

Battle of Valley Forge Science Olympiad – Optics Event– January 14, 2017

School Name: _____ Team Number _____

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

- 1) Which one of the following lists gives the correct order of the electromagnetic spectrum from *low to high frequencies*? 1) _____
- A) radio waves, microwaves, visible, x-rays, infrared, ultraviolet, gamma rays
 - B) radio waves, infrared, x-rays, microwaves, ultraviolet, visible, gamma rays
 - C) radio waves, ultraviolet, x-rays, microwaves, infrared, visible, gamma rays
 - D) radio waves, microwaves, infrared, visible, ultraviolet, x-rays, gamma rays
 - E) radio waves, infrared, microwaves, ultraviolet, visible, x-rays, gamma rays
- 2) If unpolarized light of intensity I_0 passes through an ideal polarizer, what is the intensity of the emerging light? 2) _____
- A) $I_0/\sqrt{2}$
 - B) $I_0/16$
 - C) $I_0/2$
 - D) $I_0/4$
 - E) I_0
- 3) For a beam of light, the direction of polarization is defined as 3) _____
- A) the direction that is perpendicular to both the electric and magnetic field vectors.
 - B) the direction of the magnetic field's vibration.
 - C) the direction of the electric field's vibration.
 - D) the beam's direction of travel.
- 4) Which one of the following sets of characteristics describes the image formed by a plane mirror? 4) _____
- A) virtual and upright
 - B) virtual and inverted
 - C) real and upright
 - D) virtual and larger than the object
 - E) real and inverted
- 5) You may have seen ambulances on the street with the letters of the word AMBULANCE written on the front of them, in such a way as to appear correctly when viewed in your car's rear-view mirror. (See the figure.) How do the letters appear when you look directly at the ambulance (not through the mirror)? 5) _____
- a) AMBULANCE
 - b) AMBULANCE
 - c) ECNALUBMA
 - d) AMBULANCE
 - e) AMBULANCE
- A) a
 - B) b
 - C) c
 - D) d
 - E) e
- 6) The focal length of a convex mirror is has a magnitude of 20 cm. What is its radius of curvature? 6) _____
- A) -40 cm
 - B) 20 cm
 - C) 40 cm
 - D) -10 cm
 - E) -20 cm
- 7) An object is placed in front of a convex mirror at a distance larger than twice the magnitude of the focal length of the mirror. The image will appear 7) _____
- A) inverted and reduced.
 - B) in front of the mirror.
 - C) inverted and enlarged.
 - D) upright and reduced.
 - E) upright and enlarged.

- 8) If you stand in front of a convex mirror, at the same distance from it as its focal length, 8) _____
A) you won't see your image because there is none.
B) you will see your image and you will appear larger than you.
C) you will see your image and you will appear smaller than you.
D) you won't see your image because it is focused at infinity.
E) you will see your image and it will be the same size as you except upside down.
- 9) Single convex spherical mirrors produce images that 9) _____
A) could be larger than, smaller than, or the same size as the actual object, depending on the placement of the object.
B) are always larger than the actual object.
C) are always the same size as the actual object.
D) are always smaller than the actual object.
E) are sometimes real.
- 10) If the index of refraction of a material is 2, this means that light travels 10) _____
A) 2 times as fast in air as it does in vacuum.
B) 2 times as fast in the material as it does in air.
C) 2 times as fast in the material than it does in vacuum.
D) 2 times as fast in vacuum as it does in the material.
E) 1/2 as fast in air as it does in the material.
- 11) The index of refraction of a type of glass is 1.50, and the index of refraction of water is 1.33. If light 11) _____
enters water from this glass, the angle of refraction will be
A) greater than the angle of incidence.
B) less than the angle of incidence.
C) equal to the angle of incidence.
- 12) The critical angle for a beam of light passing from water into air is 48.8° . This means that all light 12) _____
rays with an angle of incidence in the water that is greater than 48.8° will be
A) totally transmitted.
B) totally reflected.
C) totally absorbed by the water.
D) partially reflected and partially transmitted.
- 13) A convex lens has focal length f . If an object is placed at a distance of $2f$ from the lens on the 13) _____
principal axis, the image is located at a distance from the lens
A) of infinity.
B) of $2f$.
C) between the lens and f .
D) between f and $2f$.
E) of f .
- 14) Starting from very far away, an object is moved closer and closer to a converging lens, eventually 14) _____
reaching the lens. What happens to its image formed by that lens? (There could be more than one correct choice.)
A) The image gets farther and farther from the lens.
B) The image eventually changes from real to virtual.
C) The image keeps getting larger and larger.
D) The image eventually changes from virtual to real.
E) The image gets closer and closer to the lens.

- 15) Which of following statements about the image formed by a single converging lens are true? (There could be more than one correct choice.) 15) _____
- A) The image is always real.
 - B) The image is always upright.
 - C) The image is always virtual.
 - D) The image is always inverted.
 - E) None of the above choices are correct.
- 16) If the magnification of a mirror or lens is negative, it means that 16) _____
- A) the image is inverted.
 - B) the image is inverted and smaller than the object.
 - C) the object is farther from the mirror (or lens) than the image.
 - D) the image is smaller than the object.
 - E) the image is farther from the mirror (or lens) than the object.
- 17) The focal length of the lens of a simple digital camera is 40 mm, and it is originally focused on a person 25 m away. In what direction must the lens be moved to change the focus of the camera to a person 4.0 m away? 17) _____
- A) towards the CCD sensors
 - B) sideways from the CCD sensors
 - C) away from the CCD sensors
 - D) It does not make any difference.
- 18) Farsightedness can usually be corrected with 18) _____
- A) concave mirrors.
 - B) cylindrical lenses.
 - C) diverging lenses.
 - D) converging lenses.
 - E) convex mirrors.
- 19) Which one of the following is a characteristic of a compound microscope? 19) _____
- A) The final image is real.
 - B) The image formed by the objective is real.
 - C) The eyepiece is a diverging lens.
 - D) The objective is a diverging lens.
 - E) The image formed by the objective is virtual.
- 20) Spherical lenses suffer from 20) _____
- A) both spherical and chromatic aberration.
 - B) chromatic aberration, but not spherical aberration.
 - C) spherical aberration, but not chromatic aberration.
 - D) neither spherical nor chromatic aberration.
- 21) A photon of blue light and a photon of red light are traveling in vacuum. The photon of blue light 21) _____
- A) has a longer wavelength than a photon of red light and travels with a greater speed.
 - B) has a smaller wavelength than a photon of red light and travels with a greater speed.
 - C) has a smaller wavelength than a photon of red light and travels with the same speed.
 - D) has a longer wavelength than a photon of red light and travels with the same speed.

- 22) Light of a given wavelength is used to illuminate the surface of a metal, however, no photoelectrons are emitted. In order to cause electrons to be ejected from the surface of this metal you should _____ 22) _____
A) use light of the same wavelength but decrease its intensity.
B) use light of the same wavelength but increase its intensity.
C) use light of a shorter wavelength.
D) use light of a longer wavelength.
- 23) Light goes from material having a refractive index of n_1 into a material with refractive index n_2 . If the refracted light is bent away from the normal, what can you conclude about the indices of refraction? _____ 23) _____
A) $n_1 \leq n_2$ B) $n_1 = n_2$ C) $n_1 < n_2$ D) $n_1 > n_2$ E) $n_1 \geq n_2$
- 24) The innermost sensory layer of the eye that contains bipolar cells and ganglion cells is the _____ 24) _____
A) sclera B) retina C) cornea D) choroid
- 25) The ability of the eye to focus on close objects is known as _____. 25) _____
A) inversion B) refraction
C) binocular vision D) accommodation
- 26) The greatest visual acuity is housed in the _____. 26) _____
A) vitreous humor
B) blind spot
C) fovea centralis
D) optic disc
E) ciliary body
- 27) What structure of the eye focuses light on the retina? _____ 27) _____
A) choroid
B) lens
C) sclera
D) iris
E) optic chiasma
- 28) The amount of light reaching the film in a camera is determined by the _____ 28) _____
A) f -stop. B) focusing.
C) shutter speed. D) none of the given answers
- 29) A camera lens that acts like a telescope to magnify images is referred to as a _____ 29) _____
A) normal lens. B) wide-angle lens.
C) telephoto lens. D) zoom lens.
- 30) If a person's eyeball is too long from front to back, the person is likely to suffer from _____ 30) _____
A) farsightedness. B) nearsightedness.
C) spherical aberration. D) astigmatism.

- 31) If the human eyeball is too short from front to back, this gives rise to a vision defect that can be corrected by using 31) _____
- A) shaded glasses (i.e., something that will cause the iris to dilate more).
 - B) concave meniscus eyeglasses.
 - C) convex meniscus eyeglasses.
 - D) cylindrical eyeglasses.
 - E) contact lenses, but no ordinary lenses.
- 32) Consider the image formed by a refracting telescope. Suppose an opaque screen is placed in front of the lower half of the objective lens. What effect will this have? 32) _____
- A) The lower half of the image will be blacked out.
 - B) The top half of the image will be blacked out.
 - C) There will be no noticeable difference in the appearance of the image with the objective partially blocked or not.
 - D) The image will appear as it would if the objective were not blocked, but it will be dimmer.
 - E) The entire image will be blacked out, since the entire lens is needed to form an image.
- 33) Is it possible to see a virtual image? 33) _____
- A) No, since the rays that seem to emanate from a virtual image do not in fact emanate from the image.
 - B) Yes, the rays that appear to emanate from a virtual image can be focused on the retina just like those from an illuminated object.
 - C) No, since virtual images do not really exist.
 - D) Yes, since almost everything we see is virtual because most things do not themselves give off light, but only reflect light coming from some other source.
 - E) Yes, but only indirectly in the sense that if the virtual image is formed on a sheet of photographic film, one could later look at the picture formed.
- 34) Light arriving at a concave mirror on a path through the center of curvature is reflected 34) _____
- A) back parallel to the axis.
 - B) back on itself.
 - C) midway between the focal point and the center of curvature.
 - D) through the focal point.
- 35) If you stand in front of a convex mirror, at the same distance from it as its focal length, 35) _____
- A) you will see your image and you will appear smaller.
 - B) you won't see your image because there is none.
 - C) you won't see your image because it's focused at a different distance.
 - D) you will see your image at your same height.
 - E) you will see your image and you will appear larger.
- 36) The index of refraction of diamond is 2.42. This means that a given frequency of light travels 36) _____
- A) 2.42 times faster in air than it does in diamond.
 - B) 2.42 times faster in diamond than it does in vacuum.
 - C) 2.42 times faster in vacuum than it does in diamond.
 - D) 2.42 times faster in diamond than it does in air.

- 37) The angle of incidence 37) _____
 A) is always less than the angle of refraction.
 B) must equal the angle of refraction.
 C) may be greater than, less than, or equal to the angle of refraction.
 D) is always greater than the angle of refraction.
- 38) Two light sources are said to be coherent if they 38) _____
 A) are of the same frequency.
 B) are of the same amplitude, and maintain a constant phase difference.
 C) are of the same frequency, and maintain a constant phase difference.
 D) are of the same frequency and amplitude.
- 39) Sunlight reflected from the surface of a lake 39) _____
 A) has undergone refraction by the surface of the lake.
 B) tends to be polarized with its electric field vector parallel to the surface of the lake.
 C) is unpolarized.
 D) tends to be polarized with its electric field vector perpendicular to the surface of the lake.
 E) none of the given answers
- 40) Which of the following shift the colorant used to influence dye solubility? 40) _____
 A) kodachrome B) anzchromes C) chromashift D) chromatophores
- 41) Which of the following is a chemical that color substrates to which they have affinity? 41) _____
 A) dye B) colorant C) pigment D) chromatophore
- 42) Which of the following produce surface coloration? 42) _____
 A) dye B) kodachrome C) pigment D) colorant
- 43) What is the longest wavelength in the Balmer series? 43) _____
 A) 365 nm B) 240 nm C) 820 nm D) 328 nm E) 656 nm
- 44) A laser beam strikes a plane mirror's reflecting surface with an angle of incidence of 43° . What is the angle between the incident ray and the reflected ray? 44) _____
 A) 90° B) 45° C) 43° D) 0° E) 86°
- 45) An object is placed 15 cm from a spherical concave mirror with a focal length of magnitude 20 cm. If the object is 4.0 cm tall, how tall is the image? 45) _____
 A) 1.0 cm B) 8.0 cm C) 16 cm D) 2.0 cm
- 46) A plant that is 4.1 cm tall is 10.3 cm from a converging lens. You observe that the image of this plant is virtual and 6.2 cm tall. What is the focal length of the lens? 46) _____
 A) -30 cm B) 6.8 cm C) 16 cm D) -16 cm E) 30 cm
- 47) An object is placed 21 cm from a concave lens having a focal length of magnitude 25 cm. What is the magnification? 47) _____
 A) 0.54 B) -0.22 C) -0.54 D) 0.22 E) -0.32

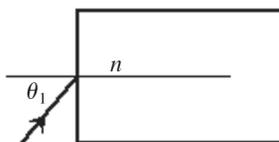
48) A thin flashlight beam traveling in air strikes a glass plate at an angle of 52° with the plane of the surface of the plate. If the index of refraction of the glass is 1.4, what angle will the beam make with the normal in the glass? 48) _____

- A) 38° B) 34° C) 56° D) 26° E) 64°

49) A beam of light in water (of refractive index of 1.33) enters a glass slab (of refractive index 1.50) at an angle of incidence of 60.0° . What is the angle of refraction in the glass? 49) _____

- A) 90.0° B) 27.5° C) 39.8° D) 50.2° E) 60.0°

50) During the investigation of a new type of optical fiber having an index of refraction $n = 1.21$, a laser beam is aimed at the flat end of a straight fiber, as shown in the figure. What is the maximum angle of incidence θ_1 if the beam is not to escape from the sides of the fiber if it is surrounded by air? 50) _____



- A) 42.9° B) 30.5° C) 36.7° D) 33.6° E) 39.8°