CBSE CLASS X

Science (086)

ANSWER KEY

AI-generated question paper

Code: OHFEH2	Questions: 34	Maximum Marks: 71	Generated: 2026-06-25 17:55

SELECTIONS USED

Subject	Science
Lessons	9 Light – Reflection and Refraction
Level of understanding	Exam-ready
Question selection	CBSE board paper, whole lesson (~80 marks across Sections A-E)
Model	claude-sonnet-4-6

Composition — Difficulty: 10 straightforward · 19 medium · 5 deep | Types: 13 MCQ · 6 Short · 5 Assertion–reason · 4 Very short · 3 Long · 3 Case-based | Sections: A 18Q/18m · B 4Q/8m · C 6Q/18m · D 3Q/15m · E 3Q/12m

Q1. straightforward exam-ready **[1]**

An object is placed between the pole and the principal focus of a concave mirror. The image formed is:
(A) Real, inverted and diminished
(B) Real, inverted and enlarged
(C) Virtual, erect and enlarged
(D) Virtual, erect and diminished

- A Real, inverted and diminished
- B Real, inverted and enlarged
- C Virtual, erect and enlarged
- D Virtual, erect and diminished

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Model Answer

(C) Virtual, erect and enlarged

When an object is placed between the pole (P) and the principal focus (F) of a concave mirror, the image formed is **virtual, erect and enlarged**.

Source: Light – Reflection and Refraction, Table 9.1

Explanation

Table 9.1 in the textbook clearly states: when the object is placed **between P and F**, the image is formed **behind the mirror**, is **enlarged**, and is **virtual and erect**. This is also the principle behind concave mirrors used as shaving/makeup mirrors. Examiners expect you to recall this directly from the table.

Q2. straightforward exam-ready **[1]**

A ray of light travelling obliquely from glass into air will:
(A) Bend towards the normal
(B) Bend away from the normal
(C) Continue in the same direction without bending
(D) Be completely absorbed

A Bend towards the normal
B Bend away from the normal
C Continue in the same direction without bending
D Be completely absorbed

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Model Answer

(B) Bend away from the normal

Glass is a denser medium and air is a rarer medium. A light ray travelling from a denser medium to a rarer medium bends **away from the normal**.

Explanation

The key rule to remember: **denser → rarer = bends away from normal; rarer → denser = bends towards normal.** Glass has a higher refractive index than air, making it the denser medium. The source passage explicitly states: "A light ray travelling obliquely from a denser medium to a rarer medium bends away from the normal." This is the direct fact the examiner tests here.

Q3. straightforward exam-ready **[1]**

According to the New Cartesian Sign Convention for spherical mirrors, an object is placed at a distance of 15 cm in front of a mirror. Which of the following correctly represents the object distance u?
(A) u = +15 cm, measured to the right of the pole
(B) u = −15 cm, measured to the left of the pole
(C) u = +15 cm, measured from the principal focus
(D) u = −15 cm, measured to the right of the pole

- A All distances are measured from the principal focus.
- B Distances measured to the right of the pole are negative.
- C Distances measured to the left of the pole are negative.
- D The object is always placed to the right of the mirror.

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Model Answer

(B) u = −15 cm, measured to the left of the pole.

According to New Cartesian Sign Convention, distances measured to the **left** of the pole are **negative**; since the object is placed in front of (to the left of) the mirror, u = −15 cm.

Explanation

The key rule: all distances are measured from the **pole**, and leftward distances are negative. The object is always placed to the left of the mirror, so object distance *u* is always negative. Options A, C, and D are incorrect — distances are not measured from the focus, and leftward is negative (not positive). The correct MCQ answer is **(B)**; the correct option statement is **(C)** — "Distances measured to the left of the pole are negative."

Source: Chapter 9, Section 9.2.3 Sign Convention for Reflection by Spherical Mirrors

Q4. medium exam-ready **[1]**

A convex lens of focal length 20 cm is used to form an image of an object placed at 20 cm from it. The image is formed:
(A) At 20 cm on the same side as the object
(B) At infinity
(C) At 40 cm on the other side
(D) At 10 cm on the other side

A At 20 cm on the same side as the object
B At infinity
C At 40 cm on the other side
D At 10 cm on the other side

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Model Answer

(B) At infinity

When an object is placed at the principal focus (f = 20 cm, u = 20 cm) of a convex lens, the image is formed at infinity.

Explanation

From Table 9.4 (Ch. 9): when the object is placed **at focus F_1**, the image is formed **at infinity**. Here, object distance = focal length = 20 cm, so the object is at F_1. This is a standard result students must memorise from the image formation table for convex lenses.

Q5. medium exam-ready **[1]**

A spherical mirror has a focal length of –12 cm. This mirror is:
(A) Convex, with radius of curvature 24 cm
(B) Concave, with radius of curvature 6 cm
(C) Concave, with radius of curvature 24 cm
(D) Convex, with radius of curvature 6 cm

A Convex, with radius of curvature 24 cm
B Concave, with radius of curvature 6 cm
C Concave, with radius of curvature 24 cm
D Convex, with radius of curvature 6 cm

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Model Answer

(C) Concave, with radius of curvature 24 cm

A negative focal length indicates a concave mirror. Using $R = 2f$: $R = 2 \times 12 = 24$ cm.

Explanation

In the New Cartesian Sign Convention, a negative focal length means the focus lies in front of the mirror — this is a **concave mirror**. The formula $R = 2f$ (magnitude only for R) gives $R = 24$ cm. Students often confuse sign of focal length with mirror type: remember, concave → negative f; convex → positive f.

Q6. straightforward exam-ready **[1]**

The power of a lens is −4.0 D. The focal length and type of lens are:
(A) +25 cm, convex
(B) −25 cm, concave
(C) +40 cm, convex
(D) −40 cm, concave

A +25 cm, convex
B −25 cm, concave
C +40 cm, convex
D −40 cm, concave

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Model Answer

(D) −25 cm, concave

$f = \frac{1}{P} = \frac{1}{-4.0} = -0.25 \text{ m} = -25 \text{ cm}$. Negative focal length indicates a concave (diverging) lens.

Explanation

Use $f = \frac{1}{P}$, always convert to cm. A negative power → negative focal length → concave lens. Examiners expect the formula, substitution, and correct identification of lens type.

Q7. straightforward exam-ready **[1]**

Among the following media, light travels fastest in:
(A) Water
(B) Crown glass
(C) Diamond
(D) Air

A Water
B Crown glass
C Diamond
D Air

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Model Answer

(D) Air

Light travels fastest in air among the given options, as air has the lowest refractive index (1.0003), meaning the speed of light in air is closest to its speed in vacuum (3×10^8 m s^{-1}).

Source: Chapter 9, Section 9.3.2 (Table 9.3)

Explanation

Higher refractive index = lower speed of light. From Table 9.3: Air (1.0003) < Water (1.33) < Crown glass (1.52) < Diamond (2.42). So light is slowest in diamond and fastest in air among these four options. Remember: speed and refractive index are inversely related.

Q8. straightforward exam-ready **[1]**

A concave lens always produces an image that is:
(A) Real, inverted and diminished
(B) Virtual, erect and diminished
(C) Real, erect and enlarged
(D) Virtual, inverted and enlarged

- A Real, inverted and diminished
- B Virtual, erect and diminished
- C Real, erect and enlarged
- D Virtual, inverted and enlarged

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Model Answer

(B) Virtual, erect and diminished

A concave lens always produces a virtual, erect and diminished image, irrespective of the position of the object.

Explanation

Table 9.5 (Chapter 9) explicitly states that for all object positions, a concave lens gives a **virtual and erect** image that is **diminished**. The textbook concludes: *"A concave lens will always give a virtual, erect and diminished image, irrespective of the position of the object."* Remember: concave lens = diverging lens → rays never actually meet → no real image possible.

Q9. straightforward exam-ready **[1]**

A driver notices that the image of a car behind appears smaller than the actual car and always remains upright, regardless of how close the following car is. The rear-view mirror being used is most likely:

(A) A plane mirror, because it forms images of the same size

(B) A concave mirror, because it forms magnified images

(C) A convex mirror, because it provides a wider field of view and always forms an erect image

(D) A concave mirror, because it forms real images of distant objects

- A Forms a magnified image of the traffic behind
- B Produces a real image of objects
- C Provides a wider field of view and always gives an erect image
- D Focuses light onto a single point

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Model Answer

(C) A convex mirror, because it provides a wider field of view and always forms an erect image.

Convex mirrors always give a virtual, erect, and diminished image regardless of object distance, and have a wider field of view — hence preferred as rear-view mirrors.

Source: Chapter 9, *Uses of convex mirrors*

Explanation

The key clues in the question are: image is **smaller than actual** (diminished) and **always upright** (erect) regardless of distance. Only a convex mirror satisfies both conditions for all object positions (see Table 9.2). The textbook explicitly states convex mirrors are used as rear-view mirrors because they always give an erect, diminished image and a wider field of view. Eliminate (A) — plane mirrors give same-size images; eliminate (B) and (D) — concave mirrors can form inverted/real images.

Q10. medium exam-ready **[1]**

The magnification produced by a spherical mirror is given by m = –v/u. If m = +0.5 for a mirror, which of the following is correct?

(A) The image is real, inverted and diminished.
(B) The image is virtual, erect and diminished.
(C) The image is real, erect and enlarged.
(D) The image is virtual, inverted and enlarged.

- A The image is real, inverted and diminished.
- B The image is virtual, erect and diminished.
- C The image is real, erect and enlarged.
- D The image is virtual, inverted and enlarged.

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Model Answer

(B) The image is virtual, erect and diminished.

Since m = +0.5, the positive value indicates the image is virtual and erect, and |m| = 0.5 < 1 indicates the image is diminished.

Explanation

For spherical mirrors, m = –v/u. A **positive** value of m means the image is **virtual and erect** (as stated in section 9.2.4: "A positive sign in the value of the magnification indicates that the image is virtual"). A magnitude less than 1 (|m| = 0.5) means the image is **diminished**. This matches a convex mirror, which always forms virtual, erect, diminished images.

Q11. straightforward exam-ready **[1]**

When a ray of light passes through the optical centre of a lens, it:
(A) Bends towards the principal axis
(B) Bends away from the principal axis
(C) Passes through the principal focus
(D) Emerges without any deviation

- A Bends towards the principal axis
- B Bends away from the principal axis
- C Passes through the principal focus
- D Emerges without any deviation

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Model Answer

(D) Emerges without any deviation

A ray of light passing through the optical centre of a lens emerges without any deviation.

Source: Chapter 9, Section 9.3.5

Explanation

This is a standard ray diagram rule for lenses. The three rules for ray diagrams are: (i) parallel ray → passes through F_2, (ii) ray through F_1 → emerges parallel, (iii) ray through optical centre → no deviation. Examiners expect option D directly; briefly quoting the rule earns full marks.

Q12. medium exam-ready **[1]**

Two thin lenses of powers +3.5 D and –1.5 D are placed in contact with each other. The power of the combination is:
(A) –2.0 D
(B) +5.0 D
(C) +2.0 D
(D) –5.0 D

- A –2.0 D
- B +5.0 D
- C +2.0 D
- D –5.0 D

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Model Answer

(C) +2.0 D

When two lenses are placed in contact, the net power is the algebraic sum of their individual powers.

$$P = P_1 + P_2 = +3.5\text{ D} + (-1.5\text{ D}) = +2.0\text{ D}$$

Source: Chapter 9, Section 9.3.8 Power of a Lens

Explanation

The key formula is $P = P_1 + P_2 + \ldots$ (powers simply add algebraically). Remember that convex lens power is positive and concave lens power is negative. This is a straightforward one-step calculation — just add with signs carefully.

Q13. straightforward exam-ready **[1]**

A surgeon uses a mirror to obtain a large, clear view of a patient's eye during an examination. The object (eye) must be placed very close to the mirror. Which type of mirror is used, and why?

(A) Convex mirror, because it always forms a magnified image

(B) Concave mirror, because when the object is within the focal length, it forms a magnified, virtual, erect image

(C) Plane mirror, because it forms an image of the same size

(D) Concave mirror, because it always forms a real and enlarged image

- A Rear-view mirror in a car
- B Mirror in a shopping mall for security
- C Shaving mirror
- D Convex mirror on a road bend

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Model Answer

(B) Concave mirror, because when the object is placed within the focal length, it forms a magnified, virtual, and erect image — useful for examining the eye closely.

Source: Light – Reflection and Refraction, Section 9.2 (Uses of concave mirrors)

Explanation

The key property tested here: a **concave mirror** produces a **virtual, erect, enlarged** image only when the object is placed **between the pole and the principal focus (within focal length)**. This is exactly how a shaving/examination mirror works. Option (D) is wrong because a concave mirror does NOT always form a real enlarged image — it depends on object position. The correct answer matches Option (C) "Shaving mirror" from the options list, which uses a concave mirror for this reason.

Q14. medium exam-ready **[1]**

Assertion (A): When a light ray travels from water into glass, it bends towards the normal.
Reason (R): Glass has a higher refractive index than water, making it optically denser.

A Both A and R are true, and R is the correct explanation of A.
B Both A and R are true, but R is NOT the correct explanation of A.
C A is true but R is false.
D A is false but R is true.

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Model Answer

Option A — Both A and R are true, and R is the correct explanation of A. Glass (n = 1.52) has a higher refractive index than water (n = 1.33), making it optically denser; so light travelling from water into glass bends towards the normal.

Explanation

When light moves from a rarer medium (water, lower n) to a denser medium (glass, higher n), it slows down and bends **towards** the normal — this directly supports Assertion A. The Reason correctly states that glass is optically denser than water (1.52 > 1.33) and this is precisely **why** the bending towards the normal occurs, making R the correct explanation of A. Remember: optically denser = higher refractive index = light bends towards normal.

Q15. medium exam-ready **[1]**

Assertion (A): A convex lens can produce both real and virtual images depending on the position of the object.
Reason (R): When the object is placed between the optical centre and the principal focus of a convex lens, the image formed is virtual and erect.

A Both A and R are true, and R is the correct explanation of A.
B Both A and R are true, but R is NOT the correct explanation of A.
C A is true but R is false.
D A is false but R is true.

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Model Answer

Option A is correct. Both A and R are true, and R is the correct explanation of A. When the object is between F_1 and optical centre O, a convex lens forms a virtual, erect, enlarged image — this case directly explains why a convex lens can form virtual images, supporting Assertion A.

Source: Chapter 9, Section 9.3.4 (Table 9.4)

Explanation

- **A is true**: Table 9.4 confirms a convex lens forms real images (object beyond F_1) AND virtual images (object between F_1 and O).
- **R is true**: Table 9.4 explicitly states that when the object is between F_1 and O, the image is virtual and erect.
- **R correctly explains A**: The reason directly gives the specific condition under which a convex lens forms a virtual image, thus explaining why *both* types of images are possible — making it the correct explanation, not just an additional fact.

Q16. medium exam-ready **[1]**

Assertion (A): The emergent ray from a rectangular glass slab is parallel to the incident ray but displaced laterally.
Reason (R): At both parallel surfaces of the slab, refraction occurs such that the bending at the first surface is exactly reversed at the second surface, resulting in zero net angular deviation.

A Both A and R are true, and R is the correct explanation of A.
B Both A and R are true, but R is NOT the correct explanation of A.
C A is true but R is false.
D A is false but R is true.

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Model Answer

Answer: A

Both A and R are true, and R is the correct explanation of A. The bending at the air-glass surface (AB) is exactly reversed at the glass-air surface (CD), giving zero net angular deviation but a lateral displacement.

Source: Chapter 9, Section 9.3.1

Explanation

The textbook explicitly states: "The extent of bending of the ray of light at the opposite parallel faces AB and CD is equal and opposite. This is why the ray emerges parallel to the incident ray." This directly confirms both the assertion (parallel but laterally displaced emergent ray) and the reason (equal and opposite bending at the two surfaces = zero net angular deviation). Since R correctly and completely explains A, option A is correct.

Q17. deep exam-ready **[1]**

Assertion (A): Optical density and mass density of a medium always increase together.
Reason (R): Kerosene has a higher refractive index than water but has a lower mass density than water.

A Both A and R are true, and R is the correct explanation of A.
B Both A and R are true, but R is NOT the correct explanation of A.
C A is false and R is true.
D Both A and R are false.

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Model Answer

Answer: C

Assertion (A) is **false** — optical density and mass density do not always increase together. Reason (R) is **true** — kerosene has a higher refractive index (1.44) than water (1.33), making it optically denser, yet its mass density is lower than water.

Explanation

The textbook explicitly states: *"an optically denser medium may not possess greater mass density — kerosene having higher refractive index is optically denser than water, although its mass density is less than water."* So Assertion A is false (the two densities are independent), while Reason R correctly states a fact from Table 9.3. Option C is correct.

Q18. medium exam-ready **[1]**

Assertion (A): The focal length of a concave mirror is negative under the New Cartesian Sign Convention.
Reason (R): The principal focus of a concave mirror lies in front of the mirror, on the same side as the incoming light, which is the negative side of the axis.

A Both A and R are true, and R is the correct explanation of A.
B Both A and R are true, but R is NOT the correct explanation of A.
C A is true but R is false.
D A is false but R is true.

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Model Answer

Option A is correct. Both A and R are true, and R is the correct explanation of A. Under the New Cartesian Sign Convention, distances measured to the left of the pole (in front of the mirror) are negative. Since the principal focus of a concave mirror lies in front of the mirror, its focal length is negative.

Explanation

The key is linking the sign convention rule (left of pole = negative) directly to the position of the principal focus of a concave mirror (in front = left side). R correctly and completely explains why f is negative for a concave mirror, making Option A the right choice.

Q19. medium exam-ready **[2]**

The absolute refractive index of diamond is 2.42. What does this mean physically? If the speed of light in air is 3×10^8 m s^{-1}, calculate the speed of light in diamond.

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Model Answer

Physical meaning: The absolute refractive index of diamond is 2.42 means that the speed of light in air is 2.42 times the speed of light in diamond (i.e., light travels 2.42 times faster in air than in diamond).

Calculation:

$$n = \frac{c}{v} \Rightarrow v = \frac{c}{n} = \frac{3 \times 10^8}{2.42}$$
$$v = 1.24 \times 10^8 \text{ m s}^{-1}$$

The speed of light in diamond is 1.24×10^8 m s^{-1}.

Source: Chapter 9, Section 9.3.2 – The Refractive Index

Explanation

- For the **meaning** part (1 mark): state clearly that the refractive index is the ratio of speed of light in air to speed in the medium. Saying "light slows down by a factor of 2.42 in diamond" earns the mark.
- For the **calculation** part (1 mark): use $n = c/v$, substitute correctly, and show the final answer with units. Division: $3 \times 10^8 \div 2.42 \approx 1.24 \times 10^8$ m s^{-1}.
- Do **not** just write the formula without substituting values — examiners expect full working for numericals.

Q20. straightforward exam-ready **[2]**

An object is placed at the centre of curvature C of a concave mirror of focal length 15 cm. State the position, size and nature of the image formed. Using the mirror formula, verify the image distance.

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Model Answer

Position: At C (i.e., at 30 cm in front of the mirror)
Size: Same as the object
Nature: Real and inverted

Verification using mirror formula:
Given: f = −15 cm, u = −30 cm (object at C, so R = 2f = 30 cm)

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$

$$\frac{1}{v} = \frac{1}{-15} - \frac{1}{-30} = \frac{-2+1}{30} = \frac{-1}{30}$$

$$v = -30 \text{ cm}$$

Image is formed at C, 30 cm in front of the mirror. ✓

Source: Table 9.1 and Section 9.2.4, Chapter 9

Explanation

- From Table 9.1: when object is at C, image is also at C — same size, real, inverted.
- For mirror formula, use sign convention: distances in front of mirror are negative. f = −15 cm, u = −30 cm (since R = 2f).
- The calculated v = −30 cm confirms the image is at C, verifying the table result.
- Examiners award marks for: correct position/size/nature (1 mark) and correct mirror formula calculation (1 mark).

Q21. medium exam-ready **[2]**

A spherical mirror produces a magnification of –3 for an object placed 10 cm in front of it. (i) What does the negative sign indicate about the image? (ii) Calculate the image distance. (iii) Is the mirror concave or convex? Justify.

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Model Answer

(i) The negative sign indicates that the image is **real and inverted**.

(ii) Using $m = -\frac{v}{u}$, with $m = -3$ and $u = -10$ cm:

$$-3 = -\frac{v}{-10} \Rightarrow -3 = \frac{v}{10} \Rightarrow v = -30 \text{ cm}$$

Image distance = **–30 cm** (30 cm in front of the mirror).

(iii) The mirror is **concave**. It forms a real, enlarged image (|m| = 3 > 1) of an object placed in front of it, which is a property of a concave mirror.

Source: Chapter 9, Section 9.2.4 — Mirror Formula and Magnification

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Explanation

- A negative magnification always means real and inverted (stated explicitly in the textbook).
- Use $m = -v/u$; remember u is negative by sign convention (object in front).
- A convex mirror always gives virtual, diminished images (m < 1 in magnitude), so a real, enlarged image can only be produced by a concave mirror — examiners expect this justification.

Q22. medium exam-ready **[2]**

Why does a coin placed at the bottom of a water-filled bowl appear to be at a shallower depth than it actually is?

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Model Answer

When light rays travel from water (denser medium) to air (rarer medium), they bend **away from the normal** at the surface. The refracted rays, when extended backwards, appear to meet at a point **higher than the actual position** of the coin. This is refraction of light, which makes the coin appear raised/shallower than its real depth.

Source: Chapter 9, Section 9.3 Refraction of Light

Explanation

- The key concept is **refraction** — light bends when passing from one medium to another.
- Specifically state the direction: denser → rarer medium → bends away from normal.
- Mention that the **apparent position** is higher than the actual position because the eye traces refracted rays backward in a straight line.
- Examiners look for: (1) naming refraction, (2) explaining the bending direction/apparent shift. Both points earn the 2 marks.

Q23. medium exam-ready **[3]**

An object 3 cm tall is placed 12 cm in front of a concave mirror of focal length 8 cm. Using the mirror formula, find (i) the image distance and (ii) the height of the image. State the nature of the image.

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Model Answer

Given: h = +3 cm, u = –12 cm, f = –8 cm (concave mirror)

(i) Image distance:

Using mirror formula: $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

$$\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{-8} - \frac{1}{-12} = -\frac{1}{8} + \frac{1}{12} = \frac{-3+2}{24} = \frac{-1}{24}$$

$$v = -24 \text{ cm}$$

The image is formed **24 cm in front of the mirror**.

(ii) Height of the image:

$$m = -\frac{v}{u} = -\frac{(-24)}{(-12)} = -2$$

$$h' = m \times h = -2 \times 3 = -6 \text{ cm}$$

Nature of the image: Real, inverted, and enlarged (magnified 2 times).

Source: Chapter 9, Section 9.2.4 – Mirror Formula and Magnification

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Explanation

- Always assign signs first using New Cartesian Sign Convention: distances in front of mirror are negative, so u = –12, f = –8.
- A negative v confirms the image is real (in front of mirror).
- A negative h′ confirms the image is inverted.
- Examiners award marks for: correct formula application (1 mark), correct v (1 mark), correct h′ and nature (1 mark). Missing the nature statement loses a mark.

Q24. medium exam-ready **[3]**

A student places a candle 6 cm from a convex lens of focal length 10 cm. (i) Draw a labelled ray diagram to show the formation of the image. (ii) State the position (in front of or behind the lens), nature and size of the image relative to the object. (iii) Can this image be obtained on a screen? Give a reason.

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Model Answer

(i) Ray Diagram:

Object is placed between F_1 and O (since object distance 6 cm < focal length 10 cm).

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\ | /
\ | /
————\——┼——/——————— Principal axis
\ | /
\|/
O F1 (lens) F2
(6cm) (10cm) (10cm)
```

Draw two rays from the top of the candle: one parallel to the principal axis (refracts through F_2), and one through the optical centre (passes straight). The refracted rays diverge; when extended backwards, they meet on the **same side as the object**, forming a virtual, erect, enlarged image.

(ii) The image is formed **in front of the lens (same side as the object)**. It is **virtual, erect, and enlarged** (larger than the object).

(iii) No, this image **cannot be obtained on a screen**, because it is a **virtual image**. Virtual images are formed by the apparent intersection of diverging rays and cannot be projected onto a screen.

Source: Chapter 9, Section 9.3.4 & 9.3.5

Explanation

- The key fact: object distance (6 cm) < focal length (10 cm), so the object lies **between F and O**. From Table 9.4, this always gives a virtual, erect, enlarged image on the same side as the object.
- Examiners award marks for: correct identification of object position → correct image characteristics → correct reason for screen question.
- Virtual images cannot be caught on a screen — this is the standard one-line reason required.
- For the ray diagram, show at least two rays and the image on the same side as the object (dotted lines for virtual rays).

Q25. medium exam-ready **[3]**

A ray of light enters a glass slab (refractive index 1.5) at an angle of incidence of 45°. (i) Calculate the angle of refraction inside the glass. (ii) When the ray reaches the second parallel surface of the slab, does it bend towards or away from the normal? Give a reason. (iii) How does the speed of light inside the glass compare to its speed in air?

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Model Answer

(i) Angle of Refraction:

Using Snell's law: $n = \dfrac{\sin i}{\sin r}$

$$1.5 = \frac{\sin 45^\circ}{\sin r} = \frac{0.707}{\sin r}$$

$$\sin r = \frac{0.707}{1.5} = 0.471$$

$$r = \sin^{-1}(0.471) \approx 28.1^\circ$$

(ii) At the second parallel surface, the ray goes from glass (denser) to air (rarer), so it **bends away from the normal**. A ray travelling from a denser medium to a rarer medium speeds up and bends away from the normal.

(iii) Speed of light inside glass is **less** than in air. Since $n = \dfrac{c}{v}$, and $n = 1.5 > 1$, the speed in glass $v = \dfrac{3 \times 10^8}{1.5} = 2 \times 10^8 \text{ m s}^{-1}$.

Source: Chapter 9, Sections 9.3.1 and 9.3.2

Explanation

- **Part (i):** Apply Snell's law directly. Show the substitution step — examiners award marks for working, not just the final answer.
- **Part (ii):** The key reason is denser→rarer = bends away from normal. This is a one-line conceptual answer; state the direction AND the reason.
- **Part (iii):** Use $n = c/v$ to both explain and calculate. The answer 2×10^8 m s^{-1} shows the speed is reduced to ⅔ of its value in air.

Q26. deep exam-ready **[3]**

The refractive index of medium A with respect to medium B is 2/3, and the refractive index of medium B with respect to air is 1.5. Which medium — A, B, or air — has (i) the highest optical density and (ii) the lowest optical density? Justify your answer.

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Model Answer

Given:

$n_{AB} = \frac{2}{3}, n_{B,\text{air}} = 1.5$

Finding absolute refractive index of A:

$$n_{B,\text{air}} = 1.5 \Rightarrow n_B = 1.5$$

$$n_{AB} = \frac{n_A}{n_B} = \frac{2}{3} \Rightarrow n_A = \frac{2}{3} \times 1.5 = 1.0$$

Summary of refractive indices:

- Air ≈ 1.0
- Medium A = 1.0
- Medium B = 1.5

(i) Highest optical density: Medium B, as it has the highest refractive index (1.5). A higher refractive index means greater optical density.

(ii) Lowest optical density: Air (and Medium A), both have refractive index ≈ 1.0, making them equally and least optically dense.

Source: Chapter 9, Section 9.3.2

Explanation

- The key formula used is $n_{AB} = \frac{n_A}{n_B}$, which lets you find the absolute refractive index of A.
- Examiners expect you to show the calculation of n_A clearly.
- Optical density is directly proportional to refractive index — higher refractive index = optically denser medium (as stated in the "More to Know" box).
- Note: optical density ≠ mass density. Don't confuse the two.
- If $n_A = 1.0$ exactly equals air, full credit is given for naming both as lowest; mentioning Medium A alone is also acceptable.

Q27. medium exam-ready **[3]**

An optician prescribes spectacle lenses of power +2.0 D for one eye and −0.5 D for the other. (i) What is the focal length of each lens? (ii) What type is each lens? (iii) If both lenses were placed in contact, what would be the power of the combination?

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Model Answer

(i) Focal length of each lens:

Using $P = \frac{1}{f}$, so $f = \frac{1}{P}$

- For +2.0 D: $f = \frac{1}{+2.0} = +0.5 \text{ m}$
- For −0.5 D: $f = \frac{1}{-0.5} = -2.0 \text{ m}$

(ii) Type of each lens:

- Lens with power +2.0 D is a **convex (converging) lens** (positive power).
- Lens with power −0.5 D is a **concave (diverging) lens** (negative power).

(iii) Power of combination:

$$P = P_1 + P_2 = (+2.0) + (-0.5) = +1.5 \text{ D}$$

The combination acts as a **convex lens** of power **+1.5 D**.

Source: Chapter 9, Section 9.3.8 Power of a Lens

Explanation

- The key formula is $f = 1/P$ (with f in metres and P in dioptres).
- Examiners expect you to state the **sign** and **type** of lens — positive power = convex, negative power = concave.
- For the combination, simply add powers algebraically: $P = P_1 + P_2$. Always state what type of lens the resultant power represents.
- Common mistake: forgetting to express focal length in **metres**, not centimetres.

Q28. medium exam-ready **[3]**

How does the image formed by a convex mirror change as an object is moved from infinity towards the pole of the mirror? What property of the convex mirror makes it suitable for use in shopping malls and on road bends?

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Model Answer

Change in image as object moves from infinity to pole:

When the object is at infinity, the image is formed at the focus F (behind the mirror) — it is highly diminished (point-sized), virtual and erect. As the object moves closer towards the pole, the image shifts from F towards the pole P, remains virtual and erect, but increases in size (though always diminished compared to the object). At the pole, the image is at P, same size as the object.

Property making it suitable for shopping malls and road bends:

A convex mirror has a **wider field of view** (curved outward) and always forms a **virtual, erect, and diminished** image regardless of object position. This allows a larger area to be viewed in a small mirror, making it ideal for surveillance in shopping malls and for monitoring traffic around road bends.

Source: Chapter 9, Section 9.2 — Image formation by a Convex Mirror / Uses of convex mirrors

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Explanation

- Examiners expect you to clearly state **both positions** (infinity and between infinity and pole) and the change in image (position shifts from F toward P, size increases but stays diminished).
- For the second part, the **two key properties** are: wider field of view + always erect & diminished image. Mention both for full marks.
- Table 9.2 is the direct source for image positions — memorise it.
- "Virtual and erect" must always be stated as the nature of image in a convex mirror.

Q29. medium exam-ready **[5]**

(a) State the mirror formula and define each term in it.
(b) A concave mirror has a focal length of 25 cm. An object is placed 40 cm in front of it. Find the position of the image. Is the image real or virtual?
(c) Now find the magnification. If the object is 2 cm tall, what is the height of the image? State whether the image is erect or inverted.

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Model Answer

(a) Mirror Formula:

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$

- **u** = object distance (from pole of mirror)
- **v** = image distance (from pole of mirror)
- **f** = focal length (distance of principal focus from pole)

(b) Finding image position:

Given: f = −25 cm (concave mirror), u = −40 cm

$$\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{-25} - \frac{1}{-40} = -\frac{1}{25} + \frac{1}{40} = \frac{-8+5}{200} = \frac{-3}{200}$$

$$v = -\frac{200}{3} \approx -66.7 \text{ cm}$$

The image is formed **66.7 cm in front of the mirror**. Since v is negative, the image is **real**.

(c) Magnification and image height:

$$m = -\frac{v}{u} = -\frac{(-66.7)}{(-40)} = -1.67$$

Height of image: $h' = m \times h = -1.67 \times 2 = -3.34$ cm

The image is **3.34 cm tall**. The negative sign indicates the image is **inverted**.

Source: Chapter 9, Section 9.2.4

Explanation

- Always apply sign convention: distances in front of the mirror are **negative**; concave mirror focal length is negative.
- A negative value of **v** confirms a **real image** (formed in front of the mirror).
- A negative magnification confirms the image is **inverted**; magnitude > 1 means it is **enlarged**.
- Examiners award marks separately for formula, substitution, answer, and nature of image — show each step clearly.

Q30. deep exam-ready **[5]**

(a) With the help of labelled ray diagrams, show the formation of image by a concave mirror when the object is (i) beyond C and (ii) between P and F.
(b) State the nature, position and relative size of the image in each case.
(c) A dentist uses a concave mirror to examine a tooth. The tooth is placed 2 cm from the mirror. The focal length of the mirror is 8 cm. Find the position and magnification of the image. Explain why this is suitable for the dentist's purpose.

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Model Answer

(a) Ray Diagrams:

Case (i) — Object beyond C:

```
Object C F P
↓ | | |
----[ray 1→ parallel to axis → reflects through F]
----[ray 2→ through C → reflects back along same path]
Image (between F and C, inverted, diminished)
```

Draw two rays: one parallel to the principal axis (reflects through F) and one through C (reflects back along the same path). They meet between F and C to form a real, inverted, diminished image.

Case (ii) — Object between P and F:

Draw one ray parallel to the axis (reflects through F) and one through C. The reflected rays diverge; when extended behind the mirror they meet to form a virtual, erect, enlarged image behind the mirror.

(b) Nature, position and size of image:

Position of Object	Position of Image	Size	Nature
Beyond C	Between F and C	Diminished	Real, Inverted
Between P and F	Behind the mirror	Enlarged	Virtual, Erect

(c) Calculation:

Given: u = −2 cm, f = −8 cm

Using mirror formula: $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

$$\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{-8} - \frac{1}{-2} = -\frac{1}{8} + \frac{1}{2} = \frac{3}{8}$$

$$v = +\frac{8}{3} \approx +2.67 \text{ cm}$$

Magnification: $m = -\frac{v}{u} = -\frac{+8/3}{-2} = +\frac{4}{3} \approx +1.33$

The image is virtual, erect, and magnified (m > 1). Since the tooth is between P and F, the concave mirror forms an enlarged, erect, virtual image behind the mirror, allowing the dentist to see a clear, magnified view of the tooth. This makes it very suitable for dental examination.

Source: Chapter 9, Section 9.2.1 and 9.2.2

Explanation

- **Ray diagrams**: Always use two standard rays. For concave mirror, the most convenient pair is (i) parallel to axis → reflects through F, and (ii) through C → reflects back along the same path.
- **Table 9.1** from the textbook directly gives the nature, position, and size for both cases — memorise it.
- **Part (c)**: Object at 2 cm, focal length 8 cm → object is between P and F (since $2 < 8$). Mirror formula gives a positive v, confirming a virtual image behind the mirror. Positive magnification > 1 confirms virtual, erect, enlarged image — exactly what a dentist needs to examine teeth closely.
- Sign convention: distances measured from pole; distances in direction of incident light are positive, opposite are negative. Here u and f are both negative (real object, concave mirror).

Q31. deep exam-ready **[5]**

(a) The speed of light in medium X is 2×10^8 m s^{-1} and in medium Y is 1.5×10^8 m s^{-1}. Calculate the refractive index of Y with respect to X. Which medium is optically denser?
(b) A ray of light passes from medium X into medium Y. Using Snell's law, determine whether the ray bends towards or away from the normal at the interface.
(c) A convex lens of focal length 15 cm and a concave lens of focal length 30 cm are placed in contact coaxially. (i) Find the power of each lens. (ii) Find the power and focal length of the combination. (iii) State whether the combination behaves as a converging or a diverging lens.

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Model Answer

(a)

Speed of light in X, $v_X = 2 \times 10^8$ m/s; in Y, $v_Y = 1.5 \times 10^8$ m/s

$$n_{YX} = \frac{v_X}{v_Y} = \frac{2 \times 10^8}{1.5 \times 10^8} = \frac{4}{3} \approx 1.33$$

Since $n_{YX} > 1$, **medium Y is optically denser** (higher refractive index means lower speed of light).

(b)

Since Y is optically denser than X, light slows down when passing from X into Y. According to Snell's law, the ray **bends towards the normal** at the interface.

(c)

- Convex lens: $f_1 = +15 \text{ cm} = +0.15 \text{ m} \rightarrow P_1 = \frac{1}{0.15} = +6.67 \text{ D}$
- Concave lens: $f_2 = -30 \text{ cm} = -0.30 \text{ m} \rightarrow P_2 = \frac{1}{-0.30} = -3.33 \text{ D}$

(ii) Net power: $P = P_1 + P_2 = 6.67 + (-3.33) = +3.33 \text{ D}$

Focal length of combination: $f = \frac{1}{P} = \frac{1}{3.33} \approx +0.30 \text{ m} = +30 \text{ cm}$

(iii) Since net power is **positive**, the combination behaves as a **converging (convex) lens**.

Source: Chapter 9, Sections 9.3.2 and 9.3.8

Explanation

- For refractive index of Y w.r.t. X, use $n_{YX} = v_X / v_Y$ (speed in the first medium divided by speed in the second).
- The medium with **higher refractive index = lower speed = optically denser**; light bends **towards** the normal entering a denser medium — a direct application of Snell's law logic.
- For lens powers: convex focal length is **positive**, concave is **negative**. Convert cm to metres before calculating power.
- Powers add algebraically; a positive net power → converging combination. Examiners expect all three sub-parts of (c) answered clearly with units.

Q32. deep exam-ready **[4]**

A student conducts an experiment to study image formation by a convex lens. She places a burning candle at various distances from the lens (focal length = 10 cm) and records the image position and nature on a screen. When the candle is 30 cm from the lens, she gets a sharp image on the screen. When she moves the candle to 8 cm from the lens, she cannot get an image on the screen at all but sees a magnified image when she looks through the lens from the other side.

(i) Using the lens formula, verify the image distance when the object is at 30 cm from the lens. [1 mark]
(ii) Why can the student not obtain an image on the screen when the candle is at 8 cm? Describe the nature and position of the image formed. [1 mark]
(iii) Calculate the magnification when the object is at 30 cm. Is the image erect or inverted? [1 mark]
(iv) Name one common optical instrument that uses the principle of image formation observed when the candle is at 8 cm from the lens. [1 mark]

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Model Answer

(i) Given: u = −30 cm, f = +10 cm

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{v} = \frac{1}{10} + \frac{1}{(-30)} = \frac{3-1}{30} = \frac{2}{30}$$

$$v = +15 \text{ cm}$$

The image is formed 15 cm on the other side of the lens. ✓

(ii) The candle is at 8 cm, which is **between the focus and the optical centre** (f = 10 cm). A convex lens forms a **virtual, erect and magnified** image on the **same side as the object** in this case. Since the image is virtual, it cannot be collected on a screen.

(iii)

$$m = \frac{v}{u} = \frac{+15}{-30} = -0.5$$

The image is **inverted** (negative magnification) and diminished.

(iv) A **magnifying glass (simple microscope)** uses this principle (object placed between F and O of a convex lens).

Source: Chapter 9, Sections 9.3.4 and 9.3.7

Explanation

- **(i)** Always apply sign convention: u is negative (object on left), f is positive for convex lens. Show the substitution step clearly for full marks.
- **(ii)** The key idea from Table 9.4 is: object between F_1 and O → virtual, erect, magnified image on the same side. "Virtual" means no screen image — examiners look for this reason explicitly.
- **(iii)** m = v/u directly. Negative m means inverted image. At 30 cm (between F and 2F), the image is real, inverted, and diminished — check this matches Table 9.4 ("between F_1 and $2F_1$ → beyond $2F_2$, enlarged"; here object is at 2F so image is at 2F, same size — but with u=30 cm > 2f=20 cm, object is beyond 2F, so image is diminished. m = −0.5 confirms this).

- **(iv)** Magnifying glass is the standard one-word answer expected here. A compound microscope's eyepiece also works but magnifying glass is safer for 1 mark.

Q33. medium exam-ready **[4]**

A physics teacher demonstrates an experiment with a concave mirror of focal length 15 cm. She places a lighted candle at four different positions: (a) 40 cm, (b) 30 cm, (c) 15 cm, and (d) 10 cm from the mirror. She asks students to predict the nature, position and size of the image in each case.

(i) For object distance 40 cm, what is the image distance? Is the image real or virtual? [1 mark]
(ii) At which of the four positions will the image be the same size as the object? [1 mark]
(iii) At which position will no image be formed on the screen? Why? [1 mark]
(iv) For object distance 10 cm, state the nature and approximate position of the image. [1 mark]

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Model Answer

(i) Using mirror formula: f = −15 cm, u = −40 cm

$$\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{-15} - \frac{1}{-40} = \frac{-8+3}{120} = \frac{-5}{120}$$

∴ v = −24 cm. The image is formed **24 cm in front** of the mirror. It is **real and inverted**.

(ii) The image is the **same size as the object** when the object is placed **at C (centre of curvature)**, i.e., at **30 cm** (= 2f) from the mirror.

(iii) When the candle is placed **at F (15 cm)**, no image is formed on the screen. This is because the reflected rays become **parallel to the principal axis** and meet only at infinity.

(iv) Object at 10 cm is **between P and F**. The image is formed **behind the mirror**, is **virtual, erect and enlarged**.

Source: Chapter 9, Section 9.2.1 (Table 9.1) and Section 9.2.4

Explanation

- **(i)** Apply the mirror formula with sign convention (concave mirror: f negative, object distance negative). v = −24 cm confirms real image (negative v in concave mirror context).
- **(ii)** Table 9.1 directly states: object at C → image at C, same size. C = 2f = 30 cm.
- **(iii)** Object at F → reflected rays are parallel → image at infinity → no image on screen. Examiners expect the reason about parallel rays.
- **(iv)** Object between P and F → virtual, erect, enlarged image behind mirror. This is the standard result from Table 9.1. No calculation needed for 1 mark.

Q34. medium exam-ready **[4]**

Riya is reading about refraction and comes across a table of refractive indices. She notes: air (1.0003), water (1.33), kerosene (1.44), crown glass (1.52) and diamond (2.42). She also reads that refraction is caused by the change in speed of light as it moves from one medium to another.

(i) In which of the listed media does light travel at the lowest speed? Justify your answer. [1 mark]
(ii) Riya notices that kerosene has a higher refractive index than water. Does this mean kerosene is also more mass-dense than water? Explain. [1 mark]
(iii) A light ray travels from water into crown glass. Does it bend towards or away from the normal? Give a reason. [1 mark]
(iv) If the speed of light in vacuum is 3×10^8 m s^{-1}, calculate the speed of light in crown glass. [1 mark]

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Model Answer

(i) Light travels at the lowest speed in **diamond** (n = 2.42). Higher refractive index means lower speed of light in the medium ($n = c/v$), so the highest n gives the lowest v.

(ii) No. Optical density (refractive index) is not the same as mass density. Kerosene is *optically* denser than water (higher n), but its mass density is actually less than that of water.

(iii) The light bends **towards the normal**. Crown glass (n = 1.52) is optically denser than water (n = 1.33). When light travels from a rarer to a denser medium, it slows down and bends towards the normal.

(iv)

$$n = \frac{c}{v} \implies v = \frac{c}{n} = \frac{3 \times 10^8}{1.52} \approx 1.97 \times 10^8 \text{ m s}^{-1}$$

Source: Light – Reflection and Refraction, Section 9.3.2

Explanation

- **(i)** The key formula is $n = c/v$; highest n → lowest v. Diamond has n = 2.42, the highest in the table.
- **(ii)** The textbook explicitly states: "an optically denser medium may not possess greater mass density" and uses kerosene vs water as the exact example. Quote or paraphrase this directly.
- **(iii)** Compare refractive indices: water (1.33) < crown glass (1.52), so water is rarer. Rarer → denser means bending towards the normal.
- **(iv)** Straightforward formula application. Show the formula, substitution, and answer with units. $3 \times 10^8/1.52 \approx 1.97 \times 10^8$ m s^{-1} is the expected result.

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