59

3 Topics and the AS practical test



Introduction

Unit 3 of the specification contains four different topics, although you have to study only one of them. The topic test paper contains four long structured questions together with spaces for your answers. Each question usually takes up four sides, consists of about five separate parts and is worth a total of 32 marks. You only have to answer one of these four questions so much of your completed question-answer booklet will remain blank! Each question mainly tests knowledge and understanding of the material in that topic and how this may be applied to other situations, although there may be a few marks for work based on material from Units 1 and 2. You are expected to be able to recall the meanings of specialist words and phrases from your chosen topic. Each question may involve quantitative work using supplied data and interpretation of supplied information, and will usually require part of the answer to be given in free prose for which there will be a quality of written communication mark. About 30% of the marks of each question will be allocated to questions on a short mini-passage taken from a relevant magazine or textbook article. You should expect such a passage to contain both familiar and new material and its questions to test both your knowledge of the topic and your comprehension of the mini-passage itself. The following section contains a checklist and a practice question for each of the four topics, look only at the part that covers your chosen topic and ignore the other three!

Checklist for topic A – Astrophysics

Before attempting the following practice question on the astrophysics topic, check that you:

- have compared the use of photographic emulsions and charge-coupled devices in recording star images
- appreciate the effect of grain and pixel size on both their sensitivity and sharpness
- understand the importance of efficiency and linearity of response
- know the effects that the Earth's atmosphere has on the different radiations passing through it

Unit 3

TOPICS AND THE AS PRACTICAL TEST

- appreciate the benefits of observing stars using orbiting telescopes such as IRAS, COBE and Hubble
- know that the distance to even the closest star is very large

- are familiar with the use of the light year as a unit of length
- can explain fully the use of annual parallax to measure the distances to nearby stars
- can sketch the energy distribution graphs for stars having different temperatures and know the effect these have on colour
- appreciate that λ_{max} is not the maximum wavelength but the wavelength at which the emitted radiation has the greatest intensity
- □ can use Wien's law to find the surface temperature of a star once it's value of λ_{max} is known
- appreciate that surface temperatures of stars range from near absolute zero (λ_{max} in radiowaves) to 10⁷ K (λ_{max} in X-rays)
- understand the difference between intensity and luminosity
- know how luminosity is calculated once distance and intensity have been measured
- appreciate how luminosity depends on surface temperature and surface area
- can sketch the Hertzsprung–Russell (H–R) diagram, showing the positions of the main sequence, red giants and white dwarfs, appreciating that temperature decreases towards the right
- realise that the H–R diagram is plotted using data obtained from nearby stars
- know how the H–R diagram is used to estimate the luminosity of a more distant main sequence star once its surface temperature has been calculated from its λ_{max}
- appreciate how this estimated luminosity and the measured intensity are used to determine how far away the more distant stars are and why annual parallax cannot be used to do this
- know that a Cepheid variable star is one whose brightness varies with a period that depends on its luminosity
- understand the use made of Cepheid variable stars in finding the distances to nearby galaxies
- appreciate that stars began as clouds of hydrogen gas that were pulled together by gravitational forces
- know that gravitational collapse results in increased temperature and can lead to 'hydrogen burning' where hydrogen fuses together to form helium
- □ can calculate the amount of energy released during the fusion process using $\Delta E = c^2 \Delta m$
- appreciate that the fusion process sets up an outward radiation pressure whose forces, in a stable star, balance the inward gravitational forces
- know that main sequence stars are in their 'hydrogen burning' stage
- understand that the more massive main sequence stars will have greater gravitational forces so will reach higher temperatures and be on the left of the H–R diagram
- appreciate that white dwarfs are hot (white) but have a low volume (dwarf) so that their surface area and, hence, luminosity are also low
- know that all white dwarfs are less than about 1.4 solar masses

3.1 .

Answers to this question, together

TIK

with explanations, are in the Answers section which follows

Chapter 6.

10⁴

³√ 10⁰ 10⁻² 10⁻⁴

Fig 3.1

Unit 3

- appreciate that red giants are cool (red) with a large volume (giant) so that their surface area and, hence, luminosity are also high
- know that all red giants are between 0.4 and 8 solar masses
- understand that a supernova results from the shock wave, created by the rapid implosion of giant stars of more than 8 solar masses, which blows away the original star's outer layers into interstellar space
- appreciate that a supernova explosion leaves behind a core remnant, and that remnants greater than about 1.4 solar masses form neutron stars whereas those greater than about 2.5 solar masses form black holes
- know that neutron stars have extremely high densities
- understand that a neutron star emits a beam of radio waves that sweeps across space as the star rotates and how this leads to its detection as a pulsar
- appreciate that a black hole is so dense that no radiation can escape from it

S Practice question for topic A – Astrophysics

The following is a typical assessment question on the astrophysics topic. Attempt this question under similar conditions to those in which you will sit your actual test.

(a)	Define power. State an appropriate unit for power.	[1] [1]
(b)	Express this unit in terms of base units. [Figure 3.1 shows a Hertzsprung–Russell diagram showing the main	2]
	sequence. Luminosity of the Sun = L_{\odot} .	
	Draw a circle on the diagram showing the region where the Sun is located. Label this circle S	
	Draw another circle showing the region where the most massive mair	1
	sequence stars are located. Label this circle M.	[2]
	Indicate on the temperature axis the approximate temperatures of the	2
	coolest and of the hottest stars.	[2]
	Explain why large mass stars spend less time than the Sun on the mai	n
	Sequence. [The luminosity of the Sun is 3.9×10^{26} W. Calculate the rate at which	2]
	mass is being convened to energy in the Sun.	3]
(c)	Charge coupled devices can have an efficiency as great as 70% compared with photographic film which has an efficiency of less than	n
	5%. State two advantages of this greater efficiency.	[2]
	Explain why astronomical telescopes are sometimes launched into	
	space.	2]
(d)	Observations with a radio telescope in 1967 detected signals from a mysterious source which was called a pulsar. What type of star is a	
	pulsar?	[1]
	What was unusual about the signals?	[2]
	Pulsars emit radio waves continuously. Explain why the signals	
	detected on Earth are not continuous. You may be awarded a mark to	r
	The clarity of your answer.	3]
(e)	Read the short passage below and answer the questions about it.	

Cepheid variables are faint red giants whose brightness changes periodically. Their periodic changes in luminosity are the result of periodic pulsations of their giant bodies. A simple relationship exists

(red) with a large volume (giant) so

A B 0 2 4 6 8 10 12 14 16 t/days

Fig 3.2

62

What is meant by the following terms used in the passage?
Red giants
Parallax displacement
The curves in Figure 3.2 are plots of intensity against time for two
Cepheid variable stars, A and B. These are known as light curves.
Estimate the period of the pulsations of star A.

between the periods of these pulsations and the luminosities of the stars. The greater the luminosity, the longer the period of pulsation. This relationship has proved very useful for measuring the distances of stars which are too far away to show a parallax displacement. By measuring the pulsation period of a star its luminosity can be

determined. This, combined with a measurement of the intensity at the

Earth's surface, enables the distance to the star to be calculated. [Adapted from *The Creation of the Universe* by George Gamow]

Estimate the period of the pulsations of star A. [1] What can be deduced about the luminosity of star B? [1] Since the average intensities of stars A and B are similar, what can be deduced about the distances of the two stars from the Earth? Give the reasoning which led to your answer. [2] Name the two forces, one which causes a star to contract and one which

(Edexcel Unit Test PHY3, June 2001, Q. 1)

[3]

\gtrsim Checklist for topic B – Solid materials

Before attempting the following practice question on the solid materials topic, check that you:

- can sketch force–extension graphs for copper, mild and high carbon steel and rubber
- understand the meanings of elastic limit, limit of proportionality and yield point

appreciate the differences between elastic and plastic behaviour

- have learnt a statement of Hooke's law
- know that when a material is stretched elastically, elastic strain energy is stored
- appreciate that work done is the area under a force–extension graph
- know that a lot more energy is used to stretch a copper wire plastically than elastically but that only the elastic portion of this is recoverable
- appreciate the difference between tough and brittle materials
- know that a ductile material can be pulled out into wires while a malleable material can be beaten into shape
- an calculate values of stress, strain and the Young modulus
- know that a material with a large Young modulus is stiff whereas one with a small Young modulus is flexible
- can sketch stress-strain graphs for copper, mild and high carbon steel and rubber
- appreciate that the Young modulus is the slope of the initial linear section of a stress–strain graph
- understand the meanings of yield stress and ultimate tensile stress and know that the latter determines if a material is strong or weak

	stored per volume
	can explain the temperature increase experienced by a repeatedly stretched and relaxed rubber band by referring to its hysteresis behaviour
L	appreciate that the area between the loading and unloading curves is the energy absorbed by the rubber during each stretching and relaxing cycle
opper	know that most metals are polycrystalline
	understand what is happening to the atoms of a metal during both elastic and plastic stretching
Tais point beelastic or plastic? Jest	can describe how the presence of edge dislocations and slip planes reduce the strength of a crystal
C graph in Figure 3.3, Label it P	appreciate that work hardening produces lots of dislocations that by getting tangled together makes it harder for plastic deformation to take place and strengthens the material
	know that dislocations cannot move beyond grain boundaries so metals with small crystals are stronger than metals with larger crystals
arded a mark for the clarity of yo	understand the differences between the processes of annealing, quench hardening and tempering
natural nubber showing its behave to force	appreciate that the strain of some materials gradually increases over time (creeps) even though the stress remains constant
bber band, which is repeatedly other band, which is repeatedly at the second seco	know that cyclic loading and unloading can produce cracking and lead to fatigue failure
nswer the questions about it:	appreciate that stress is greatest at the tip of a crack where the area is
	least
annic with a righ compressive La high Young modulus. It is britth ficium phosphate set vertically on t	know that polymers consist of long chain molecules that are either randomly arranged (amorphous) or partly random and partly ordered (semi-crystalline)
Dentine is the main structural structural structural structural structures and st	understand that thermoplastics have weak bonds between adjacent long chains so they soften and can be injection moulded at high temperatures
s tough. Faise teeth (dentures) are rethectives, and rethectives, an amorphous polym	appreciate that thermosets are rigid whatever the temperature due to strong permanent crosslinks
	know some of the uses made of thermoplastics and thermosets
n used in the passage?	can explain the shape of the stress–strain graph for rubber with reference to the uncoiling and stretching of its long chain molecules
 difference in molecular structure ophous polymer. behaviour of enamel under tension 	understand that a composite material combines two or more materials to make the best use of their individual properties and know a number of examples
Denote the second se	appreciate that concrete is strong in compression but weak in tension due to cracking
haviour of dentine under tension	know how pre-stressed reinforced concrete uses tensioned steel cables to keep the concrete in compression
Total 32 ma Edexcef Unit Test PHY3, Jane 2001,	a can apply the principle of moments studied in Unit 1 to systems involving non-parallel forces
A A A A A A A A A A A A A A A A A A A	
swers to this question	\leq Practice question for topic B – Solid materials
ether with explanations, are in Answers section which ows Chapter 6.	he following is a typical assessment question on the solid materials topic. ttempt this question under similar conditions to those in which you will t your actual test.

□ appreciate that the area under a stress–strain graph gives the energy

Ans tog the follo



Fig 3.3

Unit 3

64





3	TOPICS	AND	THE	AS	PRACTICAL	TEST
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DECISION OF AND THE AS PRACTICAL TEST
(a) Define work.[1]State an appropriate unit for work.[1]Express this unit in terms of base units.[2]
 (b) State Hooke's law. [2] The graph in Figure 3.3 shows the stress–strain relationship for a copper wire under tension. Use the graph to determine:
the ultimate tensile stress for copper the Young modulus of copper [3]
A copper wire of cross-sectional area 1.7×10^{-6} m ² and length 3.0 m is stretched by a force of 250 N.
Will the behaviour of the wire at this point be elastic or plastic? Justify your answer. [2]
Show this point on the stress-strain graph in Figure 3.3. Label it P.[1]Calculate the extension of the wire.[2]
(c) Explain with the aid of a diagram what is meant by an edge dislocation. [2]
Describe how the presence of dislocations can reduce the risk of metals failing by cracking. You may be awarded a mark for the clarity of your answer. [3]
 (d) Sketch a force-extension graph for natural rubber showing its behaviour for both increasing and decreasing force. [2] Use your graph to explain why a rubber band, which is repeatedly stretched and relaxed, becomes noticeably warmer. [2]
(e) Read the short passage below and answer the questions about it.
The outer layer of a human tooth is made of enamel and is the hardest tissue in the body. It is a typical ceramic with a high compressive strength, low tensile strength and a high Young modulus. It is brittle and consists of long crystals of calcium phosphate set vertically on the surface of the underlying dentine. Dentine is the main structural material of a tooth. It is a composite material consisting of needle shaped crystals in a collagen fibre matrix. Dentine has a much lower Young modulus than enamel and is tough. False teeth (dentures) are made from PMMA (polymethyl methacrylate), an amorphous polymer with a glass transition temperature of 110 °C. What is meant by the following term used in the passage?
Composite material [2]
Draw labelled diagrams to show the difference in molecular structure of

labelled diagrams to show the difference in me ot a crystalline material and an amorphous polymer. [3] The graph in Figure 3.4 shows the behaviour of enamel under tension. Add to the graph:

(i) a line labelled E to show the behaviour of enamel under compression, (ii) a line labelled D to show the behaviour of dentine under tension.

[4] (Total 32 marks)

(Edexcel Unit Test PHY3, June 2001, Q. 2)

Checklist for topic C – *Nuclear and particle* physics

Before attempting the following practice question on the nuclear and particle physics topic, check that you:

contrast constraints to confidential	close together
] ties are referred to as flavour	appreciate that the protons are positively charged and repel each other
hadrons: mesons consisting of a	strongly
consisting of three quarks and tiquarks	understand that there must be another force holding them together, the strong nuclear force
) neutron and a proton	know that the strong nuclear force attracts both protons and neutrons
	together but has a much shorter range than the electrostatic repulsion between protons
to any given particle interaction	appreciate that the radius <i>r</i> of a nucleus increases with nucleon number <i>A</i> , such that $r = r_0 A^{1/3}$ where r_0 is the radius of a proton
iteraction occurs with all particles	understand why the density of nuclear matter is very much larger than that of the material containing it
Craction occurs with all charged	can sketch a graph showing how the number of neutrons <i>N</i> varies with the number of protons <i>Z</i> for all nuclides
n occurs with all particles while t	know that radioactive decay tends to bring a nuclide closer to the $N-Z$ trend line
[appreciate the effects of α , β^- and β^+ decays on a nuclide's position
the only one that can produce a	know what is meant by a decay chain and can plot an $N-Z$ curve for any
and the formation of the second	given decay chain
[understand the principles of radioactive dating using both carbon and uranium
ssociated with each of the four	can sketch the energy spectrum for a typical α particle decay
annement Assess	understand why all α particles from the same decay have the same energy
	can sketch the energy spectrum for a typical β^- decay
	appreciate that in β^- decay a neutron in the nucleus splits into a proton and an electron
	understand how the emission of β^- particles with a range of energies from the same decay suggests that a further particle, an antineutrino, is also emitted
Juestion on the nuclear and part	appreciate why the antineutrino must be neutral and of very low mass
nder similar conditions to those	know that in β^+ decay a neutrino is also emitted
C. C	know the principle of conservation of mass-energy
Radius of a gold nucleus = 10^{-12}	can calculate the decrease in nuclear mass (in u) for a nuclear decay and express this as an energy in MeV (1 $u = 930$ MeV)
\mathbf{D}^{-1} . Estimate the density of a gold	understand what is meant by binding energy per nucleon and how it relates to nuclear stability
] (1 obtaining your answer?	are aware of the existence of antimatter and can name a number of particle-antiparticle pairs
C	appreciate that when a particle meets its antiparticle they annihilate each other such that both particles disappear and energy is released as electromagnetic photons
Jving the decay of a neutron to a	can calculate the energy released from the rest masses and energies of the particles involved
ne neutron and the proton. Use th	understand that a fundamental particle is one that cannot be split into anything smaller
raction can be responsible for tur- c for the clarity of your answer.	appreciate that particles can be classified as either leptons (light) or hadrons (heavy) and can name several examples of each type
lationship between number of s Z for some of the stable pucific	know that leptons are fundamental particles while hadrons consist of smaller fundamental particles called guarks

- appreciate that there are six different types of quark, each with its associated antiquark
- know that individual quark properties are referred to as flavour
- know that there are three types of hadrons: mesons consisting of a quark-antiquark structure, baryons consisting of three quarks and antibaryons consisting of three antiquarks
- have learnt the quark structure of a neutron and a proton
- understand that charge, lepton number and baryon number are conserved in all particle interactions
- can apply these conservation laws to any given particle interaction
- know the four ways in which fundamental particles may interact
- appreciate that the gravitational interaction occurs with all particles having mass
- know that the electromagnetic interaction occurs with all charged particles
- appreciate that the weak interaction occurs with all particles while the strong interaction only occurs between quarks
- know that the weak interaction is the only one that can produce a change in quark flavour
- understand that during interactions, set amounts (quanta) of energy are exchanged
- can name the exchange particles associated with each of the four fundamental interactions
- can draw and interpret simple Feynman diagrams

Practice question for topic C – Nuclear and particle physics

The following is a typical assessment question on the nuclear and particle physics topic. Attempt this question under similar conditions to those in which you will sit your actual test.

- (a) Define density. [1] Radius of a gold atom $\approx 10^{10}$ m Radius of a gold nucleus $\approx 10^{-15}$ m Show that (volume of a gold atom)/(volume of a gold nucleus) = 10^{15} The density of gold is 19 000 kg m⁻³. Estimate the density of a gold nucleus. What assumption have you made in obtaining your answer? [3]
- (b) Sketch graphs showing the energy spectra (i.e. number of particles against their kinetic energy) for
 - (i) a typical α particle decay,
 - (ii) a typical β^- decay.
 - Complete the equation below showing the decay of a neutron to a proton. [2]

[3]

 $n \rightarrow p +$

State the quark compositions of the neutron and the proton. Use these to explain why only the weak interaction can be responsible for this decay. You may be awarded a mark for the clarity of your answer. [3]

(c) The grid in Figure 3.5 shows the relationship between number of neutrons N and number of protons Z for some of the stable nuclides in the region Z = 31 to Z = 45.







67

[2]

[2]

[1]

[2]

[2]

[3]

[2]

[1]

Unit 3



Strontium-90, $\frac{90}{38}$ Sr, is an unstable nuclide. It decays by β^- emission to an unstable isotope of yttrium. On the grid mark the position of ⁹⁰₃₈Sr and

 $^{82}_{37}$ Rb is another unstable nuclide. Mark the position of $^{82}_{37}$ Rb on the

this isotope of yttrium.

[1] The Feynman diagram in Figure 3.6 shows the decay of the Ψ' . Complete the diagram by identifying the particles A, B and C. [2] What fundamental interaction is responsible for this decay? [1] Identify the exchange particle involved. [1]

(Total 32 marks)

(Edexcel Unit Test PH3, June 2001, Q. 3)

Checklist for topic D – Medical physics

Before attempting the following practice question on the medical physics topic, check that you:

- understand the difference between diagnosis and therapy
- appreciate that radiation can mutate or kill living cells
- know that alpha radiation is stopped by the skin and beta radiation by a few centimetres of flesh
- appreciate why radioisotopes that emit only gamma radiation are generally preferred
- know the functions of the main parts of a gamma camera
- understand how, by injecting a known volume of radioactive tracer with a known activity into the blood stream, the volume of blood in a patient can be determined

TOPICS

Fig 3.6

know that most radioisotopes used in medicine are prepared by neutron bombardment

- appreciate how different radioisotopes are selected for different tasks
- know that high energy (1.3 MeV) gamma rays from ⁶⁰Co are used to kill cancerous cells
- understand why ¹²³I (γ only) is used to monitor thyroid function whereas ¹³¹I (β ⁻ and γ) is used to destroy part of an over-active thyroid
- know that metastable radionuclides such as ^{99m}Tc are in a higher energy state than normal and decay to a more stable state by emitting gamma radiation
- understand the principle of an elution cell and how it provides a convenient source of gamma radiation
- appreciate that the amount of radioisotope remaining in the body is determined by a combination of how quickly it decays and how quickly the body excretes it
- know the meanings of radioactive and biological half-lives
- can use their values to calculate the effective half-life
- are aware of the basic principles of radiological protection
- know that X-rays are produced when high speed electrons are suddenly stopped
- can draw and label the structure of a typical X-ray tube and know why its anode is rotated
- appreciate that the efficiency of an X-ray tube is very low
- understand how the maximum energy (in eV) of emitted X-rays depends on the accelerating voltage
- know that X-rays with energies around 100 keV are used for diagnosis
- appreciate that bone absorbs a lot more of these X-rays than tissue or air due to its larger proton number
- know that a photographic plate, on the other side of the patient, detects non-absorbed X-rays
- appreciate how using a point source of X-rays and a lead anti-scatter grid improves image sharpness
- understand why the intensity of X-rays from a point source follows an inverse square law
- know that X-rays with energies around 1 MeV are used for therapy
- appreciate that the absorption of these X-rays is less dependent on proton number and so can be used to treat tissue as well as bone
- understand the need for alignment devices and why a multiple-beam rotational treatment method is used
- appreciate the problems associated with using X-ray doses that are either too low or too high
- know that ultrasound is very high frequency longitudinal waves
- appreciate that ultrasonic diagnosis relies on waves being reflected from boundaries along its path the sonar principle
- know that the amount of reflection depends on the difference in the acoustic impedance of each material
- can calculate the reflection coefficient for a given boundary
- have learnt the basic principles of the A- and B-scan methods for ultrasonic diagnosis
- appreciate that the probe used functions as both transmitter and receiver

nit 3

[1]

69

- know why a coupling medium (gel) is used between the probe and the skin
- understand how time delays are used to calculate depths of boundaries
- have learnt and can use the equation $c = f\lambda$

(a) Define electrical potential difference.

- appreciate that small wavelengths suffer less diffraction and so give better resolution although they are also more readily absorbed and so the reflected signal is weaker
- lacktrian have compared ultrasound and X-ray diagnostic techniques

Practice question for topic D – Medical physics

The following is a typical assessment question on the medical physics topic. Attempt this question under similar conditions to those in which you will sit your actual test.

~ ~		
	State an appropriate unit for potential difference.	[1]
	express this unit in terms of base units.	[4]
(b)	Explain why the effective half-life of a radioisotope administered to a patient is less than the half-life due to radioactive decay. ¹³¹ I has a radioactive half-life of 8 days and a biological half-life of	[1]
	21 days. Calculate the effective half-life of ¹³¹ I.	[2]
	After how many days will the fraction of a sample of ¹³¹ I remaining in	ı
	the body be 1/8 of the administered dose?	[2]
	Give one reason why gamma-emitting radionuclides are preferred for	
	tracer studies.	[1]
	State another property (other than half-life) that is important when	
	selecting an appropriate gamma-emitting radionuclide for diagnostic	
	purposes.	[1]
(c)	Explain why a coupling medium between the transducer and the body	y
	surface is necessary when carrying out an ultrasound scan. You may b	e
	awarded a mark for the clarity of your answer.	[3]
	Suggest an appropriate substance for use as a coupling medium.	[1]
	Figure 3.7 shows an A-scan trace on an oscilloscope. The pulses	
	represent reflections from opposite sides of the head of a fetus.	
	The time base of the oscilloscope is set at 50 μ s div ⁻¹ . The speed of	
	sound in the fetal head is 1.5×10^3 m s ⁻¹ . Calculate the size of the heat	ıd
	of the fetus.	[4]
(d)	Figure 3.8 shows part of a diagnostic X-ray tube.	
	Suggest an appropriate operating voltage for this tube.	[1]
	Why is the anode rotated?	[1]
	Why is the X-ray tube evacuated?	[1]
	Suggest an appropriate material for the outer case.	[1]

(e) Read the short passage below and answer the questions about it.

Attenuation is the reduction in intensity of a beam as it travels. X-ray beams are usually heterogeneous, that is they contain X-rays of many different wavelengths. In passing through a medium the different wavelengths are attenuated by different amounts. Longer wavelength (lower energy) X-rays are attenuated more than shorter wavelength ones. After passing through a filter the remaining X-rays therefore have a higher average energy and are relatively more penetrating. A more penetrating beam is said to be of better quality. As a heterogeneous

Answers to this question, together with explanations, are in the Answers section which follows Chapter 6.

TOPICS



Fig 3.7











70

beam passes through a medium its quality gradually increases. This process is described as hardening. The quality of an X-ray beam may be improved by either increasing the tube voltage or using a filter. [Adapted from Medical Physics Imaging by J~ Pope]

State the meaning of the following terms used in the passage.

Heterogeneous	
Hardening	[2]
Figure 3.9 shows the distribution of different wavelength X-rays in a	

typical X-ray beam.

Add to the graph to show the possible distribution of X-rays after passing this beam through a filter.

Why is the X-ray beam relatively more penetrating after it has been [2] filtered? [2]

Suggest why it is beneficial to the patient to filter the beam.

(Total 32 marks)

[3]

(Edexcel Unit Test PHY3, June 2001, Q. 4)



The AS practical test

R Introduction

This test examines your practical laboratory skills such as how you plan and perform experiments and how you analyse results and draw conclusions. It is based on the content of Units 1 and 2. The test consists of two questions each one lasting 40 minutes, although the apparatus may only be used for the first 35 of these. There is a further 10 minutes writing up time at the end giving a total test length of 90 minutes. Each question is worth 24 marks. Question 1 consists of a number of short practical exercises mainly involving setting up and using apparatus and recording observations. Question 2 concentrates on planning and evaluation. Neither of the questions requires the use of datalogging apparatus although you may be asked to explain how to set up and use such a device. The following section gives advice on how to maximise your AS practical test mark, together with a sample question of each type. Where possible, you should also practise these questions using the apparatus, which is listed in the questions.

\leq Advice on tackling the AS practical test

General

- make sure that you know how to use all standard apparatus met with in Units 1 and 2 such as vernier callipers, micrometers, analogue and digital electrical meters
- if you work on class practicals in pairs, take it in turns to assemble and use the apparatus
- treat each of your class practicals as a test to develop good habits throughout the course
- ask your teacher to arrange for you to attempt a number of practice questions under test conditions
- remember that the examiner is not in the room watching you and no video record is kept of what you do, so if what you are doing is important then write it down
- although the examiner is not there, the supervisor has to record certain measurements on the front of your test paper so that the examiner can compare your values with these and award marks accordingly – unfortunately these are added after you have finished the test!
- pay attention to significant figures practical tests are the only ones where too many or too few are penalised – as a general rule, it is best to keep to two or three

Methods

- the question tells you what to do so don't write out a general method
- concentrate on what you must do to achieve accurate results but still only describe this if asked to do so

- remember to use diagrams to help with any descriptions
- diagrams should be drawn carefully using a straight edge and labelled
- when labelling distances, make sure the labels accurately show the correct end-points
- If apparatus has to be vertical then align it with a door or window frame
- if apparatus has to be horizontal then check that each end is the same height above the bench

Measurements

- make sure you follow all instructions carefully
- always check such instruments as vernier callipers and micrometers for zero errors and tell the examiner that you have done so
- take measurements to the smallest division of the instrument used; e.g.
 0.1 mm with vernier callipers
- always give the correct units for all your measurements
- avoid parallax errors by having the eye positioned adjacent to the reading
- show all the measurements that you have to take; avoid doing sums in your head and just writing down the answer; for example, when finding the mass of water in a container
- repeat readings should be taken and must be written down even if they are all identical
- tabulate any series of corresponding readings and include the units in the table headings
- leave apparatus set up so that further results can be taken if shown to be needed; for example, by a graph

Graphs

- always use sensible scales that are easy to use and easy to follow don't use steps of 3, 6, 7, 9 etc
- scales must allow all points to be plotted and the plotted points must occupy at least half of the grid
- label both axes with both quantities and units
- plot points accurately in pencil using either '×' or '☉' your plotting will be checked especially those points that are furthest from your line
- fill in any large gaps by taking further measurements
- practise drawing best-fit straight lines and curves well before you sit the exam
- a long (30 cm) clear plastic ruler is essential for judging best-fit straight lines – make sure you have one
- recheck points that are furthest from your line and adjust if found to be incorrect

Calculations

- these may involve the gradient *m* or the intercept *c* of any straight line graph that you have plotted
- use as large a triangle as possible when calculating a gradient

t write out a general metho ever courate results but still

THE AS PRACTICAL TEST

Jnit 3

- the gradient at a point on a curve is found by drawing a tangent to the curve at that point
- remember that most gradients have units, those of y divided by those of x
- a line sloping down from left to right has a negative gradient
- the units of the intercept is the same as those of y
- give all calculated answers to the same number of significant figures as your measurements

Uncertainties

- only work out uncertainties if and where the question tells you to do so, therefore for most of your measurements you won't have to bother with uncertainties
- for a single measurement take the smallest division of the instrument as its uncertainty e.g. a length might be 19 ± 1 mm using a metre rule and 18.8 ± 0.1 mm using vernier callipers
- practise finding percentage uncertainties (equation given in test); e.g.
 5.3 and 0.53% for above lengths
- for a set of repeated readings take half the spread of the readings as the uncertainty of the average value e.g. 1.25, 1.29, 1.28 and 1.26 mm giving a spread of 0.04 mm so average value = 1.27 ± 0.02 mm with a percentage uncertainty of 1.6%
- for measurements, such as starting and stopping a timer, where your own error adds significantly to the uncertainty, always take several measurements and use their range to get the uncertainty
- add the uncertainties of any measurements that are either added or subtracted
- add the percentage uncertainties of any measurements that are multiplied or divided
- multiply the percentage uncertainty by any power to which the measurement is raised e.g. percentage error in r³ is 3 × percentage uncertainty in r
- use 100 × difference/average value to calculate the percentage difference between two values

Sample AS practical questions

(a) (i) Taking care not to damage the card supplied, determine average values for the length *l*, the width *w* and the thickness *t*. Explain why it is necessary to take a number of values in order to determine accurate values for the above quantities.

- *l* = 297 mm, 297 mm average *l* = 297 mm
- w = 210 mm, 210 mm average w = 210 mm
 - *l* and *w* within $\pm 2 mm$ of supervisor and to mm (or better) precision \checkmark
- both repeated and averaged \checkmark
- no zero error on micrometer
- *t* = 0.97 mm, 0.94 mm, 0.98 mm, 0.95 mm average *t* = 0.96 mm *t* within ±0.03 mm of supervisor and to 0.01 mm (or better) precision ✓

Apparatus needed: A4 piece of card about 1 mm thick, half-metre rule, micrometer, electronic top pan balance

[4]

suitable explanation 🗸

two readings 🗸

may vary

(ii) Using the top pan balance, measure the mass of the card and hence find a value for the density of the material of the card. The value you have obtained for the average thickness of the card is not necessarily the best average value. Explain how you could obtain a better average value for the thickness. You may assume that additional apparatus is available.

averaged from at least two readings or ±0.05 mm from at least

reference to zero error or at least four readings of $t \checkmark$ e.g. to eliminate anomalous/rogue measurements or card thickness

mass of card = 38.7 g

density = mass/volume = 38.7×10^{-3} kg/(0.297 m × 0.210 m $\times 0.96 \times 10^{-3}$ m) = 646 kg m⁻³

correct density calculation and unit 🗸

2 or 3 s.f. from correct calculation 🗸

e.g. measure total thickness of 20 pieces and average

use longer reach micrometer/cut card to get at centre

two appropriate explanations 11

(b) (i) Set up the circuit shown in Figure 3.10. Before you close the switch, have your circuit checked by the supervisor. You will be allowed a short time to correct any faults, but if you are unable to set up the circuit the supervisor will set it up for you. You will only lose 2 marks for this. [2]

circuit set up correctly without help [and e.m.f. in (ii) not 0 V!] 11

(ii) You may assume that the voltmeter is an ideal voltmeter which takes no current. Use your circuit to determine the e.m.f. ε of the cell and the potential difference V across the 4.7 Ω resistor. Leave the switch open after you have completed your readings. [2]

 $\varepsilon = 1.48$ V and V = 1.26 V

sensible value of ε to 0.01 V (or better) precision \checkmark sensible value of V to 0.01 V (or better) precision \checkmark

(iii) Calculate the current I through the resistor. Hence calculate the internal resistance r of the cell. [3]

 $I = V/R = 1.26 \text{ V}/(4.7 \Omega) = 0.268 \text{ A}$

correct calculation of *I* with unit and to at least 2 s.f. $r = (\varepsilon - V)/I = (1.48 \text{ V} - 1.26 \text{ V})/(0.268 \text{ A}) = 0.82 \Omega$

substitution into correct formula 🖌 correct calculation with unit and to 2 or 3 s.f. 🗸

 $c_{\rm s} = m_{\rm w} c_{\rm w} (\theta_2 - \theta_1) / [m_{\rm s} (\theta_3 - \theta_2)]$

(c) (i) Place 50 cm³ of water at room temperature in the polystyrene cup. Record the temperature θ_1 of the water. The supervisor has placed 10 washers tied together with string in a beaker of boiling water. Using the string, remove the washers from the beaker and transfer them to the polystyrene cup. Record the highest steady temperature θ_2 reached by the water. Calculate the specific heat capacity c_s of mild steel given that

where

 $m_{\rm w}$ = mass of water = 0.050 kg $c_{\rm w}$ = specific heat capacity of water = 4200 J kg⁻¹ K⁻¹ $m_s = \text{mass of 10 washers} = 0.039 \text{ kg}$ [5] θ_3 = initial temperature of washers = 100 °C



Apparatus needed: 1.5 V dry cell,

resistor in holder, five connecting

switch, digital voltmeter, 4.7 Ω

Fig 3.10

Apparatus needed: 200 cm³ of water at room temperature in 250 cm³ beaker, 100 cm³ measuring cylinder, expanded polystyrene cup, -10 °C to +110 °C thermometer, plastic stirrer, card telling you the mass of the 10 washers, paper towels for mopping up, access to 10 mild steel washers (diameter 25 mm, thickness 1 mm) of known mass, tied together to a length of thin string and pre-heated in boiling water

THE AS PRACTICAL TEST





Fig 3.12

 $\theta_1 = 17.4 \text{ °C and } \theta_2 = 23.1 \text{ °C}$ sensible θ_1 and θ_2 recorded with unit \checkmark $c_s = 0.050 \text{ kg} \times 4200 \text{ J kg}^{-1} \text{ K}^{-1} \times (23.1 - 17.4) \text{ °C/}[0.039 \text{ kg} \times (100 - 23.1) \text{ °C}] = 399 \text{ J kg}^{-1} \text{ K}^{-1}$ correct substitution (consistent units) \checkmark correct calculation with unit \checkmark

good value i.e. 400 ± 100 **//** (or 400 ± 200 **/**)

(ii) State two sources of error in this experiment.

e.g. loss of heat from washers during transfer some water transferred with washers some heat gained by thermometer/cup heat lost from cup to surroundings two appropriate sources of error \checkmark

(Edexcel Unit Test PHY3, May 2001, Q. 2A)

(a) The apparatus shown in Figure 3.11 has been set up for you. Add masses to the mass hanger until it is clear that the trolley accelerates across the table. Record the total mass *m* used to accelerate the trolley.

Determine the average time *t* for the trolley to travel a distance x = 0.500 m from rest when accelerated by this mass. Calculate the acceleration of the trolley given that $a = 2x/t^2$

- m = 40 g (i.e. hangar + 30 g)
- t = 3.7 s, 3.8 s, 3.7 s, 3.6 s average t = 3.7 s
 t to at least 0.1 s precision, repeated and averaged, with unit
 average from at least 3 readings
 value = 3.5 ± 1.5 s
- $a = 2x/t^2 = 2 \times 0.500 \text{ m}/(3.7 \text{ s})^2 = 0.073 \text{ m s}^{-2}$ correct calculation with unit to at least 2 s.f.
- (b) Explain with the aid of a diagram how you ensured that the trolley travelled a distance of 0.500 m in the measured time. [3]
 - see Figure 3.12 (good labelled diagram sufficient for all 3 marks) diagram clearly showing distance travelled ✓ using same point on trolley ✓ good method e.g. eye position shown level with each position ✓
- (c) Applying Newton's second law to this system gives

(M+m)a = mg - F

- where M = the mass of the trolley and its load = 2.42 kg F = the frictional force opposing the motion of the system g = the gravitational field strength
- Use your results from part (a) to calculate a value for *F*.
- $F = mg (M + m)a = (0.04 \text{ kg} \times 9.81 \text{ N kg}^{-1}) [(2.42 + 0.04) \text{ kg} \times 0.073 \text{ m s}^{-2}] = 0.21 \text{ N}$

correct rearrangement of equation \checkmark

- correct substitution using SI units \checkmark
- correct calculation with unit to at least 2 s.f. \checkmark

75

[2]

[4]

[3]

Unit

 \mathcal{S}

(d) Repeat the experiment with a larger value of *m* in order to calculate a second value for F. [4]

Using
$$m = 90$$
 g

t = 2.0 s, 1.9 s, 2.0 s, 2.1 s average t = 2.0 s

 $a = 2x/t^2 = 2 \times 0.500 \text{ m}/(2.0 \text{ s})^2 = 0.25 \text{ m s}^{-2}$

 $F = mg - (M + m)a = (0.09 \text{ kg} \times 9.81 \text{ N kg}^{-1}) - [(2.42 + 0.09) \text{ kg} \times 0.25]$ $m s^{-2}$] = 0.26 N

chosen *m* at least 30 g larger than previous value \checkmark t to at least 0.1 s precision, repeated and averaged, with unit 🗸 average from at least 3 readings 🖌 correct calculation of *F* with units to at least 2 s.f. \checkmark

(e) Calculate the percentage difference between your two values of *F*. Comment on the extent to which the value of *F* may be regarded as constant if it is assumed that experimental errors are in the region of 10%. [2]

Percentage difference = $100 \times (0.26 - 0.21) \text{ N}/(0.235 \text{ N}) = 21\%$ as this is >10%, *F* cannot be regarded as constant

correct calculation of percentage difference ✓ sensible conclusion ✓

- (f) The equation in part (c) may be investigated by plotting a graph of (M + m)a against m.
 - (i) Explain carefully how you would carry out the experiment to plot this graph.
 - (ii) Sketch the graph you would expect to obtain if the force F were constant.
 - (iii) State the values you would expect to obtain for both the gradient and the intercept on the vertical axis. [8]
 - (i) keep *M* constant ✓ use range of values of $m \checkmark$ measure corresponding values of $t \checkmark$ calculate corresponding values of $a \checkmark$
 - (ii) From part (c) (M + m)a = gm Fcompare this with y = mx + c to give graph shown in Figure 3.13
 - Sketch graph as shown in Figure 3.13 graph of (M + m)a against *m* with axes labelled \checkmark correct straight line ✓ with extrapolation to vertical axis \checkmark
 - (iii) gradient = $g \checkmark$ intercept with vertical axis = -F \checkmark (Edexcel Unit Test PHY3, May 2001, Q. 2B)

