

AIM: HOW TO CALCULATE THE AVERAGE ATOMIC MASS?

DO NOW: 1. WHAT ARE THE 3 SUBATOMIC PARTICLES OF AN ATOM? LIST THE THREE SUBATOMIC PARTICLES AND THEIR CHARGE.

2. IF AN ATOM HAS AN ATOMIC MASS OF 34 AND THE ATOM HAS 16 NEUTRONS, HOW MANY PROTONS DOES THE ATOM HAVE?

ISOTOPES

- ISOTOPES—ATOMS THAT HAVE THE SAME NUMBER OF PROTONS BUT DIFFERENT NUMBERS OF NEUTRONS ARE CALLED ISOTOPES.
- BECAUSE ISOTOPES OF AN ELEMENT HAVE DIFFERENT NUMBERS OF NEUTRONS, THEY ALSO HAVE DIFFERENT MASS NUMBERS.

AVERAGE ATOMIC MASS

- MOST ELEMENTS OCCUR NATURALLY AS MIXTURES OF ISOTOPES.
- THE MASS NUMBERS ON THE PERIODIC TABLE ARE THE WEIGHTED AVERAGE OF THE MOST ABUNDANT ISOTOPES' MASS NUMBERS.
- THE ATOMIC MASS OF AN ELEMENT IS A WEIGHTED AVERAGE MASS OF THE ATOMS IN A NATURALLY OCCURRING SAMPLE OF THE ELEMENT.

PERIODIC TABLE OF THE ELEMENTS

1 IA																	18 VIIIA	
1 H Hydrogen 1.0079	2 IIA		<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: auto;"> <p style="text-align: center;">14 ← Group IUPAC IVA ← Group CAS</p> <p>Atomic Number → 6 ← Selected Oxidation States Symbol → C ← Name → Carbon Electron Configuration → 2-4 ← Atomic Mass 12.011</p> </div>										13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	2 He Helium 4.0026
3 Li Lithium 6.941	4 Be Beryllium 9.0122											5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.179	
11 Na Sodium 22.990	12 Mg Magnesium 24.305	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIII	9	10	11 IB	12 IIB	13 Al Aluminium 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulphur 32.065	17 Cl Chlorine 35.453	18 Ar Argon 39.948	
19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.867	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.39	31 Ga Gallium 69.723	32 Ge Germanium 72.64	33 As Arsenic 74.922	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.80	
37 Rb Rubidium 85.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.94	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.91	46 Pd Palladium 106.42	47 Ag Silver 107.87	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 127.60	53 I Iodine 126.90	54 Xe Xenon 131.29	
55 Cs Cesium 132.91	56 Ba Barium 137.33	57-71 Lanthanide	72 Hf Hafnium 178.49	73 Ta Tantalum 180.95	74 W Tungsten 183.84	75 Re Rhenium 186.21	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.97	80 Hg Mercury 200.59	81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 208.98	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)	
87 Fr Francium (223)	88 Ra Radium (226)	89-103 Actinide	104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (264)	107 Bh Bohrium (264)	108 Hs Hassium (277)	109 Mt Meitnerium (268)	110 Uun Ununnilium (281)	111 Uuu Unununium (272)	112 Uub Ununbium (285)	113 Uut Ununtrium (284)	114 Uuq Ununquadium (289)	115 Uup Ununpentium (288)	116 Uuh Ununhexium (291)	117 Uus Ununseptium	118 Uuo Ununoctium (294)	

Electron Shells

1	K	2	S	P	D	F
2	L	8	2	6		
3	M	18	2	6	10	
4	N	32	2	6	10	14
5	O	32	2	6	10	14
6	P	18	2	6	10	
7	Q	8	2	6		
8	R	2	2			

Lanthanide

57 La Lanthanum 138.91	58 Ce Cerium 140.12	59 Pr Praseodymium 140.91	60 Nd Neodymium 144.24	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.93	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93	68 Er Erbium 167.26	69 Tm Thulium 168.93	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.97
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Actinide

89 Ac Actinium (227)	90 Th Thorium 232.04	91 Pa Protactinium 231.04	92 U Uranium 238.03	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (262)
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14 ← Group IUPAC
IVA ← Group CAS

Atomic Number	⇒	6	
Symbol	⇒	C	Selected Oxidation States
Name	⇒	Carbon	
Electron Configuration	⇒	2-4	
		12.011	Atomic Mass

-4
 +2
 +4

Name	Symbol	Natural Percent Abundance	Mass (amu)	"Average" Atomic Mass
Carbon	$^{12}_6\text{C}$	98.89	12.000	12.011
	$^{13}_6\text{C}$	1.11	13.003	

Natural Percent Abundance of Stable Isotopes of Some Elements

Name	Symbol	Natural Percent Abundance	Mass (amu)	"Average" Atomic Mass
Hydrogen	^1_1H	99.985	1.0078	1.0079
	^2_1H	0.015	2.0141	
	^3_1H	negligible	3.0160	
Helium	^3_2He	0.0001	3.0160	4.0026
	^4_2He	99.9999	4.0026	
Carbon	$^{12}_6\text{C}$	98.89	12.000	12.011
	$^{13}_6\text{C}$	1.11	13.003	
Nitrogen	$^{14}_7\text{N}$	99.63	14.003	14.007
	$^{15}_7\text{N}$	0.37	15.000	
Oxygen	$^{16}_8\text{O}$	99.759	15.995	15.999
	$^{17}_8\text{O}$	0.037	16.995	
	$^{18}_8\text{O}$	0.204	17.999	
Sulfur	$^{32}_{16}\text{S}$	95.002	31.972	32.06
	$^{33}_{16}\text{S}$	0.76	32.971	
	$^{34}_{16}\text{S}$	4.22	33.967	
	$^{36}_{16}\text{S}$	0.014	35.967	
Chlorine	$^{35}_{17}\text{Cl}$	75.77	34.969	35.453
	$^{37}_{17}\text{Cl}$	24.23	36.966	
Zinc	$^{64}_{30}\text{Zn}$	48.89	63.929	65.38
	$^{66}_{30}\text{Zn}$	27.81	65.926	
	$^{67}_{30}\text{Zn}$	4.11	66.927	
	$^{68}_{30}\text{Zn}$	18.57	67.925	
	$^{70}_{30}\text{Zn}$	0.62	69.925	

HOW TO CALCULATE AVG. ATOMIC MASS

- TO CALCULATE THE ATOMIC MASS OF AN ELEMENT, MULTIPLY THE MASS OF EACH ISOTOPE BY ITS NATURAL ABUNDANCE, EXPRESSED AS A DECIMAL, AND THEN ADD THE PRODUCTS.

SAMPLE PROBLEM 1

- RUBIDIUM HAS TWO COMMON ISOTOPES, 85-RB AND 87-RB. IF THE ABUNDANCE OF 85-RB IS 72.2% AND THE ABUNDANCE OF 87RB IS 27.8%, WHAT IS THE AVERAGE ATOMIC MASS OF RUBIDIUM?

Isotope	% abundance	Fraction of abundance	mass
85-Rb	72.2%	0.722	85 amu
87-Rb	27.8%	0.278	87 amu

$$0.722 \times 85 \text{ amu} = 61.37$$

$$0.278 \times 87 \text{ amu} = 24.186$$

$$+ \text{-----}$$

$$85.556 \text{ amu}$$

SAMPLE PROBLEM 2

- GIVEN THE AVERAGE ATOMIC MASS OF AN ELEMENT ON THE PERIODIC TABLE AND THE PERCENT NATURAL ABUNDANCE OF EACH ISOTOPE, CALCULATE THE IDENTITY OF THE UNKNOWN ISOTOPE?(ATOMIC MASS OF CHROMIUM IS 51.996 AMU)
- CHROMIUM- ?? 4.345%
- CHROMIUM-52 83.79%
- CHROMIUM-53 9.50%
- CHROMIUM-54 2.365%

- X= UNKNOWN CHROMIUM

$$[(X)(0.04345)] + [(52)(0.8379)] + [(53)(0.0950)] + [(54)(0.02365)] =$$

51.996
AMU

SAMPLE PROBLEM 3

- CHLORINE HAS TWO NATURALLY OCCURRING ISOTOPES. THE MASS OF CHLORINE-35 IS 34.696 AMU AND THE MASS OF CHLORINE-37 IS 36.966 AMU. USING THE AVERAGE MASS FROM THE PERIODIC TABLE (AVERAGE ATOMIC MASS OF CHLORINE IS 35.453), FIND THE ABUNDANCE OF EACH ISOTOPE. (REMEMBER THAT THE SUM OF THE TWO ABUNDANCES MUST BE 100)

- $X =$ FRACTION OF ABUNDANCE FOR CHLORINE-35
- $100 - X =$ FRACTION OF ABUNDANCE FOR CHLORINE-37

$$[(34.696)(X)] + [(36.966)(100 - X)] = 35.453 \text{ AMU}$$