Solutions

Multiple choice questions

Example 1 1982 Question 34, 64%

The light bends away from the normal as it goes from X to Y, therefore, $n_X > n_Y$.
The light bends towards the normal as it goes from Y to Z, therefore, $n_Z > n_Y$.
Comparing the angles in X and Y, the light bends away from the normal, therefore, $n_X > n_Z$.

$\therefore n_X > n_Z > n_Y$

$\therefore$ **C (ANS)**

Example 2 1982 Question 35, 70%

Since $n_X > n_Z$, the ray will bend away from the normal. The original effect of material Y was just to translate the beam to the right, the final angle will remain the same.

$\therefore$ **D (ANS)**

Example 3 QLD 2012 Question 9

Use $n_1v_1 = n_2v_2$

$\therefore n_{air}v_{air} = n_{diamond}v_{diamond}$

$\therefore 1.0 \times 3.0 \times 10^8 = n_{diamond} \times 124000 \times 10^3$

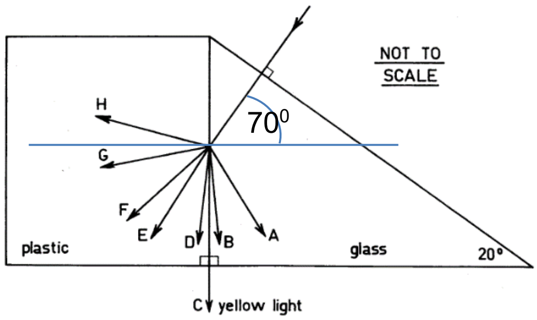
$$\therefore n_{diamond} = \frac{3.0 \times 10^8}{1.24 \times 10^8}$$

$\therefore n_{diamond} = 2.419$

$\therefore$ **C (ANS)**

Example 4 1973 Question 47, 38%

If the plastic block is replaced by quartz, then the higher refractive index for quartz means that the light will now bend towards the normal as it goes from the glass into the quartz.



Use

$\therefore$ 1.50 sin 70 = 1.54 × sin r

$\therefore$ 1.50 × 0.9397 = 1.54 × sin r

$\therefore \sin r = \dfrac{1.50 \times 0.9397}{1.54}$

$\therefore$ sin r = 0.9153

$\therefore r = 43^0$

$\therefore$ F (ANS)

G was also possible as the ray had to bend towards the normal, but the arithmetic didn't justify.

Example 5 1971 Question 62, 29%

The blue light will totally internally reflect. The angle of reflection will be the same as the angle of incidence.

$\therefore$ A (ANS)

Example 6 1970 Question 48, 80%

The light is travelling through liquid 1, then glass, then liquid 1. It will come out parallel to the incident beam, having diffracted on entering the glass. Since $n_{Glass} > n_{Liqid\ 1}$, the light will bend towards the normal in the glass block

$\therefore$ C (ANS)

Example 7 1970 Question 49, 88%

Liquid 2 has the same refractive index as glass, so the light won't diffract on entering or leaving the block.

$\therefore$ A (ANS)

Example 8 1970 Question 50, 66%

On entering the block, the light is going from air to glass. On leaving the block, the light is going from glass to Liquid 3.

On entering the block, the light will bend towards the normal, and on leaving the block the light will also bend towards the normal, as it is still going from a low n to a higher n.

$\therefore$ D (ANS)

Example 9 QLD 2013 Question 9

Use c = fλ and v = fλ to find the speed in the medium. The frequency remains constant.

$\therefore \dfrac{v}{c} = \dfrac{450}{510}$

$\therefore v = 0.8824 \times 3.0 \times 10^8$

$\therefore v = 2.65 \times 10^8$

$\therefore$ C (ANS)

Example 10 1967 Question 59, 67%

The frequency of the light does not change as it moves from one medium to another, there is still the same number of waves per second.

$\therefore$ A (ANS)

Example 11 1967 Question 60, 79%

The speed of light is a maximum in a vacuum. Therefore it must slowdown in all other medium. *n* is always greater than 1, therefore $\dfrac{c}{n}$ will be less than *c*.

$\therefore$ A (ANS)

Example 12   2010 Question 5, 78%

Use $n_1 \sin i = n_2 \sin r$

$\therefore 1.44 \sin i_c = 1.38 \times \sin 90$

$\therefore 1.44 \sin i_c = 1.38 \times \sin 90$

$\therefore \sin i_c = \frac{1.38}{1.44}$

$\therefore i_c = 73.4^o$

$\therefore$ **D (ANS)**

Example 13   2009 Question 7, 75%

Use $n_{core} \sin i_c = n_{cladding} \sin 90^0$

$\therefore 1.36 \times \sin 80^0 = n_{cladding} \times 1$

$\therefore n_{cladding} = \frac{1.36 \times \sin 80^0}{1.0}$

$\therefore n_{cladding} = \frac{1.34}{1.0}$

$\therefore n_{cladding} = 1.34$

$\therefore$ **B (ANS)**

Example 14   2007 Question 5, 83%

Use $n_{core} \sin i_c = n_{cladding} \sin 90^0$

$\therefore 1.46 \times \sin i_c = 1.43 \times 1$

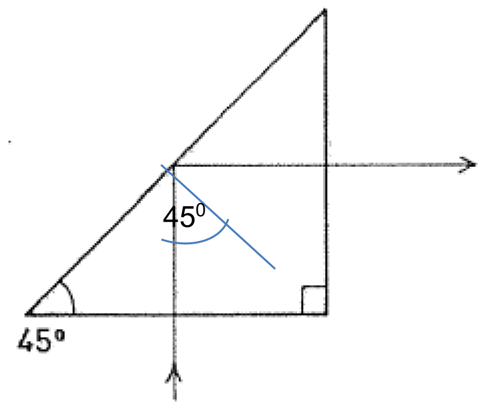
$\therefore \sin i_c = \frac{1.43}{1.46}$

$\therefore i_c = 78.4^0$

$\therefore$ **D (ANS)**

Example 15 1967 Question 55, 37%

The plastic is surrounded by air, and TIR is required.
Use $n_1 \sin i = n_2 \sin 90$



$\therefore n_1 \sin 45 = 1.0 \times \sin 90$

$\therefore n_1 \times 0.7071 = 1$

$\therefore n_1 = \frac{1}{0.7071}$

$\therefore n_1 = 1.414$

$\therefore$ **D (ANS)**

$\therefore$ **B (ANS)**

Example 16 1974 Question 51, 50%

For Total Internal Reflection (TIR) to occur the wave needs to be travelling from a high refractive index to a lower refractive index, so that it bends away from the normal.

Example 17 2004 Pilot Sample Qu 5,

The light bends towards the normal as goes from air to n_1. $\therefore n_1 > n_{air}$. The light totally internally reflects when it reaches the cladding, therefore $n_2 < n_1$. (It only shows TIR when going from high to low refractive index).

$\therefore$ **D (ANS)**

Example 18 2004 Pilot Sample Qu 7,

The green light will refract more than the red light. The angle that takes in n_1 will be less, therefore it will meet the cladding to the right of the point P.

$\therefore$ **D (ANS)**

Example 19 1976 Question 53, 69%

The white light will disperse as it enters the prism, this will cause the refracted rays to exit the prism at different angles. The red light will bend less.

$\therefore$ **A (ANS)**

Example 20 1985 Question 35, 60%

The blue light will bend more than red light on entering the prism. Therefore when it leaves the prism it will pass through X.

$\therefore$ **A (ANS)**

Example 21 QLD 2011 Question 14

Use $E = \frac{hc}{\lambda}$ to get

$\therefore E = \frac{6.63 \times 10^{-34} \times 3.0 \times 10^{8}}{450 \times 10^{-9}}$

$\therefore E = 4.42 \times 10^{-19}$

$\therefore$ **C (ANS)**

Example 22 NSW 2001 Question 6

Use $E = \frac{hc}{\lambda}$ to get

$\therefore E = \frac{6.63 \times 10^{-34} \times 3.0 \times 10^{8}}{3.5 \times 10^{-2}}$

$\therefore E = 5.6829 \times 10^{-24}$ J

$\therefore$ **B (ANS)**

Example 23 2009 Question 5, 80%

Use $E = \frac{hc}{\lambda}$ to get

$\lambda = \frac{hc}{E}$

$\therefore \lambda = \frac{4.14 \times 10^{-15} \times 3.0 \times 10^{8}}{2.30}$

$\therefore \lambda = 5.4 \times 10^{-7}$ m

$\therefore \lambda = 540$ nm

$\therefore$ **B (ANS)**

Example 24 2009 Question 6, 61%

If the voltage is increased, the voltage across the LED will remain constant, (and hence the wavelength of the light emitted by the LED will remain constant), so the voltage across the resistor will increase. This will lead to an increase in the current.

$\therefore$ **C (ANS)**

Example 25 NSW 2005 Question 14

Use E = hf

$\therefore E = 6.626 \times 10^{-34} \times 102.8 \times 10^{6}$

$\therefore E = 6.8115 \times 10^{-26}$

$\therefore$ **B (ANS)**

Example 26 NSW 2016 Question 11

Use $E = \frac{hc}{\lambda}$ to get $\lambda = \frac{hc}{E}$

$\therefore \lambda = \frac{4.14 \times 10^{-15} \times 3.0 \times 10^{8}}{3.5}$

$\therefore \lambda = 3.549 \times 10^{-7}$ m

$\therefore \lambda = 3.5 \times 10^{-7}$

$\therefore$ **B (ANS)**

Example 27 2010 Question 1, 61%

The laser produces coherent light. Sources that primarily relay on heating to excite that atoms will give incoherent light, as the process is random.

$\therefore$ **C (ANS)**

Example 28 2010 Question 4, 37%

The blue LED requires a lrger potential drop across it, so the potential drop across the resistor will decrease. Using V = iR, if V across the resistor is less, then the current will be less.

$\therefore$ **C (ANS)**

Example 29 2009 Question 2, 57%

Light is produced in incandescent bulbs by photons being emitted as a result of the heat produced by a current through a resistor.

∴ **C (ANS)**

Example 30 2009 Question 1, 61%

The incandescent light globe is broad spectrum, the Led has only one colour, and the mercury vapour lamp will have several emission peaks.

∴ **C (ANS)**

Example 31 2009 Question 3, 50%

As the electrons in the higher energy conduction band recombine with the holes in the lower energy valence band they release energy in the form of photons.

∴ **A (ANS)**

Example 32 2009 Question 4, 79%

The light emitted from a laser has a very narrow spread of frequencies when compared with light from an LED

∴ **D (ANS)**

Example 33 2008 Question 2, 72%

Use $E = \frac{hc}{\lambda}$ to get $\lambda = \frac{hc}{E}$

$\therefore \lambda = \frac{4.14 \times 10^{-15} \times 3.0 \times 10^{8}}{1.80}$

$\therefore \lambda = 6.9 \times 10^{-7}$ m

$\therefore \lambda = 690$ nm

∴ **B (ANS)**

Example 34 2008 Question 3, 80%

The light from a laser is coherent, the light from a LED is non-coherent. The laser will produce light with a narrow range of wavelengths

∴ **C (ANS)**

Example 35 2008 Question 4, 67%

The laser has a source of atoms that are excited to metastable states (particular excited state of an atom that has a longer lifetime than the ordinary excited states) by an external source of energy. When most of the atoms are excited, a single photon from an atom that undergoes de-excitation can start a chain reaction. This photon strikes another atom, stimulating it into emission, and so on, producing coherent light.

∴ **C (ANS)**

Example 36 2006 Question 2, 83%

Use $E = \frac{hc}{\lambda}$

$\therefore E = \frac{4.14 \times 10^{-15} \times 3.0 \times 10^{8}}{5.8 \times 10^{-7}}$

$\therefore E = 2.14$

∴ **A (ANS)**

Example 37 2007 Question 4, 2 marks

The red LED will require less energy to excite the electrons up to a higher energy state, so the voltage drop across the red LED will be less. This means that the voltage drop across the resistor must increase, (the two elements are in parallel and the supply voltage remains constant) therefore the current in the circuit must increase.

$\therefore$ **A (ANS)**

Example 38 2006 Question 3, 74%

Decreasing value of band gap, means decreasing energy, which means increasing wavelength.

$\therefore$ **A (ANS)**

Example 39 2004 Pilot Sample Qu 2,

The electric stove element will have a lot more red than sunlight. $\therefore$ B
The blue theatre light will have a much smaller range of wavelengths, with shorter wavelengths (when compared with sunlight). $\therefore$ A
The sodium vapour lamp will have discrete wavelengths in the yellow region. $\therefore$ C

Extended response answers

Example 40 2019 NSW Question 25

Maxwell argued that a changing electric field induced a changing magnetic field, also that a changing magnetic field induced a changing electric field (Faraday's law)

He linked these two ideas and proposed that the changing electric and magnetic fields wil produce each other in a propagating wave. (EM wave)

He determined that the speed of the EM wave would be the speed of light, c.

To create an electromagnetic wave the electric field and magnetic field must both change. This is achieved by an accelerating electric charge. An oscillating charge will produce EM waves as the charge continuously accelerates during the oscillation. The change in position of the charge produces a changing electric field, and the change in velocity of the charge produces a changing current and hence a changing magnetic field. The fields then continue to generate each other.

Example 41 2019 TAS Question 15a

Use $n_1\sin(i) = n_2 \sin(r)$

$\therefore 1.0 \times \sin 60 = 1.331 \times \sin(r)$

$\therefore \sin(r) = \frac{0.866}{1.331}$

$\therefore r = 40.6$

$\therefore$ **r = 41^0 (ANS)**

Example 42 2019 TAS Question 15b i

Use $n_1\sin(i) = n_2 \sin 90$

$\therefore 1.331 \times \sin i = 1.0 \times 1.0$

$\therefore \sin i = \frac{1.0}{1.331}$

$\therefore r = 48.7$

$\therefore$ **r = 49^0 (ANS)**

Example 43 2019 TAS Question 15b ii

Using the centre of the circle and the points A and B, the triangle formed is isosceles. Therefore the incident angle at B = 41^0, from part a.

This is less than the critical angle so red light will not TIR at point B.

Example 44 2019 TAS Question 15c

The reflection at point B, will have the same angle of reflection as the incident angle. Since OBC is an isosceles triangle the angle at C will be 40.6^0.

Use $n_1 \sin(i) = n_2 \sin(r)$

$\therefore$ 1.331 × sin 40.6 = 1.0 × sin(r)

$\therefore$ sin(r) = 1.331 × 0.651

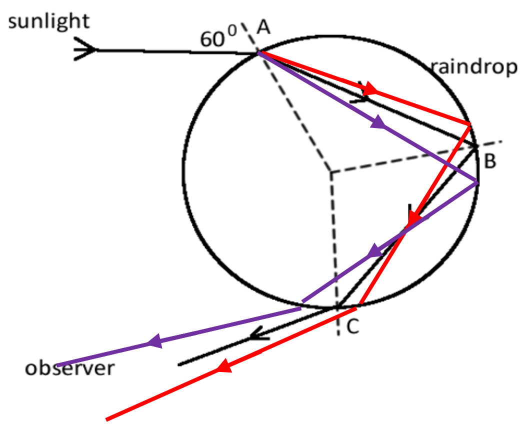
$\therefore$ sin(r) = 0.866

$\therefore$ r = 60

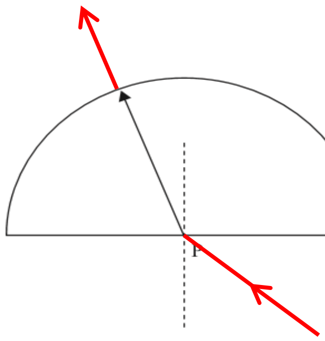
$\therefore$ **r = 60^0 (ANS)**

Example 45 2019 TAS Question 15d

This question is a little vague. I'm not sure what the black line is representing. A reasonable answer is to show the difference between the red and the blue,



Example 46   2018 QLD Question 2



The light will bend towards the normal on entering the block with a higher refractive index. The ray will not deviate on leaving the block, because it is a radial line, travelling from the centre of the 'circle' to the circumference, hence it is perpendicular to the circumference. Therefore the angle of incidence (on exiting the glass block) is zero.

Example 47   1985 Question 36, 59 %

The marker is not visible, as light from it totally internally reflects.
The critical angle occurs when d = 50 cm, this means that $\theta_c = 45^0$
Use $n_L \sin i_c = n_{air} \sin 90$

$\therefore n_L \sin 45 = 1.0 \times \sin 90$

$\therefore n_L \times 0.7071 = 1$

$\therefore n_L = \dfrac{1}{0.7071}$

$\therefore$ **n_L = 1.4 (ANS)**

Example 48   1985 Question 37, 63%

Use $n_{Air} \sin i_{air} = n_{water} \sin 45$

$\therefore 1.0 \times \sin \theta = 1.3 \times \sin 45$

$\therefore \sin \theta = 0.9192$

$\therefore \theta = 66.82^0$

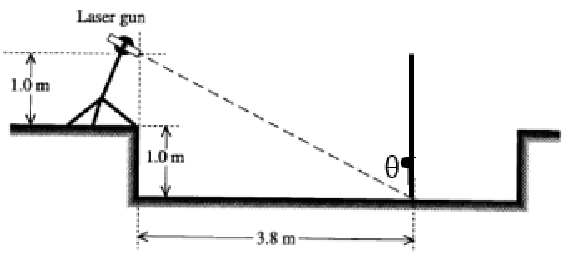
$\therefore$ **$\theta = 67^0$ (ANS)**

Example 49   1991 Question 30

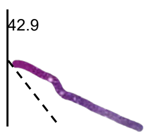
The initial angle of incidence is given by

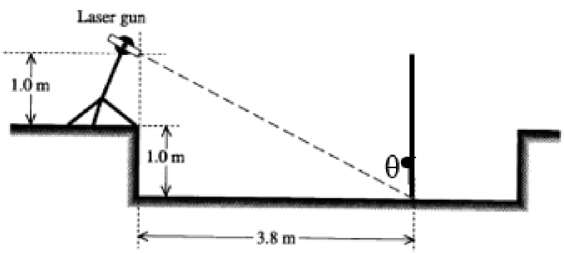
$\tan\theta = \dfrac{3.8}{2}$

$\therefore \theta = 62.2^0$



With the water in the pool the light will bend towards the normal on entry.





Use $n_{Air} \sin i_{air} = n_{water} \sin r_{water}$

$\therefore$ $1.0 \times \sin 62.2 = 1.3 \times \sin r_{water}$

$\therefore$ $r_{water} = 42.9^0$

Use $\tan 42.9 = \frac{opp}{adj}$

$\therefore$ $\tan 42.9 = \frac{x}{1}$

$\therefore$ $x = 0.929$

Therefore the beam will hit 1.9 + 0.93 m from the edge.

$\therefore$ **2.83 m (ANS)**

Example 50 1991 Question 31

When the light enters the water it slows down, and the wavelength shortens. The frequency remains unchanged.

$\therefore$ **D (ANS)**

Example 51 2004 Pilot Sample Qu 6,

Use $n_{air} \sin 9^0 = n_1 \sin 6^0$

$\therefore$ $1 \times 0.1564 = n_1 \times 0.1045$

$\therefore$ $n_1 = 1.4967$

$\therefore$ $\mathbf{n_1 = 1.50}$ **(ANS)**

Example 52 1982 Question 36, 61%

Use $n_X v_X = n_Z v_Z$ to get

$\mathbf{v_Z = \frac{n_X v}{n_Z}}$ **(ANS)**

Example 53 1974 Question 48, 79%

Use $\frac{\sin i}{\sin r} = \frac{n_2}{n_1} = \frac{v_1}{v_2}$.

In this case we are not given v_1 and v_2. The time between adjacent crests is the same, so $\frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2}$

$\therefore \frac{\sin i}{\sin r} = \frac{\lambda_1}{\lambda_2}$

$\therefore \frac{\sin i}{\sin r} = \frac{5}{4}$

$\therefore$ **1.3 (ANS)**

Example 54 1974 Question 49, 79%

The frequency of the light does not change as it moves from one medium to another, there is still the same number of waves per second.

$\therefore$ **1 (ANS)**

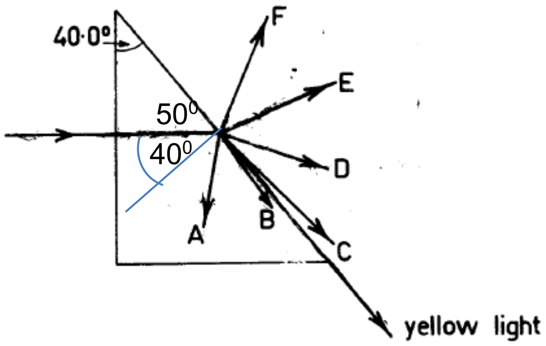
Example 55 1974 Question 50, 83%

Use $\frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2}$

$\therefore \frac{v_1}{v_2} = \frac{5}{4}$

$\therefore$ **1.3 (ANS)**

Example 56 1971 Question 63, 40%



Use $n_1 \sin i = n_2 \sin 90$

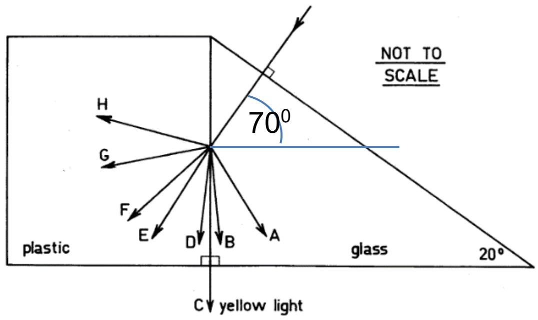
$\therefore n_{GY} \sin 40 = 1.0 \times \sin 90$

$\therefore n_{GY} \times 0.6428 = 1$

$\therefore n_{GY} = \frac{1}{0.6428}$

$\therefore$ **n_{GY} = 1.56 (ANS)**

Example 57 1973 Question 46, 47%



For TIR, the light needs to travel from a high refractive index to a lower refractive index, and $n_G \sin i = n_P \sin 90$

$\therefore 1.50 \sin 70 = n_P \times \sin 90$

$\therefore 1.50 \times 0.9397 = n_P$

$\therefore$ **n_L = 1.41 (ANS)**

Example 58 1991 Question 32

The angle of incidence on both sides is 45^0 Use $n_{prism} \sin 45 = n_{air} \sin 90$

$\therefore n_{prism} \sin 45 = 1.0 \times \sin 90$

$\therefore n_{prism} \times 0.7071 = 1$

$\therefore n_{prism} = \frac{1}{0.7071}$

$\therefore$ **n_{prism} = 1.4 (ANS)**

Example 59 2006 Question 11, 52%

Water has a greater refractive index than air. ∴total internal reflection can occur at the interface of water and air in the stream. When the angle of incidence of the laser beam is greater than the critical angle TIR will occur.

Example 60/61

2004 Pilot Question 5a/5b, 47%

Since the refractive index of the fluid is greater than that of the plastic, then less light will totally internally reflect (this only happens when the light is travelling from high refractive index to lower refractive index), so more light is likely to “escape” the plastic.

Example 62 1994 Question 1

If the power of the two sources is the same, then the energy per second from each is the same. The energy is given by $E = \frac{hc}{\lambda}$, therefore the UV photons will have three times the energy of the red photons. Therefore there will need to be three times as many red photons and UV photons.

∴ **3 (ANS)**

Example 63 1994 Question 2

Use $E = \frac{hc}{\lambda}$ to get

$\therefore E = \frac{6.63 \times 10^{-34} \times 3.0 \times 10^{8}}{200 \times 10^{-9}}$

$\therefore E = 9.945 \times 10^{-19}$

$\therefore$ **$E = 9.9 \times 10^{-19}$ J (ANS)**

Example 64 1998 Question 4, 38%

Use $E = \frac{hc}{\lambda}$ to get

$\therefore E = \frac{6.63 \times 10^{-34} \times 3.0 \times 10^{8}}{640 \times 10^{-9}}$

$\therefore E = 3.107 \times 10^{-19}$

$\therefore$ **$E = 3.1 \times 10^{-19}$ J (ANS)**

Example 65 1998 Question 5, 25%

A power of 1.0 mW means 1.0×10^{-3} joules per second.
Therefore: (number of photons per second) × (energy per photon) = 1.0×10^{-3}

$\therefore n \times 3.1 \times 10^{-19} = 1 \times 10^{-3}$

$\therefore n = 3.2 \times 10^{15}$ photons per second.

$\therefore$ **3.2×10^{15} (ANS)**

Example 66 1999 Question 2, 64%

The energy of a photon is given by $E = \frac{hc}{\lambda}$.

$\therefore$ the energy of each photon $= \frac{4.14 \times 10^{-15} \times 3 \times 10^{8}}{254 \times 10^{-9}}$

= 4.89 eV

∴ **4.9 eV (ANS)**

Example 67 2000 Question 3, 61%

Use $E = \frac{hc}{\lambda}$

$\therefore E = \frac{4.14 \times 10^{-15} \times 3.0 \times 10^{8}}{450 \times 10^{-9}}$

$\therefore$ **E = 2.76 eV (ANS)**

Example 68 2002 Question 1, 44%

Use $E = \frac{hc}{\lambda}$ $\therefore \lambda = \frac{hc}{E}$

$\therefore \lambda = \frac{4.14 \times 10^{-15} \times 3 \times 10^{8}}{70000}$

$\therefore$ **λ = 1.77 × 10^{-11} m (ANS)**

Example 69 2007 Question 7, 64%

Use $E = \frac{hc}{\lambda}$

$\therefore E = \frac{4.14 \times 10^{-15} \times 3.0 \times 10^{8}}{0.120 \times 10^{-9}}$

$\therefore$ E = 10 350 eV

$\therefore$ **E = 10.4 keV (ANS)**

Example 70 2004 Question 1, 68%

The energy of a photon is given by $E = \frac{hc}{\lambda}$.

$\therefore$ the energy of each photon

$= \frac{4.14 \times 10^{-15} \times 3.00 \times 10^{8}}{550 \times 10^{-9}}$

$\therefore$ **2.26 eV (ANS)**

Example 71 2005 Question 1, 70%

coherent,
a population inversion
photons of the same (ANS)

Example 72 2007 Question 2, 50%

A LED emits light from the energy being released when electrons drop from a higher allowed energy state to a lower one. The energy is given off as a photon. The colour of the emitted light depends on the difference between the energy state levels. The blue LED requires 2.64 V to rise the electrons to the next energy level so that photons (light) can be emitted.

Example 73 2007 Question 3, 46%

Use $E = \frac{hc}{\lambda}$ to get

$$\lambda = \frac{hc}{E}$$

$$\therefore \lambda = \frac{4.14 \times 10^{-15} \times 3.0 \times 10^{8}}{2.64}$$

$\therefore$ **$\lambda = 4.7 \times 10^{-7}$ m (ANS)**

Example 74 2006 Question 4, 57%

More intense,
Coherent,
Basically monochromatic,
More directional.

Example 75 2005 Question 3, 45%

Diode material has a specific energy gap between allowable levels, when electrons transition between the levels, (from higher to lower) they release a photon of this energy difference.

Example 76 2005 Question 4, 70%

Use $E = \frac{hc}{\lambda}$ to get

$$\lambda = \frac{hc}{E}$$

$$\therefore \lambda = \frac{4.14 \times 10^{-15} \times 3.0 \times 10^{8}}{2.1}$$

$\therefore$ **$\lambda = 5.9 \times 10^{-7}$ m (ANS)**

Example 77 2004 Pilot Question 1

This is a lot of recall, with a few ideas underpinning it. The more red, the more heat, and less light.
All sources are broad spectrum.
Source 1 looks like the sun.
Source 2 looks like a 100 W incandescent globe and
Source 3 looks even hotter, with less blue, so a candle.

Example 78 2004 Pilot Sample Qu 1,

Laser light is produced by stimulated emission from excited atoms and thus the light is **coherent** and in **phase**. The light from the incandescent source will be **incoherent** and not **in phase**.
The **wavelength** of the red light from both sources is roughly the same, except the beam from the incandescent lamp might still have a narrow range of **wavelengths**.

Example 79 2018 QLD Question 6 i

Use $n_1\sin(i) = n_2 \sin(j)$,
and $n_2\sin(k) = n_1 \sin(i')$

and j = k, as they are alternate angles.

$\therefore n_2 \sin(j) = n_2\sin(k)$
$\therefore n_1\sin(i) = n_1 \sin(i')$
$\therefore i = i'$

Therefore the incident and emerging rays are parallel.

2018 QLD Question 6 ii

Use $n_1\sin(i) = n_2 \sin(j)$, as i' = i = 32^0

$\therefore$ 1.0 × sin 32 = 1.55 × sin j

$\therefore \sin j = \frac{\sin 32}{1.55}$

$\therefore$ sin j = 0.3419

$\therefore j = 20^0$

$\therefore$ α = 32 – 20

$\therefore α = 12^0$

Find length AB,

Use $\cos 20 = \frac{w}{AB}$

$\therefore AB = \frac{w}{\cos 20}$

$\therefore AB = \frac{3}{\cos 20}$

$\therefore$ AB = 3.1925

Use △ AOB to find OB

$\sin 12 = \frac{OB}{AB}$

$\therefore$ OB = AB × sin 12

$\therefore$ OB = 3.1925 × 0.2079

∴ OB = 0.66 cm (ANS)