2021 Fall Semester Mid-term Examination
For General Chemistry I

Date: Oct 20 (Wed),   Time Limit: 19:00 ~ 22:00

NOTICE

- If you have a printer, print the papers and write the answers in the space of each question. If not, prepare several A4-size papers to write only question **#** and the answers on it in the following example. And for clarity, marking your answer is recommended. Please, print your Student ID in the upper right corner of every page for both of them. (***Handwriting only is acceptable*** and typing is not.)

  Example:

Professor Name	Class	Student I.D. Number	Name

  #1. (a)………

      (b)……..

- If you have any questions during the period, please contact the TA of your class using the Zoom chat channel to "Everyone" (the only possible choice). Proctors will make any announcements relevant to all students *via* audio.

- While still in the video conference, submit your file to [Midterm Examination], an assignment on Turnitin of your class. ***Do not leave the video conference*** until your TA is confirmed and tells you that it is fine to leave.

** This paper consists of 14 sheets with 11 problems (page 13 - 14: Equation, constants & periodic table). Please check all the page numbers before taking the exam. Please write down the unit of your answer when applicable. You will get 30% deduction for a value that is missing its unit.

NOTICE: SCHEDULES on RETURN and CLAIM of the MARKED EXAM PAPER.
(채점 답안지 분배 및 이의신청 일정)

1. Period, Location, and Procedure
  1) Return and Claim Period: Oct **25** (*Mon 12:00~24:00*)
  2) *Location: Each class of Turnitin site (online)*
  3) Procedure: If you have any claims on it, email them (Question# and reasons) to your TA.
  (The claim is permitted only during the designated claim period. Keep that in mind! A solution file with answers for the examination will be uploaded on the web.)

2. Final Confirmation
  1) Period: Oct **28-29** (*Thu – Fri*)
  2) Procedure: During this period, you can check final score of the examination *on the website* again.
    (No additional corrections. If no change in your score after reasoning, the claims were not accepted.)
**** For further information, please visit General Chemistry website at www.gencheminkaist.pe.kr**

1. (total 8 pts)

Methane (CH₄), xenon tetrafluoride (XeF₄), and sulfur tetrachloride (SCl₄) all have molecular structures of the central atom bonded to four other atoms.

(a) Draw the Lewis diagrams of CH₄, XeF₄, and SCl₄, and state their molecular geometries. (6 pts)

(Answer)

square planar   see-saw
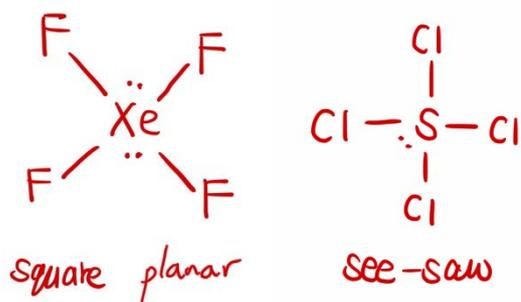
CH4: diagram 1 pt, geometry 1 pt
XeF4: diagram 1 pt, geometry 1 pt
SCl4: diagram 1 pt, geometry 1 pt

(b) Explain why these three molecules have different molecular geometries, although they all have a similar chemical formula of AX₄. (2 pts)

(Answer)

Though CH₄, XeF₄, and SCl₄ all have four bonding pairs, they have the different number of lone pairs, which give them different steric numbers. CH₄ has 4 bonding pairs and 0 lone pair, and because all four bonding pairs repel one another with equal strength, four hydrogen atoms lie at equal distance from one another, giving CH₄ the tetrahedral shape. XeF₄ has 4 bonding pairs and 2 lone pairs. While lone pairs affect the arrangement of other electron pairs, they are ignored when determining the molecular geometry, and thus XeF₄ has a molecular geometry of square planar. In a similar manner, because SCl₄ has 4 bonding pairs and 1 lone pair and a lone pair is not included in determining a molecular geometry, SCl₄ has a see-saw shape.   *full points for correct answer*
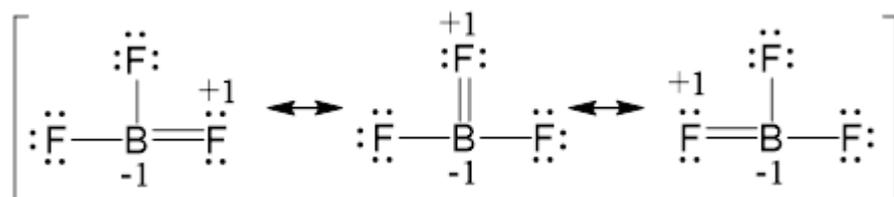
2. (total 10 pts)

Boron trifluoride, BF_3, is a highly reactive gas that condenses to a liquid at -100 °C.

(a) Draw the Lewis diagram of BF_3 when this molecule follows the octet rule. Clearly mark the formal charges. (3 pts)
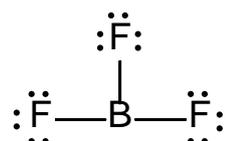
(Answer)

Lewis structure +1pt, resonance form +1pt, formal charge +1pt

(b) Experimental evidence strongly suggests there are no double bonds in BF_3. Draw the Lewis diagram if BF_3 does not follow the octet rule. (2 pts)

(Answer)

(c) Explain the three dimensional structure of BF_3 using the valence bond theory. (3 pts)

(Answer) sp^2 hybrid +1 pt, trigonal planar +1 pt, reasonable explanation +1

In the lecture slide,

➤ **sp^2-hybridization** BF_3

Promotion: B: $(1s)^2(2s)^2(2p_x)^1 \to$ B: $(1s)^2(2s)^1(2p_x)^1(2p_y)^1$

Three equivalent sp^2 hybrid orbitals:

$$\chi_1(r) = 2s + 2^{1/2}2p_y$$
$$\chi_2(r) = 2s + (3/2)^{1/2}2p_x - (1/2)^{1/2}2p_y$$
$$\chi_3(r) = 2s - (3/2)^{1/2}2p_x - (1/2)^{1/2}2p_y$$

New electronic configuration, B: $(1s)^2(\chi_1)^1(\chi_2)^1(\chi_3)^1$

Three bonds at an angle 120° in a plane → trigonal planar

(d) Although there are only single bonds in BF_3, the length of the B-F bonds (1.30 Å) is shorter than would be expected for common single bonds. What may lead to this shortness? (2 pts)

(Answer) Any reasonable descriptions, +2

This shortness may indicate stronger B-F pi-bonding (perpendicular to the molecular plane) in the fluoride, although there are no strict double bonds. The ionic nature of the bonds may also strengthen the B-F bond.
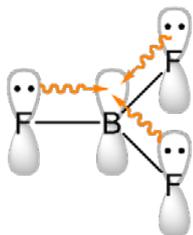
3. (total 10 pts)

The motion of an electron in a bond can be treated approximately as the motion in an one-dimensional box. Consider the electrons in O_2 and ozone (O_3), and note that the lengths of the O-O and O=O bonds are 1.48 and 1.21 Å, respectively.

(a) Calculate the energy of an electron in each of its three lowest allowed states if it is confined to move in a one-dimensional box. (6 pts)

(Answer)

The allowed energies of a particle in an one-dimensional box are given by text equation 4.37

$$E_n = \frac{h^2 n^2}{8mL^2}$$

The particle in this case is an electron, so the value of m is known. The box length of O_2 is 1.21×10^{-10} m and that of ozone with the resonance structures of $O=O^{\oplus}-O^{\ominus} \longleftrightarrow {}^{\ominus}O-O^{\oplus}=O$ is $(1.21+1.48) \times 10^{-10}$ m. For n=1,2,3,

O_2; $E_1=4.12*10^{-18}$ J, $E_2=16.5*10^{-18}$ J, $E_3=37.0*10^{-18}$ J

O_3; $E_1=0.83*10^{-18}$ J, $E_2=3.33*10^{-18}$ J, $E_3=7.49*10^{-18}$ J

+1 pt for six Es

2 pt if rationale is correct

(b) Calculate the wavelength of light necessary to excite the electron from its ground state to the first excited state. (4 pts)

(Answer)

The wavelength of the photon required to excite the electron from n=1 to n=2 is

$\lambda = \frac{hc}{E_2 - E_1}$; *for O2, $1.61*10^{-8}$ m = 16.1 nm & for O3, $7.95*10^{-8}$ m = 79.5 nm.*

+2 pt for each

4. (total 6 pts)

An electron falls from n=5 state to n=3 state and then to n=1 state.

(a) Let's define ν_1 as the frequency of light emitted in transition from n=5 state to n=3 state, ν_2 as the frequency of light emitted in transition from n=3 state to n=1 state, and ν_{tot} as the frequency of the light that would be emitted if it falls directly from n=5 to n=1 state. Find the relation between ν_1, ν_2, and ν_{tot}. (3 pts)

(Answer)

The total energy emitted is equal to the sum of the energy emitted at the two transitions. This implies

$h\nu_{tot} = h\nu_1 + h\nu_2$

dividing by h gives $\nu_{tot} = \nu_1 + \nu_2$

(b) Find the relation between the respective wavelengths, λ_1, λ_2, and λ_{tot}. (3 pts)

(Answer)

to find the relation between the wavelengths we substitute frequencies by the c/λ. I.E

$C/\lambda_{tot} = c/\lambda_1 + c/\lambda_2$

Dividing by c gives

$1/\lambda_{tot} = 1/\lambda_1 + 1/\lambda_2$ rearranging gives

$\lambda_{tot} = \lambda_1 \lambda_2/(\lambda_1 + \lambda_2)$

5. (total 10 pts)

By photoelectron spectroscopy, three ionization energies were identified for electrons in Ne: 870.2, 48.4, and 21.6 eV. Answer the following questions.

(a) Draw an energy-level diagram for Ne, assign atomic orbitals for each energy level, and fill up the electrons in the orbitals. (3 pt)

(Answer)

Diagram   *1 pt*

Orbital assignment   *1 pt*

Electron filling   *1 pt*
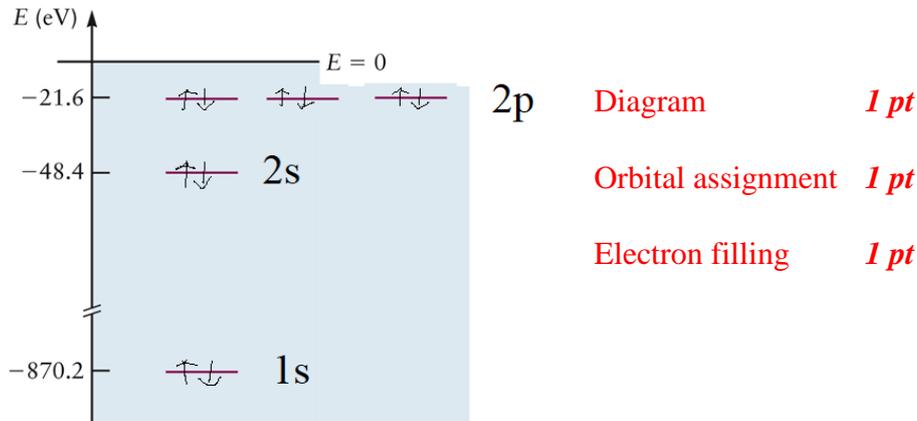
(b) Based on the Bohr theory, calculate the energy level of the lowest orbital for Ne: (2 pt)

$E_n = -2.18 \times 10^{-18}$ J (Z^2/n^2)

(Answer)

As $Z = 10$ and $n = 1$, $E_1 = -2.18 \times 10^{-16}$ J   *2 pts*

(c) Estimate the effective Z (Z_{eff}) that can match the Bohr theory with the experimental observation. (3 pt)

(Answer)

The experimentally determined $E_{1s} = -870.2$ eV $\times 1.60 \times 10^{-19}$ J/eV $= -1.39 \times 10^{-16}$ J

$(Z_{eff})^2 = -1.39 \times 10^{-16}$ J$/-2.18 \times 10^{-16}$ J$\times 1^2$, $Z_{eff} = 8.00$ 3f *pts*

(d) Suppose Ne is excited by X-ray with energy of 1000 eV. Calculate the velocity of photoelectron that was originally in the lowest orbital. (2 pt)

(Answer) As 870.2 eV $= 1000$ eV $- 1/2 m_e v_e^2$, $v_e = 6.76 \times 10^6$ m/s   *2 pts*

6. (total 6 pts)

Calculate the average distance (Å) of an electron from the nucleus in the

    a) 1s orbital in a H atom

    b) 2s orbital in a He^+ atom

    c) 2p orbital in a Be^{3+} atom

(Answer)

    a) H atom

$$\bar{r}_{nl} = \frac{n^2 a_0}{Z}\left\{1+\frac{1}{2}\left[1-\frac{\ell(\ell+1)}{n^2}\right]\right\}$$

$$\bar{r}_{10} = \frac{1^2 a_0}{1}\left\{1+\frac{1}{2}\left[1-\frac{0(0+1)}{1^2}\right]\right\}$$

$$\bar{r}_{10} = \frac{3}{2}a_0 = 0.7935 \text{ Å}$$

    b) He^+ atom

$$\bar{r}_{20} = \frac{2^2 a_0}{2}\left\{1+\frac{1}{2}\left[1-\frac{0(0+1)}{2^2}\right]\right\}$$

$$\bar{r}_{20} = 3a_0 = 1.587 \text{ Å}$$

    c) Be^{3+} atom

$$\bar{r}_{21} = \frac{2^2 a_0}{4}\left\{1+\frac{1}{2}\left[1-\frac{1(1+1)}{2^2}\right]\right\}$$

$$\bar{r}_{21} = \frac{5}{4}a_0 = 0.66125 \text{ Å}$$

2 pts each

7. (total 10 pts)

If an electron is removed from a fluorine molecule, an F_2^+ molecular ion forms.

(a) Give the molecular electron configurations for F_2 and F_2^+. (3 pt)

(Answer)

F_2 is a homonuclear diatomic molecule, which has 18 electrons of which 14 are valence electrons. The he F_2^+ ion has lost a valence electron and so has 13. Based on the correlation diagram for F_2, the energetic order can be obtained like the following.

F_2 $(\sigma_{g2s})^2(\sigma^*_{u2s})^2(\sigma_{g2p})^2(\pi_{u2p})^4(\pi^*_{g2p})^4$

F_2^+ $(\sigma_{g2s})^2(\sigma^*_{u2s})^2(\sigma_{g2p})^2(\pi_{u2p})^4(\pi^*_{g2p})^3$

(b) Give the bond order of each species. (2 pts)

(Answer)

The F_2 molecule has two more bonding than antibonding electrons. Its order is 1; F_2^+ ion has three more bonding than antibonding electrons. Its bonding order is 3/2.

(c) Predict which species should be paramagnetic. (2 pt)

(Answer)

The F_2 molecule has zero unpaired electrons. Accordingly, F_2 is diamagnetic. The F_2^+ ion has an odd number of electrons. Because at least one electron (a π^*_{g2p} electron) is unpaired. So, F_2^+ ion is paramagnetic.

(d) Predict which species has the greater bond dissociation energy. (3 pts)

(Answer)

The F_2^+ ion has a larger bond order and therefore requires more energy to dissociate than F_2^+ ion's case.
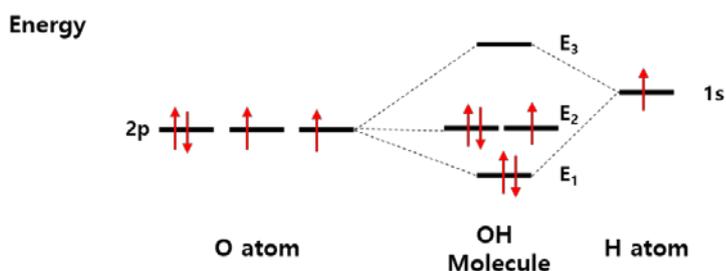
8. (total 10 pts)

The figure below shows the energy levels of OH molecular orbitals obtained by combining O and H atomic orbitals. (Note: E_2 orbitals are obtained only from O atomic orbitals and called non-bonding molecular orbitals.)
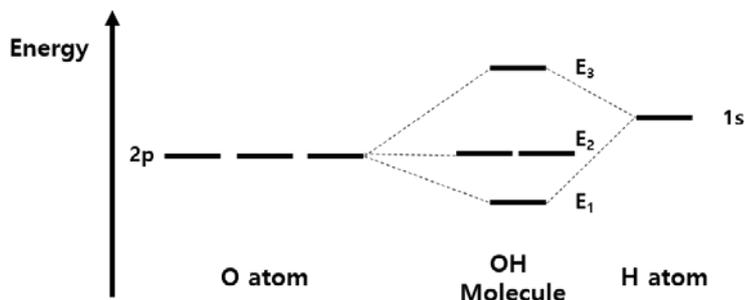
(a) Properly draw the ground state electron configuration. Fill up the electrons of atomic orbitals, too. (3 pts)

(Answer)

(b) Is the first ionization energy of OH less than that of H? Please explain the reason for your answer. (2 pts)

(Answer)
No. Because the electrons in the HOMO of OH have a lower energy level than the 1s electrons of H, and thus have higher ionization energy.

(c) What is the bond order of the ground state OH? (2 pts)

(Answer)
Bond order = (1/2) x (number of electrons in bonding MOs − number of electrons in antibonding MOs) = 2/2 = 1

(d) Why do we call OH a "radical"? How does the MO diagram support this? (2 pts)

(Answer)
It has an unpaired electron in a non-bonding orbital.

(e) Is there a nodal plane between H and O in the molecular orbital corresponding to E_3? (1 pts)

(Answer)
Yes.

9. (total 10 pts)

The following is a device that connects two containers containing gas A and gas B with a cock. Gas A reacts with gas B to form gas C. The cock was opened and equilibrium was reached. (The temperature is constant, all gases behave ideally, and the reaction proceeded completely. Ignore the volume of the connection between two containers.)

$$2A(g) + B(g) \rightarrow 2C(g)$$
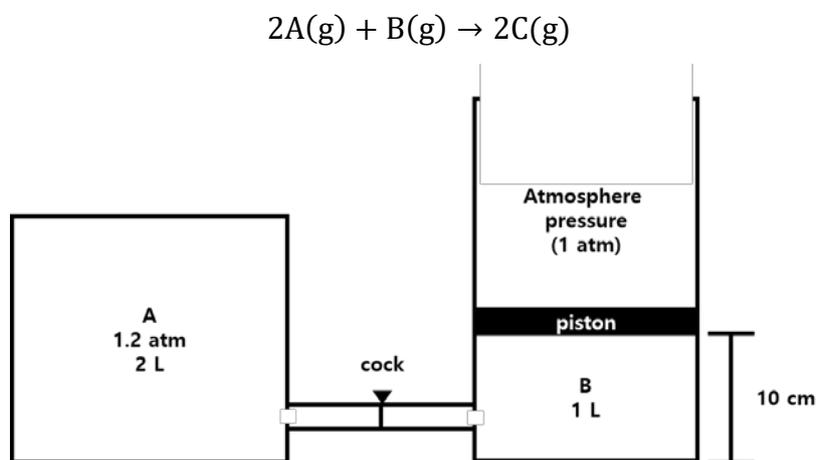
(a) How many centimeters did the piston move? Write the length and direction of piston movement. (5 pts)

(Answer)

	2A	+	B	→	2C
Before reaction	1.2atm*2L		1atm*1L		
After reaction	-2atm*L		-1atm*L		+2atm*L
	0.4atm*L				2atm*L

Total: 2.4 atm*L

Pressure of inside and outside of the piston is same as 1 atm.

So, total volume is 2.4 L. The piston should come down 6 cm to meet the volume.

Answer) 6 cm, down

Fine with different methods

(b) What is the mole fraction of each gas? (3 pts)

(Answer)

A: 1/6, B: 0, C: 5/6

(c) The ratio of the molecular weights of gas A and B is 1:2. Find the ratio of the diffusion rates of A and C. (2 pts)

(Answer)

$M_C = (2M_A + M_B)/2$, $M_A:M_B:M_C = 1:2:2$, $\dfrac{V_A}{V_C} = \sqrt{\dfrac{M_C}{M_A}} = \sqrt{2}$, $V_A = \sqrt{2}V_C$

10. (total 10 pts)

	Formula	Name	M.W.	a (bar•L^2/mol^2)	b (L/mol)
(a)	C_2H_5F	Fluoroethane	48.06	8.17	0.07758
(b)	CH_3SH	Methanethiol	48.11	8.911	0.06756
(c)	$C_2H_4O_2$	Methyl formate	60.05	11.54	0.08442
(d)	CH_3COOH	Acetic acid	60.05	17.71	0.1065
(e)	C_2F_4	Tetrafluoroethylene	100.02	6.954	0.08085
(f)	C_2H_5Br	Bromoethane	108.96	11.89	0.08406

For molecules (a)~(f), the chemical formula, the molecular weight, and the van der Waals constants a's and b's are given in the above table. Which of the following is correct in predicting boiling points in an increasing order? Choose an answer and give an explanation.

① a < b < c < d < e < f
② e < a < b < c < f < d
③ b < a < e < f < c < d
④ a < b < c < e < f < d
⑤ d < f < c < b < a < e

(Answer)

② e < a < b < c < f < d is correct.   **+5 pts**

From the van der Waals equation, the vapor pressure of real gases can be predicted. A higher "*a*" value indicates greater attractive interactions between molecules and thus smaller vapor pressure. Then more thermal energy is required for reaching 1 atm, i.e., boiling.

$$\left(P + a\frac{n^2}{V^2}\right)(V - nb) = nRT$$

$$P = \frac{RT}{\frac{V}{n} - b} - a\left(\frac{n}{V}\right)^2$$

+5 pts

11. (total 10 pts)

The boiling point of HF, HCl, HBr and HI are 293K, 189K, 206K and 238K, respectively.

(a) Which type of intermolecular forces are present in the molecules HF, HCl, HBr, and HI? (4 pts)

(Answer)

HCl, HBr and HI: dipole-dipole and London forces

HF: hydrogen bonding, dipole-dipole, and London forces

(b) Looking at the trend of boiling points of HCl, HBr and HI, which intermolecular force is predominant among these molecules? (4 pts)

(Answer)

Electronegativity decreases from Cl to I, so the dipole moment decreases from HCl to HI. As the boiling point is increasing from HCl to HI, it means London forces are predominant.

London force is directly proportional to the number of electrons in a molecule.

(c) Why is the boiling point of HF the highest? (2 pts)

(Answer)

F has the highest electronegativity. As a result, HF has the highest dipole moment and also has hydrogen bonding. Therefore, HF shows the highest boiling point.

Physical Constants

Avogadro's number	N_A = 6.02214179 $\times$ 10^{23} mol^{-1}
Bohr radius	a_0 = 0.52917720859 Å = 5.2917720859 $\times$ 10^{-11} m
Boltzmann's constant	K_B = 1.3806504 $\times$ 10^{-23} J K^{-1}
Electronic charge	e = 1.602176487 $\times$ 10^{-19} C
Faraday constant	F = 96485.3399 C mol^{-1}
Masses of fundamental particles:	
Electron	m_e = 9.10938215 $\times$ 10^{-31} kg
Proton	m_P = 1.672621637 $\times$ 10^{-27} kg
Neutron	m_n= 1.674927211 $\times$ 10^{-27} kg
Permittivity of vacuum	ε_o = 8.854187817 $\times$ 10^{-12} C^{-2} J^{-1} m^{-1}
Planck's constant	h = 6.62606896 $\times$ 10^{-34} J s
Ratio of proton mass to electron mass	m_P / m_e = 1836.15267247
Speed of light in a vacuum	c = 2.99792458 $\times$ 10^{8} m s^{-1} (exactly)
Standard acceleration of terrestrial gravity	g = 9.80665 m s^{-2} (exactly)
Universal gas constant	R = 8.314472 J mol^{-1} K^{-1} = 0.0820574 L atm mol^{-1} K^{-1}

Values are taken from the 2006 CODATA recommended values,
as listed by the National Institute of Standards and Technology.

Conversion factors

Ångström	1 Å= 10^{-10} m
Atomic mass unit	1 u = 1.660538782 $\times$ 10^{-27} kg
	1 u = 1.492417830 $\times$ 10^{-10} J = 931.494028 MeV (energy equivalent form $E = mc^2$)
Calorie	1 cal = 4.184 J (exactly)
Electron volt	1 eV = 1.602177 $\times$ 10^{-19} J = 96.485335 kJ mol^{-1}
Foot	1 ft = 12 in = 0.3048 m (exactly)
Gallon (U. S.)	1 gallon = 4 quarts = 3.785412 L (exactly)
Liter	1 L = 10^{-3} m^{-3} = 10^{3} cm^{3} (exactly)
Liter-atmosphere	1 L atm = 101.325 J (exactly)
Metric ton	1 t = 1000 kg (exactly)
Pound	1 lb = 16 oz = 0.4539237 kg (exactly)
Rydberg	1 Ry = 2.17987197 x 10^{-18}J = 1312.7136 kJ mol^{-1} = 13.60569193 eV
Standard atmosphere	1 atm = 1.01325 x 10^{5} Pa = 1.01325 x 10^{5} kg m^{-1} s^{-2} (exactly)
Torr	1 torr = 133.3224 Pa

PERIODIC TABLE OF THE ELEMENTS

http://www.kef-split.hr/periodni/en/

Legend:

GROUP NUMBERS IUPAC RECOMMENDATION (1985)	13
GROUP NUMBERS CHEMICAL ABSTRACT SERVICE (1986)	IIIA
ATOMIC NUMBER	5
SYMBOL	B
RELATIVE ATOMIC MASS (1)	10.811
ELEMENT NAME	BORON

Main table

Period	1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8	9 VIIIB	10	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1	1 H 1.0079 HYDROGEN																	2 He 4.0026 HELIUM
2	3 Li 6.941 LITHIUM	4 Be 9.0122 BERYLLIUM											5 B 10.811 BORON	6 C 12.011 CARBON	7 N 14.007 NITROGEN	8 O 15.999 OXYGEN	9 F 18.998 FLUORINE	10 Ne 20.180 NEON
3	11 Na 22.990 SODIUM	12 Mg 24.305 MAGNESIUM											13 Al 26.982 ALUMINIUM	14 Si 28.086 SILICON	15 P 30.974 PHOSPHORUS	16 S 32.065 SULPHUR	17 Cl 35.453 CHLORINE	18 Ar 39.948 ARGON
4	19 K 39.098 POTASSIUM	20 Ca 40.078 CALCIUM	21 Sc 44.956 SCANDIUM	22 Ti 47.867 TITANIUM	23 V 50.942 VANADIUM	24 Cr 51.996 CHROMIUM	25 Mn 54.938 MANGANESE	26 Fe 55.845 IRON	27 Co 58.933 COBALT	28 Ni 58.693 NICKEL	29 Cu 63.546 COPPER	30 Zn 65.39 ZINC	31 Ga 69.723 GALLIUM	32 Ge 72.64 GERMANIUM	33 As 74.922 ARSENIC	34 Se 78.96 SELENIUM	35 Br 79.904 BROMINE	36 Kr 83.80 KRYPTON
5	37 Rb 85.468 RUBIDIUM	38 Sr 87.62 STRONTIUM	39 Y 88.906 YTTRIUM	40 Zr 91.224 ZIRCONIUM	41 Nb 92.906 NIOBIUM	42 Mo 95.94 MOLYBDENUM	43 Tc (98) TECHNETIUM	44 Ru 101.07 RUTHENIUM	45 Rh 102.91 RHODIUM	46 Pd 106.42 PALLADIUM	47 Ag 107.87 SILVER	48 Cd 112.41 CADMIUM	49 In 114.82 INDIUM	50 Sn 118.71 TIN	51 Sb 121.76 ANTIMONY	52 Te 127.60 TELLURIUM	53 I 126.90 IODINE	54 Xe 131.29 XENON
6	55 Cs 132.91 CAESIUM	56 Ba 137.33 BARIUM	57-71 La-Lu Lanthanide	72 Hf 178.49 HAFNIUM	73 Ta 180.95 TANTALUM	74 W 183.84 TUNGSTEN	75 Re 186.21 RHENIUM	76 Os 190.23 OSMIUM	77 Ir 192.22 IRIDIUM	78 Pt 195.08 PLATINUM	79 Au 196.97 GOLD	80 Hg 200.59 MERCURY	81 Tl 204.38 THALLIUM	82 Pb 207.2 LEAD	83 Bi 208.98 BISMUTH	84 Po (209) POLONIUM	85 At (210) ASTATINE	86 Rn (222) RADON
7	87 Fr (223) FRANCIUM	88 Ra (226) RADIUM	89-103 Ac-Lr Actinide	104 Rf (261) RUTHERFORDIUM	105 Db (262) DUBNIUM	106 Sg (266) SEABORGIUM	107 Bh (264) BOHRIUM	108 Hs (277) HASSIUM	109 Mt (268) MEITNERIUM	110 Uun (281) UNUNNILIUM	111 Uuu (272) UNUNUNIUM	112 Uub (285) UNUNBIUM	114 Uuq (289) UNUNQUADIUM					

LANTHANIDE

57 La 138.91 LANTHANUM	58 Ce 140.12 CERIUM	59 Pr 140.91 PRASEODYMIUM	60 Nd 144.24 NEODYMIUM	61 Pm (145) PROMETHIUM	62 Sm 150.36 SAMARIUM	63 Eu 151.96 EUROPIUM	64 Gd 157.25 GADOLINIUM	65 Tb 158.93 TERBIUM	66 Dy 162.50 DYSPROSIUM	67 Ho 164.93 HOLMIUM	68 Er 167.26 ERBIUM	69 Tm 168.93 THULIUM	70 Yb 173.04 YTTERBIUM	71 Lu 174.97 LUTETIUM

ACTINIDE

89 Ac (227) ACTINIUM	90 Th 232.04 THORIUM	91 Pa 231.04 PROTACTINIUM	92 U 238.03 URANIUM	93 Np (237) NEPTUNIUM	94 Pu (244) PLUTONIUM	95 Am (243) AMERICIUM	96 Cm (247) CURIUM	97 Bk (247) BERKELIUM	98 Cf (251) CALIFORNIUM	99 Es (252) EINSTEINIUM	100 Fm (257) FERMIUM	101 Md (258) MENDELEVIUM	102 No (259) NOBELIUM	103 Lr (262) LAVRENCIUM

(1) Pure Appl. Chem., 73, No. 4, 667-683 (2001)

Relative atomic mass is shown with five significant figures. For elements have no stable nuclides, the value enclosed in brackets indicates the mass number of the longest-lived isotope of the element.

However three such elements (Th, Pa, and U) do have a characteristic terrestrial isotopic composition, and for these an atomic weight is tabulated.

Editor: Aditya Vardhan (adivar@nettlinx.com)