NOTE

On the test,
$c = \lambda\nu$ $c/\lambda = \nu$
$c/\nu = \lambda$
will not be given – you have to isolate the variables to get these.

<u>Equations and constants:</u>

$E = h\nu$ and $E = hc/\lambda$ E = energy of one photon with a frequency of $\nu$

$c = \lambda\nu$ $c/\lambda = \nu$ c = speed of light = $3.0 \times 10^8$ m/s (meters per second)

$c/\nu = \lambda$ h = Planck's constant = $6.63 \times 10^{-34}$ J-s

$\lambda$ = wavelength in meters

$\nu$ = frequency in Hz (waves/s or 1/s or $s^{-1}$)

1. A photon has a frequency ($\nu$) of $2.68 \times 10^6$ Hz. Calculate its energy. (Ans: $1.777 \times 10^{-27}$ J)

**2. Calculate the energy (E) and wavelength ($\lambda$) of a photon of light with a frequency ($\nu$)** of $6.165 \times 10^{14}$ Hz.

$$E = h\nu$$
$$= 6.63 \times 10^{-34} \text{ J-s} \times 6.165 \times 10^{14} \text{ Hz}$$
$$= 43.867395 \times 10^{-34} \times 10^{14} \text{ Js/s}$$
$$= 43.87 \times 10^{-20} \text{ J}$$
$$= 4.387 \times 10^{1} \times 10^{-20} \text{ J}$$
$$= 4.387 \times 10^{-19} \text{ J}$$

Answer: **$4.387 \times 10^{-19}$ J**

3. Calculate the frequency and the energy of blue light that has a wavelength of 400 nm ($h = 6.62 \times 10^{-34}$ J-s). (Ans: $7.500 \times 10^{14}$ Hz)

$$\nu = c/\lambda$$
$$c = 3.000 \times 10^8$$
$$\lambda = 400 \times 10^{-9} \text{ m}$$
$$\nu = 3.000 \times 10^8 / 400 \times 10^{-9} \text{ (m/s)m}$$
$$= 3.000/4.000 \times 10^8/10^{-7} \text{ (m/s)s} = /\text{s}$$
$$= 0.7500 \times 10^{15} /\text{s}$$
$$= 7.500 \times 10^{-1} \times 10^{15} /\text{s}$$
$$= 7.500 \times 10^{14} /\text{s} \quad \text{Note: /s = Hz}$$

**Answer: $7.500 \times 10^{14}$ Hz**

4. Calculate the wavelength and energy of light that has a frequency of $1.5 \times 10^{15}$ Hz.

Ans: $\lambda = 2.0 \times 10^{-7}$ m     $E = 9.95 \times 10^{-19}$ J

5. A photon of light has a wavelength of 0.050 cm. Calculate its energy.

Ans: $E = 3.978 \times 10^{-23}$ J

6. Calculate the number of photons having a wavelength of 10.0 μm required to produce 1.0 kJ of energy.     Ans; $5.000 \times 10^{21}$ photons

7. Calculate the total energy in $1.5 \times 10^{13}$ photons of gamma radiation having $\lambda = 3.0 \times 10^{-12}$ m.

Part 1: Calculate the Energy of ONE Photon

Part 2: Calculate total energy of $1.5 \times 10^{13}$ photons

Part 1:

$$E = hc/\lambda$$
$$= 6.63 \times 10^{-34} \text{ J-s} \times 3.000 \times 10^{8} \text{ m/s} / 3.0 \times 10^{-12} \text{ m}$$

$$= 6.630 \times 10^{-34} \times 10^{8} \times 10^{12} \text{ Jsm/ms}$$
$$= 6.630 \times 10^{-14} \text{ J}$$
$$= 6.630 \times 10^{1} \times 10^{-14} \text{ J}$$
$$= 6.630 \times 10^{-13} \text{ J}$$

**Part 1 Answer: $6.630 \times 10^{-13}$ J**

Part 2:

**1 Photon = $6.630 \times 10^{-13}$ J**

**$1.500 \times 10^{13}$ = ? J**

$$= (1.500 \times 10^{13} \times 1) \times 6.630 \times 10^{-13} \text{ J/J}$$
$$= (1.500 \times 6.630) \times 10^{13} \times 10^{-13}$$
$$= 9.945 \text{ J}$$

**Part 2 Answer: 9.945 J**

8. Calculate the energy and frequency of red light having a wavelength of 6.80 x $10^{-5}$ cm.
Ans: E = 2.940 x $10^{-19}$ J $\nu$ = 4.4 12x $10^{12}$ Hz

9. The wavelength of green light from a traffic signal is centered at 5.20 x $10^{-5}$ cm. Calculate the frequency.

**$\lambda = c/\nu$**

**C = 3.000 x $10^8$**

**$\nu$ = 5.20 x $10^{-5}$ Hz**

**$\lambda$ = 3.000 x $10^8$ / 5.200 x $10^{-5}$ (m/s) Hz** **(remember Hz is cycles/s)**

**= 15.600 x $10^3$ (m/s)s = m**

**= 1.560 x $10^1$ x $10^3$ = 1.560 x $10^4$ m**

**Answer: 1.560 x $10^4$ m**

10. Calculate the frequency of light that has a wavelength of 4.25 x $10^{-9}$m.
Ans: $\nu$ = 7.059 x $10^{16}$ Hz.