

- Assumptions
(need confirmation)
- Raj bhaiya imp notes
- Stuff I added
(confirmed)

Atomic Structure

Atoms are made up of 3 different sub-atomic particles

Subatomic Particle	Relative Mass	Relative Charge	Location
Proton (p)	1	+ 1	nucleus
Neutron (n)	1	0	nucleus
Electron (e^-)	$\frac{1}{1860}$ $\frac{1}{1836}$	- 1	Shell outside of nucleus

The shell number is also called Principal Quantum Number

Maximum number of e^- in each shell = $2n^2$
(n = shell no.)

There are 4 different types of subshells:

- s, p, d, f (energy level lowest to highest)

Shell no.	No. of subshells
1	1s
2	2s, 2p
3	3s, 3p, 3d
4	4s, 4p, 4d, 4f

Orbital: It is a region of space around the nucleus where an e^- spends most of its time (almost 95%).

Sub-shell	no. of orbitals ($2n - 1$)
s	1
p	3
d	5
f	7

Each orbital can hold maximum $2e^-$

Spin-pair repulsion theory: The electron in an orbital always spin in opposite directions to minimize their repulsion force.

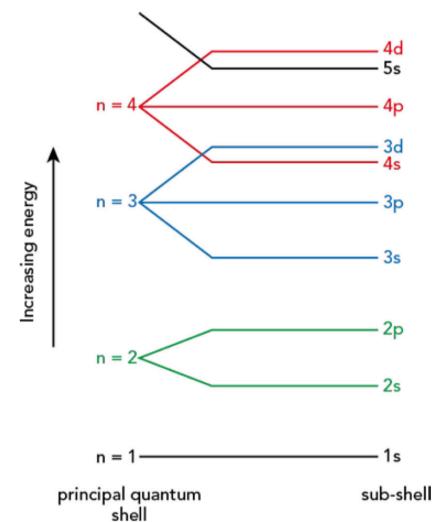
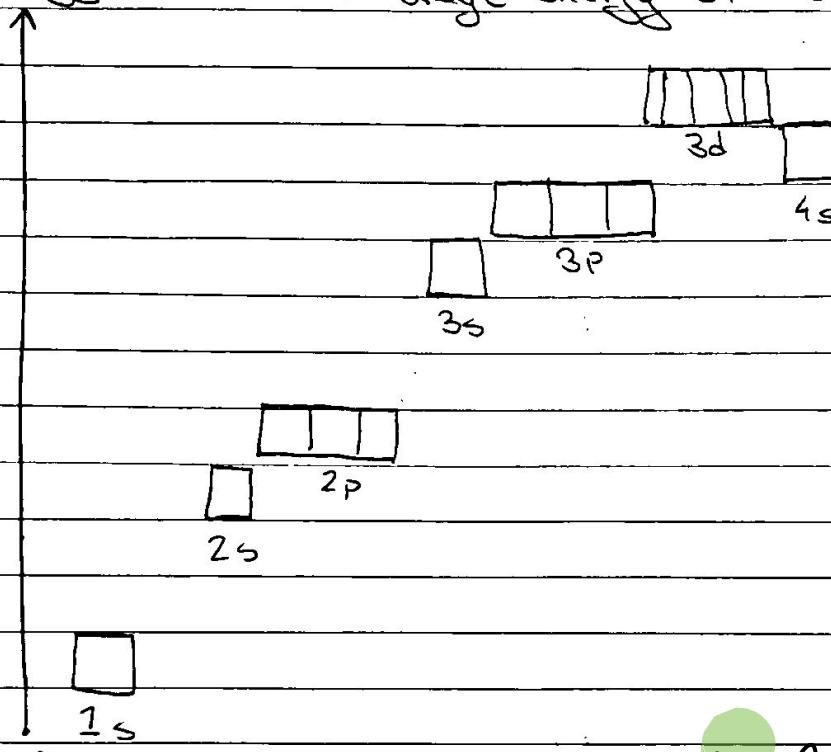
Shell no.	no. of subshells	no. of orbitals	max no. of e^-
1	1s	1	2
2	2s, 2p	4	8
3	3s, 3p, 3d	9	18
4	4s, 4p, 4d, 4f	16	32

sub-shell

- * e^- are always filled from lower energy level to higher energy level
subshell

level

- * There is a very low proximity in energy between 4s and 3d subshells
Energy of subshells (average energy of the e^- in the subshells)



~~1s
2s 2p
3s 3p 3d
4s 4p 4d 4f
5s 5p 5d 5f~~

1s
2s
2p
3s
3p
4s
3d
4p
5s
4d
5p
6s

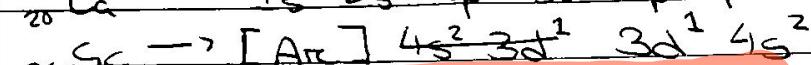
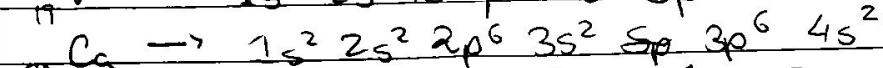
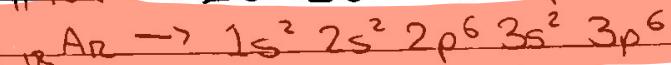
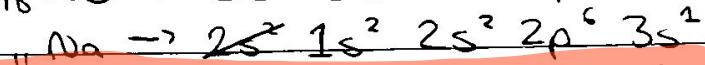
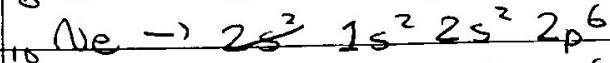
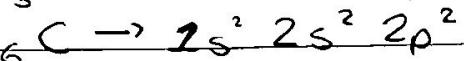
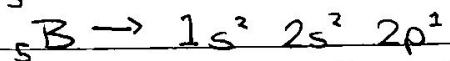
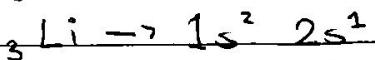
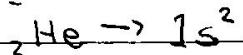
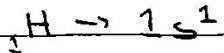
1s 2s 2p 3s

3p 4s \rightarrow -ps

3d 4p 5s \rightarrow d_{ps}

4d 5p 6s \rightarrow d_{ps}

Electronic Configuration



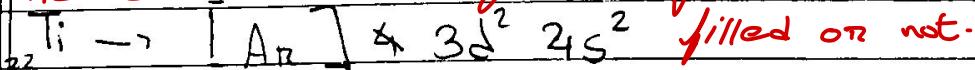
The only allowed shorthand is [Ar]

[Ar] shorthand cannot be used if the question asks for full electronic configuration

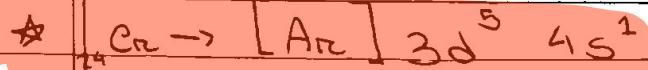
* Once the d

* Once the e^- are filled in their respective orbitals, 4s moves to the higher energy level and 3d moves to the lower energy level *

e^- will always be removed from the 4s subshell before the 3d subshell, regardless of whether the 3-d subshell is filled or not.



* Halfly filled d-subshell is more stable than a partially filled d-subshell.



only 1 e^- can jump from $4s$ to $3d$

* fully filled d-subshell is more stable than a partially filled d-subshell



* last sub-shells

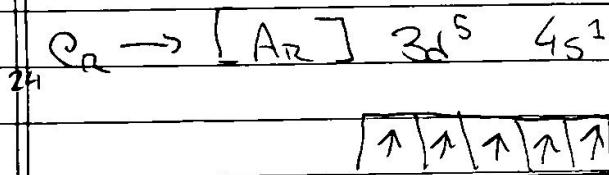
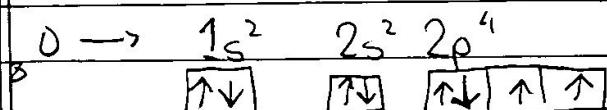
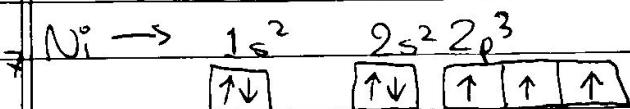
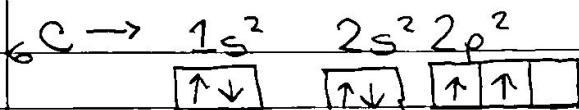
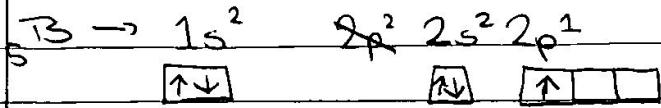


* All transition elements are d-block elements but all d-block elements are not transition elements

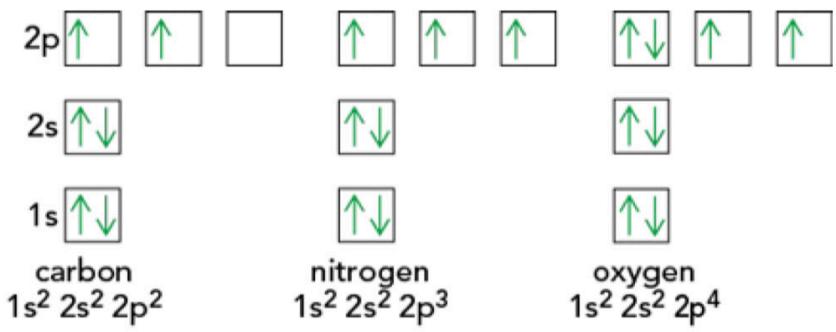
* All group-0 elements have a fully filled last outer subshell

* The orbital in each sub-shell is filled individually singly before pairing occurs

All of the following examples are free radicals

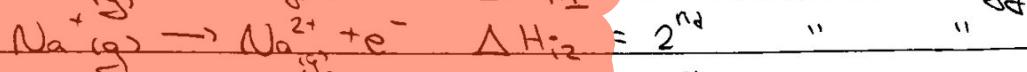


Free Radical: A free radical is a species with 1 or more unpaired e⁻ (singly-filled orbital)



Define ionization energy

It is the amount of energy required to remove 1 mol of e^- from 1 mol of gaseous atom or ion. It is always endothermic. ΔH_i ; +ve



Trend in successive ionization energy in an element

With the removal of ~~each~~ e^- , ~~per~~ effective nuclear attractive force acting on the e^- increases. This makes it more difficult to remove an e^- causing increase in successive ionization energy.

Q. The first 5 ionization energies of an element X are given below:

ΔH_{i1}	ΔH_{i2}	ΔH_{i3}	ΔH_{i4}	ΔH_{i5}
300	830	1120	9233	11000

State the group no. of the element X and explain your answer

Ans: Group No:- 3

There is a huge jump between from ΔH_{i3} to ΔH_{i4} . Thus, the 4th e^- is removed from the inner shell, which is closer to the nucleus and thus experiences greater nuclear attractive force.

Factors affecting ionization energy in elements

↳ Nuclear Charge (Proton Number) : With increase in Nuclear Charge ionization Energy increases

↳ Atomic Radius : The more the With increase in Atomic Radius, ΔH_i decreases

↳ Shielding Effect : It is the repulsion of inner shell e^- to the outer shell of e^- . With increase in shielding effect ΔH_i decreases

Shielding lowers the effective nuclear attractive force acting on the valence e^-

There is at only a ~~sign~~ significant change in shielding effect when the shell number changes. Otherwise it stays almost constant

↳ Spin-pair repulsion : The increased repulsion makes it easier to remove e^- , thus lowering ΔH_i . Affect ΔH_{i2} of Grz-6.

* Across the Period atomic radius decreases due to an increase proton number causing more nuclear attractive forces to act on e^- thus the e^- come close to each other causing the atom to shrink in size.

the nucleus and

* Stark Shielding effect remains almost constant (slightly increases)

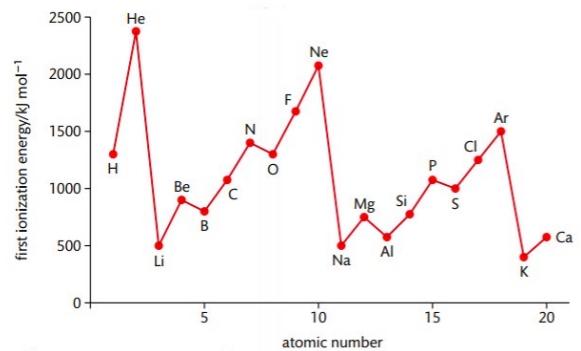
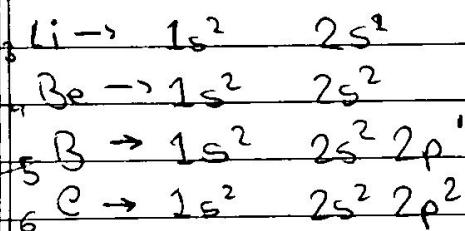
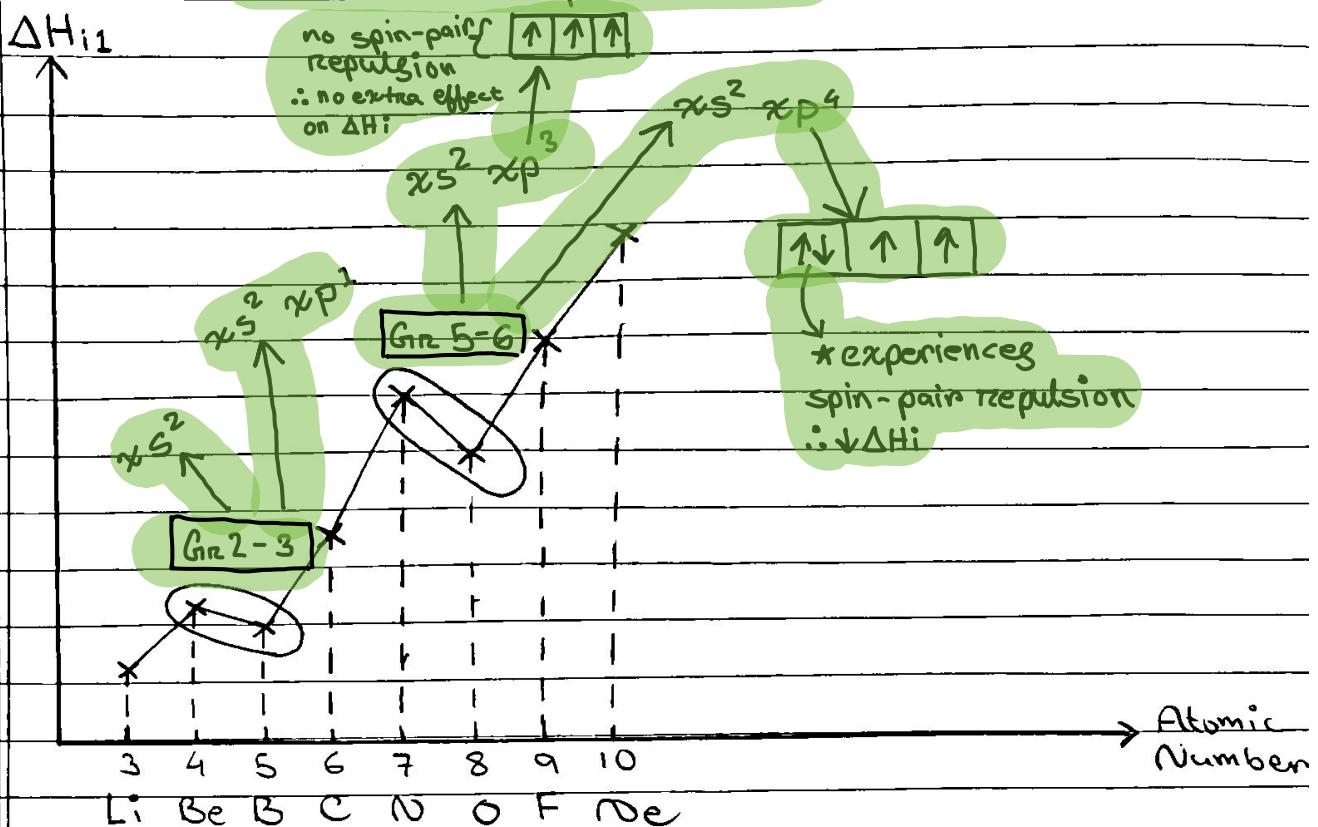
Q) Explain the trend in ΔH_i across the period (4)

Across the period ΔH_i increases due to increase in nuclear charge and decrease in atomic radius resulting in an increase in the nuclear attractive force. However however shielding effect remains almost constant of shell number remains constant.

Q) Explain the trend in ΔH_i down the Group (4)

Down the group ΔH_i decreases, due to increase in atomic radius and shielding effect resulting in a decrease in nuclear attractive force which overcomes the effect of increase in nuclear charge.

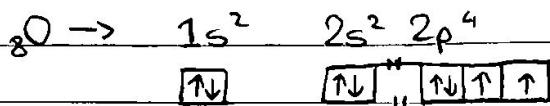
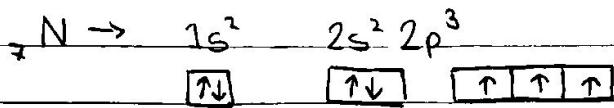
ΔH_i across period 2



Q) Explain the variation in ionization energy between Be and B.
 C) # e⁻ in 2p subshell experiences greater shielding effect → ms
 The e⁻ that is to be removed from Be belongs to a 2s subshell whereas for B it belongs to a 2p subshell. 2s subshell is closer to the nucleus than the 2p subshell. Thus the e⁻ in 2s subshell experiences greater nuclear attractive force.

The shielding effect experienced by the e⁻ in the 2p-subshell is also slightly greater than those in the 2s-subshell. The e⁻ in the 2p-subshell are also further away from the nucleus than those in the 2s-subshell. Both of these factors reduce effective

nuclear attractive force and overcome the effect of an increase in nuclear charge.



Q. Explain the variation in ΔH_i between N and O

Ans. The e⁻ that is removed from O belongs to a fully filled orbital whereas for N, it belongs to a singly filled orbital. Electrons in fully filled orbitals experience [greater] spin-pair repulsion and they can be removed easily.

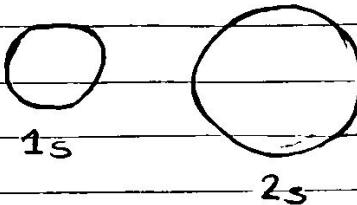
* Dragic change in ΔH_i in graph means change from group 8 to group 1: (period change)

* Group 8 has highest ΔH_i (across the period) but period change means down the group ΔH_i decreases.

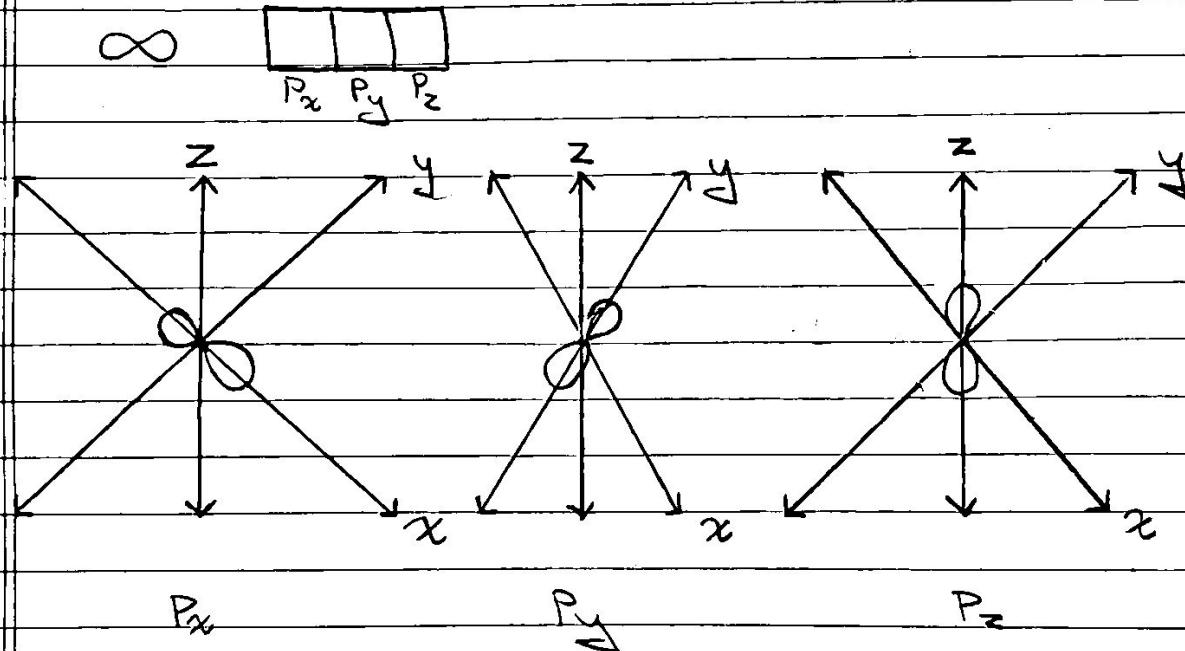
* From Li to Be, the decrease in effective nuclear attractive force due to spin-pair repulsion cannot overcome the increase in effective nuclear attractive force due to increase in proton number and decrease in atomic radius. This is because the e⁻ are in a s-subshell. If the outer e⁻ were in a p-subshell like in N and O, then the decrease in nuclear attractive force due to spin-pair repulsion could overcome the increase in nuclear attractive force. This is because the p-subshell is further away from the nucleus than its corresponding s-subshell.

Shape of Orbitals

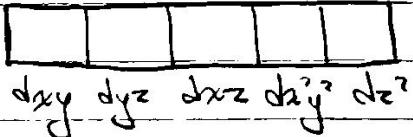
- s-orbital: It has a spherical shape



- p-orbital: It has a dumbbell shape

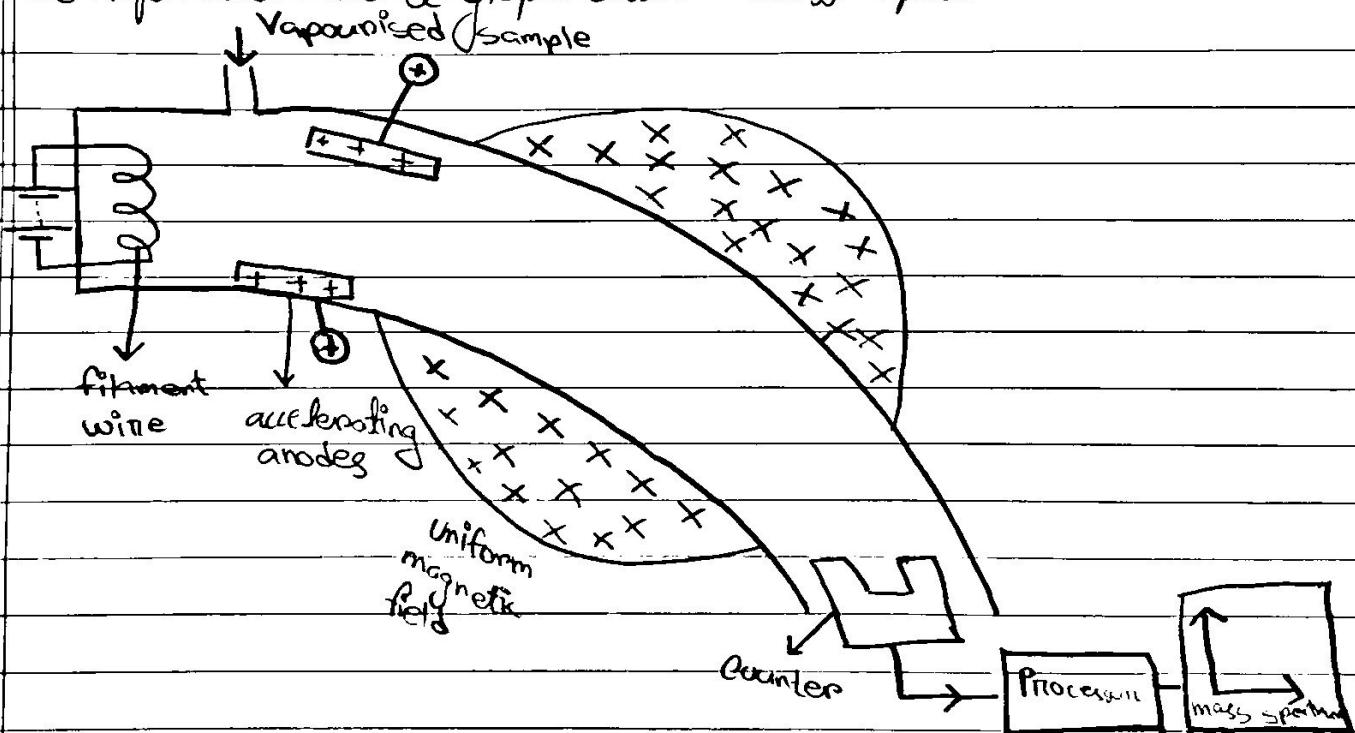


- d-orbital

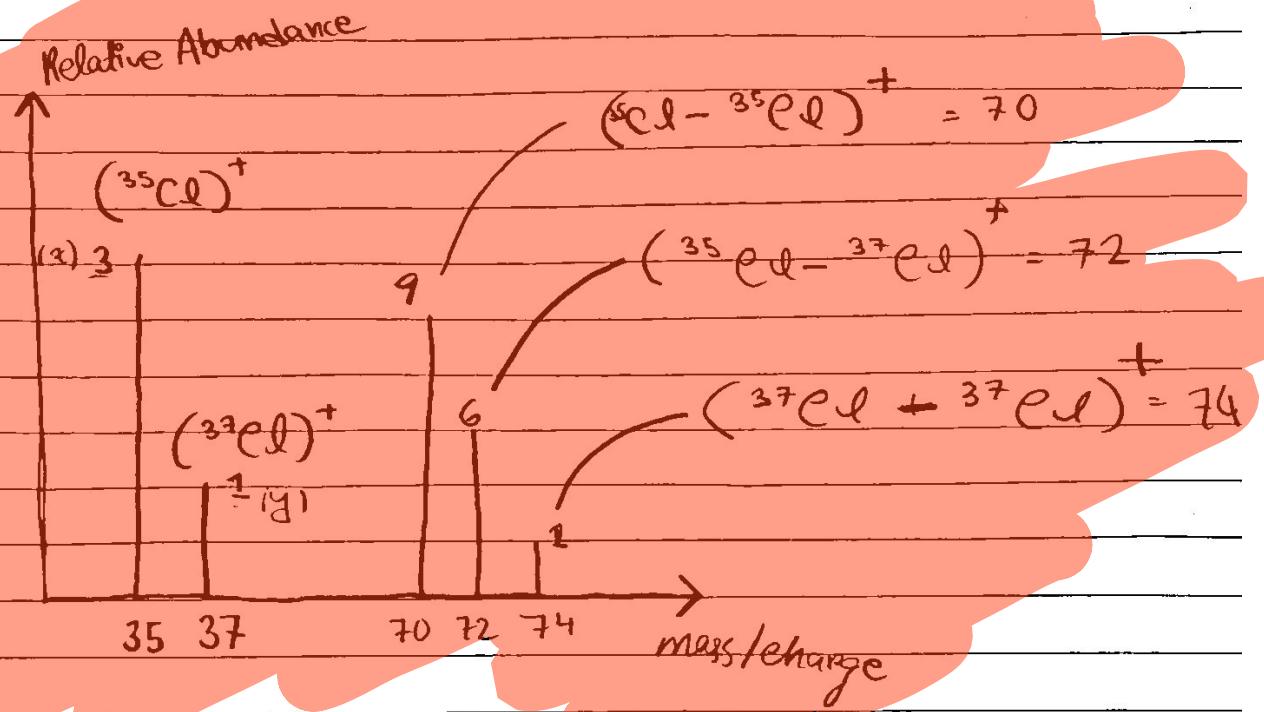


Mass Spectrometry

Mass spectrometer is a device which is used to measure the isotopic abundance of the atoms in an element. Initially a vapourised sample is inserted into the device. A 6V dc power supply is connected to a filament wire. When the power supply is switched on, due to thermionic emission, electrons are emitted from the wire. These electrons bombard the vapourised sample causing them to lose electrons. Thus uni-positive charged ions are formed. Later on they are accelerated by positive anodes towards a uniform magnetic field. The different isotopes deflect at different angles, and are collected by a counter. The counter transmits the information to a processor, and the processor generates the information into a graph called 'mass spectrum'.



Cl



~~$(3x+y)^2$~~

$$= 9x^2 + 6xy + y^2$$

Define Relative Atomic Mass

/ Relative Isotopic Mass

→ It is the average / weighted mass of an atom on a scale where Carbon-12 atom weighs exactly 12 units.

Define Relative formula Mass

→ The average / weighted mass of a formula unit on a scale on a scale where Carbon-12 atom weighs exactly 12 units.

· unified atomic mass unit : one twelfth of the mass of a carbon-12 atom

The Periodic Table of Elements

		Group																
1	2											13	14	15	16	17	18	
		Key atomic number atomic symbol <small>name relative atomic mass</small>																
3 Li lithium 6.9	4 Be beryllium 9.0	21 Sc scandium 45.0	22 Ti titanium 47.9	23 V vanadium 50.9	24 Cr chromium 52.0	25 Mn manganese 54.9	26 Fe iron 55.8	27 Co cobalt 58.9	28 Ni nickel 58.7	29 Cu copper 63.5	30 Zn zinc 65.4	31 Ga gallium 69.7	32 Ge germanium 72.6	33 As arsenic 74.9	34 Se selenium 79.0	35 Br bromine 79.9	36 Kr krypton 83.8	
11 Na sodium 23.0	12 Mg magnesium 24.3	3 K potassium 39.1	20 Ca calcium 40.1	38 Sr strontium 87.6	39 Y yttrium 88.9	40 Zr zirconium 91.2	41 Nb niobium 92.9	42 Mo molybdenum 95.9	43 Tc technetium —	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd palladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6
55 Cs caesium 132.9	56 Ba barium 137.3	57–71 lanthanoids —	72 Hf hafnium 178.5	73 Ta tantalum 180.9	74 W tungsten 183.8	75 Re rhenium 186.2	76 Os osmium 190.2	77 Ir iridium 192.2	78 Pt platinum 195.1	79 Au gold 197.0	80 Hg mercury 200.6	81 Tl thallium 204.4	82 Pb lead 207.2	83 Bi bismuth 209.0	84 Po polonium —	85 At astatine —	86 Rn radon —	
87 Fr francium —	88 Ra radium —	89–103 actinoids —	104 Rf rutherfordium —	105 Db dubnium —	106 Sg seaborgium —	107 Bh bohrium —	108 Hs hassium —	109 Mt meitnerium —	110 Ds darmstadtium —	111 Rg roentgenium —	112 Cn copernicium —	113 Nh nihonium —	114 Fl flerovium —	115 Mc moscovium —	116 Lv livermorium —	117 Ts tennessine —	118 Og oganesson —	

lanthanoids

57 La lanthanum 138.9	58 Ce cerium 140.1	59 Pr praseodymium 140.9	60 Nd neodymium 144.4	61 Pm promethium —	62 Sm samarium 150.4	63 Eu europium 152.0	64 Gd gadolinium 157.3	65 Tb terbium 158.9	66 Dy dysprosium 162.5	67 Ho holmium 164.9	68 Er erbium 167.3	69 Tm thulium 168.9	70 Yb ytterbium 173.1	71 Lu lutetium 175.0
89 Ac actinium —	90 Th thorium 232.0	91 Pa protactinium 231.0	92 U uranium 238.0	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 —

Misc. Notes

Which ions contain one or more unpaired electrons?

- 1 Cu^{2+}
- 2 Mn^{3+}
- 3 V^{3+}

Paper 1 Variant 1 Winter 2018 | Q31

Answer:

A

Once the $4s$ subshell is filled and $3d$ subshell starts (NOT finished) to be filled, the energy level of $4s$ goes above $3d$. \hookrightarrow True, when e^- are removed, they are first removed from $4s$ and then from $3d$ and so on.

Suggest why this different sample of gold has the same chemical properties as the sample found in the earth
same number of electrons/electronic structure -ms

Oxygen has three stable isotopes, ^{16}O , ^{17}O and ^{18}O . All three isotopes are present in a sample of oxygen gas, O_2 , which was analysed using a mass spectrometer.

How many peaks associated with the O_2^+ ion would be expected?

- A 3
- B 5
- C 6
- D 9

Paper 1 Variant 2 Summer 2019 | Q2

Answer:

B

157	a a
	a b
	a c
	b b
	b c
	c c

1 tonne contains 1000kg.

The first ionisation energies of elements in the first row of the d block (21Sc to 29Cu) are very similar. For all these elements, it is a $4s$ electron that is lost during the first ionisation.

Suggest why the first ionisation energies of these elements are very similar.

- nuclear charge increases
- extra electron(s) in inner shell / $n=3$ / d-subshell / d- orbital
- increased shielding (of $4s$ electrons by electrons in $n=3$ / 3rd shell / 3d)
- (overall) similar nuclear attraction (for outer electron)



There is NO such arrangement where there is $3d^4$ or $3d^9$

Halfly or fully filled d-subshell more stable than partially filled d-subshell. Thus in, these e^- transferred from $4s^2$ to $3d^4$ or $3d^5$ making $3d^5$ or $3d^1$.

* 10 In which pair does each species have the same number of unpaired electrons?

- A Al and Cu^{2+}
- B Ca and Cr^{3+}
- C Ca and Ni^{2+}
- D Fe^{3+} and O^{2-}

e^- are removed from the $4s$ subshell before the $3d$ subshell

1 Which statement is correct?

- A Cl has a relative isotopic mass of $35.5 \times Cl = 35 Cl = 37$
- B Cl_2 has a relative molecular mass of $70 \times Cl = 35.5 \times 2 = 71$
- C ICl has a relative molecular mass of $162.4 \times I = 126.9 + Cl = 35.5 \Rightarrow 162.4$
- D $NaCl$ has a relative molecular mass of $58.5 \times$ Formula mass = 58.5

Isotopes have the same chemical properties because they have the same electronic structure // same no. of e^- .

For writing any points similar to trend in electronegativity, we must always mention: x outweighs the effect of increase in y : x remaining almost constant whenever these are applicable