**Practice FRQs**

Answer the following questions about the element selenium, Se (atomic number 34). 2000 7

a) Samples of natural selenium contain six stable isotopes. In terms of atomic structure, explain what these isotopes have in common, and how they differ. *(2pts)*

b) Write the complete electron configuration (e.g., 1*s*2 2*s*2. . . etc.) for a selenium atom in the ground state. Indicate the number of unpaired electrons in the ground-state atom, and explain your reasoning. *(2pts)*

c) In terms of atomic structure, explain why the first ionization energy of selenium is

i) less than that of bromine (atomic number 35), and *(1pt)*

ii) greater than that of tellurium (atomic number 52). *(1pt)*

Answer the following questions regarding light and its interactions with molecules, atoms, and ions. 1999 2

a) The longest wavelength of light with enough energy to break the Cl–Cl bond in Cl2(*g*) is 495 nm.

i) Calculate the frequency, in s−1, of the light. *(1pt)*

ii) Calculate the energy, in J, of a photon of the light. *(1pt)*

iii) Calculate the minimum energy, in kJ mol−1, of the Cl–Cl bond. *(1pt)*

b) A certain line in the spectrum of atomic hydrogen is associated with the electronic transition in the H atom from the sixth energy level (*n* = 6) to the second energy level (*n* = 2).

i) Indicate whether the H atom emits energy or whether it absorbs energy during the transition. Justify your answer. *(2pt)*

ii) Calculate the wavelength, in nm, of the radiation associated with the spectral line. *(3pts)*

Answer the following questions related to sulfur and one of its compounds. 2009 6

a) Consider the two chemical species S and S2-.

i) Write the complete electron configuration of each species. *(2pts)*

ii) Explain why the radius of the S2− ion is larger than the radius of the S atom. *(1pt)*

iii) Which of the two species would be attracted into a magnetic field? Explain. *(1pt)*

b) The S2− ion is isoelectronic with the Ar atom. From which species, S2− or Ar, is it easier to remove an electron? Explain. *(1pt)*

|  |  |
| --- | --- |
| Atom | First Ionization Energy  (kJ mol−1) |
| F | 1,681.0 |
| O | 1,313.9 |
| Xe | ? |

Using principles of atomic and molecular structure and the information in the table, answer the following questions about atomic fluorine, oxygen, and xenon, as well as some of their compounds. 2008 5

a) Write the equation for the ionization of atomic fluorine that requires 1,681.0 kJ mol−1.

*(1pt)*

b) Account for the fact that the first ionization energy of atomic fluorine is greater than that of atomic oxygen.

(You must discuss both atoms in your response.) *(1pt)*

c) Predict whether the first ionization energy of atomic xenon is greater than, less than, or equal to the first ionization

energy of atomic fluorine. Justify your prediction. *(1pt)*

|  |  |  |  |
| --- | --- | --- | --- |
|  | 1st  Ionization Energy  (kJ mol-1) | 2nd  Ionization Energy  (kJ mol-1) | 3rd  Ionization Energy  (kJ mol-1) |
| Element 1 | 1,251 | 2,300 | 3,820 |
| Element 2 | 496 | 4,560 | 6,910 |
| Element 3 | 738 | 1,450 | 7,730 |
| Element 4 | 1,000 | 2,250 | 3,360 |

The table above shows the first three ionization energies for atoms of four elements from the third period of the periodic table. The elements are numbered randomly. Use the information in the table to answer the following questions. 2007B 6

a) Which element is most metallic in character?

Explain your reasoning. *(2pts)*

b) Identify element 3. Explain your reasoning. *(2pts)*

c) Write the complete electron configuration for an atom of element 3. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ *(1pt)*

d) What is the expected oxidation state for the most common ion of element 2 ? \_\_\_\_\_\_ *(1pt)*

e) What is the chemical symbol for element 2 ? \_\_\_\_\_\_ *(1pt)*

f) A neutral atom of which of the four elements has the smallest radius? Explain your answer. *(1pt)*

Account for each of the following observations in terms of atomic theory and/or quantum theory. *2006B 7*

a) Atomic size decreases from Na to Cl in the periodic table. *(2pts)*

b) Boron commonly forms molecules of the type BX3. These molecules have a trigonal planar structure. *(2pts)*

c) The first ionization energy of K is less than that of Na. *(2pts)*

d) Each element displays a unique gas-phase emission spectrum. *(2pts)*

Answer the following problems about gases. 2007B 2

|  |  |
| --- | --- |
| Isotope | Mass (amu) |
| Ne-20 | 19.99 |
| Ne-22 | 21.99 |

a) The average atomic mass of naturally occurring neon is 20.18 amu. There are two common isotopes of naturally occurring neon as indicated in the table.

i) Using the information in the table, calculate the percent abundance of each isotope.

*(1pt)*

ii) Calculate the number of Ne-22 atoms in a 12.55 g sample of naturally occurring neon. *(3pts)*

b) A major line in the emission spectrum of neon corresponds to a frequency of 4.34 x 1014 s-1.

Calculate the wavelength, in nanometers, of light that corresponds to this line. *(2pts)*

c) In the upper atmosphere, ozone molecules decompose as they absorb ultraviolet (UV) radiation, as shown by the equation below. Ozone serves to block harmful ultraviolet radiation that comes from the Sun.

O3(*g*) −UV→ O2(*g*) + O(*g*)

A molecule of O3(*g*) absorbs a photon with a frequency of 1.00 x 1015 s-1.

i) How much energy, in joules, does the O3(*g*) molecule absorb per photon? *(1pt)*

ii) The minimum energy needed to break an oxygen-oxygen bond in ozone is 387 kJ mol-1. Does a photon with a frequency of 1.00 x 1015 s-1 have enough energy to break this bond? Support your answer with a calculation.

*(2pts)*