AP CHEMISTRY

UNIT 1 PRACTICE TEST

TEST FORM 5

ATOMIC STRUCTURE AND PROPERTIES

60 Multiple-Choice Questions • Seven Free-Response Questions

Calculator Permitted

General Test Instructions

This examination contains only AP Chemistry Unit 1 content. It is designed as a full-length, high-volume unit assessment rather than a content-balanced simulation of the complete AP Chemistry course.

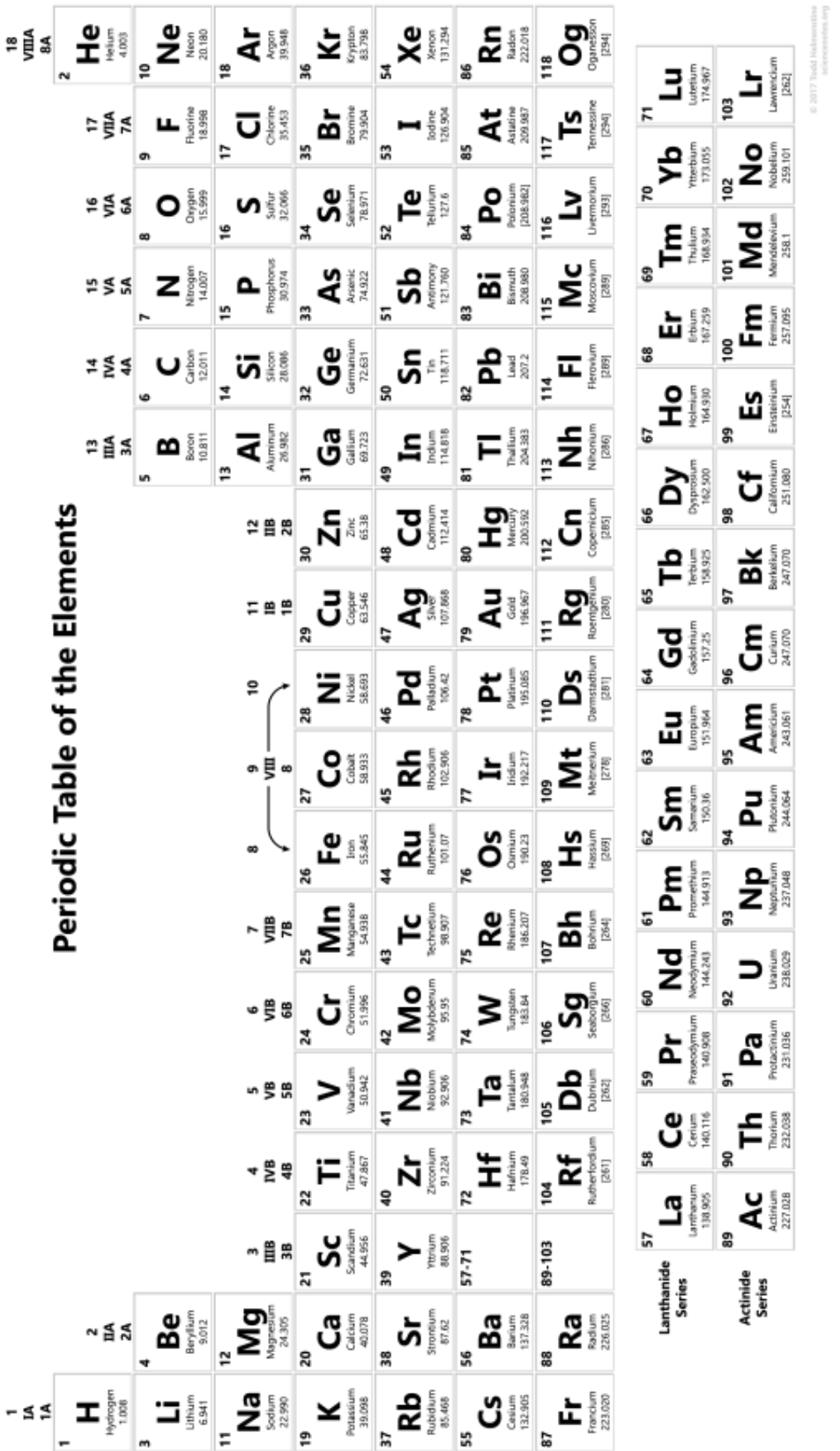
Section I: 60 multiple-choice questions; 90 minutes; choose one answer (A–D) for each question. There is no penalty for an incorrect answer.

Section II: seven free-response questions; 105 minutes; Questions 1–3 are long (10 points each) and Questions 4–7 are short (4 points each). Total: 46 points.

A calculator is permitted throughout this practice test. Show formulas, substitutions, units, significant figures, and chemically specific reasoning in the free-response section.

Student pages contain no answers or scoring commentary. Remove the teacher section before assigning the test.

Periodic Table



Section I: Multiple Choice

Time - 90 minutes

60 Questions • Calculator Permitted

Select the one best answer for each question. Record all answers on the blank grid following Question 60.

1. A student prepares a reference table for $Cu(NO_3)_2$?
(A) 171.57 g mol^{-1}
(B) 205.59 g mol^{-1}
(C) 187.57 g mol^{-1}
(D) 93.78 g mol^{-1}

2. A sample of Ag_2SO_4 contains 0.200 mol of formula units. What is the sample mass?
(A) 0.000641 g
(B) 31.2 g
(C) 624 g
(D) 62.4 g

3. How many O atoms are contained in 0.0550 mol of $Zn_3(PO_4)_2$?
(A) 3.31×10^{22}
(B) 2.65×10^{23}
(C) 4.82×10^{24}
(D) 2.65×10^{22}

4. The formula of a hydrate is $CuSO_4 \cdot 5H_2O$. What fraction of its molar mass is contributed by water?
(A) 63.9%
(B) 2.0%
(C) 36.1%
(D) 6.4%

5. A particle-count comparison is made for the four samples. Which ranks first?
(A) 0.0850 mol Xe
(B) 0.0480 mol Br_2
(C) 0.0260 mol P_4
(D) 0.0350 mol H_2O_2

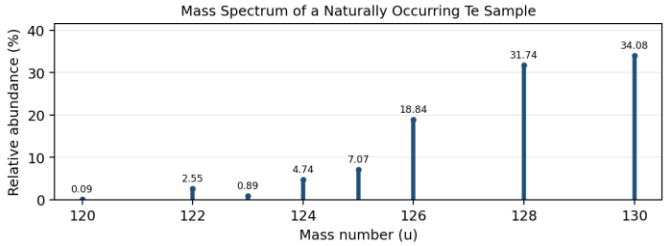
6. Which dimensional-analysis setup correctly determines moles of Cu in 12.0 g of $Cu(NO_3)_2$?
(A) 12.0 g $Cu(NO_3)_2$ × (1 mol $Cu(NO_3)_2$/187.57 g $Cu(NO_3)_2$) × (1 mol Cu/1 mol $Cu(NO_3)_2$)
(B) 12.0 g $Cu(NO_3)_2$ × (187.57 g $Cu(NO_3)_2$/1 mol $Cu(NO_3)_2$) × (1 mol Cu/1 mol $Cu(NO_3)_2$)
(C) 12.0 g $Cu(NO_3)_2$ × (1 mol $Cu(NO_3)_2$/187.57 g $Cu(NO_3)_2$) × (63.55 g Cu/1 mol $Cu(NO_3)_2$)
(D) 12.0 g $Cu(NO_3)_2$ × (1 mol Cu/187.57 mol $Cu(NO_3)_2$)

7. An unknown pure substance has a mass of 15.693 g for 0.1600 mol. What is its molar mass?
(A) 98.1 g mol^{-1}
(B) 2.51 g mol^{-1}
(C) 9.81 g mol^{-1}
(D) 15.69 g mol^{-1}

8. What mass of O is present in a 16.0 g sample of pure Ag_2SO_4?
(A) 12.7 g
(B) 0.821 g
(C) 3.28 g
(D) 32.8 g

Questions 9–15 refer to the mass spectrum below.

All labeled ions in the displayed spectrum are singly charged. Peak height is proportional to isotopic abundance.



9. Use the peak positions and abundances to calculate the average atomic mass of Te.
(A) 124.75 u
(B) 130.00 u
(C) 127.70 u
(D) 129.70 u

10. The mass-130 peak contributes 34.08% of the integrated signal from 20,000 total Te ions. What is its expected ion count?
(A) 18
(B) 6,816
(C) 2,500
(D) 13,184

11. A separate table lists all Te isotope abundances except the value for mass number 130. What abundance completes the table?
(A) 65.92%
(B) 34.08%
(C) 4.26%
(D) 99.91%

12. Which statement is supported directly by the Te mass spectrum?
(A) Every Te atom has a mass of 127.70 u.
(B) The sample contains 8 naturally occurring isotopes with different abundances.
(C) The isotope with mass number 130 has more protons than the other isotopes.
(D) Peak height gives the number of electrons in each Te atom.

13. A processed Te sample is enriched in the isotope with mass number 130. Relative to the natural sample, what happens to its average atomic mass?
(A) It remains exactly unchanged.
(B) It decreases.
(C) It becomes equal to the smallest isotope mass.
(D) It increases.

Section I Answer Grid

Mark one response for every question. This grid is intentionally blank.

Q	Response	Q	Response	Q	Response
1	◯ A ◯ B ◯ C ◯ D	21	◯ A ◯ B ◯ C ◯ D	41	◯ A ◯ B ◯ C ◯ D
2	◯ A ◯ B ◯ C ◯ D	22	◯ A ◯ B ◯ C ◯ D	42	◯ A ◯ B ◯ C ◯ D
3	◯ A ◯ B ◯ C ◯ D	23	◯ A ◯ B ◯ C ◯ D	43	◯ A ◯ B ◯ C ◯ D
4	◯ A ◯ B ◯ C ◯ D	24	◯ A ◯ B ◯ C ◯ D	44	◯ A ◯ B ◯ C ◯ D
5	◯ A ◯ B ◯ C ◯ D	25	◯ A ◯ B ◯ C ◯ D	45	◯ A ◯ B ◯ C ◯ D
6	◯ A ◯ B ◯ C ◯ D	26	◯ A ◯ B ◯ C ◯ D	46	◯ A ◯ B ◯ C ◯ D
7	◯ A ◯ B ◯ C ◯ D	27	◯ A ◯ B ◯ C ◯ D	47	◯ A ◯ B ◯ C ◯ D
8	◯ A ◯ B ◯ C ◯ D	28	◯ A ◯ B ◯ C ◯ D	48	◯ A ◯ B ◯ C ◯ D
9	◯ A ◯ B ◯ C ◯ D	29	◯ A ◯ B ◯ C ◯ D	49	◯ A ◯ B ◯ C ◯ D
10	◯ A ◯ B ◯ C ◯ D	30	◯ A ◯ B ◯ C ◯ D	50	◯ A ◯ B ◯ C ◯ D
11	◯ A ◯ B ◯ C ◯ D	31	◯ A ◯ B ◯ C ◯ D	51	◯ A ◯ B ◯ C ◯ D
12	◯ A ◯ B ◯ C ◯ D	32	◯ A ◯ B ◯ C ◯ D	52	◯ A ◯ B ◯ C ◯ D
13	◯ A ◯ B ◯ C ◯ D	33	◯ A ◯ B ◯ C ◯ D	53	◯ A ◯ B ◯ C ◯ D
14	◯ A ◯ B ◯ C ◯ D	34	◯ A ◯ B ◯ C ◯ D	54	◯ A ◯ B ◯ C ◯ D
15	◯ A ◯ B ◯ C ◯ D	35	◯ A ◯ B ◯ C ◯ D	55	◯ A ◯ B ◯ C ◯ D
16	◯ A ◯ B ◯ C ◯ D	36	◯ A ◯ B ◯ C ◯ D	56	◯ A ◯ B ◯ C ◯ D
17	◯ A ◯ B ◯ C ◯ D	37	◯ A ◯ B ◯ C ◯ D	57	◯ A ◯ B ◯ C ◯ D
18	◯ A ◯ B ◯ C ◯ D	38	◯ A ◯ B ◯ C ◯ D	58	◯ A ◯ B ◯ C ◯ D
19	◯ A ◯ B ◯ C ◯ D	39	◯ A ◯ B ◯ C ◯ D	59	◯ A ◯ B ◯ C ◯ D
20	◯ A ◯ B ◯ C ◯ D	40	◯ A ◯ B ◯ C ◯ D	60	◯ A ◯ B ◯ C ◯ D

Section II: Free Response

Time - 105 minutes

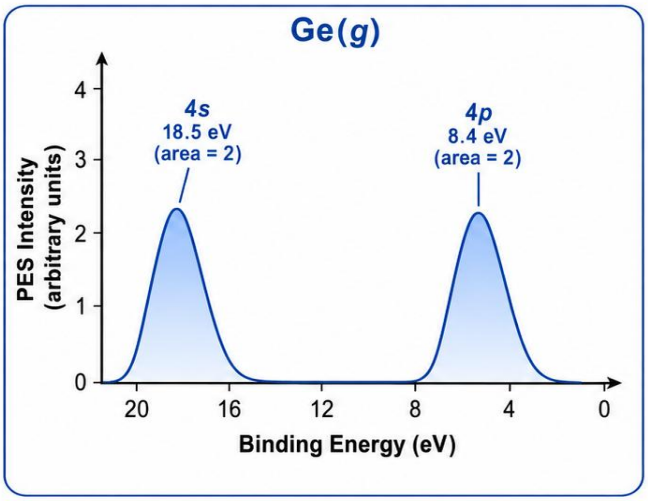
Seven Questions • 46 points total • Calculator Permitted

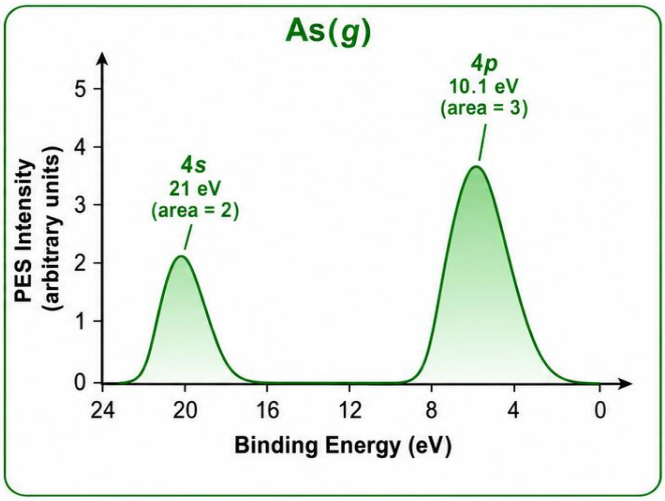
Questions 1–3 are long free-response questions worth 10 points each. Questions 4–7 are short free-response questions worth 4 points each. Show sufficient work and chemically specific justification.

Question 3 (Long, 10 points)

The table gives valence-region PES data for gaseous Ge and As atoms. Relative area is proportional to electron count.

Ge(*g*)			As(*g*)		
Orbital	Binding Energy (eV)	Relative Area	Orbital	Binding Energy (eV)	Relative Area
4*s*	18.5 eV	2	4*s*	21 eV	2
4*p*	8.4 eV	2	4*p*	10.1 eV	3





(a) Write the electron configuration represented by the displayed peaks for Ge.

(b) Write the electron configuration represented by the displayed peaks for As.

(c) Identify the least tightly bound subshell in As and cite evidence from the data.

(d) Explain why the 4p binding energy is greater in As than the corresponding outer-subshell binding energy in Ge.

Question 3, continued

(e) Predict which atom, Ge or As, has the larger atomic radius. Justify.

(f) Predict which atom, Ge or As, generally has the greater first ionization energy. Justify using the PES data.

(g) Determine the number of unpaired electrons in ground-state As.

(h) If a gaseous Ge atom is ionized to form Ge^{+}, predict how the lowest-binding-energy PES peak changes.

(i) The formula Ca_3As_2 contains an ion derived from one of the elements. Explain why an ionic formula represents a ratio rather than a discrete molecule.

Section II Scoring Guidelines and Worked Solutions

Award points only for work satisfying the stated criterion. Equivalent correct reasoning and mathematically consistent alternative methods earn credit.

Question 1: Quantitative Analysis of a Two-Component Solid (10 points)

A dry 9.000 g sample contains only Cu_2O and CuO. Independent particle-counting data show that the sample contains 0.0800 mol of total formula units. Use $M(Cu_2O) = 143.10\ g\ mol^{-1}$ and $M(CuO) = 79.55\ g\ mol^{-1}$.

Part	Points	Scoring criterion
(a)	2	One point for each independent equation.
(b)	2	One point for each correct component amount with units.
(c)	1	One point for the correct setup and result.
(d)	1	One point for converting total moles to formula units.
(e)	1	One point for using each formula subscript and Avogadro's constant correctly.
(f)	1	One point for counts totaling 20 and matching the calculated ratio within one particle.
(g)	1	One point for a correct direction tied to the component molar masses.
(h)	1	One point for a chemically relevant independent measurement.

Worked Solution

(a) x + y = 0.0800; 143.10x + 79.55y = 9.000.

(b) x = 0.04148 mol Cu2O and y = 0.03852 mol CuO.

(c) Mass Cu2O = (0.04148)(143.10) = 5.9357 g; mass percent = (5.9357/9.000) × 100 = 65.95%.

(d) (0.0800 mol)(6.02×10^{23} formula units mol^{-1}) = 4.82×10^{22} formula units.

(e) [(1)(0.04148) + (1)(0.03852)](6.02×10^{23}) = 4.82×10^{22} oxygen atoms.

(f) 20(x/0.0800) = 10.37; draw about 10 units of Cu2O and 10 units of CuO.

(g) A high average molar mass assigns too much of the sample to the heavier component (Cu2O). Therefore the calculated mass percent of Cu2O increases relative to the true value.

(h) Accept an elemental mass-percent measurement, a component-selective spectroscopic signal, or another measurement that depends differently on the two compounds.

Question 2: Isotope Evidence and Formula Composition (10 points)

A newly characterized element Z has the isotopic data shown below. All ions used for the reported spectrum are singly charged. mass 151: 40.00%; mass 153: 60.00%.

Part	Points	Scoring criterion
(a)	2	One point for a weighted-average setup and one point for the correct value.
(b)	1	One point for applying the fractional abundance.
(c)	1	One point for dividing mass by charge.
(d)	1	One point for distinguishing an abundance-weighted mean from isotope masses.
(e)	1	One point for the predicted charge.
(f)	1	One point for a charge-balanced lowest ratio.
(g)	2	One point for the formula-mass setup and one point for the correct percentage.
(h)	1	One point for the correct direction and weighted-average reasoning.

Worked Solution

(a) (151)(0.4000) + (153)(0.6000) = 152.200 u.

(b) (0.6000)(20,000) = 12,000 ions.

(c) m/z = 151/2 = 75.5.

(d) The average is a weighted mean for a population; individual atoms have one of the discrete isotope masses.

(e) Z is expected to form Z^{2+} by losing 2 valence electron(s).

(f) ZO.

(g) M = 1(152.200) + 1(16.00) = 168.200 g mol^{-1}; percent Z = 1(152.200)/168.200 × 100 = 90.49%.

(h) Because 153 u is above the original mean, enrichment shifts the mean upward.

Question 7: Electron Configuration and Magnetic Behavior (4 points)

Consider the ground-state ion Mn^{2+}.

Part	Points	Scoring criterion
(a)	1	One point for the correct ion configuration.
(b)	1	One point for the correct count using Hund’s rule.
(c)	1	One point for the correct classification.
(d)	1	One point for linking the classification to paired or unpaired electrons.

Worked Solution

(a) [Ar] $3d^5$.

(b) 5.

(c) paramagnetic.

(d) At least one electron is unpaired, so the ion is attracted to a magnetic field.

Assessment Blueprint

Unit 1 topic	MCQ count	MCQ numbers	FRQ links
1.1 Moles and Molar Mass	7	1, 2, 3, 4, 5, 6, 7	4
1.3 Elemental Composition of Pure Substances	8	8, 16, 17, 18, 19, 20, 21, 22	2, 5
1.2 Mass Spectroscopy of Elements	7	9, 10, 11, 12, 13, 14, 15	2
1.4 Composition of Mixtures	7	23, 24, 25, 26, 27, 28, 29	1
1.5 Atomic Structure and Electron Configuration	9	30, 31, 32, 33, 34, 35, 36, 37, 38	3, 7
1.6 Photoelectron Spectroscopy	8	39, 40, 41, 42, 43, 44, 45, 46	3
1.7 Periodic Trends	8	47, 48, 49, 50, 51, 52, 53, 54	3, 6
1.8 Valence Electrons and Ionic Compounds	6	55, 56, 57, 58, 59, 60	2, 3, 6

Difficulty Distribution

Foundational: 22 • Typical AP-style: 28 • Challenging: 10

Quality-Control Summary

Check	Result
MCQ count	60
FRQ count	7: three long and four short
FRQ points	46 total (10 + 10 + 10 + 4 + 4 + 4 + 4)
Answer balance	15 A, 15 B, 15 C, 15 D
Unit coverage	All eight Unit 1 topics represented
Student/teacher separation	No answers, explanations, or scoring criteria in student pages
Notation	Word subscripts/superscripts; Unicode arrows and minus signs where applicable
Pagination	No page numbers; fixed examination header in Times New Roman 8 pt
Originality	Independently authored chemical systems, values, distractors, datasets, diagrams, and FRQ scenarios