GCSE EXAMINERS' REPORTS

SCIENCE: PHYSICS

SUMMER 2016

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SCIENCE: PHYSICS

General Certificate of Secondary Education

Summer 2016

PHYSICS 1 – FOUNDATION TIER

General comments:

- A question in which the command word is 'Explain' is always worth at least two marks. In the case of a two mark question, the expectation is that two relevant, interlinked points are made, with one the consequence of another. In some instances on the paper, candidates only gave one point or two points not linked.

- QWC: Candidates need to be aware of the requirements of each band, and the consequences of not meeting the criteria in each band. Punctuation, spelling and grammar cause problems for candidates.

- Recall of facts was poor. Knowledge of heat transfer and methods of reducing energy loss was particularly poor. The meaning of the term frequency was not known.

Specific comments:

Q.1 (i) Most candidates gained one or two marks here. The coloured background was often linked with red shift.

(ii) About half of candidates could recall this is evidence for the Big Bang. Others stated cosmic background radiation.

Q.2 The first eight marks of the question did not require any recall of facts. Most candidates gained five of these.

(a) (i) Most candidates earned both marks for completing the table correctly. However a common error made by the remainder was to state 3 as the missing voltage.

(ii) The graph plotting produced some surprising outcomes. Only a minority of candidates gained all three marks. Some candidates did not plot any points and drew a straight line to a random point on the grid other than (6,48). Even in instances where the line went from (0,0) to (6,48) there were was not always evidence of plotted points. Other candidates did not draw the line through the origin. In cases where 3 had been previously inserted in the table an ecf was allowed for plotting this point, but it should have been treated as an anomalous result when drawing the line.

(iii) Nearly all candidates stated that output voltage increases with input voltage to score one mark. However the important relationship that the output voltage is double the input voltage was sometimes missed.

(iv) Candidates who inserted 3 as the missing voltage usually decided incorrectly the answer was B. However they could have arrived at the correct answer by referring to the graph.

(v) Mostly correct answers seen.

(b) Most candidates gained both marks. This was well known.

Q.3 The first six marks depended on interpreting data and completing calculations. No recall was required. It was therefore surprising that just over 2% of candidates did not attempt any part of the question.

(a) (i) A surprising number of candidates failed to complete the flow chart correctly. However this should not have affected their progress through the remaining numerical questions.

(ii) Most candidates stated the correct answer here.

(iii) Many candidates arrived at the correct value of efficiency. The remainder made errors in substitution or the multiplication by 100 was sometimes omitted.

(iv) Most candidates gained credit. An ecf was allowed from the previous answer.

(b) Generally responses were poor. A minority earned any marks. Candidates referred to the amount of heat loss. The carbon footprint caused by burning gas was ignored as was the finite reserves.

Q.4 (a) Nearly all candidates deduced the correct amplitude from the diagram but there was roughly an equal split between answers of 7 and 8 for the number of complete waves shown.

(b) (i) Very few correct definitions were given.

(ii) Candidates were required to select the appropriate equation for the calculation. The majority managed to do this successfully.

(c) Candidates were again required to select the appropriate equation for the calculation. The majority managed to do this successfully.

Q.5 (a) Many candidates selected more than two regions. Some candidates even ticked all six boxes. Therefore only a minority gained both marks. Radio waves and microwaves were common selections.

(b) Candidates obviously did not read the question stem carefully and quoted X-rays here. Even candidates who made their selections from the stem were reluctant to use gamma twice hence showing an uncertainty in their knowledge.

(c) Few candidates knew that the difficulties are due to the long half-lives of nuclear waste and problems with containment.

Q.6 (a) (i) There were errors in interpreting the readings shown on the balance and measuring cylinder. Therefore incorrect values were substituted into the table. The mass of oil was often quoted as 102 g. Errors were also seen in the substituted values for water but it is unclear where some of these originated.

(ii) Most candidates used their values from the table to arrive at a correct outcome. However the units of density were not well known.

(b) Some candidates ignored the densities when considering the advantages of tidal turbines. Others thought the higher density of water was a disadvantage. There were correct comparisons about the reliability of each type.

Q.7 This was the least well answered question on the paper. It was common to see no marks being awarded for parts (a) to (c).

(a) Many candidates realised this was due to convection but could not clearly link this with the fact that only water above heater 1 would heat up.

(b) (i) There were references to foam trapping air or air pockets in the foam but few candidates linked this with the good insulation properties of air.

(ii) Most candidates described the shiny outer surface as a good reflector. Very few understood that the relevant point here is the poor emitting property of shiny surfaces.

(c) Most candidates thought that the benefits were due to foam not adding to the carbon content of the atmosphere. Few linked the reduced heat loss to less demand for electricity so less fossil fuels being burned.

(d) The responses of most candidates limited them to the lower band of marks on this tier. This was despite the guidance in the bullet points about what should be included. Some candidates just described the data from the table in a paragraph. Others omitted units from their calculations. There were instances where the costs were quoted as £32 and £30. There were errors in substituting values into the relevant equations from page 2. Some candidates went on to calculate $\frac{30}{40}$ of their calculated cost for heater 1 and $\frac{30}{120}$ for heater 2. They did not understand that neither heater could be used to just heat 30 litres of water. The minority of candidates who attained a middle band mark showed correct calculations for the units used by both heaters and calculated their correct costs, including units. Very few candidates linked the energy used to an environmental effect. If any attempt at a response was given, it generally stated that heater 1 had most impact because it had the larger power. The usual errors in spelling and punctuation were evident.

SCIENCE: PHYSICS

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PHYSICS 1 – HIGHER TIER

General comments:

There were a number of disappointing performances on this higher tier paper. The more demanding topics on the specification, some of which are emboldened to be examined only on the higher tier didn't appear to have been taught to a number of those entered for the paper. Fortunately, some centres prepared their candidates very well for the examination.

Q.1 (a) (i) The mass of the oil was often written as 102 g.

(ii) Fortunately the error-carried-forward principle allowed credit to be gained when calculating the density, which then came out at 2.91 g/cm^3, yet it is floating on water! Few had any idea of what the unit of density was in this question despite the units being given at the top of each column in the table. Performances were very disappointing on the whole.

(b) Fortunately some credit was usually given to most of the answers to this part.

Q.2 (a)&(b) Principles of heat transfer continue to cause problems to the weaker candidates. Key words such as heat radiation, convection currents and poor conductor were not given in answers with the corresponding loss of marks.

(c) Too many thought that heat released from an uninsulated hot water tank contributes to global warming.

(d) Unstructured questioning in the QWC style shows up the inadequacies of ill-prepared candidates and this part did just that.

Q.3 (a)&(b) This question demonstrated candidates' inability to draw a smooth curve, though most plotted points correctly and in part (b)(i) most failed to find the source of data for drawing the required graph. Part (b)(ii) was answered poorly, with candidates failing to express that it is a <u>bigger temperature difference</u> between that body and its surroundings that is responsible for a greater <u>rate</u> of heat transfer by conduction and that it is due to a <u>higher temperature of the body</u> that a greater <u>rate</u> of heat transfer takes place by radiation.

(c) Most attempts can only be described as poor. The salient points to be addressed were:

(i) to identify that maximum frequency is related to the minimum wavelength (8 μm)

(ii) to convert 8 μm to 8×10^{-6} m for use in the equation

(iii) to manipulate and substitute correctly into the equation and finally

(iv) to arrive at the answer from their figures.

Many candidates failed to convert the 8 μm into a standard form number despite the fact that the conversions are printed inside the front page. Others failed to manipulate the equation correctly and many failed to identify the maximum frequency with the minimum wavelength. It is understandable that candidates could fail on one of these aspects of the question (particularly the minimum wavelength being associated with maximum frequency) but to take a mean of the given wavelengths of 8 μm to 10 μm and thereby to use 9 μm is a mystery. Even more mysterious were answers that used 8.5 μm or 18 μm or 2 μm in their calculations.

Q.4 (a) Stock answers relating to the National Grid were abundant. "The voltage is stepped up to reduce the current and minimise energy losses in the cables" is irrelevant to the first part of the question. No credit was given for such an answer to a question that asked about a different aspect of the National Grid from many such questions that have been set in the past.

(b) The rubric at the beginning of this question contained three pieces of information. Any possible combination was used in answers that were seen, even 50 kV / 400 kV. Again conversions from kilo to basic units were either omitted or done wrongly.

(c) This part again asked for an answer in a different way from normal and although the same old phraseology was churned out again, two marks could have been awarded if it was correctly written. Those who answered in this way usually failed to compare the two possible options for transferring electrical energy. Failing to sum up lost the third mark.

Q.5 A fairly straightforward data analysis question (for the early parts) allowed candidates to achieve some success. Disappointingly, too many failed to explain the meaning of "corrected for background radiation" as required in the last part of the question.

Q.6 (i) Candidates in huge numbers do not know the meaning of a light year.

(ii) Failure to take readings from a simple scale and to find their difference was poorly done in this part, which should have been straightforward for correctly entered higher tier candidates. Use of a calculator would have churned out the correct difference as 2×10^{-8} m even if the candidate didn't know what it meant.

(iii) Non attempts at the QWC, answers written in four lines, waffle and repetition which included irrelevant and wrong information, typify the standard of performance of the answers. With a facility factor of roughly 25% for the question as a whole, the figures speak for themselves.

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PHYSICS 2 – FOUNDATION TIER

General comments:

All questions on the paper were attempted by over 99% of the candidates which suggests that the paper proved to be user friendly. The standard of performance was quite pleasing overall with just question 3 showing a significant dip in terms of the facility factor. The final question, which included the QWC question proved to be accessible to the candidates and was reasonably answered on the whole but the first part, (a), which was the QWC part was not well done. The standard of mathematical competence shown by the candidates was quite pleasing and graph work was quite well done, both in terms of taking information from graphs and in expressing physical concepts in graphical form. It was evident that the vast majority of candidates had access to rulers for drawing straight lines and a calculator to answer mathematical problems. There was no requirement this time to draw a radioactive decay curve so candidates were less likely to fall foul by drawing disjointed or fluffy lines.

Specific comments:

Q.1 The first question, as expected, achieved the highest facility factor on the paper.

(a) However some candidates still think that when air resistance is greater than the weight of a skydiver that he / she moves upwards. The other two statements about the forces were generally correctly connected to their outcomes.

(b) All possible combinations of letters appeared in answer to this part.

Q.2 (a) (i) Having been asked to calculate the acceleration for the part AB of the graph candidates were likely to have been more successful than if we had asked for BC wherein the change in velocity is much more likely to attract errors and as a result, this part was well answered.

(ii) Answers included that AB showed a faster acceleration (which we accepted) or that AB took longer (which is wrong). Written expression in the answers was poor.

(iii) This was usually well answered.

(b) This was answered on the graph with a wide variety of success. Some terminated mid graph whilst others gained some credit for bringing a straight line down to the time axis ahead of 40 s. There were many fully correct answers.

Q.3 This question was particularly poorly answered by all candidates.

(a) Named gases (e.g. carbon dioxide, helium) were given to complete the first sentence and the problems associated with their answer had nothing to do with the nuclear reaction given in the question.

(b) This part should have offered an opportunity to gain three marks if a little understanding of the given reaction could have been demonstrated. The number of correct answers to all three statements was low.

(c) Very few answers identified with the availability of resources, the effect on the environment, or the large amount of energy that is available from fusion reactions. This part was very poorly answered.

Q.4 Taking data from the decay curve to answer the first two parts of the question was usually achieved correctly but then the candidates' ability to answer parts (a)(i)(III) and (a)(ii) was poor.
Many achieved two or three marks in part (b).

Q.5 (a) It was to the candidates' benefit that the height of the ramp was not given in the question such that part(a)(i) involved the multiplication of the one force and the only distance that had been presented to them and consequently there were many correct answers. Often one or the other of the answers to (a)(ii) and (iii) achieved credit for most candidates but many just played with the numbers.

(b) Failure to identify the change in velocity to get the change in momentum in (b)(i) usually led to the loss of 1 mark. The wrong answer to (i) was then carried through to the next part where the marks were often given with an ecf identified. The final part was very poorly answered with candidates not relating the question to Newton's third law.

Q.6 (a) The numbers 15 and 36 were often given as answers to the first two parts of the question but in (a)(iii) many candidates thought that as speed increases, thinking time increases and so thinking distance increases (which was credited with one of the two marks). Very few candidates hit on the correct reason for the increase in thinking distance. Indeed, many failed to identify in their answer that the thinking distance did increase.

(b) The wording was quite specific, asking for a description on how the data in the table would change but many answers concentrated attention on **thinking time** and/or **total stopping** distance.

(c) The numerical work was often well done but a small number of candidates still failed to round off their answer correctly (having chosen to do it), giving 2.58 as 2.5 and not 2.6.

(d) This part required a calculation of the total stopping distance at 70 mph and then a comparison to the distance given by the 2 chevron rule. Many failed to utilise the data in the table to give 96 m, let alone compare it with the 80 m for the two chevron rule.

Q.7 (a) It was rare to see an ammeter and a voltmeter added to the circuit diagram in the correct manner for the first part. Foundation tier candidates continue (unsurprisingly) to state that an ammeter (sometimes written as ampmeter) measures amps and that a voltmeter measures volts. Many waffled answers failed to hit on the major points in the indicative content that is shown in the mark scheme.

(b) Parts (i), (ii) and (iii) were very well answered but answers to part (iv) were drawn in all possible ways imaginable but many did draw a straight line from the origin (as is required for a resistor) and a minority drew it carefully through the desired coordinate of (10, 2.25). Carelessness in drawing the line from the origin and actually through the terminal coordinate cost many candidates one or both marks despite the fact that they knew what to draw.

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PHYSICS 2 – HIGHER TIER

General comments:

The majority of candidates appeared to be correctly entered for this tier of paper and the demands it provided. However, those at the bottom end of the scale would not have found attempting this paper to be a positive experience. They would have benefited from the more structured approach of the foundation tier paper. There were very few gaps on papers with questions 1, 2 and 3 being attempted by all candidates. Just over 1% of candidates did not attempt question 4. Recall of facts continues to be a problem for some candidates. This was especially true in question 4 – nuclear fission and fusion.

Some general points teachers need to be aware of when preparing candidates for these exams are:

- **'Explain'** questions are always worth at least two marks. In the case of a two mark question, the expectation is that two relevant, interlinked points are made, with one the consequence of another. In some instances on the paper, candidates only gave one point or two points not linked.
- **QWC**: Candidates who gave relevant points in their answers penalised themselves by adding incorrect statements or irrelevant statements, which were often more lengthy than the relevant information they included.

Specific comments:

Q.1 This question was answered well by many candidates.

(a) (i) Nearly all candidates recognised the pattern to complete the table correctly.

(ii) Most candidates arrived at the correct answer. However some candidates performed the incorrect calculation 24 – 12.

(iii) A majority of candidates stated that thinking distance increases with speed but failed to give a second linked statement. Some candidates did not read the question carefully enough and attempted to explain how thinking time varies with speed. They thought there is less time to think at higher speed. Others related their answer to braking distance.

(b) The majority answered correctly to earn both marks. The remaining candidates either referred to stopping distance and time which were not included in the table, or thought braking distance would change, or thought all distances would decrease because a tired driver would drive slower.

(c) To help candidates the phrase '**two chevron gaps'** was emboldened. The majority of candidates read the question carefully enough to use a distance of 80 m in their calculation and continued to arrive at the correct answer. However other candidates used a distance of 40 m. Occasionally values with mixed units were substituted into the equation e.g. $\frac{80}{70}$.

(d) It was expected that candidates would use the data in the table to determine that the stopping distance at 70 mph is 96 m and compare this with the two chevron distance of 80 m. Only a minority of candidates achieved this. Some did not refer to the distance of 96 m at all. Others just stated that the overall stopping distance at 70 mph is 96 m without continuing to provide a second linked statement about the consequences of this.

Q.2 This was the best-answered question on the paper. However part (a) demonstrated some gaps in the knowledge of candidates.

(a) Most candidates knew that an ammeter and voltmeter were required but it was surprising how many errors were made when adding these to the circuit diagram that was given. Some of these errors were:

- using squares or rectangles for both meters
- adding the voltmeter in series
- adding the voltmeter across the variable resistor or even the ammeter
- adding an ammeter in parallel.

Many candidates structured their answer logically and fully to score marks in the upper band. However some did not refer to starting at one extreme setting of the variable resistor, neither did they refer to pairs of readings at each setting. Some candidates added two ammeters to the circuit and stated that the current before the lamp was greater than the current after the lamp. Irrelevant information also appeared in responses e.g. as resistance increases the current decreases.

The following errors were still seen even on this tier of paper:

- not using capital letters at the start of a sentence, even at the start of their answer
- limited or no use of full stops resulting in long, rambling sentences
- spelling mistakes.

(b) Most candidates read the graph correctly and went on to perform correct calculations to earn full credit. In part (iv) candidates should have recognised that a straight line through the origin was required. The majority of candidates added this correctly to the grid to earn both marks. Others made errors such as:

- adding a curve
- adding a single vertical or horizontal line
- the straight line did not pass through the origin
- the straight line did not pass through (10,2.25)
- not taking care when drawing their line so it was outside the tolerance allowed i.e. less than ±½ small square from the points (0,0) and (10,2.25).

Q.3 (a) The term 'nature' is included in the specification. It was evident that candidates did not understand the meaning of this term since they described the properties of beta and gamma instead.

(b) Most candidates knew that something halved but it was not always clear that they were referring to the time for a property to halve. Secondly, some of the properties referred to were not acceptable e.g. radiation to halve, radioactivity to halve, even the time to halve.

(c) (i) The introduction to part (c) referred to one form of iodine being injected into the body. This part of the question asked why iodine-131 is the most suitable. Candidates referred to gamma being able to pass through the skin. This is irrelevant since the isotope is already inside the body. There were also statements that it had the shortest half-life, which is incorrect since iodine-128 with a half-life of 25 minutes was included in the table.

(ii) The first requirement was to convert 12 weeks to 84 days. Those candidates that did could then quote the correct number of half-lives. Not all candidates achieved this. Some believed there were 12 half-lives. Another error was to perform the calculation $\frac{8.4}{84} = \frac{1}{10}$ which was given as the answer. Some of the candidates who arrived at the correct number of half-lives then went on to attempt to find the fraction remaining by writing down the following sequence: 1 → ½ → ¼ etc. but ended at $\frac{1}{512}$ because they must have counted 1 → ½ as two half-lives instead of one. There were some candidates who performed the calculation $½^{10}$ to arrive at the correct answer.

Q.4 This depended on pure recall and was the least well-answered question on the paper. Almost 2% of candidates did not even attempt it.

(i) There was confusion about the role played by the named constituent parts. There were references to:

- control rods absorbing **the** neutron
- control rods absorb nuclei
- the moderator slows the nuclei
- the moderator absorbs neutrons
- uranium rods absorb neutrons.

Some candidates answered their own question by describing how raising/lowering the control rods controls the rate of reaction. A minority of candidates correctly described the roles of the moderator but even less went on to describe the neutrons released at each fission and the role of the control rods at this stage.

(ii) There were many references to nuclear fusion occurring in stars and hydrogen fusing into helium. However this did not answer the question. Very few candidates gained any credit in this part of the question.

Q.5 This did not depend on the recall of facts and the mean mark rose from the large dip in the previous question.

(i) Most candidates selected the correct information to substitute into the appropriate equation to arrive at the correct answer. However some omitted g in the expression mgh.

(ii) Again mostly correct answers seen.

(iii) Both previous answers should have been added as the first step here (allowances for ecf were given). This was not done by many candidates. Even those that did find the correct total work done often went on to make substitution or manipulation errors.

Q.6 (a) (i) Most candidates scored both marks for a correct calculation. Those that made an error did not consider either the interval of velocity or time or both in their calculation. They simply divided 10 by 20.

(ii) Candidates tended to not draw out the shape of the area to be calculated on the grid. This would have helped them. A minority of candidates determined the area and therefore distance correctly.

There were many examples of the calculation of $\frac{(10 \times 20)}{2} = 100\,\text{m}$.

Again the correct intervals were not used.

(iii) Nearly all candidates completed the horizontal section of the graph correctly. Only a minority were able to continue to complete the next section correctly. The following incomplete/incorrect scenarios were seen:

- inaccuracies in drawing the lines i.e. more than 1 square out at (35,10) and/or no tolerance allowed at (55,0)
- the constant velocity line drawn in but not the decelerating line
- downward line ending at (60,0) which is the bottom corner of the grid
- downward line which extended past the x-axis
- errors in the calculation to find the time of deceleration.

(b) Nearly all candidates were able to give a simple description of the motion between A and D. This is sufficient for a lower band mark. Many could also describe the relative size of weight and air resistance during each stage. This allowed entry into the middle band. However the non-linearity of the acceleration between A and B and of the deceleration between B and C was not always described. This prevented an upper band mark being awarded. A minority of candidates named the forces that were acting as the upthrust and down thrust.

SCIENCE: PHYSICS

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PHYSICS 3 – FOUNDATION TIER

General comments:

From start to end, the percentages of candidates attempting questions was pleasingly high and the mean for the paper was very respectable overall. The style of the paper was perhaps less mathematical compared with recent ones and this seemed to suit the candidature better. Carelessness in plotting points on a graph and failure to draw a straight line graph by not using a ruler continued to cost marks for some candidates. The mathematics needed for the candidates to be successful, particularly on question 6, could be better developed especially in the process of inserting data into equations effectively, which was a common cause of failure on part (b)(ii) of the question. The drop off of performance at the end of the paper was predictable but it was only the QWC question that suffered significantly this time. The skill of producing extended writing in answer to questions is in need of continued further development. Mastering the skill can make the difference of between one and two grades.

Specific comments:

Q.1 (a) This was usually well done.

(b) Most candidates knew the identity of each part of the motor from the list given.

(c) Many candidates failed to give the magnetic field direction in the manner required.

(d) One of the two requested ways of making the coil spin more slowly was usually successful.

(e) There was about a 50% success rate for this part of the question.

Q.2 This was poorly answered despite the direction given in the question.

(a) This was usually answered well (just a simple percentage gained from the pie chart).

(b) The nuclear equation given as a stimulus to the three parts of this question failed to help most candidates. This was the worst answered part of the question.

(c) The reason why our Sun will never produce the element uranium was not understood.

Q.3 Mistakes made in part (i) of this question allowed an error-carried-forward mark to be awarded in parts (ii) and (iii).

(i) Usually the negative sign was not applied in this part.

(ii) Often a zero was given in answer to this part.

(iii) The zero was often carried forward in to this part with no loss of credit for the correct process being applied.

Q.4 (a) (i) This was answered well.

(ii) A lack of care or not having the use of a ruler to pinpoint the position of the cross on the letters N or A or T on the map lost marks for the least careful of candidates.

(b) This was usually well answered.

Q.5 (a) One or the other of the two marks was usually awarded.

(b) The increase in kinetic energy / speed of the particles was often given in answers but its reason for producing an increase in pressure was usually missing.

Q.6 (a) An increase in speed was usually correctly given.

(b) (i) This was often successfully answered.

(ii) The wrong values for u, v or t (or for all three) were usually inserted into the equation.

(c) The term “less dense” was often given but it gained no mark if given on its own.

Q.7 (a) The answer given was often that the step-up transformer increases the voltage rather than the answer relating to how the **construction** differs in the two types of transformer.

(b) Getting just two ticks in the correct boxes was not often achieved. The clue of two marks being awarded should have itself deterred candidates from entering ticks in more (or less) than two boxes.

(c) This was very poorly answered.

(d) (i) The value of 100 was invariably correctly entered into the table of results.

(ii) The graph was more often than not correctly drawn using clearly plotted points.

(iii) Candidates continue to fail to develop their answer when describing the relationship between two quantities that are displayed graphically. Yes, one does increase as the other increases (and that is often all that is given as an answer) but the linearity of the relationship graphically is very rarely addressed.

(iv) The answer was usually correctly given but occasionally candidates failed to read the scale correctly on the graph.

(v) The answer rarely referred to the graph (its gradient or steepness) and it was not unusual to read that the output voltage would increase instead of decreasing yet alone being halved.

Q.8 (a) (i) The position of the critical angle was **very rarely** correct.

(ii) The description of what was happening to the ray of light in each diagram can only be described as poor.

(b) Most refracted the ray to the same side of the normal as the incident ray and the distances between successive internal reflections (which is related to the equal angles rule) was far from repeatable. The internal reflections needed to be at the glass-air boundary and not short of it or outside of it to earn one of the marks.

SCIENCE: PHYSICS

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PHYSICS 3 – HIGHER TIER

General comments:

The majority of candidates appeared to be correctly entered for this tier of paper and the demands it provided. There was almost a 100% attempt rate on all questions. However, even on this paper, gaps appeared in some candidates' knowledge e.g. transformer theory and gas laws.

Specific comments:

Q.1 This question was answered well by many candidates.

(a) Nearly all candidates stated the difference.

(b) Nearly all candidates selected both correct statements.

(c) This is not well understood and few candidates gained any credit. Ideas of voltage or current going through the iron core persist.

(d) (i)&(ii) Nearly all candidates earned full credit for completing the table and plotting the graph.

(iii)&(iv) Candidates described the relationship and interpreted the graph correctly to gain the three marks.

(v) This part caused difficulty and a minority of candidates earned credit. Even those who deduced that the output voltage would decrease failed to add a second linked statement about the effect on the graph.

Q.2 This question demonstrated some gaps in candidates' knowledge.

(a) (i) Most candidates were able to label the critical angle correctly though the remainder labelled it on diagram C.

(ii) Most candidates could describe what happened to the light ray in each diagram but only a minority could explain why. There was confusion between whether air or glass was more dense, the **ray** of incidence was compared with the critical **angle**, and there were references to total internal refraction. As a result, only a minority of candidates gained marks above the middle band.
The following errors are still sometimes seen even on the higher tier:

- not using capital letters at the start of a sentence, even at the start of their answer
- limited or no use of full stops resulting in long, rambling sentences
- spelling mistakes.

(b) Many candidates lost the first mark because of incorrect refraction of the ray as it entered the glass fibre. However the remaining two marks were still available as long as total internal reflection was shown with angle i = angle r (approximately) at each reflection. The equality of the angles tended to disappear as the ray progressed towards the right hand end of the fibre.

Q.3 (a) (i) A minority of candidates could refer to forces to explain why the Sun remains the same size. Others wrote about the composition of the Sun and the process of fusion without mentioning forces at all.

(ii) The red giant stage was well known but the white dwarf stage was not. Instead there were references to neutron stars and even sometimes black holes.

(iii) The equation was usually balanced correctly so both marks could be awarded.

(b) A majority of candidates completed the calculation correctly. Others made one or more of three errors:

- using the equation for kinetic energy
- manipulation errors
- failing to square the speed of light value in their workings.

Q.4 Only a minority of candidates made a list of the known and unknown quantities that could be substituted into the equations of motion. It is a very good starting point and some candidates used the space at the side of the diagram to write down:

- $u = 0$
- $v = ?$
- $a = 10$
- $t = 2.8$
- $x = ?$

It also acts as a check that they have considered all the information given in the question.

(a) Many candidates selected the appropriate equation to calculate x and arrived at the correct answer. However some errors were seen because (0×2.8) does not equal 2.8. Another method used by candidates was to use distance = speed $\times$ time. This is perfectly acceptable if the mean speed is calculated first. This was not usually done. Some candidates substituted 10 into the equation as the speed to arrive at an answer of 28 which is the final speed just before the ball hits the ground and not the height.

(b) This two-stage calculation firstly required a determination of speed just before hitting the ground and then use of this value in the momentum equation. The simplest method is to use $v = u + at$ first. A minority of candidates did this. Common errors seen were a single calculation such as:

- momentum = $0.3 \times 10 = 3$ kg m/s
- momentum = $0.3 \times 14 = 4.2$ kg m/s

Some candidates attempted to find v by using $v^2 = u^2 + 2ax$ and also by using an energy argument. Unfortunately errors were common if either of these approaches were used.

(c) (i) Most candidates successfully completed this calculation. For those who failed to do so, they either omitted to square the speed or omitted the ½ in their calculation even though they had correctly written down the equation.

(ii) Very few correct calculations were seen. Candidates did not understand the vector nature of momentum so they simply subtracted two momentum values.

(iii) This was not answered well. Some candidates just quoted the principle of conservation of momentum instead of applying it to the given situation. Others referred to forces.

(d) Again this was poorly answered. A minority of candidates applied Newton's 3rd law to the situation to describe how the force exerted on the Earth by the ball is equal and opposite to the force on the ball from the Earth. A restatement of Newton's 3rd law was insufficient to earn credit.

Q.5 (a) (i) Most candidates recognised that the scale on the graph was in kPa so a conversion into Pa was required.

(ii) I. Information in the table showed that both temperatures were the same therefore the gas law equation simplified to pV = *constant*. A minority of candidates recognised this. However, even those that did, made substitution errors. Few candidates arrived at the correct answer for atmospheric pressure in Denver. However an ecf was allowed if the altitude for their pressure was read correctly from the graph. There were instances where this was not possible since their calculated pressure extended way beyond the maximum of the scale.

II. This time since volume is constant the equation reduces to $\frac{p}{T}$ = *constant*. Again this was only recognised by a minority. Substitution errors were common. Very few instances were seen where the temperature in K was calculated correctly. However, a mark was awarded if there was a correct conversion from K into ^{o}C.

(b) The majority of responses gained lower band marks. The theory was not well known. A typical lower band response included references to a property that varied with temperature, for example:

- some recognition that gas pressure / volume / molecular speed or energy depends on temperature
- higher the temperature the greater the gas pressure / volume / molecular speed or energy.

It was rare to see further explanation.
To enter the middle / upper band further content was required, such as:

- molecular separation increases with temperature
- collisions with the walls of the container occur more frequently at higher temperatures
- V or p are proportional to the temperature in K
- absolute zero is the temperature where the speed or energy of molecules would be zero
- temperature scale uses variation of V or p with T where zero V or p occurs at 0 K

SCIENCE: PHYSICS

General Certificate of Secondary Education

Summer 2016

SCIENCE A CONTROLLED ASSESSMENTS

Overview

In general, the standard of the candidates' work was similar to the previous year. The candidates were well prepared and understood the controlled assessment system, but the strengths and weaknesses shown throughout the life of the specification remain largely the same. The research task continues to provide problems for a wide range of candidates.

Administration and marking

In general, samples were submitted on time and were well organised. A significant number of centres were found to be marking their candidates' work too generously. This particularly applied to those at the upper end of the mark range, but sometimes spread across the whole entry. The award of marks in the top band should indicate work of very high quality, both in the understanding of science and the communication of that understanding. Too often, very high marks were being awarded for work that was competent but showed significant weaknesses or omissions. In general, the safety task was the most accurately marked, and the main areas of marker generosity were in the research task. There were a number of instances of clerical errors by centres, but these were rare.

Pupil performance

Overall the standard appeared to be very similar to that shown in previous years. As always, there was some excellent work submitted, but the average candidates still have a weak understanding of some areas of scientific enquiry, most notably in designing investigations and in judging the strength of evidence. There are still significant gaps in their understanding of how science works in the real world, which were particularly evident in the research task.

RESEARCH TASK - GENERAL ISSUES

This task proves difficult as it combines the need for both a good understanding of the methods of scientific enquiry and good communication skills. In this task, the necessary communication skills required go further than simple spelling and grammar, although it is obvious that some candidates struggle in these areas. The best work shows a logical structure, an ability to discuss ideas and precise use of language.
The main issues in the research task are as follows.

- When judging strength of evidence, candidates focus far too heavily on the issue of bias. They do not consider the scientific methodology, e.g. sample size, confirmation by other data, significance of differences, the quality of fair testing and variability in results.

- On the issue of bias, candidates do not appreciate that data is usually correct, even in biased sources. The bias lies in the omission of data or information, and in the interpretation of the data.

- Candidates often do not seem to understand the nature and relevance of peer review. They sometimes seem to assume that 'professional scientists' are infallible and that media sources (especially the BBC) are inherently accurate and reliable.

- The descriptions of investigations in Part 2 are very often too vague. Candidates will sometimes ignore issues of practicality and ethics. They are far less confident about the design of a scientific study compared to that of a laboratory experiment.

PRACTICAL TASK – GENERAL ISSUES

Several problems listed in previous reports were still very evident this year. They were as follows.

- Candidates do not seem to understand the relationship between variability and repeats. They still often stick to the 'standard' 3 repeats, which would hardly ever be enough in a real research situation (but sometimes would be, if there was a *very* high degree of repeatability). Others seem to apply an approach of 'the more the better' which is not always either necessary or practical.

- Some candidates erroneously believe that doing more repeats improves repeatability or improves the accuracy of results (as opposed to accuracy of the *mean*, which is improved). Occasionally, a candidate would state (correctly) that doing repeats allows the identification of anomalous results. However, in such a situation, doing just three repeats would give limited evidence for any anomaly.

- Many candidates do not really understand the concept of outliers or anomalous results. They often use the term to refer to results that are unexpected, rather than anomalous. In particular, we saw examples of 'anomalous' points that were means. This should rarely happen. If the repeatability of that data set is good, the point is unlikely to be anomalous. If the mean is the result of one anomalous result within the dataset, that result should have been ignored when calculating the mean. Another fault was to pick one result as anomalous when, due to limitations in the number of data points, there were several possibilities depending on where the line of best fit was drawn. On occasions, where a curved line of best fit would have gone close to the points, a straight line was drawn and a point that did not fit it was described as being anomalous.

SAFETY TASK – GENERAL ISSUES

In both packs this task generally produced the best performances and the highest marks, and the quality of the risk assessments is gradually improving. Hazards were sometimes identified without stating their nature. Candidates failed to consider the precise risks brought about by the method used, and resorted to generic and largely irrelevant risks about chemicals splashing into eyes and glassware breaking without any reference to which parts of the method are likely to lead to these events, and how.

PACK A – RESEARCH TASK

PART 1

Most candidates produced reports that contained only relevant material, although sometimes too few sources were used, meaning that relevant material was missed out. The issues around bias, described in the general points above, were particularly evident here, where many of the sources available were from organisations which were clearly in favour or against badger culling.

Candidates seem to expect that a scientific study will always have very clear results, and therefore obvious conclusions. They struggle to draw sensible conclusions in situations like this, where the data is complex and not clear cut, and where badger culling may be appropriate in some circumstances but not in others. Some candidates with high marks gave very clear and balanced conclusions, but these were the exception rather than the rule.

PART 2

Many of the scripts seen gave very vague descriptions of the proposed methodology. For example, often there was no mention of standardising the dosage given to any test groups. A number of candidates (possibly with Jenner in mind) suggested deliberately infecting cattle with bovine TB. Ethically, this could be considered acceptable in a very small trial, but not when using hundreds of cattle from farmers' herds. Such obviously unethical or impractical designs should not be credited.

PACK A – PRACTICAL TASK

PART 1

There were relatively few specific issues with this practical task, apart from poor lines of best fit being drawn in some cases.

PART 2

No real issues with this part of the task, which was done well in many cases.

PACK A - SAFETY TASK

The only issues around this task were some weak risk assessments where the nature of the hazard and/or the action in the experiment which would lead to a risk were not defined. Some candidates ignored the message on the video and included repeats as an improvement (lack of repeat data was relevant in relation to strength of evidence, but not in relation to improvements).

PACK B – RESEARCH TASK

PART 1

The difficulty in this task was the lack of data on the topic. Nevertheless, many candidates still came to firm conclusions despite the fact that there is no clear justification either way at the moment given the lack of information. Their 'conclusions' were basically just gut feelings, which could not be justified scientifically.

PART 2

Once again the descriptions of the proposed study were very vague in many cases. Quite a number of candidates proposed deliberately exposing people to various levels of nanoparticles and seeing if they developed health conditions, which is clearly unethical and cannot be credited as a valid method.

PACK B - PRACTICAL TASK

PART 1

No specific issues with this part.

PART 2

Many candidates misinterpreted the hypothesis, which was, “the smaller the volume of a *filled* can of water, the faster it cools down”. They suggested using different volumes of water in a can of standard volume, rather than using filled cans of different volumes. Where this occurred, the centre marking often failed to pick this up. The overall effect of such a mistake was minimal, however, provided the candidate went on to design an experiment which fitted with their own idea of the hypothesis.

PACK B – SAFETY TASK

The quality of risk assessments was once again variable, but the main issue was that the candidates failed to appreciate that the experiment *was* repeated (each seed, if effect, being an experiment). Therefore, lack of repeats was not relevant either in dealing with the strength of evidence or with improvements.

SCIENCE: PHYSICS

General Certificate of Secondary Education

Summer 2016

ADDITIONAL SCIENCE & SEPARATE SCIENCES CONTROLLED ASSESSMENTS

Overview

This year's controlled assessment samples were similar in quality to those of previous years. Candidates now have a better understanding of the structure of the assessment and know what they ought to include but, perhaps unexpectedly, there are still significant gaps in their understanding of scientific methodology when considering the sample as a whole.

This report covers both the Additional Science and Separate Sciences investigations, as the structures of the schemes are identical and the Additional Science investigations could also be used for Separate Biology, Chemistry or Physics.

Administration and marking

In general, samples were submitted on time and were well organised, with helpful annotation.

The quality of marking by centres was generally good, and consistency of marking within centres has improved over the years, indicating good quality internal moderation. Where errors occurred, these generally involved over-generous marking, particularly for candidates at the top end of the mark range.

Where marking was inaccurate, it generally related to a failure to penalise candidates for the types of fault listed in the *Pupil Performance* section, below.

Pupil performance

The sections below indicate common faults that occurred in the different investigations. Certain things, however, occurred in all of the investigations, such as:

- Poor explanation of the scientific knowledge used to inform the hypothesis (even amongst the more able candidates).

- Failure to properly relate numbers of repeats to the repeatability shown in the practice work.

- Mis-identification of 'anomalous' results. Results which are generally consistent yet have anomalies are actually rare, and candidates should appreciate this. It is particularly unlikely for a mean result to be anomalous. If the mean is calculated from a set of data that has good repeatability, this suggests that it is not anomalous. If the mean has been influenced by one genuinely anomalous result, that result should have been ignored when calculating the mean. Candidates also refer to results as anomalous when they actually mean 'unexpected'.

- Lines of best fit drawn inaccurately, or when the data points did not provide enough information to judge the appropriate position. Sometimes, the line was also too thick or 'fuzzy' to be fit for purpose.

- Candidates tend to be too focussed on drawing straight lines of best fit. A number of examples were seen where the points clearly formed a curve, yet a straight (and therefore inappropriate) line of best fit was drawn, and sometimes the candidate went on to indicate that the points that did not fit the straight line were anomalous.

- Underlying the last point is a basic misunderstanding of scientific methodology, which is also sometimes evident in the conclusion. Candidates seem to regard experiments as a justification of their hypothesis, not a test. They work on the basis that the hypothesis is correct, and twist the presentation and analysis of their data to fit their pre-conceived idea.

- The erroneous belief that doing more repeats improves repeatability or the accuracy of *results* (only the mean is more accurate).

- Unscientific use of the term 'accuracy/accurate' unrelated to measurements. Also, confusion between accuracy and fair testing. When candidates refer to an experiment as accurate, it often seems to mean 'free of problems' or 'generally okay'.

BIOLOGY INVESTIGATIONS

CATALASE

This was a fairly standard enzyme experiment, and the only common specific issue was that candidates sometimes omitted to relate the theory to the factor that they were actually investigating, i.e. the rise of the paper discs. In both their hypothesis and conclusion, they dealt with the action of the variable on the enzyme, but did not go on to explain why that would affect the rising of the discs.

PHOTOSYNTHESIS

Relatively few centres used this investigation, and so it is difficult to make any generalised statements about candidate performance.

CHEMISTRY INVESTIGATIONS

MAGNESIUM AND HYDROCHLORIC ACID

The only recurring issue with this investigation was the plotting of a straight line of best fit when the candidate's data clearly showed that a curved line was more appropriate from the data.

NEUTRALISATION

This was done less frequently than the other investigation. The theory behind the hypothesis was sometimes poorly explained, but otherwise there were no specific issues.

PHYSICS INVESTIGATIONS

PAPER CAKE CASES

This was a very straightforward investigation to do. It was done by many centres for Additional Science, and almost exclusively for Physics. The main problem for candidates was the scientific explanation of the effect of their chosen variable on the drop time.

REFRACTION

This investigation was hardly seen during moderation and no general comment on candidate performance can be made.

WJEC
245 Western Avenue
Cardiff CF5 2YX
Tel No 029 2026 5000
Fax 029 2057 5994
E-mail: exams@wjec.co.uk
website: www.wjec.co.uk