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

EXAM 3 A
December 2, 2015

Name: Key _____
Last First Initial

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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 5.00×10^2 g, and is traveling in a straight line with a speed of 50.0 m s^{-1}.
   a. 0.625 kJ
   b. 1.25 kJ
   c. 2.5 kJ
   d. 6.25 kJ
   e. 25 kJ

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

$= \frac{1}{2}(0.5\,kg)(50.0\,m/s)^2$

$= 0.625\,KJ$

$5.00 \times 10^2\,g \left(\frac{1\,kg}{1000\,g}\right) = 0.5\,kg$

2. How many kilojoules are equivalent to 8.18 kilocalories?
   a. 1.96 kJ
   b. 1,955 kJ
   c. 8,180 kJ
   d. 34,200 kJ
   e. 34.2 kJ

$1\,cal = 4.184\,J$

$8.18\,Kcal \left(\frac{1000\,cal}{1\,Kcal}\right)\left(\frac{4.184\,J}{1\,cal}\right)\left(\frac{1\,KJ}{1000\,J}\right) = 34.2\,KJ$

3. A system that does not allow the transfer of mass but does allow 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 1.068 g mL^{-1} and a specific heat of 1.628 J g^{-1} $^{\circ}C^{-1}$. Calculate the heat capacity of one gallon of this oil. (1 gallon = 3.785 liters)
   a. 0.3747 kJ $^{\circ}C^{-1}$
   b. 0.4027 kJ $^{\circ}C^{-1}$
   c. 2.483 kJ $^{\circ}C^{-1}$
   d. 5.770 kJ $^{\circ}C^{-1}$
   e. 6.581 kJ $^{\circ}C^{-1}$

$C = S \cdot m$

$1\,gal \left(\frac{3.785\,L}{1\,gal}\right)\left(\frac{1000\,mL}{1\,L}\right)\left(\frac{1.068\,g}{1\,mL}\right) = 4042.38\,g$

$= 1.628\,\frac{J}{g^{\circ}C}\left(4042.38\,g\right)\left(\frac{1\,kJ}{1000\,J}\right) = 6.5809$

5. A 500.0 gram sample of aluminum is initially at 25.0 $^{\circ}C$. It absorbs 32.60 kJ of heat from its surroundings. What is its final temperature, in $^{\circ}C$? (specific heat = 0.9930 J g^{-1} $^{\circ}C^{-1}$ for aluminum)
   a. 40.4 $^{\circ}C$
   b. 64.7 $^{\circ}C$
   c. 65.7 $^{\circ}C$
   d. 89.7 $^{\circ}C$
   e. 90.7 $^{\circ}C$

$q = mS\Delta T$

$\Delta T = \frac{q}{mS} = \frac{32.60\,kJ\left(\frac{1000\,J}{1\,kJ}\right)}{(500\,g)\left(0.9930\,\frac{J}{g^{\circ}C}\right)} = 65.6596\,^{\circ}C$

$\Delta T_f = 65.6596 + 25.0 = 90.7\,^{\circ}C$

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6. The wavelength of an electromagnetic wave is
   a. the number of complete oscillations or cycles over a distance of one meter.
   b. the number of complete oscillations or cycles in a one second time interval.
   c. the distance between successive maxima in the wave.
   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 3.818×10^{14} s^{-1}?
   a. 1145 nm
   b. 1.274×10^{-1} nm
   c. 1.274×10^{-7} m
   d. 7.852×10^{-7} nm
   e. 7.852×10^{-7} m

$\lambda = \frac{c}{\nu} = \frac{3.00 \times 10^{8}\ m/s}{3.818 \times 10^{14}\ s^{-1}} = 7.8575 \times 10^{-7}\ m$

8. Which radiation has the highest frequency?
   a. blue visible light
   b. radio waves
   c. infrared radiation
   d. microwave radiation
   e. television

9. What is the energy of one photon of visible radiation with a wavelength of 464.1 nm?
   a. 1.026×10^{-48} J
   b. 2.100×10^{35} J
   c. 2.341×10^{11} J
   d. 4.280×10^{-19} J
   e. 4.280×10^{-12} J

$E = h\nu$

$\nu = \frac{c}{\lambda} = \frac{3.00 \times 10^{8}\ m/s}{464.1 \times 10^{-9}\ m} = 6.4641 \times 10^{14}$

$E = 6.626 \times 10^{-34}\ J \cdot s \left(6.4641 \times 10^{14}\right)$

$= 4.2831 \times 10^{-19}$

10. The photoelectric effect
    a. describes the interaction of light with a photograph.
    b. describes how electrons interact with each other.
    c. is the process in which electrons are ejected from certain material by photons.
    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 are the same provided they belong to the same family ***and*** are combined with oxygen.
    c. The line spectra of elements are the same provided they belong to the same family ***and*** are in the same physical state.
    d. The line spectra of elements can be used for separation of elements from mixtures.
    e. The line spectra of elements can be used to identify the elements.

Name: _____

12. Calculate the wavelength of the spectral line in the spectrum of hydrogen for which $n_1 = 1$ and $n_2 = 3$.
    a. 277 nm
    b. 103 nm
    c. 345 nm
    d. 397 nm
    e. 489 nm

$\frac{1}{\lambda} = R_H\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) = 109{,}678\ cm^{-1}\left(\frac{1}{1^2} - \frac{1}{3^2}\right)$

$\frac{1}{\lambda} = 97491.55\ cm^{-1}$

$\lambda = 1.0257 \times 10^{-5}\ cm \left(\frac{1\ m}{100\ cm}\right)\left(\frac{10^9\ nm}{1\ m}\right) = 103\ nm$

13. The de Broglie relationship provides a link between which two properties of the electron?
    a. The mass and the charge.
    b. The mass and the energy.
    c. Its energy and its charge.
    d. The orbit and its wavelike movements.
    e. Its wave and particle properties.

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. n l m_l
    e. l m_l m_s

15. The notation for the subshell with $n = 4$ and $l = 2$ is
    a. 4d subshell.
    b. 4p subshell.
    c. 4f subshell.
    d. 4s subshell.
    e. There is no subshell fitting this description.

0 1 2
s p d

4d

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

$d \rightarrow l = 2$

$m_l = -2, -1, 0, 1, 2$

5 orb → 10 elec

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.	3	2	2	-½
b.	3	1	-1	½
c.	4	3	2	½
d.	4	3	-2	-½
e.	5	2	3	½

Name: _____

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

19. What does the orbital angular momentum quantum number specify?
    a. The size of an orbital
    b. The number of electrons in an orbital
    c. The shape of an orbital
    d. The orientation of an orbital
    e. None of the above

20. Which atom has the electron configuration of $[Ar]4s^2 3d^{10} 4p^3$?
    a. P
    b. Sb
    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]		↑↓ ↑↓ ↑↓

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

23. The decrease in atomic radius as one progresses from element Z = 11 to Z = 18 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 experienced by the electron(s) in the outermost occupied orbital in the atom.
    d. the decrease in the effective nuclear charge 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.

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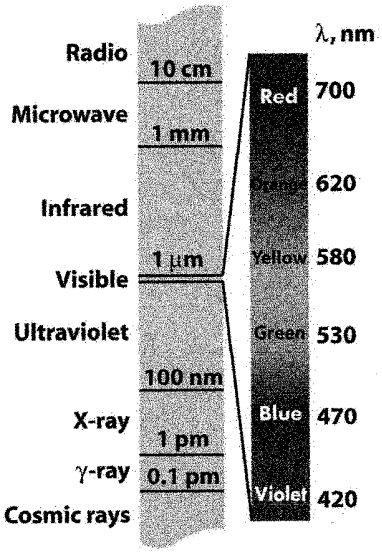
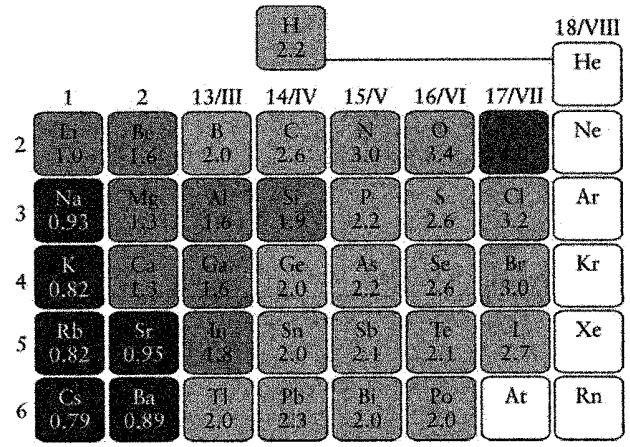
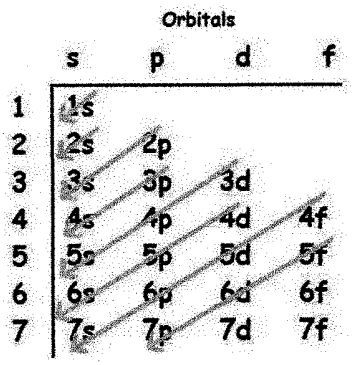
24. Which of the following solids is likely to have the largest exothermic lattice energy?
    a. LiF
    b. NaCl
    c. $AlCl_3$
    d. Al_2O_3
    e. $CaCl_2$

bigger charge

25. Which species below has eight valence electrons in its Lewis symbol?
    a. Ar^+
    b. F^+
    c. Mg^+
    d. S^{2-}
    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 25.00 gram pellet of lead (specific heat = 0.128 J g^{-1} $°C^{-1}$) at 25 °C is added to 95.3 g of boiling water (specific heat of 4.18 J g^{-1} $°C^{-1}$) at 100 °C in an insulated cup. What is the expected final temperature of the water?

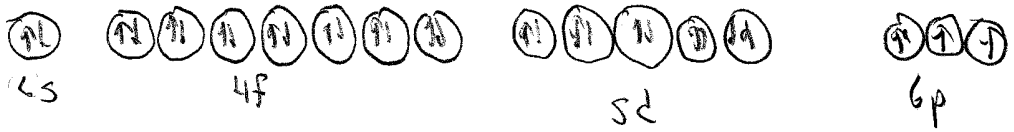
$$q_{lead} = -q_{water}$$
$$m_p s_p (T_f - T_i) = -m_w s_w (T_f - T_w)$$
$$m_p s_p T_f - m_p s_p T_i = -m_w s_w T_f + m_w s_w T_w$$
$$m_p s_p T_f + m_w s_w T_f = m_p s_p T_i + m_w s_w T_w$$
$$T_f = \frac{m_p s_p T_i + m_w s_w T_w}{m_p s_p + m_w s_w} = 99.4\,°C$$

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 bismuth.

Step 1: Ground State Electron Configuration

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

Step 3: Orbital Diagram for Abbreviated Ground State Electron Configuration



Step 4: Valence Shell

$6s^2 6p^3$

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 785 x 10^3 m/s. The mass of electron is 9.109 x 10^{-31} kg.

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

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

$= \frac{1}{2}(9.109\times10^{-31}\ kg)(785\times10^{3}\ m/s)^2$

$= 2.8065\times10^{-19}\ J$

   b. Using the energy value calculated above. What is the wavelength of the radiation that caused photoejection of the electron? The **work function** of zinc is 3.63 eV. Identify the electromagnetic spectrum.
   (Hint: 1.602x10^{-19} J/eV)

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

$E = h\nu - \Phi$

$\nu = \frac{E+\Phi}{h} = \frac{2.8065\times10^{-19}\ J + 3.63\ eV\left(\frac{1.602\times10^{-19}}{1\ eV}\right)}{6.626\times10^{-34}}$

$\nu = 1.3012\times10^{15}\ \frac{1}{s}$

Step 2: Calculate the wavelength.

$\lambda = \frac{c}{\nu} = \frac{3.00\times10^{8}\ m/s}{1.30\times10^{15}\ \frac{1}{s}} = 2.30\times10^{-7}\ m\left(\frac{10^{9}\ nm}{1\ m}\right)$

$= 230.76\ nm$

Step 3: Identify the electromagnetic spectrum.

ultraviolet

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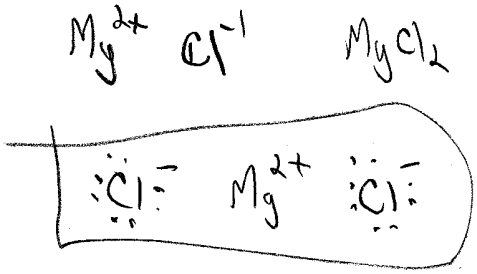
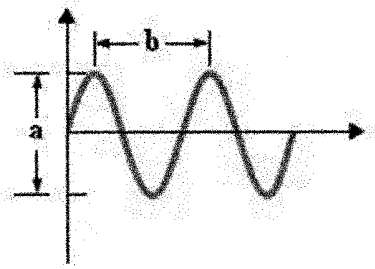
4. (5 Points) Use the Lewis symbol to diagram the reaction between Mg and Cl



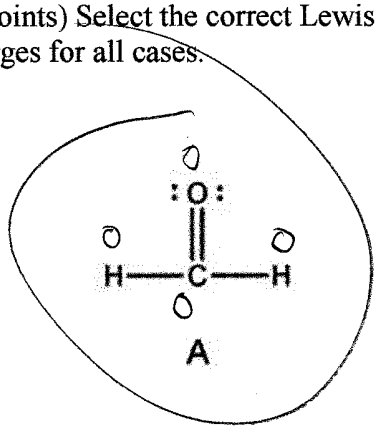
5. (5 Points) Examine the following picture of a wave and label its wavelength and its amplitude.



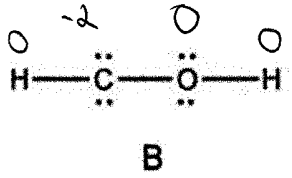
a: amplitud

b = wavelength

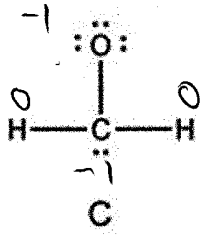
6. (8 Points) Select the correct Lewis structure for CH_2O. Calculate the formal charges for all cases.



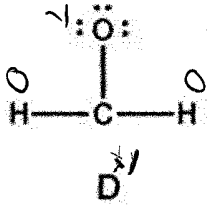
A



B



C



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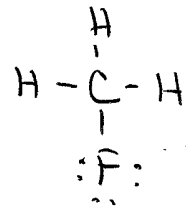
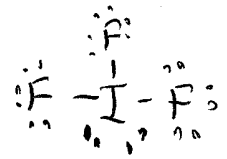
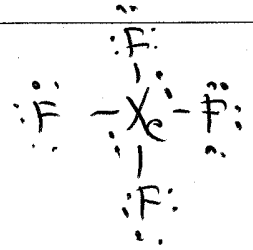
Name: _____

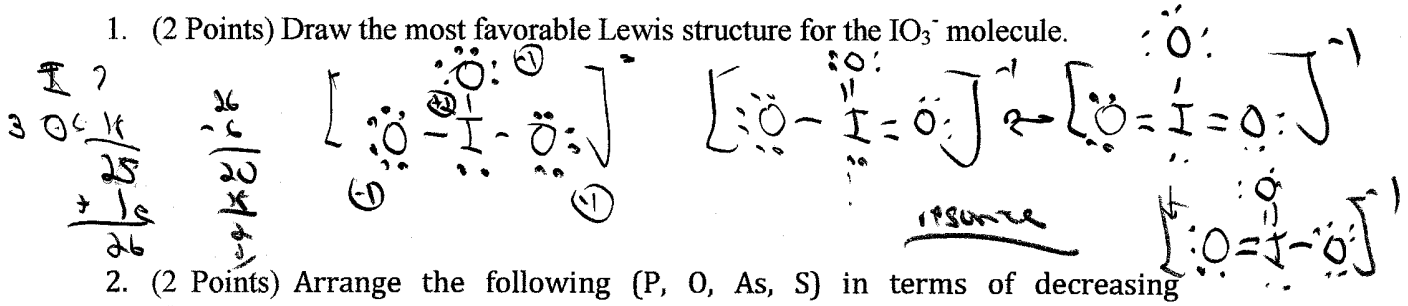
7. (10 Points) Complete each of the following.

Molecule	Lewis Structure
CH_3F	C 4 3H 3 F 7 14 -8 6 
IF_3	I 7 3F 21 28 -6 22 -14 4 
H_2O	H 2 O 6 8 -4 4 
XeF_4	Xe 8 4F 28 36 -8 28 -24 4 -4 0 

Name: _____

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

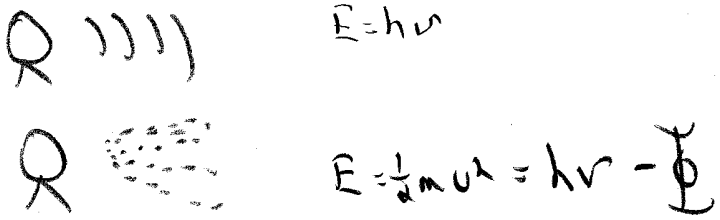
1. (2 Points) Draw the most favorable Lewis structure for the IO_3^- molecule.



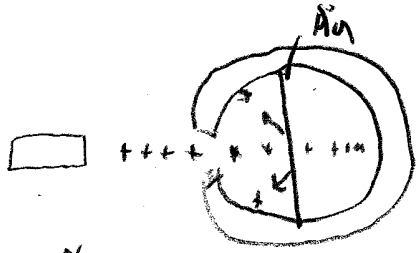
2. (2 Points) Arrange the following (P, O, As, S) in terms of decreasing electronegativity values.

O > S > P > As

3. (2 Points) Describe the Wave Model and Photon Model



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 directions indicating that nucleus is composed of + particles

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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

$\Delta U = w + q$

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

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

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

$T_K = {}^{\circ}C + 273.15$

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

1 cal = 4.184 J

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

$E = E_k + E_p$

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

$E_p = mgh$

$m = nM$

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

$M = m_{atom}N_A$

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

$N = nN_A$

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

$q = C \times \Delta T$

$C = s \times m$

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

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

$\lambda\nu = c$

$E = h\nu$

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

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

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

$-q = q_{cal}$

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