Chemical Principles 115
Department of Chemistry
Rutgers, The State University of New Jersey- Camden

EXAM 3 B
December 2, 2015

Name: Key
Last First Initial

RU Number:_____

Exam 3 B

Name: _____

SECTION I

MULTIPLE CHOICE: Choose the option that best completes the statement or answers the question. Each question is worth 2.0 points unless indicated otherwise.

1. Calculate the kinetic energy (KE) of an object which has a mass of 9.00×10^2 g, and is traveling in a straight line with a speed of 4.0×10^1 m s^{-1}.
   a. 0.72 kJ
   b. 1.44 kJ
   c. 2.88 kJ
   d. 16.2 kJ
   e. 18 kJ

   $m = 9.00 \times 10^2\ g \left(\frac{1\ kg}{1000\ g}\right) = 0.9\ kg$

   $E = \frac{1}{2}(0.9\ kg)(4.0 \times 10^1\ m/s)^2$

   $= 720\ J \Rightarrow 0.72\ kJ$

2. How many kilocalories are equivalent to 18.9 kilojoules?
   a. 79.1 kcal
   b. 4.52 kcal
   c. 9.03 kcal
   d. 7.91 kcal
   e. 34.2 kcal

   $18.9\ kJ \left(\frac{1000\ J}{1\ kJ}\right)\left(\frac{1\ cal}{4.184\ J}\right)\left(\frac{1\ kcal}{1000\ cal}\right) = 4.52\ kcal$

3. A system that allows the transfer of mass and allows the transfer of thermal energy would best be classified as
   a. an open system.
   b. a closed system.
   c. an isolated system.
   d. an adiabatic system.
   e. an isobaric system.

4. A certain oil used in industrial transformers has a density of 1.086 g mL^{-1} and a specific heat of 1.826 J g^{-1} $^\circ C^{-1}$. Calculate the heat capacity of one gallon of this oil. (1 gallon = 3.785 liters)
   a. 0.4442 kJ $^\circ C^{-1}$
   b. 0.5239 kJ $^\circ C^{-1}$
   c. 2.251 kJ $^\circ C^{-1}$
   d. 6.364 kJ $^\circ C^{-1}$
   e. 7.506 kJ $^\circ C^{-1}$

   $C = s \cdot m$

   $1\ gal \left(\frac{3.785\ L}{1\ gal}\right)\left(\frac{1000\ mL}{1\ L}\right)\left(\frac{1.086\ g}{1\ mL}\right) = 4110.51\ g$

   $= 1.826 \frac{J}{g\,^\circ C}\left(4110.51\ g\right)\left(\frac{1\ kJ}{1000\ J}\right) = 7.505\ kJ/^\circ C$

5. A 113.25 gram sample of gold is initially at 100.0 °C. It gains 20.00 J of heat from its surroundings. What is its final temperature? (specific heat of gold = 0.129 J g^{-1} $^\circ C^{-1}$)
   a. 98.6 °C
   b. -98.6 °C
   c. 101.4 °C
   d. -101.4 °C
   e. 96.6 °C

   $q = ms(T_f - T_i)$

   $\frac{q}{ms} + T_i = T_f$

   $\frac{20.00\ J}{(113.25\ g)\left(0.129 \frac{J}{g\,^\circ C}\right)} + 100^\circ C = 101.4^\circ C$

Name: _____

6. The wavelength of an electromagnetic wave is
   a. the number of complete oscillations or cycles over a distance of one meter.
   b. the distance between successive maxima in the wave.
   c. the number of complete oscillations or cycles in a one second time interval.
   d. the number of complete oscillations or cycles over a distance of one centimeter.
   e. the distance between a minimum and the nearest maximum in the oscillation.

7. What is the wavelength of electromagnetic radiation which has a frequency of 6.282×10^{14} s^{-1}?
   a. 1.883×10^{23} m
   b. 2.095×10^{6} m
   c. 4.772×10^{-7} m
   d. 4.772×10^{-7} nm
   e. 530.9 nm

   $\lambda = \frac{3.00 \times 10^{8}\ m/s}{6.282 \times 10^{14}\ s} = 4.77 \times 10^{-7}\ m$

8. Which radiation has the lowest frequency?
   a. gamma rays
   b. infrared radiation
   c. microwave radiation
   d. visible light rays
   e. ultraviolet rays

9. What is the energy of one ~~mole~~ of photons of visible light having a wavelength of 486.1 nm?
   a. 12.41 kJ
   b. 2.461×10^{-4} J
   c. 2.461×10^{5} J
   d. ~~$6.[illegible] \times 10^{14}$ J~~ 4.089×10^{-19} J
   e. ~~$8.770.[illegible] \times 10^{25}$ J~~ None of the Above

   $E = h\nu$

   $\nu = \frac{3.00 \times 10^{8}}{486.1 \times 10^{-9}} = 6.1715 \times 10^{14}\ \frac{1}{s}$

   $E = 6.626 \times 10^{-34}\ J \cdot s \left(6.1715 \times 10^{14}\ \frac{1}{s}\right)$

   $= 4.089 \times 10^{-19}\ J$

10. The photoelectric effect
    a. describes the interaction of light with a photograph.
    b. is the process in which electrons are ejected from certain material by photons.
    c. describes how electrons interact with each other.
    d. is the process of light being emitted from an electrical wire.
    e. describes the interactions of photons with a pane of glass.

11. Which statement is true?
    a. The line spectra of elements are the same provided they belong to the same family.
    b. The line spectra of elements can be used to identify the elements.
    c. The line spectra of elements are the same provided they belong to the same family ***and*** are combined with oxygen.
    d. The line spectra of elements are the same provided they belong to the same family ***and*** are in the same physical state.
    e. The line spectra of elements can be used for separation of elements from mixtures.

Name: _____

12. Calculate the wavelength of the spectral line in the spectrum of hydrogen for which $n_1 = 2$ and $n_2 = 4$.
    a. 207 nm
    b. 365 nm
    c. 486 nm
    d. 274 nm
    e. 131 nm

$\frac{1}{\lambda} = 109{,}678\ cm^{-1}\left(\frac{1}{2^2} - \frac{1}{4^2}\right) = 20\,564.625\ cm^{-1}$

$\lambda = 4.8629 \times 10^{-5}\ cm\left(\frac{1\ m}{100\ cm}\right)\left(\frac{10^9\ nm}{1\ m}\right) = 486.2\ nm$

13. The first description of the electron in the hydrogen atom by application of the wave nature of matter was presented by
    a. Louis de Broglie.
    b. Werner von Heisenberg.
    c. Wolfgang Pauli.
    d. Ernest Rutherford.
    e. Erwin Schrödinger.

14. The three quantum numbers which characterize the solutions to Schrodinger's equation describing the behavior of the electron in the H atom are usually designated as
    a. *1s 2s 2p*
    b. $n\ \ l\ \ m_s$
    c. $m_l\ \ m_s\ \ m_p$
    d. $l\ \ m_l\ \ m_s$
    e. $n\ \ l\ \ m_l$

15. The notation for the subshell with $n = 3$ and $l = 3$ is
    a. 3d subshell.
    b. 3f subshell.
    c. 3p subshell.
    d. 3s subshell.
    e. There is no subshell fitting this description.

16. What is the maximum number of electrons that can fill all the orbitals of a *f* subshell?
    a. 6
    b. 8
    c. 10
    d. 12
    e. 14

17. Given the following sets of quantum numbers for *n, l, m_l, and m_s*, which one of these sets is not possible for an electron in an atom?

	n	*l*	m_l	m_s	
a.	4	2	2	-½	NO
b.	3	1	-1	½	
c.	4	3	2	½	
d.	4	3	-2	-½	
e.	5	2	2	½	

Name: _____

18. The total number of electron in a shell with principal quantum number 5 is:
    a. 32
    b. 10
    c. 25
    d. 50
    e. 5

19. An orbital is a representation of:
    a. Wave Function
    b. Velocity Function
    c. Acceleration Function
    d. Mass Function
    e. None of the above

20. Which atom has the electron configuration of $[Ar]4s^2 3d^{10} 4p^4$?
    a. P
    b. Se
    c. Bi
    d. N
    e. As

21. Which of the following choices is the correct electron configuration for a sulfur atom?

	3s	3p
a. [Ne]	↑↓	↑ ↑ ↑
b. [Ne]	↑	↑↓ ↑ ↑↓
c. [Ne]	↑↓	↑↓ ↑ ↑
d. [Ne]	↑↓	↑↓ ↑↓
e. [Ne]	↑↓	↑↓ ↑↓

9 [Ne] $3s^2 3p^4$

(N) (↑↓) (↑) (↑)

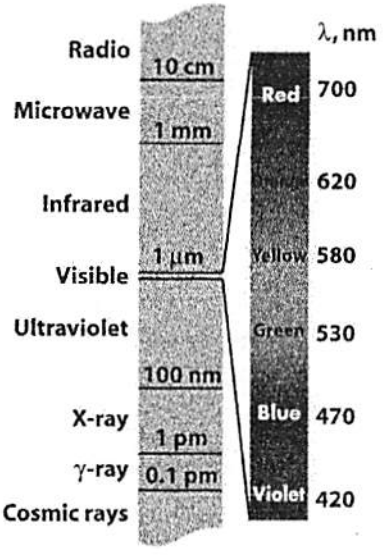
22. Which atom has the largest radius?
    a. Ca
    b. Ba
    c. Al
    d. Mg
    e. C

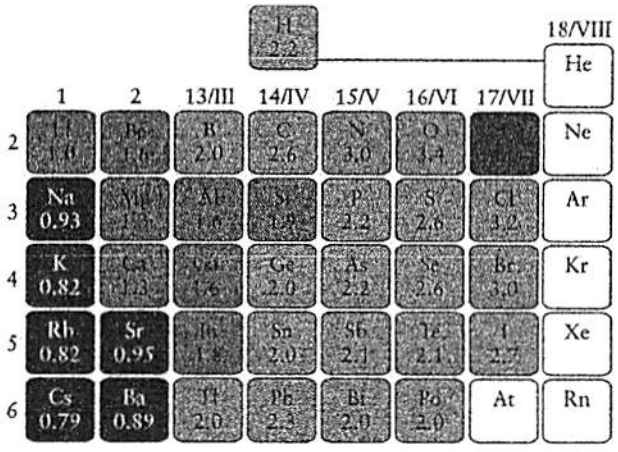
23. The increase in atomic radius as one progresses *within the alkali metal family* from element Z = 3 to Z = 87 in the periodic table can be attributed to
    a. the increase in the principal quantum number of the outermost occupied orbital in the atom.
    b. the decrease in the principal quantum number of the outermost occupied orbital in the atom.
    c. the increase in the effective nuclear charge being experienced by the electron(s) in the outermost occupied orbital in the atom.
    d. the decrease in the effective nuclear charge being experienced by the electron(s) in the outermost occupied orbital in the atom.
    e. the increase in the secondary quantum number of the outermost occupied orbital in the atom.

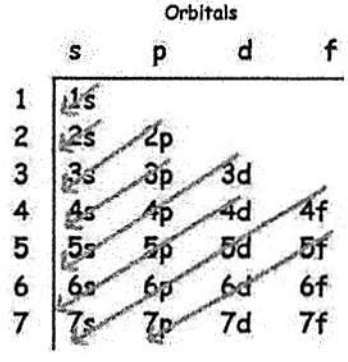
Name: _____

24. Which ionic solid is likely to have the least exothermic lattice energy?
    a. KCl
    b. NaCl
    c. LiCl
    d. CsCl → r is bigger than Σ smallest
    e. RbBr

25. Which species below has eight valence electrons in its Lewis symbol?
    a. S^{2-}
    b. Ar^{+}
    c. F^{+}
    d. Mg^{+}
    e. Si







Name: _____

SECTION II

Complete each of the following.
Show all work. No Credit will be given for answer only.

1. (6 Points) A 55.00 gram pellet of lead at 25 °C is added to 58.5 g of boiling water (specific heat of 4.18 J g^{-1} $°C^{-1}$) at 100 °C in an insulated cup. If the final temperature of the water in the cup is 97.9 °C, what is the specific heat of lead?

$$q_l = -q_{wth}$$

$$m_l s_l \Delta T_l = -m_w s_w \Delta T_w$$

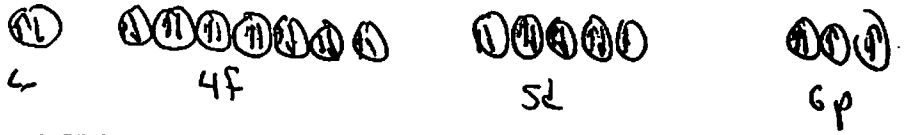
$$s_l = -\left(\frac{m_w}{m_l}\right)\left(\frac{\Delta T_w}{\Delta T_l}\right) s_w = -\left(\frac{58.5\,g}{55.0\,g}\right)\left(\frac{97.9-100}{97.9-25}\right)\left(4.18\,\frac{J}{g°C}\right) = 0.12807\,\frac{J}{g°C}$$

2. (10 Points) Write the ground state electron configuration, abbreviated ground state electron configuration, orbital for the abbreviated electron configuration, valence shells and Lewis structure for polonium.

Step 1: Ground State Electron Configuration

$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2 4f^{14} 5d^{10} 6p^4$

Step 3: Orbital Diagram for Abbreviated Ground State Electron Configuration



Step 4: Valence Shell

$6s^2 6p^4$

Step 5: Lewis Structure

Name: _____

3. (6 Points) The speed of an electron that is emitted from the surface of a sample of zinc by a photon is 1.5×10^{6} m/s. The mass of electron is 9.109×10^{-31} kg.

a. What is the kinetic energy of the ejected electron?

$$E_k = \frac{1}{2}(9.109 \times 10^{-31}\ kg)(1.5 \times 10^{6}\ m/s)^2$$

$$E_k = 1.0247 \times 10^{-18}\ J$$

b. The work function of zinc is 4.37 eV. What is the wavelength of the radiation that caused photoejection of the electron? Identify the electromagnetic spectrum. (Hint: 1.602×10^{-19} J/eV).

Step 1: Using the energy value calculate above and the work function, calculate the frequency.

$$E = h\nu - \Phi$$

$$\nu = \frac{E + \Phi}{h} = \frac{1.0247 \times 10^{-18}\ J + 4.37\ eV\left(\frac{1.602 \times 10^{-19}\ J}{1\ eV}\right)}{6.62 \times 10^{-34}}$$

$$\nu = 2.6053 \times 10^{15}\ \frac{1}{s}$$

Step 2: Calculate the wavelength.

$$\lambda = \frac{3.00 \times 10^{8}\ m/s}{2.6053 \times 10^{15}\ 1/s} = 1.1514 \times 10^{-7}\ m\left(\frac{10^{9}\ nm}{1\ m}\right)$$

$$\lambda = 115.14\ nm$$

Step 3: Identify the electromagnetic spectrum.

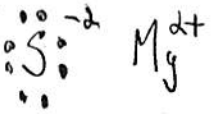
Ultraviolet

Name: _____

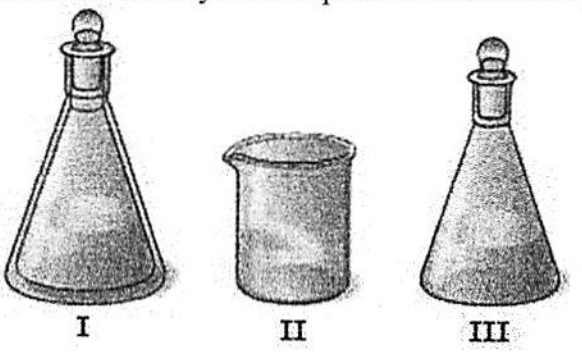
4. (5 Points) Use the Lewis symbol to diagram the reaction between Mg and S

Mg^{2+} S^{2-}

MgS



5. (5 Points) Consider the three systems depicted in the following drawing:



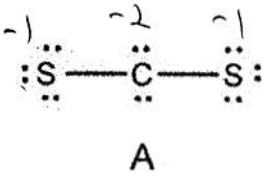
Label them as isolated, closed, and open. Describe each system.

I Isolated no charge mass or energy

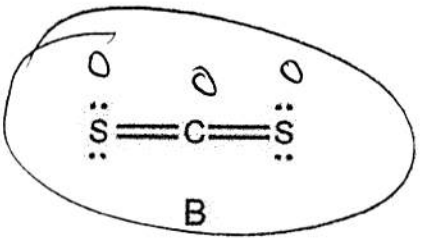
II open change mass and energy

III closed change in energy

6. (8 Points) Select the correct Lewis structure for carbon disulfide and prove it with formal charges for all cases.



A



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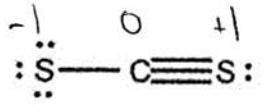

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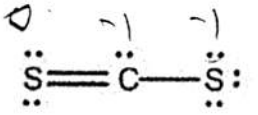
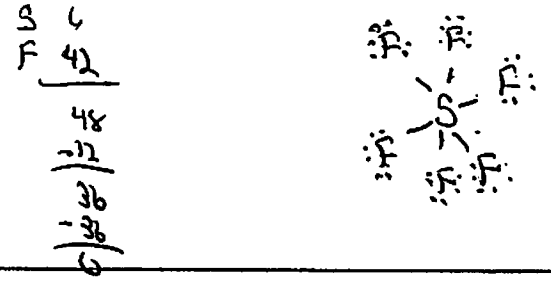
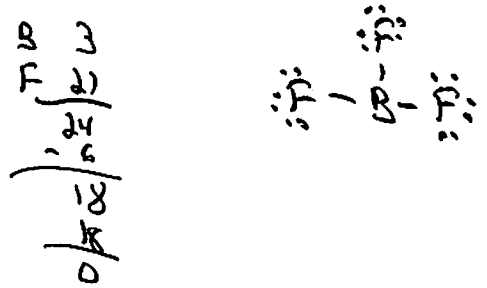
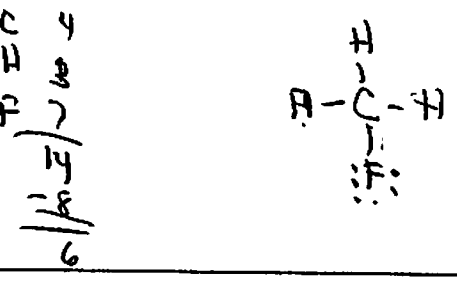
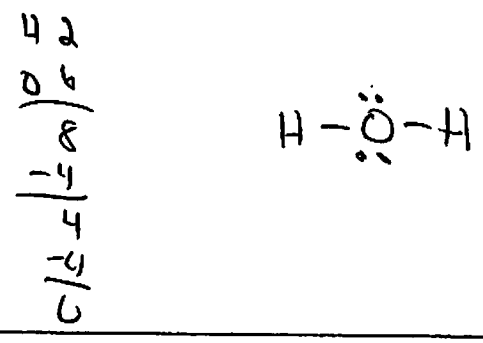


D

Name: _____

7. (10 Points) Complete each of the following.

Molecule	Lewis Structure
SF_6	
BF_3	
CH_3F	
H_2O	

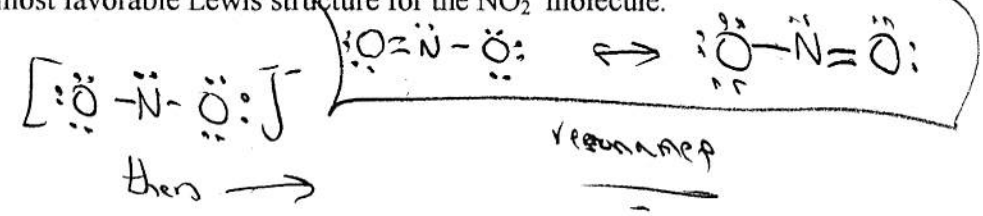
Name: _____

SECTION III: BONUS POINTS
Show all work. No Credit will be given for answer only.

1. (2 Points) Draw the most favorable Lewis structure for the NO_2^- molecule.

N 5
O 12
17
+1
18

18
-4
14



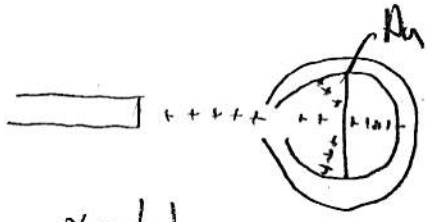
2. (2 Points) Arrange the following (Ga, P, As, Ge) in terms of ~~increasing~~ decreasing electronegativity values.

P, As, Ge, Ga

3. (2 Points) Define state function

thermodynamic quantity whose value depend on the state, only considering initial and final is does not care about the pathway

4. (2 Points) Describe Ernest Rutherford experiment in which he concluded that the nucleus of the atom is composed on positive particles. (Show Diagram)



deflected in different direction indicating that nucleus is composed of + particles

Name: ____________________

Periodic Table of the Elements

1A	2A	3B	4B	5B	6B	7B	8B	8B	8B	1B	2B	3A	4A	5A	6A	7A	8A
1 H 1.008																	2 He 4.003
3 Li 6.939	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 18.99	10 Ne 20.18
11 Na 22.99	12 Mg 24.31											13 Al 26.96	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.90	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.71	29 Cu 63.55	30 Zn 65.37	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc [99]	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57 La 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (210)	85 At [210]	86 Rn [222]
87 Fr [223]	88 Ra [226]	89 Ac (227)	104	105	106												

Lanthanum series	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (145)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175
Actinium series	90 Th	91 Pa 231	92 U 238.0	93 Np (237)	94 Pu (242)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (249)	99 Es (254)	100 Fm (253)	101 Md (256)	102 No (256)	103 Lr (257)

Name: _____

USEFUL INFORMATION

$\Delta U = w + q$

$w = -P_{ex}\Delta V$

$T_K = {}^{o}C + 273.15$

$N = \frac{sample_{mass}}{atom_{mass}}$

$Mass\%_{element} = \frac{mass_{element}}{mass_{total-sample}} * 100\%$

$\frac{molar\_mass\_of\_compound}{molar\_mass\_of\_empirical\_formula\_unit} = \text{interger}$

1 cal = 4.184 J

$E = E_k + E_p$

$E_k = \frac{1}{2}mv^2$

$E_p = mgh$

$m = nM$

$M = m_{atom}N_A$

$N = nN_A$

$c = \frac{n}{V}$

$V_{final} \cdot c_{final} = V_{initial} \cdot c_{intial}$

$\Delta H = \Delta U + P\Delta V$

$E_{p,12} = \frac{z_1 z_2 e^2}{4\pi\varepsilon_o r_{12}}$

$q = C \times \Delta T$

$C = s \times m$

$q = s \times m \times \Delta t$

$\Delta H^o = \sum n\Delta H_f^o(products) - \sum n\Delta H_f^o(reactans)$

$\lambda\nu = c$

$E = h\nu$

$E_k = \frac{1}{2}m_e v^2 = h\nu - \Phi$

$\frac{1}{\lambda} = R_H\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

$\lambda = h/p = h/(mv)$

$-q = q_{cal}$

1 Hz = 1 s^{-1}

FC = V – (B+L)

R= 8.31446 J/mol K

R_H = 109,678 cm^{-1} = Rydberg constant
h = Planck's constant = **6.626×10^{-34} J s**
c = **speed of light** = 2.9979×10^8 m/s
1 J = 1 kg m^2/s^2