

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

- Return and Claim Period: **Oct 25 (Mon 12:00~24:00)**
- Location: Each class of Turnitin site (online)**
- 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

- Period: **Oct 28-29 (Thu - Fri)**
- 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.)

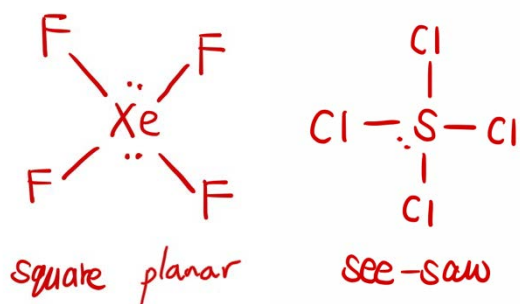
**** For further information, please visit General Chemistry website at www.gencheminkaist.pe.kr**

1. (total 8 pts)

Methane (CH_4), xenon tetrafluoride (XeF_4), and sulfur tetrachloride (SCl_4) all have molecular structures of the central atom bonded to four other atoms.

(a) Draw the Lewis diagrams of CH_4 , XeF_4 , and SCl_4 , and state their molecular geometries. (6 pts)

(Answer)



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 AX_4 . (2 pts)

(Answer)

Though CH_4 , XeF_4 , and SCl_4 all have four bonding pairs, they have the different number of lone pairs, which give them different steric numbers. CH_4 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 CH_4 the tetrahedral shape. XeF_4 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 XeF_4 has a molecular geometry of square planar. In a similar manner, because SCl_4 has 4 bonding pairs and 1 lone pair and a lone pair is not included in determining a molecular geometry, SCl_4 has a see-saw shape. *full points for correct answer*

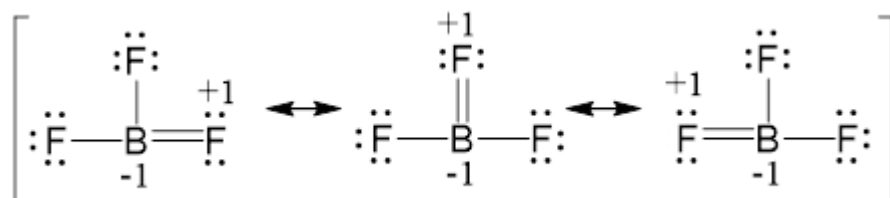
2. (total 10 pts)

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)

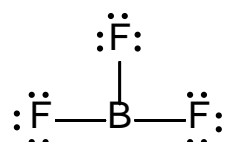
(Answer)

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: $\text{B}: (1s)^2(2s)^2(2p_x)^1 \rightarrow \text{B}: (1s)^2(2s)^1(2p_x)^1(2p_y)^1$

Three equivalent sp^2 hybrid orbitals:

$$\chi_1(r) = 2s + 2^{1/2}2p_y$$

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

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

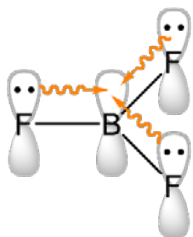
New electronic configuration, $\text{B}: (1s)^2(\chi_1)^1(\chi_2)^1(\chi_3)^1$

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

(d) Although there are only single bonds in BF_3 , the length of the B-F bonds (1.30 \AA) 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 O₂ and ozone (O₃), 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 O₂ is 1.21×10^{-10} m and that of ozone with the resonance structures of

$\text{O}=\text{O}^{\oplus}-\text{O}^{\ominus} \longleftrightarrow \text{O}^{\ominus}-\text{O}^{\oplus}=\text{O}$ is $(1.21+1.48) \times 10^{-10}$ m. For n=1,2,3,

O₂; E₁=4.12*10⁻¹⁸ J, E₂=16.5*10⁻¹⁸ J, E₃=37.0*10⁻¹⁸ J

O₃; E₁=0.83*10⁻¹⁸ J, E₂=3.33*10⁻¹⁸ J, E₃=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

$$\lambda = \frac{hc}{E_2 - E_1}; \text{ for O}_2, 1.61 \times 10^{-8} \text{ m} = 16.1 \text{ nm} \text{ \& for O}_3, 7.95 \times 10^{-8} \text{ m} = 79.5 \text{ nm}.$$

+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

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

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

(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

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

Dividing by c gives

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

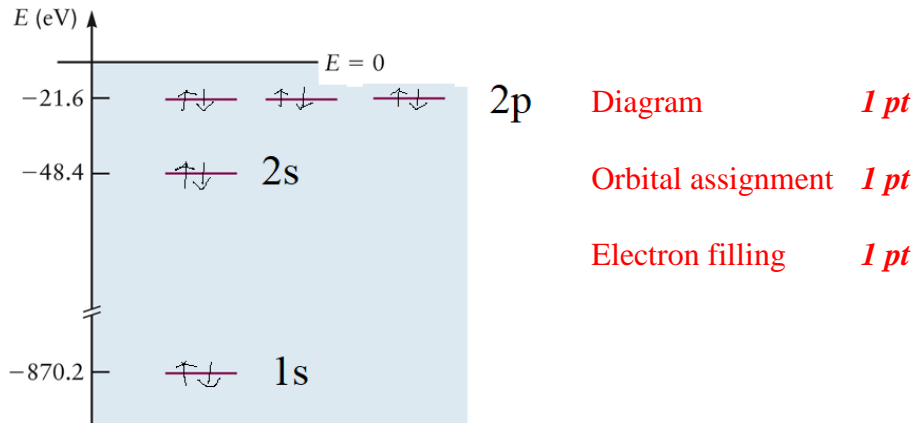
$$\lambda_{\text{tot}} = \lambda_1 \lambda_2 / (\lambda_1 + \lambda_2)$$

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)



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

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

(Answer)

As $Z = 10$ and $n = 1$, $E_1 = -2.18 \times 10^{-16} \text{ J}$ 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 $E_{1s} = -870.2 \text{ eV} \times 1.60 \times 10^{-19} \text{ J/eV} = -1.39 \times 10^{-16} \text{ J}$

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

(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 $870.2 \text{ eV} = 1000 \text{ eV} - 1/2 m_e v_e^2$, $v_e = 6.76 \times 10^6 \text{ m/s}$ 2 pts

6. (total 6 pts)

Calculate the average distance (\AA) 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

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

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

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

b) He^+ atom

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

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

c) Be^{3+} atom

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

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

2 pts each

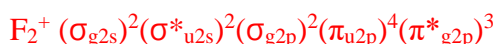
7. (total 10 pts)

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 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.



(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.

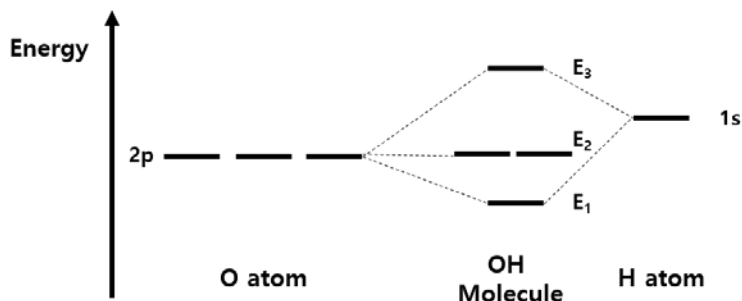
(d) Predict which species has the greater bond dissociation energy. (3 pts)

(Answer)

The F_2^+ ion has a larger bond order and therefore requires more energy to dissociate than F_2 ion's case.

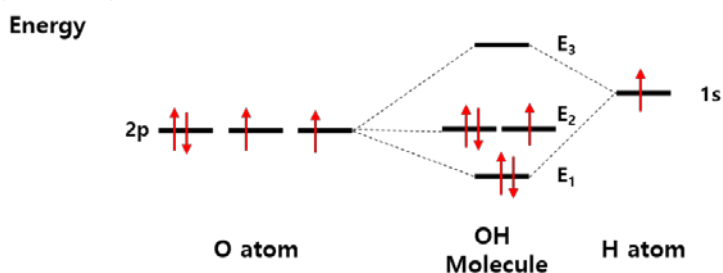
8. (total 10 pts)

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 = $(1/2) \times (\text{number of electrons in bonding MOs} - \text{number of electrons in antibonding MOs}) = 2/2 = 1$

(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.

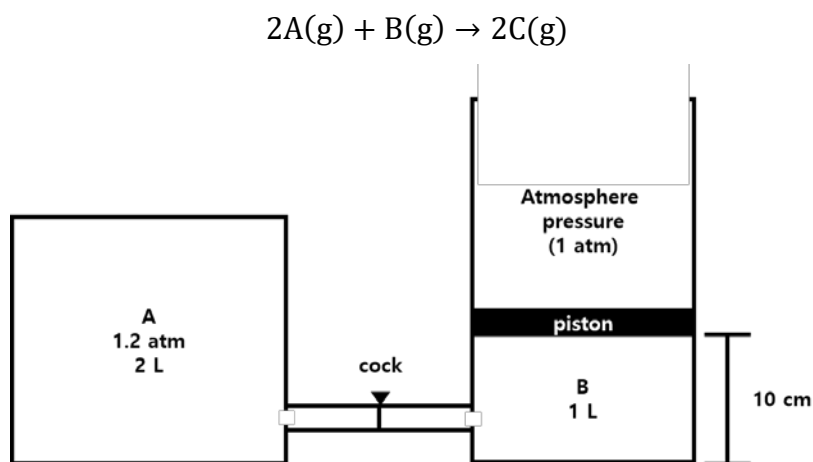
(e) Is there a nodal plane between H and O in the molecular orbital corresponding to E_3 ? (1 pts)

(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.)



(a) How many centimeters did the piston move? Write the length and direction of piston movement. (5 pts)

(Answer)



Before reaction $1.2\text{atm} \cdot 2\text{L}$ $1\text{atm} \cdot 1\text{L}$

After reaction $-2\text{atm} \cdot \text{L}$ $-1\text{atm} \cdot \text{L}$ $+2\text{atm} \cdot \text{L}$

$0.4\text{atm} \cdot \text{L}$ $2\text{atm} \cdot \text{L}$

Total: $2.4 \text{ atm} \cdot \text{L}$

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)

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

10. (total 10 pts)

	Formula	Name	M.W.	a (bar•L ² /mol ²)	b (L/mol)
(a)	C ₂ H ₅ F	Fluoroethane	48.06	8.17	0.07758
(b)	CH ₃ SH	Methanethiol	48.11	8.911	0.06756
(c)	C ₂ H ₄ O ₂	Methyl formate	60.05	11.54	0.08442
(d)	CH ₃ COOH	Acetic acid	60.05	17.71	0.1065
(e)	C ₂ F ₄	Tetrafluoroethylene	100.02	6.954	0.08085
(f)	C ₂ H ₅ Br	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	$N_A = 6.02214179 \times 10^{23} \text{ mol}^{-1}$
Bohr radius	$a_0 = 0.52917720859 \text{ \AA} = 5.2917720859 \times 10^{-11} \text{ m}$
Boltzmann's constant	$K_B = 1.3806504 \times 10^{-23} \text{ J K}^{-1}$
Electronic charge	$e = 1.602176487 \times 10^{-19} \text{ C}$
Faraday constant	$F = 96485.3399 \text{ C mol}^{-1}$
Masses of fundamental particles:	
Electron	$m_e = 9.10938215 \times 10^{-31} \text{ kg}$
Proton	$m_p = 1.672621637 \times 10^{-27} \text{ kg}$
Neutron	$m_n = 1.674927211 \times 10^{-27} \text{ kg}$
Permittivity of vacuum	$\epsilon_0 = 8.854187817 \times 10^{-12} \text{ C}^{-2} \text{ J}^{-1} \text{ m}^{-1}$
Planck's constant	$h = 6.62606896 \times 10^{-34} \text{ J s}$
Ratio of proton mass to electron mass	$m_p / m_e = 1836.15267247$
Speed of light in a vacuum	$c = 2.99792458 \times 10^8 \text{ m s}^{-1}$ (exactly)
Standard acceleration of terrestrial gravity	$g = 9.80665 \text{ m s}^{-2}$ (exactly)
Universal gas constant	$R = 8.314472 \text{ J mol}^{-1} \text{ K}^{-1}$ $= 0.0820574 \text{ L atm mol}^{-1} \text{ K}^{-1}$

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

Conversion factors

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

PERIODIC TABLE OF THE ELEMENTS

<http://www.kj-soft.com/periodictable/>

GROUP	PERIOD																																		
1	IIA												VIIIA																						
1	H													2																					
2	Li	Be											He																						
3	Na	Mg											Ne																						
4	K	Ca											Ar																						
5	Rb	Sr											Kr																						
6	Cs	Ba											Xe																						
7	Fr	Ra											Rn																						
19	39.098	20	40.078	21	44.956	22	47.867	23	50.942	24	51.996	25	54.938	26	55.845	27	58.933	28	58.693	29	63.546	30	65.39	31	69.723	32	72.64	33	74.922	34	78.96	35	79.904	36	83.80
37	85.468	38	87.62	39	88.906	40	91.224	41	92.906	42	95.94	43	(99)	44	101.07	45	102.91	46	106.42	47	107.87	48	112.41	49	114.82	50	118.71	51	121.76	52	127.60	53	126.90	54	131.29
55	132.91	56	137.33	57-71		72	178.49	73	180.95	74	183.84	75	186.21	76	190.23	77	192.22	78	195.08	79	196.97	80	200.59	81	204.38	82	207.2	83	208.98	84	(209)	85	(210)	86	(222)
87	(223)	88	(226)	89-103		104	(261)	105	(262)	106	(266)	107	(264)	108	(277)	109	(268)	110	(281)	111	(272)	112	(285)	113		114	(289)	115		116		117		118	
Fr	Ra	Ac-Lr		Rf	Db	Sg	Bh	Hs	Mt	Uu	Uu	Uu	Uu	Uu	Uu	Uu	Uu	Uu	Uu	Uu	Uu	Uu	Uu	Uu	Uu	Uu	Uu	Uu	Uu	Uu	Uu	Uu	Uu	Uu	Uu
FRANCIUM	RADIUM	ACTINIDE		RUTHENIUM	DUBNIUM	SEABORGIUM	BOHRIUM	HASSIUM	MEITNERIUM	UNUNILLIUM	UNUNILLIUM	UNUNILLIUM	UNUNILLIUM	UNUNILLIUM	UNUNILLIUM	UNUNILLIUM	UNUNILLIUM	UNUNILLIUM	UNUNILLIUM	UNUNILLIUM	UNUNILLIUM	UNUNILLIUM	UNUNILLIUM	UNUNILLIUM	UNUNILLIUM	UNUNILLIUM	UNUNILLIUM	UNUNILLIUM	UNUNILLIUM	UNUNILLIUM	UNUNILLIUM	UNUNILLIUM	UNUNILLIUM	UNUNILLIUM	UNUNILLIUM

GROUP NUMBERS
IUPAC RECOMMENDATION (1985)

GROUP NUMBERS
CHEMICAL ABSTRACT SERVICE (1986)

ATOMIC NUMBER

SYMBOL

RELATIVE ATOMIC MASS (1)

ELEMENT NAME

LANTHANIDE															
57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	
LANTHANUM	CERUM	PRASEODYMIUM	NEODYMIUM	PROMETHIUM	SAMARIUM	EUROPIUM	GADOLINIUM	TERBIUM	DYSPROSIUM	HOLIUM	ERBIUM	THULIUM	YTERBIUM	LUTETIUM	
57	138.91	140.12	140.91	144.24	150.36	151.96	157.25	158.93	162.50	164.93	167.26	168.93	173.04	174.97	
89	(227)	90	232.04	91	231.04	92	238.03	93	(237)	94	(244)	95	(243)	96	(247)
Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr	
ACTINIUM	THORIUM	PROTACTINIUM	URANIUM	NEPTUNIUM	PLUTONIUM	AMERICIUM	CURIUM	BERKELIUM	CALIFORNIUM	EINSTEINIUM	FERMIUM	MEYERBERGIUM	NOBELIUM	LAWRENCIUM	

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

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

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

Editor: Aditya Varshney (aditya@rediffmail.com)

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