SI Chemistry - Full Discipline Demo

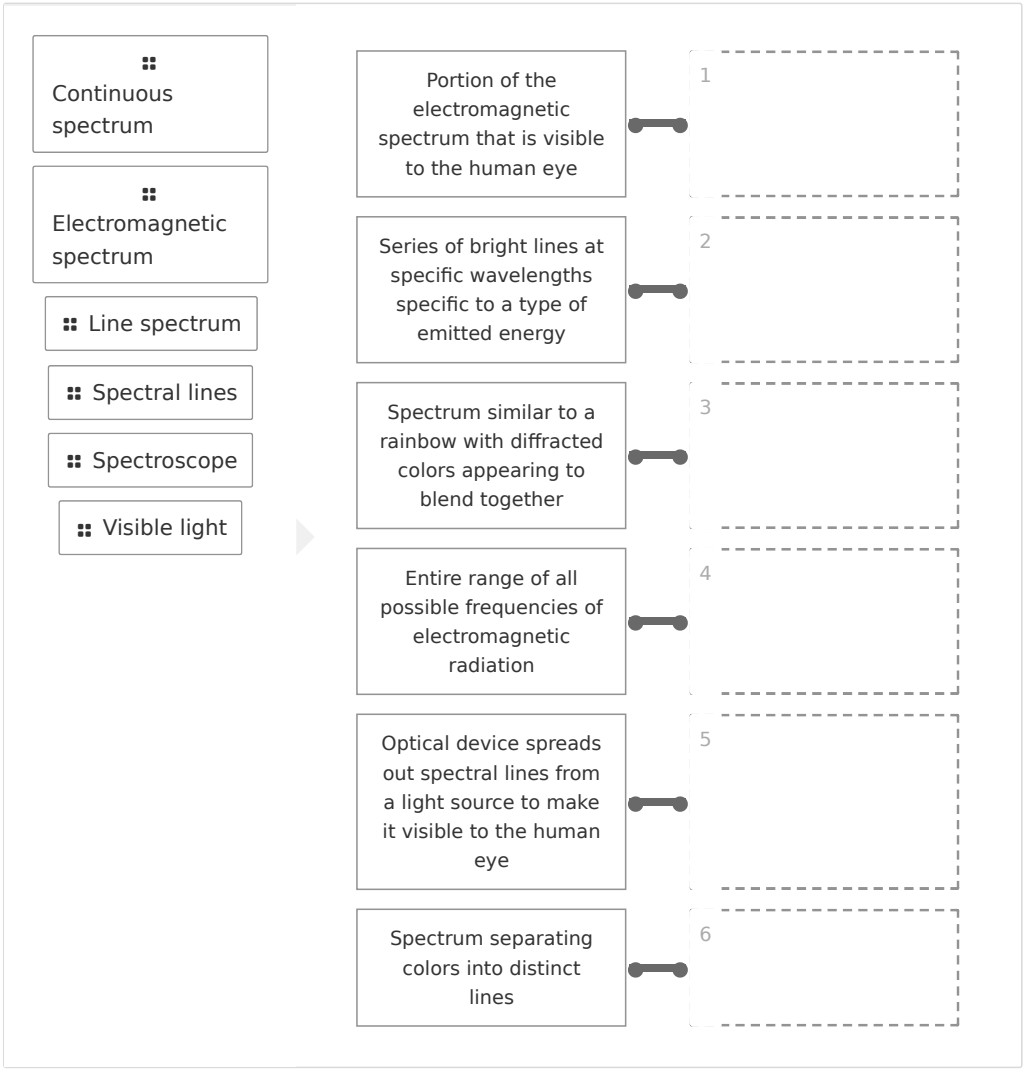
Quantitative Spectroscope and Visible Light

Final Report - Answer Guide

Institution	Science Interactive University
Session	SI Chemistry - Full Discipline Demo
Course	SI Chemistry - Full Discipline Demo
Instructor	Sales SI Demo

Test Your Knowledge

Match each term with the best description.



Correct answers:

1 Visible light 2 Spectral lines 3 Continuous spectrum

4 Electromagnetic spectrum 5 Spectroscope 6 Line spectrum

Order the types of electromagnetic radiation from highest energy to lowest energy.

≡ Gamma-ray

1 **Correct answer:** Gamma-ray

≡ Infrared

2 **Correct answer:** X-ray

≡ Microwave

3 **Correct answer:** Ultraviolet

≡ Radio wave

4 **Correct answer:** Visible light

≡ Ultraviolet

5 **Correct answer:** Infrared

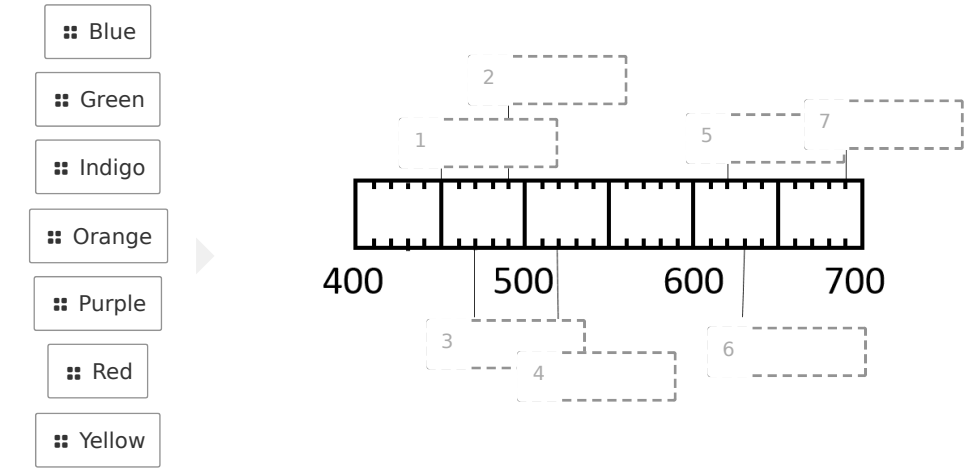
≡ Visible light

6 **Correct answer:** Microwave

≡ X-ray

7 **Correct answer:** Radio wave

Label the spectroscope grid with the correct colors that occur at each frequency (nm).



Correct answers:

1 Purple 2 Blue 3 Indigo 4 Green 5 Yellow 6 Orange 7 Red

Exploration

Visible light is composed of _____ colors.

- 5
- 6
- 7 ✔
- 8

Gamma rays contain the _____ wavelengths and _____ frequency.

- shortest; highest ✔
- shortest; lowest
- longest; highest
- longest; lowest

Frequency refers to the number of wave peaks that pass a stationary point per unit time.

- [x] True ✔
- [ ] False

Visible light is released from matter upon exposure to _____.

- [ ] heat
- [ ] radiation
- [ ] pressure
- [x] heat or radiation ✔
- [ ] All of the above

The _____ spectroscope is based on the principle of dispersion.

- [ ] diffraction grating
- [x] prism ✔

Exercise 1

Hold the grating several inches from your face, at an angle. Look at the grating that you will be using. Record what details you see at the grating surface.

The grating is hazy and appears to have a film. As it is moved in light, it appears to contain a rainbow.

Hold the diffraction grating up to your eye and look through it. Record what you see. Be specific.

As you look through the diffraction grating, everything appears to be surrounded by rainbow outlines.

Before mounting the diffraction grating, look through the opening that you made for your grating. Record what you see across the back of your spectroscope.

Looking through the slit in the box, it is dark inside with white light entering through the slit.

After mounting the diffraction grating, look through your spectroscope and record what you see across the back of your spectroscope. Be specific.

After mounting the diffraction grating, a rainbow band of colors appear, both to the right and left of the slit.

Starting at the light inlet slit and going outward, what colors do you see in the spectrum? List them all.

The colors in the spectrum that are visible are: purple, indigo, blue, green, yellow, orange, and red.

When you view the spectrum, you should be able to see a spectral image to the right and left of the light inlet slit. How are the spectral images the same? How are they different? Record your findings.

The spectral images are the same as they are the same relative intensity of color and are in the same order as you move outward from the slit: for example, red is the first color on either side of the slit. They are different in that the two spectra images are mirror images of one another.

Try narrowing and widening the light inlet slit. How does this affect the spectra that appear? Compare the shape, thickness, and resolution of the spectral lines before and after narrowing the slit. Record your findings.

The narrower the slit is, the finer the bands of color. The spectral lines have clear, straight lines. As the slit is larger, the spectral lines appear to bleed together.

Exercise 2

Describe the similarities and differences between the spectra of incandescent light and fluorescent light. Use your results in Data Table 1 to explain your answer.

Both the incandescent light and the fluorescent light show all colors in the visible light region of the electromagnetic spectrum. However, the incandescent light creates a continuous spectrum in the spectroscope, almost looking like a rainbow, while the fluorescent light creates a line spectrum of separated, clearly identifiable line emissions.

The wavelength (λ) and frequency (ν) of light are related through the equation:

$$c = \lambda \times \nu$$

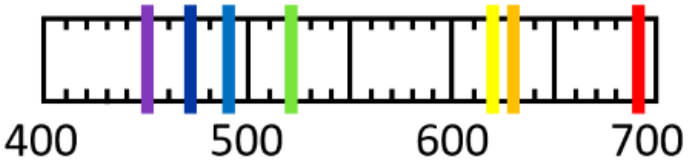
where:

$c =$ speed of light $(3.00 \times 10^8\ \mathrm{m \cdot s^{-1}})$

$\lambda =$ wavelength (m)

$\nu =$ frequency $(\mathrm{s^{-1}})$

Using the following emission spectrum:



Calculate the frequency for each of the 7 emission lines (1 nm = 1 x 10^{-9} m):

a) Violet (450 nm)
b) Indigo (470 nm)
c) Blue (490 nm)
d) Green (520 nm)
e) Yellow (620 nm)
f) Orange (630 nm)
g) Red (690 nm)

a) $\nu = 6.67 \times 10^{14}\ s^{-1}$
b) $\nu = 6.38 \times 10^{14}\ s^{-1}$
c) $\nu = 6.12 \times 10^{14}\ s^{-1}$
d) $\nu = 5.77 \times 10^{14}\ s^{-1}$
e) $\nu = 4.84 \times 10^{14}\ s^{-1}$
f) $\nu = 4.76 \times 10^{14}\ s^{-1}$
g) $\nu = 4.35 \times 10^{14}\ s^{-1}$

Data Table 1: Light Sources
(SAMPLE ANSWER BELOW)

Light Source	Continuous or Line
Fluorescent	No sample answer
Incandescent	No sample answer
Street Light	No sample answer

Car Headlight	No sample answer
Additional Light Source: No sample answer	No sample answer

Photo 1: Fluorescent Light
(SAMPLE ANSWER BELOW)

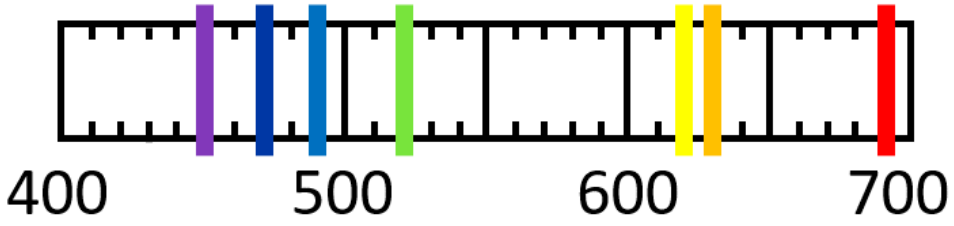


Photo 2: Incandescent Light
(SAMPLE ANSWER BELOW)

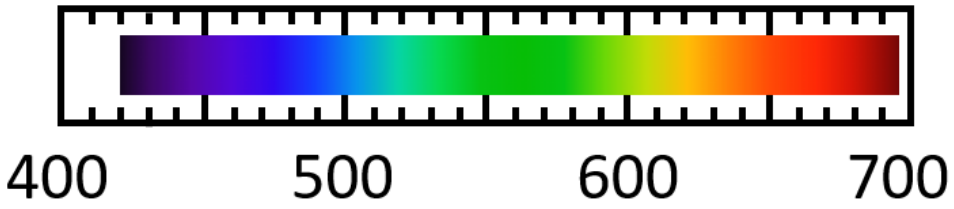


Photo 3: Street Light

(SAMPLE ANSWER BELOW)

Student grids will vary depending on the light source of the street light

Photo 4: Car Headlight

(SAMPLE ANSWER BELOW)

*Student grids will vary depending on the light source of the student's car

Photo 5: Additional Light Source

(SAMPLE ANSWER BELOW)

*Student grids will vary depending on the light source they choose to view

Competency Review

The electromagnetic spectrum consists of _____ regions.

- radio wave and infrared radiation
- microwave
- visible light and UV radiation
- X-ray
- radio wave and gamma ray
- All of the above ✔

Visible light spans the electromagnetic spectrum from wavelengths of approximately _____ to _____.

- 250 nm; 800 nm
- 390 nm; 750 nm ✔
- 350 nm; 875 nm
- 275 nm; 650 nm

Wavelength and frequency are related by the equation that _____.

- the speed of light is equal to the wavelength times the frequency ✔
- the wavelength is equal to the speed of light times the frequency
- the speed of light is equal to the frequency divided by the wavelength
- the frequency is equal to the speed of light times the wavelength

The _____ of energy from matter occurs when its electrons are excited and move to a higher energy level and then return to a lower energy level.

- wavelength
- emission ✔
- frequency
- diffraction

The difference in energy when moving from the excited energy level to the lower energy level is released in the form of ____.

- pressure
- heat
- temperature
- light ✔

The diffraction grating spectroscope is based on the principle of dispersion, where light enters the device and is prismatically dispersed.

- True
- False ✔

The light inlet slit of a spectroscope should be ideally ____ wide to create ____ spectral lines, which are easier to measure.

- 1 cm; wider
- 1 mm; narrower ✔
- 1 m; wider
- 1 cm; narrower

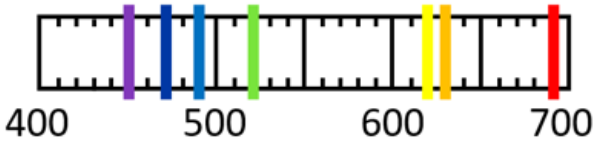
When calibrating a spectroscope, the violet spectral line should lie over the ____ mark.

- 400 nm
- 450 nm ✔
- 550 nm
- 700 nm

An incandescent light has a _____ spectra.

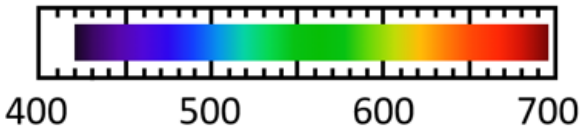
- continuous ✔
- line
- variable

The drawing is a _____ spectrum, and indicative of a(n) _____ light source.



- continuous; fluorescent
- continuous; incandescent
- line; fluorescent ✔
- line; incandescent

According to the spectrum, blue light is roughly between _____.

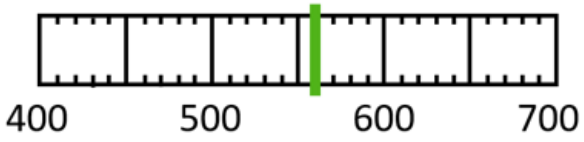


- 400 nm to 450 nm
- 470 nm to 510 nm ✔
- 500 nm to 550 nm
- 560 nm to 600 nm

The formula for calculating the speed of light ($3.00 \times 10^{8} ms^{-1}$) is ____.

- ν = λ/c
- c = λ/ν
- λ = c x ν
- c = λ x ν ✔

Calculate the frequency for the emission line.



- $5.35 \times 10^{5} s^{-1}$
- $5.35 \times 10^{14} s^{-1}$ ✔
- $1.86 \times 10^{-6} s^{-1}$
- $1.68 \times 10^{20} s^{-1}$

Extension Questions

Write up to five sentences describing how a spectroscope works. Make certain to mention things like the light inlet slit, diffraction grating, light, spectrum, etc. (SAMPLE ANSWER BELOW)

Light enters the spectroscope through the light inlet slit, where it then hits the diffraction grating and is diffracted along the side of the spectroscope. The diffracted light creates a spectrum of light, which is unique to the source of the light. The grid template along the spectrum of light allows for quantitative measurements of the spectrum to be made and the values to be assigned to each wavelength of light.