

# Sample Items: **PHYSICAL SCIENCES**

(Extracted from *MCAT Practice Test 3R*)

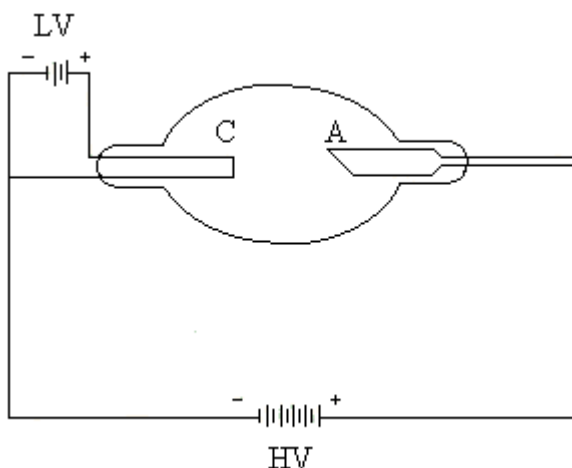
### Passage III (Questions 11-16)

When X-rays are produced in an X-ray tube, two types of X-ray spectra are observed: *continuous spectra* and *line spectra*.

A continuous spectrum is produced by *bremsstrahlung*, the electromagnetic radiation produced when free electrons are accelerated during collisions with ions.

A line spectrum results when an electron having sufficient energy collides with a heavy atom, and an electron in an inner energy level is ejected from the atom. An electron from an outer energy level then fills the vacant inner energy level, resulting in emission of an X-ray photon. For example, if an electron in the  $n = 1$  energy level is ejected from an atom, an electron in the  $n = 2$  level of the atom can fill the vacancy created in the  $n = 1$  level, and a photon with an energy equal to the energy difference between the two levels will be emitted.

A scientist produced both types of spectra using the X-ray tube shown in Figure 1 below.

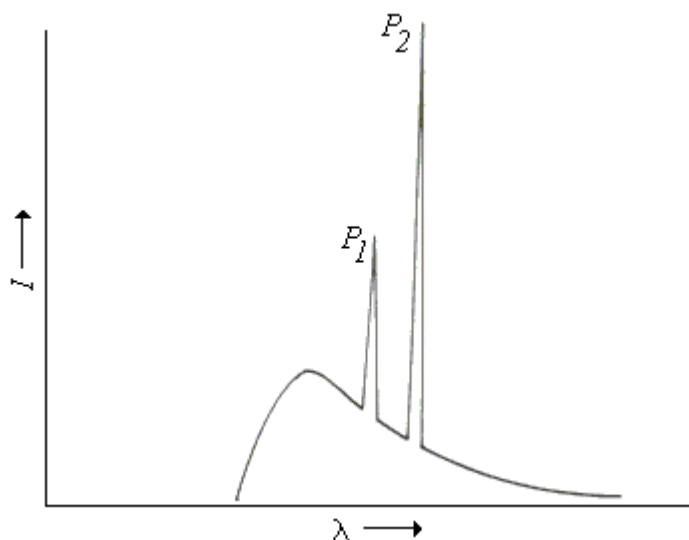


**Figure 1** Heated cathode X-ray tube

The tube contains a heated filament cathode (C), which emits electrons. A power supply (LV) regulates the filament temperature, the electrical current in the tube, and the number of X-rays produced at the anode (A). Another power supply (HV) regulates electron acceleration.

The scientist used an X-ray tube to determine the relationship between X-ray wavelength,  $\lambda$ , and X-ray intensity,  $I$ , which is proportional to the number of X-

ray photons emitted at  $\lambda$ . The scientist then graphed the results of the experiment, as shown in Figure 2.



**Figure 2** X-ray intensity versus wavelength

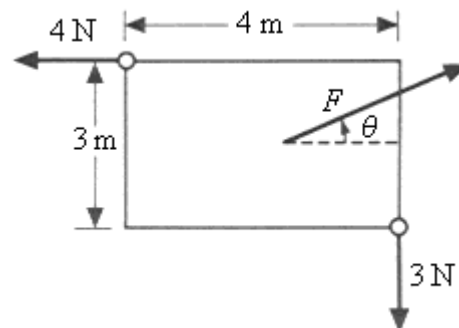
11. In Figure 2, which of the following represents the source of emission peaks  $P_1$  and  $P_2$ ?
  - A) Bremsstrahlung
  - B) Absorption of X-ray photons resulting in electronic excitations in atoms
  - C) Emission of X-ray photons as a result of electronic transitions in atoms
  - D) Acceleration of electrons in a magnetic field
12. Based on the tube in Figure 1, to maintain an electron current of 0.005 A and a potential drop of  $10^5$  V between the anode and the cathode, approximately how much power must the tube consume?
  - A)  $5 \times 10^2$  W
  - B)  $1 \times 10^3$  W
  - C)  $2 \times 10^5$  W
  - D)  $2 \times 10^7$  W

13. The ionization potentials for electrons in the  $n = 1, 2,$  and  $3$  energy levels of Pb are  $1,400 \times 10^{-17} \text{ J},$   $240 \times 10^{-17} \text{ J},$  and  $48 \times 10^{-17} \text{ J},$  respectively. When an electron in the  $n = 2$  level fills a vacancy in the  $n = 1$  level, what is the energy of the X ray that is emitted?
- A)  $1.92 \times 10^{-15} \text{ J}$   
B)  $2.40 \times 10^{-15} \text{ J}$   
C)  $1.16 \times 10^{-14} \text{ J}$   
D)  $1.40 \times 10^{-14} \text{ J}$
14. According to the passage, bremsstrahlung will NOT be produced by collisions between electrons and:
- A) He.  
B)  $\text{He}^{2+}$ .  
C)  $\text{Li}^{1+}$ .  
D) protons.
15. In order to increase the maximum kinetic energy of electrons colliding with the anode, the scientist made which of the following changes?
- A) The voltage of HV was increased.  
B) The voltage of HV was decreased.  
C) The voltage of LV was increased.  
D) The voltage of LV was decreased.
16. In Figure 2, peaks  $P_1$  and  $P_2$  were produced by events that occurred with unequal probabilities. Which peak was produced by the more probable event?
- A)  $P_1,$  because the peak has the longer wavelength  
B)  $P_1,$  because the peak has the lower intensity  
C)  $P_2,$  because the peak has the longer wavelength  
D)  $P_2,$  because the peak has the higher intensity
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Questions 23-26 are NOT based on a descriptive passage.

23. How much work is done when a constant horizontal 20-N force pushes a 50-kg block a distance of 10 m on a horizontal surface?
- A) 50 J  
B) 100 J  
C) 200 J  
D) 500 J
24. Evaporation occurs when molecules at the surface of a liquid overcome the attractive forces of the liquid. This occurs when molecules within the liquid attain a sufficient amount of:
- A) resonance.  
B) kinetic energy.  
C) surface tension.  
D) potential energy.
25. How long will it take a runner, starting from rest and accelerating uniformly at  $1.5 \text{ m/s}^2$ , to travel 3.0 m?
- A)  $2^{1/2}$  sec  
B) 1.5 sec  
C) 2.0 sec  
D) 3.0 sec

26. A rectangular sheet of material has a width of 3 m and a length of 4 m. Forces with magnitudes of 3 N and 4 N, respectively, are applied parallel to two edges of the sheet, as shown in the figure below.



A third force,  $F$ , is applied to the center of the sheet, along a line in the plane of the sheet, at an angle  $\theta = \arctan 0.75$  with respect to the horizontal direction. The sheet will be in translational equilibrium when  $F$  has what value?

- A)  $F = 3 \text{ N}$   
B)  $F = 4 \text{ N}$   
C)  $F = 5 \text{ N}$   
D)  $F = 7 \text{ N}$