1. (a) Explain what is meant by the Rayleigh criterion.

(2)

(b) A telescope uses wavelengths in the range 90 nm to 120 nm.

Explain why this telescope must be located in space.

Go on to discuss **one** advantage that this telescope has compared to a telescope with the same aperture that uses visible light.

(3)

(c) The table below shows information about two telescopes.

Telescope	Diameter / m	Dish shape
Arecibo	305	spherical
Lovell	76	parabolic

Each telescope detects radio waves with a wavelength of 21 cm.

Compare the performances of the telescopes in the table above when both are used to observe the same faint radio objects.

(3)

(Total 8 marks)

2. The Kielder Observatory in Northumberland includes two optical telescopes attached to the same mount, so that they can be used to view the same object.
Some of the properties of these telescopes are summarised in the table.

Telescope	Type	Objective diameter/mm
A	refractor	70
B	refractor	400

(a) The telescopes are used to view the same object.

Suggest which telescope in the table produces the brighter image.
Support your answer with a suitable calculation.

(3)

(b) The minimum angular resolution of a telescope can be determined using the Rayleigh criterion.

Explain what is meant by the Rayleigh criterion.

(2)

(c) Discuss which of the two telescopes in the table would be better at resolving the images of two objects that are close together.

_____

_____

_____

_____

_____

_____

_____

(2)

(Total 7 marks)

3. (a) Draw a ray diagram for a Cassegrain telescope.
Your diagram should show the paths of **two** rays up to the eyepiece lens.
The rays should initially be parallel to the principal axis.

_____ principal axis

(2)

(b) A spacecraft passes Pluto at a distance of 12 500 km. The telescope on board has an aperture of diameter 0.21 m and operates at a wavelength of 450 nm.

Discuss whether this telescope is suitable for studying a crater with a diameter of approximately 1 km on Pluto.

(3)

(c) The Hubble telescope has an aperture of diameter 2.4 m.

Compare the collecting power of the Hubble telescope with the telescope on the spacecraft in part (b).

(2)

(d) An astrophysicist had to decide whether to use a reflecting telescope or a refracting telescope on the spacecraft in part (b).

Discuss which type of telescope to use.

_____

_____

_____

_____

_____

_____

_____

_____

(3)

(Total 10 marks)

4. The Griffith Observatory in Los Angeles includes an astronomical refracting telescope (Griffith telescope) with an objective lens of diameter 305 mm and focal length 5.03 m

(a) Calculate the wavelength of light for which the Griffith telescope has a minimum angular resolution of 1.8×10^{-6} rad

wavelength = _____ m

(2)

(b) The Griffith telescope is used to observe two point objects which subtend an angle of 1.8×10^{-6} rad at the unaided eye.

The typical human eye has a minimum angular resolution of approximately 3.2×10^{-4} rad

Calculate the focal length of the eyepiece lens so that an observer can just resolve the two objects when observing them through the Griffith telescope.

focal length = _____ m

(3)

(c) The asteroid Apophis has a diameter of 325 m

It has been calculated that, in 2029, its distance of closest approach to the Earth's surface will be 3.0×10^4 km

The Griffith telescope may be used to view Apophis using the eyepiece calculated in question (b)

Deduce whether this telescope is suitable to obtain a detailed view of Apophis. Support your answer with a calculation.

(3)

(Total 8 marks)

5. (a) The lenses used in refracting telescopes can cause chromatic aberration.

Complete the diagram to show how a lens produces chromatic aberration.

(1)

(b) A Cassegrain telescope uses mirrors.

What are the shapes of the primary and secondary mirrors in a Cassegrain telescope?

Tick (✓) **one** box.

Primary mirror	Secondary mirror	
concave	concave	
concave	convex	
convex	concave	
convex	convex	

(1)

(c) The table contains information about two telescopes, **A** and **B**. Each telescope is planned to be the biggest of its type in the world.

Telescope	**A**	**B**
Type	Optical reflecting telescope	Radio telescope
Diameter / m	39.3	110
Range of wavelengths detected	350 nm to 1800 nm	2.5 mm to 1000 mm

Discuss the similarities and differences between optical reflecting telescopes and radio telescopes. Your answer should include references to:

- structure
- positioning
- collecting power.

Go on to discuss which telescope, **A** or **B**, will give a more detailed image of an astronomical object that emits both radio waves and visible light.

(6)

(Total 8 marks)

6. Draw the ray diagram for a Cassegrain telescope. Your diagram should show the paths of two rays, initially parallel to the principal axis, as far as the eyepiece.

(Total 2 marks)