1a. $1046028\ cm \left| \frac{10^{-2}\ m}{1\ cm} \right| \frac{1\ Km}{10^{3}\ m} = 10.46028\ Km$

7 S.F.

1b. $958378\ \mu g \left| \frac{10^{-6}\ g}{1\ \mu g} \right| \frac{1\ Mg}{10^{6}\ g} = 9.58378 \times 10^{-7}$

6 S.F.

2a. $14056\cancel{000}$ → 5 S.F.

$\cancel{00}25$ → 2 S.F.

9.04589 → ALL significant → 6 S.F.

3 a. mass → kg   length → meter (m)

Density → $\frac{mass}{volume} = \frac{kg}{m^3}$ Velocity → $\frac{distance}{time} = \frac{m}{s}$

4. Units of density in the table is $g/cm^3 = g/mL$

a. $\frac{0.1157\ kg}{42.86\ mL} \left| \frac{10^{3}\ g}{1\ kg} \right. = 2.70\ g/mL$ Aluminum

b. $\frac{118632\ \mu g}{1.16 \times 10^{4}\ nL} \left| \frac{1\ nL}{10^{-9}\ L} \right| \frac{10^{-3}\ L}{1\ mL} \left| \frac{10^{-6}\ g}{1\ \mu g} \right. = 10.2\ g/mL$ Molybdenum

5 a. $\frac{14.59\ g}{mL} \left| \frac{1\ Pound}{453.592\ g} \right| \frac{1\ mL}{1\ cm^3} \left| \frac{2.54\ cm}{1\ in} \right| \frac{2.54\ cm}{1\ in} \left| \frac{2.54\ cm}{1\ in} \right.$

$0.527\ \frac{Pounds}{in^3}$

b. Strategy: $\frac{kg \rightarrow g \rightarrow pounds \rightarrow oz}{m^3 \rightarrow cm^3 \rightarrow in^3 \rightarrow ft^3}$

$\frac{86.84\ kg}{m^3} \left| \frac{10^{3}\ g}{1\ kg} \right| \frac{1\ Pound}{453.592\ g} \left| \frac{16\ oz}{1\ Pound} \right| = 3063\ \frac{oz.}{m^3}$

$\frac{3063\ oz}{m^3} \left| \frac{10^{-2}\ m}{1\ cm} \right| \frac{10^{-2}\ m}{1\ cm} \left| \frac{10^{-2}\ m}{1\ cm} \right| \frac{2.54\ cm}{1\ in} \left| \frac{2.54\ cm}{1\ in} \right| \frac{2.54\ cm}{1\ in} \left| \frac{12\ in}{1\ ft} \right| \frac{12\ in}{1\ ft} \left| \frac{12\ in}{1\ ft} \right. = 86.74$

6a. $r = 70\,pm$ need Volume of sphere ($V = \frac{4}{3}\pi r^3$) in SI units (m^3)

① convert pm → m $\quad \frac{70\,pm \mid 10^{-12}\,m}{\mid 1\,pm} = 7.0 \times 10^{-11}\,m$

② solve for V $\quad V = \frac{4}{3}(3.1415)(7.0\times10^{-11}\,m)^3 = 1.4 \times 10^{-30}\,m^3$

6b. $r = \frac{1.80\times10^{2}\,pm \mid 10^{-12}\,m}{\mid 1\,pm} = 1.80\times10^{-10}\,m$

$V = \frac{4}{3}(3.1415)(1.80\times10^{-10}\,m)^3 = 2.44\times10^{-29}\,m^3$

7a. $6.5\times10^{-25}\,mL$ ① We need to convert mL to meaningful units to determine the radius of the sphere

mL → cm^3 $\quad \frac{6.5\times10^{-25}\,mL \mid 1\,cm^3}{\mid 1\,mL} = 6.5\times10^{-25}\,cm^3$

② no determine radius

$6.5\times10^{-25}\,cm^3 = \frac{4}{3}(3.1415)\,r^3$ $\quad r^3 = 1.55\times10^{-25}\,cm^3$

$r = 5.37\times10^{-9}\,cm$

③ cm → m → pm

$\frac{5.37\times10^{-9}\,cm \mid 10^{-2}\,m \mid 1\,pm}{\mid 1\,cm \mid 10^{-12}\,m} = 53.7\,pm \rightarrow 54\,pm$

7b) $\frac{6.54\times10^{-29}\,L \mid 1\,mL \mid 1\,cm^3}{\mid 10^{-3}\,L \mid 1\,mL} = 6.54\times10^{-26}\,cm^3 = \frac{4}{3}\pi r^3$

$r^3 = 1.56\times10^{-26}\,cm^3$

$r = \frac{2.499\times10^{-9}\,cm \mid 10^{-2}\,m \mid 1\,pm}{\mid 1\,cm \mid 10^{-12}\,m} = 25.0\,pm$

8 a. NO_3H_2 b. $C_2H_6N_2O$

9.

Iron-55	^{55}Fe	26 protons	55-26 = 29 neutrons	26 e^-	A=55
Molybdenum-96	^{96}Mo	42 Protons	96-42 = 54 neutrons	42 e^-	A=96
Gadolinium-157	^{157}Gd	64 Protons	157-64 = 93 neutrons	64 e^-	A=157

10. a Z = 29, neutral atom has 29 e^-. This ion has lost 2 → 27 e^-

b. Z = 33 3 extra electrons 36 electrons

11.

a. Avg Mass = 35.9675422(0.003365) + 37.9627325 (0.000632) + 39.96238 (0.996003)

Avg mass = 39.9477 → Argon

b. 135.907140 (0.00185) + 137.905985 (0.00215) + 139.905433 (0.88450) + 141.909241 (0.11114)

Avg = 140.116 amu → Cerium

12a $x + y + 0.030872 = 1$

$x = 0.9691 - y$

$28.0855 = 27.976927x + 28.9764949y + 29.9737707(0.0309)$

$27.1602 = 27.976927(0.9691 - y) + 28.9764949y$

$27.1602 = 26.32171 - 27.976927y + 28.9764949y$

$0.046976 = 0.9995684y$

$y = 0.046997$ → 4.7 % ^{29}Si

$x = 0.9691 - y = 0.9221$ → 92.21% ^{28}Si

12b.

$10.811 = 10.012937x + 11.9305y$ $x + y = 1$

$10.811 = 10.012937(1-y) + 11.9305y$ $x = 1 - y$

$10.811 = 10.012937 - 10.012937y + 11.9305y$

$0.798063 = 1.917563y$

$y = 0.41619$ $x = 1 - y = 0.5838$

41.62% 58.38%

(^{12}B) (^{10}B)

13. Elements in the same period have similar properties

Argon – Xenon   Strontium – magnesium   Boron – Aluminum

Arsenic – Phosphorus   Francium – Sodium   Iodine – Chlorine

tin – Carbon

14. a. All noble gases. Xe is the largest, meaning that the outermost e- (1st removed) is attracted to the nucleus the least
→ Ar is the smallest, so highest IE

b. Cl is the smallest, so Coulomb's law predicts its valence e- are more stable. . so Cl

c. Mg → it is the smallest, so VE more stable

15. a. $\dfrac{2.998 \times 10^{4}\ \text{PHz}}{} \Big| \dfrac{10^{-12}\ \text{Hz}}{1\ \text{PHz}} = 2.998 \times 10^{-8}\ \text{Hz}$

$E = h\nu = 6.626 \times 10^{-34}\ \text{J}\cdot\text{s}\ (2.998 \times 10^{8}\ \tfrac{1}{s})$

$E = 1.99 \times 10^{-41}\ \text{J}$

b. $642\ \text{nm} \Big| \dfrac{10^{-9}\ \text{m}}{1\ \text{nm}} = 6.42 \times 10^{-7}\ \text{m}$

$E = \dfrac{hc}{\lambda} = \dfrac{6.626 \times 10^{-34}\ \text{J}\cdot\text{s}\ (2.998 \times 10^{8}\ \text{m/s})}{6.42 \times 10^{-7}\ \text{m}}$

$E = 3.09 \times 10^{-19}\ \text{J}$

c. $15.631\ \mu\text{m} \Big| \dfrac{10^{-6}\ \text{m}}{1\ \mu\text{m}} = 1.5631 \times 10^{-5}\ \text{m}$ $E = \dfrac{hc}{\lambda}$ $E = 1.27 \times 10^{-20}\ \text{J}$

16. $E_{photon} = \phi + KE$

E_{photon} ↗ incoming photon; ϕ ↑ threshold energy; KE ↖ ejected electron

a. incoming photon: $E = h\nu = \dfrac{hc}{\lambda} = \dfrac{6.626 \times 10^{-34}\ (2.998 \times 10^{8})}{4.00 \times 10^{-7}\ \text{m}} = 4.97 \times 10^{-19}\ \text{J}$

$\lambda = 400\ \text{nm} \Big| \dfrac{10^{-9}\ \text{m}}{1\ \text{nm}} = 4.00 \times 10^{-7}\ \text{m}$

Ejected electron: $KE = \frac{1}{2}mv^2 = \frac{1}{2}(9.109\times10^{-31}\,kg)(7.308\times10^5\,\frac{m}{s})^2$

$KE = 2.4324\times10^{-19}\,J$

$E_{photon} = \phi + KE$

$\phi = E_{photon} - KE = 4.97\times10^{-19}\,J - 2.4324\times10^{-19}\,J = 2.53\times10^{-19}\,J$

b. incoming photon: $E = h\nu = \frac{hc}{\lambda} = \frac{6.626\times10^{-34}(2.998\times10^8)}{5.80\times10^{-7}\,m} = 3.42\times10^{-19}\,J$

$\lambda = 580\,nm \cdot \frac{10^{-9}\,m}{1\,nm} = 5.80\times10^{-7}\,m$

Ejected electron: $KE = \frac{1}{2}mv^2 = \frac{1}{2}(9.109\times10^{-31}\,kg)(7.308\times10^5\,\frac{m}{s})^2$

$KE = 2.4324\times10^{-19}\,J$

$E_{photon} = \phi + KE$

$\phi = E_{photon} - KE = 3.42\times10^{-19}\,J - 2.4324\times10^{-19}\,J = 9.93\times10^{-20}\,J$

17. a. Sulfur → lowest shell & furthest to right (more Z_{eff})
b. Oxygen → lowest shell & higer Z_{eff} than others in shell 2
c. Aluminum → lowest shell & highest Z_{eff}

18. Ne: $1s^2 2s^2 2p^6$ Sodium: $1s^2 2s^2 2p^6 3s^1$ Argon: $1s^2 2s^2 2p^6 3s^2 3p^6$

19. Ne: 2P Na: 3S Ar: 3P

20. Ne: $1s^2 2s^2 2p^5 3s^1$ Sodium: $1s^2 2s^2 2p^6 3s^0 3p^1$ (← this can be left out) Argon: $1s^2 2s^2 2p^6 3s^2 3p^5 4s^1$

21 & 22

Sr: Ground State $[Kr]5s^2$ Excited $[Kr]5s^1 4d^1$

Yb: Ground State $[Xe]6s^2 4f^{14}$ Excited $[Xe]6s^2 4f^{13} 5d^1$

Ba: Ground State $[Xe]6s^2$ Excited $[Xe]6s^1 4f^1$

some periodic tables show it @ f^{13}, others @ f^{14} — credit awarded either way

23. Sr: 4d ⟹ any of these

4,2,-2,-½ 4,2,2,-½
4,2,-2,½ 4,2,2,½
4,2,-1,-½ 4,2,1,-½
4,2,-1,½ 4,2,1,½
4,2,0,-½
4,2,0,½

Yb: 5d ⇒ any of these

5, 2, -2, -1/2   5, 2, 2, -1/2
5, 2, -2, 1/2   5, 2, 2, 1/2
5, 2, -1, -1/2   5, 2, 1, -1/2
5, 2, -1, 1/2   5, 2, 1, 1/2
5, 2, 0, -1/2
5, 2, 0, 1/2

Ba: 4f ⇒ any of these

4, 3, -2, -1/2   4, 3, 2, -1/2
4, 3, -2, 1/2   4, 3, 2, 1/2
4, 3, -1, -1/2   4, 3, 1, -1/2
4, 3, -1, 1/2   4, 3, 1, 1/2
4, 3, 0, -1/2   4, 3, -3, -1/2
4, 3, 0, 1/2   4, 3, -3, 1/2
4, 3, 3, -1/2
4, 3, 3, 1/2

24. N: $1s^2 2s^2 2p^3$ ⇒ 5   S: [Ne] $3s^2 3p^4$ ⇒ 6

Zn: [Ar] $4s^2 3d^{10}$ ⇒ 2 (3d: Not valence!)   Au: [Xe] $6s^2 4f^{14} 5d^9$ ⇒ 2 ($4f^{14} 5d^9$: Not valence)

Am: [Rn] $7s^2 5f^7$ ⇒ 2   Eu: [Xe] $6s^2 4f^7$ ⇒ 2

25. N: 2s = 2, 0, 0, 1/2 ; 2, 0, 0, -1/2
2p: 2, 1, -1, 1/2   2, 1, 0, 1/2   2, 1, 1, 1/2
2, 1, -1, -1/2   2, 1, 0, -1/2   2, 1, 1, -1/2

S: 3s = 3, 0, 0, 1/2 ; 3, 0, 0, -1/2
3p: 3, 1, -1, 1/2   3, 1, 0, 1/2   3, 1, 1, 1/2
3, 1, -1, -1/2   3, 1, 0, -1/2   3, 1, 1, -1/2

Zn: 4s   4, 0, 0, 1/2 ; 4, 0, 0, -1/2   Au: 6s   6, 0, 0, 1/2 ; 6, 0, 0, -1/2

Am: 7s   7, 0, 0, 1/2 ; 7, 0, 0, -1/2   Eu 6s: 6, 0, 0, 1/2 ; 6, 0, 0, -1/2

26. Ar < K < S < Cl ← higher Z_{eff} AND creates stable e⁻ config

↗ noble gas has stable e⁻ config!   ↖ wants to lose e⁻, not gain

b. P < N < O < F

↗ largest atom (lower E_p)   as Z_{eff} increases, so does e⁻ affinity

27. All are isoelectric! cations = smallest   anions = biggest

a. $Ne < F^{-1} < O^{-2} < N^{-3}$

b. $Mg^{2+} < Ne < Ca^{2+} < K^{+}$

c. $Na^{+} < Ca^{2+} < Ar < Cl^{-} < S^{2-} < P^{3-}$

28. Ionization occurs when the e⁻ no longer interacts with the nucleus ... or has an $E = \emptyset$

- this occurs @ $n = \infty$

In this case, the photon that is needed will have the energy $E_{photon} = E_{\infty} - E_n = -E_n$

So, the ionization energy is readily calculable by determining E_n

a. $E_n = -2.1799 \times 10^{-18}\,J\left(\frac{1}{3^2}\right) = -2.42 \times 10^{-19}\,J$ $E_{photon} = 2.42 \times 10^{-19}\,J$

b. $E = -2.1799 \times 10^{-18}\,J\left(\frac{1}{6^2}\right) = -6.06 \times 10^{-20}\,J$ $E_{photon} = 6.06 \times 10^{-20}\,J$

29+30a. $E = h\nu$

$2.42 \times 10^{-19}\,J = 6.626 \times 10^{-34}\,J \cdot s\,(\nu)$

$\nu = 3.65 \times 10^{14}\,Hz \left| \frac{1\,GHz}{10^9\,Hz} \right. = 3.65 \times 10^5\,GHz$

$c = \lambda\nu$

$2.998 \times 10^8\,\frac{m}{s} = \lambda\left(3.65 \times 10^{14}\,\frac{1}{s}\right)$ $\lambda = 8.21 \times 10^{-7}\,m \left| \frac{1\,nm}{10^{-9}\,m} \right. = 821\,nm$

b. $6.06\times10^{-20}\,J = 6.626\times10^{-34}\,\nu$

$$\nu = 9.15\times10^{13}\,Hz \left|\frac{1\,GHz}{10^9\,Hz}\right. = 9.15\times10^{4}\,GHz$$

$$2.998\times10^{8}\,m/s = \lambda(9.15\times10^{13}\,s^{-1}) \quad \lambda = 3.28\times10^{-6}\,m\left|\frac{1\,nm}{10^{-9}\,m}\right. = 3280\,nm$$

31. Paschen $n_i \rightarrow n=3$

a. $1282\,nm\left|\frac{10^{-9}\,m}{1\,nm}\right. = 1.282\times10^{-6}\,m \quad E=\frac{hc}{\lambda}=\frac{6.626\times10^{-34}(2.998\times10^{8})}{1.282\times10^{-6}} = 1.55\times10^{-19}\,J$

$E_{photon} = E_n - E_3$

$$E_3 = \frac{-2.1799\times10^{-18}\,J}{9} = -2.42\times10^{-19}\,J$$

$1.55\times10^{-19}\,J = E_n - {-2.42\times10^{-19}}$

$$E_n = -8.705\times10^{-20}\,J = \frac{-2.1799\times10^{-18}\,J}{n^2}$$

$n^2 = 25$

$n=5$

b. $923\,nm\left|\frac{10^{-9}\,m}{1\,nm}\right. = 9.23\times10^{-7}\,m \quad E=\frac{hc}{\lambda} = 2.15\times10^{-19}\,J$

$E_{photon} = E_n - E_3$

$$E_3 = \frac{-2.1799\times10^{-18}\,J}{9} = -2.42\times10^{-19}\,J$$

$2.15\times10^{-19}\,J = E_n - {-2.42\times10^{-19}}$

$$E_n = -2.7\times10^{-20} = \frac{-2.1799\times10^{-18}\,J}{n^2}$$

$n^2 = 80.$

$n=9$

32. a. lowest energy is the smallest distance between lines. Generate a photon, so start at a higher energy $A \rightarrow B$

b. low λ = high energy

- so the largest gap $D \rightarrow A$
- energy is required, so start low and end high

33. a. $n=1$ $l=0$ ↖ s orbital 1s

b. $n=4$ $l=3$ ↖ orbital 4f

c. $n=3$ $l=1$ 3p

34. $l=3$ $m_l = -3, -2, -1, 0, 1, 2, 3 \rightarrow 7$

$l=0$ $m_l = 0 \rightarrow 1$

$l=5$ $m_l = -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5 = 11$

35. Se [Ar] $4s^2 3d^{10} 4p^4$

Bi [Xe] $6s^2 4f^{14} 5d^{10} 6p^3$ $\xrightarrow{-2e^-}$ Bi^{+2}: [Xe] $6s^2 4f^{14} 5d^{10} 6p^1$

Sn [Kr] $5s^2 4d^{10} 5p^2$ $\xrightarrow{+4e^-}$ Sn^{-4}: [Kr] $5s^2 4d^{10} 5p^6$ = [Xe]