Laboratory 2: Spectra & Refracting Telescopes

Experiments are to be completed on the provided laboratory sheets below; any supporting material (eg. graphs) should be attached. Make sure your name and your partners name(s) are clearly indicated on the front page of your lab. **Neatness and clarity count!** Use complete sentences in answering all questions, explain your answers when asked clearly, and if you use an equation to do a calculation, *write the equation down* first, then put in numbers and solve. **Show all your work!**

Labs are due on VIULearn one week after the lab; please use the provided lab pages and submit your lab (in the correct order) as a single, reasonably sized PDF file.

APPARATUS

High voltage gas discharge box (with 6 gas filled tubes), spectroscope, refracting telescope & select eyepieces; a mm scale ruler. Colour pencils are helpful.

OBJECTIVE

1. To learn about how refracting telescopes and magnification.
2. To examine and identify various gases by their spectral signature.

THEORY

Telescopes act as our window on the heavens, greatly extending our ability to view distant and/or faint objects. While they may come in a variety of styles and function at varying wavelengths, all telesopes collect & focus light. A *refracting*, visible light telescope is among the simplest of telescopes; it makes use of an objective lens to collect and form an image and an ocular (*eyepiece*) lens to magnify and make this image viewable to us. The magnification of a telescope is given by:

$$m = \frac{f_{objective}}{f_{eyepiece}} \quad (1)$$

where f represents the *focal length* of a lens or mirror.

If we take light and break it into its component wavelengths we have a *spectrum*. When electric current is run through a gas in an evacuated tube the gas emits light, but only at specific wavelengths. A *spectroscope* is used to view the emission line spectrum of the gas and identify the gas. Sample emission line spectra for common gases are provided on the course website for comparison.

Mark this lab: ☐ individually ☐ as a group NAME: PARTNER:

Laboratory 2: Spectra & Refracting Telescopes

Part A: Refracting Telescopes & Magnification

1. For this section, refer to image gallery *'eyepiece views'* on the ASTR 112 website under Labs.

2. [***2 marks***] In the above gallery, under *'General Refractor View'*, the final two images show a model of the Sun, Moon & Earth in a regular 'naked eye' (non-telescopic) view and as seen under low magnification through a refractor, respectively. Click on the thumbnail images to see a larger, more detailed version of each image. **Sketch these two views in the circles provided below. In what way(s) does the refractor view differ from the regular view? Why is the refractor image 'different'?** (You may use a separate drawing to help explain if you wish).

Non-telescopic (regular) view

Refractor view

3. [***2 marks***] Four *different* focal length eyepieces were used with the same (refracting) telescope to view the Earth model. The resulting magnified views of the Earth are shown in the image gallery under *'Eyepiece Magnification Comparison'*. **Use a ruler to measure the *diameter* of the Earth (in mm) in each eyepiece view and record the values in the table below.** Make sure that you view each image at FULL size (click on the thumbnails) and in the SAME relative orientation (i.e. don't rotate your phone or tablet between views). Since you cannot see the entire Earth in the view for eyepiece 4 you will need to be 'clever' to come up with a value for the diameter - **clearly explain your thinking & show your calculations to determine this value.**

eyepiece	eyepiece 1	eyepiece 2	eyepiece 3	eyepiece 4
diameter of Earth (mm)				

4. [***1 mark***] The *unmagnified* ('naked-eye') view of the Earth model should (theoretically) have a diameter *42.5 times SMALLER than when viewed using eyepiece 3*. Given this and your diameter of the Earth using eyepiece 3 (above), **calculate the unmagnified diameter of the Earth:**

__________ mm. Using this value & your previous diameter measurements, **calculate the magnification of each eyepiece and record below, showing ONE full sample calculation.**

eyepiece	eyepiece 1	eyepiece 2	eyepiece 3	eyepiece 4
magnification m			42.5	

5. [***3 marks***] How does magnification depend on eyepiece focal length? **Based STRICTLY on a visual comparison of the eyepiece views in the image gallery** (i.e. without any calculations) **how do you *think* the focal lengths of the eyepieces compare to each other?** *i.e. given the images & their varying degree of magnification, how should the focal length change as you switch from eyepiece 1 through to eyepiece 4?* **Justify your answer briefly** (see the Theory section). If the focal length of the refractor's objective lens is $f_{objective} = 510$mm, use your previous *magnification* (m) values to **calculate the focal length of each eyepiece & record these values in the table below. Show ONE complete sample calculation. Does the trend of your calculated focal lengths agree with your expectations based on the images? Comment.**

eyepiece	eyepiece 1	eyepiece 2	eyepiece 3	eyepiece 4
focal length $f_{eyepiece}$ (mm)				

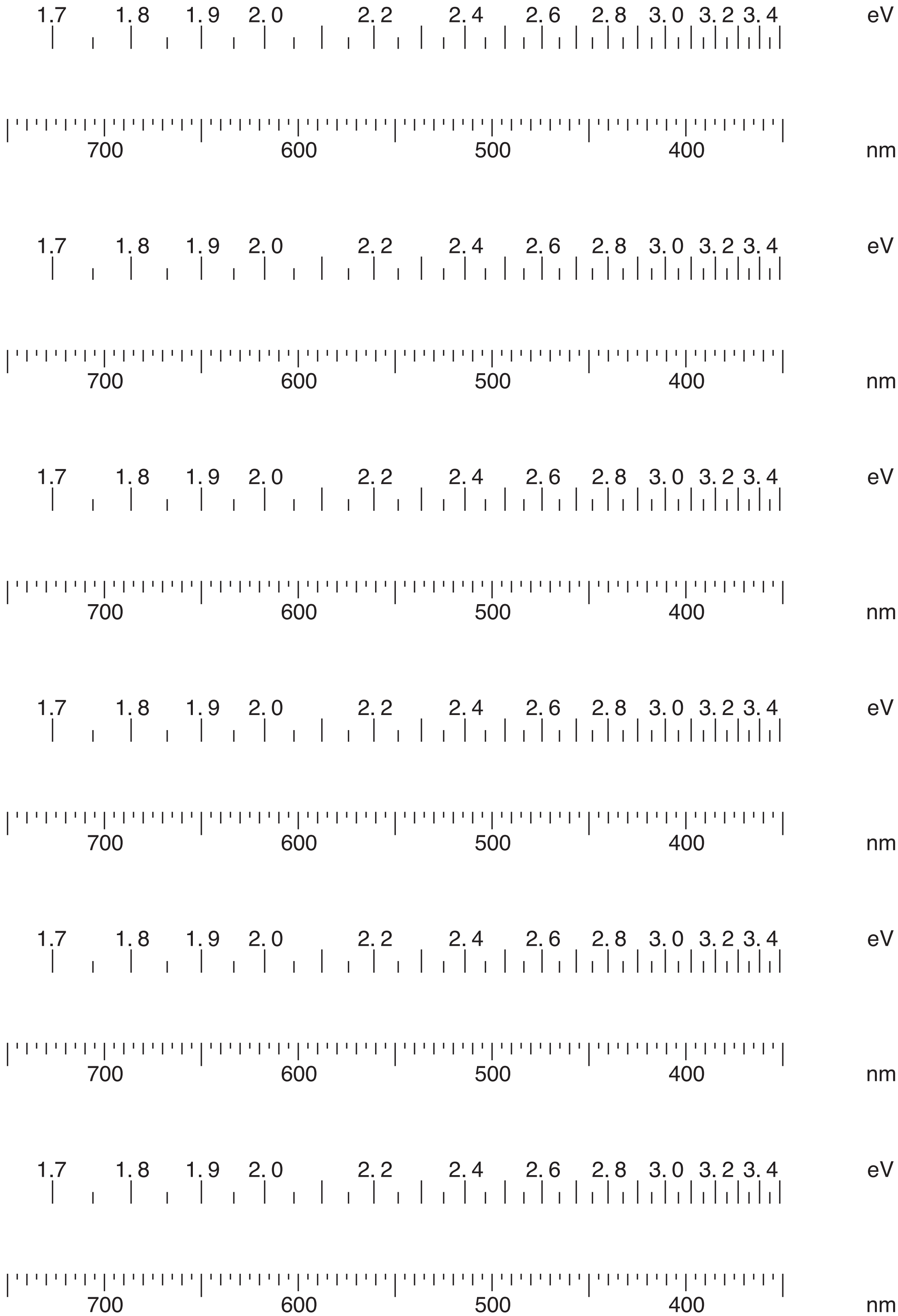
Part B: Spectra

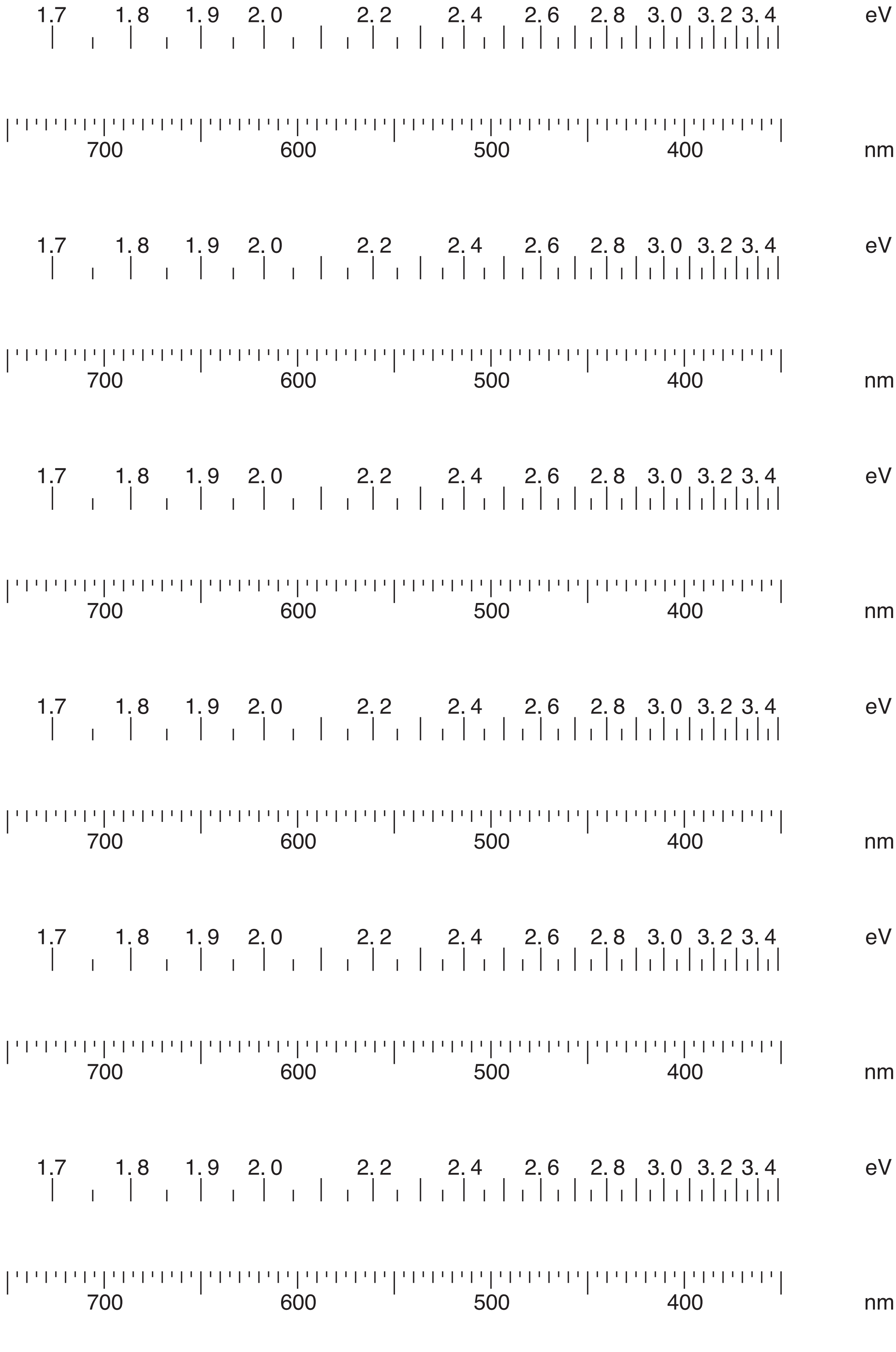
1. [***1 mark***] Use one of the provided high voltage discharge boxes for this portion of the lab. Switch it on (if it isn't already) and turn up the intensity enough to see well defined emission lines when viewed using the spectroscope. **Other 'ghostly' spectral lines & bands will appear in addition to the desired emission lines, especially when the intensity (current) of the high voltage box is high. Where do these other lines & bands originate?**

2. [***6 marks***] **Rotate the black knob on top of the high voltage discharge box until you reach a tube emitting a bright orange colour; this tube will be gas #1**. Proceed through all six gases by rotating the knob in the *clockwise* direction. **** Please note: the order of the gases will be DIFFERENT from the video for the lab available on the website! ****

Given the above starting point & order, CAREFULLY draw the emission lines for each of the six gases on the grids provided at the end of the lab, noting position, colour and brightness. If there are regions with many tightly packed lines, record the endpoints and shade in the region in question, making note of the overall pattern including any brighter/dimmer portions. Remember: red is long wavelength ($\approx$ 700 nm) and blue is short wavelength ($\approx$ 400 nm) - position your lines as accurately as possible! **Record as many of the bright spectral lines *as possible* to help you to identify the gas, ignoring very dim lines or 'ghostly' lines due to external sources**. Using appropriate colour pencils to draw your lines will help in identification of the spectra. **It takes practice to see the lines & note details in the spectra; be patient and TAKE YOUR TIME. Next to each detailed spectrum also record the overall 'naked eye' colour observed for that gas.**

3. [***5 marks***] A gallery of reference emission line spectra of common gases is provided on the ASTR 112 website (under Class Materials, next to Lab 2). **Compare your drawings above to the reference gallery & identify each of the samples in the carousel**; use the same order as previously. *All of the gases in the carousel are different and not all of the provided reference spectra will be used.* **Briefly justify your choices, referring to specific, unique identifying feature(s)**. Differences between some gases may be subtle - observe carefully & use multiple differentiating characteristics where possible!


1.7 1.8 1.9 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 eV
700 600 500 400 nm
1.7 1.8 1.9 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 eV
700 600 500 400 nm
1.7 1.8 1.9 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 eV
700 600 500 400 nm
1.7 1.8 1.9 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 eV
700 600 500 400 nm
1.7 1.8 1.9 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 eV
700 600 500 400 nm
1.7 1.8 1.9 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 eV
700 600 500 400 nm


1.7 1.8 1.9 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 eV
700 600 500 400 nm
1.7 1.8 1.9 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 eV
700 600 500 400 nm
1.7 1.8 1.9 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 eV
700 600 500 400 nm
1.7 1.8 1.9 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 eV
700 600 500 400 nm
1.7 1.8 1.9 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 eV
700 600 500 400 nm
1.7 1.8 1.9 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 eV
700 600 500 400 nm