GENERAL CHEMISTRY LECTURE NOTES ©mm 2007

CHAPTER 8

ELECTRONIC STRUCTURE AND THE PERIODIC LAW

THE PERIODIC LAW:

ELEMENTS WITH SIMILAR CHEMICAL PROPERTIES OCCUR AT REGULAR (PERIODIC) INTERVALS WHEN THE ELEMENTS ARE ARRANGED IN ORDER OF INCREASING ATOMIC NUMBER

THERE ARE ELEMENTS WITH SIMILAR PROPERTIES. THESE ARE CALLED GROUPS OR FAMILIES

THE GROUPS ARE ARRANGED IN COLUMNS. EACH COLUMN HAS A ROMAN NUMERAL AND A LETTER.

HORIZONTAL ROWS ARE CALLED PERIODS, NUMBERED 1, 2, 3 etc

DUE TO SPACE LIMITATIONS TWO ROWS ON THE BOTTOM OF THE TABLE ARE USUALLY SHOWN SEPARATELY (FIG. 8.3)

ELECTRONIC ARRANGEMENTS IN ATOMS

THE LOCATION OF AN ELECTRON CAN BE SPECIFIED BY ITS SHELL, SUBSHELL AND ORBITAL

ANALOGOUS TO YOUR ADDRESS OF STREET, BUILDING, APARTMENT

A <u>SHELL</u> IS A LOCATION FOR ELECTRONS, DESIGNATED BY A NUMBER, n, WHERE $n = 1, 2, 3, 4 \ldots$

$n=1$ IS A SHELL THAT IS CLOSEST TO THE NUCLEUS AND HAS THE LOWEST ENERGY

$n=2$ IS A LOCATION A BIT FARTHER OUT FROM THE NUCLEUS AND HAVING HIGHER ENERGY

EACH SHELL IS SUBDIVIDED INTO SUBSHELLS DESIGNATED BY THE LETTERS; s, p, d, f

THE NUMBER OF SUBSHELLS IN A SHELL IS EQUAL TO n, THE SHELL NUMBER

SHELLS AND SUBSHELLS

1	1s
2	2s 2p
3	3s 3p 3d

ALL ELECTRONS IN A SPECIFIC SUBSHELL HAVE THE SAME ENERGY

ELECTRONS MOVE WITHIN A DEFINITE REGION OR VOLUME OF SPACE CALLED ATOMIC ORBITALS

ORBITALS HAVE SPECIFIC SHAPES: FIG 3.3

S ORBITALS ARE SPHERICAL

P ORBITALS HAVE A "DUMBBELL" SHAPE

EACH ORBITAL CAN HOLD A MAXIMUM OF 2 ELECTRONS

S SUBSHELLS ALWAYS CONTAIN ONE ORBITAL

P SUBSHELLS ALWAYS CONTAIN THREE ORBITALS

d SUBSHELLS ALWAYS CONTAIN FIVE ORBITALS

SINCE EACH ORBITAL CAN HAVE A MAXIMUM OF 2 ELECTRONS

A FULL S SUBSHELL HAS 2 ELECTRONS

A FULL P SUBSHELL HAS 6 ELECTRONS

A FULL d SUBSHELL HAS 10 ELECTRONS

THE ENERGY OF THE ELECTRONS IN A SHELL INCREASES IN THE ORDER S, P, D, F

FOR AN ATOM IN THE SECOND ROW ($n=2$)

1) WHAT ARE THE SUBSHELLS?
2) HOW MANY ORBITALS?
3) WHAT IS THE MAXIMUM NUMBER OF ELECTRONS IN EACH?
4) WHAT IS THE TOTAL NUMBER OF ELECTRONS IN THE SHELL?

1) 2s and 2p
2) ONE s AND THREE p → TOTAL 4
3) 2 ELECTRONS FILL THE S ORBITAL
4) 6 ELECTRONS FILL THE 3 p ORBITALS → 8 TOTAL IN THE SHELL

THE VALENCE SHELL AND CHEMICAL PROPERTIES

THE OUTERMOST OCCUPIED SHELL OF AN ATOM IS THE VALENCE SHELL

ELEMENTS IN THE SAME GROUP OR FAMILY (COLUMN) HAVE THE SAME NUMBER OF ELECTRONS IN THEIR VALENCE SHELL

THIS MAKES THEM HAVE VERY SIMILAR PROPERTIES AND CHEMISTRY

ELECTRON CONFIGURATIONS

IMAGINE FILLING THE ORBITALS OF AN ATOM WITH ELECTRONS, ONE AT A TIME, LOWEST ENERGY FIRST

THE SUBSHELLS FILL IN THIS ORDER:

1s 2s 2p 3s 3p 4s 3d 4p

TWO RULES:

1) ELECTRONS GO INTO EMPTY ORBITALS FIRST. ONLY WHEN ALL ORBITALS OF A SUBSHELL HAVE 1 ELECTRON IN THEM WILL A SECOND ELECTRON GO IN AN ORBITAL

RULES FOR FILLING ORBITALS WITH ELECTRONS

1) ELECTRONS WILL NOT JOIN OTHER ELECTRONS IN AN ORBITAL IF AN EMPTY ORBITAL OF THE SAME ENERGY IS AVAILABLE (HUND'S RULE)

2) ONLY ELECTRONS WITH OPPOSITE SPIN CAN OCCUPY THE SAME ORBITAL (11) (PAULI EXCLUSION PRINCIPLE)

AS AN EXAMPLE, ELEMENT 12 $^{24}_{12}Mg$ MAGNESIUM

$1s^2\ 2s^2\ 2p^6\ 3s^2$

THIS ELEMENT HAS A COMPLETE FIRST SHELL AND SECOND SHELL AND 2 VALENCE ELECTRONS IN THE 3rd SHELL

FILLED SHELLS ARE ESPECIALLY STABLE

A FILLED SHELL IS CALLED A "NOBLE GAS CONFIGURATION"

AN ABBREVIATION FOR THE MAGNESIUM ATOM USES THE SYMBOL FOR THE NOBLE GAS TO SHOW THE 2 FILLED SHELLS

$[Ne]\ 3s^2$ THIS EMPHASIZES THE IMPORTANCE OF THE VALENCE ELECTRONS

NOTE THAT ALL GROUP IIA ELEMENTS HAVE THE <u>SAME</u> VALENCE ELECTRONS

ELEMENT	ELECTRON CONFIGURATION
Be	$[He]\ 2s^2$
Mg	$[Ne]\ 3s^2$
Ca	$[Ar]\ 4s^2$
Sr	$[Kr]\ 5s^2$
Ba	$[Xe]\ 6s^2$
Ra	$[Rn]\ 7s^2$

THE LAST, HIGHEST ENERGY ELECTRON FOUND IN AN ELEMENT IS CALLED THE DISTINGUISHING ELECTRON

FIGURE 8.6 PG 310 SHOWS HOW THE PERIODIC TABLE IS DIVIDED BY WHICH ORBITAL HOLDS THE DISTINGUISHING ELECTRON

THE PERIODIC TABLE IS ALSO DIVIDED THIS WAY

- NOBLE GASSES → TOTALLY FILLED SHELLS
- REPRESENTATIVE ELEMENTS → DISTINGUISHING ELECTRON IN A S OR P ORBITAL
- TRANSITION ELEMENTS → DISTINGUISHING ELECTRON IS IN A d ORBITAL

MOST OF THE COMMON ELEMENTS ARE REPRESENTATIVE ELEMENTS

A FINAL DIVISION OF THE PERIODIC TABLE

- METALS → SHINY, CONDUCT HEAT AND ELECTRICTY WELL, MALLEABLE AND DUCTILE
- NONMETALS → FOUND IN THE UPPER RIGHT OF THE TABLE THEIR PROPERTIES ARE OPPOSITE OF METALS
- METALLOIDS → HALFWAY BETWEEN FOR INSTANCE Si SILICON, A SEMICONDUCTOR

PERIODIC TRENDS

THERE ARE MANY REGULAR TRENDS IN THE PERIODIC TABLE.

ATOMIC SIZE INCREASES FROM TOP TO BOTTOM

ATOMS LOWER IN THE TABLE HAVE MORE SHELLS

ATOMIC SIZE DECREASES GOING FROM LEFT TO RIGHT IN A PERIOD OR ROW

IN A PERIOD, ALL ELECTRONS GO IN THE SAME SHELL AND HAVE ABOUT THE SAME DISTANCE FROM THE NUCLEUS

BECAUSE NUCLEAR POSITIVE CHARGE INCREASES FROM LEFT TO RIGHT AS PROTONS ARE ADDED TO THE NUCLEUS, ELECTRONS IN THE SHELL FEEL AN INCREASING ATTRACTION AND ARE DRAWN CLOSER TO THE NUCLEUS AND ATOMIC SIZE DECREASES FIG. 8.12 PG 318

FIRST IONIZATION ENERGY

IF AN ELECTRON IS REMOVED FROM AN ATOM, THE ATOM BECOMES POSITIVELY CHARGED.

THE POSITIVELY CHARGED ATOM IS CALLED AN ION AND THE ACT OF REMOVING AN ELECTRON IS CALLED IONIZATION

FIRST IONIZATION ENERGY IS THE AMOUNT OF ENERGY IT TAKES TO REMOVE THE FIRST ELECTRON FROM AN ATOM

FIRST IONIZATION ENERGY INCREASES FROM LEFT TO RIGHT IN A PERIOD AND DECREASES FROM THE TOP TO THE BOTTOM OF A GROUP

EXPLANATION

AS WE GO DOWN A GROUP, ELECTRONS ARE LOCATED IN LARGER SHELLS, FARTHER AWAY FROM THE ATTRACTIVE FORCE OF THE NUCLEUS

AS WE GO ACROSS A PERIOD, NUCLEAR CHARGE INCREASES BUT ELECTRONS REMAIN IN THE SAME SHELL, "FEEL" MORE ATTRACTIVE FORCE

CHAPTER 8

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