Physics Standard X: Lenses Short-Answer Questions

Comprehensive Question Bank with Detailed Answers for Examinations

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1 Short-Answer Questions and Answers

1. **What makes a lens different from a thin sheet of glass?**
   Answer: A lens refracts light to converge or diverge it, forming images or magnifying objects, due to its curved surfaces (parts of spheres). A thin glass sheet does not significantly bend light, maintaining the size of the illuminated area regardless of distance, as it lacks curvature. For example, a convex lens can focus sunlight to burn paper, unlike a glass sheet.

2. **List four uses of lenses in daily life.**
   Answer:
   - Spectacles: Correct vision (e.g., convex for hyperopia, concave for myopia).
   - Telescopes: View distant objects (e.g., stars).
   - Microscopes: Magnify small objects (e.g., cells).
   - Cameras: Capture images on sensors or film.

3. **What are the main characteristics of a convex lens?**
   Answer: A convex lens is thicker in the middle, thinner at edges, converges light rays to a real principal focus, and can magnify objects. It can focus sunlight to a small, intense spot, potentially burning paper, and in spectacles, it corrects farsightedness.

4. **Describe the features of a concave lens.**
   Answer: A concave lens is thinner in the middle, thicker at edges, diverges light rays, appearing to originate from a virtual principal focus on the same side. It cannot burn paper and always forms virtual, erect, diminished images, used in myopia correction.

5. **How can you distinguish between convex and concave lenses using letter observation?**
   Answer: Move the lens sideward while observing letters. In a convex lens, letters appear to move in the opposite direction due to convergence. In a concave lens, letters move in the same direction due to divergence, providing a simple identification method.

6. **What are the refracting surfaces of a lens?**
   Answer: The refracting surfaces of a lens are the two curved surfaces, each part of a sphere, where light undergoes refraction. These surfaces cause the bending of light, enabling image formation or magnification.

7. **Define the optic centre of a lens.**
   Answer: The optic centre (O) is the midpoint of the lens. Light rays passing through it travel undeviated, as it lies on the optic axis, connecting the centres of curvature of the lens's spherical surfaces.

8. **What is meant by the optic axis of a lens?**
   Answer: The optic axis is an imaginary line passing through the optic centre and the centres of curvature of the lens's two spherical surfaces. It serves as a reference for light ray paths and image formation.

9. **What is the aperture of a lens?**
Answer: The aperture is the area of the lens through which light passes. In optical instruments like cameras, it can be adjusted using a stop to control the amount of light entering, affecting image brightness.

10. **What is the principal focus of a convex lens?**
Answer: The principal focus (F) of a convex lens is the point on the optic axis where light rays parallel to the optic axis converge after refraction. It is real, located on the opposite side of the lens, and equidistant on both sides.

11. **How is the principal focus of a concave lens different?**
Answer: The principal focus of a concave lens is the point from which parallel rays appear to diverge after refraction, located on the same side as the incident light. It is virtual, unlike the real focus of a convex lens.

12. **How can the approximate focal length of a convex lens be determined? (Application)**
Answer: Use the distant object method: project the image of a distant object (e.g., a tree) onto a screen using a convex lens. The distance from the lens to the screen, where a clear image forms, is the approximate focal length, measured in meters.

13. **Why can't a concave lens form a real image?**
Answer: A concave lens diverges light rays, making them appear to originate from a virtual focus on the same side. Since the rays do not actually converge, a real image cannot be projected onto a screen, only virtual images are formed.

14. **What are the characteristics of an image formed by a convex lens when the object is beyond 2F?**
Answer: When the object is beyond 2F, the image is formed between F and 2F on the opposite side, is real, inverted, and diminished. For example, in a camera, distant objects form smaller images on the sensor.

15. **What happens to the image when an object is placed at the principal focus of a convex lens?**
Answer: The image forms at infinity, is real, inverted, and highly magnified. The refracted rays become parallel, making it impractical to capture on a screen, as seen in some optical setups.

16. **Describe the image formed by a convex lens when the object is between F and the optic centre. (Application)**
Answer: The image is on the same side as the object, virtual, erect, and magnified. This is used in magnifying glasses, where the lens is held close to a book, making text appear larger for reading.

17. **What are the characteristics of images formed by a concave lens?**
Answer: Images are always virtual, erect, and diminished, located between the principal focus and the optic centre on the same side as the object, regardless of object position, due to the lens's diverging nature.

18. **State the lens equation and explain its components.**
Answer: The lens equation is $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$, where f is the focal length, u is the

object distance, and v is the image distance, all measured from the optic centre. It relates these distances to determine image position.

19. **What is the Cartesian sign convention for lenses?**
Answer: Distances are measured from the optic centre. Positive: distances in the direction of incident rays (e.g., v for real images), heights above the optic axis. Negative: distances opposite to incident rays (e.g., u), heights below the optic axis (e.g., inverted image height).

20. **Calculate the focal length of a convex lens if an object is 90 cm away and the image is 30 cm on the opposite side. (Application)**
Answer: Using sign convention, $u = -90\,\text{cm}$, $v = +30\,\text{cm}$.
Lens equation: $\frac{1}{f} = \frac{1}{v} - \frac{1}{u} = \frac{1}{30} - \frac{1}{-90} = \frac{1}{30} + \frac{1}{90} = \frac{4}{90}$.
Thus, $f = \frac{90}{4} = 22.5\,\text{cm}$. The positive focal length confirms a convex lens.

21. **What is magnification, and how is it calculated?**
Answer: Magnification (m) is the ratio of image height (h_i) to object height (h_o): $m = \frac{h_i}{h_o} = \frac{v}{u}$. It indicates size change and orientation (positive for erect, negative for inverted images).

22. **Calculate the magnification for an object 90 cm from a convex lens with an image at 30 cm. (Application)**
Answer: Using $u = -90\,\text{cm}$, $v = +30\,\text{cm}$,
$m = \frac{v}{u} = \frac{30}{-90} = -\frac{1}{3}$.
The image is diminished ($|m| < 1$) and inverted (negative), typical for objects beyond 2F.

23. **What does a negative magnification indicate?**
Answer: Negative magnification indicates an inverted image, typically real, formed by a convex lens when the object is outside the focal point (e.g., beyond F). For example, a camera image is inverted.

24. **What is the power of a lens, and what is its SI unit?**
Answer: Power (P) is the ability of a lens to converge or diverge light, defined as $P = \frac{1}{f}$ (f in meters). The SI unit is dioptre (D). Convex lenses have positive power; concave lenses have negative power.

25. **Calculate the power of a concave lens with a focal length of 25 cm. (Application)**
Answer: Focal length $f = -25\,\text{cm} = -0.25\,\text{m}$ (negative for concave).
Power $P = \frac{1}{f} = \frac{1}{-0.25} = -4\,\text{D}$.
The negative power confirms the lens is concave, used in myopia correction.

26. **What does a +2.00 D prescription for spectacles indicate? (Application)**
Answer: It indicates a convex lens with power $P = +2.00\,\text{D}$, so focal length $f = \frac{1}{2} = 0.5\,\text{m} = 50\,\text{cm}$. This corrects farsightedness (hyperopia), helping focus on near objects.

27. **Describe the role of the objective lens in a compound microscope.**
Answer: The objective lens, a convex lens with a short focal length, is placed close to the object. It forms a real, inverted, magnified image beyond $2F_o$, which serves as the object for the eyepiece, enabling high magnification of small objects like cells.

28. **Why should the objective lens of a microscope have a shorter focal length? (Application)**
Answer: A shorter focal length increases magnification, as the image size is larger when the object is between F_o and $2F_o$. A longer focal length reduces image size, decreasing magnification, which is undesirable for observing microscopic objects.

29. **What are the characteristics of the image formed by the eyepiece in a telescope?**
Answer: The eyepiece, a convex lens, forms a virtual, magnified, erect image of the real, inverted image created by the objective. This allows clear viewing of distant objects, as in astronomical observations.

30. **How does a refracting telescope make distant objects appear distinct? (Application)**
Answer: The objective lens (long focal length, large aperture) forms a small, real, inverted image of a distant object at its focus. The eyepiece (short focal length) magnifies this image, forming a virtual image visible to the observer, making stars appear closer and clearer.

31. **Why is the aperture of the objective lens in a telescope larger than that of the eyepiece?**
Answer: A larger aperture allows the objective to collect more light from distant objects, improving image brightness and clarity. The eyepiece, with a smaller aperture, focuses on magnifying the image formed by the objective.

32. **What precautions should be taken when using a telescope? (Application)**
Answer: Do not look at the sun, as focused sunlight can damage eyes. Fix the telescope on a stand for stability during observations of celestial bodies, ensuring accurate and safe viewing.

33. **How can a water-filled polythene bag act as a convex lens? (Application)**
Answer: A water-filled polythene bag, shaped like a sphere, converges light due to its curved surfaces, similar to a convex lens. It can form real, inverted images of a candle when held at the right distance, demonstrating lens-like behavior in a simple experiment.