

Reading Hospital
School of Health Sciences
Medical Imaging Program

MI 132 – Principles of Imaging and Equipment 2022-2023

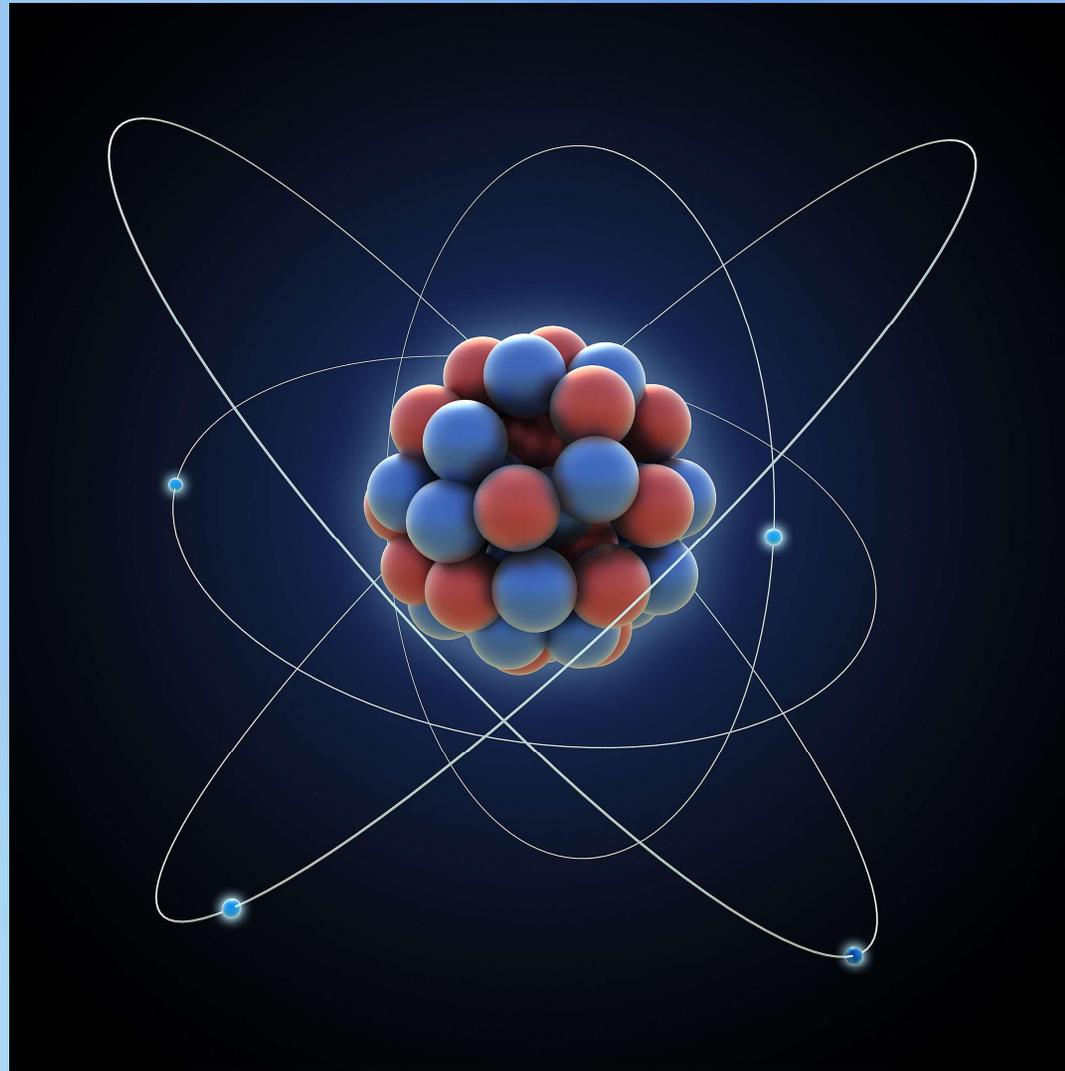
Unit 1

Structure of the Atom and Electromagnetic Radiation

Learning Objectives

1. Compare the fundamental particles of atoms.
2. Define and differentiate atomic number and atomic mass number.
3. Describe the structure of the atom, its nucleus and electron shells, along with associated binding energy and the significance in Radiology.
4. Explain the process of ionization and its importance to Radiology.

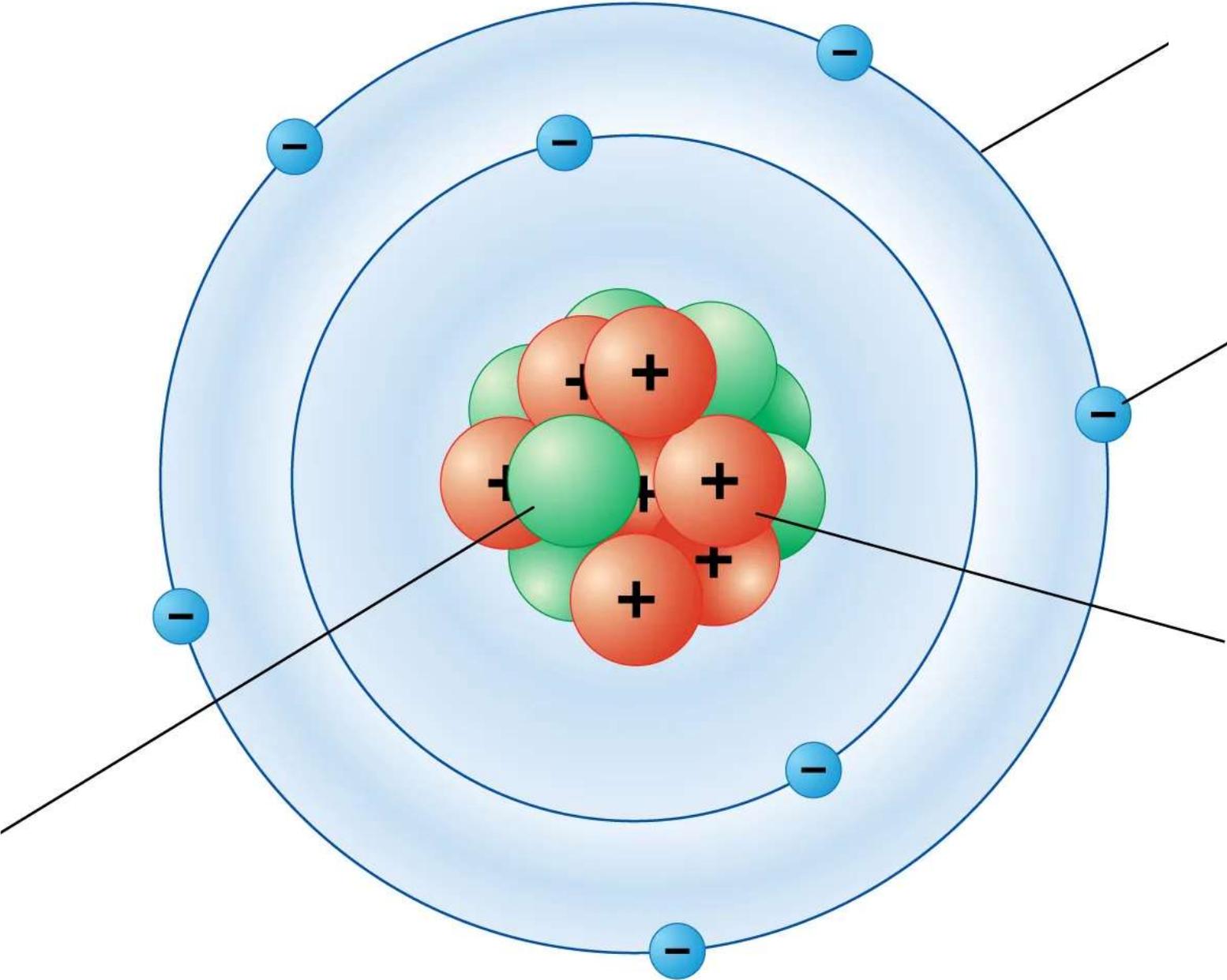
Why study the atom??



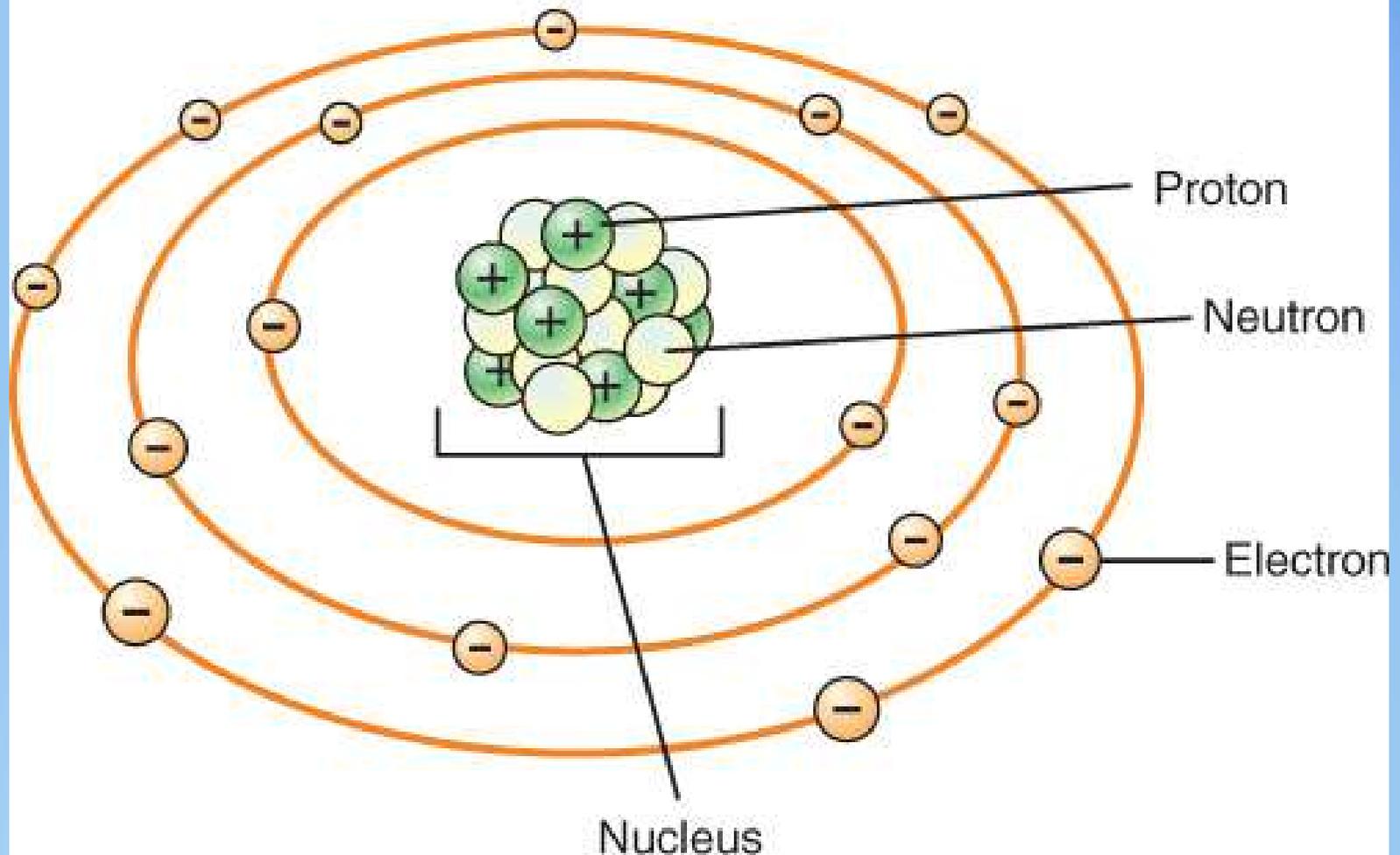
#1 - Which model of the atom is most accepted today?

- Get into groups of 2 and draw a picture of this model
- Describe this model to each other including:
 - Fundamental particles
 - Associated charges
 - Location of the particles
 - Associated weights

Bohr atomic model of a nitrogen atom



Structure of atom



Fundamental Particles (Cont.)

	Electrical Charge	Mass
Proton	Positive	1.673×10^{-27} kg
Neutron	Neutral	1.675×10^{-27} kg
Electron	Negative	9.109×10^{-31} kg

Which of the following is considered a nucleon?

- ★ A. Proton
- B. Electron
- C. Alpha particle
- D. Beta particle



In a neutral atom, the number of _____ and _____ are equal.

- ★ A. Protons; electrons
- B. Neutrons; protons
- C. Neutrons; electrons
- D. None of the above



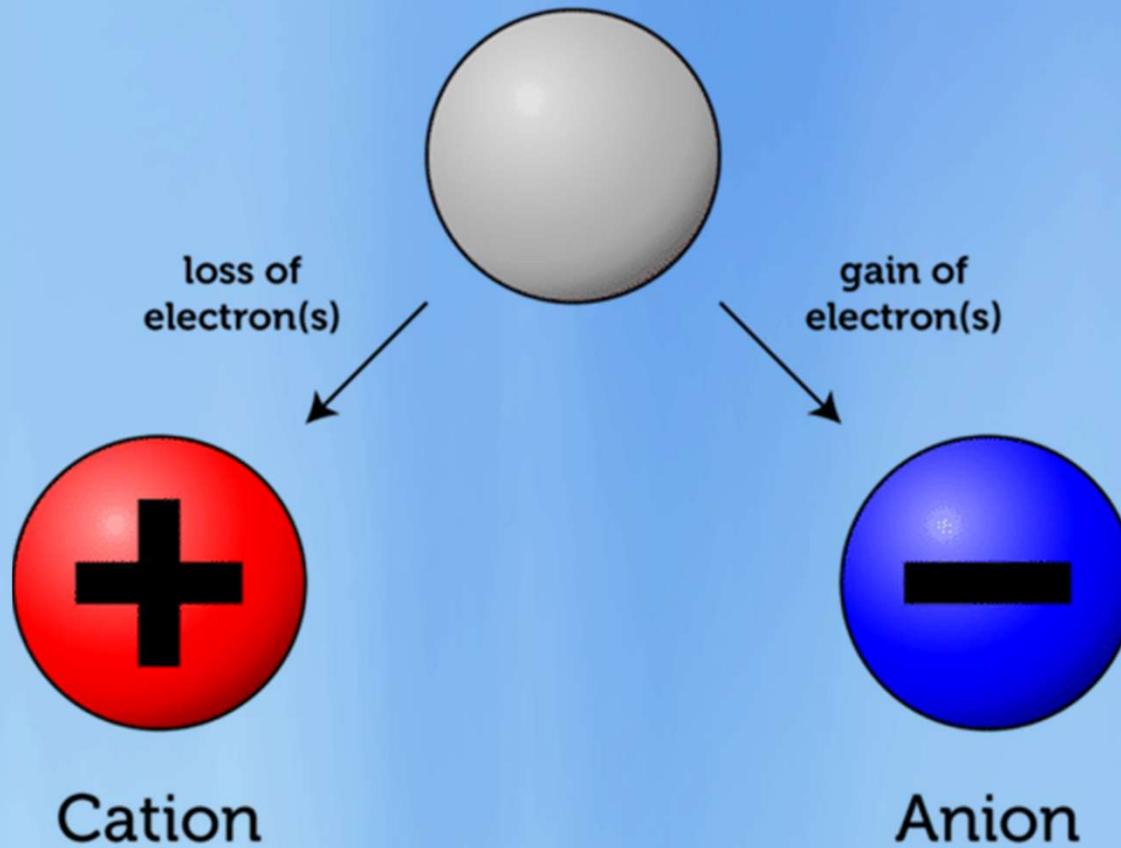
#3 - Explain the process of ionization.

gaining or removing electrons from an atom

cation - + - loses electron

anion - '-' - gain electron

Neutral atom



#4 - Differentiate between atomic number and atomic mass number.

- Atomic number:

number of protons
elements are arranged in order of increasing atomic number
distinguish the element
Z number

- Atomic mass number:

number of protons and neutrons (nucleons)
A number

 $A - Z = \text{neutrons}$

**Calculate how many neutrons
an atom has, if it has a Z
number of 74 and an A number
of 184.**

#5 - Identify the format used for chemical shorthand? Identify what each component designates.

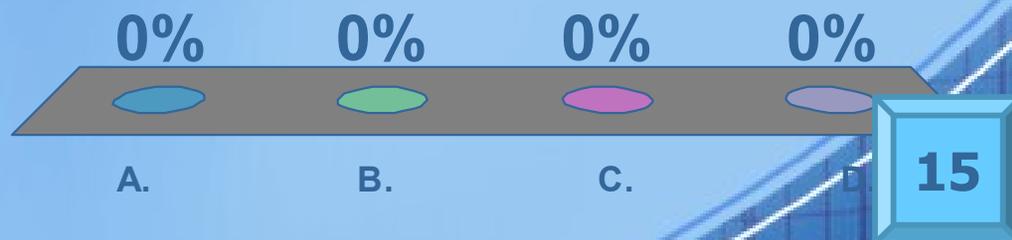
How many protons does $^{131}_{53}\text{I}$ have?

- A. 131
- ★ B. 53
- C. 78
- D. 184



How many nucleons are in ${}_{19}^{39}\text{K}$?

- ★ A. 39
- B. 19
- C. 20
- D. 58



#6 - Explain electron shells and how electrons exist within the electron shells, including how to calculate the maximum number of electrons that can exist within each shell.

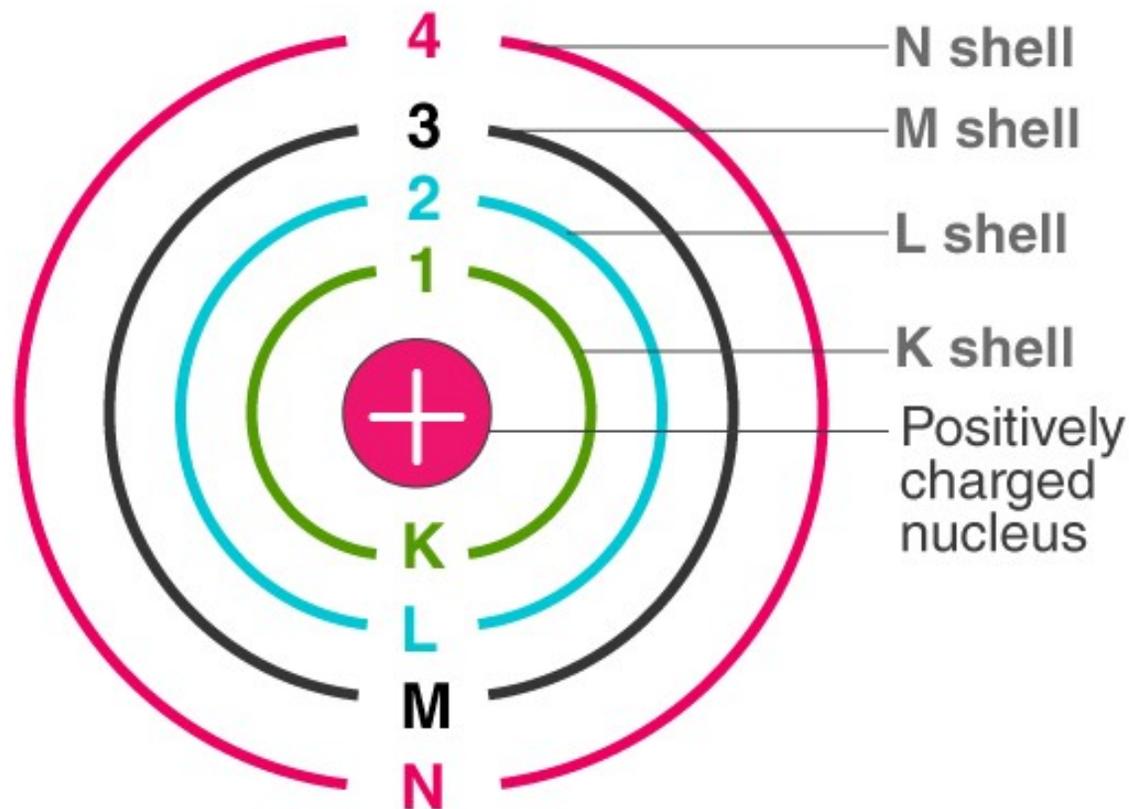
#7 - Explain the factors that affect electron binding energy and what influence electron binding energy has on x-ray production.

- Get into groups of 2
- Draw atom with shells K through P identified
- Calculate the maximum number of electrons that can exist in each shell from K through P
- Identify which shell has the highest electron binding energy

Electron Shells and Electron Binding Energy

BOHR'S MODEL OF AN ATOM

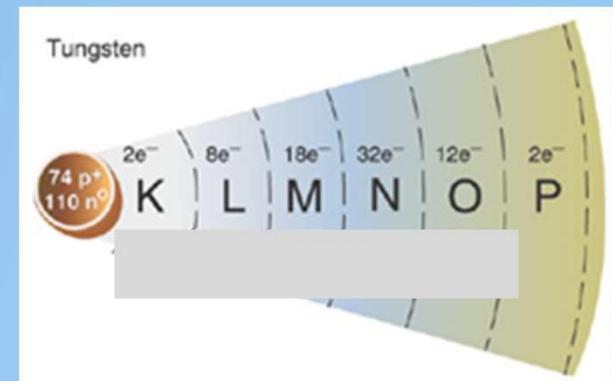
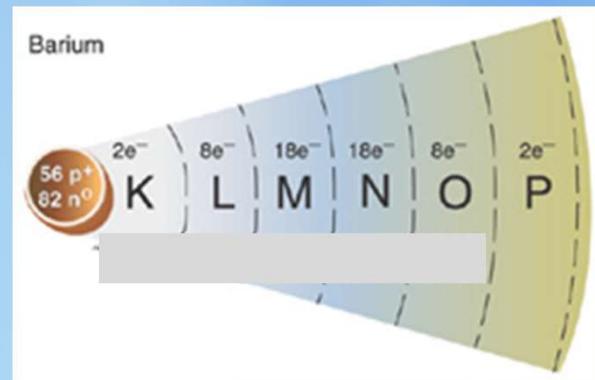
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Electron Shells and Electron Binding Energy

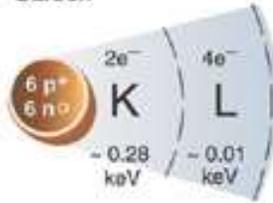
- Identify which has the highest K-shell binding energy



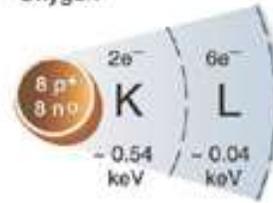
Hydrogen



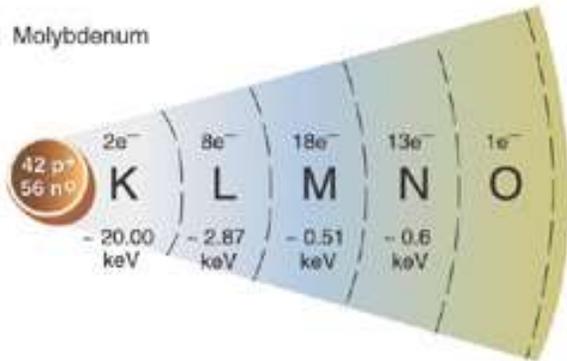
Carbon



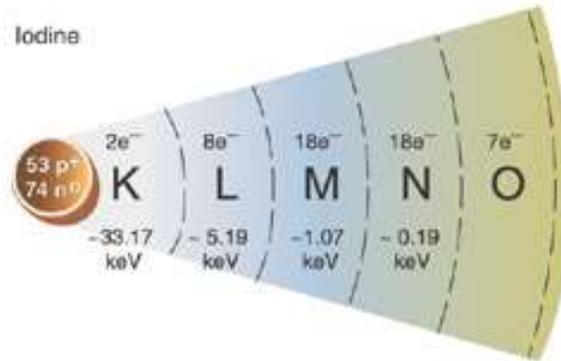
Oxygen



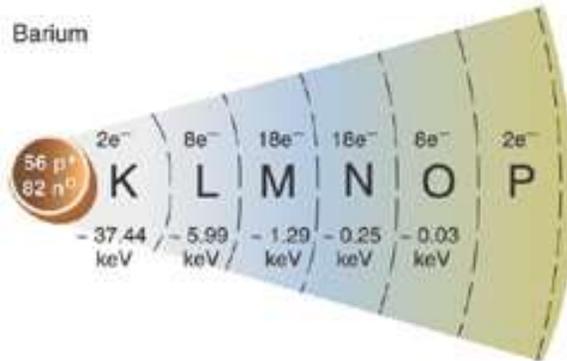
Molybdenum



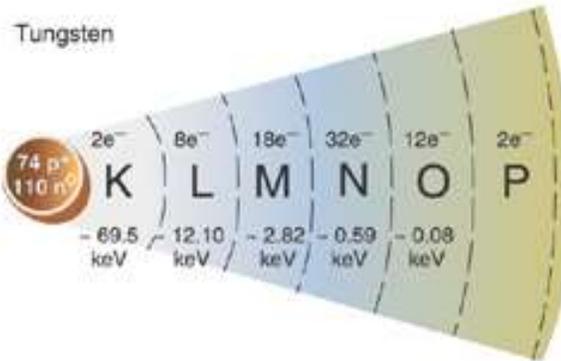
Iodine



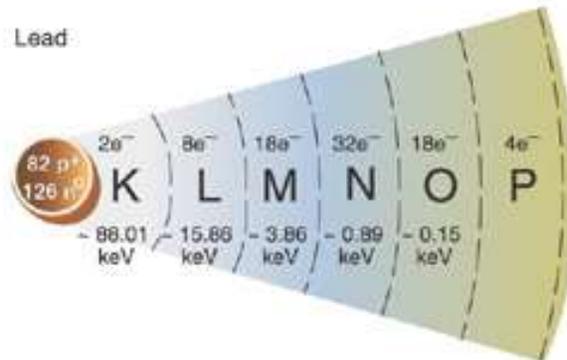
Barium



Tungsten

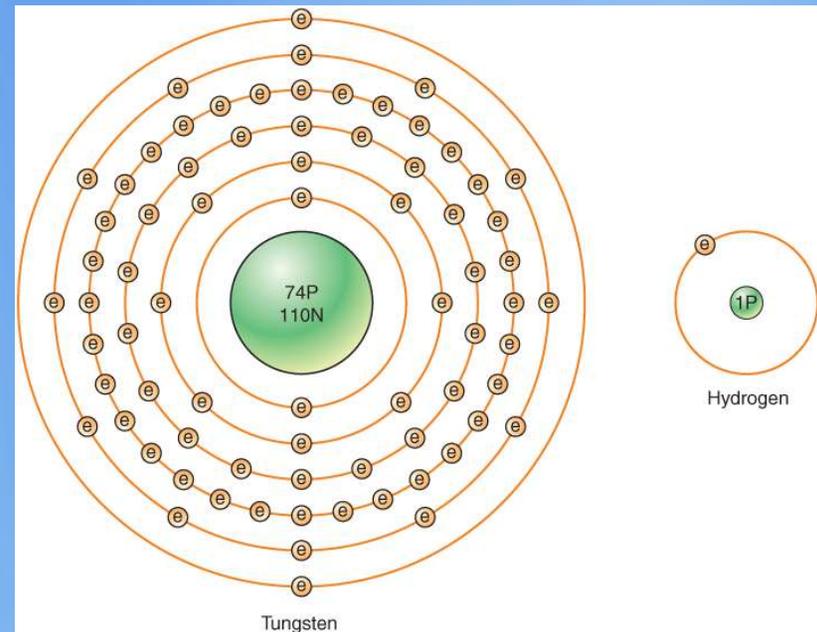


Lead



Interactions

- Atoms represent “targets” for interaction.
- The more complex the atom, the greater the opportunity for interaction.



Electron binding energy is affected by:

- A. The electron to nucleus distance
- B. The number of protons in an atom
- C. The energy of the x-ray
- ★ D. Both A and B



What is the maximum number of electrons permitted in the M-shell?

- A. 8
- ★ B. 18
- C. 32
- D. 50



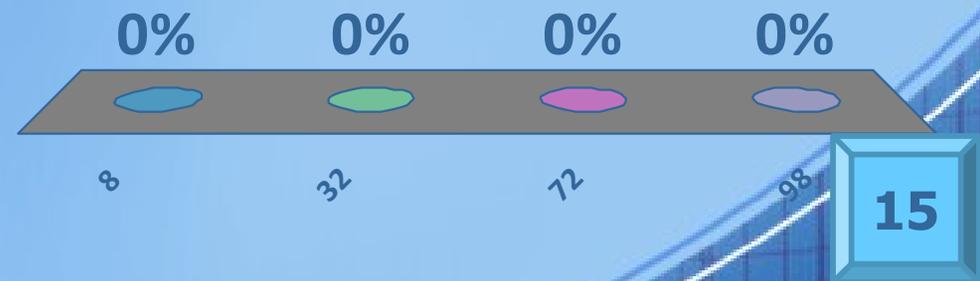
What is the maximum number of electrons permitted in the P-shell?

A. 8

B. 32

★ C. 72

D. 98



#8 - Compare and contrast the periods and groups on the periodic table of elements.

Key:																			
element name atomic number Symbol atomic weight (mean relative mass)																			
hydrogen 1 H 1.0079															helium 2 He 4.0026				
lithium 3 Li 6.941	beryllium 4 Be 9.0122													boron 5 B 10.811	carbon 6 C 12.011	nitrogen 7 N 14.007	oxygen 8 O 15.999	fluorine 9 F 18.998	neon 10 Ne 20.180
sodium 11 Na 22.990	magnesium 12 Mg 24.305													aluminum 13 Al 26.982	silicon 14 Si 28.085	phosphorus 15 P 30.974	sulfur 16 S 32.065	chlorine 17 Cl 35.453	argon 18 Ar 39.948
potassium 19 K 39.098	calcium 20 Ca 40.078	scandium 21 Sc 44.956	titanium 22 Ti 47.867	vanadium 23 V 50.942	chromium 24 Cr 51.996	manganese 25 Mn 54.938	iron 26 Fe 55.845	cobalt 27 Co 58.933	nickel 28 Ni 58.693	copper 29 Cu 63.546	zinc 30 Zn 65.39	gallium 31 Ga 69.723	germanium 32 Ge 72.61	arsenic 33 As 74.922	selenium 34 Se 78.96	bromine 35 Br 79.904	krypton 36 Kr 83.80		
rubidium 37 Rb 85.468	strontium 38 Sr 87.62	yttrium 39 Y 88.906	zirconium 40 Zr 91.224	niobium 41 Nb 92.906	molybdenum 42 Mo 95.94	technetium 43 Tc (98)	ruthenium 44 Ru 101.07	rhodium 45 Rh 102.91	palladium 46 Pd 106.42	silver 47 Ag 107.87	cadmium 48 Cd 112.41	indium 49 In 114.82	tin 50 Sn 118.71	antimony 51 Sb 121.76	tellurium 52 Te 127.60	iodine 53 I 126.90	xenon 54 Xe 131.29		
caesium 55 Cs 132.905	barium 56 Ba 137.327	57-70 ★	lutetium 71 Lu 174.97	hafnium 72 Hf 178.49	tantalum 73 Ta 180.95	tungsten 74 W 183.84	rhenium 75 Re 186.21	osmium 76 Os 190.23	iridium 77 Ir 192.22	platinum 78 Pt 195.084	gold 79 Au 196.97	mercury 80 Hg 200.59	thallium 81 Tl 204.38	lead 82 Pb 207.2	bismuth 83 Bi 208.98	polonium 84 Po (209)	astatine 85 At (210)	radon 86 Rn (222)	
francium 87 Fr (223)	radium 88 Ra (226)	89-102 ★★	lawrencium 103 Lr (262)	rutherfordium 104 Rf (261)	dubnium 105 Db (262)	seaborgium 106 Sg (266)	bohrium 107 Bh (264)	hassium 108 Hs (269)	meitnerium 109 Mt (276)	ununnilium 110 Uun (271)	unununium 111 Uuu (272)	ununbium 112 Uub (277)	ununquadium 114 Uuq (289)						

*lanthanoids

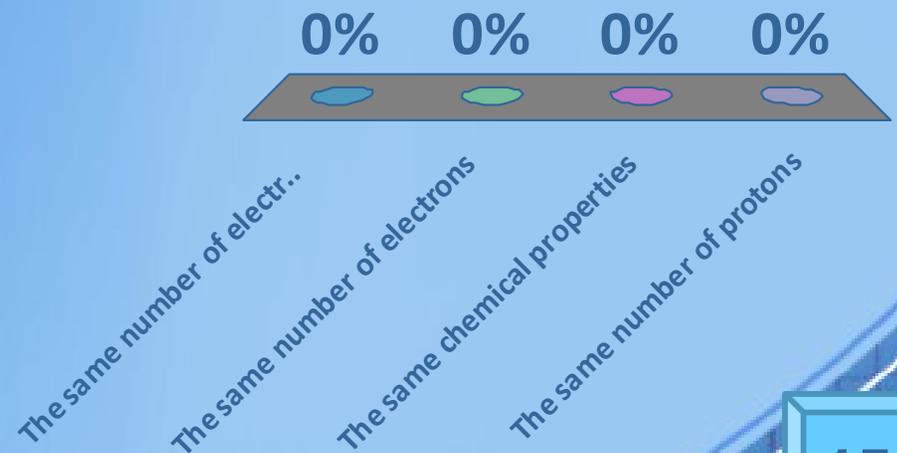
lanthanum 57 La 138.91	cerium 58 Ce 140.116	praseodymium 59 Pr 140.90	neodymium 60 Nd 144.24	promethium 61 Pm (145)	samarium 62 Sm 150.36	europium 63 Eu 151.96	gadolinium 64 Gd 157.26	terbium 65 Tb 158.93	dysprosium 66 Dy 162.50	holmium 67 Ho 164.93	erbium 68 Er 167.26	thulium 69 Tm 168.93	ytterbium 70 Yb 173.04
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**actinoids

actinium 89 Ac (227)	thorium 90 Th 232.04	protactinium 91 Pa 231.04	uranium 92 U 238.03	neptunium 93 Np (237)	plutonium 94 Pu (244)	americium 95 Am (243)	curium 96 Cm (247)	berkelium 97 Bk (247)	californium 98 Cf (251)	einsteinium 99 Es (252)	fermium 100 Fm (257)	mendelevium 101 Md (258)	nobelium 102 No (259)
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The horizontal periods of the periodic table contain elements with:

- ★ A. The same number of electron shells
- B. The same number of electrons
- C. The same chemical properties
- D. The same number of protons



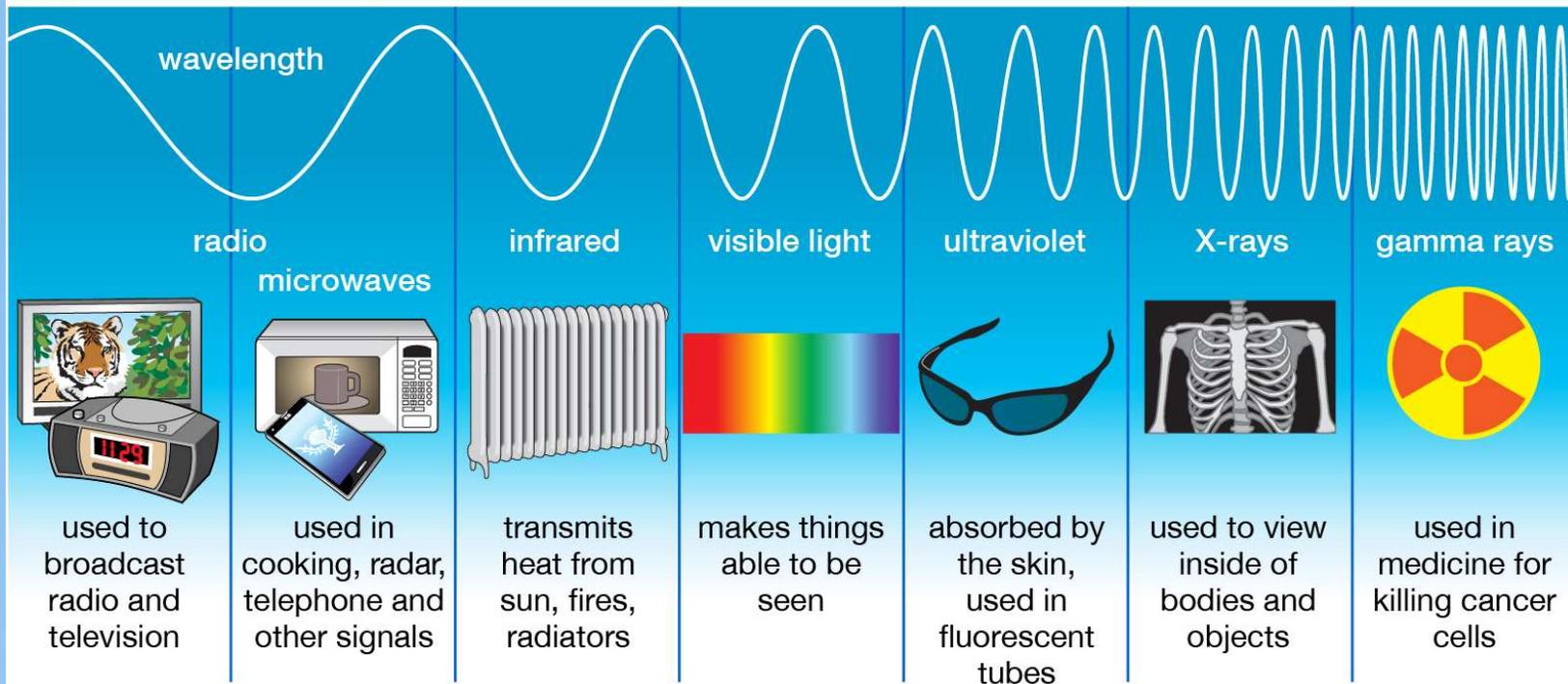
Using periodic table of elements, identify # of electron shells and # of electrons in the outermost shell



Table 4-1			
Elements Radiographers Should Know			
Application	Element	Abbreviation	Atomic (Z) Number
Basic	Hydrogen	H	1
	Helium	He	2
In the body	Carbon	C	6
	Oxygen	O	8
X-ray filter	Aluminum	Al	13
In the body	Calcium	Ca	20
Contrast agent	Iodine	I	53
Contrast Agent	Barium	Ba	56
X-ray tube	Tungsten	W	74
	Rhenium	Re	75
Shielding.	Lead	Pb	82
Radioactive	Uranium	U	92

Part 2 - EMR

Types of Electromagnetic Radiation



Learning Objectives

- List and define the four common characteristics of all waves.
- Describe wavelength and frequency and how they are related to velocity.
- Explain the relationship between energy, wavelength and frequency.

Learning Objectives

- Explain the wave particle duality theory.
- Differentiate between radiations along the EM spectrum in reference to energy, frequency and wavelength.
- Differentiate between ionizing and non-ionizing radiation.
- Explain the process of excitation and its importance to Radiology.
- Identify and describe the properties of x-rays.

Why study electromagnetic radiation??

#1 - According to James Maxwell's electromagnetic theory, what three things do all types of electromagnetic radiation have in common?

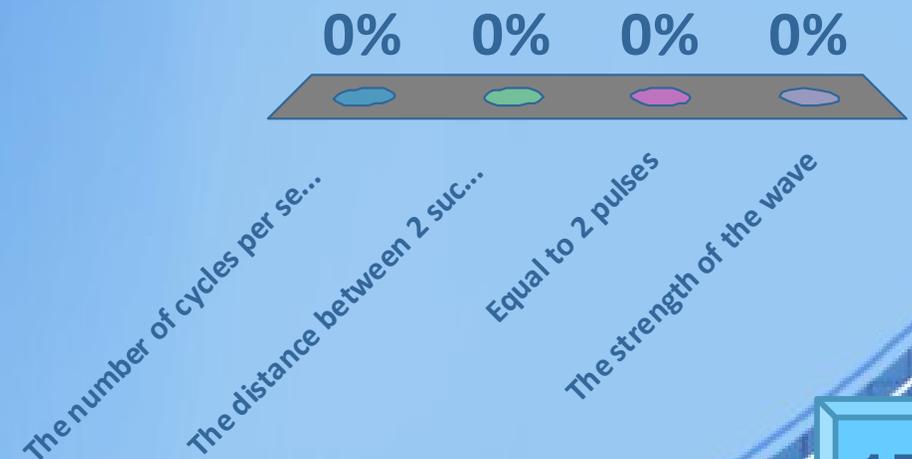
have no mass
carries energy as electrical and mag disturbances
travels at speed of light

Characteristics

#2 - Define and describe the four common characteristics of all waves – wavelength, velocity, amplitude and frequency.

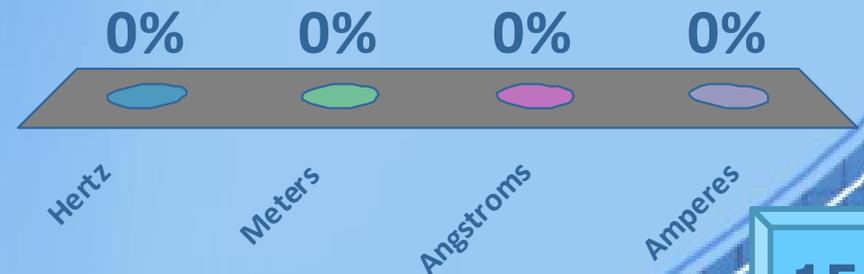
Wavelength is defined as:

- A. The number of cycles per second between 2 points on a wave.
- ★ B. The distance between 2 successive points on a wave
- C. Equal to 2 pulses
- D. The strength of the wave



Unit of measurement for frequency is:

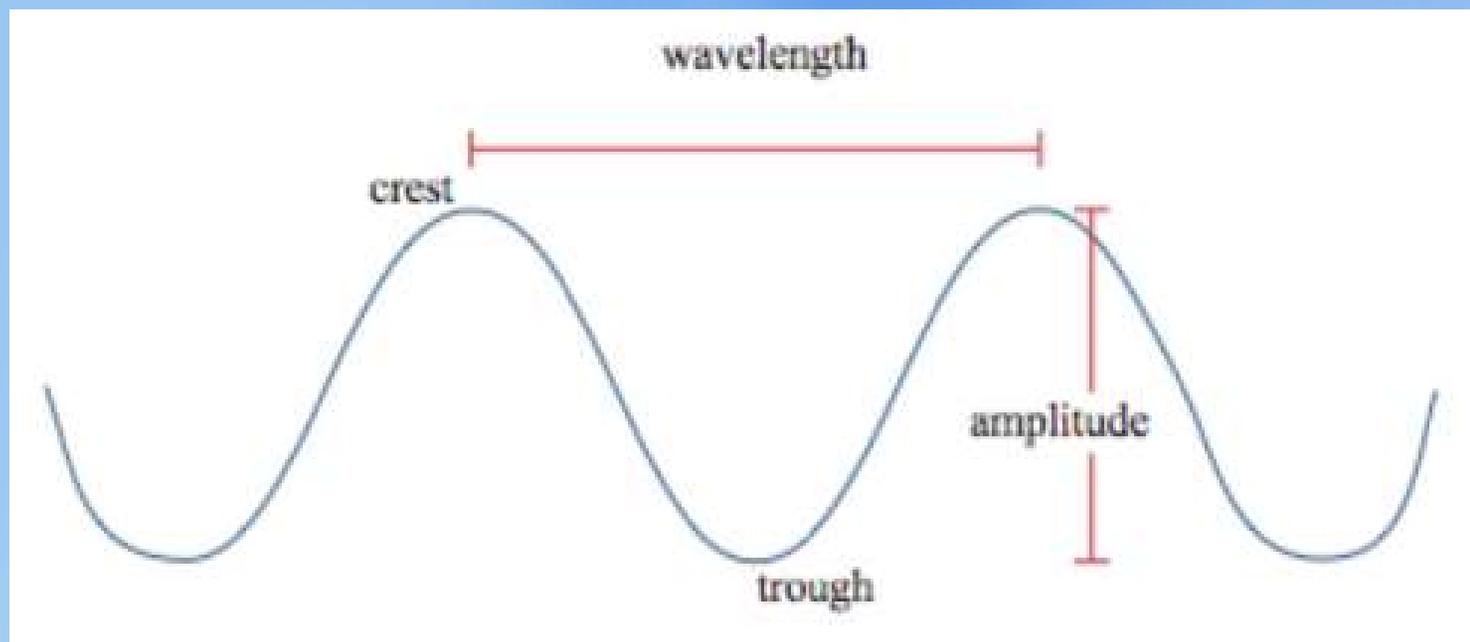
- ★ A. Hertz
- B. Meters
- C. Angstroms
- D. Amperes



Characteristics & Wavelength and Frequency Relationship

Get into groups of 2

1. Draw a wave and label wavelength, amplitude and frequency
2. Draw 2 waves with differing frequencies – one with low frequency, one with high frequency
 - Identify what happens to the wavelength between these 2 drawings

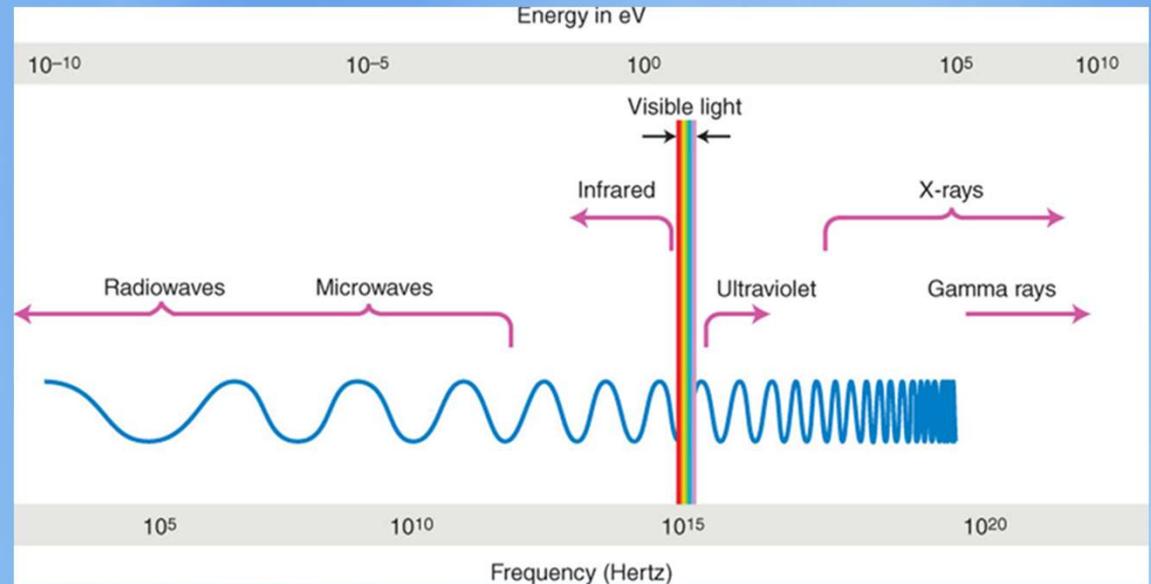
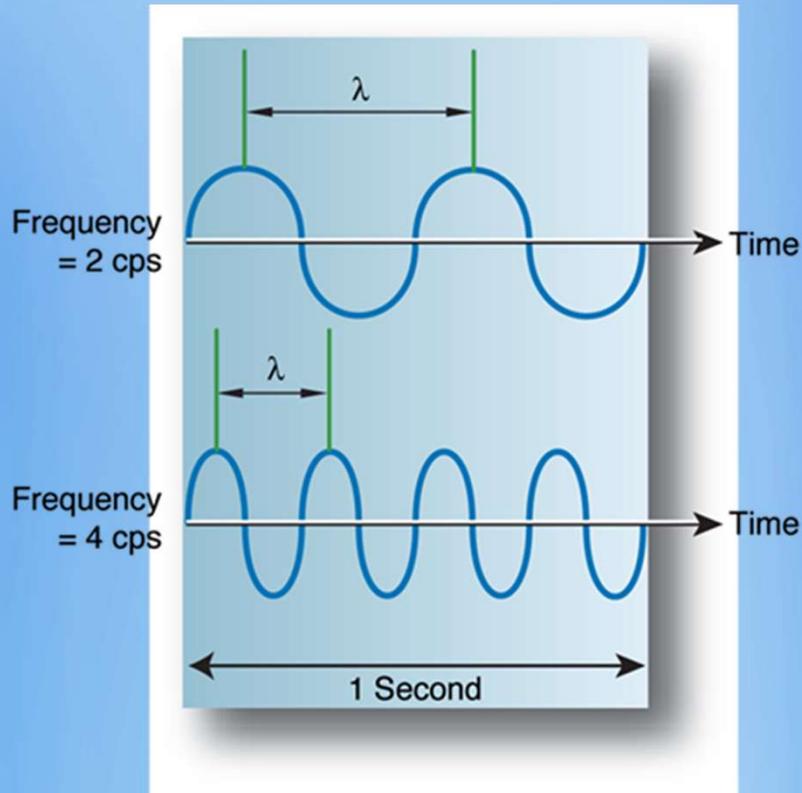


As the frequency of EMR decreases, wavelength will:

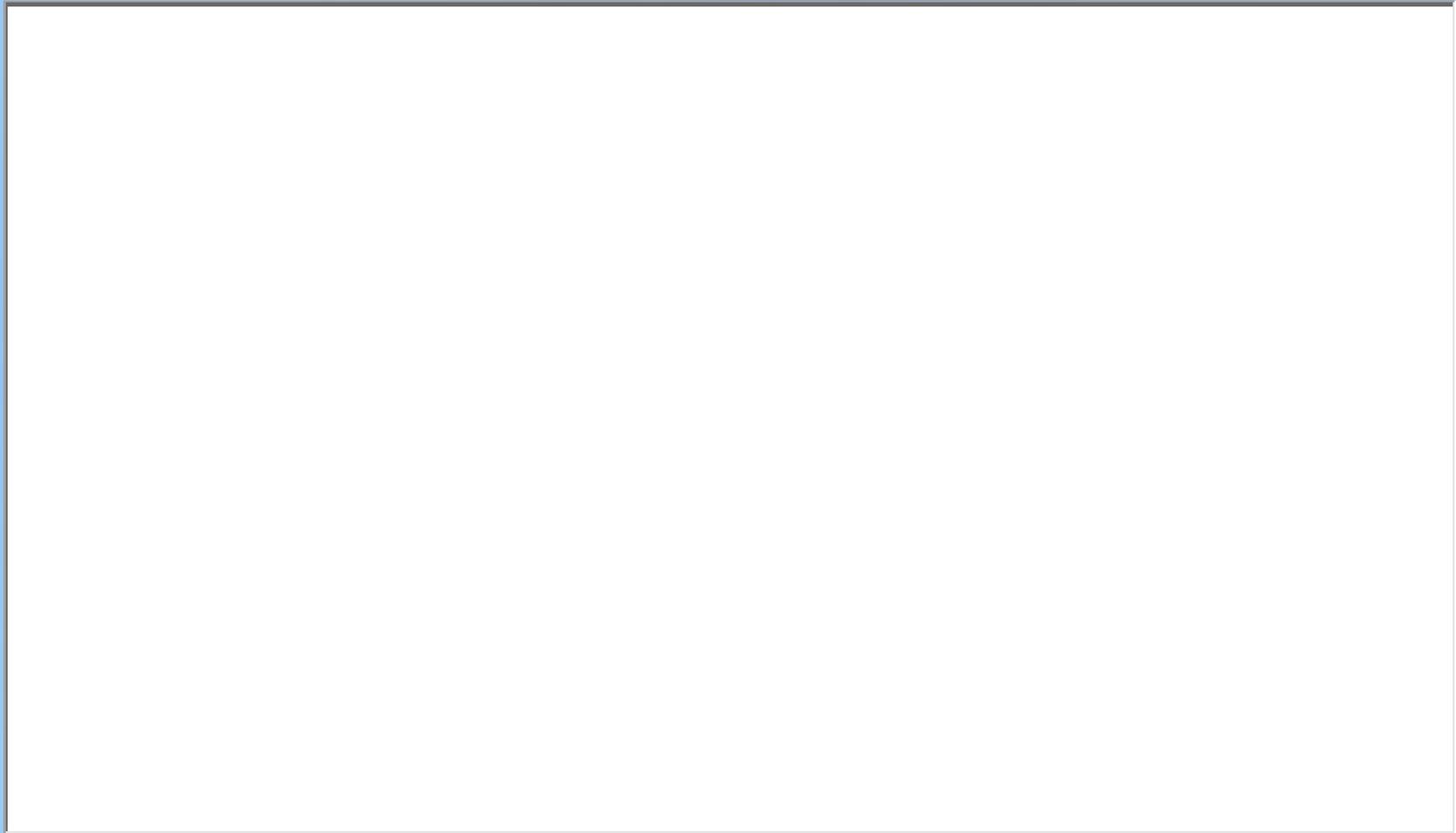
- ★ A. Increase
- B. Decrease
- C. Remain the same
- D. Frequency and wavelength are unrelated



#3 - Explain the relationship that exists between wavelength and frequency. What formula is used to describe the relationship between wavelength and frequency?

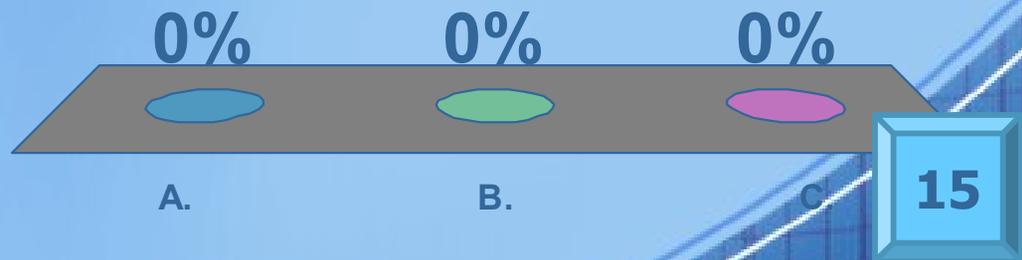


Wave Formula ??



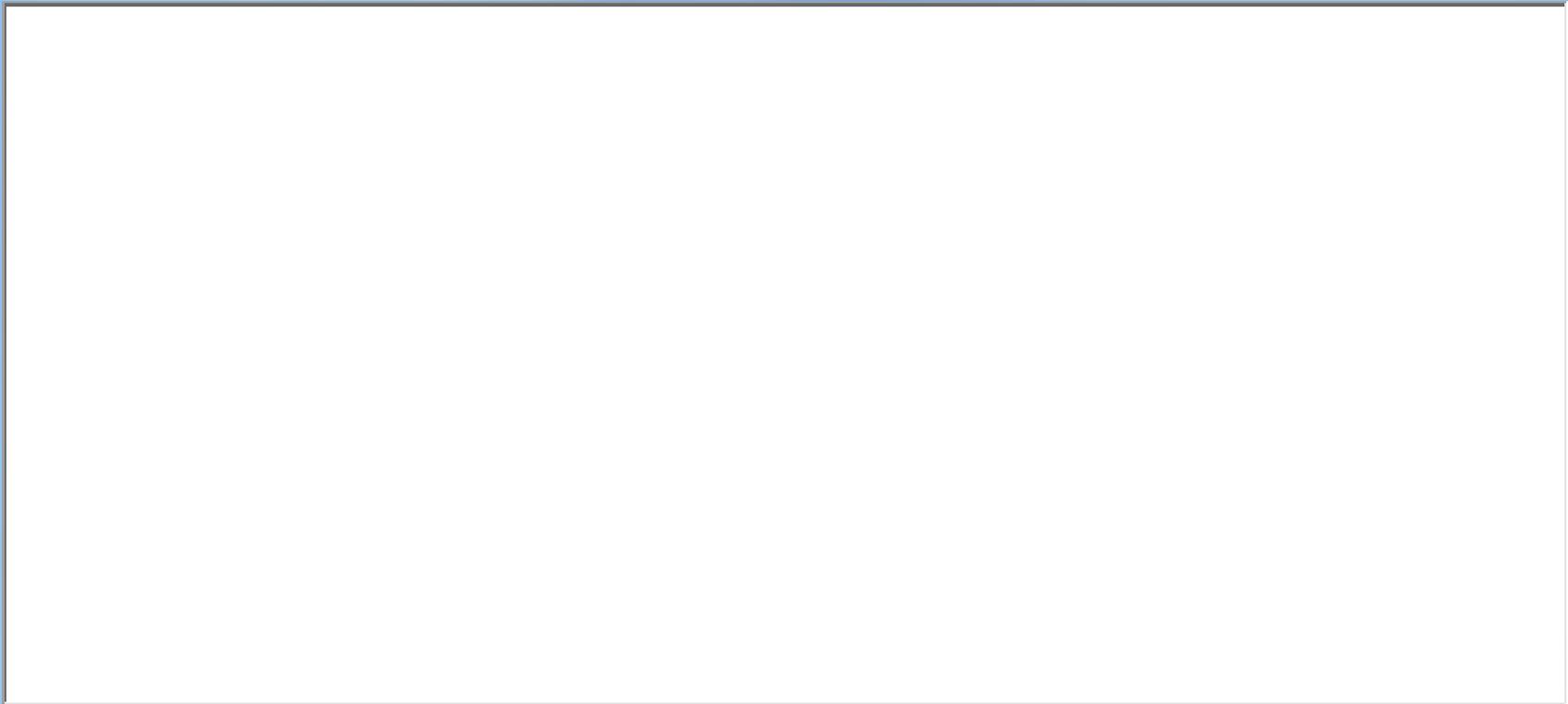
How are energy and frequency related?

- ★ A. They are directly proportional.
- B. They are inversely proportional.
- C. They are not related.



Frequency and Energy Relationship

#4 - What formula is used to describe the relationship between frequency and energy? What type of relationship exists between frequency and energy?



Electromagnetic Spectrum

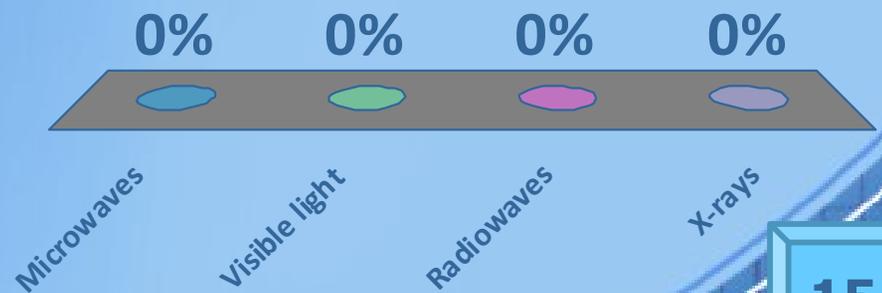
#5 - List the members of the electromagnetic spectrum in order of lowest to highest energy.

#6 - Identify the portions of the electromagnetic spectrum that can ionize matter. Why?

- Get into groups of 2
- List members of EMR spectrum from lowest to highest frequency.
- List members of EMR spectrum for shortest to longest wavelength.
- Discuss which members are ionizing and which are not

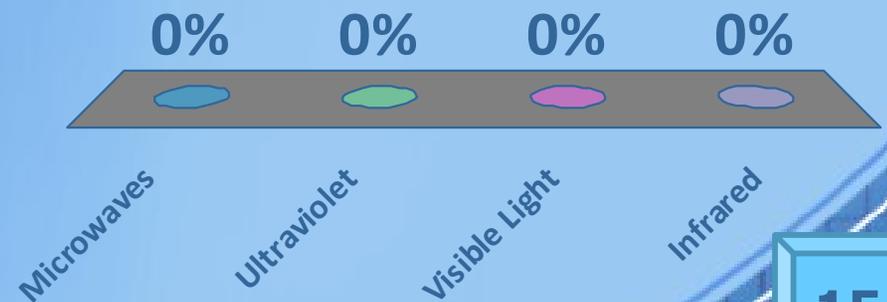
Which member of the EM spectrum has the longest wavelength?

- A. Microwaves
- B. Visible light
- ★ C. Radiowaves
- D. X-rays



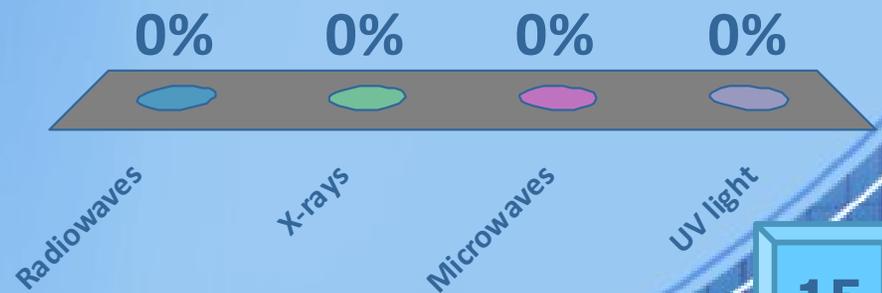
Which member of the EM spectrum below has the highest frequency?

- A. Microwaves
- ★ B. Ultraviolet
- C. Visible Light
- D. Infrared



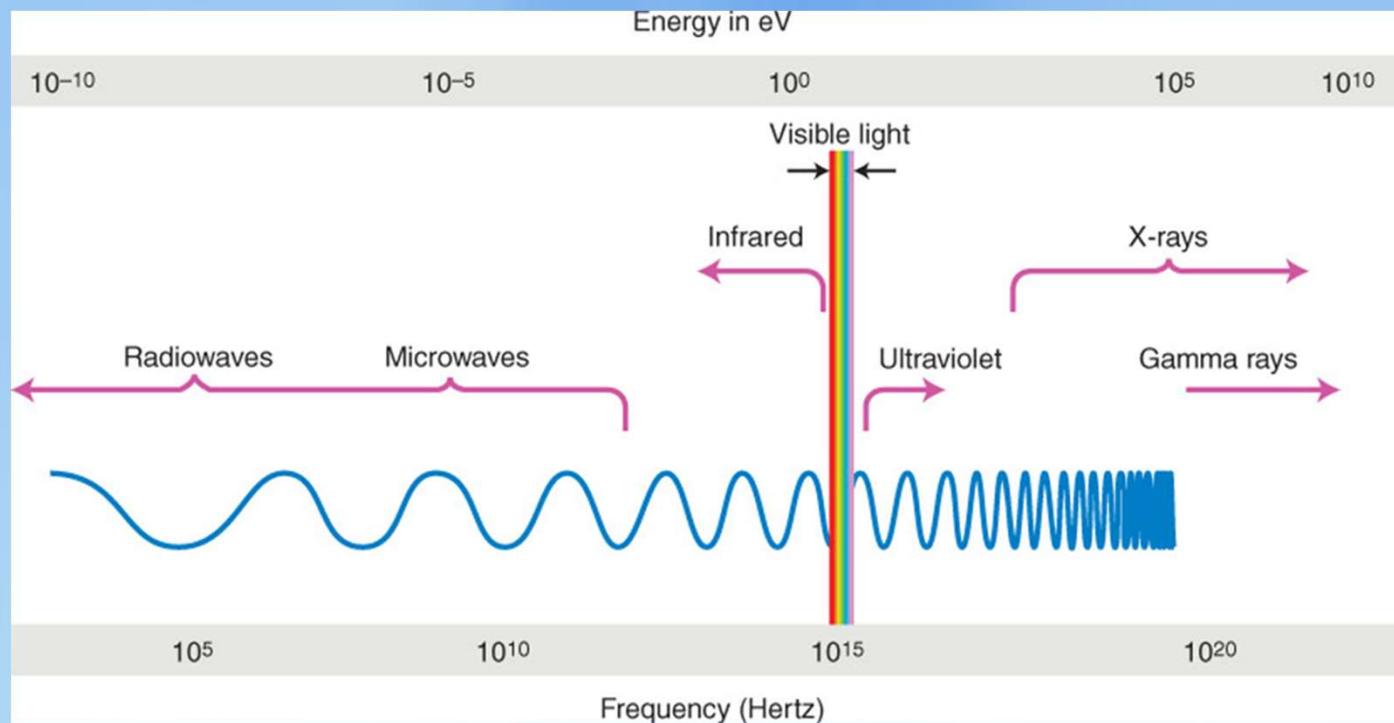
Which of the following has the ability to ionize matter?

- A. Radiowaves
- ★ B. X-rays
- C. Microwaves
- D. UV light

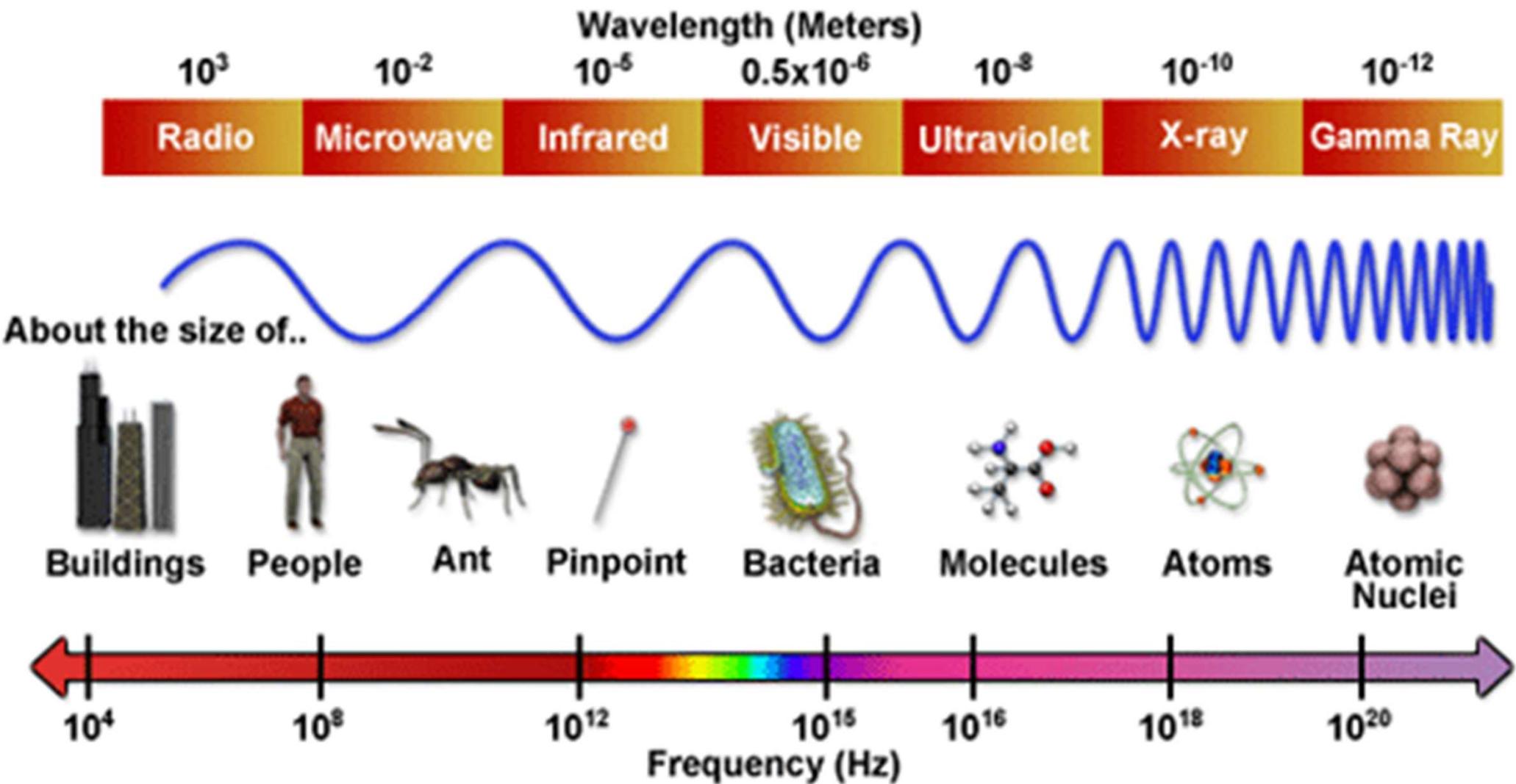


Electromagnetic Spectrum

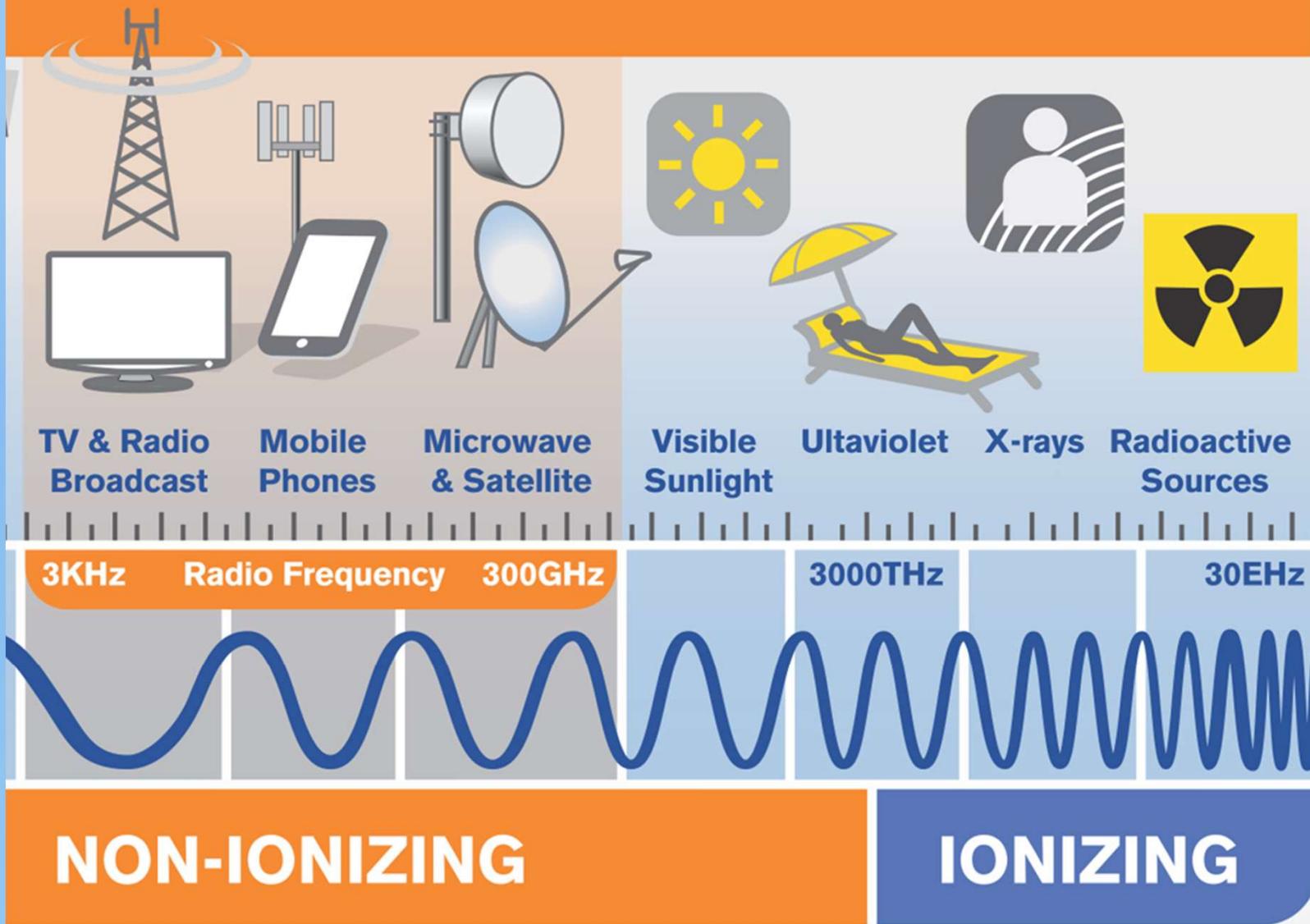
- Wavelengths range from 10^6 to 10^{-16} meters (m)
- Frequencies range from 10^2 to 10^{24} hertz (Hz)
- Energy ranges from 10^{-12} to 10^{10} electron volts (eV)



Electromagnetic Spectrum



ELECTROMAGNETIC SPECTRUM

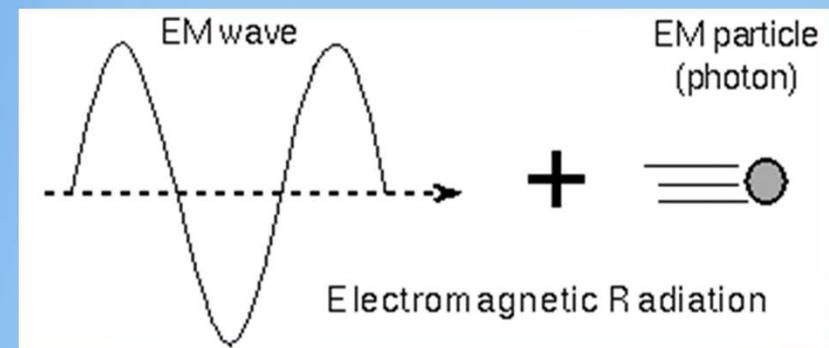
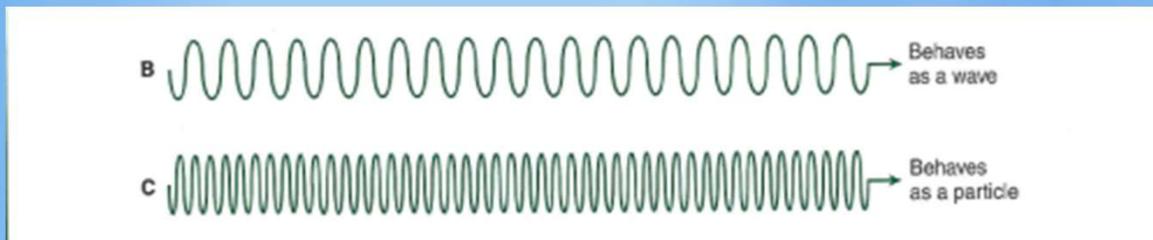


Wave Particle Duality Theory

- #7 - Explain the wave-particle duality theory and what influences how the different members of the electromagnetic spectrum interact.

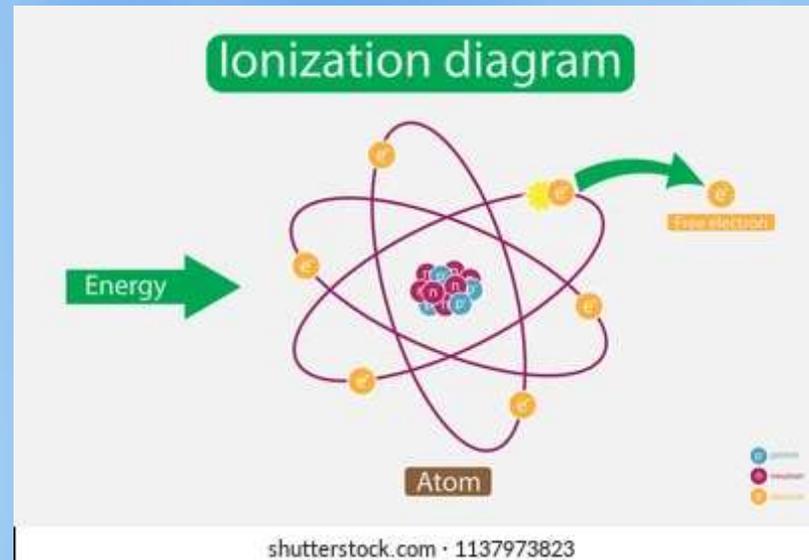
Wave Particle Duality Theory

- EMR can also be characterized by how it interacts with matter.
 - exhibits properties of a wave or a particle depending on its energy
 - This is called wave-particle duality.



X-rays and Gamma Rays

- Because of their high energy they exhibit more particulate characteristics.
 - Both have the ability to ionize matter – a particulate characteristic

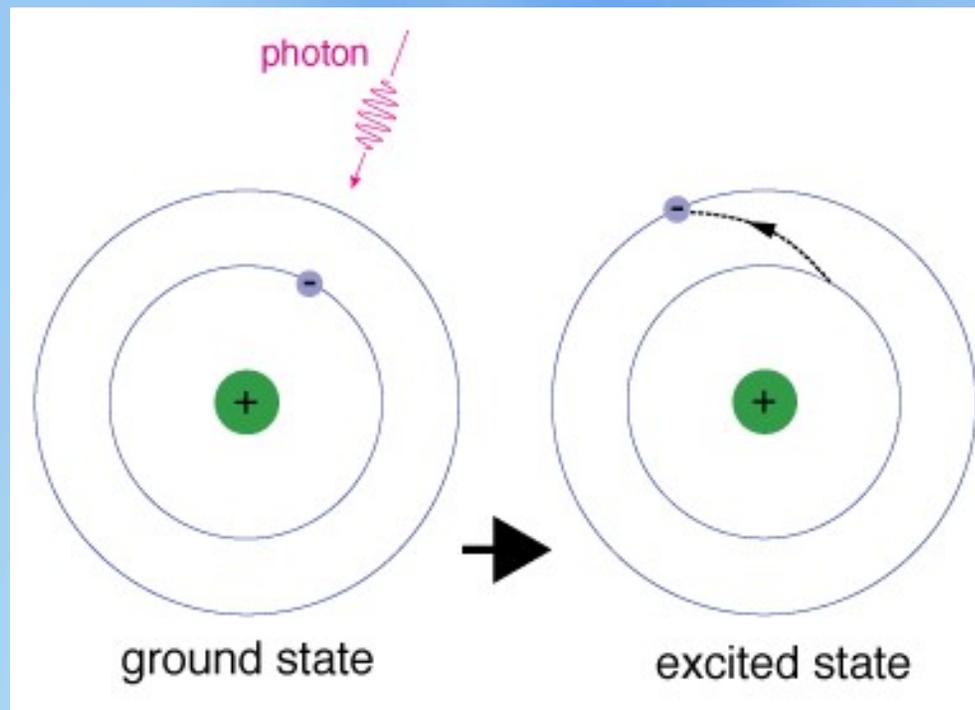


X-rays and Gamma Rays

#8 - Identify the difference between x-rays and gamma rays.

Excitation

- All types of EMR are capable of causing excitation



X-ray Properties

- Penetrating and invisible form of EMR
- Electrically neutral
- Polyenergetic or heterogenous energies
- Release heat when passing through matter

X-ray Properties

- Travel in straight lines
- Travel at the speed of light
- Can ionize matter
- Cause fluorescence in certain crystals
- Cannot be focused by a lens

X-ray Properties

- Affect photographic film
- Produce chemical and biological changes in matter through ionization and excitation
- Produce secondary and scatter radiation