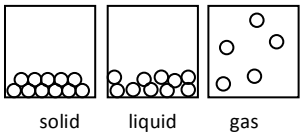
**Equations**

| |
|---|
| (final velocity)$^2$ – (initial velocity)$^2$ = 2 × acceleration × distance<br><br>$v^2 - u^2 = 2 \times a \times x$ |
| energy transferred = current × potential difference × time<br><br>$E = I \times V \times t$ |
| potential difference across primary coil × current in primary coil = potential difference across secondary coil × current in secondary coil<br><br>$V_p \times I_p = V_s \times I_s$ |
| change in thermal energy = mass × specific heat capacity × change in temperature<br><br>$\Delta Q = m \times c \times \Delta\theta$ |
| thermal energy for a change of state = mass × specific latent heat<br><br>$Q = m \times L$ |
| $P_1 V_1 = P_2 V_2$<br><br>to calculate pressure or volume for gases of fixed mass at constant temperature |
| energy transferred in stretching = 0.5 × spring constant × (extension)$^2$<br><br>$E = ½ \times k \times x^2$ |

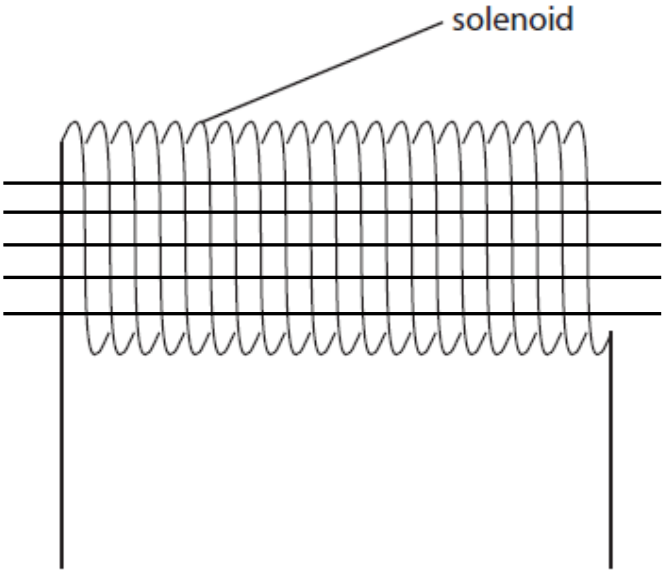
## Paper 2 Foundation

| Question number | Answer | Additional guidance | Mark |
|---|---|---|---|
| **1(a)(i)** | In the solid box:<br>regular arrangement and particles touching (1)<br><br>In the liquid box:<br>irregular arrangement and most particles touching (1)<br><br>In the gas box:<br>random and spaced (compared to liquid) (1) | ignore variation in particle size<br><br>ignore arrows/lines indicating movement<br><br>allow solid and liquid arrangements that do not fill the box<br><br>  <br> | **(3)** |

| Question number | Answer | Mark |
|---|---|---|
| **1(a)(ii)** | C | **(1)** |

| Question number | Answer | Additional guidance | Mark |
|---|---|---|---|
| **1(b)(i)** | substitution (1)<br>100 ÷ 13<br><br>answer (1)<br>7.7 (g/cm$^3$) | award full marks for correct numerical answer without working<br><br>allow<br>7.692 (g/cm$^3$) | **(2)** |

| Question number | Answer | Additional guidance | Mark |
|---|---|---|---|
| **1(b)(ii)** | An answer that provides a description by making reference to:<br>• part fill a measuring cylinder with water and record the starting volume (1)<br>• completely immerse the stone in the water and record the final volume of water and stone (1)<br>• volume of stone = final volume – initial volume (1) | accept valid alternative methods, e.g.<br><br>fill a displacement can until some water overflows/flows out of spout<br><br>completely immerse the stone in the displacement can and collect the displaced water in a measuring cylinder<br><br>volume of water displaced = volume of stone | **(3)** |

| Question number | Answer | Additional guidance | Mark |
|---|---|---|---|
| **2(a)(i)** | magnetic lines of force closely packed AND (almost) parallel (1) | ignore any arrows as direction of field is not required<br><br>ignore any lines outside the coil<br><br>  <br> | **(1)** |

| Question number | Answer | Additional guidance | Mark |
|---|---|---|---|
| **2(a)(ii)** | An answer that combines the following points of understanding to provide a logical description:<br>• plotting compass placed on card near wire and pencil mark made near N pole of compass (1)<br>• move compass so S pole is above pencil mark and keep repeating this until arrive at starting point (1) | allow<br><br>sprinkle iron filings on card<br><br>tap card to allow filings to align with field | **(2)** |

| Question number | Answer | Mark |
|---|---|---|
| **2(b)** | All three materials correctly identified (1)<br>(rod A – wood, rod B – soft iron, rod C – steel)<br>One mark for each reason:<br>• rod B only attracts paper clips when there is a current in the coil (1)<br>• rod C attracts paper clips when there is a current in the coil and for some time after (1) | **(3)** |

| Question number | Answer | Mark |
|---|---|---|
| **3(a)(i)** | A | **(1)** |

| Question number | Answer | Additional guidance | Mark |
|---|---|---|---|
| **3(a)(ii)** | An answer that provides a description by making reference to:<br>• thermal/heat energy (1)<br>• dissipated in/transferred to air/surroundings (1) | allow heat 'lost' to surroundings | **(2)** |

| Question number | Answer | Additional guidance | Mark |
|---|---|---|---|
| **3(b)** | An explanation that combines identification – improvement of the experimental procedure (1 mark) and justification/reasoning which must be linked to the improvement (1 mark):<br><br>• place the beaker on an insulator (1)<br>• so this (material) will reduce rate of energy transfer (1)<br>or<br><br>• wrap the beaker in an insulator (1)<br>• so this (material) will reduce the rate of energy transfer (1)<br>or<br><br>• reduce the surface areas of the water (1)<br>• to give less evaporation (1) | allow named insulator, e.g. cork mat<br><br>put a lid on the beaker/make the beaker taller and narrower | **(2)** |

| Question number | Answer | Additional guidance | Mark |
|---|---|---|---|
| **3(c)** | rearrangement (1)<br>$(l =) \frac{\Delta Q}{\Delta m}$<br><br>substitution (1)<br>$l = \frac{270\,000}{0.12}$<br><br>answer (1)<br>2 250 000 (J/kg °C) | award full marks for correct numerical answer without working<br><br>2250 (J/kg °C) gains 2 marks as power of 10 error | **(3)** |

| Question number | Answer | Mark |
|---|---|---|
| **4(a)(i)** | B | **(1)** |

| Question number | Answer | Mark |
|---|---|---|
| **4(a)(ii)** | vertical arrow, acting downward through the suitcase | **(1)** |

| Question number | Answer | Additional guidance | Mark |
|---|---|---|---|
| **4(b)(i)** | substitution (1)<br>$(KE =) \frac{1}{2} \times 85 \times 1.5^2$<br><br>answer (1)<br>96 (J) | award full marks for correct numerical answer without working<br><br>allow 95.625 (J) | **(2)** |

| Question number | Answer | Additional guidance | Mark |
|---|---|---|---|
| **4(b)(ii)** | rearrange (1)<br>force = work done ÷ distance<br><br>answer (1)<br>(force) = 15 (N) | accept rearrangement with values subst., i.e. (force ) = 1200 ÷ 80<br><br>award full marks for correct numerical answer without working | **(2)** |

| Question number | Answer | Additional guidance | Mark |
|---|---|---|---|
| **4(c)** | An explanation that combines identification – understanding (1 mark) and reasoning/justification – understanding (1 mark):<br>• the work done is the same for walking and running (1)<br>• because work done depends on force and distance only, not time (1) | allow<br>energy for work done<br><br>because work done ÷ time is power | **(2)** |

| Question number | Answer | Additional guidance | Mark |
|---|---|---|---|
| **4(d)** | rearrangement (1)<br>(height) = change in GPE ÷ (mass × $g$)<br><br>answer (1)<br>2.2 (m) | accept rearrangement with values, i.e. ($h$) = 264 ÷ (12 × 10) or = 264 ÷ 120<br><br>award full marks for correct numerical answer without working | **(2)** |

| Question number | Answer | Mark |
|---|---|---|
| **5(a)(i)** | B | **(1)** |

| Question number | Answer | Mark |
|---|---|---|
| **5(a)(ii)** | A | **(1)** |

| Question number | Answer | Mark |
|---|---|---|
| **5(b)(i)** | substitution into correct equation (1)<br>= 1.9 × 10.0 × 9.0<br><br>answer (1)<br>171 (J)<br>(which is about 170 J)<br><br>Answer must be shown to 3 significant figures | **(2)** |

| Question number | Answer | Additional guidance | Mark |
|---|---|---|---|
| **5(b)(ii)** | rearrangement (1)<br>(useful energy transferred) = efficiency × total energy supplied<br><br>substitution (1)<br>= (70 × 170)÷100<br><br>answer (1)<br>119 (J) | award full marks for correct numerical answer without working<br><br>accept (useful energy transferred) = 170 × 0.7<br>OR<br>= 171 × 0.7<br><br>accept alternative answer from 171 (J) i.e. 120 (J) | **(3)** |

| Question number | Answer | Mark |
|---|---|---|
| 5(c) | B | (1) |

| Question number | Answer | Mark |
|---|---|---|
| 5(d) | An explanation that combines identification – understanding (1 mark) and reasoning/justification – understanding (2 marks):<br>• the coil contains wires which have a resistance (1)<br>• and current in the wire is due to movement of electrons through (close-packed) lattice of positive ions (1)<br>• hence collisions between electrons and ions in the lattice transfer energy from electrons to the lattice (causing the temperature of the wires/coil to rise) (1) | (3) |

| Question number | Answer | Mark |
|---|---|---|
| 6(a)(i) | pressure = force ÷ area | (1) |

| Question number | Answer | Additional guidance | Mark |
|---|---|---|---|
| 6(a)(ii) | rearrangement (1)<br>($F$ =) $P \times A$<br><br>calculation of area (1)<br>2.4 × 1.5 = 3.6<br><br>substitution (1)<br>($F$ =)12 000 × 3.6<br><br>answer (1)<br>43 200 (N) | award full marks for correct numerical answer without working<br>maximum 3 marks if kPa not converted to Pa | (4) |

| Question number | Answer | Mark |
|---|---|---|
| 6(a)(iii) | B | (1) |

| Question number | Answer | Mark |
|---|---|---|
| 6(b) | An answer that combines the following points to provide a plan:<br>• put weights on the plunger to increase the pressure of the trapped air (1)<br>• use scale on syringe to measure the volume of trapped air (1)<br>• calculate the pressure from P = weight added/area of plunger (1)<br>• compare the increase in pressure to the volume of trapped air (1) | (4) |

| Question number | Answer | Mark |
|---|---|---|
| 7(a)(i) | B | (1) |

| Question number | Answer | Additional guidance | Mark |
|---|---|---|---|
| 7(a)(ii) | • label to indicate that balloon Q has a positive charge (1)<br>• label to indicate that balloon R has a negative charge (1) | accept responses showing appropriate +/− signs or worded label | (2) |

| Question number | Answer | Additional guidance | Mark |
|---|---|---|---|
| 7(b)(i) | An explanation that combines identification – knowledge (1 mark) and reasoning/justification – understanding (2 marks):<br>• use of a conductor to connect between aircraft and ground (1)<br>• allowing negative charge to move onto the aircraft (1)<br>• therefore neutralising the positive charge(s) (1) | accept (copper) wire<br><br>accept earth for ground | (3) |

| Question number | Answer | Additional guidance | Mark |
|---|---|---|---|
| **7(b)(ii)** | An explanation that combines identification – understanding (1 mark) and reasoning/justification – understanding (2 marks):<br>• there is friction between aircraft and air (1)<br>• which causes electron transfer between aircraft and air (1) | accept idea of air rubbing against wings<br><br>ignore "charge" "static"<br><br>do not allow (for second mark) idea of protons moving | **(2)** |

| Question number | Answer | Additional guidance | Mark |
|---|---|---|---|
| **7(c)** | equating energy in both equations (1)<br>$E$ = weight × height = power × time<br><br>rearrangement (1)<br>time = $\frac{(\text{weight} \times \text{height})}{\text{power}}$<br><br>substitution and answer (1)<br>time = 230 000 × $\frac{4.7}{1600}$<br>time = 680 (s) | allow answers which round to 680, e.g. 675.6 | **(3)** |

| Question number | Answer | Additional guidance | Mark |
|---|---|---|---|
| **8(a)(i)** | Any one reason from:<br>• the thermistor and the water are at the same temperature (1)<br>• large volume of water gives a steady temperature rise (1) | accept idea that only small part of thermometer would be in contact with a thermistor in air<br><br>accept difficult to control change in temperature of thermistor when heated in air | **(1)** |

| Question number | Answer | Additional guidance | Mark |
|---|---|---|---|
| **8(a)(ii)** | Any one of the following developments to the procedure:<br>• add ice to increase lower limit of temperature range (1)<br>• use liquid with higher boiling point to increase upper limit of temperature range (1) | accept named liquid with higher boiling point, e.g. oil | **(1)** |

| Question number | Answer | Additional guidance | Mark |
|---|---|---|---|
| **8(b)** | A comparison and contrast that must include at least **one** similarity and **one** difference from the following points to a maximum of three marks:<br><br>Similarities<br>• resistance of both changes with temperature (1)<br>• both graphs show a non-linear relationship (1)<br>• data comparison, e.g. both have the same resistance at 80 °C (1)<br><br>Differences<br>• resistance of A decreases with temperature but resistance of B increases with temperature (1)<br>• for A, (largest slope/rate of change) is at lower temperature but for B, (largest slope/rate of change) is at higher temperature(s) (1)<br>• for B, resistance is constant below 50 °C but for A resistance is roughly constant above 60 °C (1) | accept (smallest slope/rate of change) for A is at higher temperature but (smallest slope/rate of change) for B is at lower temperature | **(3)** |

| Question number | Indicative content | Mark |
|---|---|---|
| *8(c) | Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme.<br><br>The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant.<br><br>**AO1 (6 marks)**<br><br>• Use of top pan balance to measure mass<br>• Insulate beaker to reduce heat loss<br>• Ammeter connected in series with heater<br>• Voltmeter connected in parallel with heater<br>• Use of $E = I \times V \times t$ to determine energy supplied to the water<br>• Accept use of joule-meter to measure energy supplied<br>• Use of $\Delta E = m \times c \times \Delta\theta$ to determine the specific heat capacity of the water<br>• Measure p.d. across heater<br>• Use stopwatch to measure time liquid is heating<br>• Measure current in heater<br>• Determine mass of water as mass of (beaker and water) – mass of beaker<br>• Measure temperature before and after heating | **(6)** |

| Level | Mark | Descriptor |
|---|---|---|
| | 0 | No awardable content. |
| Level 1 | 1–2 | Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific, enquiry, techniques and procedures lacks detail. (AO1)<br><br>Presents a description which is not logically ordered and with significant gaps. (AO1) |
| Level 2 | 3–4 | Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas, enquiry, techniques and procedures is not fully detailed and/or developed. (AO1)<br><br>Presents a description of the procedure that has a structure which is mostly clear, coherent and logical with minor steps missing. (AO1) |
| Level 3 | 5–6 | Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas, enquiry, techniques and procedures is detailed and fully developed. (AO1)<br><br>Presents a description that has a well-developed structure which is clear, coherent and logical. (AO1) |

| Question number | Answer | Additional guidance | Mark |
|---|---|---|---|
| **9(a)** | evidence that anomalous reading excluded (1)<br><br>answer (1)<br>average length = 20.31 (mm) | accept 101.57 (÷5) for first mark<br><br>accept 20.314 (mm) | **(2)** |

| Question number | Answer | Additional guidance | Mark |
|---|---|---|---|
| **9(b)(i)** | • Axes with linear scales that use more than half of each edge of the grid and labelled with units from table (1)<br>• All points correctly plotted to ± half a square (1)<br>• Single straight line passing through all points and the origin (1) | allow 1 mark if only one plotting error and correct line drawn for points plotted | **(3)** |

| Question number | Answer | Additional guidance | Mark |
|---|---|---|---|
| **9(b)(ii)** | A comment that makes reference to the following points:<br><br>(using table)<br>• idea that equal increments of force/weight/mass cause equal increments of extension (1)<br>• correct reference to figures in the table (1)<br><br>OR<br>(using graph)<br>• the graph line is straight (1)<br>• the graph line passes through the origin (1)<br><br>AND<br>therefore the student's conclusion is correct (1) | last marking point can only be achieved if at least one of the other two marks is awarded | **(3)** |

| Question number | Answer | Additional guidance | Mark |
|---|---|---|---|
| 9(c) | An answer that combines points of interpretation/evaluation to provide a logical description:<br>• above 37.5 N/4 mm there are large increases of extension for small increases in load (1)<br>• the maximum extension of the wire is about 16.5 mm before it breaks (1)<br>• above 12 mm the wire keeps on extending when the load is reduced below 46 N (1) | accept extension is (much) greater for each 1 N increase in load above 37.5 N | **(3)** |

| Question number | Answer | Mark |
|---|---|---|
| **10(a)** | An explanation that combines identification – application of knowledge (1 mark) and reasoning/justification – application of understanding (3 marks):<br>• the gas cylinders have the same weight (1)<br>• but cylinder A has the smallest area (that is in contact with the ground) (1)<br>• the smaller the area, the greater the pressure (or reference to $P = \frac{F}{a}$) (1)<br>• hence cylinder A exerts a greater pressure on the ground (1) | **(4)** |

| Question number | Answer | Additional guidance | Mark |
|---|---|---|---|
| **10(b)** | rearrangement (1)<br><br>force up = (force down × distance of force down from pivot)/distance of force up from pivot<br><br>substitution into correct equation (1)<br>$F = \frac{120 \times 1.3}{0.40}$<br><br>answer (1)<br>390 (N) | award full marks for correct numerical answer without working | **(3)** |

| Question number | Indicative content | Mark |
|---|---|---|
| *10(c) | Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme.<br><br>The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant.<br><br>**AO2 (6 marks)**<br><br>• The bubbles get bigger<br>• Molecules of gas in constant motion<br>• Molecules widely spaced and moving randomly<br>• Molecules impact on surface of bubble/liquid molecules<br>• Average of impacts produces gas pressure<br>• Pressure is due to rate at which gas particles collide with liquid molecules/bubble surface<br>• Liquid pressure decreases as bubble rises<br>• $P_1V_1 = P_2V_2$<br>• If pressure decreases, volume of bubble will increase/volume of bubble must increase to give a decrease in pressure<br>• As volume increases, rate at which particles collide with surface of bubble decreases | **(6)** |

| Level | Mark | Descriptor |
|---|---|---|
| | 0 | No awardable content. |
| Level 1 | 1–2 | The explanation attempts to link and apply knowledge and understanding of scientific ideas, flawed or simplistic connections made between elements in the context of the question. (AO2)<br><br>Lines of reasoning are unsupported or unclear. (AO2) |
| Level 2 | 3–4 | The explanation is mostly supported through linkage and application of knowledge and understanding of scientific ideas, some logical connections made between elements in the context of the question. (AO2)<br><br>Lines of reasoning mostly supported through the application of relevant evidence. (AO2) |
| Level 3 | 5–6 | The explanation is supported throughout by linkage and application of knowledge and understanding of scientific ideas, logical connections made between elements in the context of the question. (AO2)<br><br>Lines of reasoning are supported by sustained application of relevant evidence. (AO2) |