

1.1 Measurements in Physics

Question Paper

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|------------|--------------------------------|
| Course | DPIB Physics |
| Section | 1. Measurement & Uncertainties |
| Topic | 1.1 Measurements in Physics |
| Difficulty | Medium |

Time allowed: 80
Score: /64
Percentage: /100

Question 1a

(a)

Define 1 Farad in fundamental SI units.

[3 marks]

Question 1b

A parallel plate capacitor of capacitance $86 \mu\text{F}$ is connected to a 6.00 kV power supply.

(b)

Calculate the charge between the plates in mC. Give your answer to an appropriate number of significant figures.

[3 marks]

Question 1c

(c)

List the following capacitance in increasing magnitude:

100 pF , $0.1 \mu\text{F}$, 100 cF , 0.01 fF

[4 marks]

Question 1d

(d)

Estimate the current through a 1700 W kettle connected to a UK mains supply.

[3 marks]

Question 2a

Pressure at a certain depth in a fluid can be calculated using the value for the density of the fluid, the gravitational field constant g and the depth within the fluid.

(a)

State the following measurements in standard form:

(i) 20 000 kPa

(ii) 0.18 Gm

(iii) 1.15 μg

(iv) 82.6 pN

[4 marks]

Question 2b

Pressure is measured in pascals.

(b)

Define 1 Pascal in fundamental SI units.

[3 marks]

Question 2c

Atmospheric pressure on Earth is 101 325 Pa. The Mariana trench at the bottom of the western Pacific Ocean has a pressure of around 110 MPa.

(c)

Calculate how many times larger the pressure in the Mariana trench is than the atmospheric pressure on Earth.

[2 marks]

Question 2d

Pressure changes with depth, as well as force and area.

(d)

List the following in order of decreasing pressure:

- Atmospheric pressure at the summit of Mount Everest
- Surface pressure on the Moon
- Atmospheric pressure ~ 101 kPa
- Water pressure of an average garden hose
- The Mariana trench ~ 110 MPa

[3 marks]

Question 3a

An electron microscope is used to analyse the arrangement of atoms and their nuclei on a new design for a special sheet of silver foil. The foil is a new material being added to various components in a military medical aircraft.

(a)

Estimate the orders of magnitude with an appropriate fundamental SI unit and correct prefix for the following quantities

| Quantity | Order of magnitude |
|------------------------------|--------------------|
| Mass of an aeroplane | |
| Radius of a proton | |
| Current through an LED | |
| Time between two heart beats | |

[4 marks]

Question 3b

The sheet of silver foil has a thickness of $0.992 \mu\text{m}$. A silver atom has a radius of 172 pm .

(b)

Approximate how many layers of atoms there are in this sheet.

[3 marks]

Question 3c

Using the electron microscope, the cross-sectional area of the silver nuclei can be measured accurately in units of 'barn', with symbol b.

$$1 \text{ barn} = 100 \text{ fm}^2$$

(c)

Calculate the value of 1 nb in m^2

[4 marks]

Question 3d

Einstein's famous equation Energy (J) = Mass (kg) \times (Speed of light (m s^{-1}))² demonstrates that energy and matter are interchangeable.

$$\text{Atomic mass unit, } 1 \text{ u} = 931.5 \text{ MeV}$$

$$1 \text{ eV} = 1.60 \times 10^{-19} \text{ J}$$

(d)

Use this equation to show that the value in kg of 1 u of silver in the foil is approximately equal to the mass of a proton in kg.

[4 marks]

Question 4a

X-ray pulsars are detected by X-ray telescopes on a satellite in low Earth orbit 2000 km above the surface of the Earth.

(a)

Calculate the number of cubic millimetres (mm^3) in a volume of 2000 km^3 .

[3 marks]

Question 4b

X-rays from a pulsar travel at the speed of light and are detected on Earth with a wavelength of 8.0 nm.

(b)

Calculate the frequency of the X-rays in PHz. Give your answer to an appropriate number of significant figures. .

[4 marks]

Question 4c

X-rays from the nearest pulsar PSR J0109-1431 take 8.82 Gs to travel to Earth.

- (c)
Calculate the number of oscillations of the X-rays from the pulsar to the surface of the Earth. Give your answer to an appropriate number of significant figures.

[3 marks]

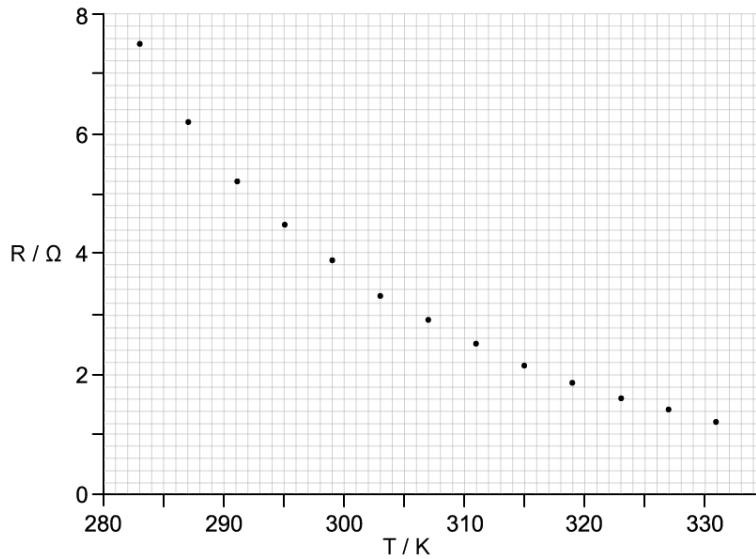
Question 4d

- (d)
Show the distance from Earth to PSR J0109-1431 is around 280 light years.

[3 marks]

Question 5a

A student conducts an experiment to study the variation of resistance R of a negative temperature coefficient (NCT) thermistor with temperature T . The data from the experiment is shown plotted on the graph.



The electric current through the thermistor for $T = 283 \text{ K}$ is 0.0078 mA .

(a)

What is the units of resistance R in SI units?

[5 marks]

Question 5b

(b)

Convert 0.0078 mA to A and write in standard form.

[2 marks]

Question 5c

(c)

Calculate the ratio $\frac{R}{T}$ when $T = 291 \text{ K}$. Write your answer in fundamental SI units to an appropriate number of significant figures.

[3 marks]

Question 5d

(d)

Estimate the resistance of the thermistor at a temperature of 335 K

[1 mark]