# MARKING KEY

# Sample examination
# Stage 3
# Physics



2008/18613

PHYSICS

## Section one: Short answer

**Question 1**
**Spectra**

| Description | Mark |
|---|---|
| A torch and B laser | 1 |
| laser light is monochromatic ie one frequency only unlike a incandescent filament | 1 |

**Question 2**
**Gravity on Everest**

| Description | Mark |
|---|---|
| A | 1 |
| Explanation can be verbal and/or mathematical, e.g.<br>g at any point depends on the square of the distance from that point to the centre of the earth (g is proportional to $\frac{1}{r^2}$). | 1 |
| The height of Mt Everest (about 9000 m) is very much less than the radius of the Earth. The two distances are about 6 409 000 m and 6 400 000 m, and so g will be not very different from what it is at sea level. ($\mathbf{g}_{\text{Everest}}$ = 99.7% $\mathbf{g}_{\text{sea level}}$) | 1 |

**Question 3**
**Quasars**

| Description | Mark |
|---|---|
| Large redshift means that the object is receding from us at high speed | 1 |
| Hubble's law suggests that high recession rates mean great distances | 1 |

**Question 4**
**Screwdrivers**

| Description | Mark |
|---|---|
| Q is better | 1 |
| there is a greater torque for the same applied force as torque is proportional to the radius of the handle $\tau = r \times F$ | 1 |

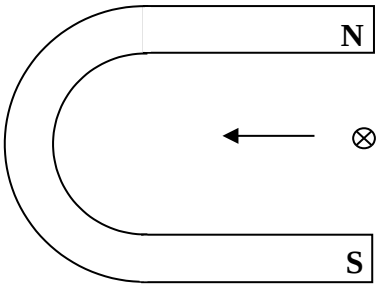
**Question 5(a)**
**Orbital velocity**

| Description | Mark |
|---|---|
| $v = \frac{2\pi r}{T}$ | 1 |
| $= \frac{2\pi(1.85 \times 10^6)}{119(60)} = 1.63 \times 10^3 \text{ m s}^{-1}$ | 1 |

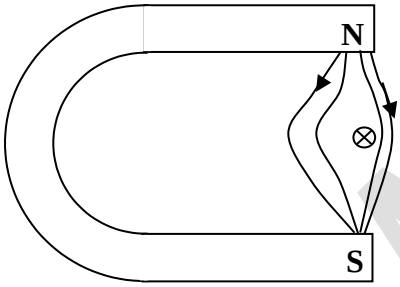
**Question 5(b)**
**Moon mass**

| Description | Mark |
|---|---|
| $F = \frac{mv^2}{r} = \frac{Gmm_m}{r^2}$ | 1 |
| $m_m = \frac{v^2 r}{G} = \frac{(1.63 \times 10^3)^2 (1.85 \times 10^6)}{6.67 \times 10^{-11}} = 7.35 \times 10^{22} \text{ kg}$ | 1 |

**Question 6(a)**
**Magnet**

| Description | Mark |
|---|---|
|   | 1 |

**Question 6(b)**
**Magnetic field**

| Description | Mark |
|---|---|
|   | 1 |

**Question 7(a)**
**Enclose magnetic flux**

| Description | Mark |
|---|---|
| Plane of the rim must be vertical | 1 |
| and in the east-west direction | 1 |

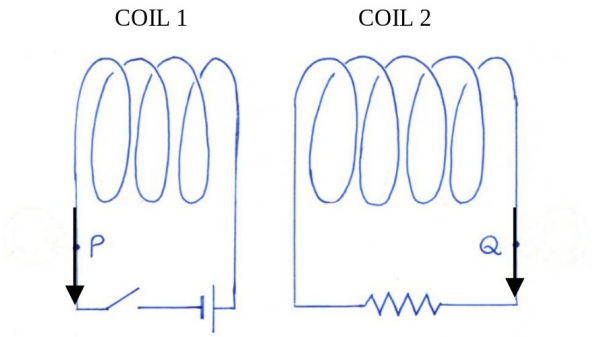
**Question 7(b)**
**Estimate magnetic flux**

| Description | Mark |
|---|---|
| Reasonable estimate of radius of wheel eg 0.3 m | 1 |
| $\Phi$ = B A | 1 |
| = $55 \times 10^{-6} \times \pi \times 0.3^2$ Wb<br>= 2 x $10^{-5}$ Wb | 1 |

**Question 8**
**Waves in a pulse**

| Description | Mark |
|---|---|
| frequency is number of pulses or vibrations each second | 1 |
| substitute time to be 0.10 $\mu$s, so number is [3.3 x $10^9$] x 0.1 x $10^{-6}$ = 330 | 1 |

**Question 9(a)**
**Induced current**

| Description | Mark |
|---|---|
|  <br>Current in coil 1 1 mark<br>Current in coil 2 1 mark | 2 |

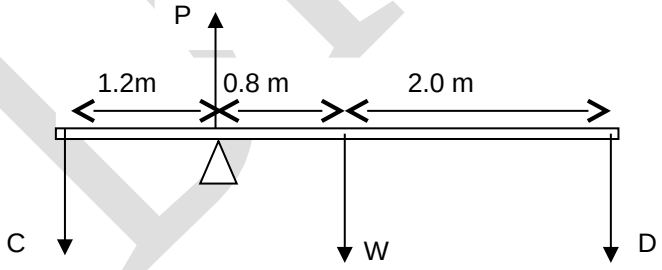
**Question 9(b)**
**Current change**

| Description | Mark |
|---|---|
| It decreases to zero | 1 |

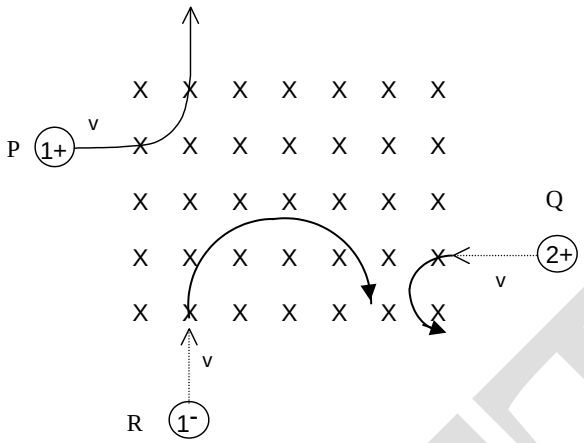
**Question 10(a)**
**Directions of forces**

| Description | Mark |
|---|---|
|  <br>1 mark for each correct arrow | 2 |

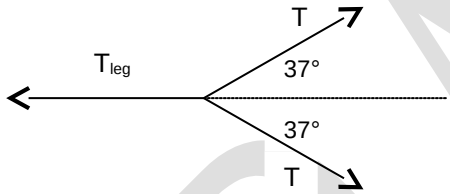
**Question 10(b)**
**Magnitudes of forces**

| Description | Mark |
|---|---|
|  <br>Board is in equilibrium therefore Σ CWM = Σ ACWM<br>Taking moments about P:<br>W (0.8) + D (2.8) = C (1.2)<br>(120) (9.8) (0.8) + (62.5) (9.8) (2.8) = (C (1.2)<br>C = $2.21 \times 10^4$ N | 1 |
| $\Sigma F_{up} = \Sigma F_{down}$<br>P = C + W + D<br>= $2.21 \times 10^4$ + 120 (9.8) + 62.5 (9.8)<br>= $4.00 \times 10^3$ N | 1 |

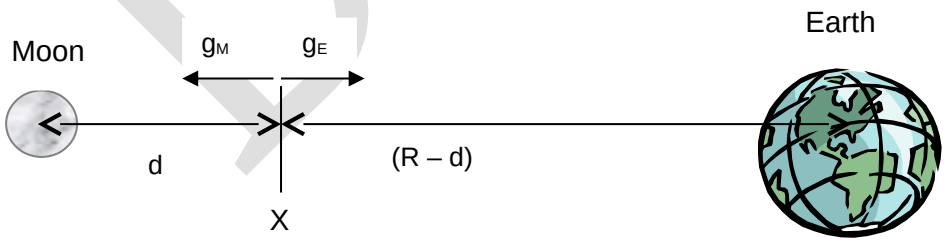
**Question 11**
**Particle motion in magnetic field**

| Description | Mark |
|---|---|
|  <br>Directions of paths of Q, R = 1 each = 2 marks<br>Relative curvature = 1 mark | 3 |

**Question 12**
**Free body diagram and force calculation**

| Description | Mark |
|---|---|
|  | 1 |
| For equilibrium: $\Sigma F = 0$<br>$\therefore \Sigma F_{left} = \Sigma F_{right}$ | 1 |
| $T_{leg} = 2\ T_{rope} \cos 37°$<br>$= 2 \times 20 \times 9.8 \cos 37°$<br>$= 313$ N (=310 N) | 1 |

**Question 13**
**Gravitational null point**

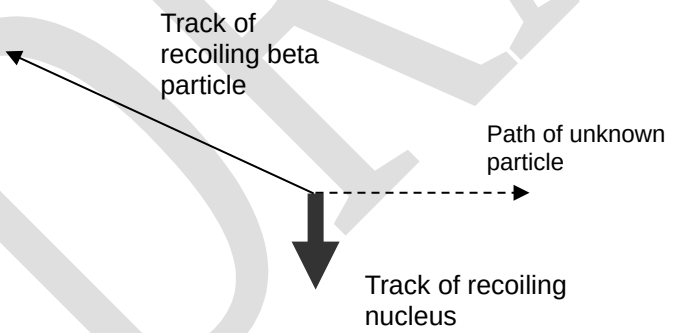
| Description | Mark |
|---|---|
|  | 1 |

| | |
|---|---|
| $g_E = g_m$<br>$\frac{Gm_E}{r^2} = \frac{Gm_M}{r^2}$<br>$\frac{m_E}{(R-d)^2} = \frac{m_M}{d^2}$<br>$\frac{m_E}{m_M} = \frac{(R-d)^2}{d^2}$ | 1 |
| $\frac{5.98x10^{24}}{7.34x10^{22}} = \left(\frac{R-d}{d}\right)^2$<br>$\sqrt{81.4} = \frac{R-d}{d}$<br>$\frac{d}{R-d} = \frac{1}{9}$<br>$\therefore \frac{d}{R} = \frac{1}{10} = 10\%$ | 1 |

**Question 14**
**Cancelling electric and magnetic fields**

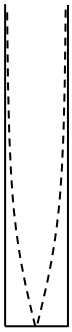
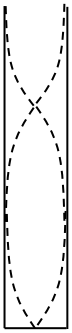
| Description | Mark |
|---|---|
| Electric force given by $F = Eq$ and magnetic force given by $F = qvB$ | 1 |
| In order to cancel these must be numerically equal i.e. $Eq = qvB$ | 1 |
| Hence $v = \frac{Eq}{qB} = \frac{E}{B}$ | 1 |

**Question 15**
**Evidence for neutrinos**

| Description | Mark |
|---|---|
| To conserve momentum something must recoil approximately as shown<br>  <br> | 1 |
| This particle does not produce visible tracks so is unlikely to be charged or to have a mass comparable to an electron mass. | 1 |

## Section two: Problem-solving

**Question 16(a)**
**Fundamental and harmonic**

| Description | Mark |
|---|---|
| Fundamental  | 1 |
| Next possible harmonic  | 1 |
| Chimney is open at one end and closed at the other | 1 |
| Open end is a displacement antinode, closed end is a displacement node | 1 |

**Question 16(b)**
**Length of chimney**

| Description | Mark |
|---|---|
| Assume that speed of sound in air is 342 m $s^{-1}$ | 1 |
| $v = f\lambda$ | 1 |
| $\lambda = \frac{v}{f} = \frac{342}{30} = 114 \text{ m}$ | 1 |
| Open pipe so length= $\frac{1}{4}\lambda = \frac{114}{4} = 28 \text{ m}$ | 1 |

**Question 17(a)(i)**
**Electron transitions**

| Description | Mark |
|---|---|
| Completed all 6 transitions to high degree of accuracy **or** | 2 |
| Has at least three transitions correctly identified, correct arrow direction | 1 |
| maximum | 2 |

**Question 17(a)(ii)**
**Electron transition calculation**

| Description | Mark |
|---|---|
| $\Delta E_{3->1} = \frac{hc}{\lambda}$ | 1 |
| $= \frac{(6.63\text{x}10^{-34})(3\text{x}10^{8})}{102.6\text{x}10^{-9}} = 1.939\text{x}10^{-18} \text{ J}$ | 1 |

**Question 17(b)(i)**
**Phenomenon**

| Description | Mark |
|---|---|
| Fluorescence | 1 |

**Question 17(b)(ii)**
**Occurrence**

| Description | Mark |
|---|---|
| Atom excited by UV light to a higher energy level | 1 |
| Electrons drop to the ground state in a series of transitions. | 1 |
| At least one of these transitions emits coloured light. | 1 |

**Question 17(b)(iii)**
**Colour of rabbit**

| Description | Mark |
|---|---|
| Peak wavelength of **emitted** light is about 510 nm. | 1 |
| This corresponds to **green** light—from spectrum chart at beginning of question 17 | 1 |

**Question 18(a)**
**Slip rings**

| Description | Mark |
|---|---|
| Enables alternating current to be withdrawn from the generator. Maintains constant contact between a particular side of the coil and a given terminal for the external circuit. [Students should indicate this on the diagram.] | 1 |

**Question 18(b)(i)**
**Graph of emf**

| Description | Mark |
|---|---|
| sinusoidal output | 1 |
| Period shown correctly | 1 |

**Question 18(b)(ii)**
**Graph of new emf**

| Description | Mark |
|---|---|
| Voltage is doubled | 1 |
| Period is halved | 1 |

**Question 18(c)(i)**
**Emf calculation**

| Description | Mark |
|---|---|
| 3000 rpm = 50 Hz | 1 |
| Using 'quarter turn' method A = 0.14 x 0.09 = 0.0126m$^2$ and t = 0.005 s | 1 |
| $V = -N\frac{(\Phi_2 - \Phi_1)}{t} = -N\frac{B(A_2 - A_1)}{t} = -200\frac{0.15(0 - 0.0126)}{0.005} = 76\ V$ | 1 |

**Question 18(c)(ii)**
**Maximum or average**

| Description | Mark |
|---|---|
| This is an 'average' voltage. (student's statement must agree with the method used) [Maximum voltage would be given by NAB(2πf)] | 1 |
| OR | |
| (Students can also calculate rms value given by $\sqrt{2}\pi BANf$ ) | 1 |

**Question 18(d)**
**Ways to increase emf: any two of**

| Description | Mark |
|---|---|
| Number of turns can be increased, increasing the length of the wire in the coil | 2 |
| Magnetic field can be increased, greater magnetic fields produce greater induced emfs | 2 |
| Area of coil can be increased, greater area means the flux change is greater. | 2 |
| maximum | 4 |

**Question 19(a)(i)**
**Wavelength calculation**

| Description | Mark |
|---|---|
| $E = hf = \frac{hc}{\lambda}$ | 1 |
| $\lambda = \frac{hc}{E} = \frac{6.626 \times 10^{-34} \times 3 \times 10^{8}}{2.3 \times 10^{6} \times 1.6 \times 10^{-19}}$<br>$= 5.40 \times 10^{-13}$ m | 1 |

**Question 19(a)(ii)**
**spectrum**

| Description | Mark |
|---|---|
| X-rays (It is acceptable to have gamma rays). | 1 |

**Question 19(b)**
**Using radiation**

| Description | Mark |
|---|---|
| Yes | 1 |
| Short wavelength means it penetrates solids well | 1 |
| More radiation would pass through a crack so highlighting its presence | 1 |

**Question 19(c)(i)**
**Radius of circle**

| Description | Mark |
|---|---|
| KE $= \frac{1}{2} m v^2 \Rightarrow v = \sqrt{\frac{2E}{m}}$ | 1 |
| $r = \frac{mv}{qB} = m\sqrt{\frac{\left(\frac{2E}{m}\right)}{qB}}$ | 1 |
| $r = \sqrt{\frac{2 \times 1.67 \times 10^{-28} \times 2.3 \times 10^{6} \times 1.6 \times 10^{-19}}{1.6 \times 10^{-19} \times 0.35}}$<br>$= 198$ mm | 1 |

**Question 19(c)(ii)**
**Radius change**

| Description | Mark |
|---|---|
| If kinetic energy increases then speed increases | 1 |
| From the formula $r = \frac{mv}{qB}$, then radius would increase | 1 |

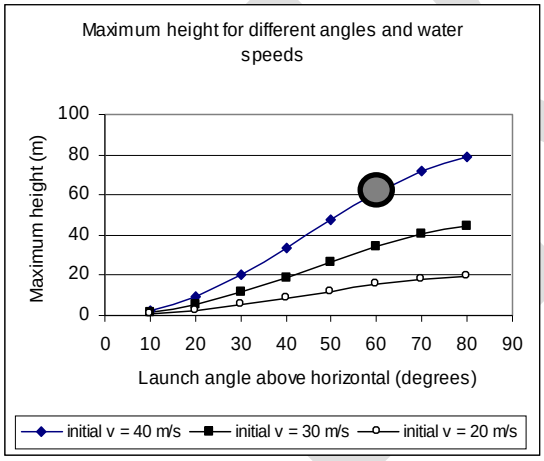
**Question 20(a)**
**Maximum height and range**

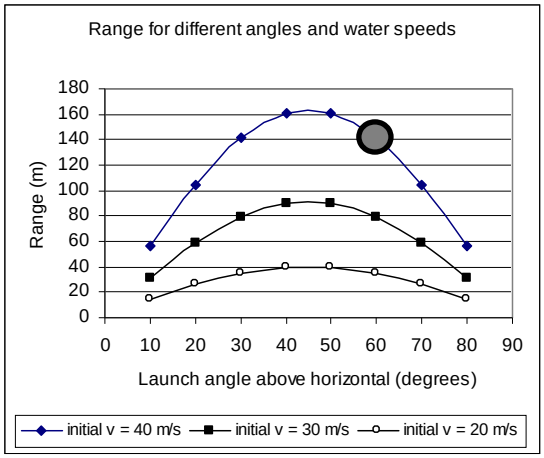
| Description | Mark |
|---|---|
| $v_H = 40 \cos 60^o \quad v_V = 40 \sin 60^o$ | 1 |
| $v^2 = u^2 + 2as$<br>$s = h = \frac{v^2 - u^2}{2g} = \frac{0 - (40 \sin 60^o)^2}{2 \times (-9.8)} = 61.2\,\text{m}$ (max height above nozzle) | 1 |
| $v = u + at$<br>$\therefore t = \frac{v - u}{g} = \frac{0 - 40 \sin 60^o}{-9.8} = 3.53\,\text{s}$<br>$v = \frac{s}{t}$<br>$s = R = v_H t = 40 \cos 60^o \times 2 \times 3.53 = 141\,\text{m}$ (range) | 1 |

**Question 20(b)**
**Helicopter height**

| Description | Mark |
|---|---|
| Horizontal: $s_H = 150$ m $\quad v_H = 22$ m s$^{-1}$ $\quad v = \frac{s}{t}$ | 1 |
| hence $\quad t = \frac{s_H}{v_H} = \frac{150}{22} = 6.82\,\text{s}$ | 1 |
| Vertical: $\quad s = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2}(9.8)(6.82)^2 = 228\,\text{m}$ (= minimum height) | 1 |

**Question 20(c)(i)**
**Height and range from graph**

| Description | Mark |
|---|---|
|  | 1 |

| | |
|---|---|
|  | 1 |

**Question 20(c)(ii)**
**Angles and speed**

| Description | Mark |
|---|---|
| Best angle = 60° Best velocity = 30 m $s^{-1}$ | 1 |
| Explanation may include any of the following:<br>Maximum height should be around 35 m<br>Launch speed = 20 m $s^{-1}$ won't reach required height<br>Launch speed = 30 m $s^{-1}$ but angles $\leq$ 50° and $\geq$ 60° won't reach required height<br>Launch speed = 40 m $s^{-1}$ at angle of 70-80° is possible but reaches too great a height | 1 |

**Question 21(a)(i)**
**Distance travelled**

| Description | Mark |
|---|---|
| Distance = **v.T** | 1 |

**Question 21(a)(ii)**
**Number of particles**

| Description | Mark |
|---|---|
| number of particles in a length $\ell = \frac{n}{\ell}$ | 1 |
| number of particles in a length v.T $= \frac{nvT}{\ell}$ | 1 |

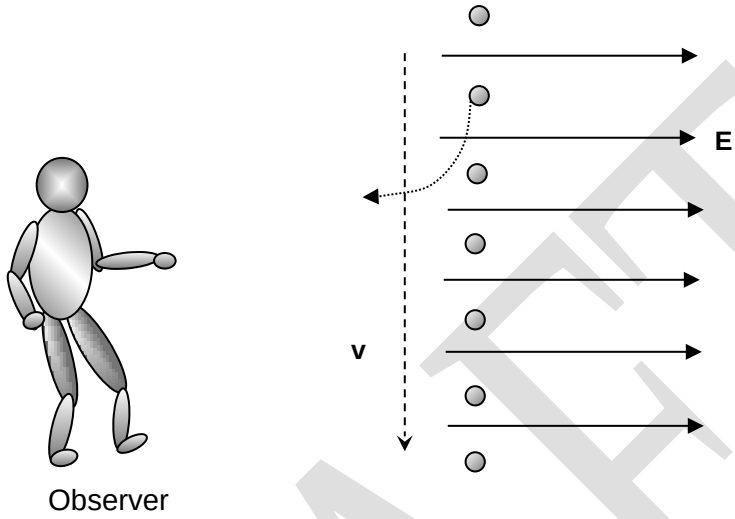
**Question 21(b)**
**Current equivalence**

| Description | Mark |
|---|---|
| charge on particles (in a length $\ell$) $= Q\left(\frac{nvT}{\ell}\right)$ | 1 |
| current $= \frac{\text{charge}}{\text{time}} = \frac{Q}{T}$ | 1 |
| but charge $= Q\left(\frac{nvT}{\ell}\right)$<br>$\therefore I = \frac{Q\left(\frac{nvT}{\ell}\right)}{T} = \frac{vnQ}{\ell}$ | 1 |

**Question 21(c)(i)**
**Direction of electric force**

| Description | Mark |
|---|---|
| to the left, eg ←○ | 1 |

**Question 21(c)(ii)**
**Particle path**

| Description | Mark |
|---|---|
|  Observer<br>Path curves clockwise as shown | 1 |

**Question 21(d)(i)**
**Magnetic field direction**

| Description | Mark |
|---|---|
| Out of the page **or** | 2 |
| Into the page | 1 |

**Question 21(d)(ii)**
**Magnetic force equivalence**

| Description | Mark |
|---|---|
| since $v = \frac{\ell}{T}, \therefore BvQ = \frac{B\ell Q}{T}$ | 1 |
| $BvQ = \frac{B\ell Q}{T} = B\ell\left(\frac{Q}{T}\right)$ | 1 |
| but $\frac{Q}{T} = I$<br>$\therefore BvQ = B\ell I = I\ell B$ | 1 |

## Section three: Comprehension

**Question 22(a)**
**Resonant frequency of bubbles**

| Description | Mark |
|---|---|
| $f_0 = \frac{1}{2\pi}\sqrt{\frac{3\gamma P_0}{\rho {R_0}^2}}$ | 1 |
| $= \frac{1}{2\pi}\sqrt{\frac{3(1.4)(100\times10^3)}{(1\times10^3)(3\times10^{-3})^2}}$ | 1 |
| $\approx$ 1100 Hz | 1 |

**Question 22(b)(i)**
**Cavitation location**

| Description | Mark |
|---|---|
| $f = \frac{300}{60} = 5$ Hz  $v = 14$ m s$^{-1}$ | 1 |
| $v = \frac{2\pi r}{T} = 2\pi r f$ | 1 |
| $r = \frac{v}{2\pi f} = \frac{14}{2\pi(5)} = 0.45$ m<br>i.e. 0.45 m along blade from centre. | 1 |

**Question 22(b)(ii)**
**Cavitation damage**

| Description | Mark |
|---|---|
| The tips of the blades or where water speed (relative to blade) is greatest | 1 |

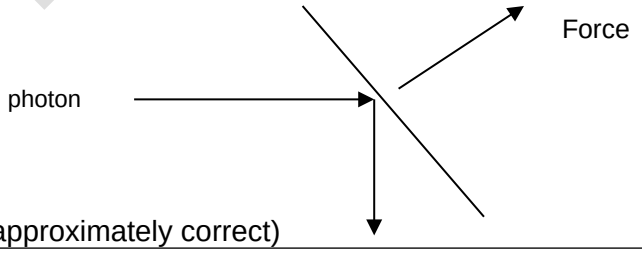
**Question 22(c)(i)**
**Snapping shrimp bubbles**

| Description | Mark |
|---|---|
| From figure 1: radius $\approx$ 3.5 mm | 1 |

**Question 22(c)(ii)**
**Bubble collapse time**

| Description | Mark |
|---|---|
| From either figure: time $\approx$ 0.3 ms | 1 |

**Question 23(a)**
**Photon momentum**

| Description | Mark |
|---|---|
| Photons have momentum | 1 |
| change in momentum (on reflection) creates a force | 1 |
|  <br>(1 mark if angles not approximately correct) | 2 |

**Question 23(b)**
**Compton scattering**

| Description | Mark |
|---|---|
| Particle property | 1 |
| Possible reasons are momentum is a property of particles, or collisions are characteristic of particles | 1 |

**Question 23(c)**
**Momentum units**

| Description | Mark |
|---|---|
| Particle : $p = m v = kg\ m\ s^{-1}$ | 1 |
| Photon : $p = \frac{h}{\lambda} = \frac{J\,s}{m}$ | 1 |
| $= \frac{kg\,m^2\,s}{s^2\,m} = kg\ m\ s^{-1}$ | 1 |

**Question 23(d)(i)**
**Higher momentum**

| Description | Mark |
|---|---|
| X-ray photon has the larger momentum | 1 |
| Reason : It has a smaller wavelength | 1 |

**Question 23(d)(ii)**
**Momentum calculation**

| Description | Mark |
|---|---|
| $E = \frac{hc}{\lambda} \qquad \lambda = \frac{hc}{E}$ | 1 |
| $p = \frac{h}{\lambda} = \frac{hE}{hc} = \frac{E}{c}$ | 1 |
| $p = \frac{110 \times 10^3 \times 1.6 \times 10^{-19}}{3 \times 10^8} = 5.87 \times 10^{-23}$ kg m s$^{-1}$ | 1 |

**Question 23(d)(iii)**
**Scattering angle**

| Description | Mark |
|---|---|
| Needs to be scattered through 180° | 1 |
| cos (180°) = -1 so change in wavelength is greatest | 1 |

**Question 23(e)**
**Energy of scattered electron**

| Description | Mark |
|---|---|
| $\lambda' = \lambda + \frac{h}{mc}(1 - \cos\theta) = \frac{hc}{E} + \frac{h}{mc}(1 - \cos\theta)$ = $1.251 \times 10^{-11}$ m | 1 |
| $E' = \frac{hc}{\lambda'} = 1.59 \times 10^{-14}$ J = 99.2 keV<br>= 99.2 keV | 1 |
| Hence scattered electron energy is 19.8 keV or 3.17 x $10^{-15}$ J | 1 |

**Overall - units**

| Description | Mark |
|---|---|
| Consistent, appropriate use of units in final answers (no more than two unit errors in entire paper) **or** | 2 |
| Inconsistent or inappropriate use of units in final answers (three or four unit errors in entire paper) **or** | 1 |
| Poor use of units in final answers (five or more unit errors in entire paper) | 0 |

**Overall – significant digits**

| Description | Mark |
|---|---|
| Consistent, appropriate use of significant digits in final answers (no more than two SD errors in entire paper) **or** | 2 |
| Inconsistent or inappropriate use of significant digits in final answers (three or four SD errors in entire paper) **or** | 1 |
| Poor use of significant digits in final answers (five or more SD errors in entire paper) | 0 |

**Physics Stage 3 exam**

| | 3A | | | | 3B | | |
|---|---|---|---|---|---|---|---|
| | **Working in physics** | **Motion and forces in a gravitational field** | **Electricity and magnetism** | | **Working in physics** | **Particles, waves and quanta** | **Motion and forces in electric and magnetic fields** |
| **SECT 1** | | | | | | | |
| **1** | | | | | | **Dpt 7** | |
| **2** | | **Dpt 9** | | | | | |
| **3** | | | | | | **Dpt 15** | |
| **4** | | **Dpt 12** | | | | | |
| **5** | | **Dpt 10** | | | | | |
| **6** | | | **Dpt 2, 3** | | | | |
| **7** | | | **Dpt 8** | | | | |
| **8** | | | | | | **Dpt 1** | |
| **9** | | | **Dpt 9** | | | | |
| **10** | | **Dpt 3, 13** | | | | | |
| **11** | | | | | | | **Dpt 4** |
| **12** | | **Dpt 2, 3** | | | | | |
| **13** | | **Dpt 2, 9** | | | | | |
| **14** | | | | | | | **Dpt 6** |
| **15** | | | | | | **Dpt 11** | |
| **SECT 2** | | | | | | | |
| **16** | | | | | | **Dpt 3, 4** | |
| **17** | | | | | | **Dpt 9, 10, 16** | |
| **18** | | | **Dpt 8, 9** | | **X** | | |
| **19** | | | | | | **Dpt 6, 10, 16** | **Dpt 4** |
| **20** | **X** | **Dpt 1, 2, 5** | | | | | |
| **21** | | **Dpt 5** | **Dpt 5** | | | | **Dpt 3, 4, 6** |
| **SECT 3** | | | | | | | |
| **22** | | | | | **X** | | |
| **23** | | **Dpt 5** | | | **X** | **Dpt 5, 6** | |
| **overall** | | | | | | | |
| | **X** | | | | **X** | | |

Sample physics exam stage 3 design brief fit analysis (2008/18609)

| | | section 1 items | section 1 marks | section 2 items | section 2 marks | section 3 items | section 3 marks | overall marks* | total marks | total % | total allowed |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 15–20% | Working in Physics | nil | 0 | 20c | 4 | 22a, 22b(ii), 22c, 23c, 23d, 23e | 19 | 4 | 27 | 19.3 | 15-20% |
| 20–25% | Motion and forces in a gravitational field | 2, 4, 5, 10, 12, 13 | 19 | 20a, 20b, 21a | 9 | 23a, 22b(i) | 7 | | 35 | 25 | 20-25% |
| 15-20% | Electricity and magnetism | 6, 7, 9 | 10 | 18a, 18b, 18c, 18d, | 13 | | | | 23 | 16.4 | 15-20% |
| 20–25% | Particles, waves and quanta | 1, 3, 8, 15 | 8 | 16a, 16b, 17a, 17b, 19a, 19b | 24 | 23b | 2 | | 34 | 24.3 | 20-25% |
| 15–20% | Motion and forces in electric and magnetic fields | 11, 14 | 6 | 19c, 21b, 21c, 21d, 21e, | 15 | - | - | | 21 | 15 | 15-20% |
| | totals | 13 items | 43 | 6 items | 65 | 2 items | 28 | 4 | 140 | 100 | |
| | total % | | 30.7 | | 46.4 | | 20 | 2.9 | | | |
| | total allowed | 12-15 items | 25-35% | 6-8 items | 45-55% | 1-2 items | 15-25% | 2-3% | | | |

* ‘overall marks’ refers to an allocation for appropriate use of units and significant digits.