1.1 Measurements in Physics

Question Paper

Course	DP IB Physics
Section	1. Measurement & Uncertainties
Topic	1.1 Measurements in Physics
Difficulty	Hard

Time allowed: 60

Score: /47

Percentage: /100

Question 1a

A simple pendulum oscillates in simple harmonic motion. It can be assumed that there are no energy losses in the system.

(a)
Prove dimensionally that the work-energy principle applies for this system.

[2]

[2 marks]

Question 1b

(b)
Complete the following table by giving the SI base units. Then estimate the order of magnitude for each of the physical quantities.

[4]

Physical Quantity	SI Base Unit	Order of Magnitude
Acceleration of freefall Earth (g)	$m\,s^{-2}$	
Stephan-Boltzmann constant (σ)		10^{-7}
Speed of a β particle		
Specific heat capacity of water (c)		

[4 marks]

Question 1c

The density, ρ, and pressure, p, of a gas are related by the expression:

$$x = \sqrt{\frac{\gamma p}{\rho}}$$

where x and γ are constants.

(c)
Given that the constant γ is dimensionless

(i)

Determine the unit of x.

[1]

(ii)
Suggest what quantity is being represented by the symbol x.

[1]

[2 marks]

Question 2a

(a)
Identify the quantity with the SI base units of $m^3\,kg^{-1}\,s^{-2}$.

[3]

[3 marks]

Question 2b

(b)
Convert the following measurements to the appropriate unit, and express to an appropriate number of significant figures.

90 000 GW = _____ mW

45.1 hF = _____ fF

0.60 pm = _____ km

214 minutes = _____ ms

[4]

[4 marks]

Question 2c

A sheet of silver has a thickness of 0.671 µm. A silver atom has a radius of 172 pm.

(c)
Estimate the number of layers of atoms in this sheet to the nearest thousand.

[2]

[2 marks]

Question 3a

(a)
Identify the variable that has the SI base units kg m^2 s^{-3} A^{-2}.

[3]

[3 marks]

Question 3b

(b)
Explain why potential difference is not defined as current × resistance.

[2]

[2 marks]

Question 3c

(c)
Convert 0.01 kWh into PeV.

[3]

[3 marks]

Question 4a

Tensile stress (σ) is defined as the *force applied per unit cross-sectional area* on a material. The tensile strength is the maximum amount of tensile stress a material can be subjected to before fracturing, meaning that it is equivalent to the tensile stress at the breaking point.

The humerus bone is approximately cylindrical and has a tensile strength of 0.17 GPa and a diameter of 20 mm.

(a)
Calculate the maximum force on the humerus bone before it fractures.

[4]

[4 marks]

Question 4b

The femur bone is the strongest bone in the body. It has a tensile strength of 0.135 kN mm^{-2}.

(b)
Calculate the tensile strength of the femur bone in GPa.

[4]

[4 marks]

Question 4c

(c)
Calculate the number of cubic millimetres (mm^3) in 23 km^3.

[2]

[2 marks]

Question 5a

(a)
Estimate the time it takes light to cross the nucleus of a hydrogen atom.

[2]

[2 marks]

Question 5b

(b)
Estimate the order of magnitude with an appropriate SI unit and correct prefix for the following quantities.

(i) Mass of an aeroplane.

[1]

(ii) Current through an LED.

[1]

(iii) Time between two heartbeats.

[1]

[3 marks]

Question 5c

1 u is the atomic mass unit and a common unit used in nuclear physics.

(c)
Show that its value in kg is approximately equal to the mass of a proton in kg.

[3]

[3 marks]

Question 5d

The cross-sectional area of nuclei are commonly measured in the units *barn*, which are represented by the symbol *b*. 1 barn = 100 fm^2

(d)
Calculate the value of a nano barn (nb) in m^2.

[4]

[4 marks]