H2 PHYSICS

Exam papers with worked solutions

(Selected from Top JC)

SET C

PAPER 2

Compiled by

THE PHYSICS CAFE

READ THESE INSTRUCTIONS FIRST

Do not open the booklet until you are told to do so.

Candidates answer on the Question Paper.

No Additional Material are required.

Write your name, class index number and class at the top of this page and on all the work you hand in.

Write in dark blue or black pen on both sides of the paper.

You may use a soft pencil for any diagrams, graphs or rough working.

Do not use staples, paper clips, highlighters, glue or correction fluid or correction tape.

Answer **all** questions.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question of part of question.

Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
permeability of free space,	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_o	=	8.85×10^{-12} F m^{-1}
			$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e	=	1.60×10^{-19} C
the Planck constant,	h	=	6.63×10^{-34} J s
unified atomic mass constant,	u	=	1.66×10^{-27} kg
rest mass of electron,	m_e	=	9.11×10^{-31} kg
rest mass of proton,	m_p	=	1.67×10^{-27} kg
molar gas constant,	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k	=	1.38×10^{-23} J K^{-1}
gravitational constant,	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall,	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion,	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
work done on/by a gas,	$W = p\Delta V$
hydrostatic pressure,	$p = \rho gh$
gravitational potential,	$\phi = -Gm/r$
displacement of particle in s.h.m.,	$x = x_o \sin \omega t$
velocity of particle in s.h.m.,	$v = v_o \cos \omega t$
	$= \pm \omega \sqrt{x_o^{\ 2} - x^2}$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \ldots$
electrical potential,	$V = Q/(4\pi\varepsilon_o r)$
alternating current /voltage,	$x = x_o \sin \omega t$
transmission coefficient,	$T = \exp(-2kd)$
	where $k = \sqrt{\frac{8\pi^2 m(U-E)}{h^2}}$
radioactive decay,	$x = x_o \exp(-\lambda t)$
decay constant,	$\lambda = \frac{0.693}{t_{1/2}}$

1 (a) (i) Explain the meaning of the term *base* unit. [1]

(ii) Give an SI unit and an estimate of the magnitude of each of the following physical quantities. (Marks will be awarded for the correct order of magnitude of each estimate, not for its accuracy.)

	Magnitude	Unit
Resistance of a domestic filament lamp		
Mass of Earth		
Size of nucleus		

[3]

(b) (i) Explain the meaning of the term *systematic error*. [1]

(ii) The theory of gas flow through small diameter tubes at low pressures is an important consideration of high vacuum technique. One equation which occurs in the theory is

$$Q = \frac{kr^3(P_1 - P_2)}{l}\sqrt{\frac{M}{RT}}$$

where k is a number without units, r is the radius of the tube, P_1 and P_2 are the pressures at each end of the tube of length l, M is the molar mass of the gas, R is the molar gas constant and T is the thermodynamics temperature.

In using the equation, the value of r is $(1.67 \pm 0.03) \times 10^{-4}$ m. What percentage uncertainty does this introduce into the value of Q? [2]

2 This question gives some statements which can lead to misconceptions in Physics. Each statement is correct.

(a) Friction is sometimes described as a force which prevents motion.

How is it that a forward frictional force on tyres is essential to give a car a forward acceleration? [2]

(b) Newton's third law states that for every force which body A exerts on body B there is an equal and opposite force which body B exerts on body A.

How can anything ever accelerate? [2]

(c) When an astronaut is in the International Space Station, the gravitational force acting on him is 90% of the force acting on him when he is on the Earth's surface.

Why does the astronaut imagine himself to be weightless? [3]

3 (a) A sample of nitrogen gas occupies 2.0 m^3 at pressure of 1.5×10^5 Pa and a temperature of 300 K. Calculate

(i) The number of moles in the sample. [1]

(ii) The root mean square speed of the nitrogen molecules. (The molar mass of nitrogen = 2.8×10^{-2} kg). [1]

(b) The sample of gas in (a) is allowed to increase its volume by 1 %.

(i) <u>Case I:</u> Calculate the work done by the gas in expanding, neglecting any change in pressure. [1]

(ii) <u>Case II:</u> Assuming no heat enters or leaves the system. Using the first law of thermodynamics, explain where the energy to do work comes from. [1]

State, without calculation, what would happen to the temperature of the gas. [1]

(c) The pressure and mean temperature of the atmosphere are recorded at sea-level and at an altitude of 5000 m.

Altitude / m	0	5000
Pressure / kPa	100	54
Mean temperature / K	288	255

The molar mass of air, considered as an ideal gas, is 0.029 kg mol^{-1}.
A mass of air with a volume at sea-level of 10 m^3 rises to 5000 m.

Calculate:

(i) The volume of air mass on reaching 5000 m. [1]

(ii) The density of the air at 5000 m. [1]

4 (a) State the principles of

(i) The conservation of momentum [1]

(ii) The conservation of mechanical energy [1]

(b) Discuss how these two principles apply when two objects collide

(i) Elastically [1]

(ii) Inelastically [1]

(c) A body of mass m_1 travelling with velocity u_1, collides elastically with a body of mass m_2 travelling with velocity v_1 in the same direction. After the collision their velocities become u_2 and v_2 respectively. This is illustrated in Figure 4.1.

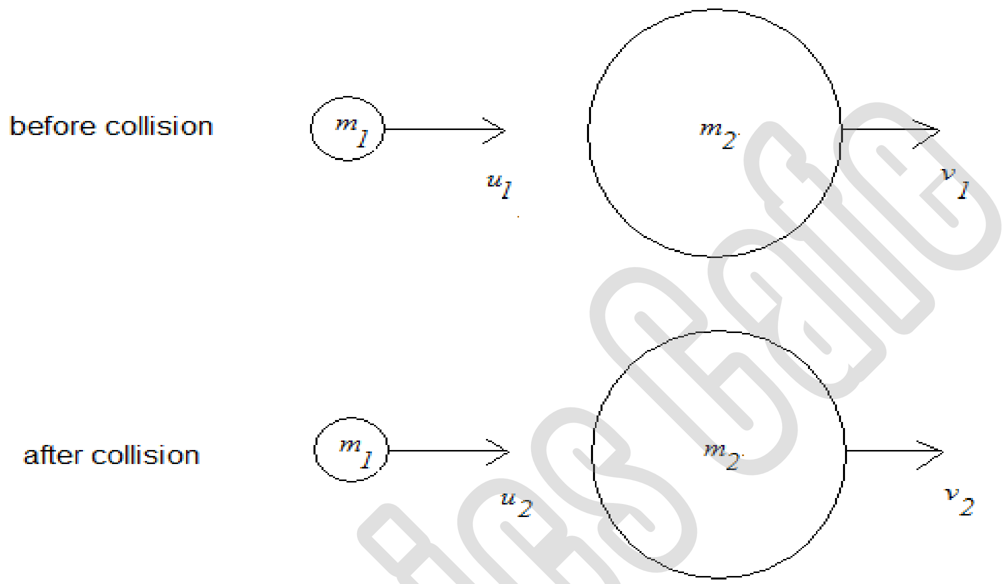

Figure 4.1

(i) For this collision write a conservation of momentum equation and a conservation of kinetic energy equation. [1]

(ii) Rewrite your two equations, keeping m_1 on the left hand side and m_2 on the right hand side of each equation. [1]

(iii) Using your answer to (ii), show that $(u_1 + u_2) = (v_1 + v_2)$. [1]

5 A wooden block of mass m floats in still water. When pushed lightly into the water and released, it is found to bob up and down with a frequency

$$f = \frac{1}{2\pi}\sqrt{\frac{28}{m}}$$ where $\boldsymbol{f}$ is measured in Hz and $\boldsymbol{m}$ in kg.

Surface water waves of speed 0.9 m s^{-1} and wavelength 0.30 m are then incident on the stationary block. These cause resonance in the up-and-down motion of the block.

(a) Calculate the mass of the wooden block. [3]

(b) Describe and explain what happens to the amplitude of vertical oscillations of the block after making the following changes independently.

(i) water waves of larger amplitude are incident on the block [2]

(ii) the distance between the wave crests increases [2]

6 (a) Distinguish between *spontaneous emission* and *stimulated emission*. [3]

(b) Explain how stimulated emission enables a laser to deliver an intense and monochromatic light beam. [3]

(c) A laser has intensity 4.0×10^{20} W m^{-2}, and shines on an area 7.2×10^{-10} m^2. Calculate the rate at which the laser emits energy. [1]

7 The table gives the half-lives of four radioactive nuclides together with some of the decay constants. The fourth column lists the significant emissions from the nuclides together with their energies. The total number of each of the emissions given as a percentage of the total number of nuclei which decay is also given.

nuclide	*half-life/s*	*decay constant/s*$^{-1}$	*emissions*		
			type	*energy/ x10*$^{-13}$ *J*	*percentage*
Americium ^{241}Am	1.48×10^{10}	4.68×10^{-11}	α α	8.78 8.70	85 13
Cobalt ^{60}Co	1.66×10^{8}	4.18×10^{-9}	β γ γ	0.496 1.87 2.13	100 100 100
Phosphorus ^{32}P	1.24×10^{6}		β	2.74	100
Sodium ^{24}Na	5.42×10^{4}	1.28×10^{-5}	β γ γ	9.60 2.19 4.11	100 100 100

(a) Calculate the decay constant of ^{32}P. [2]

(b) (i) Which of the nuclides would have the greatest activity per unit mass? [3]

(ii) Calculate the activity of a mass of 1.0×10^{-12} kg of the nuclide which you have named in part b(i). [2]

(c) A laboratory has facilities suitable for the storage of waste radioactive material for periods not exceeding 3 months (7.8×10^6 s). For which of the nuclides would storage for 3 months before disposal be worthwhile? Give your reasons. [4]

(d) Give an explanation for the figures in the percentage column for the nuclides ^{60}Co and ^{241}Am. [3]

(e) A power source with an output of 1.00 kW is required for use in a space probe. This power is to be derived from the energy of the emitted radiations from the nuclide ^{60}Co. It is known that 2.68×10^{-9} cm^3 of this nuclide has a total activity of 3.00×10^6 Bq. What volume of cobalt is required? [4]

[BLANK PAGE]