Questions Periodic Table Live! can help students answer.

The questions in the Periodic Table Live! (PTL!) are divided into five categories:

1. *Introductory questions* are meant to familiarize users with the features of PTL!
2. *Trend questions* teach how the periodic table can be used to make qualitative predictions of physical and chemical properties.
3. *Situation questions* require that students determine which data are relevant to answer a question, and then combine appropriate data and write a report.
4. *Calculation questions* involve a calculation based on data available within PTL!
5. *Mendeleev questions* put students in the shoes of Dmitri Mendeleev; they must predict properties for elements as yet unknown or for which properties have not yet been measured.

Introductory questions

Following each question, the functionalities of PTL! that can be used to answer the question are given in brackets [ ]. Braces { } are used to specify either a value within an appropriate range or a choice of terms that could give more than one kind of question.

1. Which elements melt below {give a temperature here}?

   [Graph/Table > Table > Melting Point]

2. Which elements boil above {give a temperature here}?

   [Graph/Table > Table > Boiling Point]

3. Which are the five {most / least} expensive elements when in pure form?

   [Graph/Table > Table > Pure Cost]

4. Which element is more reactive with {air / water}, Li or Mg {many other pairs could be chosen; both elements need to have video showing the reaction with air or water}?

   [Click on each element in the periodic table and view video of the reaction with air or water.]

5. Compare the relative abundances the {solar system/Earth’s crust} of the alkali metals with the abundances of the halogens.

   [Graph/Table > Table > Abundance {solar system/Earth’s crust}]

6. Give the year in which each element in Group {give a group number here} was discovered.

[Click on each element and look in the discovery information (upper right of the description) for year of discovery.]

7. Which elements were discovered between {give a year} and {give another year}? (Suggested ranges of years are 1600–1750, 1750–1805, 1805–1850, 1850–1901, 1901–1950, and 1950–present.)

   [Graph/Table > Table > Year Discovered]

8. List the second ionization energies for each pair of elements: Na and Mg, K and Ca, Cs and Ba. Note any relationships you find.

   [Click on each element in the periodic table and look up the ionization energies.]

9. Compare the radii of Group 1 ions (1+) with the radii of Group 2 ions (2+). Are there pairs of ions that have similar radii? If so, how are the pairs related in the periodic table?

   [Graph/Table > Deselect all > Select Group 1 and Group 2 > Table > Ionic Radius (1+) and Ionic Radius (2+)]

10. Is there a mathematical relationship between boiling point and heat of vaporization for nonmetallic elements?

    [Graph/Table > Graph > *x*-axis: Boiling Point and *y*-axis: Heat of Vaporization] (For all but a few elements the data are close to a straight line; this is Trouton’s Rule.)

Trend questions

For questions 1–3, we suggest these the following properties in the braces: melting point, boiling point, heat of atomization, first ionization energy, electron affinity, electronegativity, atomic volume, and covalent radius.

1. Discuss the trend in {put property here} for {group/period}.

2. Plot {put property here} against atomic number for elements of the {second/third/fourth} period}. Comment on the trends you find. Write a brief report including a copy of the graph.

3. Plot {put property here} against atomic number and discuss any trend observed. Are there any deviations from the trend? Suggest an explanation for the trend and for any deviations.

4. Choose any period and plot {number of isotopes/abundance, solar system} against atomic number. Compare even and odd atomic numbers and see whether there is a trend.

5. Plot heat of vaporization against boiling point. Describe the trend. Then plot heat of atomization against boiling point. Discuss similarities and differences between the two plots.

6. For this question, first make predictions based solely on your knowledge of periodic table trends. Then, use PTL! to check your predictions. Arrange each list of atoms in order of {covalent radius/ionization energy/electronegativity}. If the data in PTL! differ from your predictions, try to figure out why.

    a. Sn Si Ge C Pb
    b. B, Be, C, N, Li
    c. Al, In, Tl, B, Ga
    d. Ba, Ce, Sm, Yb, Hf
    e. S, Ar, Ca, Ne, Kr

Situation questions

1. Electrical wiring in most houses involves copper wires. Suppose that at some time in the future, copper is much harder to find and mine than it is today. Which other element would be the best substitute for wiring in a house?

    Al is the best answer based on electric conductivity and cost.

2. In old-fashioned typesetting (as was done in the 18th and 19th centuries), a molten metal was forced into molds for the letters and then covered with copper. The metal should be solid at room temperature, but melt at a relatively low temperature (below 700 K), and should have a high density to offer good support for the copper. Which element would be the best choice? What would be a good second alternative metal?

    Pb is the best choice based on the criteria given; Cd or Tl are good second choices.

3. A mystery element is expensive because it is not readily available on the surface of Earth. It has a high density and can be scratched by glass or iron. It can be melted in a chromium or vanadium crucible. It forms the chloride MCl_3. What is the mystery element?

    Gold.

4. Zirconium and hafnium occur together in natural deposits, and it is very difficult to separate these two elements to obtain a pure sample of each.

    a. Based on data from PTL! explain why these two elements are difficult to separate.

        The physical properties of the two elements are very similar, which makes them hard to separate.

b. If you had a sample of Hf and a sample of Zr and both samples were the same size, how could you determine which was which?

The major difference is that the density of Zr is less than half the density of Hf, so samples of equal volume would have very different weights.

5. Consider an element with these properties:

- Reacts mildly with 6 M HCl
- Does not react with base or with water at room temperature
- Has electrical conductivity of at least 200 reciprocal milliohms per centimeter
- Costs less than $1 per hundred grams in bulk

a. What element has these properties?
b. If this element undergoes combustion in air, write a balanced chemical equation for the reaction.
c. How much energy would it take (in kJ) to melt 1 kg of this element?
d. Graph the electrical conductivity for all elements in the group that includes this element. Is this element the best choice in its group for an electrical conductor? Explain.
e. Would this element make a good copper replacement for wiring in a house? Explain why or why not.

Mg meets the criteria.

Calculation questions

1. Compare the density of an atom of an element with the density of the element. Explain any discrepancies.

   The density of an iron atom can be calculated from the atomic radius given in the atomic data and the molar mass of 55.845 g/mol. Assuming a spherical atom, the volume is $4/3\pi r^3 = 8.379 \times 10^{-24}$ *cm*^{3}*. The mass of an iron atom is 55.845 g/mol divided by Avogadro's number, which gives* 9.27×10^{-23} *g. The density of an atom is then 11.06 g/cm*^{3}*. The density of iron in the physical data section of PTL! is 7.874 g/cm*^{3}*, which is significantly smaller. There must be some space between the spherical atoms—allowing the density of iron metal to be less than the density of a single atom.*

2. Calculate the ratio of the density of iron to the density of an iron atom. Do the same for sulfur. Are the two ratios the same? If not, explain why they differ.

   The ratio for iron is (7.874 g/cm^3*)/(11.06 g/cm*^{3}*) = 0.7119. The ratio for sulfur is (2.069 g/cm*^{3}*)/(11.30 g/cm*^{3}*) = 0.1831. Apparently, sulfur atoms have more space between them than iron atoms do.*

3. The enthalpy of formation for sodium fluoride is -573.647 and the enthalpy of formation of potassium chloride is -436.747 kJ/mol. Use a Born-Haber cycle to calculate the lattice

energy of each compound. Use data from PTL! for first ionization energy, electron affinity, and heats of atomization. The bond dissociation enthalpy for fluorine is 158 kJ/mol and for chlorine is 242 kJ/mol.

a. Based on the lattice energies you calculated, which crystal lattice has stronger ionic bonding?

   NaF

b. Other data from PTL! can be used to explain why one lattice would have stronger bonding than another. Which data and how can the difference be explained?

   The ionic radius for Na+ is smaller than the ionic radius for K+ and the ionic radius for F- is smaller than the ionic radius for Cl-. Because the ions are closer together in NaF, the attraction between the ions is stronger.

Mendeleev questions

1. All elements beyond bismuth ($Z = 83$) are radioactive. Those beyond uranium ($Z = 92$) do not occur naturally in appreciable quantities because their half-lives are short compared with the age of Earth. Predict the values of these properties for element {chose atomic number > 120 and enter here}:

   - Atomic weight
   - Density
   - Molar volume (Atomic volume)
   - Melting point
   - Boiling point
   - Typical oxidation numbers
   - Formula of oxide
   - Formula of chloride
   - Color
   - Reaction with air
   - Reaction with 6 M HCl
   - Reaction with 6 M Na\OH

2. Elements with atomic numbers of 114 and just above are thought to be in an "island of nuclear stability" in a sea of less stable nuclei. Another island of nuclear stability is predicted to occur at approximately atomic number 164. For element 164, predict the properties listed in question 1.

   The properties of element 164 should be similar to those of Pb and element 114. (There is a new type of orbital, a g orbital, that has to be filled before the third lanthanide/actinide series; there are nine different g orbitals. Thus, element 164 would be below element 114.)

3. Predict the properties listed in question 1 for {enter the symbol for any known element}. Do not consult the list of properties in PTL! until after you have made your predictions based on the properties of other elements.

   Choose Ir, for example. Ir should have atomic weight, density, molar volume, melting point, boiling point, and color similar to the same properties for the elements to the left and right of it (Os and Pt). Chemical properties, such as typical oxidation numbers, formula of oxide, formula of chloride, reaction with air, reaction with 6 M HCl and reaction with 6 M NaOH, should be similar to those of the elements above and below Ir (i.e., Rh and Mt, or elements in the same periodic group). For example, the densities of Os and Pt are 22.57 g/cm^3 and 21.41 g/cm^3. For Ir, the density is 22.61 g/cm^3. Typical oxidation numbers are not available for Mt; for the elements above Ir (Co and Rh), typical oxidation numbers are +2 and +3 for Co and +3 for Rh. For Ir, typical oxidation numbers are +3 and +4.