Physics Standard X: Lenses Essay Questions

Comprehensive Question Bank with Detailed Solutions for Examinations

1 Essay Questions and Solutions

1. **Explain the differences between convex and concave lenses, including their characteristics, light behavior, and practical applications. (Application Level)**
Solution: As a student, I learned that convex lenses are thicker in the middle, converging light rays to a real principal focus, as seen when burning paper by focusing sunlight. They form real or virtual images, depending on object position, and are used in cameras (real images) and magnifying glasses (virtual, magnified images). Concave lenses, thinner in the middle, diverge light, appearing to come from a virtual focus, forming only virtual, erect, diminished images. They're used in spectacles to correct myopia. In experiments, convex lenses move letters oppositely when shifted, while concave lenses move them similarly, aiding identification. These properties make convex lenses ideal for telescopes and microscopes, while concave lenses correct vision, showing their practical significance in daily life. (126 words)

2. **Describe the smoke box experiment to find the principal focus of convex and concave lenses, and explain how it demonstrates their light behavior. (Application Level)**
Solution: In the smoke box experiment, I set up a 50 cm x 30 cm x 20 cm box with transparent sides and small holes sealed with transparent sheets. For a convex lens, I fixed it inside, filled the box with smoke, and passed parallel laser rays through a hole. The rays converged at the principal focus on the opposite side, visible in smoke, confirming the real focus. For a concave lens, rays diverged, appearing to originate from a virtual focus on the same side. This shows convex lenses converge light for real images (e.g., cameras), while concave lenses diverge light for virtual images (e.g., myopia correction), helping me understand their optical behavior practically. (117 words)

3. **An object of height 2 cm is placed 12 cm from a convex lens with a focal length of 6 cm. Draw the ray diagram, calculate the image position, height, and describe its characteristics. (Application Level)**
Solution: As a student, I drew a ray diagram for a convex lens ($f = 6\,\text{cm}$) with an object ($h_o = 2\,\text{cm}$) at $u = -12\,\text{cm}$. Using the lens equation: $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$, $\frac{1}{6} = \frac{1}{v} - \frac{1}{-12}$, so $\frac{1}{v} = \frac{1}{6} - \frac{1}{12} = \frac{1}{12}$, giving $v = 12\,\text{cm}$. Magnification: $m = \frac{v}{u} = \frac{12}{-12} = -1$, so image height $h_i = m \cdot h_o = -1 \cdot 2 = -2\,\text{cm}$. The image is at 12 cm (at 2F), real, inverted, same size. This setup mimics a projector, forming clear images on a screen. (130 words)

4. **A concave lens has a focal length of 20 cm, and an object of height 2 cm is placed 30 cm away. Calculate the image distance, magnification, and describe the image characteristics. (Application Level)**
Solution: For a concave lens ($f = -20\,\text{cm}$), with an object ($h_o = 2\,\text{cm}$) at $u = -30\,\text{cm}$, I used the lens equation: $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$. So, $\frac{1}{-20} = \frac{1}{v} - \frac{1}{-30}$, giving $\frac{1}{v} = -\frac{1}{20} + \frac{1}{30} = -\frac{3}{60} + \frac{2}{60} = -\frac{1}{60}$, so $v = -12\,\text{cm}$. Magnification: $m = \frac{v}{u} = \frac{-12}{-30} = 0.4$. Image height: $h_i = m \cdot h_o = 0.4 \cdot 2 = 0.8\,\text{cm}$. The image is virtual, erect, diminished, located 12 cm from the lens on the same side, typical for concave lenses in myopia correction. (134 words)

5. **Explain how a compound microscope uses lenses to magnify small objects, including the roles of the objective and eyepiece. (Application Level)**
Solution: As a student, I understand a compound microscope uses two convex lenses to magnify tiny objects like cells. The objective lens, with a short focal length, is placed near the object (between F_o and $2F_o$). It forms a real, inverted, magnified image beyond $2F_o$. This image acts as the object for the eyepiece, a convex lens with a longer focal length, positioned between its focus and optic centre. The eyepiece produces a virtual, further magnified, erect image for viewing. The short focal length of the objective ensures high initial magnification, critical for detailed observation in biology labs, making microscopic structures visible. (109 words)

6. **Describe the construction and working of a refracting telescope, explaining how it makes distant objects appear closer. (Application Level)**
Solution: To build a refracting telescope, I used a 1 m PVC pipe, fixing a convex lens (10 cm diameter, 100 cm focal length) as the objective at one end and a smaller convex lens (watch repair eyepiece) at the other, adjustable via a plastic bottle. The objective, with a long focal length and large aperture, collects light from distant objects (e.g., stars), forming a small, real, inverted image at its focus. The eyepiece, with a shorter focal length, magnifies this image, producing a virtual, magnified image. Adjusting the eyepiece distance ensures clarity, making celestial objects appear closer, as in astronomy. (110 words)