FREE PREVIEW

AP CHEMISTRY

FULL-LENGTH PRACTICE EXAMINATION 5

Printable simulation of the current examination content

Original questions designed to closely reflect the format, style, complexity, data presentation, and reasoning demands of current AP Chemistry examinations

60 Multiple-Choice Questions • 7 Free-Response Questions Complete Answer Key, Scoring Guidelines, and Detailed Solutions

Section I	60 multiple-choice questions	90 minutes	50%
Section II	7 free-response questions	105 minutes	50%

Calculator permitted in both sections. Equations, constants, and a periodic table are provided.

Section I: Multiple Choice

Time—1 hour and 30 minutes

60 Questions • Calculator Permitted • 50% of Examination Score

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

1. Which ground-state orbital diagram is consistent with a nitrogen atom and Hund's rule?
(A) Two 2p electrons pair in one orbital before the third occupies another orbital.
(B) The three 2p electrons occupy three separate 2p orbitals with parallel spins.
(C) All five valence electrons occupy the 2p subshell.
(D) The 2s electrons occupy separate orbitals with parallel spins.

2. Why is the atomic radius of K larger than that of Br?
(A) K has a larger nuclear charge than Br.
(B) Br has fewer occupied electron shells than K.
(C) The valence electrons of K occupy the n = 4 shell while experiencing a smaller effective nuclear charge than the valence electrons of Br.
(D) The 4s electrons of K experience no shielding.

3. What is the frequency of electromagnetic radiation with wavelength 620 nm?
(A) $2.07 \times 10^{-15}\ s^{-1}$
(B) $1.86 \times 10^{11}\ s^{-1}$
(C) $4.84 \times 10^{5}\ s^{-1}$
(D) $4.84 \times 10^{14}\ s^{-1}$

Questions 4–6 refer to the following successive ionization-energy data for element X.

The values are reported in $kJ \cdot mol^{-1}$.

Ionization	IE_1	IE_2	IE_3	IE_4
Energy ($kJ \cdot mol^{-1}$)	578	1,817	2,745	11,577

4. What does the large increase between IE_3 and IE_4 indicate about a neutral atom of X?
(A) It has one valence electron.
(B) It has two valence electrons.
(C) It has three valence electrons.
(D) It has four valence electrons.

5. The location of the large ionization-energy jump identifies X as which period-3 element?
(A) Mg
(B) Al
(C) Si
(D) P

6. Which electron configuration is expected for the most common monatomic ion of X?
(A) $1s^2\ 2s^2\ 2p^6\ 3s^2$
(B) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$
(C) $1s^2\ 2s^2\ 2p^6$
(D) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

7. Which comparison of the first ionization energies of Mg and Al is correct?
(A) The value for Mg is greater because the electron removed from Al is a higher-energy 3p electron.
(B) The value for Al is greater because Al has a filled 3s subshell.
(C) The values are identical because both atoms are in period 3.
(D) The value for Mg is greater because Mg has fewer protons.

8. In a lowest-formal-charge Lewis structure for ClO_3^-, how many equivalent resonance structures can be drawn?
(A) 1
(B) 2
(C) 3
(D) 4

9. What molecular geometry is predicted for BrF_3?
(A) Trigonal planar
(B) Trigonal pyramidal
(C) T-shaped
(D) Tetrahedral

10. Which statement best describes CH_2Cl_2?
(A) It is tetrahedral and nonpolar because all tetrahedral molecules are nonpolar.
(B) It is trigonal planar and polar.
(C) It is bent and nonpolar.
(D) It is tetrahedral and polar because the bond dipoles do not cancel.

11. The electrostatic potential-energy model is applied to LiF(s) and KBr(s). Which comparison follows from the model?
(A) KBr, because K and Br have more electrons.
(B) KBr, because its ions have larger radii.
(C) LiF, because Li^+ and F^- have smaller ionic radii.
(D) The magnitudes are equal because both compounds contain ions with charges of ±1.

12. Why can brass conduct electricity and be shaped without shattering?
(A) Its valence electrons are delocalized, and the metal-ion layers can shift while metallic attraction is maintained.
(B) It contains discrete polar molecules that rotate under stress.
(C) Its ions are fixed by rigid directional covalent bonds.
(D) It contains alternating cations and anions that repel after shifting.

Section I Answer Grid

Fill one response for each question.

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

Question 2 (Long, 10 points)

Crystal violet, $CV^+(aq)$, reacts with $OH^-(aq)$ to form a colorless product. In each trial, $[OH^-]$ is much greater than $[CV^+]$ and changes negligibly. A student monitors the absorbance at the wavelength of maximum absorption for CV^+ using a 1.00 cm cuvette. For a trial with $[OH^-] = 0.100$ M, the following data are obtained.

Time (s)	**0**	**60**	**120**	**180**	**240**
Absorbance	0.600	0.444	0.329	0.244	0.181

(a) Explain why absorbance can be used as a measure of $[CV^+]$ during the reaction.

(b) State which plot—absorbance versus time, ln(absorbance) versus time, or 1/absorbance versus time—should be linear if the disappearance is pseudo-first order in CV^+.

(c) Use the data at 0 s and 240 s to calculate the pseudo-first-order rate constant k'.

(d) Calculate the half-life of CV^+ under these conditions.

Continue your response to Question 2 on this page.

(e) Predict the absorbance at 300 s.

(f) A second trial uses 0.200 M OH^- and gives $k' = 1.00 \times 10^{-2}\ s^{-1}$. Determine the reaction order with respect to OH^-.

(g) Write the full rate law in terms of $[CV^+]$ and $[OH^-]$.

Continue your response to Question 2 on this page.

(h) Calculate the bimolecular rate constant k and give its units.

(i) A student uses a cuvette with fingerprints on its clear faces. Predict how the calculated [CV^+] values are affected and justify your answer.

(j) Predict the effect of increasing temperature on the magnitude of k and justify the prediction using collision-energy ideas.

TEACHER MATERIALS

DO NOT REVIEW UNTIL THE EXAMINATION IS COMPLETE

Section I Answer Key and Explanations
Section II Scoring Guidelines and Worked Solutions
Examination Blueprint and Quality-Control Summary

Section I Answer Key

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

Answer-position audit: A = 15, B = 15, C = 15, D = 15. The sequence is intentionally irregular.

Section I Explanations

Each explanation identifies the controlling chemical principle and the principal misconception represented by the distractors.

1. B The three 2p electrons occupy three separate 2p orbitals with parallel spins.

Nitrogen has $2s^2 2p^3$. Hund's rule places the three 2p electrons singly, with parallel spins, in the three degenerate p orbitals.

2. C The valence electrons of K occupy the n = 4 shell while experiencing a smaller effective nuclear charge than the valence electrons of Br.

Both atoms use the fourth principal shell, but effective nuclear charge increases across the period from K to Br, drawing Br's valence electrons closer.

3. D 4.84×10^{14} s^{-1}

$\nu = c/\lambda = (2.998 \times 10^8\ m{\cdot}s^{-1})/(620 \times 10^{-9}\ m) = 4.84 \times 10^{14}\ s^{-1}$.

4. C It has three valence electrons.

After three electrons are removed, the next electron is a core electron and requires far more energy; therefore X has three valence electrons.

5. B Al

A period-3 element with three valence electrons is aluminum, and the listed ionization energies match that pattern.

6. C $1s^2\ 2s^2\ 2p^6$

Al loses its three n = 3 valence electrons to form Al^{3+}, which has the neon electron configuration.

7. A The value for Mg is greater because the electron removed from Al is a higher-energy 3p electron.

Mg loses a 3s electron, whereas Al loses its single, higher-energy 3p electron; that subshell change outweighs the increase in nuclear charge.

8. C 3

The single Cl–O bond carrying the negative formal charge can be placed on any one of the three oxygen atoms, producing three equivalent structures.

9. C T-shaped

BrF_3 has five electron domains: three bonding domains and two equatorial lone pairs. The remaining bonds form a T-shaped molecule.

10. D It is tetrahedral and polar because the bond dipoles do not cancel.

Carbon has four bonding domains, so the geometry is tetrahedral. The two C–Cl and two C–H bond dipoles are not symmetrically equivalent and do not cancel.

11. C LiF, because Li^+ and F^- have smaller ionic radii.

The charge products are equal, so the shorter distance between the smaller Li^+ and F^- ions produces stronger electrostatic attraction.

12. A Its valence electrons are delocalized, and the metal-ion layers can shift while metallic attraction is maintained.

Metallic bonding involves mobile delocalized electrons and nondirectional attraction, allowing conduction and deformation.

13. D It is intermediate between typical C–O single- and double-bond lengths.

Resonance delocalizes electron density, giving the C–O bond partial multiple-bond character and an intermediate length.

14. B Y

Liquid Y reaches 760 torr at the higher temperature, so Y has the higher normal boiling point.

15. B Liquid X has the greater vapor pressure and therefore the weaker intermolecular attractions.

At a common temperature, X has the larger vapor pressure. Easier escape from the liquid indicates weaker intermolecular attractions.

16. A It decreases because the vapor pressure equals the lower external pressure at a lower temperature.

Boiling occurs when vapor pressure matches external pressure; a lower target pressure is reached at a lower temperature.

Section II Scoring Guidelines and Worked Solutions

Award whole points only. Unless a criterion states otherwise, a later response may earn credit when it uses a previous result consistently and applies the correct chemistry.

Question 7 — Scoring Guidelines (4 points)

Part	Points	Criteria
(a)	1	Writes $2\ H_2(g) + 4\ OH^-(aq) \rightarrow 4\ H_2O(l) + 4\ e^-$.
(b)	1	Writes $2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(l)$.
(c)	1	Calculates $E°_{cell} = 1.229$ V.
(d)	1	Uses n = 4 to calculate $\Delta G° = -4.74 \times 10^2$ kJ·mol⁻¹rxn.

Verified total: 4 points

Question 7 — Worked Solution

(a) Reverse and double the hydrogen reduction half-reaction: $2\ H_2(g) + 4\ OH^-(aq) \rightarrow 4\ H_2O(l) + 4\ e^-$.

(b) Adding the anode reaction to $O_2 + 2\ H_2O + 4\ e^- \rightarrow 4\ OH^-$ and canceling common species gives $2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(l)$.

(c) $E°_{cell} = E°_{cathode} - E°_{anode(reduction)} = 0.401 - (-0.828) = 1.229$ V.

(d) $\Delta G° = -nFE°_{cell} = -(4)(96{,}500\ C\cdot mol^{-1})(1.229\ J\cdot C^{-1}) = -4.74 \times 10^5\ J\cdot mol^{-1}rxn = -474\ kJ\cdot mol^{-1}rxn$.

Final Examination Blueprint

Question	Section	Unit(s)	Principal topic	Science practice	Type	Difficulty	Answer / points
1	I	1	Orbital occupancy and Hund's rule	Models and representations	conceptual	foundational AP	B
2	I	1	Periodic trends in atomic radius	Argumentation	conceptual	typical AP	C
3	I	1	Wavelength and frequency	Mathematical routines	quantitative	typical AP	D
4	I	1	Successive ionization energies	Model analysis	conceptual	typical AP	C
5	I	1	Element identification	Model analysis	conceptual	typical AP	B
6	I	1	Electron configuration of an ion	Models and representations	conceptual	foundational AP	C
7	I	1	Ionization-energy exceptions	Argumentation	conceptual	typical AP	A
8	I	2	Resonance structures	Models and representations	conceptual	typical AP	C
9	I	2	VSEPR molecular geometry	Models and representations	conceptual	typical AP	C
10	I	2	Molecular geometry and polarity	Models and representations	conceptual	typical AP	D
11	I	2	Lattice energy	Argumentation	conceptual	typical AP	C
12	I	2	Metallic bonding and alloys	Argumentation	conceptual	foundational AP	A
13	I	2	Resonance and bond length	Argumentation	conceptual	typical AP	D
14	I	3	Vapor pressure and boiling point	Representing data	conceptual	foundational AP	B
15	I	3	Intermolecular forces and vapor pressure	Argumentation	conceptual	typical AP	B
16	I	3	External pressure and boiling	Argumentation	conceptual	typical AP	A
17	I	3	Gas density and molar mass	Mathematical routines	quantitative	typical AP	A
18	I	3	Dalton's law	Mathematical routines	quantitative	typical AP	C
19	I	3	Henry's law	Mathematical routines	quantitative	typical AP	A
20	I	3	Dilution and solution amount	Mathematical routines	quantitative	typical AP	B
21	I	3	Particulate representation of ionic dissolution	Models and representations	conceptual	typical AP	A
22	I	3	Chromatography	Mathematical routines	quantitative	foundational AP	C
23	I	3	Molecular shape and dispersion forces	Argumentation	conceptual	typical AP	D
24	I	4	Net ionic equations	Models and representations	conceptual	typical AP	D
25	I	4	Limiting reactant	Mathematical routines	quantitative	typical AP	C
26	I	4	Precipitation stoichiometry	Mathematical routines	quantitative	challenging AP	D
27	I	4	Oxidation numbers	Models and representations	conceptual	typical AP	C
28	I	4	Balancing redox reactions	Models and representations	conceptual	challenging AP	D
29	I	4	Percent yield	Mathematical routines	quantitative	typical AP	A
30	I	4	Reaction stoichiometry	Mathematical routines	quantitative	foundational AP	A

Quality-Control Summary

Unit	Primary MCQs	Share of 60
1. Atomic Structure and Properties	7	11.7%
2. Compound Structure and Properties	6	10.0%
3. Properties of Substances and Mixtures	10	16.7%
4. Chemical Reactions	7	11.7%
5. Kinetics	6	10.0%
6. Thermochemistry	4	6.7%
7. Equilibrium	6	10.0%
8. Acids and Bases	6	10.0%
9. Thermodynamics and Electrochemistry	8	13.3%

- Exactly 60 MCQs; every item has four choices and one keyed best answer.
- Answer positions are balanced at 15 each for A, B, C, and D, with no mechanical repeating pattern.
- Exactly seven FRQs: three 10-point long questions and four 4-point short questions; total = 46 points.
- All nine units and all six AP Chemistry science practices are represented across the examination.
- The student portion contains no answer key, scoring criteria, unit labels, or learning-objective labels.
- The examination includes stimulus sets, tables, graphs, particulate and ionic representations, experimental design, error analysis, calculations, net ionic equations, and qualitative justification.
- All questions are original and were written to reproduce general AP assessment characteristics without copying or closely paraphrasing published questions.
- Chemical equations, numerical results, units, signs, scoring totals, and answer distribution were checked programmatically and editorially.