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**

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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.
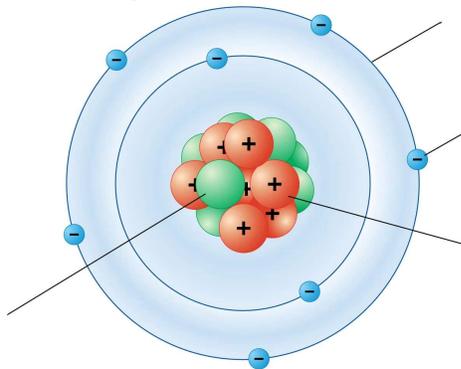
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Why study the atom??
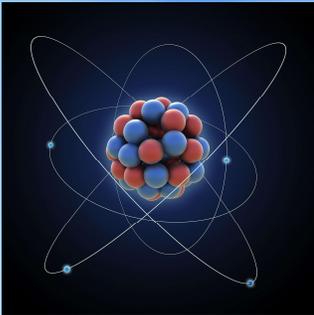
3

#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
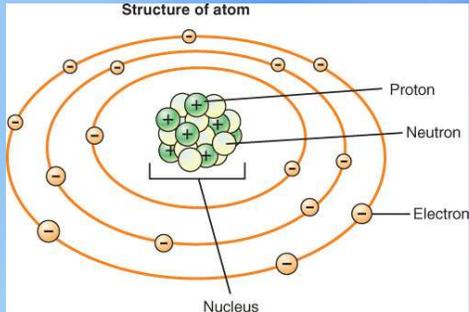 - Location of the particles
  - Associated weights

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Bohr atomic model of a nitrogen atom

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Structure of atom

Proton

Neutron

Electron

Nucleus

6

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

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Which of the following is considered a nucleon?

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

0%	0%	0%	0%
Proton	Electron	Alpha particle	Beta particle

15

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

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

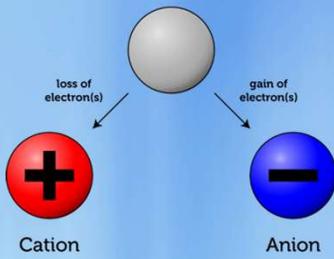| 0%	0%	0%	0%
A.	B.	C.	

15

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#3 - Explain the process of ionization.

gaining or removing electrons from an atom

cation - + - loses electron

anion - '-' - gain electron

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Neutral atom

loss of
electron(s)

gain of
electron(s)

Cation

Anion

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**#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 = neutrons

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Calculate how many neutrons an atom has, if it has a Z number of 74 and an A number of 184.
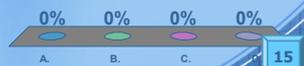
13

_____

_____

_____

_____

_____

_____

_____

_____

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

14

_____

_____

_____

_____

_____

_____

_____

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

A. 131
B. 53
C. 78
D. 184

0%   0%   0%   0%

A.   B.   C.

15

15

_____

_____

_____

_____

_____

_____

_____

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

★A. 39
B. 19
C. 20
D. 58

0%   0%   0%   0%
A.   B.   C.

15

16

#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

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Electron Shells and Electron Binding Energy

BOHR'S MODEL OF AN ATOM

4 — N shell
3 — M shell
2 — L shell
1 — K shell
— Positively charged nucleus
K
L
M
N

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Electron Shells and Electron Binding Energy

- **Identify which has the highest K-shell binding energy**

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Carlton: *Principles of Radiographic Imaging*

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Interactions

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

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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

0% 0% 0% 0%
A.   B.   C.
15

22

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

A. 8
⭐B. 18
C. 32
D. 50

0% 0% 0% 0%
A.   B.   C.
15

23

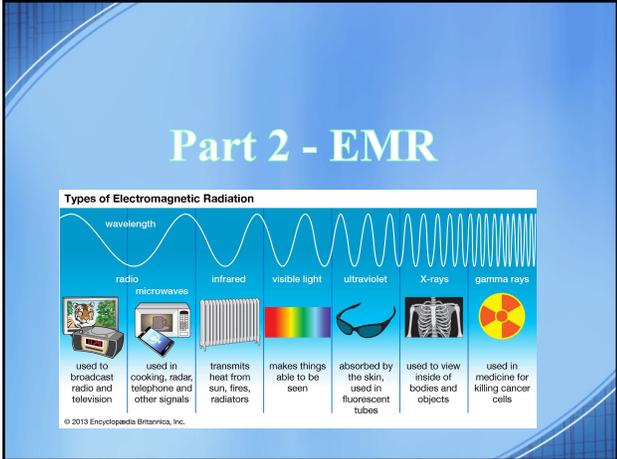**What is the maximum number of electrons permitted in the P-shell?**

A. 8
B. 32
⭐C. 72
D. 98

0% 0% 0% 0%
8   32   72
15

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

25

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

0%   0%   0%   0%

The same number of electr...   The same number of electrons   The same chemical properties   The same number of protons

15

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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

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

Carroll: *Radiography in the Digital Age*

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Part 2 - EMR

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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.

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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.

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Why study electromagnetic radiation??

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#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

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Characteristics

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

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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

0%   0%   0%   0%

15

34

Unit of measurement for frequency is:

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

0%   0%   0%   0%

15

35

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

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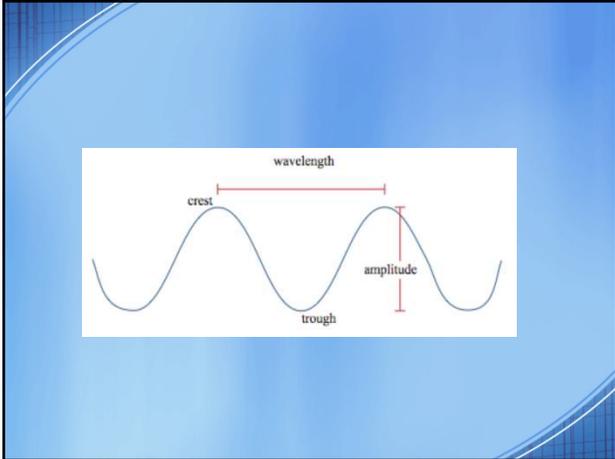
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As the frequency of EMR decreases, wavelength will:

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

0%   0%   0%   0%

Increase   Decrease   Remain the same   Frequency and wavelength...

15

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

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Wave Formula ??

40

How are energy and frequency related?

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

0%   0%   0%
A.   B.   15

41

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?

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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

43

Which member of the EM spectrum has the longest wavelength?

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

| 0% | 0% | 0% | 0% |

Microwaves Visible light Radiowaves X-rays

15
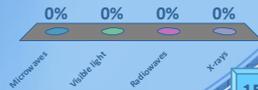
44

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

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

| 0% | 0% | 0% | 0% |

Microwaves Ultraviolet Visible Light Infrared

15
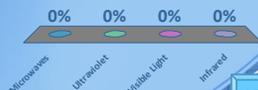
45

Which of the following has the ability to ionize matter?

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

| 0% | 0% | 0% | 0% |

Radiowaves · X-rays · Microwaves · UV light

15

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Electromagnetic Spectrum

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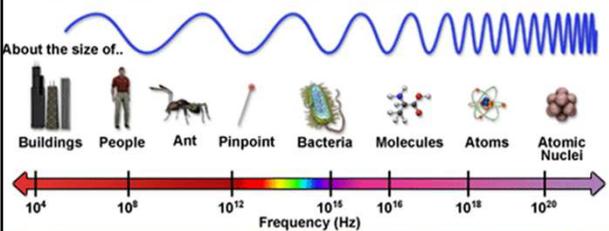- Energy ranges from 10^{-12} to 10^{10} electron volts (eV)

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48
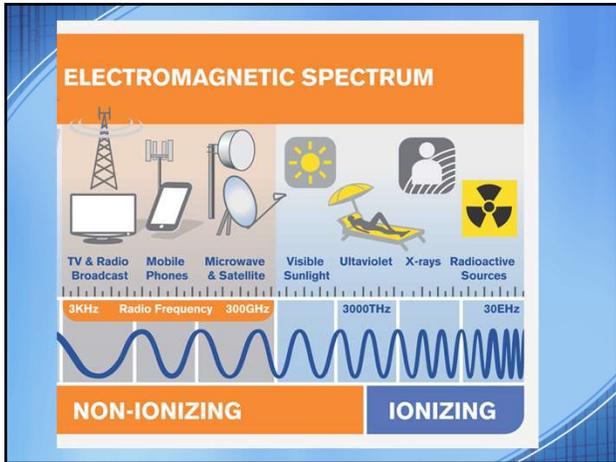
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Wave Particle Duality Theory

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

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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
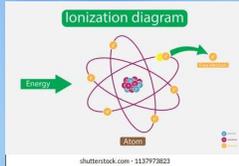   - This is called **wave-particle duality**.

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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
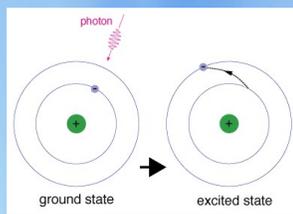
Ionization diagram

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X-rays and Gamma Rays

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

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Excitation

- All types of EMR are capable of causing excitation

photon

ground state   excited state

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X-ray Properties

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

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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

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X-ray Properties

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

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