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Examiners' Report
June 2017

IAL Physics WPH05 01

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Introduction

The assessment structure of WPH05 mirrors that of other units in the specification. It consists of 10 multiple choice questions, a number of short answer questions and some longer, less structured questions. As an A2 assessment unit, synoptic elements are incorporated into this paper. There is overlap with circular motion and exponential variation in Unit 4, but also overlap with some of the AS content from Units 1 and 2.

This paper gave candidates the opportunity to demonstrate their understanding of a wide range of topics from this unit, with all of the questions eliciting responses across the range of marks. However, marks for questions 13b, 16a, 17aii, 17c, 18aiii and 18bii tended to be clustered at the lower end of the scale.

Calculation and 'show that' questions gave candidates an opportunity to demonstrate their problem-solving skills to good effect. Some very good responses were seen for such questions, with accurate solutions which were clearly set out. Occasionally in calculation questions the final mark was lost due to a missing unit. Candidates understood the convention that in the "show that" questions it was necessary to give the final answer to at least one more significant figure than the value quoted in the question. Not all candidates recognised the importance of showing all stages in their working in this type of question.

Once again there were examples of candidates disadvantaging themselves by not actually answering the question, or by not expressing themselves using suitably precise language. This was particularly the case in extended answer questions such as 12b, 16a and 17c where candidates sometimes had knowledge of the topic, but could not express it accurately and succinctly. Candidates could most improve by ensuring they describe all aspects in sufficient detail and always use appropriate specialist terminology when giving descriptive answers.

Scientific terminology was used imprecisely and incorrectly in a number of responses seen on this paper.

Once again there was confusion demonstrated between atoms, molecules, nuclei and particles. At A2 level it is to be expected that, where candidates use such terms, they do so with accuracy.

The space allowed for responses was usually sufficient. Candidates should be encouraged to consider the number of marks available for a question, and to use this to inform their response. If candidates either need more space or want to replace an answer with a different one, they should indicate clearly where that response is to be found.

The response to the multiple-choice questions was acceptable, with 8 of the questions having 50 % or more correct answers. In order of highest percentage correct they were Q1 (95%), Q3 (91%), Q7 (82%), Q8 (79%), Q9 (72%), Q6 (70%), Q10 (60%), Q4 (60%), Q5 (32%) and Q2 (21%).

There was some evidence of candidates learning previous mark schemes in the expectation of earning marks. Candidates should be encouraged to work with mark schemes in preparation for their exam. However, it is important that they understand that mark schemes are written for examiners, and so sometimes refer to what examiners expect to see rather than giving a complete answer.

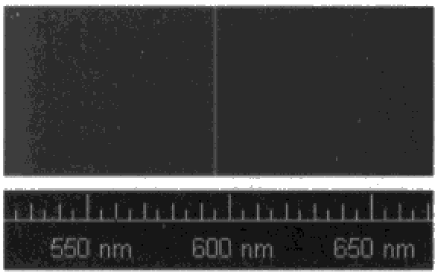
Question 11

Almost all candidates realised that this question required use of the equation for the Doppler shift of electromagnetic radiation, given in the List of Data, Formulae and Relationships at the back of the question paper. It is clear that there was a significant minority who were confused about which of the two values of wavelength they obtained from the images corresponded to λ in the equation, being unaware that λ is the value of wavelength measured in the laboratory. They used 590 nm in the denominator and as a consequence, scored only 2 of the possible 3 marks. It is possible that they had not thoroughly read the introduction to the question above the images.

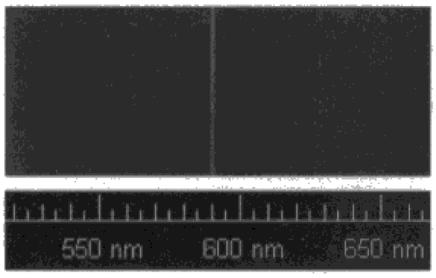
It was surprising how many could not correctly read the scale in the two images, recording the wavelengths as 600 nm and 595 nm and some identifying Δλ as 1 nm or 10 nm. They seemed to be unaware that the numbers on the scale correspond to the longer lines on the scale. These candidates could still score the second marking point and sometimes also the first.

11 The two images show a small part of the spectrum produced by helium. One image is a spectrum produced in a laboratory and the other is a spectrum produced by the light from a star.

Both images contain a bright yellow line. In the spectrum produced by light from the star, the yellow line is shifted in wavelength.



spectrum produced in a laboratory



spectrum produced by light from a star

Calculate the magnitude of the velocity of the star relative to the Earth.

(3)

$$\frac{\Delta F}{F} = \frac{v}{c}$$

$$\frac{600\text{nm} - 595\text{nm}}{600\text{nm}} = \frac{v}{3 \times 10^8 \text{ms}^{-1}}$$

$$\frac{v}{3 \times 10^8} = \frac{1}{120}$$

$$v = 2500000 \text{ ms}^{-1} \approx 2.5 \times 10^6 \text{ ms}^{-1}$$

Velocity of star = $2.5 \times 10^6 \text{ ms}^{-1}$

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Examiner Comments

The scale has not been correctly read, although the difference in the two wavelengths is 5 nm. Values have been substituted but the final answer is incorrect. This scores the first 2 marks.

Question 12 (a)

It was anticipated that candidates would realise that since molecular kinetic energy is proportional to temperature and the temperature is the same for both krypton and xenon, mass is inversely proportional to the mean squared speed, i.e. that the problem would be solved using ratios. However, some candidates who attempted this method thought that mass was proportional to the mean squared speed and so scored no marks. Those who equated expressions for the kinetic energy of krypton and xenon were usually successful. A number of candidates used the data given for krypton to calculate the temperature inside the glass bulb, then used this temperature to calculate the mean squared speed of xenon, scoring both marks.

Some estimated a temperature then used the mass of xenon, to find its mean squared speed. They did not use the data for krypton and so scored a maximum of 1 mark.

A few candidates looked up the value of the Boltzmann constant in the back of the question paper and used the Coulomb's law constant instead. This should be pointed out to students as a potential error to be avoided.

(a) The glass bulb contains a mixture of krypton gas and xenon gas at room temperature. The mean squared speed of the krypton molecules is 8.72×10^4 m^2 s^{-2}.

Calculate the mean squared speed of the xenon molecules.

mass of 1 molecule of krypton = 1.39×10^{-25} kg
mass of 1 molecule of xenon = 2.18×10^{-25} kg

(2)

$\frac{1}{2} m \langle c^2 \rangle = \frac{3}{2} kT$

$\Rightarrow T = \frac{1}{2}(1.39 \times 10^{-25})(8.72 \times 10^4) \times \frac{2}{3 \times 1.38 \times 10^{-23}} = 292.8\text{K}$

$\therefore \langle c^2 \rangle = \frac{3}{2} \times 1.38 \times 10^{-23} \times 292.8 \times \frac{2}{2.18 \times 10^{-25}} = 5.56 \times 10^4 \text{ m}^2\text{s}^{-2}$

Mean squared speed = 5.56×10^4 m^2 s^{-2}

ResultsPlus
Examiner Comments

This response scores both marks. The candidate has calculated the temperature using the data for krypton, then used that temperature to find the mean squared speed for xenon.

298 K.

(a) The glass bulb contains a mixture of krypton gas and xenon gas at room temperature.
The mean squared speed of the krypton molecules is 8.72×10^4 m^2 s^{-2}.

$\langle c^2 \rangle$

Calculate the mean squared speed of the xenon molecules.

mass of 1 molecule of krypton = 1.39×10^{-25} kg
mass of 1 molecule of xenon = 2.18×10^{-25} kg

(2)

$\frac{1}{2} \times m \times \langle c^2 \rangle = \frac{3}{2} kT.$

$\langle c^2 \rangle = \dfrac{\frac{3}{2} \times 1.38 \times 10^{-23} \times 298}{\frac{1}{2} \times 2.18 \times 10^{-25}}$

$\langle c^2 \rangle = 5.66 \times 10^4$ m^{2}s^{-1}

Mean squared speed = 5.66×10^4 m^2 s^{-2}

ResultsPlus
Examiner Comments

In this response the data given for krypton has not been used, a temperature of 298 K has been estimated and used to calculate a mean squared speed for xenon. This scores 1 mark.

ResultsPlus
Examiner Tip

Candidates should be encouraged to think carefully before ignoring given data.

Question 12 (b)

Questions asking candidates to explain pressure changes in terms of molecular momentum changes have been set previously. Many responses gave the right physics principles but lacked sufficient detail, or failed to make their points with sufficient clarity or did not use the correct terminology. References to particles instead of atoms or molecules, collisions between molecules rather than with the glass bulb, and the change in momentum rather than the rate of change of momentum were seen all too frequently.

*(b) When a current flows through the filament, the gas in the bulb heats up and the pressure exerted by the gas increases.

Explain, including ideas of momentum, why the pressure exerted by the gas increases.

(4)

* When the bulb heats up temperature increases. Average kinetic energy of the molecule increases. (Since $E_k \propto T$)

* The speed of the molecules increases. Frequancy of collisions increases. (~~to~~ Collisions rate increases)

* ~~Force per unit~~ Rate of change of momentum increases. Force per unit area increases. ($P = \frac{F}{A}$).

* Hence, pressure increases

ResultsPlus

Examiner Comments

A clearly set out response that scores 2 marks. The candidate has not said either that it is the collision rate with the glass bulb that has increased, or that it is the force on the glass bulb that has increased.

ResultsPlus

Examiner Tip

A bulleted list is often helpful when outlining a process.

As ~~[illegible]~~ $\frac{3}{2}kT = \frac{1}{2}m\langle c^2 \rangle$, when temperature increases, kinetic energy of the gas particles increases, so collision rate of the gas particles with the walls of the bulb increases, so rate of change of momentum increases. The particles exert a greater force on the walls of the bulb, and pressure increases.

ResultsPlus
Examiner Comments

This scored 3.
The candidate has referred to gas particles instead of the atoms or molecules required for both the first and the second marks. They have included all the other points required. They have lost only one mark.

Question 13 (a)

Part (i) was well answered with most candidate scoring full marks. Some candidates failed to notice that the number of seconds in a year was given in the question and so wasted time calculating it for themselves.

Part (ii) required the use of Newton's law of gravitation, but some candidates could not identify this law and attempted to use the expression for gravitational field strength instead. This approach could score no marks. Many correctly equated the gravitational force with an expression for centripetal force and could derive the expression $\omega^2 = GM/r^3$, but omitted to say that ω^2 is only inversely proportional to $1/r^3$ because G and M are constants, thus failing to score the second mark.

Part (iii) asked that the expression in (ii) was used, with the expectation that this would prompt candidates to realise that $\omega^2 r^3$ would be the same for the both the Sun and the star, which taken with the value of the angular velocity of the Sun from (i) gives a straightforward solution. The common error for many students was to use the diameter of the galaxy instead of its radius and so they could score the first mark only.

However, many candidates took a longer route, calculating a value for the mass of the nucleus of the Milky Way from the Sun's data and then using this to find the angular velocity of the star. This approach could score both marks.

(a) The galaxy is rotating about its centre and astronomers estimate that the Sun makes one complete revolution every 240 million years.

(i) Show that the angular velocity of the Sun ω_{Sun}, about the centre of the galaxy, is about 8×10^{-16} rad s^{-1}.

1 year = 3.15×10^7 s

(2)

$$\omega_{Sun} = \frac{2\pi}{T} = \frac{2\pi\,(1\,\text{rev})}{(240 \times 10^6)(3.15 \times 10^7)}$$

$$= \boxed{8.31 \times 10^{-16} \text{ rad sec}^{-1}}$$

ResultsPlus
Examiner Comments

This is a correct solution scoring full marks.

(iii) Use the expression from (ii), together with the value of ω_{Sun} from (i), to calculate a value for the angular velocity ω_{star} of a star similar to the Sun, but located at the edge of the Milky Way.

diameter of galaxy ≈ 100 000 light years

(2)

~~$\frac{\omega^2_{sun}}{\omega^2}$~~ $\omega^2_{star} \times r^3_{star} = \omega^2_{sun} \times r^3_{sun}$

$\omega^2_{star} = (8.31 \times 10^{-16})^2 \times \frac{(27000 \times 3 \times 10^8 \times 3.15 \times 10^7)^3}{(100000 \times 3 \times 10^8 \times 3.15 \times 10^7)^3}$

~~$\omega^2_{star} = 1.864 \times 10^{-31}$~~

1 ly = $1 \times 3 \times 10^8 \times$ ~~$\omega = 4.318 \times 10^{-16}$~~ $\omega = \sqrt{1.35 \times 10^{-32}} = 1.19 \times 10^{-16}$

ω_{star} = ~~4.32~~ 1.17×10^{-16} rad s^{-1}

ResultsPlus
Examiner Comments

In part (iii), this candidate has used the diameter instead of the radius but their method is correct and so it scored 1 of the 2 marks.

(2)

$(8.3 \times 10^{-16})^2 = \frac{GM_{sun}}{r^3}$ $\omega^2_{star} = \frac{Gm}{r^3}$

$M_{sun} = \frac{(8.3 \times 10^{-16})^2 (r^3)}{G} = 5.48 \times 10^{18}$ kg $= \frac{G(5.48 \times 10^{18})}{(\frac{100,000}{2} \times 3.0 \times 10^8)^3}$

$\omega = 3.29 \times 10^{-16}$ $\omega^2 = 1.08 \times 10^{-31}$ rad s^{-1}

$\omega_{star} = 3.29 \times 10^{-16}$ rad s^{-1}

ResultsPlus
Examiner Comments

Part (iii). This is an example of a candidate who has used the expression $\omega^2 = GM/r^3$ and the data for the Sun, to find a value for M. They then repeated the calculation for the star, remembering to divide the diameter by 2 and arriving at the correct answer. It scored 2 marks.

Question 13 (b)

Whilst some candidates realised that the question is hinting at the existence of dark matter, only a few realised that there must be greater gravitational forces and thus that the mass of the galaxy must be greater than expected and it is this that leads to the conclusion that there is dark matter. Those that did realise that it is something to do with mass thought it was the mass of the Universe or the mass of the stars which they had already been told were similar to the Sun. There were many varied attempts to explain the observation including attempts to use the equations from the earlier parts of the question, red shift, the expanding Universe and suggestions that the measurements were incorrect none of which scored any marks.

(b) In fact, stars similar to the Sun, but further away from the centre of the galaxy, are observed to have angular velocities that are all approximately the same.

Explain what astronomers can conclude from these observations.

(2)

They can conclude that the mass of the galaxy is greater than initially thought leading to the conclusion of the existence of dark matter.

ResultsPlus
Examiner Comments

A rare good answer worth 2 marks.

Question 14 (a)

This is a standard definition, and candidates should be ready to state this without difficulty. However, it was common to see just the second mark being awarded. This suggests that an incomplete definition has been learnt. It is essential to specify where the displacement is measured from for the first mark. A statement that “acceleration is proportional to displacement” is only a condition for simple harmonic motion if the displacement is measured from the equilibrium position.

(a) State the conditions for an object to move with simple harmonic motion.

(2)

The resultant force is directly proportional to the displacement and always toward the equilbrium position.

ResultsPlus
Examiner Comments

This response scored 1.
The candidate has not said where the displacement is measured from, but the second mark was awarded.

ResultsPlus
Examiner Tip

Learn the conditions for effects such as s.h.m., resonance etc.

Question 14 (b)

The majority of candidates made a good attempt at this question with most scoring marks in both parts.

Part (b)(i) is a 'show that' question and so it is essential that all stages in the working are shown. The 'show that' value of 2.6 Hz is given to 2 significant figures which means that the final answer must be to at least 3 significant figures and intermediate working should be to more than this. Early rounding can lead to an incorrect answer.

Show that the arms oscillate with a frequency of about 2.6 Hz.

(3)

$t_{avg} = \frac{18.9 + 19.2 + 19.1}{3} = 19.07\,s.$

$f = \frac{1}{T}$

$frequency = \frac{1}{19.07s} = 0.052\ Hz$

for 50 oscillation $= 0.052\ Hz \times 50 = 2.61\ Hz$ (shown.)

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Examiner Comments

In this response the calculation of the mean time for 50 oscillations has been correctly done, but the calculation for frequency has used this time instead of the periodic time and has been rounded to 2sf. The candidate has then realised that their value of frequency is too small and finally multiplied by 50. The final answer is incorrect because of the earlier rounding. The response scored 2 of the 3 marks.

In part (b)(ii), most candidates realised that the maximum speed in s.h.m. is given by *v=-Aω* and could calculate *ω* using the frequency from part (i). However, many thought that the amplitude was 0.75 cm instead of half this value. Those that attempted to use *v=-Aωsinωt* were almost always unsuccessful, being unable to identify the time as *T*/4 and failing to set their calculator to radians.

(ii) From the top to the bottom of the movement, the hands travel a distance of 0.75 cm.

Calculate the maximum speed of the hands.

(3)

$v_{max} = \pm 2\pi f A$

$= 2\pi \times 2.61 \times \frac{0.75}{100}$

$= 0.122\ ms^{-1}$

Maximum speed of hands = $0.122\ ms^{-1}$

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Examiner Comments

The calculation has been attempted in one go, with the correct values to find *ω* and the correct conversion from cm to m. However, the value used for amplitude is twice the actual value so the final answer is incorrect. This scored 2 marks.

Question 15 (a)

This was a straightforward use of the ideal gas equation and was answered well by most candidates. A small number did not realise that they needed to convert the temperature unit from Celsius to Kelvin, and a few incorrectly added a final unit of mol.

(a) A basketball is filled with air at a pressure of 1.55×10^5 Pa and at a temperature of 20 °C.

Calculate the number of air molecules inside the basketball.

(3)

$pV = NkT$ $\quad T = 20 + 273 = 293\,K$

$1.55 \times 10^5 \times 8.18 \times 10^{-3} = N \times 1.38 \times 10^{-23} \times 293$

$N = 3.135727358 \times 10^{23}$

$= 3.14 \times 10^{23}$

Number of air molecules = 3.14×10^{23}

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Examiner Comments

An example of a well set-out correct solution scoring 3 marks.

Question 15 (b) (iii)

This should have been a straightforward mark for most candidates but it was surprising how often the mark was not awarded. We were looking for the idea that no thermal energy was transferred to the surroundings, something that has come up many times in the past. In this case because of the wording in the question paper introduction to (b) we also accepted that the ball always rebounded to 1.40 m. Common responses that did not score included reference to no air resistance or no energy lost.

Question 15 (b) (i) – (ii)

There were many good attempts at this question which included understanding of gravitational potential and kinetic energies and use of specific heat capacity.

In part (b)(i), most students realised that the difference in gpe between when the ball was dropped from 1.80 m and when it had rebounded to 1.40m would give them the required maximum decrease in kinetic energy and solved the question with one simple calculation using $\Delta E = mg\Delta h$.

(b) A standard basketball rebounds to a height of between 1.40 m and 1.60 m when dropped onto a hard surface from a height of 1.80 m.

(i) Show that the maximum allowable decrease in kinetic energy during the bounce is about 2.4 J.

(3)

$\Delta E_k = mgh_1 - mgh_2$

$= mg(h_1 - h_2)$

$= 0.62 \times 9.81 (1.8 - 1.4)$

$= 2.43 \text{ J}$

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Examiner Comments

A clearly set out response that scored 3 marks.

GPE = mgh $mgh_1 = 10.9368$ J   (h = 1.8m)

max decrease, h = ~~1.6m~~ 1.4m. $mgh_2 = 8.51508$ J   (h = 1.4m)

$mgh_1 - mgh_2 = 10.9 - $ ~~8.5~~ 8.5

$= 2.4$ J

∴ maximum allowable decrease = 2.4 J

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Examiner Comments

This candidate has worked out the two values of gravitational potential energy separately but then rounded their values to 1 decimal place. When they did their subtraction they had a final answer to 2 significant figures, one less than is required in this 'show that' question.

In part (b)(ii), there are two possible initial approaches: either to calculate the energy required for a temperature rise of 0.5°C or to find the temperature rise for one drop. Many candidates were muddled about which value of energy they should use from part (i), failing to realise that it was the maximum decrease in E_K, i.e. the answer to (i) that should be used to find the number of drops required.

Some candidates attempted to change the given temperature rise to Kelvin showing a lack of understanding of Kelvin and Celsius temperature scales. Some added the 0.5°C to an estimated room temperature, showing a lack of understanding of the $\Delta\theta$ term.

(ii) The specific heat capacity of the basketball can be taken to be 1170 J kg^{-1} K^{-1}.

Calculate the number of times a standard basketball must be dropped from 1.80 m to increase the temperature of the basketball and the air inside by 0.5 °C.

(3)

$E = mc\Delta\theta$

$E = 0.620\,kg \times 1170 \times 0.5\,°C$

$= 362.7$

$\therefore \frac{362.7}{2.43} = 149.26$

Number of times basketball must be dropped = 150 times

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Examiner Comments

In this response which scored 3 marks, the total energy needed for a temperature rise of 0.5°C has been calculated, then divided by the value of maximum decrease in kinetic energy from part (i) to get an answer of 149.26. This candidate has realised that there would need to be 150 drops to achieve the required temperature rise and so rounded up to 150 drops.
A final answer of either 149 or 149.26 would both have scored all 3 marks

$E = mc\Delta\theta$

$2.43\ J = 0.620 \times 1170 \times \Delta\theta$

$\frac{2.43}{0.620 \times 1170} = \Delta\theta = 3.35 \times 10^{-3}\ °C$ — 1 bounce.

0.5 °C — ?

$3.35 \times 10^{-3}\ °C$ — 1 bounce | $\frac{0.5}{3.35 \times 10^{-3}} = 149$

0.5 °C — ?

Number of times basketball must be dropped = 149 bounces

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Examiner Comments

In this response the temperature rise for one drop of the ball has been correctly calculated using the value of ΔE_K from part (i). This value has then been used to find the total number of drops required. The response scored 3 marks.

Question 16 (a)

This question required careful consideration before answering if any marks were to be scored. It was clear that many candidates did not understand that if, as the questions stated, the metallic instruments in their sealed plastic packaging were passed in front of a radioactive source, the instruments could only be thoroughly sterilised if the radiation passed through to the back of the instruments. In other words that gamma radiation would be necessary. Many candidates thought that beta would be the most suitable. In general, although some understanding was shown, answers lacked sufficient, appropriate detail to score.

Many candidates simply gave as much information as they could about the penetrating power of alpha, beta and gamma radiation, often at a very basic, GCSE level. At A level, the relevant property of the radiation is its ionising ability which in turn dictates the penetrating ability. It was expected that candidates should relate their knowledge to the context, for example, that alpha radiation would not penetrate the plastic packaging. It is irrelevant to comment that alpha is stopped by paper. There was a clear misunderstanding, probably from an oversimplified approach to the topic at GCSE level, that gamma radiation is stopped by a few cm of lead.

*(a) By considering relevant properties of each type of radiation, determine whether α, β, or γ radiation would be most appropriate for this method.

(4)

α radiation has the most ionising power but its range is short and easily stopped by a few centimetres in air. β radiation has a moderate ionising power and it can be stopped by an aluminium foil. So it can pass through plastic package but not through the instruments. γ radiation has the least ionising power but ~~will b~~ its count rate only decreases by a ~~few~~ metres of lead or concrete. So γ radiation is the most suitable as it can pass through the metallic surgical instruments.

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This response scores the first 3 marks.

Alpha has low pentrating power and high ionising Beta has medium penetrating power and medium ionising. Gamma has high penetrating power and low ionising. For sterilising metallic surgical instrument gamma rays would be the most appropriate for this method. Easily passing through the plastic packages and through the instruments

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Examiner Comments

This response scores 1.
It begins with three general statements about alpha, beta and gamma radiation which whilst they are correct, are too general to score any marks in this question. However, they have identified that gamma would be the most suitable because it will pass through both the packaging and the instruments, thus scoring the 3rd mark.

Question 16 (b) (i) – (ii)

This question enabled the majority of the candidates to demonstrate their ability to successfully complete calculations using the decay constant and the equation for radioactive decay.

In part (ii), most candidates used the value of the decay constant that they had already worked out with units of s^{-1}, giving an answer for the time required for the decay in seconds, that then had to be converted to years. A few realised that using a value of the decay constant in $year^{-1}$ would make the calculation simpler and give an answer directly in years. Almost all the candidates who could substitute correctly into the decay equation were able to use logs to solve it.

Question 16 (c)

Candidates were expected to use their experience of using radioactive sources or seeing them demonstrated to answer this question. Answers gleaned from TV or movies relating to the sort of precautions required when handling highly radioactive materials were not credited.

Question 17 (a) (i)

This was generally answered well, with most candidates scoring 2 marks. There was a small minority of responses that had incorrect proton or nucleon numbers for the alpha particle.

Question 17 (a) (ii)

Many candidates did not appreciate that the question was asking for a comparison between the two products of the decay and attempted an explanation in terms of binding energy. Those that did realise that they needed to consider the momentum of the alpha particle and the neptunium nucleus, usually could not express their ideas with sufficient relevant detail to score more than the first mark. Even this mark was not scored by some candidates because they referred to alpha being 'smaller' than Np, instead of comparing the masses.

*(ii) Explain why most of the energy released in the decay becomes kinetic energy of the α-particle.

(3)

As total momentum before emission = 0.
After emission, the momentum of Np = momentum of α particles.
As total momentum after emission = 0. (momentum of Np - momentum of α-particles = 0)
~~Af~~ As mass of Np is >> mass of α-particles.
∴ velocity of α particle >> velocity of Np.
As K.E. ∝ velocity of particles, so most energy in α-particles become K.E.

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Examiner Comments

Using the first version of the mark scheme, this response scores the first 2 marks. It is acceptable to use the mathematical symbol for 'much greater than'. The final statement is not correct as KE is proportional to velocity^2 and they have not said that the kinetic energy of the alpha particle is much greater than that of the neptunium nucleus so the third mark is not scored. It was common not to be able to award the final mark because candidates simply repeated the stem of the question, that most of the energy becomes the kinetic energy of the alpha particle, even though they may have otherwise satisfied the conditions for the mark. The idea of 'much greater' was essential.

* The kinetic energy is equal to $\frac{1}{2}m(v)^2$. $\frac{p^2}{2m}$. Alpha has a lower mass so it has greater kinetic energy and Neptunium has larger mass so less kinetic energy.

kinetic energy is $\propto \frac{1}{2m}$.

ResultsPlus

Examiner Comments

The response includes a comparison of the mass of alpha and neptunium and so scores the first mark. Although they have quoted a relevant equation, p has not been defined and they have not stated that the kinetic energy of the alpha particle is much greater than that of the neptunium nucleus.

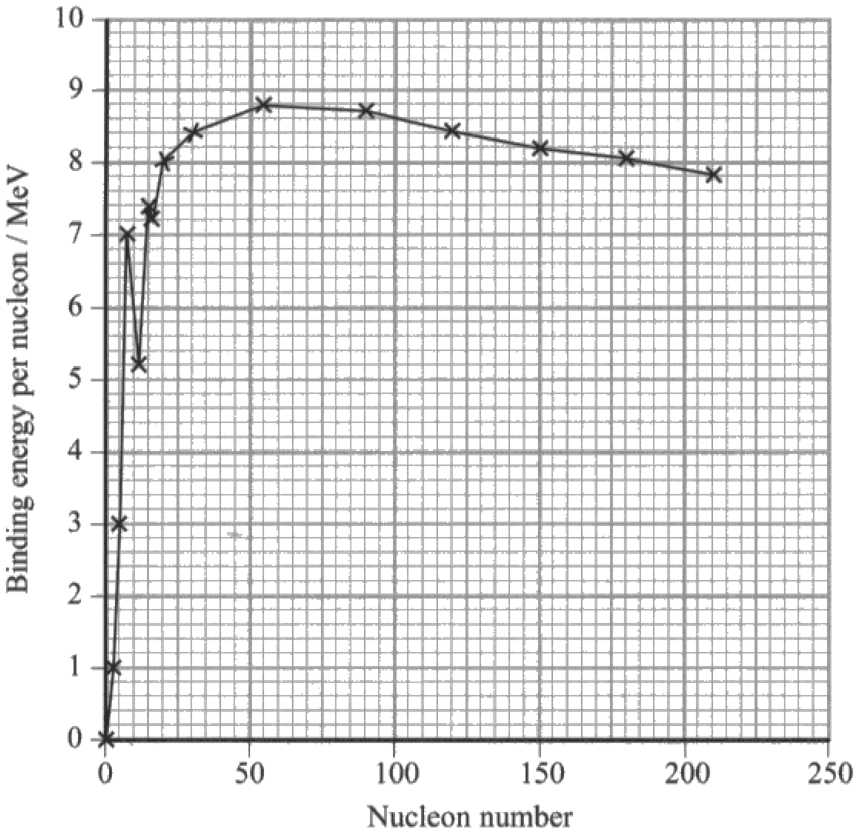
Question 17 (b)

There were many good responses to this question with the process of finding a mass defect, converting mass to kg and using $\Delta E = c^2\Delta m$ to find the binding energy in Joules being clearly understood. Disappointingly, many able candidates forgot that they had been asked to calculate the binding energy per nucleon and omitted this final step, thus reducing their maximum possible score to 3. Some candidates did not understand that they only had to consider the americium nucleus and its components and tried to include the neptunium nucleus and the alpha particle as well. The first mark was given for a realistic attempt at finding the mass defect, not necessarily an absolutely correct one.

Question 17 (c)

This question proved very challenging, showing that this topic is poorly understood. Many responses referred to binding energy instead of binding energy per nucleon. Some simply described the shape of the curve. Those that did attempt to explain what fission is, described a large nucleus splitting to form smaller nuclei instead of explaining that it is the mass of the products that is smaller. Some candidates did score the second mark by stating that the binding energy per nucleon of the products of fission is greater. Those that attempted to explain why large amounts of energy are released often confused this situation with fission in a nuclear reactor where the rate of fission is very high.

(c) The graph shows how the binding energy per nucleon varies with nucleon number for a range of nuclides.



Use the graph to explain why the fission of nuclei with large numbers of nucleons releases large amounts of energy.

(3)

When massive nuclei split into less massive nuclei in a fission reaction, there is an increase in the binding energy per nucleon. e.g. ~~Americium - 241 has a binding energy of 8.4 x 10^-17~~. nuclei with nucleon number 150 has a binding energy per nucleon of 8.2 MeV but at nucleon number 100, the nuclei have 8.6 MeV binding energy per nucleon. Hence, large amounts of energy are released in the fission reactions.

(Total for Question 17 = 12 marks)

ResultsPlus
Examiner Comments

This response scores 2.
There is an attempt at the third mark with numerical data taken from the graph, but the argument has not been taken far enough.

(3)

Only some massive nuclei, which have large numbers of nucleons, will undergo fission, and the binding energy per nucleon in original nucleus is smaller than the binding energy per nucleon in fragments, so there is energy released. Even though the energy released each fission is small, but the rate of fission is very high, so overall, fission will produce large amounts of energy.

ResultsPlus
Examiner Comments

This response scores 1.
Although the nucleus that undergoes fission is referred to as massive, the mass of the products is not mentioned. The comment about binding energy per nucleon scores the second mark. This candidate has confused this situation with that in a nuclear reactor where the rate of fission is high.

At start when the nucleon number increased, the binding energy increased dramatically. Then when the nucleon number increased, the binding energy decreased slightly.

ResultsPlus
Examiner Comments

This scored 0.
This is probably an attempt to describe the shape of the graph although it does not refer to binding energy per nucleon.

ResultsPlus
Examiner Tip

Always read questions carefully and make sure to use the correct technical terms.

Question 18 (a) (iii)

This question required candidates to think about the rate at which energy arrives at the Earth from the Sun. The response of many revealed a poor understanding of the equation for radiant energy flux *F* which they had just used in part (a)(ii).

Some responses suggested that the rate at which energy arrives at the top of the Earth's atmosphere is much less than $F \times A$ is because the energy is spread over a much larger area invoking the inverse square law, not realising that this has already been accounted for. Candidates who stated that the Earth reflects some of the incident energy had not read the question carefully. There were many responses that suggested that a significant amount of energy is absorbed by other astronomical bodies between the Sun and the Earth. This may be true to a very small extent but the question specifies 'much less than' so is not a valid answer.

Some candidates did realise that only half the Earth's surface is illuminated at any time. Very few candidates understood the physics well enough to realise that the equation for radiant energy flux applies to a surface which is perpendicular to the radiation, and most of the illuminated half of the Earth is not perpendicular to the incident radiation.

Question 18 (a) (i) – (ii)

Many excellent responses were seen to this question although some candidates only scored 2 marks of the available 3 in part (i).

Part (a)(i) asks candidates to use data from the graph, and it is essential to do this to score all three marks. A significant number of candidates used the Stefan-Boltzmann law rather than reading a value of *L/A* from the graph and so scored a maximum of 2 marks.

In part (a)(ii), almost all candidates identified the equation to use, substituted correctly, could do the calculation and remembered to include the unit Wm^{-2}, thus scoring both marks.

Question 18 (b) (i)

This question was accessible to almost all candidates and marks were lost only because as a 'show that' question it is essential to show all stages in the working and some were omitted or the final answer had insufficient significant figures. A few candidates managed to incorrectly copy the constant in the equation for Wien's law.

(b) The Sun is often referred to as a yellow star.

(i) Show that the wavelength λ_{max} at which peak energy emission occurs for the Sun is about 5×10^{-7} m.

(2)

$\lambda_{max} T = 2.898 \times 10^{-3}$

$\lambda_{max} = \frac{2.898 \times 10^{-3}}{5900} = 5 \times 10^{-7}$ m

ResultsPlus

Examiner Comments

This response scored only 1.
The working is clear but it is necessary to give the final answer to at least one more significant figure than the 'show that' value which this candidate has not done.

$\lambda_{max} T = 2.898 \times 10^{-3}$ mK.

$\lambda_{max} = 4.91 \times 10^{-7}$ m

ResultsPlus

Examiner Comments

This response scored 1.
A value for temperature has not been substituted. The correct value must have been used because the final answer is correct, but it is a 'show that' question and all substitutions must be shown.

Question 18 (b) (ii)

For the final question on the paper it was necessary to consider another aspect of the radiation received from the Sun. It was anticipated that candidates would recall that the Sun's spectrum includes a range of wavelengths that peaks at 5×10^{-7} m and could base their answer around that.

Although many candidates had the right idea, they often could not express themselves with sufficient clarity to score a mark. There were a number of responses that suggested that white light has a specific wavelength, and that the peak wavelength is closer to the wavelength of white light than yellow light. Others suggested that yellow is outside the visible spectrum. These are worrying misunderstandings at this level.

Other incorrect responses cited the expanding Universe or Doppler shift as the reason.

(ii) The visible region of the electromagnetic spectrum extends from a wavelength of about 400 nm to a wavelength of about 700 nm.

Suggest why light from the Sun is white rather than yellow.

(2)

The light has a λ max that falls almost in the middle of the visible spectrum. So the light emitted is a range of visible wavelengths, and not just completely yellow. Hence it appears white.

ResultsPlus

Examiner Comments

This response scored 2 marks

Paper Summary

Based on their performance on this paper, candidates are offered the following advice:

- Ensure they have a thorough knowledge of the physics for this unit.
- Read the question carefully and answer what is asked.
- For descriptive questions, take note of the marks available and include that number of different physics points.
- In 'show that' questions include all substitutions and all stages in the working.
- Show all their workings in calculations.

Grade Boundaries

Grade boundaries for this, and all other papers, can be found on the website on this link:

http://www.edexcel.com/iwantto/Pages/grade-boundaries.aspx

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