# ANSWERS TO UNIT VIII : ATOMS AND THE PERIODIC TABLE

1. Contradict. The Greek view of nature assumed that experimental work could be misleading and that philosophy should be used to reveal how nature worked.
2. Metals were immediately recognizable, valuable and useful in everyday life.
3. Dalton's work allowed the composition of chemicals to be known more accurately and compounds to be made efficiently without wasting reactants.
4. Thomson's work showed that atoms contained different particles having positive and negative charges.
5. The Law of Definite Proportions
6. The last column in the table below gives the result of dividing the mass of oxygen in each compound by the mass of oxygen in compound #1.

| Compound # | Mass of N (g) | Mass of O (g) | Ratio |
|---|---|---|---|
| 1 | 0.3160 | 0.0903 | 1 |
| 2 | 0.3160 | 0.3611 | 4 |
| 3 | 0.3160 | 0.7223 | 8 |
| 4 | 0.3160 | 0.5417 | 6 |

7. The "plum pudding" model assumed that the protons and electrons were uniformly distributed throughout the volume of the atom, such that the mass associated with the protons was distributed throughout the atom. When Rutherford found that most of the atom was empty space except for a tiny nucleus containing almost all the atom's mass, the even distribution of proton mass throughout the atom assumed by J.J. Thomson was seen to be incorrect.
8. Rutherford had found that the presence of protons in the nucleus could account for the charge on the nucleus but it could not account for all of the mass present in the nucleus.
9. Dalton's model is not in conflict with Rutherford's model because Rutherford accepted the idea that atoms exist and concerned himself with the internal structure of the atom. Dalton was concerned with the manner in which atoms had constant properties and were able to combine in specific ways.
10. Protons (but he suspected that some particle like the neutron existed in the nucleus).
11. (a) beta and gamma (alpha is stopped by a piece of paper) (b) gamma
12. Protons and neutrons exist in the nucleus and have a substantial mass while the region outside the nucleus consists only of electrons, which are almost massless. Therefore, most of the mass of the atom is concentrated in the nucleus.
13. (a) 4 (b) 92 (c) 25
14. (a) 6 (b) 26 (c) 18
15. (a) 10 (c) 20 (e) 18 (g) 54 (i) 2
    (b) 10 (d) 10 (f) 10 (h) 24 (j) 36
16. (a) $S^{2-}$ (c) $Cl^{-}$ (e) $Cr^{2+}$ (g) $V^{5+}$ (i) $O^{-}$
    (b) $Ca^{2+}$ (d) $Al^{3+}$ (f) $Mn^{4+}$ (h) $Sb^{3-}$
17. (a) +12 (b) +10 (c) +19 (d) +16
18. Proton = ${}_{1}^{1}p$ , neutron = ${}_{0}^{1}n$ , electron = ${}_{-1}^{0}e$

19.

| Particle | Atomic Number | Atomic Mass | Number of protons | Number of neutrons | Number of electrons |
|---|---|---|---|---|---|
| ${}^{52}_{24}Cr$ | **24** | **52** | **24** | **28** | **24** |
| ${}^{222}_{86}Rn$ | **86** | **222** | **86** | **136** | **86** |
| ${}^{70}_{31}Ga$ | 31 | **70** | **31** | 39 | 31 |
| ${}^{27}_{13}Al$ | **13** | **27** | 13 | 14 | 13 |
| ${}^{197}_{79}Au^{3+}$ | **79** | 197 | **79** | 118 | 76 |
| ${}^{75}_{33}As^{3-}$ | **33** | 75 | 33 | **42** | 36 |
| ${}^{209}_{83}Bi^{5+}$ | **83** | **209** | 83 | 126 | 78 |

20. (a) heavy water is $\frac{27.65}{25.00}$ = **1.106** times heavier than ordinary water

(b) molar mass of ordinary water = 18.0 g, so heavy water's molar mass = 1.106 x 18.0 g = **19.908 g.**

(c) heavy water = $D_2O$ = 2 D + O = 19.908 g , so that: 2 D + 16.0 g = 19.908 g and: D = **1.95 g**

(d) ${}^{2}_{1}D$

(e) For D: # of $e^-$ = 1, # of p = 1, # of n = 1 For H: # of $e^-$ = 1, # of p = 1, # of n = 0
Since both H and D have one proton, they are both "hydrogen" but the extra neutron makes D a heavier version of hydrogen.

21. Sample 2 is $\frac{1.670}{1.539}$ = 1.085 times heavier than Sample 1
molar mass of Sample 1 = 2 x 1.008 + 32.066 = 34.082 g
molar mass of Sample 2 = 34.082 g x 1.085 = 36.983 g
mass of artificial S–isotope = 36.983 – 2 x 1.008 = **34.97 g**

22.

| | Symbol | Atomic Mass | Atomic Number | Number of protons | Number of neutrons | Number of electrons |
|---|---|---|---|---|---|---|
| (a) | ${}^{84}_{36}Kr$ | 84 | 36 | **36** | **48** | 36 |
| (b) | ${}^{80}_{35}Br$ | **80** | **35** | 35 | 45 | 35 |
| (c) | ${}^{127}_{53}I^-$ | 127 | 53 | **53** | **74** | 54 |
| (d) | ${}^{59}_{27}Co$ | **59** | 27 | **27** | 32 | 27 |
| (e) | ${}^{66}_{30}Zn$ | **66** | **30** | **30** | 36 | **30** |
| (f) | ${}^{112}_{48}Cd^{2+}$ | 112 | **48** | **48** | **64** | **46** |
| (g) | ${}^{88}_{38}Sr^{2+}$ | **88** | **38** | 38 | 50 | 36 |
| (h) | $X^{2-}$ = ${}^{127}_{52}Te^{2-}$ | **127** | **52** | **52** | 75 | 54 |
| (i) | $X^{3+}$ = ${}^{103}_{45}Rh^{3+}$ | 103 | **45** | **45** | **58** | 42 |
| (j) | $X^{3-}$ = ${}^{75}_{33}As^{3-}$ | **75** | 33 | **33** | 42 | **36** |

23. (a) 10.8 g (c) 108.0 g (e) 65.4 g (g) 95.9 g
(b) 69.8 g (d) 72.7 g (f) 91.3 g

24. Average mass = 0.9890 x 12.000 000 + 0.0110 x 13.003 355 = **12.011 g**

25. Average mass = 0.9223 x 27.976 927 + 0.0467 x 28.976 495 + 0.0310 x 29.973 770 = **28.0855 g**

26. (a) P ( $1s^2 2s^2 2p^6 3s^2 3p^3$ )
(b) Ti ( $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^2$ )
(c) Co ( $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^7$ )
(d) Br ( $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^5$ )
(e) Sr ( $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2$ )
(f) Ar ( $1s^2 2s^2 2p^6 3s^2 3p^6$ )
(g) K ( $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$ )
(h) Cd ( $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10}$ )
(i) Ca ( $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$ )
(j) Xe ( $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6$ )
(k) Cs ( $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^1$ )
(l) Pb ( $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2 4f^{14} 5d^{10} 6p^2$ )
(m) Ga ( $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^1$ )
(n) Mn ( $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^5$ )
(o) Zr ( $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^2$ )

27. (a) P ( [Ne] $3s^2 3p^3$ )
(b) Ti ( [Ar] $4s^2 3d^2$ )
(c) Co ( [Ar] $4s^2 3d^7$ )
(d) Br ( [Ar] $4s^2 3d^{10} 4p^5$ )
(e) Sr ( [Kr] $5s^2$ )
(f) Ar ( [Ne] $3s^2 3p^6$ )
(g) K ( [Ar] $4s^1$ )
(h) Cd ( [Kr] $5s^2 4d^{10}$ )
(i) Ca ( [Ar] $4s^2$ )
(j) Xe ( [Kr] $5s^2 4d^{10} 5p^6$ )
(k) Cs ( [Xe] $6s^1$ )
(l) Pb ( [Xe] $6s^2 4f^{14} 5d^{10} 6p^2$ )
(m) Ga ( [Ar] $4s^2 3d^{10} 4p^1$ )
(n) Mn ( [Ar] $4s^2 3d^5$ )
(o) Zr ( [Kr] $5s^2 4d^2$ )

28. (a) $H^-$ ( $1s^2$ )
(b) $Sr^{2+}$ ( [Ar] $4s^2 3d^{10} 4p^6$ )
(c) $Br^-$ ( [Ar] $4s^2 3d^{10} 4p^6$ )
(d) $N^{3+}$ ( [He] $2s^2$ )
(e) $Ti^{2+}$ ( [Ar] $3d^2$ )
(f) $N^{2-}$ ( [He] $2s^2 2p^5$ )
(g) $Mn^{2+}$ ( [Ar] $3d^5$ )
(h) $Ge^{4+}$ ( [Ar] $3d^{10}$ )
(i) $Fe^{3+}$ ( [Ar] $3d^5$ )
(j) $Ge^{2+}$ ( [Ar] $4s^2 3d^{10}$ )
(k) $Ru^{3+}$ ( [Kr] $4d^5$ )
(l) $Sb^{3+}$ ( [Kr] $5s^2 4d^{10}$ )

29. (a) 6 (b) 5 (c) 5 (d) 2 (e) 0 (f) 2 (g) 6 (h) 0 (i) 2 (j) 6 (k) 0 (l) 0 (m) 3 (n) 2 (o) 7 (p) 2

30. The actual properties of Germanium are as follows. How close were your estimates?
atomic mass = 72.6 ; density = 5.35 ; density of oxide = 4.23 ; formula of chloride = $GeCl_4$ ; density of chloride = 1.84 ; color = greyish white ; lustre = metallic

31. (a) noble gases
(b) alkaline earth metals
(c) transition metals
(d) alkali metals
(e) halogens
(f) transitions metals
(g) alkali metals
(h) halogens

32. (a) two of Li, K, Rb, Cs and Fr
(b) two of He, Ne, Kr, Xe and Rn
(c) two of Be, Ca, Sr, Ba and Ra
(d) two of F, Cl, I and At

33. (a) two of Li, Be, B, N, O, F and Ne
(b) two of Na, Mg, Al, Si, P, Cl and Ar

34.

| SAMPLE | PROPERTIES | CLASSIFICATION |
|---|---|---|
| A | pale yellow gas, non–conductor | NONMETAL |
| B | conductor, shiny, hard, silvery, malleable | METAL |
| C | non–conductor, yellow, looks waxy, soft, brittle | NONMETAL |
| D | hard, silvery–grey, brittle, somewhat shiny, fair conductor | MIXTURE |
| E | liquid, shiny, silvery, conductor | METAL |
| F | dark red, liquid, non–conductor | NONMETAL |
| G | fair conductor, brittle, dull grey | MIXTURE |

35. On the right side.

36. (a) Ga (b) Ge (c) Sn (d) Mg (e) Bi

37. Ca, Ge, Si, P, F

38. (a) Sb (b) K (c) Ge (d) Al (e) Tl (f) Sb

39. P = iii , Ba = ii , Sb = iv , Ar = v , As = i

40. The atomic radius increases. The more electrons around the nucleus, the greater the volume needed to contain them (since electrons repel each other and can't easily be "compacted"). Therefore, going down a group the atomic radius of the elements in the group should increase.

41. Going across a row, the positive charge on the nucleus increases, and each electron experiences a greater attraction to the nucleus. This results in a smaller distance between the individual electrons and the nucleus, which causes the atomic radius to decrease going across each period of the table.

42.

| If an atom has: | Then its outermost shell is: | If an atom has: | Then its outermost shell is: |
|---|---|---|---|
| 1 electron | **OPEN** | 10 electrons | **CLOSED** |
| 2 electrons | **CLOSED** | 11 electrons | **OPEN** |
| 3 electrons | **OPEN** | 16 electrons | **OPEN** |
| 8 electrons | **OPEN** | 18 electrons | **CLOSED** |

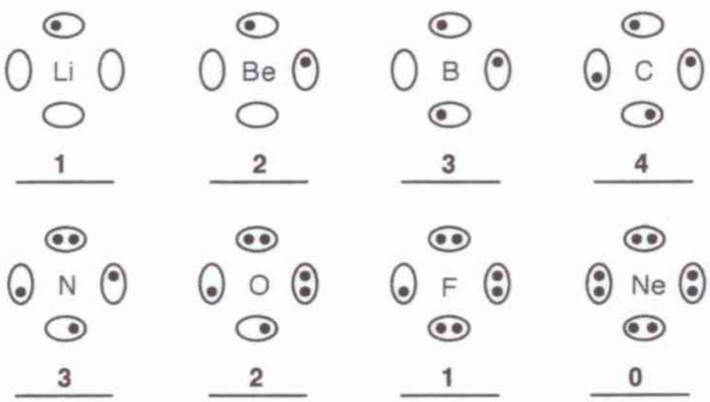
43. The NOBLE GASES have CLOSED SHELLS. All other elements have OPEN SHELLS.

44. (a) Cl : open (c) Mg : open (e) $Na^+$ : closed (g) $O^-$ : open (i) I : open
(b) Ne : closed (d) Si : open (f) $Cl^-$ : closed (h) $Ca^{2+}$ : closed (j) $Al^+$ : open

45.

| atom | # of valence electrons | atom | # of valence electrons |
|---|---|---|---|
| F | 7 | Pb | 4 |
| Ne | 0 | $Pb^{2+}$ | 2 |
| Na | 1 | $S^-$ | 7 |
| $Ne^+$ | 7 | $S^{2-}$ | 0 |

46. (a, b)



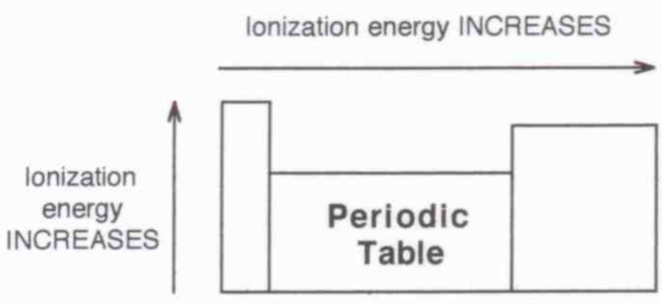

47.

| atom | H | He | | | | | | |
|---|---|---|---|---|---|---|---|---|
| valence | 1 | 0 | | | | | | |
| atom | Li | Be | B | C | N | O | F | Ne |
| valence | 1 | 2 | 3 | 4 | 3 | 2 | 1 | 0 |
| atom | Na | Mg | Al | Si | P | S | Cl | Ar |
| valence | 1 | 2 | 3 | 4 | 3 | 2 | 1 | 0 |

48. (a) The distance between the nucleus and the outermost electrons increases. The greater the number of electrons, the larger the atomic radius.
   (b) The nucleus has a decreasing hold on the outer electrons because of the increasing nucleus–electron distance.
   (c) The ionization energy will decrease going down a family. The less hold the nucleus has on the outer electrons, the easier it is to remove one of them.

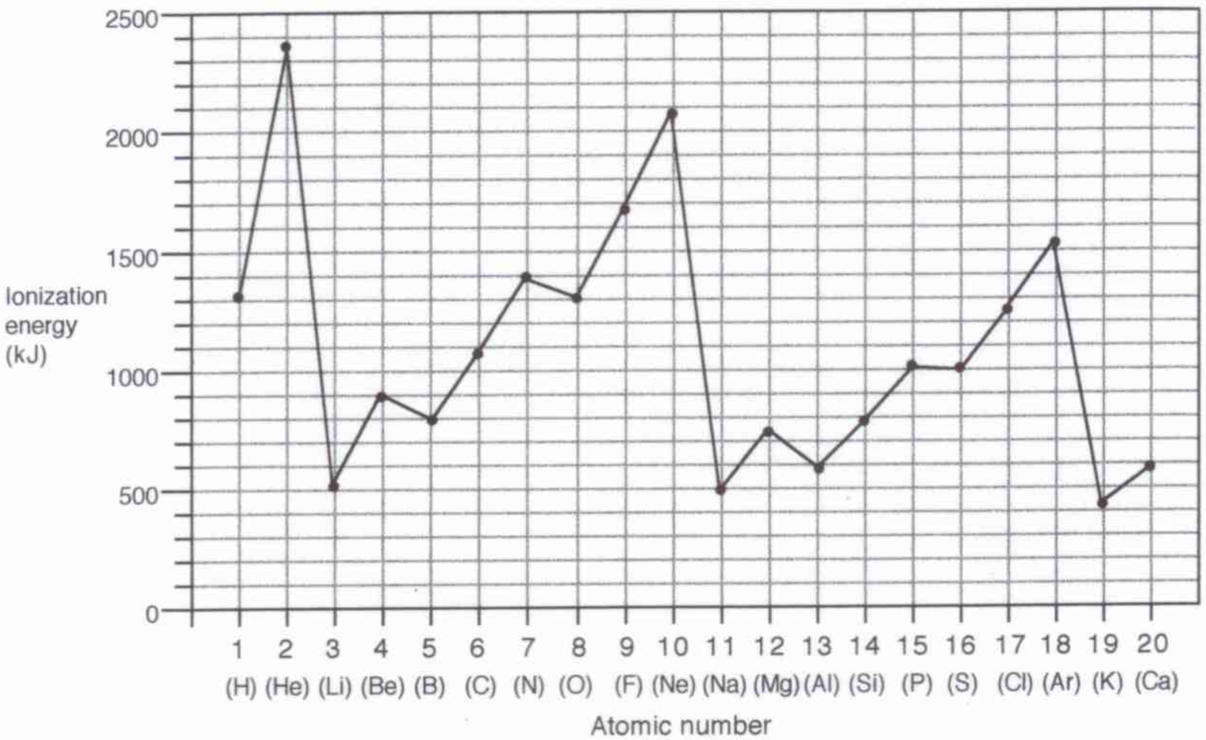
49. (a) The distance decreases as the increasing nuclear charge pulls the electrons in closer.
   (b) increases
   (c) The nucleus can hold more strongly to a given outer electron because of the greater charge and the smaller electron–nucleus distance.
   (d) The ionization energy (energy required to remove an outer electron) will therefore increase going across a period.

50.




51. (a) Cl (b) Cl (c) Ne (d) Mg (e) Ne (f) I

52.




(a) Electrons are being removed from full shells, which is very difficult to do.
(b) The outermost electrons are farther from the nucleus, so that the attraction between the nucleus and outer electrons is decreased and less energy is required for electron removal.
(c) The outer electrons are drawn closer to the nucleus (recall exercise 40), causing an increased attraction between the larger nuclear charge and the outermost electrons. The increased attraction requires a greater energy to be applied before an electron can be removed.
(d) Be and Mg have filled s–subshells, so that their ionization energies are higher than those of the elements immediately before and after them. Similarly, N and P have half–filled p–subshells and their ionization energies are higher than those of the elements immediately before and after them. The filling of the p–subshells (Ne and Ar) is a special case of increased stability leading to increased ionization energy.

53. (a) Te (b) O (c) Te (d) 6 (e) 2 (f) O

54. $Li^+$ and $F^-$ (smaller ions are closer together)

55. (a) Ga (b) Br (c) same (d) Ga = 3, Br = 7 (e) Ga = 3, Br = 1 (f) Br

56. Se, $Sr^+$, $Kr^+$ and Ge

57. (a) Ba and S = ionic (d) Rb and I = ionic
(b) P and Cl = non–ionic (e) O and H = non–ionic
(c) Ca and O = ionic (f) S and O = non–ionic

58. (a) Li (b) F (c) F (d) F
(e) IN GENERAL, going from left to right across the periodic table the electronegativity of the atoms will INCREASE.

59. (a) I (more electron shells) (b) F
(c) IN GENERAL, going down a family of the periodic table the electronegativity of the atoms will DECREASE.