Conceptual Questions

29.1 Quantization of Energy

1.

Give an example of a physical entity that is quantized. State specifically what the entity is and what the limits are on its values.

2.

Give an example of a physical entity that is not quantized, in that it is continuous and may have a continuous range of values.

3.

What aspect of the blackbody spectrum forced Planck to propose quantization of energy levels in its atoms and molecules?

4.

If Planck's constant were large, say 10^{34} times greater than it is, we would observe macroscopic entities to be quantized. Describe the motions of a child's swing under such circumstances.

5.

Why don't we notice quantization in everyday events?

29.2 The Photoelectric Effect

6.

Is visible light the only type of EM radiation that can cause the photoelectric effect?

7.

Which aspects of the photoelectric effect cannot be explained without photons? Which can be explained without photons? Are the latter inconsistent with the existence of photons?

8.

Is the photoelectric effect a direct consequence of the wave character of EM radiation or of the particle character of EM radiation? Explain briefly.

9.

Insulators (nonmetals) have a higher BE than metals, and it is more difficult for photons to eject electrons from insulators. Discuss how this relates to the free charges in metals that make them good conductors.

10.

If you pick up and shake a piece of metal that has electrons in it free to move as a current, no electrons fall out. Yet if you heat the metal, electrons can be boiled off. Explain both of these facts as they relate to the amount and distribution of energy involved with shaking the object as compared with heating it.

29.3 Photon Energies and the Electromagnetic Spectrum

11.

Why are UV, x rays, and γ rays called ionizing radiation?

12.

How can treating food with ionizing radiation help keep it from spoiling? UV is not very penetrating. What else could be used?

13.

Some television tubes are CRTs. They use an approximately 30-kV accelerating potential to send electrons to the screen, where the electrons stimulate phosphors to emit the light that forms the pictures we watch. Would you expect x rays also to be created?

14.

Tanning salons use "safe" UV with a longer wavelength than some of the UV in sunlight. This "safe" UV has enough photon energy to trigger the tanning mechanism. Is it likely to be able to cause cell damage and induce cancer with prolonged exposure?

15.

Your pupils dilate when visible light intensity is reduced. Does wearing sunglasses that lack UV blockers increase or decrease the UV hazard to your eyes? Explain.

16.

One could feel heat transfer in the form of infrared radiation from a large nuclear bomb detonated in the atmosphere 75 km from you. However, none of the profusely emitted x rays or γ rays reaches you. Explain.

17.

Can a single microwave photon cause cell damage? Explain.

18.

In an x-ray tube, the maximum photon energy is given by $hf = qV$. Would it be technically more correct to say $hf = qV + BE$, where BE is the binding energy of electrons in the target anode? Why isn't the energy stated the latter way?

29.4 Photon Momentum

19.

Which formula may be used for the momentum of all particles, with or without mass?

20.

Is there any measurable difference between the momentum of a photon and the momentum of matter?

21.

Why don't we feel the momentum of sunlight when we are on the beach?

29.6 The Wave Nature of Matter

22.

How does the interference of water waves differ from the interference of electrons? How are they analogous?

23.

Describe one type of evidence for the wave nature of matter.

24.

Describe one type of evidence for the particle nature of EM radiation.

29.7 Probability: The Heisenberg Uncertainty Principle

25.

What is the Heisenberg uncertainty principle? Does it place limits on what can be known?

29.8 The Particle-Wave Duality Reviewed

26.

In what ways are matter and energy related that were not known before the development of relativity and quantum mechanics?