

Electron configurations, PES and periodic trends

AP Chemistry · Worksheet

Name: _____ Date: _____ Class: _____

These 20 problems cover electron configurations, ions of transition metals, photoelectron spectra, successive ionisation energies and periodic trends explained with Coulomb's law.

They follow AP Chemistry unit 1. Early problems ask for configurations and short answers. Later ones need quantitative reasoning and paragraph arguments in the style of free-response questions.

Level: AP Chemistry · **Curriculum:** AP Chem Unit 1

Problem 1 Configuration of sulfur (easy)

Sulfur has atomic number 16.

1. Write its full electron configuration.
2. State the number of valence electrons.
3. Write the noble-gas short form.

Problem 2 Configuration of a cation (easy)

Calcium has atomic number 20.

1. Write the configuration of a calcium atom.
2. Write the configuration of Ca^{2+} .
3. Name the noble gas with the same configuration.

Problem 3 Chromium and copper (easy)

Wanjiru in Nairobi writes copper as $[\text{Ar}] 4s^2 3d^9$.

1. Give the correct configuration.
2. Explain why the correct configuration is more stable.

Problem 4 Unpaired electrons in nitrogen (easy)

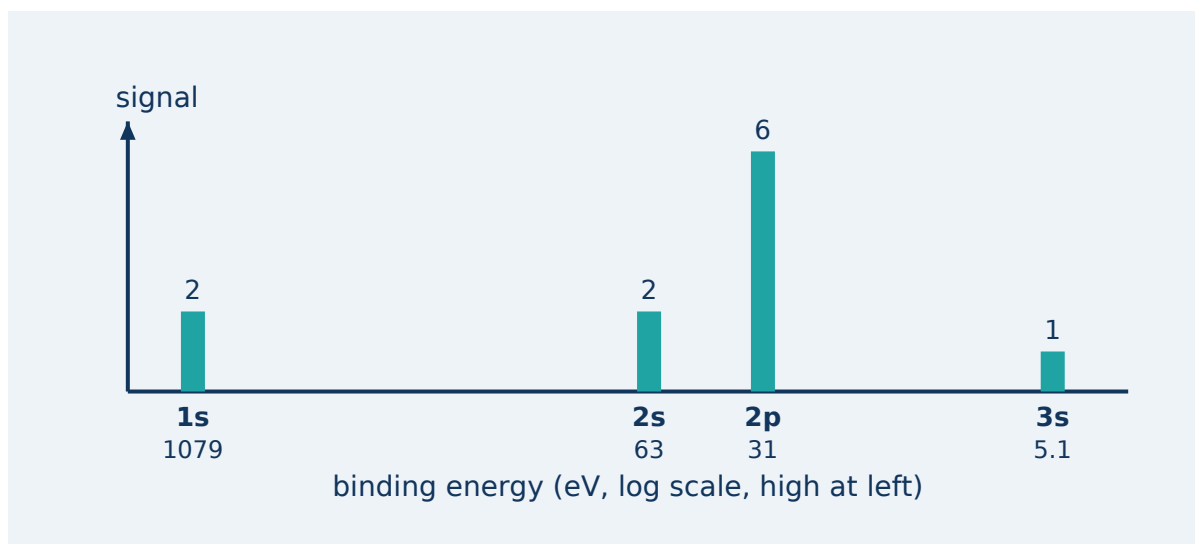
Nitrogen has atomic number 7.

1. Draw the 2p orbital box diagram for nitrogen, using arrows.
2. State the number of unpaired electrons.
3. Name the rule that decides this arrangement.

Problem 5 Identify the element from PES (easy)

The figure shows a photoelectron spectrum of an element.

1. Give the subshell for each peak.
2. Write the configuration and name the element.
3. State which peak corresponds to the valence electron.



PES of an element.

Problem 6 Coulomb's law quick checks (easy)

Two charged particles attract each other with force F .

1. State the new force when the distance doubles.
2. State the new force when one charge doubles.
3. State the new force when one charge doubles and the distance halves.

Problem 7 Which atom is bigger? (easy)

Compare sodium and chlorine atoms, both in period 3.

1. State which has the larger radius.
2. Explain using effective nuclear charge.

Problem 8 Effective nuclear charge (medium)

Estimate $Z_{\text{eff}} \approx Z - \text{core electrons}$ for the valence electrons of Mg ($Z = 12$), Si ($Z = 14$) and Cl ($Z = 17$), all with 10 core electrons.

1. Calculate the three values.
2. Predict which element has the smallest radius.
3. Predict which has the greatest first ionisation energy.

Problem 9 Successive ionisation energies (medium)

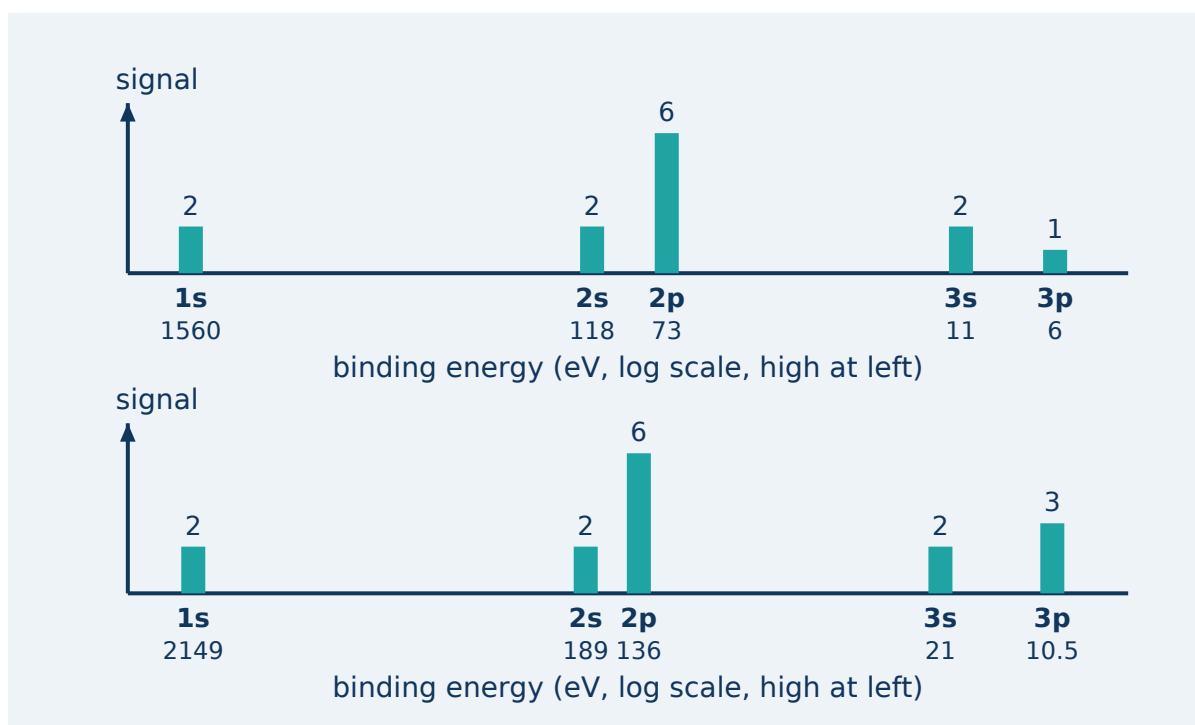
An element has ionisation energies of 578, 1817, 2745, 11577 and 14842 kJ/mol.

1. Identify the electron number after which the large jump occurs.
2. State the number of valence electrons.
3. Identify the element in period 3.

Problem 10 Comparing two spectra (medium)

Look at the two spectra in the figure. They have the same peak heights, 2 : 2 : 6 : 2 : 1 (A) and 2 : 2 : 6 : 2 : 3 (B).

1. Identify elements A and B.
2. Explain why the 1s peak of B is at higher binding energy than A.
3. State the difference in the valence peak heights and what it shows.



Top: element A. Bottom: element B.

Problem 11 Isoelectronic ions (medium)

Consider the ions F^- , Na^+ and Mg^{2+} .

1. Give the number of electrons in each.
2. Rank their radii from largest to smallest.
3. Explain the ranking.

Problem 12 Ionisation energy exceptions (medium)

IE_1 values (kJ/mol): Mg 738, Al 578; N 1402, O 1314.

1. Explain why Al is lower than Mg.
2. Explain why O is lower than N.

Problem 13 Transition-metal ions (medium)

Write the configuration and the number of unpaired electrons for each ion.

1. Fe^{3+}
2. Zn^{2+}
3. Cu^{+}

Problem 14 Kinetic energy of photoelectrons (medium)

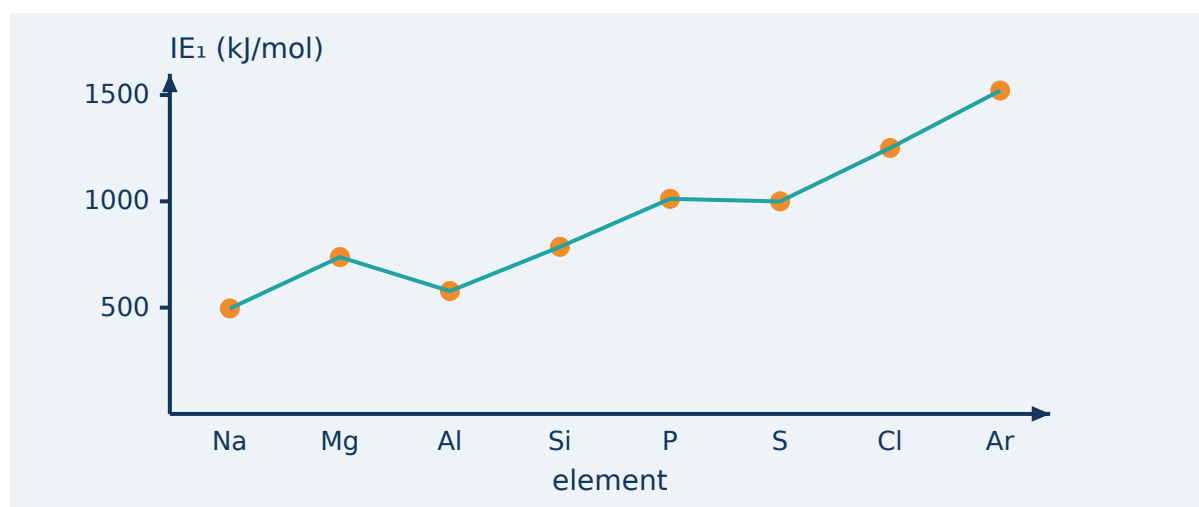
X-ray photons of energy 1500 eV strike aluminium. The binding energies are 118 eV (2s) and 73 eV (2p).

1. State the equation linking photon energy, binding energy and kinetic energy.
2. Calculate the kinetic energy of an electron from the 2s subshell.
3. Calculate the kinetic energy of an electron from the 2p subshell.

Problem 15 Ionisation energy across period 3 (medium)

The graph shows IE_1 for sodium to argon.

1. Describe the general trend.
2. Explain the dip at aluminium.
3. Explain the dip at sulfur.



First ionisation energies across period 3.

Problem 16 Force between ions (hard)

The distance between Na^+ and Cl^- in a crystal is 2.76×10^{-10} m. Use $k = 8.99 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2$ and $e = 1.602 \times 10^{-19} \text{ C}$.

1. Calculate the force between the ions.
2. Calculate the force between Mg^{2+} and O^{2-} at 2.10×10^{-10} m.
3. Calculate the ratio of the two forces and connect it to melting point.

Problem 17 Ranking ionisation energies (hard)

Rank Li, Na, K, Be and Mg by first ionisation energy, highest to lowest.

1. Give the ranking.
2. Justify the order within group 1.
3. Justify why Be and Mg are above their group-1 neighbours.

Problem 18 Interpreting a sulfur spectrum (hard)

A spectrum has peaks at 2472, 229, 165, 23 and 10.4 eV with relative heights 2 : 2 : 6 : 2 : 4.

1. Give the configuration and the element.
2. Predict how the 1s peak would shift for chlorine.
3. Explain why the shift happens.

Problem 19 Why two electrons then a jump? (hard)

IE_1 and IE_2 for sodium are 496 and 4562 kJ/mol. For magnesium they are 738 and 1451 kJ/mol.

1. Explain why IE_2 is much larger than IE_1 for sodium.
2. Explain why IE_2 for magnesium is only about twice IE_1 .
3. Predict whether IE_3 for magnesium is larger or smaller than 4562 kJ/mol.

Problem 20 Paragraph argument (hard)

Write a paragraph explaining why the radius decreases from Na to Cl but increases from Li to Cs.

1. Use Coulomb's law in your argument.
2. Mention nuclear charge, shielding and shell number.