IB · DP · Physics

3 hours 15 questions

Structured Questions

1.1 Measurements in Physics

1.1.1 SI Units / 1.1.2 Using Scientific Notation / 1.1.3 Estimating Physical Quantities

Easy (5 questions)	/54
Medium (5 questions)	/64
Hard (5 questions)	/47
Total Marks	**/165**

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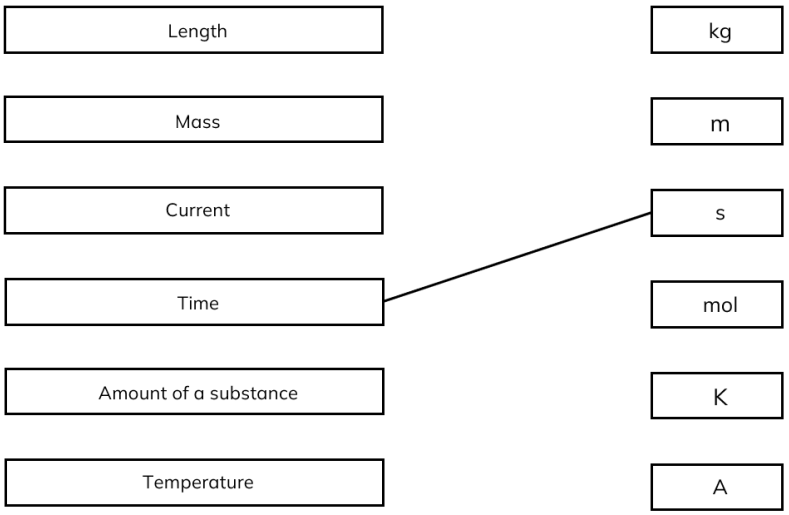
Easy Questions

1 (a) Match the correct quantity to the SI base unit



(3 marks)

(b) Newton's second law of motion describes the relationship between force, F, mass, m, and acceleration, a.

$$F = ma$$

The derived unit for force is the newton (N).

Using Newton's second law, determine the SI base units of force

(2 marks)

(c) The kinetic energy equation describes the relationship between energy E, mass, m, and velocity, v.

$$E = \frac{1}{2}mv^2$$

The derived unit for energy is the joule (J).

Using the kinetic energy equation, determine the SI base units for energy

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(2 marks)

(d) The derived unit for power, P, is the watt (W).

Given that power is the energy transferred, E, per unit time, t, deduce the SI base units for power

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(2 marks)

2 (a) Outline the reason why scientists use scientific notation

.....

(1 mark)

(b) Express the following numbers in scientific notation

(i) 491

[1]

(ii) 54 070

[1]

(iii) 2 310 000

[1]

.....

.....

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(3 marks)

(c) Express the following numbers in scientific notation

(i) 0.011

[1]

(ii) 0.000503

[1]

(iii) 0.0000045

[1]

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.....

.....

(3 marks)

(d) Express the following numbers in their original form

(i) 4.031×10^3

[1]

(ii) 6.7×10^6

[1]

(iii) 7.71×10^{-5}

[1]

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(3 marks)

3 (a) Complete the table by adding in the missing names of the unit prefixes and their corresponding metric multiplier:

Unit Prefix	Multiplier
tera	
	10^{9}
	10^{3}
centi	10^{-2}
milli	
micro	
	10^{-9}
pico	10^{-12}

(3 marks)

(b) Convert the following measurements into SI units using scientific notation

(i) 9.3 MJ to J

[1]

(ii) 7.4 kW to W

[1]

(iii) 10 mm to m

[1]

(3 marks)

(c) State the number of significant figures in the following measurements

(i) 93 100 m

[1]

(ii) 4003 kg

[1]

(iii) 0.0052 J

[1]

(3 marks)

(d) State the measurement 103 660 pg to

(i) 4 significant figures

[1]

(ii) 2 significant figures

[1]

(iii) 1 significant figure

[1]

(3 marks)

4 (a) The distance from Earth to the edge of the observable universe is approximately 4.40×10^{26} m.

State the order of magnitude for this distance

.....

(1 mark)

(b) State the order of magnitude that is:

(i) 100 times larger than 5.5×10^{2}

[1]

(ii) 1 000 000 times smaller than 9.1×10^{4}

[1]

(iii) 1000 times larger than 3×10^{-20}

[1]

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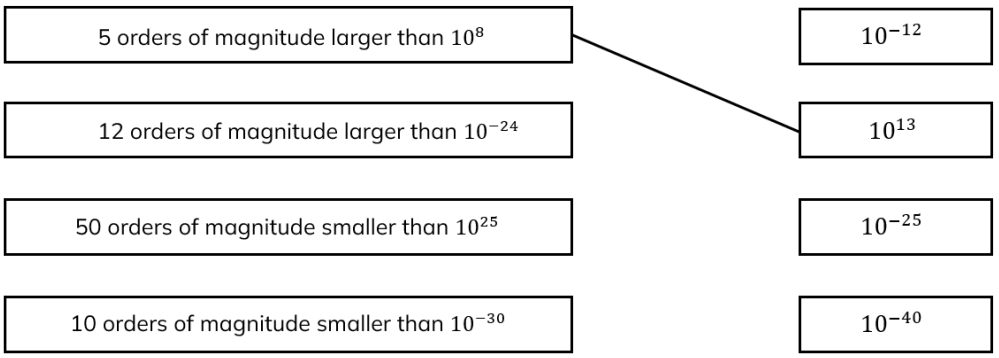
.....

.....

(3 marks)

(c) Match the description to the correct order of magnitude



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(3 marks)

(d) The radius of the Earth is approximately 6.4×10^6 m.

Using an approximation for the typical arm span of a person, estimate the number of people it would take to circle the Earth holding hands.

(4 marks)

5 (a) Convert 1 year into seconds. Give your answer to 2 significant figures in scientific notation.

(3 marks)

(b) The wave equation describes the relationship between wave speed, c, frequency, f, and wavelength, λ.

$$c = f\lambda$$

UV rays travel at the speed of light and have a frequency of 900×10^{12} Hz.1

Calculate the wavelength of the UV ray in nm.

(3 marks)

(c) UV rays travel from the Sun to the Earth in 500 ms.

State the relevant SI base unit for time and convert the given value to its SI base unit.

(2 marks)

(d) A light-year is the distance that light travels in a year.

Calculate the value of 1 light-year in km. You may use your answer from part (a) in your calculation.

(4 marks)

Medium Questions

1 (a) Define 1 Farad in fundamental SI units.

(3 marks)

(b) A parallel plate capacitor of capacitance 86 μF is connected to a 6.00 kV power supply.

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

(3 marks)

(c) List the following capacitance in increasing magnitude:

100 pF, 0.1 μF, 100 cF, 0.01 fF

(4 marks)

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

(3 marks)

2 (a) 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.

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)

(b) Pressure is measured in pascals.

Define 1 Pascal in fundamental SI units.

(3 marks)

(c) 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.

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

(2 marks)

(d) Pressure changes with depth, as well as force and area.

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)

3 (a) 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.

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)

(b) The sheet of silver foil has a thickness of 0.992 μm. A silver atom has a radius of 172 pm.

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

(3 marks)

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

1 barn = 100 fm^2

Calculate the value of 1 nb in m^2

(4 marks)

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

Atomic mass unit, 1 u = 931.5 MeV

1 eV = 1.60 × 10^{-19} J

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)

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

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

(3 marks)

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

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

(4 marks)

(c) X–rays from the nearest pulsar PSR J0109–1431 take 8.82 Gs to travel to Earth.

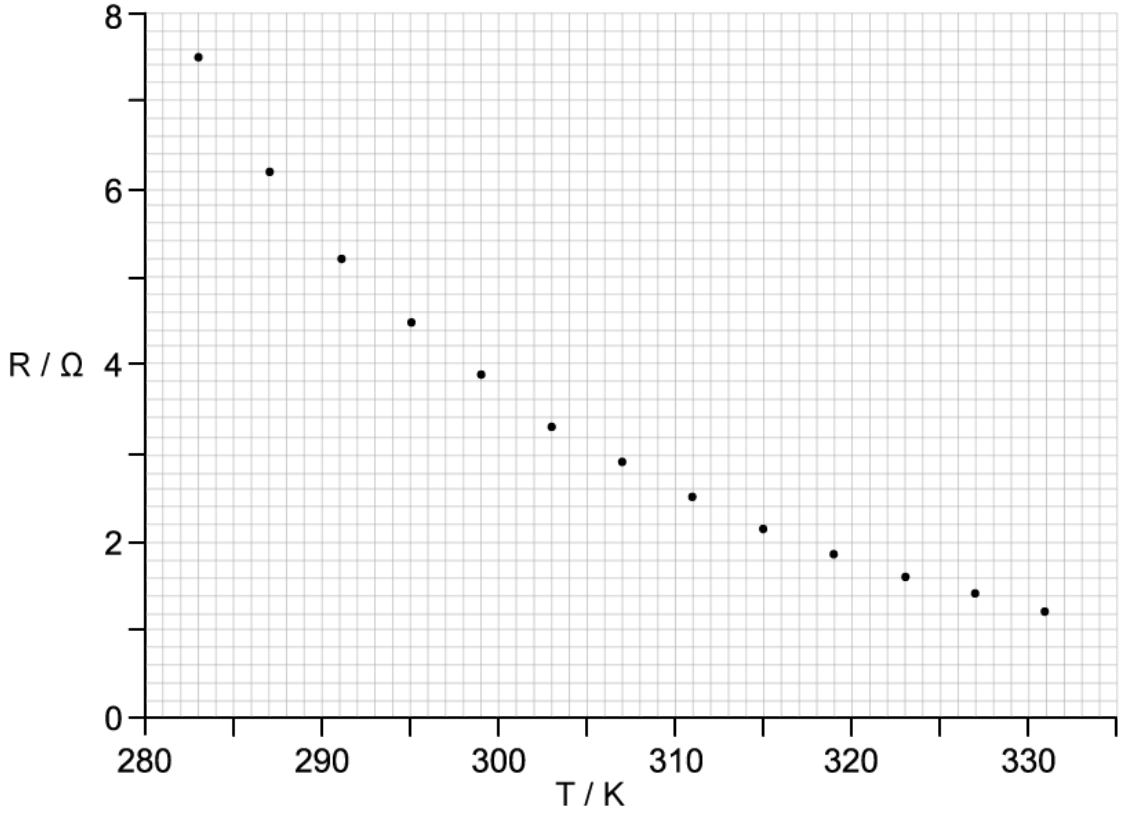
Calculate the number of oscillations of the X–rays from the pulsar to the surface of the Earth. Give your answer to an appropriate number of significant figures.

(3 marks)

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

(3 marks)

5 (a) 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 K is 0.0078 mA.

What is the units of resistance *R* in SI units?

(5 marks)

(b) Convert 0.0078 mA to A and write in standard form.

(2 marks)

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

(3 marks)

(d) Estimate the resistance of the thermistor at a temperature of 335 K

(1 mark)

Hard Questions

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

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

(2 marks)

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

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)

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

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

where x and y are constants.

Given that the constant y is dimensionless

(i) Determine the unit of x.

[1]

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

[1]

.....

.....

(2 marks)

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

(3 marks)

(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 marks)

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

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

(2 marks)

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

(3 marks)

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

(2 marks)

(c) Convert 0.01 kWh into PeV.

(3 marks)

4 (a) 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.

Calculate the maximum force on the humerus bone before it fractures.

(4 marks)

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

Calculate the tensile strength of the femur bone in GPa.

(4 marks)

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

(2 marks)

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

(2 marks)

(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)

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

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

(3 marks)

(d) 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

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

(4 marks)