TOPIC 2 AND 3 PROBLEM SET – ATOMIC THEORY AND PERIODICITY

Atomic Theory

1. What is the atomic number? What information does it provide?

2. What is the mass number? How is this different from atomic mass?

3. According to the most current model of the atom, describe the location, charge, and relative mass of protons, neutrons and electrons. A labeled diagram may help.

4. Define isotope.

5. Four elements are described below:

Element	# of protons	# of neutrons	# of electrons
A	5	6	2
B	1	1	1
C	1	0	0
D	5	5	5

A) Which elements are isotopes of each other? (2 pairs)

B) How will elements A and D compare in terms of chemical/physical properties?

C) How will elements A and D compare in terms of atomic mass?

D) How will elements B and C compare in terms of charge?

E) Draw atomic symbols for all four elements.

6. Fill in the chart:

Isotope	# of protons	# of neutrons	# of electrons
$^{57}_{26}Fe$			
$^{24}_{12}Mg^{+2}$			
$^{14}_{6}C$			
$^{12}_{6}C$			
$^{235}_{92}U$			
$^{35}_{17}Cl^{-1}$			

7. Fill in the chart:

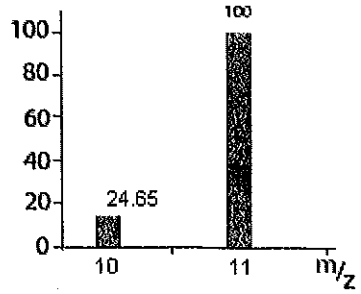
Atomic #	Symbol	# protons	Mass #	# neutrons	Charge	# electrons
	As			42	-3	
64			155			61
		12	25		+2	
	I^-			74		54
48			115			48
58				82	+4	
		16	32		-2	

8. Sketch a simple diagram of a mass spectrometer. Label each phase of the mass spectrometer's operation on the diagram.

9. What specific piece of a mass spectrometer is adjusted in order to detect particles with varying masses?

10. Of the following particles, $^{16}O^+$, $^{15}O^+$, $^{16}O^{2+}$, $(^{16}O - ^{16}O)^+$ which experiences the greatest amount of deflection in a mass spectrometer? Why are all ions formed in a mass spectrometer positively charged?

11. The following graph is produced when a pure sample of boron is passed through a mass spectrometer. Use the data to calculate the relative atomic mass for boron.



12. Lithium occurs naturally as two isotopes, ^6Li and ^7Li. The relative atomic mass of lithium is 6.941 g/mol. Determine the percent abundance of each of lithium's isotopes.

13. State the name and the mass number of the isotope relative to which **all** atomic masses are measured.

14. Write the symbol for the species with 17 protons, 19 neutrons, and 18 electrons.

15. Write the symbol for the species with 6 protons, 8 neutrons, and 6 electrons.

16. Write the symbol for the species with 3 protons, 3 neutrons, and 2 electrons.

17. Explain why most atomic masses are not whole numbers.

18. In the context of electromagnetic radiation, what is wavelength? How does wavelength relate to energy?

19. In the context of electromagnetic radiation, what is frequency? How does frequency relate to energy?

20. List the colors of visible light in order of increasing energy.

21. a) Indicate the wavelength of each wave in the following wave diagrams.

    b) Which of the waves has a higher frequency?

    c) Which of the waves has a lower energy?

Wave A

Wave B

22. As wavelength gets shorter, frequency _____.

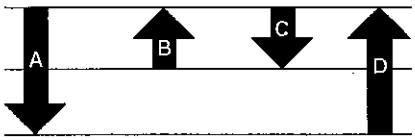
23. As wavelength gets shorter, energy _____.

24. Describe the Bohr model of the atom, including the evidence collected that led to its development.

25. What is the difference between a bright line spectrum and a continuous spectrum? How do energy levels account for the appearance of bright line spectra?

26. What is the electromagnetic (EM) spectrum? What is the highest energy wave? Lowest?

27. Consider this diagram of an atom with arrows representing electron movement.



nucleus

a) Which two arrows correspond to energy absorption by the atom? _____

b) Which two arrows correspond to energy emission by the atom? _____

c) If violet and green light are produced by the movement illustrated here, which arrow represents emission of violet light? _____ green light? _____

28. Consider the spectroscopy lab. How did the flame tests you performed on different metals relate to firework production? Why did each metal produce a different color flame when excited?

29. Consider the spectroscopy lab. What caused the gas in the tubes to glow? How does this topic relate to "neon" sign production? Why is the term "neon sign" a bit misleading?

31. How do scientists use bright line spectra to identify unknown elements in far off stars or other samples of matter?

32. Consider only the first four primary energy levels of a hydrogen atom. The transition that would result in photon of the **shortest** wavelength would be
    a) from n = 4 to n = 1 b) from n = 4 to n = 3
    c) from n = 2 to n = 1 d) from n = 1 to n = 4

33. Consider only the first four primary energy levels of a hydrogen atom. The transition that would result in photon of the **longest** wavelength would be
    a) from n = 4 to n = 1 b) from n = 4 to n = 3
    c) from n = 2 to n = 1 d) from n = 1 to n = 4

34. The Lyman series of bright lines in the hydrogen atom are due to electrons dropping to the first energy level, the Balmer series are due to electrons dropping to the second energy level. Which one of these series is U.V. and which is visible? Explain.

35. How do waves of red light and blue light differ with respect to frequency? wavelength? energy?

36. How many electrons can a single atomic orbital hold? How many orbitals can be found in an s sublevel? p? d? f?

37. "s" sublevels can hold a total of ___ electrons. p sublevels can hold ___ electrons, while d sublevels can hold ___, and f sublevels can hold ___ electrons.

38. Which is bigger, the 3s sublevel or the 5s sublevel? How many electrons can each hold?

39. What are valence electrons and why are they important? What is the octet rule?

40. Every element wants a full outer energy level (valence level). This is normally ____ electrons, although in the case of helium it is ____ electrons.

41. An atom is in the _____state when the electrons in an atom are in the lowest possible energy levels.

42. An atom is in the _____ state when one or more electrons moves to a higher than normal energy level.

43. Which of the following has the highest energy?
    A) 4d B) 5s C) 5p D) 3p

44. Which of the following has the lowest energy?
    A) 6s B) 5p C) 4f D) 6p

45. Give electron complete configurations for: Na^{+}, Fe, Br, Ar, Al^{+3}, O^{-2}, He, Ni^{+2}, K, Ne, Cu^{+}.

46. Give shorthand electron configurations for: Ag, I, Rb, Au, Cu, S^{-2}

47. What does isoelectronic mean? Give three elements that are isoelectronic with Kr.

48. $1s^2 2s^2 2p^6 3s^2 3p^4$ is the electron configuration for which element? How many valence electrons does the element have?

49. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6$ is the electron configuration for which noble gas? How can you use its electron configuration to confirm it is a noble gas?

Periodicity

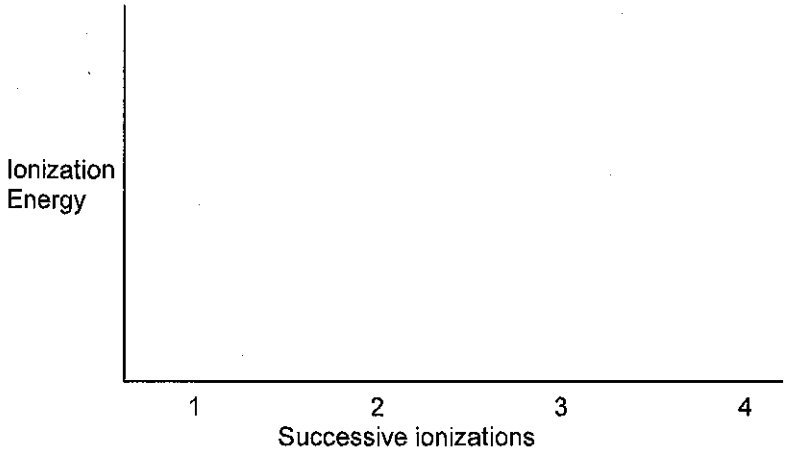
50. What is meant by effective nuclear charge?

51. Compare the effective nuclear charge on the valence electrons of sodium, magnesium and aluminum.

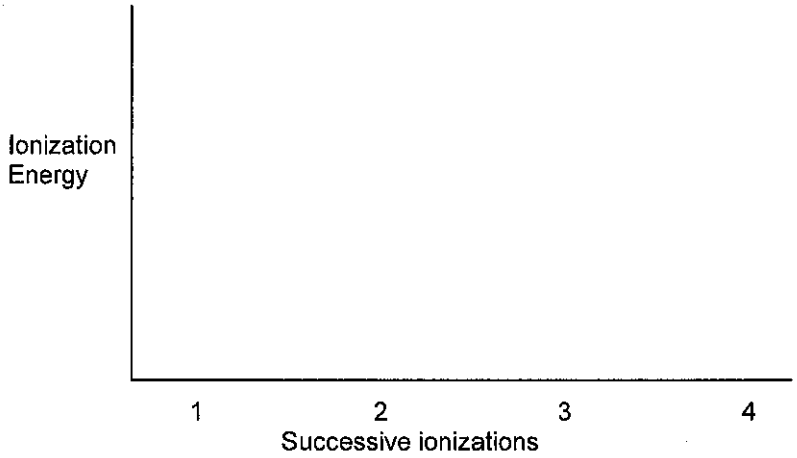
52. How can effective nuclear charge explain the observed difference in first ionization energy between sodium and magnesium? Consult table 7 of the data booklet for data regarding first ionization energies.

53. Despite the trend in effective nuclear charge, magnesium has a higher first ionization than aluminum. Explain this in terms of electron configuration.

54. Sketch a graph of successive ionization energies for Mg.



55. Sketch a graph of successive ionization energies for Al.



56. Write a chemical equation that shows which is more reactive:
    a) Na or K

    b) Cl_2 of F_2

57. Consider a reaction where gaseous chlorine is bubbled through a solution of potassium bromide.
    a) Write and balance an equation for the reaction, including state symbols.

    b) Write the net ionic equation for the reaction

    c) Describe the color change that would be observed as the reaction progresses.

    d) Explain why the reaction would not proceed in the reverse direction.

58. A solution of silver (I) nitrate is added to an unknown solution of halide ions. Upon mixing, a faint yellow precipitate is produced. What is the likely identity of the halide ions?

59. Consider the 3rd period elements.
    a) Write the formula of their common oxides

    b) Write a chemical equation (or equations) to show if sodium oxide is acidic, basic, or amphoteric

    c) Write a chemical equation (or equations) to show that sulfur dioxide is acidic, basic, or amphoteric

    d) Write a chemical equation (or equations) to show that aluminum oxide is acidic, basic, or amphoteric.

    e) Describe how the pH of a solution of sodium oxide would differ from the pH of a solution of sodium chloride (acidic solutions have a pH < 7, basic solutions have a pH > 7).

60. Consider the complex ion $[Cu(H_2O)_6]^{2+}$
    a) State the oxidation state (charge) of the transition element.

    b) Hydrated Cu^{2+} ions have a light blue color. Explain why the species is colored.

    c) Explain why complex ions of zinc are colorless.

    d) What is the coordination number of the ion?

    e) What is the ligand? If the water molecules were replaced with ammonia (NH_3) in a ligand exchange reaction, would the solution appear to be the same color, or would the color be changed?

61. Consider the following compounds containing complex ions of iron:

    $Na[FeCl_4]$ $[Fe(H_2O)_6]SO_4$ $[Fe(H_2O)_6]SO_4$ $[Fe(H_2O)_4]PO_4$

    a) State the oxidation state (charge) for iron in each of the four compounds.

    b) State the coordination number for each of the complex ions.

    c) Identify three factors that affect the color of complex ions containing transition metals.

62. Write balanced equations, including state symbols, for the Contact Process and the Haber Process (include the catalyst). Describe these as examples of homogeneous catalysis or heterogeneous catalysis.