

# Weird Chemist

## Electromagnetic Waves — DPP-2 Solutions

Chapter: Structure of Atom

“Formula yaad karo, unit check karo, phir solve karo — in teen steps mein 90% questions seedha ho jaate hain.”

### Key Formulae for This DPP

- Speed of light:  $c = \nu\lambda \Rightarrow \lambda = \frac{c}{\nu}$
- Wave number:  $\bar{\nu} = \frac{1}{\lambda}$  (in  $\text{cm}^{-1}$ , always convert  $\lambda$  to cm first)
- Time of travel:  $t = \frac{d}{c}$  (frequency is irrelevant for travel time)
- $c = 3 \times 10^8 \text{ m/s} = 3 \times 10^{10} \text{ cm/s} = 3 \times 10^{17} \text{ nm/s}$
- EM spectrum order (increasing frequency / decreasing wavelength):  
Radio < Microwave < Infrared < Visible < UV < X-rays < Gamma rays

### TYPE 1 : Wavelength, Frequency and Wave Number

**Q.1** AIR broadcasts at 1368 kHz. Find wavelength.

[NEET 2021]

#### Explanation

Given:  $\nu = 1368 \text{ kHz} = 1368 \times 10^3 \text{ Hz} = 1.368 \times 10^6 \text{ s}^{-1}$ ,  $c = 3.0 \times 10^8 \text{ m s}^{-1}$

$$\lambda = \frac{c}{\nu} = \frac{3.0 \times 10^8}{1.368 \times 10^6} = \frac{3.0}{1.368} \times 10^2 = 2.193 \times 10^2 \text{ m} \approx 219.3 \text{ m}$$

#### Concept

The only formula needed here is  $\lambda = c/\nu$ . The entire task reduces to a unit conversion: convert kHz to Hz (multiply by  $10^3$ ), then divide into  $c$ . Everything else is arithmetic.

#### Answer

**Option (1): 219.3 m**

#### Common Student Mistake

Students forget to convert kHz to Hz and directly use 1368, giving  $\lambda \approx 2.19 \times 10^5 \text{ m}$  — which matches no option, causing confusion. Always convert to base SI unit (Hz) before plugging in.

**Q.2** Station 1: 1120 kHz, Station 2: 98.7 MHz. Find both wavelengths.

### Explanation

**Station 1:**  $\nu_1 = 1120 \times 10^3 \text{ Hz} = 1.120 \times 10^6 \text{ Hz}$

$$\lambda_1 = \frac{3.0 \times 10^8}{1.120 \times 10^6} = 267.86 \text{ m}$$

**Station 2:**  $\nu_2 = 98.7 \times 10^6 \text{ Hz} = 9.87 \times 10^7 \text{ Hz}$

$$\lambda_2 = \frac{3.0 \times 10^8}{9.87 \times 10^7} = \frac{3.0}{9.87} \times 10^1 \approx 3.04 \text{ m}$$

### Concept

Two separate applications of  $\lambda = c/\nu$ . Key step is correctly converting the prefix: **k** (kilo) =  $10^3$ , **M** (Mega) =  $10^6$ . Get this right and the rest is straightforward division.

### Answer

**Option (1): 267.86 m and 3.04 m**

### Common Student Mistake

A common error is treating MHz as  $10^3$  instead of  $10^6$ , or confusing the two stations' answers and reporting them in swapped order. Label Station 1 and Station 2 clearly in your working.

### Q.3 Speed of electromagnetic radiation through vacuum is:

#### Explanation

All electromagnetic waves — radio, microwave, infrared, visible, UV, X-rays, gamma rays — travel through vacuum at the same speed:

$$c = 3.00 \times 10^8 \text{ m s}^{-1}$$

This is a fundamental constant. It does **not** depend on wavelength or frequency in vacuum. (Speed does change in a medium, but not in vacuum.)

#### Concept

Option (1): 186000 m/s is actually 186000 *miles/s* — the value of  $c$  in imperial units, not SI. Option (4) is wrong because wavelength-dependence (dispersion) only occurs in a medium, not in vacuum.

#### Answer

**Option (3):  $3.00 \times 10^8 \text{ m/s}$**

### Q.4 Time for radio wave ( $\nu = 6 \times 10^3 \text{ s}^{-1}$ ) to travel $8 \times 10^7 \text{ km}$ from Mars to Earth?

### Explanation

Time =  $\frac{\text{distance}}{\text{speed}}$ . The frequency is irrelevant — all EM waves travel at  $c$  in vacuum.

Convert distance:  $d = 8 \times 10^7 \text{ km} = 8 \times 10^{10} \text{ m}$

$$t = \frac{d}{c} = \frac{8 \times 10^{10}}{3 \times 10^8} = \frac{8}{3} \times 10^2 \approx 2.66 \times 10^2 \text{ s}$$

### Concept

The frequency  $6 \times 10^3 \text{ s}^{-1}$  is deliberately given as a distractor. Time of travel depends only on distance and speed —  $t = d/c$ . Never bring frequency into a travel-time calculation.

### Answer

**Option (1):**  $2.66 \times 10^2 \text{ s}$

### Common Student Mistake

Many students try to use frequency somehow (e.g.  $t = 1/\nu$  or  $\lambda/\nu$ ) and get a completely wrong answer. Travel time has nothing to do with frequency. Also, forgetting to convert km to m gives  $t$  off by a factor of 1000.

**Q.5**  $h = 6.63 \times 10^{-34} \text{ J s}$ ,  $c = 3 \times 10^{17} \text{ nm s}^{-1}$ ,  $\nu = 6 \times 10^{15} \text{ s}^{-1}$ . Find  $\lambda$  in nm.

### Explanation

Use  $\lambda = \frac{c}{\nu}$  directly. Note that  $c$  is already given in  $\text{nm s}^{-1}$ , so the answer will directly be in nm.

$$\lambda = \frac{3 \times 10^{17} \text{ nm s}^{-1}}{6 \times 10^{15} \text{ s}^{-1}} = \frac{3}{6} \times 10^2 \text{ nm} = 0.5 \times 10^2 \text{ nm} = 50 \text{ nm}$$

The value of Planck's constant  $h$  is not needed here — it is another deliberate distractor.

### Concept

Always check what units  $c$  is given in. Here  $c = 3 \times 10^{17} \text{ nm/s}$ , so  $\lambda = c/\nu$  directly gives nanometres. No unit conversion is needed at all. The trap is thinking you need  $h$  for this calculation — you do not.

### Answer

**Option (4):** 50 nm

### Common Student Mistake

Students try to use  $E = h\nu$  and then  $E = hc/\lambda$ , which is fine but slower. The bigger mistake is using  $c = 3 \times 10^8 \text{ m/s}$  instead of the  $c$  given in the problem ( $3 \times 10^{17} \text{ nm/s}$ ), leading to a unit mismatch and a wrong answer.

**Q.6** Wavelength = 400 nm. Find wave number in  $\text{cm}^{-1}$ .

[NCERT Pg. 38]

### Explanation

Wave number:  $\bar{\nu} = \frac{1}{\lambda}$  where  $\lambda$  must be in **cm** to get  $\bar{\nu}$  in  $\text{cm}^{-1}$ .

Convert:  $\lambda = 400 \text{ nm} = 400 \times 10^{-9} \text{ m} = 400 \times 10^{-7} \text{ cm} = 4 \times 10^{-5} \text{ cm}$

$$\bar{\nu} = \frac{1}{4 \times 10^{-5} \text{ cm}} = 0.25 \times 10^5 \text{ cm}^{-1} = 2.5 \times 10^4 \text{ cm}^{-1}$$

### Concept

Wave number in  $\text{cm}^{-1}$  requires  $\lambda$  in cm. The conversion chain is:

$$\text{nm} \xrightarrow{\times 10^{-9}} \text{m} \xrightarrow{\times 10^2} \text{cm} \quad \Rightarrow \quad 1 \text{ nm} = 10^{-7} \text{ cm}$$

Memorise:  $1 \text{ nm} = 10^{-7} \text{ cm}$ . It saves time in every wave number question.

### Answer

**Option (1):**  $2.5 \times 10^4 \text{ cm}^{-1}$

### Common Student Mistake

The most frequent error is forgetting to convert nm to cm and directly computing  $1/400$ , giving  $2.5 \times 10^{-3}$  — which is the wave number in  $\text{nm}^{-1}$ , not  $\text{cm}^{-1}$ . Always convert  $\lambda$  to cm before taking the reciprocal.

### Q.7 Wave number of yellow radiation with $\lambda = 5800 \text{ \AA}$ in $\text{cm}^{-1}$ ?

### Explanation

Convert:  $\lambda = 5800 \text{ \AA} = 5800 \times 10^{-8} \text{ cm} = 5.8 \times 10^{-5} \text{ cm}$   
(Recall:  $1 \text{ \AA} = 10^{-8} \text{ cm}$ )

$$\bar{\nu} = \frac{1}{5.8 \times 10^{-5}} = \frac{1}{5.8} \times 10^5 = 0.17241 \times 10^5 = 17241.37 \text{ cm}^{-1}$$

### Concept

Two unit conversions to memorise for wave number problems:

- $1 \text{ nm} = 10^{-7} \text{ cm}$
- $1 \text{ \AA} = 10^{-8} \text{ cm}$

Once  $\lambda$  is in cm, wave number =  $1/\lambda$ .

### Answer

**Option (1):**  $17241.37 \text{ cm}^{-1}$

### Common Student Mistake

Students confuse angstrom with nm:  $1 \text{ \AA} = 0.1 \text{ nm} = 10^{-10} \text{ m}$ . Using nm conversion instead of  $\text{\AA}$  conversion shifts the answer by a factor of 10. Option (2) = 8620.68 corresponds to using  $\lambda = 11600 \text{ \AA}$  by mistake.

## TYPE 2 : Electromagnetic Spectrum

**Q.8** Correct sequence of increasing frequency in EM spectrum?

### Explanation

The electromagnetic spectrum in order of **increasing frequency** (= decreasing wavelength):

$$\begin{array}{ccccccc} \text{Radio} & < & \text{Micro-} & < & \text{IR} & < & \text{Visible} \\ \text{waves} & & \text{waves} & & & & \\ \hline & < & \text{UV} & < & \text{X-rays} & < & \text{Gamma rays} \end{array}$$

So among the four given: Radio < Microwave < UV < X-rays.

Correct option: **X-rays > UV > Microwaves > Radio waves**

### Concept

The mnemonic “**Raging Martians Invaded Venus Using X-ray Guns**” gives the order of increasing frequency: **Radio – Microwave – Infrared – Visible – UV – X-ray – Gamma**. Wavelength runs in the opposite direction.

### Answer

**Option (1): X-rays > UV rays > Microwaves > Radio waves**

### Common Student Mistake

Students often swap UV and X-rays, or place microwaves incorrectly relative to radio waves. Remember: radio waves have the *longest* wavelength (lowest frequency), gamma rays have the *shortest* wavelength (highest frequency).

**Q.9** Electromagnetic radiation with maximum wavelength is:

### Explanation

From the EM spectrum order above, **radio waves** have the maximum wavelength (minimum frequency). Radio wave wavelengths range from millimetres to hundreds of metres.

UV (~10–400 nm), infrared (~700 nm – 1 mm), X-rays (<10 nm) all have much shorter wavelengths.

### Answer

**Option (2): Radio waves**

### Common Student Mistake

Students sometimes pick infrared because they associate it with “heat” and assume it is more energetic. Infrared has longer wavelength than UV but far shorter than radio waves. Maximum wavelength = minimum frequency = minimum energy = Radio waves.

## Answer Key — DPP-2

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	1	2	1	3	3	4	1	5	4
6	1	7	1	8	1	9	2		

*“Units check karna bhool gaye? Wahi ek galti 4 marks kha jaati hai. Har step ke baad unit dekho.”*  
— **Weird Chemist**