

2024 Fall Semester Mid-term Examination
For General Chemistry I

Date: October 23(Wed), Time Limit: 19:00 ~ 21:00

Write down your information neatly in the space provided below; print your Student ID in the upper right corner of every page.

Professor Name	Class	Student I.D. Number	Name

Problem	points	Problem	points	TOTAL pts
1	/24	6	/12	/100
2	/26			
3	/18			
4	/11			
5	/9			

** This paper consists of 20 sheets with 10 problems (*page 18 - 19*: Equation, constants & periodic table, *page 20*: claim form). Please check all page numbers before taking the exam. Write down your work and answers in the Answer sheet. Please write down the unit of your answer when applicable. You will get 30% deduction for a missing unit.

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

1. Period, Location and Procedure

0 Return and Claim Period: **October 28 (Monday, 19:00 ~ 21:00, 2 hrs)**

The claim is permitted only on this period. Keep that in mind!

0 Location: Each designated room of Creative Learning Bldg. (E11)

Class	Room(E11)
A	201
C	202
D	301

0 Procedure

Rule 1: Students cannot bring their writing tools into the rooms (Use a pen only provided by TA)

Rule 2: With or without claim, you must submit the paper back to TA. (Do not go out of the room with it)

If you have any claims on it, write them on the claim form and attach it to the top of the exam paper with a stapler.
Give them to your TA.

WARNING!!

If you deliberately alter any original answers or insert something on your marked paper to achieve a better grade, you will get a F grade for this course. Or if you don't keep the rules above, we will regard it as a kind of cheating and give you 0 point. So please don't cheat.

2. Final Confirmation

1) Period: *October 31(Thu.) ~ November 1(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. (24 points; 3pts for each)

Choose answers for the following questions:

(a) A substance that cannot be broken down into two or more simpler substances by chemical methods is called a(n):

- ① compound ② mixture ③ element ④ isotope

(b) Which of the following substances below are considered molecules?

- ① NaCl ② Fe ③ Fe₃O₄ ④ SO₃

(c) What differentiates a compound from a homogeneous mixture of two or more elements?

- ① The molar ratios between elements in a compound are constant, while they are variable in a homogeneous mixture.
② A compound does not exhibit the individual properties of the components (elements).
③ A compound contains less elements than a homogeneous mixture.
④ A compound cannot be made up of more than two elements.

(d) Which of the following properties does NOT show periodicity throughout the periodic table?

- ① Atomic mass
② Atomic radius
③ Ionization energy
④ Electronegativity

(e) From left to right across the periodic table, which of the following trend is generally true?

- ① Atomic radius increases.
② Ionization energy decreases.
③ Electron affinity increases.
④ Electronegativity decreases.

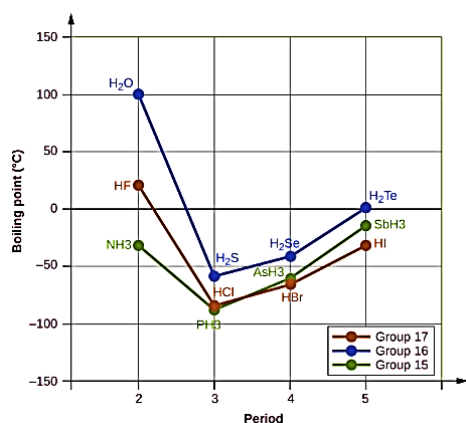
particle	proton	neutron	electron
actual mass (kg)	1.67×10^{-27}	1.67×10^{-27}	9.11×10^{-31}

(f) Given the above information, which of the following is the most accurate answer for the molar mass of ¹H? Avogadro's number is $N_A = 6.02214076 \times 10^{23} \text{ mol}^{-1}$ and please consider the number of significant figures.

- ① 1.008 ② 1.0057 ③ 1.0062 ④ 1.01

(g) Which of the following is a mixture?

- ① a sample of vinegar
② a sample of copper
③ steam coming from a pan of boiling water
④ a sample of "laughing gas"



(h) The left figure shows the boiling point variations across the periods. Which of the following is incorrect?

- ① This trend explains the high heat capacity of water.
- ② Given this trend, CH₄ will have a higher boiling point than SiH₄.
- ③ This trend explains why ice floats on liquid water.
- ④ The similar trend is expected for melting point.

- (a) ③ element
- (b) ④ SO₃
- (c) ② A compound does not exhibit the individual properties of the components (elements).
- (d) ① Atomic mass
- (e) ③ Electron affinity increases.
- (f) ④ 1.01

To get a molar mass of ¹H,

$$(\text{proton mass} + \text{electron mass}) \times \frac{10^3 \text{ g}}{\text{kg}} \times \frac{N_A}{\text{mol}}$$

$$= (1.67 + 0.000911) \times 10^{-24} \times 6.02214076 \times 10^{23} = 1.67 \times 0.602214076 = 1.01$$

Given 3 significant figures, the answer is 1.01.

- (g) ① a sample of vinegar
- (f) ② Given this trend, CH₄ will have a higher boiling point than SiH₄.

2. (26 points)

Nitrogen can react with oxygen and generate diverse “NO_x” compounds.

(a) Name the following compounds. (4 pts; 1 pt for each)

- (1) NO
- (2) NO₂
- (3) N₂O
- (4) N₂O₄

(b) Draw the Lewis dot diagrams of the above compounds (1)~(4) in (a). Please indicate formal charge when it is not 0. (12 pts; 3 pts for each)

(c) Describe the molecular shapes of (2) NO₂ and (3) N₂O. (4 pts)

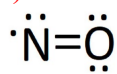
(d) Write balanced chemical equations for the reactions between nitrogen and oxygen to form the above compounds (1)~(4) in (a). (4 pts)

(e) Using the structures drawn in (b), discuss why NO_x compounds are toxic while N₂ is not. (2 pts)

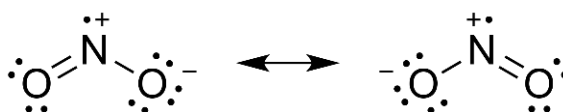
(a) (1) nitrogen monoxide; (2) nitrogen dioxide; (3) dinitrogen monoxide; (4) dinitrogen tetroxide

(b) Give full points (3 pts) when one of the resonance or allowed structures is given. But for missing formal charges, take -1 point.

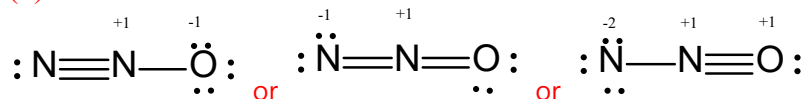
(1)



(2)

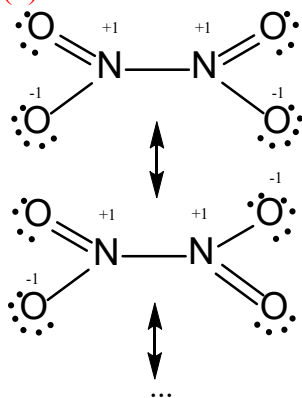


(3)



The text provides the above three structures, but the first one is the most stable structure considering the charge separation and electronegativity.

(4)



(c) (2) NO₂ has a “bent” structure, while (3) N₂O is “linear”.



(e) The Lewis dot diagrams in (b) show that NO_x molecules have either unpaired electrons (radical) or charge separations, which can induce further chemistry with other molecules. But N₂ is very stable as fully satisfying the octet rule and having a triple bond.

3. (18 points)

Ozone in the stratosphere protects us from UVB (280~320 nm) and UVC (200~280 nm) light, while ozone in the troposphere is toxic for us.

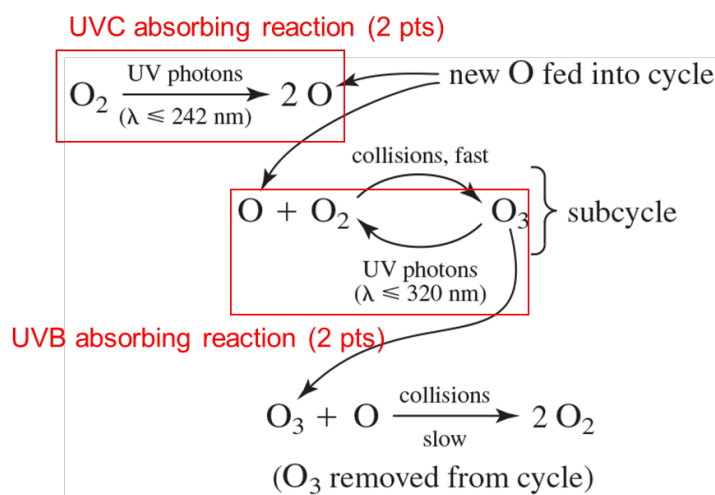
(a) Write chemical equations that show how UVB and UVC lights are absorbed in the ozone layer. Use the chemical equations to discuss the importance of a “steady-state” concentration of ozone in the stratosphere. (6 pts)

(b) Describe how Freon gases can destroy the ozone layer, and discuss why even a small amount of Freon gas can cause much larger changes in the ozone concentration. Given this chemistry, what kind of properties needs to be considered to develop alternative refrigerants? (6 pts)

(c) Ozone in the troposphere is a “secondary pollutant”, as it is produced from other pollutants such as NO₂. Write the chemical equations to generate ozone from NO₂ and discuss why ozone levels drop off sharply at night. (3 pts)

(d) How many numbers of ozone molecules does 1.00 Dobson Unit indicate? Assume the base area of the column is 1.00 square centimeter. (3 pts)

(a)



Full cycle description or showing/explaining how a decrease in [O₃] can also reduce O₂ (2 pts)

In the stratosphere, because of the following two reactions, UVC and UVB lights can be screened.

(1) UVC absorbing reaction: O₂ + UVC light → 2O (2 pts)

(2) UVB absorbing reaction: O₃ + UVB light → O₂ + O (2 pts)

The 2nd reaction is reversible and thus can feed [O₂], along with the reaction of O₃ + O → 2O₂. If there is a reduction in the ozone concentration, UVB screening and the amount of O₂ will be reduced. The latter will then also reduce the UVC screening and more high-energy light will arrive in the troposphere. (2 pts)

(b) Freon gases (CCl₃F or CCl₂F₂) contain the C-Cl bond, which can generate Cl• radical under UVC light. Then the Cl• radical can convert ozone to O₂, causing ozone depletion. (2 pts for describing Cl radical that can react with ozone)



The effect of the Cl• radical in the ozone depletion reaction is *catalytic* (2 pts), because of the following radical propagation cycles. Thus, even a small amount of the chlorine radical can destroy many ozone.



Overall: $2\text{O}_3 \rightarrow 3\text{O}_2$ (no consumption of $\text{Cl}\cdot$)

To avoid the above chemistry, *the C-Cl bond should be avoided* in alternative refrigerants. (2 pts)

(c) The high temperature of car engines can cause the oxidation of N_2 and generate NO_2 . This NO_2 molecule can be dissociated to NO and O under the sun light. Then the atomic O and O_2 can react to form ozone.



(2 pts for the above two equations)

At night, there are less cars operating (thus less NO_2 generated) and there is no day light to induce the generation of O from NO_2 . Therefore, the ozone concentration drops down at night. (1 pts)

(d) 100 Dobson Unit (DU) = if all the ozone over a certain area is compressed at 0°C to form a 1-mm-thick slab with a pressure of 1 atm.

1.00 DU gives 0.0100 mm slab at 0°C , 1 atm. The area was given to be 1.00 cm^2 .

of ozone molecules

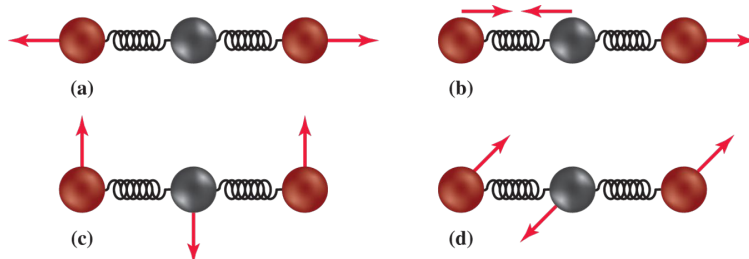
$$= N_A \times n = N_A \times \frac{PV}{RT} = \left(6.02214076 \times \frac{10^{23}}{\text{mol}}\right) \frac{(1\text{ atm})(0.0100 \times 10^{-3}\text{ m})(1.00 \times 10^{-4}\text{ m}^2)\left(1000 \frac{\text{L}}{\text{m}^3}\right)}{\left(0.0820574 \text{ L} \frac{\text{atm}}{\text{molK}}\right)(273.15\text{ K})}$$

$$= 2.69 \times 10^{16} \text{ molecules (3 pts)}$$

4. (11 points)

(a) The surface temperatures of both Venus and Earth are warmer than would be expected on the basis of their respective distances from the Sun. Why is this so? (3 pts)

(b) The vibrational modes of CO_2 are given below. Which of these vibrations contribute to the greenhouse effect? Explain. (3 pts)



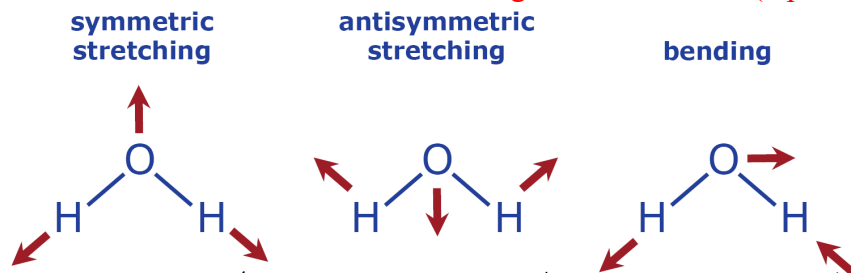
(c) Describe three vibrational modes of water and discuss which of them can contribute to the greenhouse effect. (3 pts)

(d) Explain why N_2 and O_2 are not greenhouse gases. (2 pts)

(a) These two planets are warmer than would be expected, *because they have atmospheric gases that produce a "greenhouse effect."* Sunlight enters the atmosphere of both Earth and Venus, warming the surfaces of the planet. The atmospheric gases are able to trap some of the heat radiated by the planet surfaces. Without these gases, the planets would be the temperatures expected as a result of their distance from the Sun.

(b) For the greenhouse effect, the IR radiation from the earth surface should be absorbed by gas molecules. Molecules can absorb IR, when the molecular dipole moment changes during the vibration. Among the four vibrational modes given, *except for (a), all other modes involve net dipole changes and thus contribute to the greenhouse effect.*

(c) There are symmetric stretching, antisymmetric stretching, and bending vibrations. All three modes can absorb IR and thus contribute to the greenhouse effect. (1 pt for each mode; overall 3 pts)



(d) $\text{N}\equiv\text{N}$ and $\text{O}=\text{O}$ contain non-polar bonds and their stretching motions do not involve dipole changes. Thus, these two molecules cannot absorb IR and are not greenhouse gases.

5. (9 pts)

From ice cores, we can learn how CO_2 concentration and global temperature change over the past 400,000 years. Explain what principles or techniques can be used to obtain the above data. Provide at least three examples that human activities produce CO_2 .

The ice cores contain air bubbles that include $\text{CO}_2(\text{g})$. From the density changes of the ice, each year can be distinguished and thus we can determine which year the air bubble belongs to. *By analyzing the content of the air bubbles, we can determine the CO_2 concentration in the air for each year.* (3 pts)
For the global temperature, the isotope ratios of each ice layer can be analyzed. (3pts) The $^1\text{H}:^2\text{H}$ ratio or the $^{16}\text{O}:^{18}\text{O}$ ratio in the ice layer decreases as the global temperature increases, because heavier atoms can fly better with a higher temperature.

Examples of CO_2 producing human activities are (1 pt for each example; up to 3 pts)

- Respiration; humans (animals) burn glucose and sugars to CO_2 and H_2O via respiration, to obtain energy.
- Burning fossil fuels; for energy production in power plants and transportation, we have been burning carbon-based fuels and produced CO_2 .
- Smelting processes; to obtain pure metals, we reduce their natural forms (oxides) by using carbon. For example, $2\text{CuO} + \text{C} \rightarrow 2\text{Cu} + \text{CO}_2$ (any reactions converting metal oxides to pure metal are fine)
- Silicone for chips is obtained from sand, SiO_2 , by reducing it with carbon as generating CO_2 .
 $\text{SiO}_2 + \text{C} \rightarrow \text{Si} + \text{CO}_2$
- Deforestation; for other purpose land usages, humans have removed forests, which can absorb CO_2 and thus it has a net effect of producing CO_2 .
- And so on...

6. (12 points)

Quantum mechanical principles for a free particle in an 1-dimensional box can be applied to many chemical problems. Let's discuss several examples.

(a) Begin with the wave function formula $\psi(x) = A \sin \frac{2\pi x}{\lambda}$ to derive the 1-dimensional (time-independent) Schrödinger equation. Describe potential energy as $V(x)$. Use the De Broglie's wave-

particle duality equation $\lambda = h/p$. (2 pts)

(b) For a free particle in an 1D box with the length of L , $V(x) = 0$ and the boundary condition is $\psi(0) = \psi(L) = 0$. Use the normalization condition and boundary conditions to derive the wave function formula. FYI, $\int_0^a \sin^2\left(\frac{n\pi x}{a}\right) dx = \frac{a}{2}$ (2 pts)

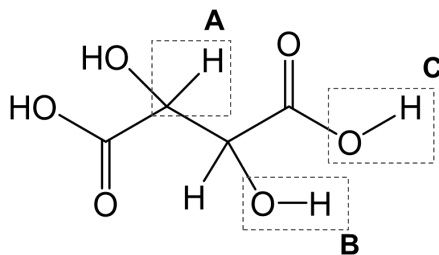
(c) Use the above wave function obtained in (b) to derive the energy for a free particle in an 1D box. (2 pts)

(d) The π -bonding electrons in ethene ($\text{H}_2\text{C}=\text{CH}_2$) can be treated like free particles in an 1D box. Use the energy expression obtained in (c) to calculate the wavelength of light that can promote an electron from the $n=1$ to the $n=2$ level. The $\text{C}=\text{C}$ bond length is 1.50 \AA . (2 pts)

(e) Tartaric acid is an organic acid that is found in grapes, bananas, and avocados. As you can see in its structure below, there are three different types of hydrogens. **A** is the one bonded to carbon, while **B** and **C** are bonded to oxygens.

(1) Which of these three types can form hydrogen bonds to water molecules? Discuss why. (2 pts)

(2) Among the three bonds, which one is most acidic in water? Let's assume that the anion charge (electron) generated after proton dissociation behaves like a free particle in a box. Use the energy expression obtained in (c) to discuss why one of the three bonds is more acidic than the others. (2 pts)



(a) To use the wave property, by differentiating the wave equation, $\psi(x) = A \sin \frac{2\pi x}{\lambda}$, we can obtain

$$\frac{d^2}{dx^2} \psi(x) = -A \left(\frac{2\pi}{\lambda}\right)^2 \sin \frac{2\pi x}{\lambda} = -\left(\frac{2\pi}{\lambda}\right)^2 \psi(x).$$

$$\text{By using } \lambda = h/p, \frac{d^2}{dx^2} \psi(x) = -\left(\frac{2\pi}{\lambda}\right)^2 \psi(x) = -\left(\frac{2\pi}{h} p\right)^2 \psi(x)$$

Rearranging the above,

$$-\frac{h^2}{8\pi^2 m} \frac{d^2}{dx^2} \psi(x) = \frac{p^2}{2m} \psi(x) = T\psi(x)$$

By adding the potential energy term, the total energy expression can be obtained.

$$-\frac{h^2}{8\pi^2 m} \frac{d^2}{dx^2} \psi(x) + V(x)\psi(x) = E\psi(x)$$

(b) To satisfy $\psi(0) = \psi(L) = 0$, a general sine wave can be used.

$$\psi(x) = A \sin kx; \quad \psi(L) = A \sin kL = 0$$

Then, $kL = n\pi$ for $n = 1, 2, 3, \dots$

$$\text{Thus, } \psi(x) = A \sin \left(\frac{n\pi x}{L}\right) \quad n = 1, 2, 3, \dots$$

$$\text{For normalization, } A^2 \int_0^L \sin^2 \left(\frac{n\pi x}{L}\right) dx = A^2 \left(\frac{L}{2}\right) = 1; \quad A = \sqrt{\frac{2}{L}}$$

$$\text{Therefore, } \psi_n(x) = \sqrt{\frac{2}{L}} \sin \left(\frac{n\pi x}{L}\right) \quad n = 1, 2, 3, \dots$$

(c) From the equation in (a) & $V(x)=0$

$$-\frac{h^2}{8\pi^2m} \frac{d^2}{dx^2} \psi(x) = E\psi(x)$$

Apply the above wave equation in (b)

$$\frac{d^2\psi_n(x)}{dx^2} = -\left(\frac{n\pi}{L}\right)^2 \psi_n(x) = -\frac{8\pi^2mE}{h^2} \psi(x)$$

Thus, $E_n = \frac{n^2h^2}{8mL^2}$ $n = 1, 2, 3, \dots$

(d) $L = 1.50 \times 10^{-10} \text{ m}$

$$E_2 - E_1 = h\nu = hc/\lambda$$

$$\frac{6.626 \times 10^{-34} \text{ m}^2 \text{ kg s}^{-1}}{8(9.109 \times 10^{-31} \text{ kg})(1.50 \times 10^{-10} \text{ m})^2} (4 - 1) = \frac{2.998 \times 10^8 \text{ m/s}}{\lambda}$$

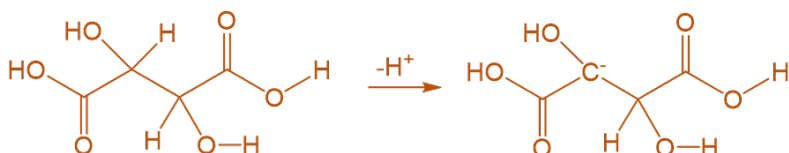
$$\lambda = 2.47 \times 10^{-8} \text{ m} = \mathbf{24.7 \text{ nm}}$$

(e) (1) B and C are the O-H bonds and thus they can form H bonds to water molecules. However, A is the C-H bond, which does not form H bond because the electronegativity difference between C and H is not as large as that between O and H.

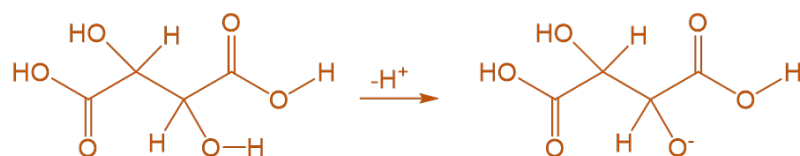
(2) When A or B is acidic, after losing a proton, the (-) charge is localized on C or O, respectively for A and B. Since carbon is not as electronegative as oxygen, A must be weaker acid than B.

Now if we compare C's structure after losing a proton, now the (-) charge is delocalized over three atoms. This is like L is larger for C than B in the energy expression of $E_n = \frac{n^2h^2}{8mL^2}$. C can lose a proton better than B, because the de-protonated form of C is more stable than that of B.

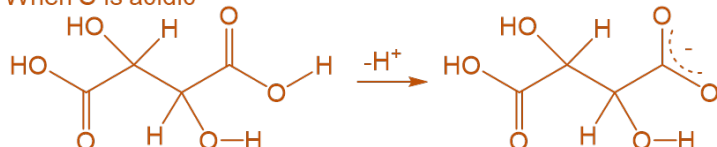
When A is acidic



When B is acidic



When C is acidic



Physical Constants

Avogadro's number	$N_A = 6.02214076 \times 10^{23} \text{ mol}^{-1}$
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.ktf-split.hr/periodni/en/>

GROUP	PERIOD																	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
IA	IIA	IIIB	IVB	VB	VIB	VII B	VIII B	VIII B			IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
GROUP NUMBERS IUPAC RECOMMENDATION (1985)		GROUP NUMBERS CHEMICAL ABSTRACT SERVICE (1986)																
ATOMIC NUMBER		RELATIVE ATOMIC MASS (1)																
SYMBOL		ELEMENT NAME																
1 H HYDROGEN	2 He HELIUM	3 Li LITHIUM	4 Be BERYLLIUM	5 B BORON	6 C CARBON	7 N NITROGEN	8 O OXYGEN	9 F FLUORINE	10 Ne NEON	11 Na SODIUM	12 Mg MAGNESIUM	13 Al ALUMINIUM	14 Si SILICON	15 P PHOSPHORUS	16 S SULPHUR	17 Cl CHLORINE	18 Ar ARGON	
19 K POTASSIUM	20 Ca CALCIUM	21 Sc SCANDIUM	22 Ti TITANIUM	23 V VANADIUM	24 Cr CHROMIUM	25 Mn MANGANESE	26 Fe IRON	27 Co COBALT	28 Ni NICKEL	29 Cu COPPER	30 Zn ZINC	31 Ga GALLIUM	32 Ge GERMANIUM	33 As ARSENIC	34 Se SELENIUM	35 Br BROMINE	36 Kr KRYPTON	
37 Rb RUBIDIUM	38 Sr STRONTIUM	39 Y YTRIUM	40 Zr ZIRCONIUM	41 Nb NIOBIUM	42 Mo MOLYBDENUM	43 Tc TECHNETIUM	44 Ru RUTHENIUM	45 Rh RHODIUM	46 Pd PALLADIUM	47 Ag SILVER	48 Cd CADMIUM	49 In INDIUM	50 Sn TIN	51 Sb ANTIMONY	52 Te TELLURIUM	53 I IODINE	54 Xe XENON	
55 Cs CAESIUM	56 Ba BARIUM	57-71 La-Lu LANTHANIDE	72 Hf HAFNIUM	73 Ta TANTALUM	74 W TUNGSTEN	75 Re RHENIUM	76 Os OSMIUM	77 Ir IRIDIUM	78 Pt PLATINUM	79 Au GOLD	80 Hg MERCURY	81 Tl THALLIUM	82 Pb LEAD	83 Bi BISMUTH	84 Po POLONIUM	85 At ASTATINE	86 Rn RADON	
87 Fr FRANCIUM	88 Ra RADIUM	89-103 Ac-Lr ACTINIDE	104 Rf RUTHERFORDIUM	105 Dfb DUBNIUM	106 Sg SEABORGIUM	107 Bh BOHRNIUM	108 Hs HASSIUM	109 Mt MEITNERIUM	110 Uu UNUNNIUM	111 Uu UNUNNIUM	112 Uub UNUNBIUM	114 Uuq UNUNQUADIUM						

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(1) Pure Appl. Chem., 73, No. 4, 667-693 (2001)

Relative atomic mass is shown with five 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, 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 (aditya@netlinx.com)

LANTHANIDE																
57 La LANTHANUM	58 Ce CERIUM	59 Pr PRASEODYMIUM	60 Nd NEODYMIUM	61 Pm PROMETHIUM	62 Sm SAMARIUM	63 Eu EUROPIUM	64 Gd GADOLINIUM	65 Tb TERBIUM	66 Dy DYSPROSIUM	67 Ho HOLIUM	68 Er ERBIUM	69 Tm THULIUM	70 Yb YTTERIUM	71 Lu LUTETIUM		
ACTINIDE																
89 Ac ACTINIUM	90 Th THORIUM	91 Pa PROACTINIUM	92 U URANIUM	93 Np NEPTUNIUM	94 Pu PLUTONIUM	95 Am AMERICIUM	96 Cm CURIUM	97 Bk BERKELIUM	98 Cf CALIFORNIUM	99 Es EINSTEINIUM	100 Fm FERMIUM	101 Md MENDELEVIUM	102 No NOBELIUM	103 Lr LAWRENCIUM		

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