$

Substitution: $0.693 / 0.045 \text{ s}^{-1} = 15.4 \text{ s}$

Final answer: 15 s (2 significant figures)

10. Gibbs free energy

Unit conversion: $\Delta S = -198 \text{ J/K} = -0.198 \text{ kJ/K}$

Relationship: $\Delta G = \Delta H - T\Delta S$

Substitution: $\Delta G = -92 \text{ kJ} + (298 \text{ K})(-0.198 \text{ kJ/K}) = -33.0 \text{ kJ}$

Final answer: -33.0 kJ; the process is thermodynamically favorable under the stated conditions

Part C: Particle Diagram Questions

1. NaCl dissolving in water

Show equal numbers of separated Na^+ and Cl^- ions, not touching in a lattice.

Around Na^+ , orient the oxygen end of each bent water molecule toward the cation.

Around Cl^- , orient the hydrogen ends of water molecules toward the anion.

Label all ions aqueous and show water surrounding each ion in a hydration shell.

2. Gas at high temperature versus low temperature

Use identical containers and the same number of particles in both.

Particle spacing is comparable at the same volume, but velocity arrows are longer at high temperature and shorter at low temperature.

The high-temperature sample has greater average kinetic energy and a wider range of speeds.

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

Before mixing: Ag^+ and Cl^- are separated aqueous ions; any spectator ions remain dispersed.

After reaction: Ag^+ and Cl^- are joined in a packed solid cluster at the bottom as AgCl(s) . Spectator ions remain separated in solution.

The solid must contain Ag and Cl in a 1:1 ratio.

4. Weak acid HA in water

Show mostly intact HA molecules, with much smaller and equal numbers of H_3O^+ and A^- .

The equal $\text{H}_3\text{O}^+:\text{A}^-$ count follows the 1:1 dissociation stoichiometry.

Do not show complete ionization; a weak acid remains predominantly molecular at equilibrium.

Part D: Data and Graph Questions

D1. PES spectrum

The peak ratio is consistent with $1s^2 2s^2 2p^6$, for a total of 10 electrons. Element X is most likely neon, Ne.

D2. Maxwell-Boltzmann distribution

At higher temperature, the curve has a lower peak, its most probable speed shifts to the right, and the distribution becomes broader with a longer high-speed tail. The total area under the curve remains the same because the number of molecules is unchanged.

D3. Reaction energy diagram

Activation energy is the vertical energy difference from the reactant energy level to the top of the curve (transition state). ΔH is the vertical difference from reactants to products. The products lie below the reactants, so ΔH is negative and the reaction is exothermic.

D4-D5

D4. Determining reaction order

The nonlinear $[\text{A}]$ -versus-time curve rules out zero-order behavior. Test $\ln[\text{A}]$ versus time for first order and $1/[\text{A}]$ versus time for second order; the linear plot identifies the order.

D5. Titration equivalence point

The equivalence point is approximately 25.0 mL of NaOH. It is located in the region of the largest pH change, between the low-pH buffer region and the high-pH excess-base region. Reporting about 24.5-25.0 mL with a valid steepest-rise explanation is acceptable.

D6. Galvanic cell