# PHYSICAL SCIENCE

**Paper 0652/11**
**Core Multiple Choice**

| Question Number | Key | Question Number | Key | Question Number | Key | Question Number | Key |
|---|---|---|---|---|---|---|---|
| 1 | B | 11 | B | 21 | C | 31 | D |
| 2 | D | 12 | B | 22 | B | 32 | A |
| 3 | C | 13 | A | 23 | C | 33 | A |
| 4 | C | 14 | D | 24 | C | 34 | D |
| 5 | A | 15 | A | 25 | A | 35 | B |
| 6 | D | 16 | D | 26 | D | 36 | B |
| 7 | C | 17 | D | 27 | B | 37 | A |
| 8 | A | 18 | C | 28 | C | 38 | B |
| 9 | D | 19 | A | 29 | A | 39 | B |
| 10 | B | 20 | B | 30 | D | 40 | C |

## General comments

**Questions 21**, **30** and **37** proved to be the most challenging questions in the physics section.

## Comments on specific questions

### Question 1

A majority of the candidates recognised that the process shown the diagram is diffusion.

### Question 3

Most candidates recognised that food colouring R contained food colouring S but a significant proportion of weaker candidates thought that R contained food colouring U and chose option **D**.

### Question 4

Many candidates knew that isotopes of the same element have the same number of protons and a different number of neutrons.

### Question 5

Most candidates recognised that element J combines with chlorine to give an ionic compound. However, many of these candidates did not recognise that element M also forms an ionic chloride and chose option **B**.

### Question 6

Stronger candidates were able to deduce the formula of cryolite.

**Question 8**

Many candidates thought that one of the products of the electrolysis of concentrated aqueous sodium chloride is sodium and chose either option **B** or **D**. The electrolysis of aqueous solution was not well understood even by stronger candidates.

**Question 9**

Most candidates knew that the reactions of natural gas and the reaction of coal with oxygen are exothermic but the fact that the reaction of hydrogen with oxygen is also exothermic was only known by a small number of candidates.

**Question 10**

Most candidates knew that adding water to the dilute sulfuric acid decreases the rate of the reaction.

**Question 11**

The concept of oxidation and reduction was well understood by stronger candidates.

**Question 13**

The test for ammonia was well known by stronger candidates but weaker candidates were not secure in this knowledge.

**Question 14**

Only stronger candidates showed an understanding of the properties of transition metals .

**Question 15**

Most candidates recognised that metal M is less reactive than carbon. However many of these candidates thought that the oxide of metal M is acidic and chose option **B**.

**Question 16**

Stronger candidates recognised that copper is used for electrical wiring because it is malleable and conducts electricity. Other candidates thought that aluminium is used for aircraft parts because it conducts electricity and chose option **A**.

**Question 17**

The colour change observed when water is added to anhydrous copper(II) sulfate was not well known by many candidates.

**Question 18**

This question was well answered by stronger candidates.

**Question 19**

There was evidence of guesswork even amongst stronger candidates.

**Question 20**

There was a misconception, particularly amongst weaker candidates, that alkanes contain a double covalent bond.

**Question 21**

Many candidates here opted for **D**, choosing the graph representing uniform speed rather than the graph for uniform acceleration.

**Question 22**

A popular tactic in this question on moments was to multiply the two values given, leading to option **D**, whereas it was the moment and the distance from the pivot that were provided, not the force and distance.

**Question 28**

In this question a very common mistake was to think that the image is real, leading candidates to choose option **A**.

**Question 29**

The topic here was refraction, and many candidates opted for **B**, possibly believing that one column must include “bigger” and the other “smaller”.

**Question 30**

Only the strongest candidates were aware that the speed of all electromagnetic waves is the same in a vacuum. Many other candidates thought radio waves to be slower than light, and X-rays faster (option **C**).

**Question 37**

This question was challenging for many candidates. Option **C** was a common incorrect response with candidates failing to take into account the fact that both the magnet’s poles and the current direction had been reversed.

**Question 39**

Here, although most candidates were aware that the radiation involved was $\alpha$, a significant proportion of candidates believed that $\alpha$-particles are negatively charged.

**Question 40**

In this question on half-life many candidates chose 2.5 days rather than the correct 2.0 days. Possibly this value was chosen because it is half of the last plotted time of 5 days.

# PHYSICAL SCIENCE

**Paper 0652/21**
**Extended Multiple Choice**

| Question Number | Key | Question Number | Key | Question Number | Key | Question Number | Key |
|---|---|---|---|---|---|---|---|
| 1 | B | 11 | B | 21 | C | 31 | A |
| 2 | D | 12 | C | 22 | B | 32 | D |
| 3 | C | 13 | A | 23 | A | 33 | D |
| 4 | A | 14 | A | 24 | B | 34 | A |
| 5 | D | 15 | D | 25 | C | 35 | B |
| 6 | D | 16 | A | 26 | A | 36 | D |
| 7 | C | 17 | B | 27 | C | 37 | C |
| 8 | C | 18 | C | 28 | D | 38 | B |
| 9 | B | 19 | A | 29 | B | 39 | A |
| 10 | B | 20 | A | 30 | A | 40 | C |

**General comments**

**Questions 23**, **32**, **35**, **36** and **37** were most challenging in the physics section.

**Comments on specific questions**

**Question 1**

The vast majority of the candidates recognised that the process shown the diagram is diffusion.

**Question 3**

The concept of $R_f$ values in chromatography was not well understand by many candidates.

**Question 4**

Most candidates recognised that element J combines with chlorine to give an ionic compound. However, a number of weaker candidates did not recognise that element M also forms an ionic chloride and chose option **B**.

**Question 5**

Stronger candidates were able to recall the outer electron arrangement in a molecule of ethene.

**Question 6**

The structure and properties of graphite and diamond are well understood by most candidates.

**Question 7**

Stronger candidates were able to use the stoichiometry of the equation to calculate the volumes of oxygen and carbon dioxide.

**Question 8**

There was evidence of guesswork even amongst stronger candidates.

**Question 9**

Only stronger candidates recognised that the energy diagram showed an endothermic reaction and then related this to a reaction in which bonds are broken.

**Question 10**

Most candidates knew that adding water to the dilute sulfuric acid decreases the rate of the reaction.

**Question 11**

The definition of a base was well known by stronger candidates.

**Question 12**

Most candidates recognised that an oxide that reacts with both acids and bases is an amphoteric oxide but a significant proportion of these candidates thought that an oxide that reacts with carbon dioxide is an acidic oxide and chose option **A**.

**Question 13**

The test for ammonia was well known by stronger candidates.

**Question 14**

This question was well answered by stronger candidates. There was a misconception amongst weaker candidates that non-metallic elements react by losing their outer shell electrons.

**Question 15**

The properties of transition metals were well known by many candidates.

**Question 16**

Most candidates deduced the order of reactivity of the metals but a significant proportion of these candidates chose option **D**, where the order is most reactive to least reactive.

**Question 17**

Stronger candidates understood the reactions that occur in a catalytic converter.

**Question 18**

This question was well answered by stronger candidates.

**Question 19**

Stronger candidates knew that gases are collected at the top of the fractionating column.

**Question 20**

Many candidates recognised that reaction 1 was cracking. However, many of these candidates thought that reaction 2 was fermentation and chose option **B**.

**Question 23**

In this question on force and extension, many candidates did not take into account the unstretched length of the spring, leading them to choose the incorrect option **D**.

**Question 27**

Although most candidates knew that the changes to the thermometer would increase its sensitivity, many of them thought that its range would also be greater, even though its length was unchanged.

**Question 29**

The topic here was waves and many candidates could recall and rearrange the wave equation. However, a significant proportion of these failed to deduce the wavelength from the graph, incorrectly choosing the full length of the two cycles shown. This led them to opt for **A**.

**Question 32**

Only stronger candidates were aware that the speed of all electromagnetic waves is the same in a vacuum. Other candidates thought radio waves to be slower than light, and X-rays faster (option **C**).

**Question 35**

This was a challenging question for many candidates who correctly multiplied the current and time, but failed to take into account that the values were given in milliamps and minutes rather than in amps and seconds.

**Question 36**

The topic of factors affecting the resistance of a wire was not well understood, with all options chosen.

# PHYSICAL SCIENCE

**Paper 0652/31**
**Core Theory**

## Key messages

Candidates should follow the instructions in the question. For example, when asked for a word equation, many candidates gave a symbolic equation, giving themselves a more demanding task requiring correct formulae and correct balancing for credit to be awarded.

## General comments

Generally, calculation questions were answered well. Those candidates that showed working were able to be credited for a correct method if a subsequent error was made. Units were not given so well and many candidates seemed unaware that if two values are being multiplied then the units must also be multiplied.

## Comments on specific questions

### Question 1

**(a)** Almost all candidates were able to calculate the average speed correctly.

**(b)** The description of the motion of the aircraft needed to refer to specific physical quantities such as speed and acceleration, rather than ambiguous quantities such as motion. Statements like “the motion was increasing” were not sufficiently clear.

**(c)** The question asked candidates to respond to the fact that the take-off speed was higher than the average speed of the aircraft. Very many candidates gave answers which referred to various physical quantities like kinetic energy, momentum and power. References to these quantities were ignored.

**(d)** Candidates usually answered this question well but a common error was to state that the fuel contained thermal/heat energy.

### Question 2

**(a)** Many candidates correctly identified the halogen group by name

**(b)** Most candidates answered this correctly.

**(c)** This question was more challenging, with all of the different halogens being nominated by some of the candidates. Both iodine and astatine were accepted as correct answers.

**(d) (i)** Most candidates were able to name the salt, sodium chloride, and many gave the correct formula.

**(ii)** While the majority of candidates stated that sodium chloride was ionic in nature, a significant minority opted for covalent. Almost all candidates gave one of these two responses.

**(e) (i)** Giving the atomic number and the relative atomic mass caused few candidates any difficulties.

**(ii)** The question about isotopes was more challenging for many candidates who wrote about protons and electrons or proton and electron numbers.

**(f)** Some candidates did not know this test for water. A significant number gave the answer “blue”, confusing the colour before and after testing a sample.

**Question 3**

**(a)** The expected answer was the idea that other lamp would stay on in the event that one lamp fails. Other answers such as the statement that the lamps would be brighter in parallel were accepted. One incorrect answer see was that the connection in parallel “would ensure both lamps received equal amounts of current”. This would be true of a series circuit but is not an advantage of a parallel circuit.

**(b)** Only stronger candidates answered this correctly. Many candidates suggested “alpha/beta”, “positive/negative”, “series/parallel” or similar. Heat was not accepted as an alternative to IR but thermal and heat rays/radiation were given credit.

**(c) (i)** The current 5A was correctly calculated by most candidates.

**(ii)** Many candidates thought the current in the fuse would be less than, or the same as, the current in one of the lamps.

**(iii)** Candidates needed to realise that a fuse is rated by its current carrying capacity and so the units indicated the correct option.

**(d)** This question proved to be challenging for many candidates. Stronger candidates knew that the fuse wire would get hot and melt and that this would then stop current flow. Ideas about controlling/limiting/absorbing current were common.

**Question 4**

**(a)** A wide range of suitable colours were accepted for the colour of iron ore, including red, orange, green, yellow and rust, but there were a significant number of incorrect answers.

**(b)** Many candidates did not give the chemical meaning of reduction and suggested things like ‘getting smaller’. Others took reduction to mean the same as extraction (of a metal).

**(c) (i)** Few candidates stated that CO was poisonous or toxic. Stating that it was harmful, on its own, was considered too vague. ‘Greenhouse gas’ and ‘a cause of acid rain’ were common answers which were not allowed. Burning or being inflammable were accepted as a danger from CO.

**(ii)** Some candidates gave a good word equation and correctly stated the formula of carbon dioxide. Many other candidates found this challenging, suggesting “carbon + oxide”. Other candidates attempted a symbol equation which they often failed to balance .

**(d)** References to greenhouse gases and global warming were not frequently seen. Damage to the ozone layer and reference to acid rain were commonly seen incorrect responses.

**Question 5**

**(a)** Most candidates were able to calculate the thickness of the card to be 0.096 cm.

**(b)** The few candidates who knew the method of finding the centre of mass of a laminar answered this very well. Most candidates offered various trial and error methods like balancing it on their finger. Some suggested other measurements, including weighing it.

**(c)** While the calculation was often correct (3 Ncm), the units were often incorrect. Many candidates quoted the units as being simply newtons (N) while others gave N/cm rather than Ncm. An answer of 0.03 Nm was given full credit

**(d)** Any mention of a turning effect was extremely rare. Candidates gave answers based on the point or distance at which a force is applied.

**Question 6**

**(a)** Many candidates answered this question well. Incorrect answers often showed a misunderstanding of the terms in the table. For example, under arrangement an answer of “spaced out” was seen when this was relevant for the term separation.

**(b)** This was well answered.

**(c)** The dot and cross diagram for water enabled most candidates to gain at least partial credit for showing two bonding pairs of electrons. Often, the number of remaining electrons was not correct, for example making the number of electrons in each H atom up to eight.

**(d) (i)** The majority of candidates correctly named the process as being filtration.

**(ii)** Most candidates were aware that the purpose of chlorination was to kill microorganisms.

**Question 7**

**(a)** This question related to the behaviour of magnetic materials and the difference between the behaviours of iron and steel and many candidates answered well. Common errors included swapping iron and steel and believing that carbon would behave differently from aluminium and plastic when used in the core of an electromagnet.

**(b)** Those candidates that drew in field lines from North to South poles, frequently had contradictory field arrow directions. It was common to see the arrows above the magnet in one direction and those below in the opposite direction.

**Question 8**

**(a) (i)** Very few candidates could identify the fraction.

**(ii)** The majority of candidates correctly named bitumen as the fraction used to make road surfaces.

**(b)** While most candidates correctly explained why the diagram showed bitumen boiled at the highest temperature, some candidates gave answers referring to “being given off first/last”. These answers were ignored as the process is continuous and first/last is not apparent from the diagram.

**(c)** Although most candidates correctly included carbon and hydrogen as components of hydrocarbons, a significant number also included other elements, particularly oxygen.

**(d) (i)** Many candidates were unable to identify unsaturated as the term for compounds with double bonds between carbon atoms.

**(ii)** Stronger answers explained how ethene was the starting material for the manufacture of polythene. Many candidates gave no answer to this question.

**(iii)** The double carbon bond and two hydrogens with a single bond to each carbon atom was needed for full credit.

**Question 9**

**(a) (i)** Only stronger candidates answered this correctly. Other candidates did not recognise that as the bottom surface was a mirror, the light would reflect off it. Some candidates did not take sufficient care to get the angles of incidence and reflection equal.

**(ii)** Most candidates correctly extended ray **R** to the top surface and many also showed the refraction that took place there.

**(b)** Many candidates correctly identified refraction and reflection as the processes taking place at the two surfaces.

**(c)** The image of the circle needed to be the same distance behind the mirror as the circle was in front. Some candidates did not measure the distances carefully and drew their image of the circle just outside the allowed region.

Stronger candidates drew a triangle with a vertex pointing towards the mirror. Candidates who misunderstood ideas of lateral inversion and drew the circle at the lower position and the triangle at the top were not given any credit.

**Question 10**

**(a)** Only stronger candidates correctly identified oxygen as the gas which reacts with ethanol when it burns.

**(b)** Most candidates knew that exothermic was the term for reactions that released thermal energy.

**(c) (i)** Answers of 78 – 80 per cent and 4/5 Nitrogen were accepted.

**(ii)** This question, which tested the understanding of the term “diatomic”, was correctly answered by many candidates.

**(d) (i)** Only stronger candidates were able to name the process as being fermentation.

**(ii)** A large majority of candidates correctly stated that the effect of the catalyst was to increase the rate of reaction/ethanol production.

# PHYSICAL SCIENCE

**Paper 0652/41**
**Extended Theory**

## Key messages

- Candidates should read the questions carefully to avoid giving answers that have already been given in the question. This is often the case in questions that ask for one "other reason".
- Stronger candidates included their working out in calculations so that credit for correct working could be awarded even if the final answer was incorrect.

## General comments

Candidates were not confident drawing dot-and-cross diagrams.

Candidates would benefit from practicing the conversion of units. For example, mA to A and ms to s.

The explanation of an electric field was not well known.

Some candidates were not familiar with the use of Roman numerals to name group numbers in the Periodic Table.

The correct use of significant figures was not well known.

Descriptions of why a reaction is exothermic in terms of bond breaking and forming were confused and showed a general lack of understanding on this aspect of the syllabus.

## Comments on specific questions

### Question 1

**(a)** The force acting due to gravity was usually correct. Occasionally, 85 N was given, where candidates had divided rather than multiplied by 10.

**(b)** The effect of increased air resistance was well known. Very few responses referred to a decrease in the resultant force.

**(c) (i)** Terminal velocity was well known. Some weaker responses stated "constant or equilibrium velocity".

**(ii)** Most candidates correctly stated 0 N.

### Question 2

**(a) (i)** Some candidates may have incorrectly interpretated diatomic to mean a species containing two different types of atom by the responses, as $CO_2$ and $C_2H_4$ were commonly seen answers.

**(ii)** CaO was well known.

**(iii)** $CH_3CH_2OH$ was stated in many responses.

**(iv)** There was confusion between displacement reactions of Group VII and the reaction of alkenes with bromine as $Cl_2$ was often given. Some responses stated ethane, $C_2H_6$.

**(v)** Most candidates recognised an oxide but $CO_2$ was a common incorrect response.

**(vi)** $CO_2$ was often correctly stated.

**(b)** Many responses did not include the atom symbols C O and H. Missing lone pairs on the oxygen were common.

**Question 3**

**(a) (i)** The moment was often correct. Stronger candidates included their working.

**(ii)** Common incorrect responses included reducing the distance, lubricating the nut, turning the nut in the opposite direction, using a bigger wrench. Using more force was also seen, despite this being excluded in the question.

**(b)** The work done by the force was often correct. Some responses incorrectly divided force by distance. The unit frequently was given as N/m or lowercase "j".

**Question 4**

**(a) (i)** Very few candidates knew that electrolysis involves the breakdown of an ionic compound. Answers that related to metal extraction were common.

**(ii)** Common errors included reversing the products and giving the ions, chloride and $Na^+$.

**(iii)** Very few candidates considered electrons and cations. There were a number of suggestions about cations going to an electrode or electrons moving but it was not made clear they moved onto the cation. Some responses stated loss of electrons.

**(iv)** All of the state symbols were seen in the responses. Some responses included numbers rather than state symbols.

**(b)** Very few candidates stated features of the structure of ionic compounds.

**Question 5**

**(a) (i)** A few vertical arrows were seen but generally the wavelength was correctly indicated. Stronger candidates took care to take the arrow heads to both wavefronts and did not stop short of a wavefront.

**(ii)** Refraction, reflection and diffusion were common incorrect answers.

**(iii)** Most responses showed three arcs spreading as they went through the gap. The wavelength was not always constant and often smaller than before the diffraction.

**(b) (i)** The speed of the wave was often correct and stronger responses included working out. A common error was $28 \times 0.80$ to give 22.4.

**(ii)** The frequency was usually correct based on the candidates' answer to **(i)**. Some responses incorrectly multiplied **(i)** by 5.6.

**Question 6**

**(a)** The number of protons and electrons was often correct. Candidates found the determination of the number of neutrons more challenging. 23 was a commonly seen incorrect number of neutrons.

**(b)** Stronger answers stated that the number of electrons was the same. Many responses referred only to the number of protons.

**Question 7**

**(a)** Many candidates referred to voltage, power or energy being kept under control or reduced. These statements were ignored.

**(b)** The formula was often incorrectly stated as charge = current ÷ time. Candidates were not confident converting mA and ms so answers were often incorrect by several powers of ten.

**(c)** The explanation of an electric field was not well known and very few candidates were able to give a fully correct response.

**(d)** It was rare for responses to consider charge.

**Question 8**

**(a)** A number of responses gave a definition rather than relating this definition to carbon. Some candidates seemed unfamiliar with Roman numerals.

**(b)** Many candidates showed a knowledge of layers but did not correctly establish what was in these layers. Common errors included electrons in layers and atoms sliding. There were also references to weak covalent bonds.

**(c)** The most common correct equation was $C + CO_2 \rightarrow 2CO$. Many other incorrect equations were seen.

**(d)** Many candidates calculated the Mr of ZnS and ZnO but could often go no further than this point. A number of responses gave an answer to more than two significant figures.

**(e) (i)** A number of initially correct responses went on to contradict their answer by referring to compounds or mixtures bonding or joining.

**(ii)** Candidates found this diagrammatic representation challenging. Common errors included the use of + and −, atoms that were overlapping or widely spaced, atoms in a regular arrangement and atoms of all the same size with no differentiation.

**Question 9**

**(a) (i)** A resistance of 5 Ω was often correctly calculated but some candidates went on to add the resistance of the resistor (2.2 Ω) to this value.

**(ii)** The resistance of the lamp was usually correctly determined from the candidates' total resistance in **(i)**.

**(b)** Responses often stated there is a greater voltage or a greater current. Both reasons were rarely given.

**Question 10**

**(a)** Many correct definitions stating that acids were proton donors were seen.

**(b) (i)** Candidates were generally not able to give a correct formula for $CaCO_3$ or $CaCl_2$. The few candidates who did give these formulae correctly usually balanced the equation correctly.

**(ii)** Many candidates appeared unfamiliar with the apparatus needed for this experiment. Unrecognisable apparatus was seen and unlabelled diagrams were common. Where gas syringes were given, often the tubing was blocked off.

**(c)** A number of candidates did not answer this question. Those that did attempt the sketch often correctly gave a steeper gradient but did not produce the same volume of carbon dioxide.

**(d)** There was significant confusion around all aspects of bond making, bond breaking, heat given out and heat taken in.

**Question 11**

**(a) (i)** Only stronger candidates answered this correctly.

**(ii)** Candidates were able to gain credit by identifying the element they showed in the equation in **(i)**.

**(b) (i)** Most candidates correctly deduced the background count.

**(ii)** Almost all responses stated a source of background radiation.

**(iii)** Many correct half-lives were determined with clear working out shown. There were some responses where only an answer was provided. This practice should be avoided as it prevents credit being given for any correct working.

# PHYSICAL SCIENCE

**Paper 0652/51**
**Practical Test**

## Key messages

Candidates need to have a thorough understanding of practical work and should have as much personal experience of carrying out experiments themselves as possible.

Centres are provided with a list of required apparatus well in advance of the examination date. Where centres wish to substitute apparatus, it is essential to contact Cambridge to check that the change is appropriate and that candidates will not be disadvantaged. Any substitutions of apparatus must be recorded in the Supervisor's report.

When describing the colour changes when solutions are mixed, candidates should be made aware that "clear" is not a suitable description of a colour. Both coloured and colourless solutions can be clear.

## General comments

Most candidates were able to demonstrate some ability and understanding across the whole of the range of practical skills being tested. All parts of both practical tests were attempted and there was no evidence of candidates running short of time. Most candidates were able to follow instructions correctly, record observations clearly and perform calculations accurately and correctly. Many candidates seemed less able to derive conclusions backed up by evidence they had gathered.

## Comments on specific questions

### Question 1

**(a)** Most candidates recorded the values of current and potential difference in the three circuits containing different combinations of identical resistors in the table provided. The values of the currents and potential differences recorded indicated that some difficulty was experienced by most candidates in the manipulation of the resistors to produce the required combinations.

Stronger candidates correctly found that the current increased as each different specified combination of resistors was connected into the circuit.

The results recorded by some candidates indicated potential differences across the resistor combinations that were higher than the electromotive force of the cells used.

**(b)** Most candidates calculated the resistance of each circuit correctly but were only awarded partial credit because the resistance values were not recorded to a consistent number of significant figures.

**(c)** The current obtained when the unknown combination of resistors was connected into the circuit should have been the same as that measured for circuit 2. This was rarely the case. However, the resistance of the unknown arrangement was usually calculated correctly using the actual values of candidates' values for current and potential difference.

**(d)** Candidates usually ticked the correct box here.

**(e)** Few candidates were able to draw a fourth arrangement of the three resistors that was different to the three resistor arrangements given in the question.

**Question 2**

**(a)** The table was usually completed with values of the position of the pivot for each position of the mass placed on the rule recorded to the nearest millimetre. The calculation of the distance *b* between the pivot and the centre of the mass was usually calculated correctly from the equation provided. Most tables of results showed the correct trend in *b*, that the values of *b* deceased as the mass was moved closer to the middle of the rule.

**(b)** Although most candidates used linear, labelled scales on the axes of their graphs, in many cases the scale chosen was too small. This was because candidates ignored the instruction given in the question that there was no need to start the graph at the origin (0, 0). Generally, candidates should make sure that the scale that they choose enables at least half of the grid space to be occupied.

Most points were plotted accurately and were within half of a small grid square of the actual value. Many candidates produced well-judged, best-fit straight lines. There was a tendency for the best-fit lines to be drawn too thickly. Candidates should attempt to make the thickness of their graph lines no thicker than the thickest lines on the grid provided. Some candidates drew point-to-point graphs.

**(c) (i)** Although most candidates understood what the term “gradient” meant, there were many poor gradient calculations. Candidates often used data points from the table that did not lie on their best-fit line or chose points which were too close together. The instruction to indicate on the graph the values chosen to calculate the gradient was frequently not followed and so many candidates could only be awarded partial credit.

**(ii)** The calculation of the mass *M* of the metre rule was usually done correctly, but some responses were not accurate enough for full credit. Candidates who performed the experiment with precision and care obtained values of *M* within the tolerance allowed.

**(d)** Candidates had difficulty in stating reasons why the mass of the metre rule that they had just calculated was different to the actual mass of the rule. Despite having just performed the experiment, few candidates referred to the difficulty of obtaining a balance of the metre rule on the pivot. No candidate commented on the fact that the mass placed on the rule obscured the graduations on the rule so it was very difficult to ensure that the centre of the mass was placed directly over the correct point on the rule.

**Question 3**

**(a)** This question on the use of chromatography to determine the number of colours that make up universal indicator was only answered correctly by stronger candidates. Candidates had very little knowledge of the techniques involved in a practical exercise of this type.

The diagrams drawn of the chromatogram were often poor and not labelled. Most candidates were able to draw and label the base line and the solvent front, but many omitted to show the initial position of the spot of universal indicator, or to label the colours produced. The number of colours in the universal indicator was often given incorrectly, as many candidates included the initial spot produced by the universal indicator in their totals.

**(b) (i)** The table, giving the number of drops of dilute hydrochloric acid needed to neutralise the three alkaline solutions X, Y and Z was usually completed. However, only stronger candidates produced a table where the number of drops was in the order Y > Z > X.

**(ii)** Many candidates were unable to deduce that the concentrations of the three alkaline solutions were dependent upon the number of drops of dilute hydrochloric acid needed to neutralise them. The order in which the three solutions were listed, frequently did not correspond to the answers given in **(i)**.

**(c) (i)** Candidates were required to describe the appearances of solutions of X and Y when aqueous copper sulfate was added to them in a test-tube. Only stronger candidates gave answers which obtained any credit at all. Most of the answers contained phrases and observations taken from the qualitative analysis data at the back of the question paper.

**(ii)** This part of the question proved challenging for almost all the candidates.

**Question 4**

Many candidates found this planning question very difficult and struggled to devise a suitable plan to compare the amount of thermal energy given out by the two fuels, ethanol and propanol, when they were burnt.

Candidates needed to recognise that they should focus on the idea of heating equal volumes of water with the spirit burner, containing first ethanol and then propanol, and measuring the temperature rises produced for each fuel.

Candidates were asked to state the apparatus needed to carry out the investigation. Some candidates realised that a container of some sort e.g., test tube, beaker or a conical flask would be needed to hold the water. Far fewer mentioned that a pipette/burette or measuring cylinder would be needed to measure the volume of fuel added to spirit burner. Thermometers were nearly always missing from the list.

Descriptions of the method were often vague, needing structure and a logical sequence. Candidates should be encouraged to consider the separate stages involved in performing an investigation before starting their response.

A few candidates gained partial credit for listing a relevant control variable in this investigation, usually that the same volume/amount of each fuel should be used.

Candidates need to check that they have addressed all the bullet points given in the ‘Your plan should include’ section in order to maximise their marks.  No candidate stated what measurements would be taken, or explained how the results would be processed so that a conclusion could be drawn.

# PHYSICAL SCIENCE

**Paper 0652/61**
**Alternative to Practical**

## Key messages

Candidates need to read questions carefully to ensure they answer the question that has been set.

Candidates need to match the degree of accuracy of their answer with that already present in other given entries when completing a table.

When planning questions, candidates must address the bullet points in the question in order to cover all of the question. It also helps if candidates have engaged in as many practical tasks as possible over the course of their studies .

## General comments

Few candidates left blanks, suggesting that the paper was accessible to the vast majority of candidates, and few seemed to run out of time.

Inorganic qualitative analysis was a weakness which needs extra attention in terms of practical experience and better interpretation of results.

Drawing of graphs was generally good but scales must be chosen so that the plotted line covers at least half the paper both ways, and evidence of gradient measurement must be obvious on the graph, including choosing a triangle which covers at least half of the plotted points.

## Comments on specific questions

### Question 1

Here candidates needed to calculate and compare the total resistances of three resistors in three different arrangements, and to suggest a fourth arrangement of three resistors, having taken meter readings.

Most candidates read the scales correctly, and could calculate R but too often the degree of accuracy, either the number of significant figure or decimal places, was inconsistent. A few over-approximated in **(c)**, and most identified circuit two in **(d)** due to similar numerical values to the new data provided.

In **(e)** a few candidates introduced extra resistors and many repeated one of the circuit diagrams already provided, but many candidates answered correctly.

### Question 2

Here candidates needed to find the mass of a metre rule by placing a mass at various points and adjusting the position of a pivot to achieve balance, plot a graph of the two balancing lengths, determine the gradient, substitute it correctly into a given formula, and comment on sources of inaccuracy.

In **(a)(i)** very few candidates addressed the error in recording the data to zero decimal places in one entry, leading to discussion about the difficulty in achieving balance and non-sequential entry of data.

In **(a)(ii)** there were very few errors.

In **(b)(i)** there were a few candidates who plotted the data figures with no concept of linearity of scale. Some others reversed the axes, chose very small scales, plotted incorrectly, or failed to show working on the graph

when calculating the gradient. However, there were also some excellent well-drawn graphs which gained full credit. Candidates should be careful of entering 0 at the origin if it leads to non-linearity of scale. Most candidates entered their gradient value into the formula successfully

There were a few blanks in **(d)**, and not many candidates addressed the possible non-uniformity of the ruler, the difficulty of placing the mass on the ruler accurately, or the error inherent in finding a line of best fit. The answers 'not recording the data to sufficient accuracy' and 'not repeating and averaging' were not credited, as candidates needed to aim for specific rather than generic improvements.

**Question 3**

Here candidates needed to understand chromatography as a separation and analytical technique, to apply titration principles, and to interpret inorganic analysis results.

In **(a)(i),** many candidates did not realise that the solvent needed to flow over the original spot or omitted it altogether.

In **(a)(ii),** many candidates realised that the ink would run or separate or smudge, but a few candidates justified the choice of a pencil for the base line as it could be rubbed out and corrected.

In **(a)(iii),** most candidates realised that the number of spots represented the number of colours contained in the ink, and in **(a)(iv),** measurements were usually correctly substituted into the $R_f$ expression unless the wrong colour was chosen, or the fraction occasionally inverted.

In **(a)(v),** some candidates correctly used the 10 per cent limitation of experimental error to compare their answer with 0.45, but weaker candidates omitted to do so and answers such as "no, due to different value" were not creditworthy.

In **(b)(i),** nearly all candidates added the tally charts correctly, and then realised that the most concentrated alkali needed the most acid to derive the correct order YZX. However, a few candidates entered numbers rather than letters, and more reversed the order.

In **(c)** some candidates were unable to pick out the distinguishing tests, and from those that did, some did not add the result of that test. In **(iii)** the fact that ammonia had no flame colour, combined with it needing to be an alkali, was not apparent to most candidates.

**Question 4**

Candidates were expected to plan an experiment to compare the amount of thermal energy given out when propanol and ethanol were allowed to burn. They were provided with a diagram of a spirit burner and told that water was available.

It was clear that there was much unfamiliarity with the expected approach, which was to investigate the temperature rise of a beaker of water heated by the alcohol by measuring initial and final temperature while heating for the same time, one of a variety of possible approaches.

There were some excellent answers which achieved full credit by addressing all five bullet points listed in the question, but they were quite rare. Incorrect approaches included finding the temperature of the burning flame, heating the spirit burner with a Bunsen, and adding water to help the fuel burn better.