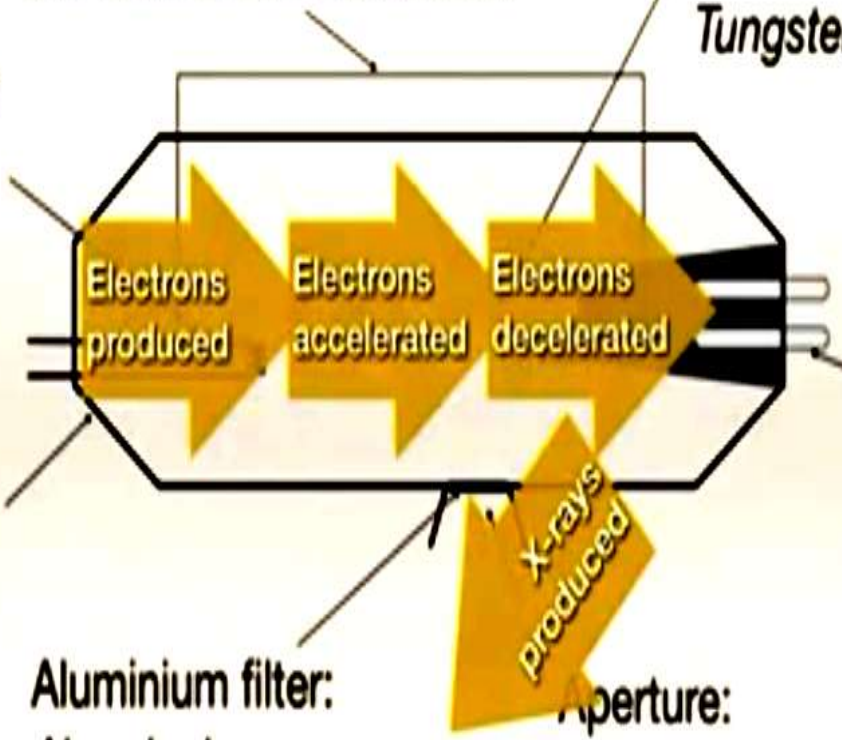
Factors affecting X-ray beam quality and quantity

X-Ray Tube / Linear Accelerator

High-voltage supply:
Accelerates the electrons from the cathode to the anode.

Tungsten anode:
Electrons strike the anode, energy converted into x-rays and heat. Tungsten has very high melting point.

Cathode filament:
Produces electrons through a process called thermionic emission.



Lead shielding:
Prevents x-rays escaping.

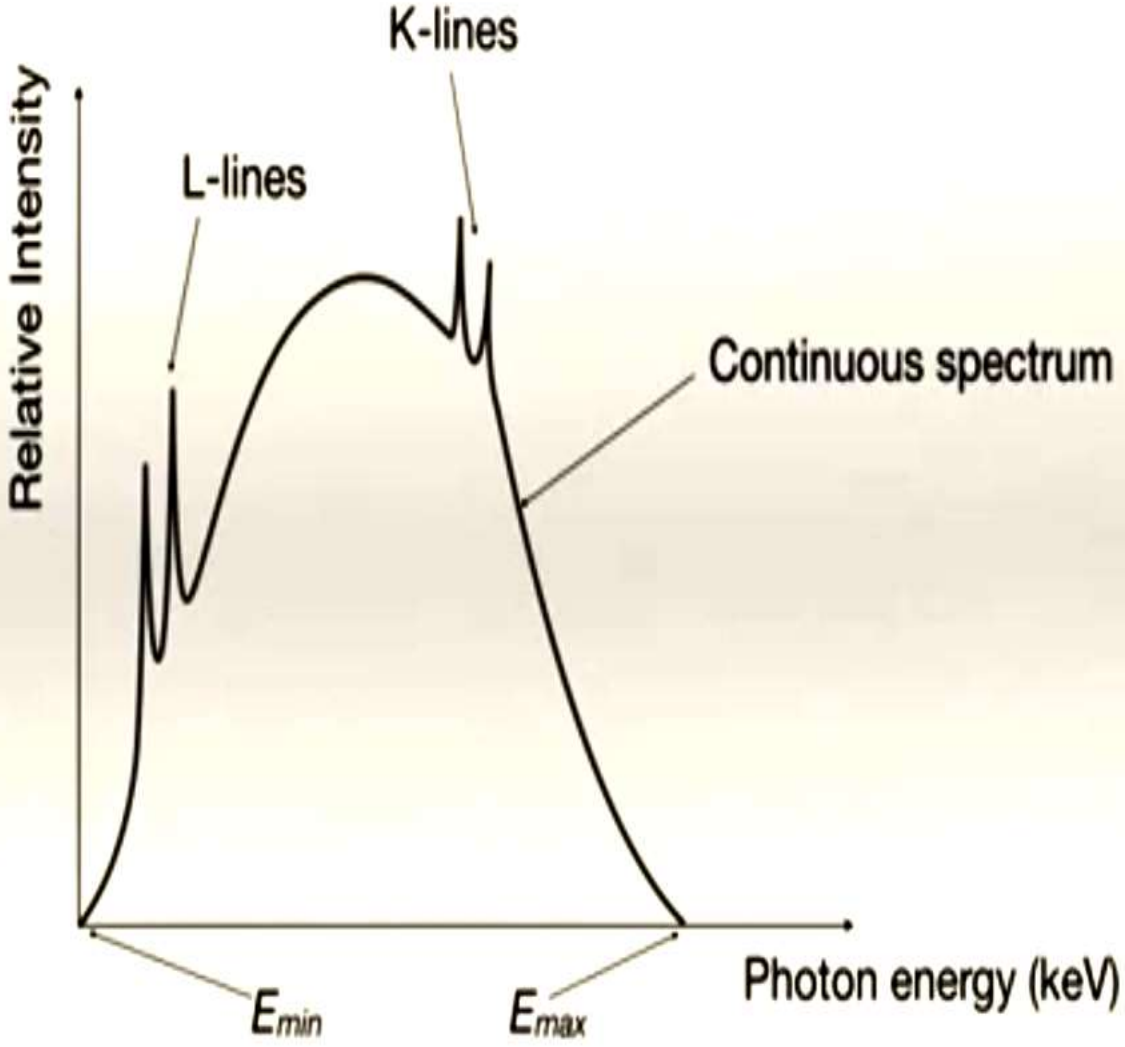
Cooling coils:
Cool anode to prevent it melting.

Aluminium filter:
Absorbs low energy x-rays to reduce

Aperture:
A small window in the lead for the x-rays to pass through.

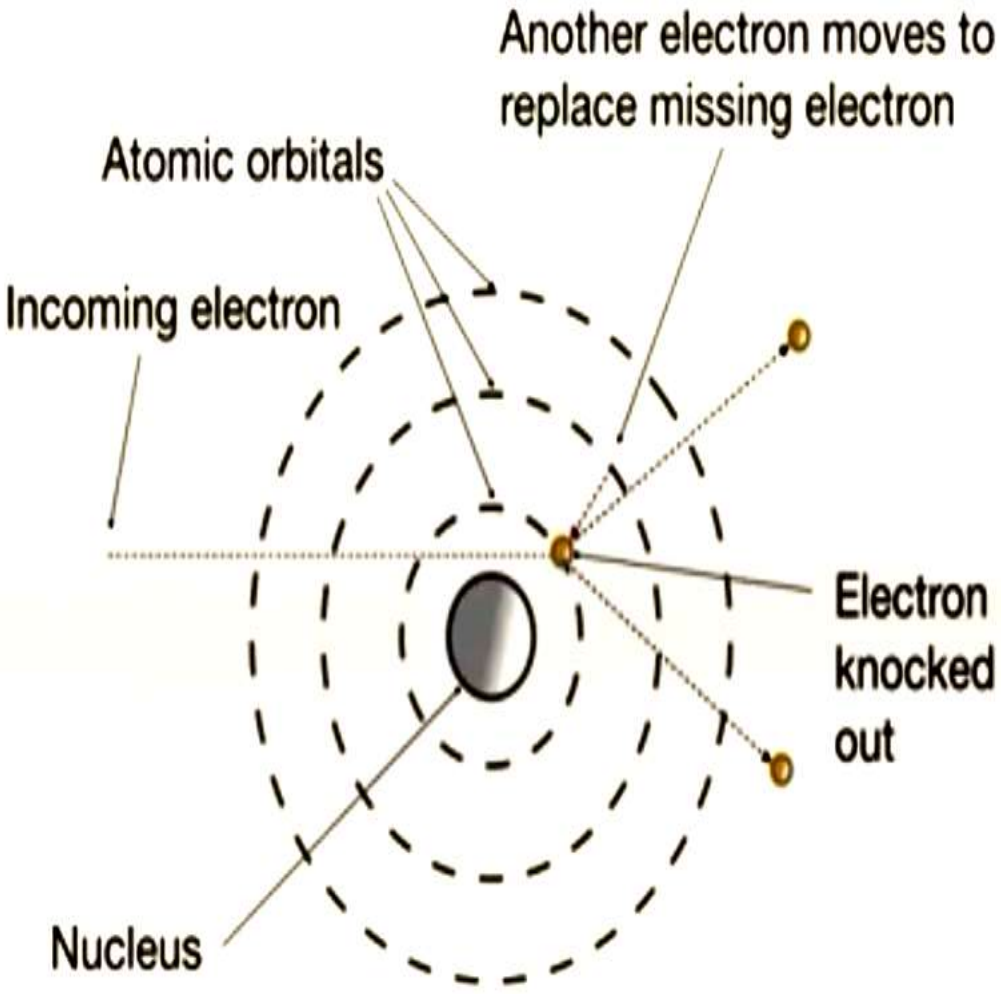
X-ray Spectra

- Incident electrons are decelerated by positive nuclei in the anode.
- Some of the KE is converted into electromagnetic photons. This is known as the *braking radiation*.
- The photons have a continuous range of energies.
- The max. photon energy is:
  $E_{max} = eV$
  Where V is the tube voltage



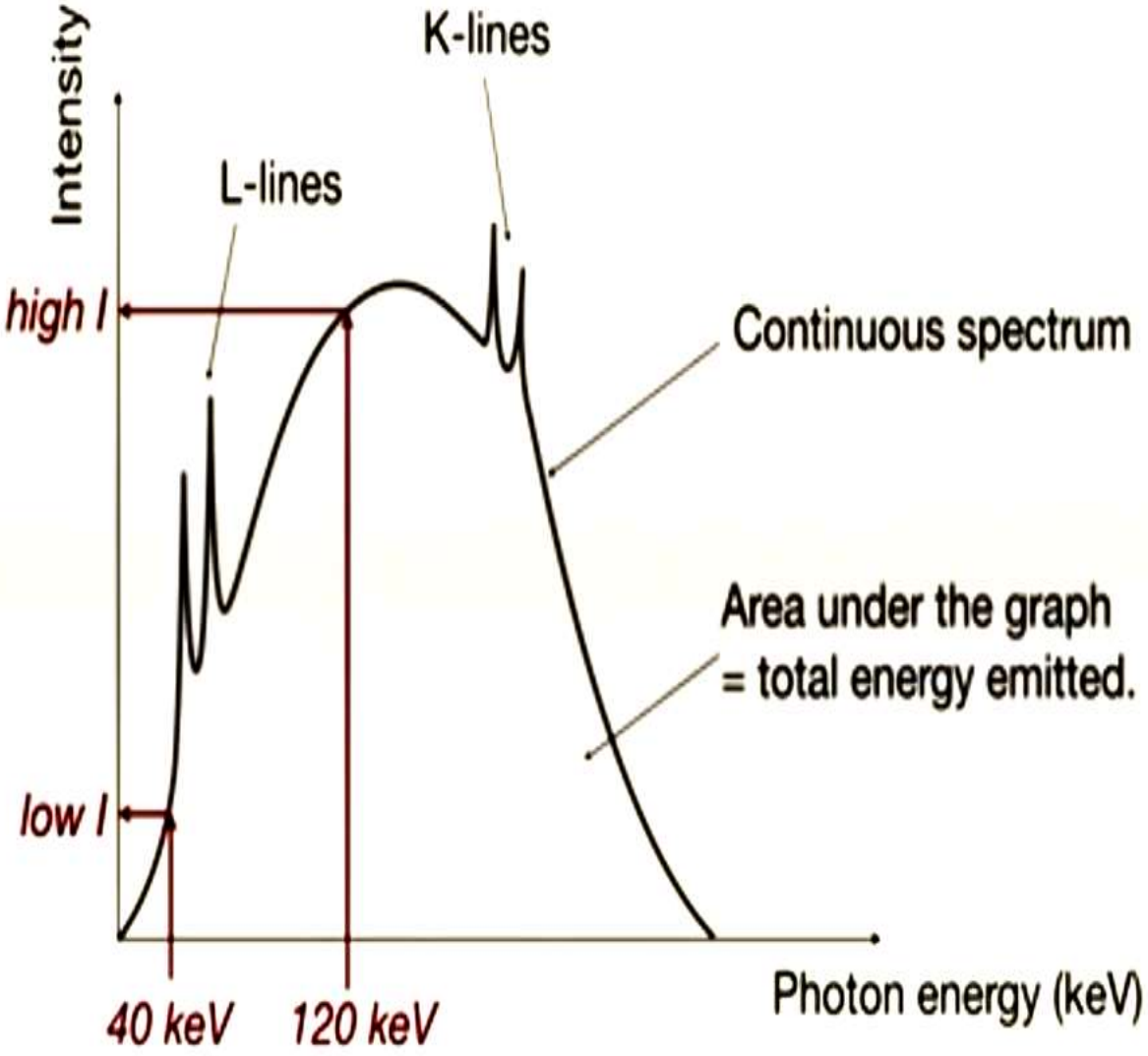
Characteristic Lines

- Characteristic lines are superimposed on the spectrum if electrons have sufficient energy.
- Incoming electrons knock electrons out of inner atomic orbitals.
- Electrons in outer shells move down to replace them.
- Photons are released as they do so.
  These photons produce K-Lines and L-Lines etc.



Understanding Spectra

- X-ray output is plotted on graphs called spectra.
- X-ray spectra are **continuous**.
- *I.e. all photon energies in a range are present.*
- A **higher intensity** means more of those photons are present.
- K-lines and L-lines may be present: called **characteristic lines** (more on them later).



What is intensity?

1- Quantity : is the number of X-ray photons in the beam.

2- Quality : is the energy of X-ray photons in the beam.

Together = the intensity of the X-ray.

Intensity:

Total energy contained in the beam (product of quality and quantity of X-ray photons) .

The factors that affect the quantity and quality of X-rays and their characteristics are:

1- Anode material
2- Voltage applied (kVp)
3- Tube Current (mA)
4- Filters used

X-ray Quantity

measurement of the number of X-ray photons in the beam. Directly affected by:

1- Milliamperage-second (mAs)
2- Peak Kilovoltage (kVp)
3- Anode materials
4- Filtration

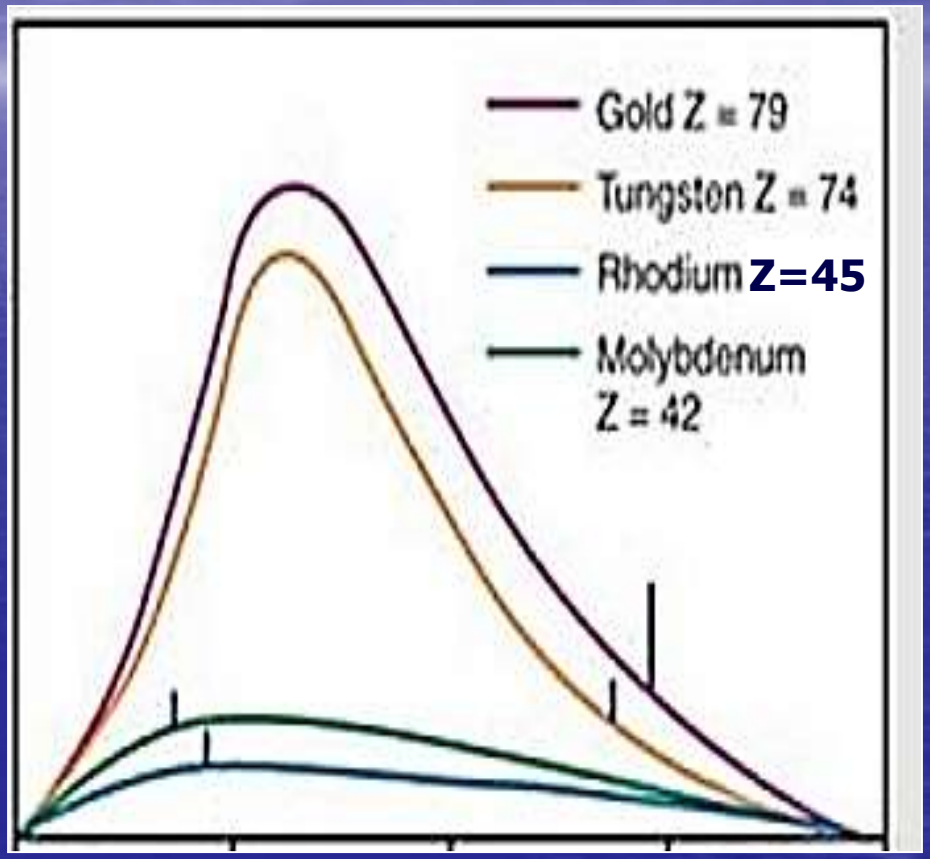
X-ray Quality

measurement of the penetrating ability of X-ray beam. High energy X-ray photons travel farther in matter – more penetrating. Directly affected by:

1- Peak Kilovoltage (kVp)
2- Filtration

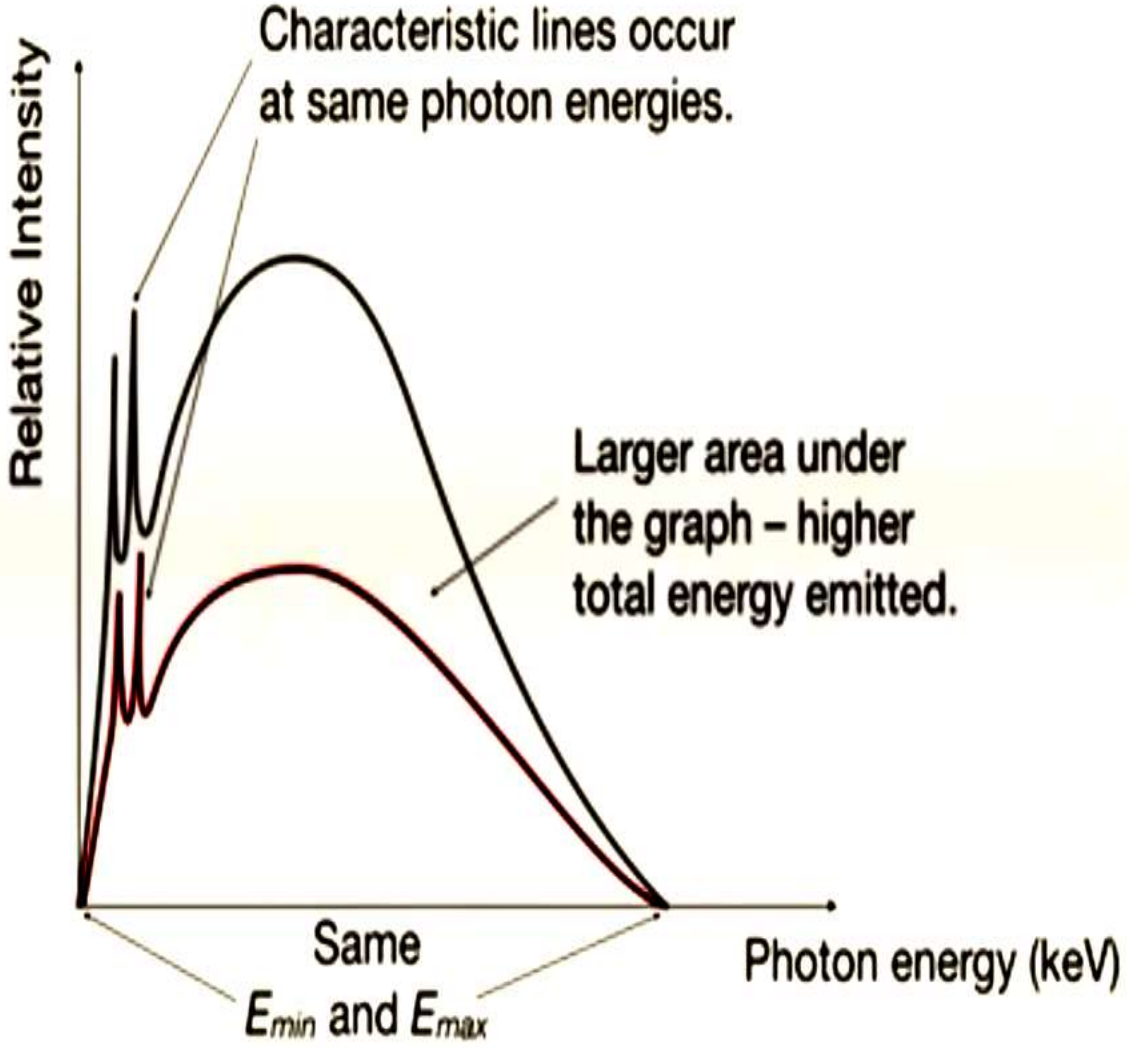
X-Ray Spectra for anode materials

Different anode materials will produce different characteristic X-ray spectra and different amounts of bremsstrahlung radiation.



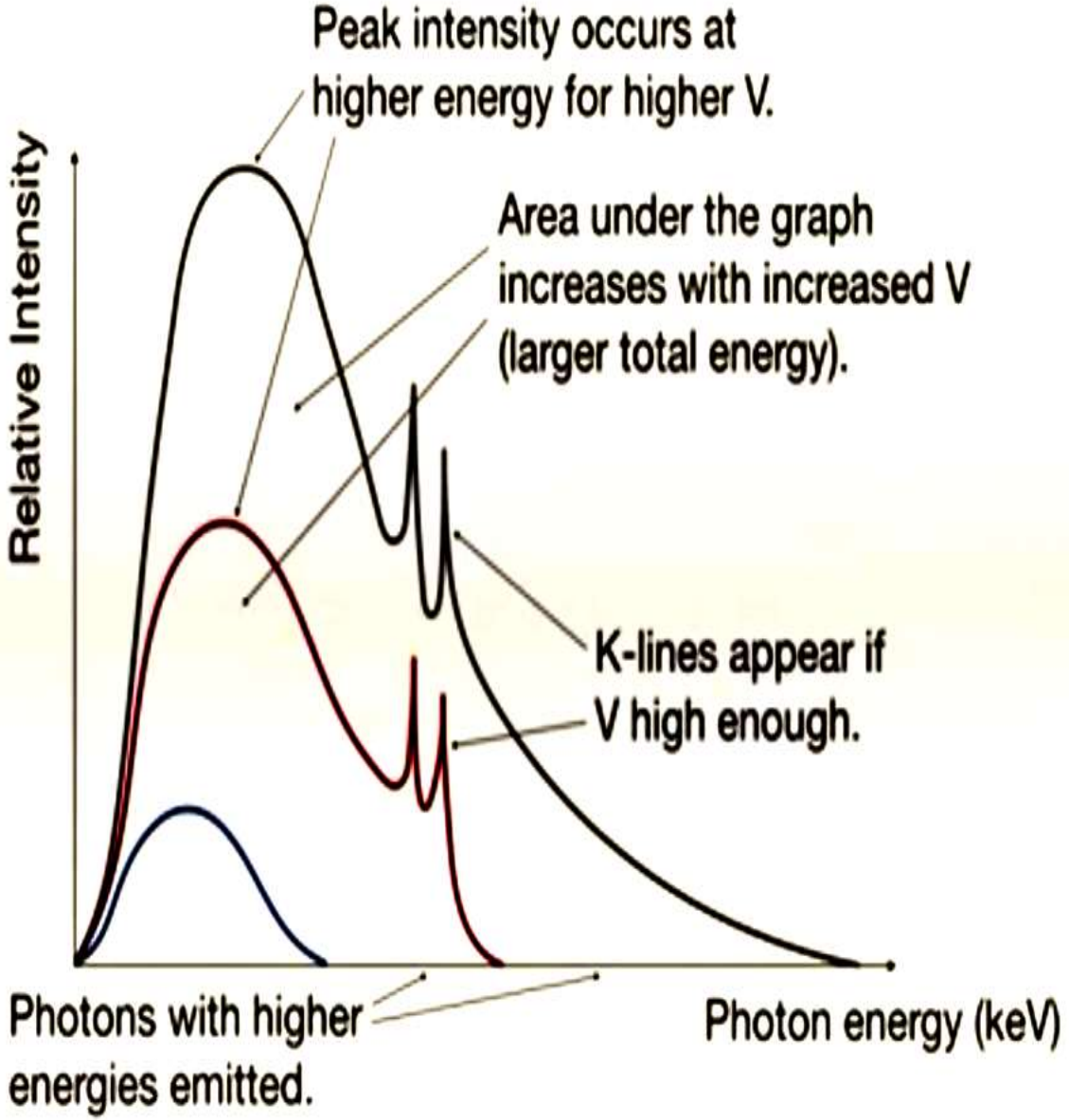
X-ray Spectra for Tube Current

- Different tube currents:
  $I_1 > I_2$
- Larger current ⇒ larger rate of flow of charge ⇒ more electrons arriving per unit time.
- More x-ray photons produced per unit time.
- Max. and min. electron KE unaffected.



X-ray Spectra for Tube Voltage

- Different tube voltages:
  $V_1 > V_2 > V_3$
- Increasing voltage increases work done on electrons
  ⇒ larger KE
- New subatomic transitions possible.



X-ray Spectra for Filters

- Different target material: Unfiltered / Filtered
- Filters absorb some photons.
- Higher proportion of low energy photons absorbed.