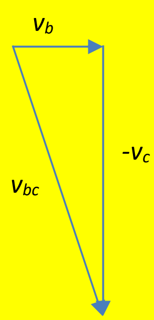
H2 Physics 9749 – 2020 A Level Exam

Paper 1

1	**Essential Question(s):** • What is the relationship between V and r? • Which rule do we apply to determine percentage uncertainty for value obtained through multiplication/division? **Solution:** volume $V = 4/3\pi r^3$ $\Delta V / V = 3\ \Delta r/r$ $\Delta V / V$ x 100 % = = 3 $\Delta r/r$ x 100% percentage uncertainty in volume = 3 percentage uncertainty in radius graph of percentage uncertainty in volume vs percentage uncertainty in radius is a straight line graph passing through the origin with gradient = 3 **Answer: B**
2	**Essential Question(s):** • What are the four conditions that action-reaction force need to meet? **Solution:** The reaction force of the weight of the car is the gravitational force on the Earth by the car; the reaction force of the normal contact force on the car in the force on the ground by the car. **Answer: D**
3	**Essential Question(s):** • What is the unit of stress? • What is the unit of strain? • How do we determine the unit of a quantity represented as the area under a graph? Solution: stress= F/A ; strain = e/L Units of stress = N m^{-2} Units of e = unit of L = m units of strain = unit of e / units of L = m / m strain has no unit units of area under stress-strain graph = units of stress x units of strain = N m^{-2} J = N m ➔ N = J m^{-1} units of area under stress-strain graph = N m^{-2} = (J m^{-1}) m^{-2} = J m^{-3} **Answer: D**

	This question gave candidates a novel situation and asked them to use their knowledge of units to answer it. Those candidates who got this wrong tended to choose distractor **C**, probably because they confused newtons and joules.
4	**Essential Question(s):** • What does the area under the velocity – time graph represent? **Solution:** distance travelled by car X = P + Q + R distance travelled by car Y = S + Q + R Both cars were at the same position at t = 0, and again at t = T. Hence between t = 0 to t = T, **both cars travelled the same distance**. P + Q + R = S + Q + R P = S **Answer: A**
5	**Essential Question(s):** • What is relative velocity? • How do we determine the relative velocity on an object with respect to another? **Solution:** relative velocity of bicycle with respect to car $v_{bc} = v_b - v_c = v_b + (-v_c)$ v_b = velocity of the bicycle v_c = velocity of the car v_{bc} = velocity of the bicycle relative to the car  **Answer: C** **Examiner's comments:** This was on relative velocities and proved demanding with a significant number of candidates choosing distractor **D**, where the relative velocity of the bicycle is shown pointing away from the car.
6	**Essential Question(s):** • What are the two conditions for a body to be in equilibrium? **Solution:** Option C is wrong because the direction of the torque is to be mentioned. The statement should be "The torque provided by the vertical forces is **<u>equal and opposite to</u>** the torque provided by the horizontal forces." Option A, B and D are statements that follow the condition that the sum of forces is equal to zero for the object to be in equilibrium.

	Answer: C
7	**Essential Question(s):** • What is the torque of a couple? • How do we determine the torque of a couple? **Solution:** The perpendicular distance of F from the centre of wheel, $d_{\perp} = (d/2)\sin\theta$ Torque of F $= 2 \times F \times d_{\perp}$ $= (d/2)\sin\theta$ $= 2 \times F\ (d/2)\sin\theta$ $= F\ d\ \sin\theta$ **Answer: B**
8	**Essential Question(s):** • How does the Free-Body Diagram of the basket and the balloon look like? • How to determine the upthrust of a hot air balloon? **Solution:** forces acting on the balloons are 1. Upthrust = $V\ \rho_{air\ outside}\ g$ = 2800 (1.204)g acts upwards 2. Weight of air inside balloon = $V\ \rho_{air\ inside}\ g$ = 2800 (0.898)g acts downwards 3. Weight of basket and balloon = mg = 700 g acts downwards 4. Total tension of the two rope = $2T$ acts downwards , where T = tension in one rope the balloon is at rest, net force = 0 $2800\ (1.204)g = 2800\ (0.898)g + 2T + 700g$ $2T = 2800\ (1.204)g - 700g - 2800\ (0.898)g$ $= [2800\ (1.204) - 700 - 2800\ (0.898)]\ 9.81$ $= 1538$ T = 769 N = 770 N **Answer: A** **Examiner's Comments:** The incorrect answers were spread fairly evenly among the distractors, indicating that candidates forgot that there were two ropes (distractor **B**), confused the air densities (distractor **C**) or neglected to account for the weight of air inside the balloon (distractor **D**).
9	**Essential Question(s):** • How do we determine the mechanical power output of the car? • How do we determine the input power of the car? • What is the efficiency of a car in converting the thermal energy of fuel to useful work done on the car? **Solution:** power input to the car engine = thermal energy of fuel per second $= 3.3 \times 10^{6} / 60\ \text{J s}^{-1}$ power output from the car engine = useful work done of car per second = driving force x speed $= 1.6 \times 10^{3} \times 22\ \text{J s}^{-1}$ efficiency of car engine = (power output from the car engine / power input to the car engine) x 100

	$= (1.6 \times 10^3 \times 22) / [3.3 \times 10^6 / 60] \times 100$ $= 64\ \%$ **Answer: D**
10	**Essential Question(s):** • How do we determine the centripetal acceleration on an object in circular motion? **Solution:** centripetal acceleration of moon $= r\,\omega^2$ $= r\,(2\pi/T)^2$ $= (3.85 \times 10^8) \times (2\pi / 27.3 \times 24 \times 60 \times 60)^2$ $= 2.73 \times 10^{-3}$ m s^{-2} **Answer: B**
11	**Essential Question(s):** • What is the period of a minute hand of a clock? • How do we determine the angular velocity of an object in circular motion? **Solution:** angular velocity $\omega = 2\pi/T$ $= 2\pi/(60 \times 60)$ $= 1.75 \times 10^{-3}$ rad s^{-1} **Answer: B** **Examiner's Comments:** Some candidates did not realise that the minute hand of an analogue clock takes 1 hour (3600 s) to complete one revolution.
12	**Essential Question(s):** • How do we determine the GPE of two masses? • How do we determine the *change* in GPE of two masses? **Solution:** change in *GPE* = final *GPE* – initial *GPE* $= (-Gm_1m_2/ 2r) - (-Gm_1m_2/ r)$ $= Gm_1m_2/ 2r$ **Answer: A**
13	**Essential Question(s):** ○ How do we determine the gravitational field strength of a point mass at a distance away? **Solution:** gravitational field strength $= GM / r^2$ $= 6.67 \times 10^{-11} \times 2.0 \times 10^{31} / (150 \times 10^6 \times 10^3)^2$ $= 5.9 \times 10^{-2}$ N kg^{-1} **Answer: A**
14	**Essential Question(s):** • What is an ideal gas? • How is the graph related to the macroscopic properties, p, V and T of an ideal gas?

	Solution: Apply pV = nRT At L, $(2.0 \times 10^6 \times 0.001) = nRT \rightarrow T = 2 \times 10^3(1/nR)$ At M, $(2.0 \times 10^6 \times 0.003) = nRT \rightarrow T = 6 \times 10^3(1/nR)$ At N, $(0.8 \times 10^6 \times 0.005) = nRT \rightarrow T = 4 \times 10^3(1/nR)$ temperature $T_M > T_N > T_L$ **Answer: B** **Examiner's Comments:** Candidates who got it wrong tended to choose distractor **C** as they thought that line MN on the graph was showing an isothermal change, when the numbers show that in fact the temperature is decreasing.
15	**Essential Question(s):** • What is the 1st Law of Thermodynamics • What do $\Delta U = \Delta Q + W$ mean? **Solution:** Experiment 1, at constant volume, work done is zero, $W = 0$, hence $\Delta U = \Delta Q + W = \Delta Q$ Option A is wrong Option B is correct Experiment 2, at constant pressure, as heat is supplied, part of the heat is used to do work against external environment and part become internal energy *(Note that for a constant pressure process and fixed mass of ideal gas, as volume increases, product pV and hence T increases, which implies that internal energy U also increases! A quick way is to sketch the p-V graph for a constant p process – you'll notice that the state moves to a point of higher T.)* the volume increases, work is done by the gas, W is negative the temperature and internal energy increases, ΔU is positive from $\Delta U = \Delta Q + W$ since ΔU is positive and W is negative ΔQ must be positive and more than ΔU D is incorrect Also since ΔU is positive, $(\Delta Q + W)$ must be positive, since ΔQ is positive and W is negative, ΔQ must be is greater than $-W$, more heat must be supplied than work done by the gas C is also incorrect **Answer: B**
16	**Essential Question(s):** • How is the max PE of an oscillation related to amplitude of the oscillation? **Solution:** In a simple harmonic motion, max $PE = \frac{1}{2} m \omega^2 x_o^2$ Using the symbols in the given question, Initially, $E = \frac{1}{2} m \omega^2 x^2$ …….(1) Subsequently, *PE is reduced* **by** *E/4* $\rightarrow$ New $PE = E - 1/4E = \frac{3}{4} E$ $\frac{3}{4} E = \frac{1}{2} m \omega^2 x'^2$ ….(2)

	since the same pendulum is used, m and ω are the same (2) /(1) : $\frac{3}{4} = x'^2 / x^2$ $x' / x = 0.866$ $x' = 0.866x$ Therefore the change in the amplitude is $x - x' = 0.134\ x$ **Answer: A** **Examiner's Comments:** The most popular answer was **C**, which may mean that candidates misread the question and thought that the energy of the oscillations reduced **to** E / 4 rather than **by** E / 4.
17	**Essential Question(s):** • How do we determine the phase difference from the displacement – time graphs of two different waves at a point? **Solution:** one wave leads the other by ¼ of a period, i.e the 2 waves are ¼ cycle out of phase. 1 cycle phase difference = 2π rad ¼ cycle phase difference = $\pi / 2$ rad **Answer: C** **Examiner's Comments:** A significant number of candidates got it wrong, choosing distractors **B** and **D**.
18	**Essential Question(s):** • What is the equation that describe the velocity, frequency and wavelength of a wave? • What is the distance between two adjacent rarefactions in a sound wave known as? **Solution:** distance between two adjacent rarefactions = 8 m. ➔ wavelength of the wave = 8 m using $v = f\lambda$ $f = v / \lambda = 12/8 = 1.5$ Hz **Answer: C**
19	**Essential Question(s):** • What is the equation used to relate the width of a diffraction to the wavelength? **Solution:** angle of diffraction for first minimum intensity $b\ sin\theta = \lambda$ ➔ $sin\theta = \lambda/b = c / fb$ b = slit width; f = frequency; c = speed of light let x = width of central maximum, D = distance between slit and screen; $(\frac{1}{2}x) / D = tan\theta \approx sin\theta$ since θ is very small hence $(\frac{1}{2}x) / D = c / fb$ $b = 2cD / fx$ **Answer: D** **Examiner's Comments:** Most of those candidates who got the wrong answer in this question did so because they believed that the width of the central maximum was the same as the letter *x* in the single-

	slit diffraction equation so they were out by a factor of 2 and subsequently chose distractor **C**.
20	**Essential Question(s):** • What is the relationship between the electric potential at a point due to a point charge and the distance from the point charge? **Solution:** $V = Q/4\pi\varepsilon\, r$ when $r = d$, electric potential $V = Q/4\pi\varepsilon\, d$ when $r = d/2$, electric potential $V' = Q/\ 4\pi\varepsilon\ (d/2)$ $V' = 2\ V$ **Answer: C**
21	**Essential Question(s):** • What is the relationship between the electric field strength at a point due to a point charge and the distance from the point charge? **Solution:** $E = Q/4\pi\varepsilon_o\, r^2$ rearrange $E = (Q/4\pi\varepsilon_o)\ (1/r^2)$ graph of E against $(1/r^2)$ is a straight line with gradient = $Q/4\pi\varepsilon_o$ & y-intercept = 0 Hence $Q = 4\pi\varepsilon_o$ x gradient **Answer: A**
22	**Essential Question(s):** • How does the power dissipated in a certain length of wire depends on its diameter when it is connected to the same voltage supply? o How are *resistivity*, *energy transfer*, and *diameter* related? **Solution:** power dissipated P $= V^2/\ R$ $= V^2/\ (\rho L/A)$ $= V^2A/\ (\rho L)$ $= V^2\ (\pi r^2)\ /\ (\rho L)$ $= V^2\ (\pi d^2/4)\ /\ (\rho L)$ *hence* $P \propto d^2$ since V, L and ρ are constants $P_x\ /\ P_Y = (d_x/\ d_Y)^2$ $1.0\ /\ 1.5 = (d_x\ /d_Y)^2$ $(d_x\ /d_Y) = \sqrt{(1.0\ /\ 1.5)} = 0.816 = 0.82$ **Answer: B** **Examiner's Comments:**

	Most of the candidates who answered this question incorrectly did so because they got the ratio the wrong way up. This could be due to a number of reasons, the most likely being getting the powers of X and Y the wrong way round.
23	**Essential Question(s):** • What is the relationship among e.m.f. *E*, current *I*, internal resistance *r* and external resistance *R* when a cell is connected to a load? • How is a series circuit different from a parallel circuit? **Solution:** $E = I_{tot} (r + R_{ext})$ circuit 1 current is **I**, total external resistance = 2R $E = I (r + 2R)$ …(1) circuit 2 current is 3**I**, total external resistance = R/2 $E = 3I (r + R/2)$ …(2) (1) = (2) : $I (r + 2R) = 3I (r + R/2)$ $r + 2R = 3r + 3/2 R$ $2r = 2R – 3/2 R = ½ R$ $r = 1/4 R$ **Answer: A**
24	**Essential Question(s):** • What is the equation of a potential divider circuit? **Solution:** Option A when sliding contact is at the upper end V_{XY} = 6.0 V when sliding contact is at the lower end V_{XY} = 6.0 (R / 2R) = 3.0 V range of V_{XY} = 3.0 V to 6.0 V incorrect Option B when sliding contact is at the upper end V_{XY} = 0.0 V when sliding contact is at the lower end V_{XY} = 6.0 (R / 2R) = 3.0 V range of V_{XY} = 0.0 V to 3.0 V correct option Option C V_{XY} = 6.0 V always because X and Y are connected to the source directly when sliding contact is at the middle, incorrect Option D when sliding contact is at the upper end V_{XY} = 6.0 *(R / 2R)* = 3.0 V when sliding contact is at the lower end, the upper resistor is shorted

<table>
<tr><td></td><td>$V_{XY} = 6.0$
incorrect

Answer: B

Examiner's Comments:
This question did not require any calculations, but candidates found it challenging, possibly because of a misconception between potential and potential difference. The key, B, had X connected to 6.0 V which may have meant that some candidates ruled it out.</td></tr>
<tr><td>25</td><td>Essential Question(s):
• What is the path of a charged particle in a uniform electric field?
• How do we determine the uniform acceleration of a charge particle moving in between the parallel plates?
• How do we determine the time of flight of the charge particle moving in between the parallel plates?

Solution:
electric field strength $E = V/d$
electric force $F = eE = eV/d$
acceleration of electron
$a = F / m = eV / dm$ = $(1.6 \times 10^{-19} \times 3000) / 0.1 \times 9.1 \times 10^{-31}) = 5.275 \times 10^{15}$ m s^{-2}

consider horizontal motion, a = 0
$x = vt$
$0.05 = 1.97 \times 10^{7}\ t$
$t = 2.53 \times 10^{-9}$s

consider vertical motion, $a = 5.275 \times 10^{15}$ m s^{-2}
$s = ut + ½ at^2 = 0 + ½ (5.275 \times 10^{15})(2.53 \times 10^{-9})^2 = 0.0169$ m $= 1.7 \times 10^{2}$ m

Answer: B</td></tr>
<tr><td>26</td><td>Essential Question(s):
• How do we determine the magnetic flux linkage to the magnetic flux density of an N turns coils of area A?

Solution:

Magnetic flux linkage
$\Phi = NBA \sin \theta$
$= 10 (2.1 \times 10^{-5}) (20 \times 20) \sin 90°$
$= 0.084$ Wb
$= 8.4 \times 10^{-2}$ Wb
Units of $\Phi = [B][A]$ = T m^2 = Wb
$\Phi = 8.4 \times 10^{-2}$ T m^2

Answer: D</td></tr>
<tr><td>27</td><td>Essential Question(s):
• What is the relationship between average power and the r.m.s. current in a resistor?

Solution:
average power $P = I_{r.m.s}{}^2 R$
$I_{r.m.s} = \sqrt{P / R}$

Answer: C</td></tr>
<tr><td>28</td><td>Essential Question(s):</td></tr>
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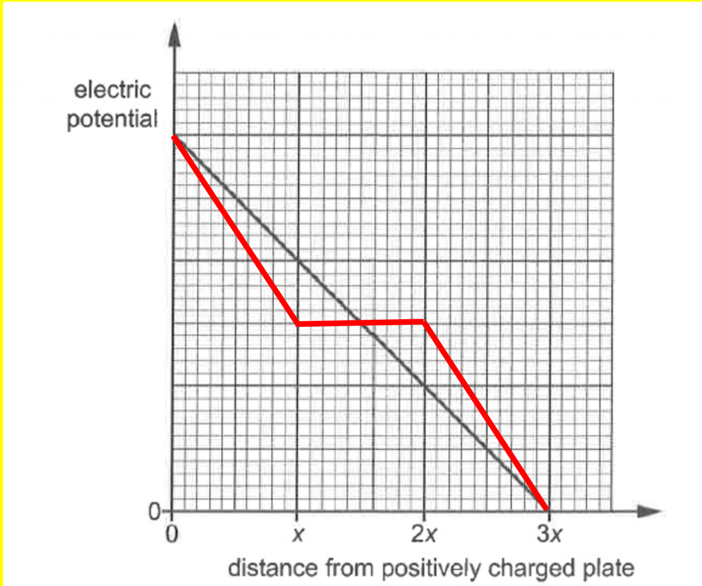
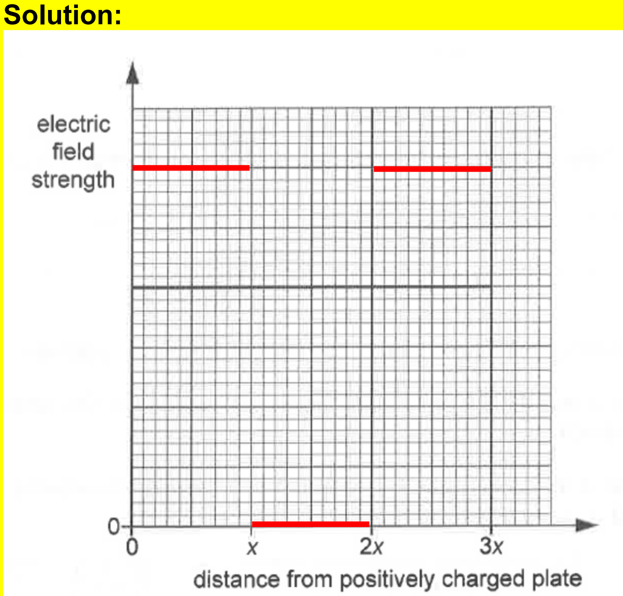
	• What is the relationship between the wavelength of the photon emitted during a transition from a higher energy state to a lower energy state? **Solution:** energy of an emitted photon $E = E_1 – E_2$ also $E = hf$ $= hc / \lambda$ since $f = c / \lambda$ $hc/ \lambda = E_1 – E_2$ $\lambda = hc / (E_1 – E_2)$ **Answer: D**
29	**Essential Question(s):** • How do we determine the energy released in a nuclear fission reaction? **Solution:** mass decrease = mass of reactants – mass of products = (140.91u – 91.91u – 3 x 1.10u) – (235.04u – 1.01u) = 0.2 u = 0.2 x 1.66 x 10^{-27} kg Energy release = mass decrease x c^2 = (0.2 x 1.66 x 10^{-27}) x (3.00 x 10^8)^2 = 3.0 x 10^{-11} J **Answer: A**
30	**Essential Question(s):** • How is number of nuclei decayed related to decay constant? **Solution:** number of nuclei that remain undecayed is given by $N = N_o e^{-\lambda t}$ number of nuclei decayed $\Delta N = N_o – N = N_o – N_o e^{-\lambda t} = N_o (1 – e^{-\lambda t})$ $(1 – e^{-\lambda t}) = \Delta N / N_o$ $(e^{-\lambda t}) = 1 – (\Delta N / N_o) = 1 – (3.00 \times 10^{-12} / 5.00 \times 10^{-12}) = 2/5$ $-\lambda t = \ln 2/5 = -0.9163$ $t = 0.9163/\lambda = 0.9163/ 1.15 \times 10^{-8} = 7.97 \times 10^7$ s **Answer: D**

Paper 2

1	**a**		**Essential Question(s):** • What is Newton's 1st law of motion? • How do we apply this law in this context? **Solution:** By Newton's first law of motion, the **net** force acting on the cyclist **along his path** must be **equal to zero**. This implies that the **cyclist applies a driving force** which is <u>**equal in magnitude and opposite in direction**</u> to the frictional force. **Examiner's comments:** The majority of candidates quoted Newton's first law rather than using it to explain the motion of the cyclist. A significant number did go on to describe the forces acting on the cyclist. Many stated that the force of friction was equal to the driving force on the cycle. Some stated that since the cyclist had constant speed, there were no external forces. These candidates made no reference to any of the forces acting on the cyclist.
1	**b**		**Essential Question(s):** • How to apply the product and quotient rules in the calculations of uncertainty? • To which significant figures should the absolute uncertainty be presented to? • How do we present the speed value after we have determined the absolute uncertainty? **Solution:** Given $F = ½\, c_D\, \rho\, A\, v^2$ make v the subject $v^2 = 2F / c_D\, \rho\, A$ $v = (2F / c_D\, \rho\, A)^{½}$ $= [(2 \times 22) / (0.88 \times 1.2 \times 0.32)]^{½}$ $= 11.41$ m s^{-1} From $v = (2F / c_D \rho A)^{½}$ $\Delta v/v = ½\, [(\Delta F/F) + (\Delta c_D/c_D) + (\Delta A/A) + (\Delta\rho/\rho)]$ $= ½\, [2/22 + 0.01/0.88 + 0.1/1.2 + 0.02/0.32]$ $= 0.124$ $\Delta v/11.411 = 0.124$ $\Delta v = 1.415 = 1$ m s^{-1} (1 s.f.) v = (11 $\pm$ 1) m s^{-1} **Examiners' Comments:** There were a considerable number of correct answers. There were some candidates that calculated the fractional uncertainty in the speed by subtracting the fractional uncertainties of c_D, ρ, and *A* from the fractional uncertainty of *F*. A small minority did not halve the sum of the fractional uncertainties of the four terms to determine the fractional uncertainty in *v.* There was a significant number of candidates giving two significant figures instead of one for the final uncertainty in *v*.
1	**c**	**i**	**Essential Question(s):** • How do you derive the expression $P = Fv$ from the definition of power and work done? **Solution:** definition of work done

			$W = F x$ where x is the displacement moved in the direction of F definition of power P = rate of work done or work done per unit time P = work done per unit time $= F x / t$ where t is the time taken to do work of Fx $= F (x / t)$ $= F$ (displacement moved per unit time) $= F v$ where v = displacement moved per unit time = velocity **Examiner's Comments:** The majority of derivations were correct. A few candidates started with an incorrect statement that work done equals the force × the perpendicular distance moved.
	c	ii	**Essential Question(s):** • What is F in the equation $P = Fv$ where P is the power output of the cyclist and v is the velocity of the cyclist? **Solution:** $P = Fv$ = 22 x 11 = 242 W = 240 W **Examiner's Comments:** The vast majority of candidates calculated the correct answer.
2	**a**		**Essential Question(s):** **Solution:** The gravitational potential <u>at a point</u> is the <u>work done **per** unit **mass**</u> by an <u>external agent</u> in bringing a <u>point mass</u> <u>from infinity to that point</u>. **Examiners' Comments:** The majority of definitions were given correctly. There were some answers that did not include the work done **per** unit mass.
2	**b**		**Essential Question(s):** • How do we determine the GPE of the satellite? • How do we determine the change in GPE of the satellite? **Solution:** GPE $E_p = - GMm / r$ change in GPE ΔE_p = final GPE – Initial GPE $= (- GMm / r) - (- GMm / R)$ $= (- GMm) (1/ r - 1/R)$ $= (- 6.67 \times 10^{-11} \times 6.0 \times 10^{24} \times 1600)(1/2.7 \times 10^{7} - 1/6.4 \times 10^{6})$ $= 7.63 \times 10^{10}$ J $= 7.6 \times 10^{10}$ J **Examiners' Comments:** There were a number of candidates adding the radius of the Earth to the radius of the orbit of the satellite even though the question stated that the orbit radius was from the centre of the Earth. There were answers that did not convert the radius of the Earth given in km into m. Some candidates began with an incorrect formula and used the formula for gravitational force instead of gravitational potential energy.

2	**c**	**i**	**Essential Question(s):** • How to relate the speed of a satellite in orbit to the mass of Earth and the radius of the orbit? **Solution:** centripetal force is provided by the gravitational force $mv^2/ r = GMm/ r^2$ $mv^2 = GMm/ r$ Kinetic energy $E_k = ½ mv^2 = ½ GMm/ r = GMm/ 2r$ **Examiners' Comments:** The majority of candidates gave an adequate proof. There were some derivations that did not show algebra with all the steps clearly set out. The first statement of the gravitational force providing the centripetal force was followed immediately by the expression for the kinetic energy. In 'show that' questions, all the steps are required as the final answer is given in the question.
2	**c**	**ii**	**Essential Question(s):** • What d *G*, *M*, *m* and *r* mean in the equation? **Solution:** Kinetic energy $E_k = GMm/ 2r$ $= (6.67 \times 10^{-11} \times 6.0 \times 10^{24} \times 1600)/(2 \times 2.7 \times 10^7)$ $= 1.186 \times 10^{10}$ $= 1.2 \times 10^{10}$ J **Examiners' Comments:** The majority of candidates gave the correct answer.
2	**c**	**iii**	**Essential question:** • Why the expression $E_k = GMm/ 2r$ *is not applicable to a body resting on the Earth surface?* • Is the satellite moving when on the Earth's surface? • If it is moving, how do we determine the kinetic energy of the satellite on the Earth's surface? **Solution:** Incorrect. *Reason: The expression* $E_k = GMm/ 2r$ is not applicable to a body resting on the Earth because in addition to the gravitational force exerted by the Earth, the body (satellite) also experiences a normal contact force exerted by the Earth. The expression $E_k = GMm/ 2r$ is derived for the case where the only force providing for the centripetal force is gravitational force. The expression can only be used to calculate the final KE of the satellite in this case, when it is in the orbit. **Examiner's Comments:** A significant number of candidates stated that the satellite was not in orbit or in circular motion when on the Earth's surface. A significant number considered the calculation incorrect as changes to the potential energy needed to be taken into account, when the question was asking if the expression for kinetic energy in **(c)(i)** was valid for calculating the change in kinetic energy.
3	**a**		**Essential question:**

			• What is the potential and electric field inside a conductor which is placed in a uniform electric field? **Solution:**  Inside the conductor the electric field is zero and the electric potential is constant. Outside the conductor the electric field is constant. Since electric field strength $E = -dV/dx$, the electric potential change linearly with distance and the *V*-*x* graph is a straight line with a constant gradient. **Examiner's Comments:** There were a small number of correct answers. Only a small minority showed the potential to be constant through the conductor. Few candidates showed the variation of the potential with distance between the plates and the conductor to be the same on both sides of the conductor.
3	**b**	**i**	**Essential Question(s):** • How is the electric field related to the gradient of the potential against distance graph? **Solution:**  <u>Without the conductor,</u>

			E = negative gradient of V-x graph = 3 / $3x$ = $1/x$ <u>With the conductor,</u> outside the conductor: E = negative gradient of V–x graph = 1.5 / x = 1.5 times that without conductor inside the conductor: E = 0 **Examiner's Comments:** A significant number of candidates realised that the electric field was constant between the plates and the conductor. A similar number showed the field was zero inside the conductor. The majority of candidates did not seem to know that the electric field was given by the gradient of the potential graph.
4	**a**		**Essential Question(s):** **Solution:** Diffraction is the <u>spreading</u> of waves <u>into the geometrical shadow regions</u> when they <u>pass through an opening or around an obstacle</u>. *Do NOT rephrase 'spreading' as 'bending'.* **Examiners' Comments:** The majority of candidates described the spreading of waves as they pass through a slit or aperture. Some gave imprecise explanations and described the bending of waves or missed the point that for diffraction to occur, the waves have to pass through a slit or go round an edge or obstacle.
4	**b**	**iii**	**Essential Question(s):** • What are the conditions to produce an observable two source interference pattern? **:** **Solution:** 1. the two waves must be of the same nature and must overlap. 2. the two waves must be coherent. **Examiners' Comments:** There were a majority of correct answers. Some incorrect answers compared the width of the slit with the wavelength or the distance to the screen with the separation of the slits. There were many answers that referred to polarisation without a clear statement of how the waves needed to be polarised. There were a number of candidates that considered coherent waves and waves of the same frequency / wavelength to be two separate conditions.
4	**c**	**i**	**Essential Question(s):** • How is the distance between the double slit and the fringe width related? **Solution:** In the two source interference pattern, x, fringe width is related to D, the distance between the double slit by the relation $x = \lambda D/a$ where a is the slit separation Hence the gradient of the x against D graph = λ/a From the graph gradient = (8.8 – 4.4) x 10^{-3} / (2.0 -1.0) = 4.4 x 10^{-3} m hence λ/a = 4.4 x 10^{-3} λ =(4.4 x 10^{-3}) a = (4.4 x 10^{-3}) (0.12 x 10^{-3})

= 5.28×10^{-7}m
= 5.3×10^{-7}m

**Calculate the gradient using 2 points separated far apart enough on the graph.*

Examiners' Comments:
The majority of answers were correct. There were a small number of candidates that omitted the power of ten given on the *y*-axis for *x* and some who gave the gradient of the graph as the wavelength.

4 c ii

Essential Question(s):

- What is the relationship between intensity and amplitude of a wave?
- What is the amplitude of the resultant wave when two waves of amplitude A_1 *and* A_2 interfere (1) constructively and (2) destructively?

Solutions
let A_1 and A_2 be the amplitudes of the two waves that interfere

At bright fringe resultant amplitude $A_{bright} = A_1 + A_2$
At dark fringe resultant amplitude $A_{dark} = A_1 - A_2$

let $A_2 = A$ *then* $A_1 = 2A$

At bright fringe resultant amplitude $A_{bright} = A_1 + A_2 = 2A + A = 3A$
At dark fringe resultant amplitude $A_{dark} = A_1 - A_2 = 2A - A = A$

Intensity is proportional to the square of the amplitude
$I = kA^2$

Max intensity of centre bright fringe / Max intensity of adjacent dark fringe
$= kA_{bright}{}^2 / kA_{dark}{}^2$
$= A_{bright}{}^2 / A_{dark}{}^2$
$= (3A/A)^2$
= 9.0

Examiner's Comments:
There were many correct answers. A significant number were unable to determine the amplitudes of the central and dark fringes in the new situation. There were some that gave the correct relationship between intensity and amplitude but then were unable to correctly apply this relationship and determined the square root of the new amplitudes for the required ratio. A small number of candidates squared the individual wave amplitudes and then added them together to gain the resultant intensity for each of the bright and dark fringes.

5 a

Essential Question(s):

- How do we calculate current from drift velocity and number density of free electrons?

Solution:
In a wire, current
$I = nAve = (5.9 \times 10^{28})[\pi \times (0.38 \times 10^{-3}/2)^2](7.2 \times 10^{-5})(1.6 \times 10^{-19})$
= 0.007708 A

$Q = It$
= 0.007708 x (30 x 60)
= 139 C
= 140 C

Examiners' Report:

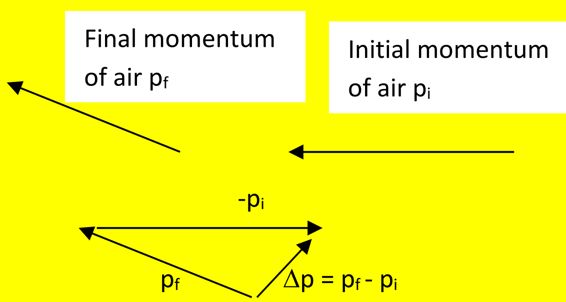
			There were many correct answers. Some candidates did not show an understanding of the term *n* in the expression for the current ($I = nAve$). Many tried to calculate a total number of charge particles in the volume of the wire using the given length of wire. A significant number miscalculated the charge after stating the correct expression. A small number of candidates incorrectly used $I = Qt$.
5	**b**	**i1**	**Essential Question(s):** • What is the expression that represents an a.c. voltage? • How do we determine the maximum value and the frequency from the expression? **Solution:** Given $V = 9.0 \sin 120\,\pi t$ Amplitude = 9.0 V angular frequency $\omega = 120\pi$ frequency $f = \omega / 2\pi = 120\pi / 2\pi = 60$ Hz **Examiners' Report:** The majority of answers were correct.
5	**b**	**i2**	**Essential Question(s):** • What is the relationship between r.m.s. voltage and peak voltage? **Solution:** $V_{rms} = V_o / \sqrt{2} = 9.0 / \sqrt{2} = 6.36$ V = 6.4 V **Examiners' Comments:** The majority of answers were correct.
5	**b**	**ii1**	**Essential Question(s):** • What is relationship between peak current and peak voltage in an a.c. supply? **Solution:** to calculate the total resistance: combined resistance of the parallel circuit = $(1/6 + 1/12)^{-1} = 4\ \Omega$ total resistance = $12 + 4 = 16\ \Omega$ Current $I_o = V_o / R = 9.0 / 16 = 0.5625 = 0.56$ A **Examiners' Comments:** The majority of answers were correct.
5	**b**	**ii2**	**Essential Question(s):** • What is the relationship between the mean power and the peak current? **Solution:** consider the parallel circuit, Let peak p.d. across 6.0 Ω resistor be V_1 Let peak p.d. across 12 Ω resistor be V_2 Let peak current in 6.0 Ω resistor be I_1 Let peak current in 12 Ω resistor be I_2 $V_1 = I_1 \times 6$ and $V_2 = I_2 \times 12$ also $V_1 = V_2$ $I_1 \times 6 = I_2 \times 12 \Rightarrow I_1 = 2 I_2 \Rightarrow \frac{1}{2} I_1 = I_2$ *total peak current*

			$= I_1 + I_2 = I_1 + ½ I_1 = 3/2 I_1$ Hence $3/2 I_1 = 0.5625 \Rightarrow I_1 = 0.5625 \times 2/3 = 0.375$ A Power dissipated in 6.0 Ω resistor $= ½ I_1^2 \times 6$ $= ½ (0.375^2) \times 6$ = 0.42 W **Examiners' Comments:** The majority of candidates used an incorrect potential difference or current for the 6 Ω resistor. Many used the peak or rms potential difference of the supply or the circuit current.
6	**a**		**Essential Question(s):** **Solution:** The magnetic flux density at a point is the magnetic force per unit current per unit length experienced by a long straight current-carrying conductor placed at right angle to a uniform magnetic field. **Examiners' Comments:** There were many correct answers. A significant number did not make the definition clear or that the wire needed to be perpendicular to the direction of the magnetic field.
6	**b**		**Essential Question(s):** • What does the equation $R = \rho L / A$ mean? • How is the equation related to a solenoid of diameter *D* is made up of *N* turns of wire of diameter *d*? **Solution:** $L = (N \times \pi D)$ $A = \pi d^2/4$ $R = \rho L / A = \rho (N \times \pi D) / \pi (d^2/4)$ $= 1.7 \times 10^{-8} \times (520 \times 0.04) / [(0.46 \times 10^{-3})^2/4]$ = 6.68 = 6.7 Ω **Examiners' Comments:** There were a significant number of correct answers. There was some confusion concerning the wire diameter and the diameter of the solenoid. The length of wire was incorrectly determined by a number of candidates, many of whom did not use the circumference of the solenoid but the diameter of the wire or the diameter of the solenoid.
6	**c**		**Essential Question(s):** • How to determine the magnetic flux density at the centre of a solenoid? **Solution:** Current in solenoid $I = V / R$ = 24 / 6.68 = 3.593 A Length of the solenoid = $(520 \times 0.46 \times 10^{-3})$ since no gaps between each turn the number of turns per unit length of solenoid *n* = 520 / length of solenoid $= 520 / (520 \times 0.46 \times 10^{-3})$ $= 1 / (0.46 \times 10^{-3})$

			Magnetic flux density at the centre of a solenoid $B = u_o nI$ $= (4\pi \times 10^{-7})[1 / (0.46\times10^{-3})](3.593)$ $= 9.8 \times 10^{-3}$ T **Examiners' Comments:** There were a minority of correct answers. A significant number of candidates used the total number of turns on the solenoid instead of the number per unit length. The diameter of the wire and the diameter of the solenoid were confused by many candidates. A small number of candidates chose the incorrect formula from page 3 of the question paper.
6	**d**		**Essential Question(s):** • What is the expression to determine the magnetic force on a current carrying conductor in a magnetic field? **Solution:** The wire experiences zero magnetic force because the current in the wire flows in the direction of the magnetic field. The magnetic force $F = BIL \sin\theta$ where θ is the angle between current I and magnetic flux density B In this case $\theta = 0$ since the current I is along B the magnetic flux density B Hence $F = 0$ **Examiners' Comments:** The majority of answers were correct. There were some vague answers that stated that there was zero force as the current was not perpendicular to the direction of the magnetic field. A few candidates referred to the wire being parallel to the solenoid rather than the magnetic field it produces.
7	**a**		**Solution:** A **photon** is a quantum of electromagnetic radiation energy. The amount of energy E carried by **one photon** is given by $E = hf$ where h : Planck's constant f : frequency of the electromagnetic radiation **Examiner's Comments:** The majority of answers were correct. There were some explanations that referred to particles with energy and others gave no reference to the electromagnetic spectrum. A very small number of responses omitted any reference to energy.
7	**b**		**Essential Question(s):** • What is meant by a cloud of gas? • What is meant by "spectrum" and "dark lines? **Solution:** • In the gas, the atoms are mostly at the ground state. • When white light is incident on the gas, the gas atoms **absorb** photons of **energies** equal to the **electron** energy **levels** ***differences*** present in the gas atoms, causing the electrons in the gas atoms to be excited. • The excited **electrons** then de-excite, emitting **photons** of energies that were previously absorbed. Due to the **quantised nature of electron energy levels in an atom, the photons emitted are only of certain discrete values of energies and hence frequencies/wavelengths**. • The emitted photons are emitted in **all** directions **randomly**.

			• Consequently, **in the direction of the incident white light, there is a decrease in the number of those frequencies/wavelengths of photons which were absorbed and re-emitted hence the observed spectrum consists of a continuous coloured spectrum with dark lines corresponding to those absorbed**. **Examiner's Comments:** There was a minority of candidates that gave a full explanation of the formation of the absorption spectrum. A significant number described the gas, the molecules of the gas or the atoms of the gas absorbing light of specific frequencies. There were some that described an electron absorbing a photon to become excited. There were more answers that described the electron de-exciting to produce a photon and that photons produced in this way were emitted in random directions.
7	c	(i)	**Essential Question(s):** **Solution:** Energy $= -13.6 / n^2$ $= -13.6 / 2^2$ $= -3.40$ eV **Examiner's Comments:** The majority of answers were correct.
7	c	(ii)	**Essential Question(s):** • How does an electronic transition works? • How is the wavelength of the light related to the energy level diference? **Solution:** Energy of photon absorbed $= (-13.6 / 3^2) – (-13.6 / 2^2)$ $= 1.889$ eV $= 1.889 \times 1.6 \times 10^{-19}$ $= 3.022 \times 10^{-19}$ J Energy of a photon $E = hf = hc / \lambda$ wavelength of light $\lambda = hc/ E$ $= (6.63 \times 10^{-34}) \times (3.00 \times 10^{8}) / 3.022 \times 10^{-19}$ $= 6.58 \times 10^{-7}$ m $= 6.6 \times 10^{-7}$ m **Examiner's Comments:** There were a large number of correct answers. The vast majority gave the correct expression for the wavelength in terms of the energy difference between the two energy levels. A significant number did not convert the energy difference calculated in eV to joule.
		(iii)	**Essential Question(s):** • Which energy, kinetic or potential energy, can be negative? • In gravitational fields and electric fields, when two objects are attracted to one another, is the potential energy negative or positive? **Solutions** The energy of a free, unbound electron at rest <u>outside</u> an atom is defined to be zero. The negative energy values of the energy levels implies that an electron <u>in</u> an atom require energy to be excited and to be escaped from the atom.

			Examiner's Comments: Some candidates considered that the energy of each level is negative because the charge on the electron is negative. Some candidates only referred to the potential or the potential energy being zero at infinity.
8	**a**		**Essential Question(s):** • Which equation of motion may be used to determine the max deceleration of a car? **Solution:** paragraph 2 braking distance from max speed of 185 km h^{-1} = 80 m using " $v^2 = u^2 + 2as$" and taking direction of initial velocity as positive direction, $0 = (185\ 000/\ 60\text{x}60)^2 + 2a(80)$ a = - 16.5 m s^{-2} the negative sign indicates deceleration hence deceleration = 16.5 m s^{-2} = 17 m s^{-2} **Examiner's Comments:** There were a majority of correct answers. A significant number of candidates attempted to determine the acceleration by estimating the value of the coefficient of friction from the graph to determine a frictional force even though the temperature of the tyres was not given. Some candidates did not convert the speed given in km h^{-1} to m s^{-1}. A number gave the correct equation of constant acceleration but then did not square the term for the initial speed.
8	**b**	**i**	**Essential Question(s):** • What physical force provides the centripetal force on a car going round a corner? **Solution:** Para 7, the centripetal acceleration of a car to go round corner of radius 30 m = 4g For circular motion centripetal acceleration $a = v^2 / r$ hence $4g = v^2 / r$ $v = \sqrt{4gr} = \sqrt{4 \times 9.81 \times 30}$ = 34.3 m s^{-1} = 34 m s^{-1} **Examiner's Comments:** A significant number of candidates obtained the correct answer. There were many candidates that attempted to use an equation for constant acceleration even though the car was travelling around a circular corner. There were a number that tried to obtain a maximum frictional force using a maximum coefficient of friction determined from the graph, although the temperature of the tyre was unknown. The maximum acceleration that the tyres could withstand when cornering, given in the text, was ignored. Many equated the maximum acceleration of 4 g with the expression for the centripetal force, mv^2 / r.
8	**b**	**ii**	**Essential Question(s):** • How does the coefficient of friction affect the frictional force? • How does the temperature affect the coefficient of friction • How does the contact area affect the frictional force? **Solution:** This is to increase the maximum frictional force.

			As surrounding temperature is usually less than 80°C, as the temperature is raised by heating, the coefficient of friction increases according to Fig. 8.1. Hence the friction $F = \mu W$ is larger where W the weight is constant. As temperature is increased, the tyre becomes softer and results in a larger area of contact between the tyre and the road according to Fig 8.2. Larger area of contact means the maximum frictional force is increased. High frictional force is needed to provide for greater acceleration, deceleration and cornering at higher speeds. **Examiner's Comments:** This was generally well answered. There were a number of incomplete answers as the candidates referred to only one of the figures stated in the question. The majority of candidates described the need to obtain large frictional forces in order to accelerate, decelerate and corner at fast speeds.
8	**c**		**Essential Question(s):** • What is the direction of the momentum of the air after moving over the real wind? • How does the change in momentum of the air result in a force on the car? • When the "weight" increase, which quantity is actually increased? **Solution:** Refer to Fig.8.3, the air which moves over the surface of the real wing is deflected up and the momentum of the deflected air is at an angle above the horizontal. The initial momentum of the air is horizontal. This means that there is an upwards **change in** the momentum of the air as shown in the vector diagram below.  According to Newton's 2nd Law of Motion, there is an upwards force exerted on the air by the rear wing (= rate of change of the upward momentum on the air). According to Newton's 3rd Law of Motion, the air exerts a downwards force on the rear wing. This force causes an apparent increase in the weight of the car. **Examiner's Comment:** The majority of answers did not refer to the *change in* momentum of the air as it went over the rear wing as required in the question. There were many answers that described the forces acting on the air and the car without any reference to the change in momentum of the air being a result of the air being deflected upwards by the wing.
8	d	i	**Essential Question(s):** • What must the value of the net moment about the centre of gravity for the car not to topple? • What must be the net vertical force for the car? **Solution:** the car is in equilibrium vertically $N_R + N_F = W$ ➔ $N_F = W - N_R$ -----(1)

			the car does not topple the net moment about the centre of gravity = 0 this means that the total clockwise moment about the c.g. = total anticlockwise moment about the c.g. $N_R\, x_R = N_F x_F + Dh$ *Sub (1):* $N_R\, x_R = (W - N_R)\, x_F + Dh$ since $N_F = W - N_R$ $N_R = (W\, x_F + Dh) / (x_F + x_R)$ -----(2) **Examiner's Comment:** Stronger responses determined the expression for the normal contact force at the rear wheels following the instructions given in the question. A significant number of weaker responses were unable to make any progress after obtaining the expression for the moments about the centre of gravity. The relationship between the forces acting vertically was not considered in these responses. A large number of candidates took moments about the front wheels instead of about the centre of gravity as required by the question.
8	**d**	**ii**	**Essential Question(s):** • What must the value of the net moment about the centre of gravity for the car not to topple? • What must be the net vertical force for the car? **Solution**: *From equations (1) and (2) in (d)(i), sub (2) into (1):* $N_F = W - (W\, x_F + Dh) / (x_F + x_R)$ $N_F = (W\, x_R - Dh) / (x_F + x_R)$ **Examiner's Comments:** There were many candidates with an incorrect expression.
8	**d**	**iii**	**Essential Question(s):** • What is the value of N_F with driving force D and without D? • What is the value of N_R with driving force D and without D? **Solution:** With driving force D, N_R will be increased by a value equal *to* $Dh / (x_F + x_R)$ With driving force D, N_F will be decreased by a value equal *to* $Dh / (x_F + x_R)$ Hence there is an apparent weight transfer of $Dh / (x_F + x_R)$ from the front wheel to the rear wheel. **Examiner's Comment:** The majority of candidates seemed unaware that *D* represented the driving force and that the weight transfer occurred during acceleration of the car. The vast majority of candidates attempted to compare the two expressions for the normal contact forces without mentioning that *D* would increase as the car accelerates.
8	**e**	**i**	**Essential Question:** • What happens to the kinetic energy loss when the brake is applied? **Solution:** the loss in the KE of the car equals to the work done by the frictional forces, which in turn becomes the gain in the thermal energy in the 4 brakes. loss in KE of car $= \frac{1}{2}\, m_{car}\, v^2$ $= \frac{1}{2}\,(750)[(185 \times 1000) / (60 \times 60)]^2$

			= 990400 J Gain in thermal energy in the 4 brakes = $m_{brakes}\ c\ \Delta\theta$ = (1.2 **x 4**)(1130) $\Delta\theta$ loss in the KE of the car = gain in the thermal energy in the brake 990400 = (1.2 x 4)(1130) $\Delta\theta$ $\Delta\theta$ = 183 °C = 180 °C **Examiner's Comments:** The majority of candidates appeared not to see the link between the change in kinetic energy or the work done by the frictional forces, as the car was brought to rest and the temperature increase of the carbon fibre brakes. There were many candidates that used the same mass for the car and the brakes. These candidates seemed not to check their working when their answer for the increase in the temperature of the brakes was only just over 1°C.
8	**e**	**ii**	**Essential Question(s):** **Solution:** Assumption: All the thermal energy gained is in the brake discs and pads alone and there is no heat transfer to the other parts in the brake system or to the surroundings. **Examiner's Comments:** The majority gave a vague answer that energy was not lost to the surroundings.
8	**d**	**ii**	**Essential Question(s):** **Solution:** 1. To allow better heat dissipation by increasing the surface area, so as to reduce the temperature of the brakes and to prevent them overheating. The brake disc and pads will be heated up by the friction between them during braking. 2. To reduced water trapped between the surfaces of the brake disc and pad when the wheels are subjected to wet weather conditions. **Examiner's Comments:** The majority of candidates recognised the need to reduce the temperature of the brakes and to stop them overheating. There were many answers that suggested there would be better friction with the small holes and the brakes would be more efficient as the air in the holes would insulate and cause higher temperatures.

Paper 3
Section A

1	**a**	**i**	**Essential Question(s):** • What is the origin of the upthrust? **Solution:** The pressure of the fluid increases with depth. As compared to the upper half of the sphere, the lower half of the sphere experiences a larger pressure. Since, force is the product of the pressure and area, the upward forces on the lower half of the sphere is larger than the downward forces on the upper half. There is thus a **net** force acting upward which is known as the upthrust.

Examiner's comments:
Most candidates realised that upthrust is due to a pressure difference between the lower surface and the upper surface of the sphere. Few candidates explained why this difference in pressure occurred and even fewer linked the difference in pressure to the net upward force. Many candidates also thought that the sphere was in equilibrium and some also thought that the upthrust was due to the difference in densities of the liquid and the sphere.
A significant number tried to answer this question in terms of Newton's third law.
A weak response would be, 'the upthrust is due to a difference in pressure between the top and the bottom of the sphere.' The candidate has linked the origin of the force to the pressure difference but has gone no further in explaining why there is a pressure difference or why this produces an upward force.

1 a ii

Essential question:

- How to calculate the upthrust?

Solution:

By Archimedes' Principle,
Upthrust = Weight of fluid displaced
= Mass of fluid displaced x g
= Volume of fluid displaced x ρ_L x g
= Volume of object, V x ρ_L x g
= $V\rho_L g$

Examiner's comments:
Nearly all candidates gave the right expression for the upthrust, but some neglected to explain why this was the expression.

1 b

Essential Question(s):

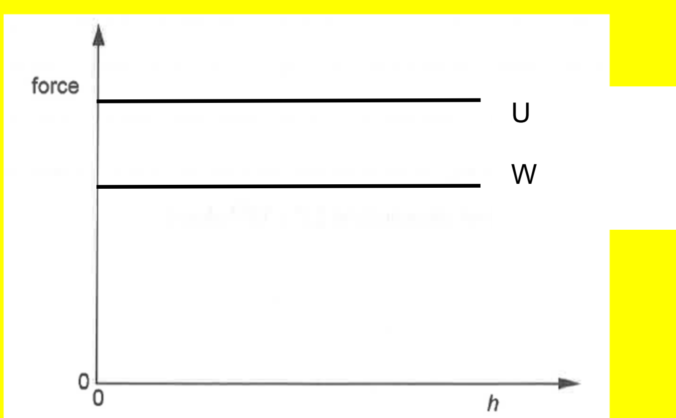
- What factors determine the weight and upthrust? (What are the mathematical expressions for weight and upthrust?) Are these dependent on the depth in the fluid?

Solution:

weight of object = $m_S g = V \rho_S g$
upthrust = $m_L g = V \rho_L g$

Both weight and upthrust are **in**dependent of the depth h
➔ Both graphs are horizontal straight lines.

ρ_S is less than ρ_L, and, V and g are the same for both
hence weight is less than upthrust
➔ Horizontal graph for weight is below the horizontal graph for upthrust.



Examiner's comments:
Most candidates realised that the weight of the object was independent of its depth in the liquid, but far fewer realised that the same was true for the upthrust, even though their expression for the upthrust in the previous answer did not have *h* in it. Those who did realise this nearly always had the upthrust as greater than the weight.

1 c

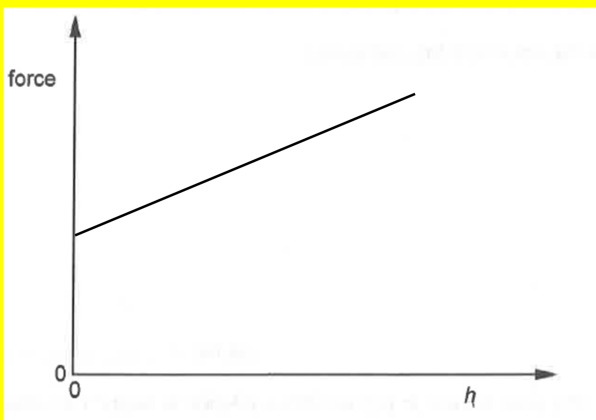
Essential Question(s):

- How does the pressure dependent on depth ?

Solution:
Pressure at the upper surface
$= P_{atm} + P_{water}$
$= P_{atm} + h\rho_L g$

force $= (P_{atm} + h\rho_L g)\, A = P_{atm} A + hA\rho_L g$

the pressure varies linearly with h
with constant positive gradient = A*hg*
and positive y-intercept = AP_{atm}



Examiner's comment(s):
This question was answered well and there were few wrong answers.

2 a

Essential question:

- What is mean velocity?

Solution:
The mean velocity <v> of n number of molecules is given by the vector sum of the velocities of the n molecules divided by n.

The **gas molecules are in random motion** and this means that **every molecule has equal probability of moving in every direction. Also, the mean speed in all directions are equal.**

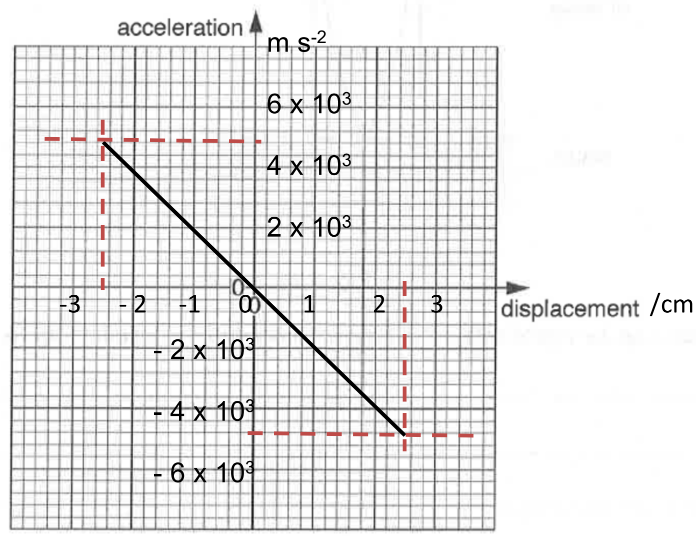
Consequently, the **vector sum of all their velocities is equal to zero**. Hence, the mean velocity is zero.

Examiners' Comments:
There was evidence of a misconception here. Candidates realised that the atoms were in random motion, but they did not know what that meant. Most of them thought that this meant that the atoms were moving in random directions but all at the same speed as the temperature was constant. The idea of atoms moving in one direction 'cancelling out' with atoms moving in another direction was frequently used. The idea of velocity being a vector quantity was also poorly understood.

			A significant number of candidates said that the kinetic energy of the atoms was zero because the gas was at a constant temperature, so therefore the velocity must be zero.
2	**b**		**Essential Question(s):** ▪ What does ideal gas mean? **Solution:** $pV = NkT$ $(3.6 \times 10^5)(4.2 \times 10^{-3}) = N(1.38 \times 10^{-23})(70 + \mathbf{273.15})$ $N = 3.2 \times 10^{23}$ **Examiners' Comments:** This part was well done.
2	**c**		**Essential Question(s):** ▪ What is the assumption of the shape of an atom when *diameter* is mentioned? **Solution:** Assume that the atoms is a sphere of radius r radius of atom $r = 2 \times 10^{-10} / 2 = 1 \times 10^{-10}$ m Total volume of the atoms $= N (4/3 \pi r^3)$ $= 3.2 \times 10^{23} \times 4/3\ \pi\ (1 \times 10^{-10})^3$ $= 1.3 \times 10^{-6}$ m^3 $= 1 \times 10^{-6}$ m^3 **Examiners' Comments:** Most candidates gave their answer to 3 significant figures, which is incorrect for the context of the question. A large number of candidates estimated the volume of one gas atom instead of estimating the value of all the gas atoms.
2	**d**		**Essential Question(s):** ▪ What are the characteristic of an ideal gas? **Solution:** Comparing the **volume of the container occupied by the gas** with the **total volume of the gas atoms:** The volume of the container occupied by the gas = 4.2×10^{-3} m^3 The volume of the container occupied by the gas is about 1000 times larger than the volume of the atoms from part **c** (1×10^{-6} m^3). The volume of the gas atoms is negligible **compared to** the volume of the container occupied by the gas, which is one of the assumptions of an ideal gas. **Examiners' Comments:** A lot of candidates answered this question well. There were some who did not understand the command words. When a question states 'Explain..' and ' …provides evidence..' candidates are expected to refer to numerical values from previous parts of the question. A number of candidates attempted to answer without any reference to the values of the volume of atoms or the volume of the gas. Many candidates referred to the volume of the gas atom rather than atoms (or omitted the word atoms altogether). It is also important that candidates differentiate between the volume of the gas atoms and the volume of the container they occupy.

3	a	i	**Essential Question(s):** **Solution:** At the highest point, x = 1.0 cm, time = t_3 & t_7 **Examiners' Comments:** There were very few errors here.
3	a	ii	**Essential Question(s):** ▪ How do you determine the max speed from the displacement-time graph? **Solution:** t_4& t_8 Reason max speed = max gradient of the displacement-time graph moving away from the top implies x increases **Examiners' Comments:** There were very few errors here.
3	b	i	**Essential Question(s):** ▪ What does revolutions in 1.0 minute mean? **Solution:** frequency = 4200/60 = 70 s^{-1} = 70 Hz **Examiners' Comments:** There were very few errors here.
3	b	ii	**Essential Question(s):** ▪ How do we determine the maximum acceleration for an object in simple harmonic motion from its frequency and amplitude? **Solution:** amplitude x_o = (6 – 1)/ 2 = 2.5 cm magnitude of max acceleration in SHM $a_{max} = \omega^2 x_o$ $= (2\pi f)^2 x_o$ $= (2\pi \times 70)^2 (0.025)$ $= 4.836 \times 10^3$ $= 4.8 \times 10^3$ m s^{-2} **Examiners' Comments:** Most candidates had little difficulty with this calculation. The most common error was to use an incorrect value of displacement in the substitution; 5 cm and 6 cm were occasionally used.
3	c		**Essential Question(s):** ▪ What is the graph of acceleration against displacement for a simple harmonic motion? **Solution:**

<table>
<tr><td></td><td></td><td></td><td>



Examiners' Comments:
The vast majority of candidates drew the correct shape; a straight line of negative gradient going through the origin. A significant number did not label the axes with either values or units.</td></tr>
<tr><td>4</td><td>a</td><td></td><td>

Essential Question(s):

- How does two waves form a stationary waves?

Solution:
A stationary waves is formed by the **repeated interference** of **two progressive coherent waves of the same type, frequency and wavelength (and hence the same speed) and approximately the same amplitude, travelling in opposite directions along the same line and overlap**.

Examiners' Comments:
Most candidates performed well here. The mistakes being made when candidates used a wave and its reflection (which is not necessarily travelling in the opposite direction), rather than two waves travelling in opposite directions.</td></tr>
<tr><td>4</td><td>b</td><td></td><td>

Essential Question(s):

- How is a stationary waves be represented?

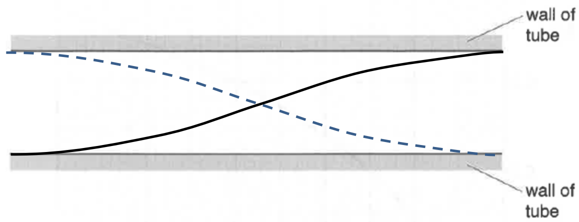
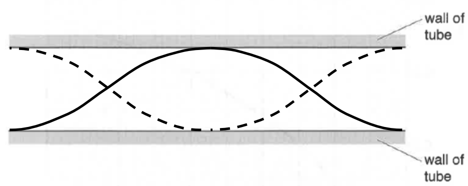
Solution:
The figure represents the two amplitude positions, that are attained half a period apart, of the vibrating particles in the air column. For a longitudinal wave in a closed-end air column in its first resonance, the amplitude of vibration of the particles in the air column is maximum near the rim of the tube, and decreases to zero at the water surface.

Examiners' Comments:
Most candidates simply wrote a definition of longitudinal waves which was not sufficient. Many mentioned nodes and antinodes without explaining how these related to the representation of the wave, others referred to the amplitude of waves without mentioning particles. A lot of candidates also talked about pressure, which was irrelevant.</td></tr>
<tr><td>4</td><td>c</td><td></td><td>

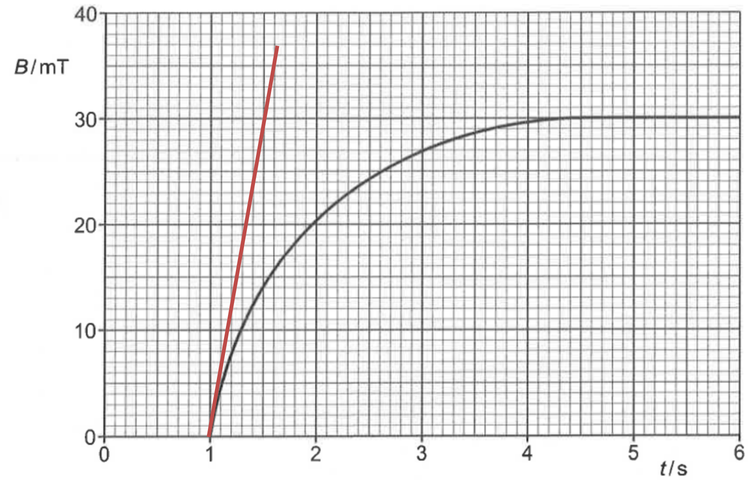
Essential Question(s):

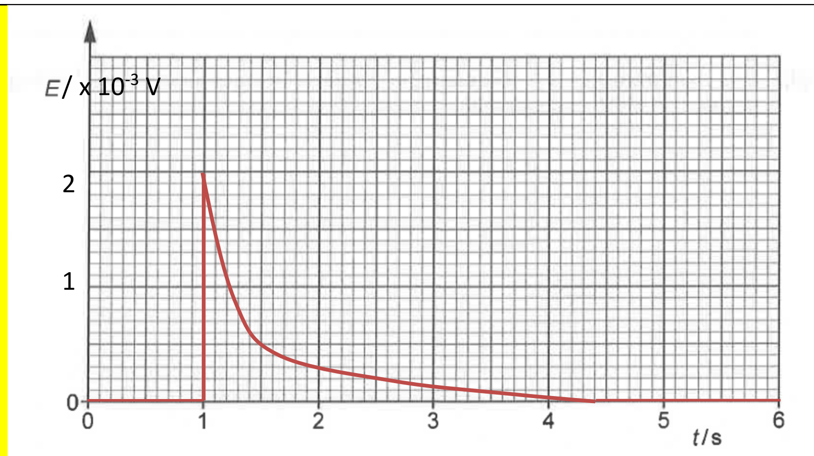
- Where are the nodes and antinodes of the lowest frequency (fundamental mode) of the stationary sound waves in an open tube?

Solution:
For the fundamental mode stationary wave in an open tube, there are two displacement antinodes at the two ends, and a displacement node at the middle.</td></tr>
</table>

			 **Examiners' Comments:** Candidates tended to understand what was required of them; their draughtsmanship sometimes let them down. Candidates should take great care when drawing diagrams.
4	**d**		**Essential Question(s):** ▪ What is the wavelength of the stationary waves related to the fundamental mode of a stationary waves and the next higher frequency mode of the stationary waves **Solution:** let *L* be the length of the tube fundamental mode, $L = \lambda/2 \rightarrow \lambda = 2L$ $\rightarrow$frequency $f = v/\lambda = v/2L = 540$ *Hz* $v/L = 2 \times 540 = 1080$ next higher frequency mode,  $L = \lambda \rightarrow \lambda = L$ $\rightarrow$ frequency $f = v/\lambda = v/L = 1080$ Hz = 1100 Hz **Examiners' Comments:** Most candidates answered this correctly, with the most common incorrect answer being 270 Hz, even though candidates had been told that the frequency had increased.
5	**a**		**Essential Question(s):** ▪ How do you determine the resistance from a current against p.d. graph **Solution:** from the graph when $V = 1.5$ V, $I = 0.2$ A $\rightarrow R = V / I = 1.5 / 0.2 = 7.5\ \Omega$ when $V = 3.0$ V, $I = 0.3$ A $\rightarrow R = V / I = 3.0 / 0.3 = 10\ \Omega$ change in resistance = final resistance – initial resistance = 10 - 7.5 = 2.5 Ω **Examiners' Comments:** This was generally answered well. Any incorrect answers were due to candidates trying to use the gradient of the graph to calculate resistance.
5	**b**	**i**	**Essential Question(s):** ▪ Which quantity is the same in a parallel connection of two resistors? **Solution:**

			current in 5 Ω resistor = 0.36 A p.d. across 5 Ω resistor = 0.36 x 5 = 1.8 V current in lamp = 0.36 A from the graph, p.d. across lamp 4.5 V p.d. across series connection of the 5 Ω resistor and lamp = 1.8 + 4.5 = 6.3 V p.d. across 5 Ω resistor and lamp in series = p.d. across 14 Ω resistor because they are in parallel ➔ p.d. across 14 Ω resistor = 6.3 V ➔ current in the 14 Ω resistor = 6.3 / 14 = 0.45 A **Examiners' Comments:** Candidates mostly got this correct. Those who got it wrong did so for one of two reasons: either they did not include the resistance of the bulb in their calculations, or they thought that the potential difference across the external circuit was 7.5 V.
5	**b**	**ii**	**Essential Question(s):** ▪ How do you determine the terminal p.d. across a cell connected to an external resistor? **Solution:** current in the cell = current in lamp + current in 14 Ω resistor = 0.36 + 0.45 = 0.81 A terminal p.d. V = E – Ir 6.3 = 7.5 – 0.81r internal resistance r = 1.48 Ω = 1.5 Ω **Examiners' Comments:** In general, if candidates got **(i)** correct then they also got this part correct. Some envisaged the 5.0 Ω resistor, the lamp and the internal resistance in a loop with the e.m.f., without realising that the currents were different in different places in their loop.
6	**a**		**Essential Question(s):** **Solution:** The magnitude of the electromotive force (e.m.f.) induced in a conductor is directly proportional to the rate of change of magnetic flux linkage of the conductor **Examiners' Comments:** This is a well-known definition.
6	**b**	**i**	**Essential Question(s):** ▪ How do we determine the rate of change magnetic field on a *B*-*t* graph? **Solution:**

			 Draw the tangent to the graph at t = 1.0 s *[Candidates should draw a tangent that is long enough, and use two points on the tangent that are far apart enough when determining its gradient.]* rate of change of magnetic flux density = *dB/dt* = gradient of the tangent to the *B-t* graph at *t* = 1.0 s = $(30 \times 10^{-3} - 0) / (1.5 - 1.0) = 6.0 \times 10^{2}$ T s^{-1} **Examiners' Comments:** Most candidates knew that the answer was obtained from taking the gradient of the graph at 1.0 s. Some candidates did not use a tangent that was long enough; a tangent should use points on it as far apart as possible.
6	**b**	**ii**	**Essential Question(s):** ▪ How is the induce e.m.f. related to the change in the magnetic flux linkage? **Solution:** Magnetic flux linkage Φ = NBA rate of change of magnetic flux linkage $E = - d\Phi/dt$ $= - d(NBA)/ dt$ $= - NA\ (dB / dt)$ since N and A are constants $= - (140)(2.4 \times 10^{-4})(6 \times 10^{-2})$ $= - 2.02 \times 10^{-3}$ $= - 2.0 \times 10^{-3}$ V **Examiners' Comments:** Most candidates found the correct answer here; although there were one or two powers of ten errors.
6	**b**	**iii**	**Essential Question(s):** ▪ How is the change in magnetic flux density in Fig. 6.2 related to the induced e.m.f.? **Solution:**

			 *E, magnitude of the induced e.m.f. = NA (dB / dt)* Since a graph grid is given, must plot with some precision. Plot at least the 'boundary points', and 3 points well spread out between the 'boundary points'. ▪ From t = 0 *to* 1.0 s, E = 0 ▪ At t = 1.0 s, E = 2.0 x 10^{-3} V ▪ From t = 1.0 s to 4.4 s, repeat calculation in (b)(ii) for 2-3 points well spread out ▪ At t = 1.5 s, E = *NA (dB / dt)* = …. = 0.52 x 10^{-3} V ▪ At t = 2.6 s, E = *NA (dB / dt)* = …. = 0.20 x 10^{-3} V ▪ At t = 3.65 s, E = *NA (dB / dt)* = …. = 0.075 x 10^{-3} V ▪ From t = 4.4 s, gradient = 0, E = 0 **Examiners' Comments:** The quality of graph drawing was variable. Most candidates realised that the e.m.f. was zero between 0 and 1 seconds and also after 4.5 seconds, although some began the graph at a maximum e.m.f. at 0 seconds and a small number finished at zero e.m.f. before 4.2 s or after 4.5 s. Many did not include units on the e.m.f. axis. A significant number of candidates drew a straight line instead of a curve with decreasing gradient and a small number drew a curve with an increasing gradient.
7	**a**	**i**	**Essential Question(s):** ▪ What is binding energy of a nucleus? ▪ How do you relate the binding energy to mass defect? **Solution:** The binding energy of a nucleus is the minimum energy required to separate a nucleus into its constituent protons and neutrons. The binding energy is equal to the product of the mass defect and the square of the speed of light.
7	**a**	**ii**	**Essential Question(s):** ▪ How to determine the binding energy per nucleon from mass defect? **Solution:** **Given: 1.000 u c^2 = 931.4 MeV** Binding energy of Na-23 = mass defect x c^2 = [(11)(1.00814u)+(12)(1.00898u) – (22.99706u)] c^2 = [11.08954 + 12.10776 – 22.99706] (**931.4**) MeV = 0.20024 x 931.4 MeV

			= 186.503 MeV Binding energy per nucleon of Na-23 = 186.503 / 23 = 8.109 MeV
7	b	i	**Essential Question(s):** ▪ How to calculate the mass change of a nuclear reaction? **Solution:** mass change = 22.99706u + 1.00898u – 23.99857u = 0.00747u =7.47×10^{-3} u
7	b	ii	**Essential Question(s):** ▪ How to relate the energy of a photon to its wavelength? **Solution:** Energy released = 7.47×10^{-3} **u x *c*²** = 7.47×10^{-3} x **931.4** Mev = $7.47 \times 10^{-3} \times (931.4 \times 10^{6} \times 1.6 \times 10^{-19})$ J 1MeV = $10^{6} \times 1.6 \times 10^{-19}$ J = 1.1132×10^{-12} J energy of a photon $E = hf = hc/\lambda$ The energy of the photon is converted from the change in mass of the nuclear reaction Hence $hc/\lambda = 1.1132 \times 10^{-12}$ $(6.63 \times 10^{-34} \times 3.00 \times 10^{8}) / \lambda = 1.1132 \times 10^{-12}$ $\lambda = 1.787 \times 10^{-13} = 1.8 \times 10^{-13}$ m
7	c	ii	**Essential Question(s):** ▪ How is the decay constant related to probability of decay per unit time? **Solution:** From $A = A_o e^{-\lambda t}$ $ln (A / A_o) = - \lambda t$ $A = (1/20)A_o$ *when time* $t = 65$ *h* In (1/20) = $-\lambda(65)$ $\lambda = 0.046$ h^{-1} decay constant = fractional of the nuclei that will decay per unit time = probability per unit time of decay probability per hour of decay = 0.046 h^{-1}

Section B

8			**General examiner's comments:** It appeared as if the candidates who performed less well overall attempted this question as they felt more comfortable with questions about dynamics and mechanics than they did about fields and circular motion.

8	a	i	**Essential Question(s):** ▪ What is an inelastic collision in term of speed of the bodies? **Solution:** For an inelastic collision, the relative speed of approach is larger than the relative speed of separation. the relative speed of approach = $u_1 - u_2$ the relative speed of separation = $v_2 - v_1$ where u_1 and v_1 are the initial and final speed of approaching body u_2 and v_2 are the initial and final speed of the body being collided. Hence $u_1 - u_2$ is greater than $v_2 - v_1$ Note : For an elastic collision, the relative speed of approach is equal to the relative speed of separation. For a completely inelastic collision, the relative speed of separation is zero since the two bodies stick together after collision. **Examiners' Comments:** Candidates tended to confuse speed and velocity and did not talk about the relative speeds of approach and separation, even though it is a syllabus learning outcome.
8	a	ii	**Essential Question(s):** ▪ What is an inelastic collision in term of energy of the bodies? **Solution:** The **total kinetic** energy of the objects before collision is larger than that after collision **Examiners' Comments:** Candidates were often careless in their approach to this answer. Energy was frequently used instead of kinetic energy and the idea of kinetic energy being transferred from the system was sometimes missed. A weak response would be, 'the energy is not conserved'. The candidate has not referred to kinetic energy and they have not got the idea of the energy being transferred from the system.
8	b		**Essential Question(s):** ▪ How do we apply conservation of energy of a falling body? **Solution:** gain in Kinetic Energy = loss in Gravitational Potential Energy $\frac{1}{2} mv^2 - 0 = mgh$ $\frac{1}{2} mv^2 = mg (L - L\cos 21°)$ $v^2 = 2gL (1 - \cos 21°)$ $v^2 = 2 (9.81)(1.50)(1 - \cos 21°)$ $v = 1.398 = 1.4$ m s^{-1} **Examiners' Comments:** If candidates realised that this was an energy question then they generally performed well. Other candidates did not realise this and tried to use circular motion or SHM.
8	c	i	**Essential Question(s):** ▪ How do we apply the principle of the conservation of momentum in a collision problem? **Solution:** Take initial direction of velocity of A to be positive direction.

			Total momentum before collision = (0.096)(1.4) Total momentum after collision = (-0.096 x 0.79) + p By principle of conservation of momentum, (0.096)(1.4) = (-0.096 x 0.79) + p p = 0.21 kg m s^{-1} **Examiners' Comments:** The most common error was to subtract the velocities rather than adding them as they did not realise that the velocity of sphere A was negative after the collision.
8	c	ii	**Essential Question(s):** ▪ During a collision in which there is a loss in the KE. What has become the energy that remained in the system? **Solution:** percentage of total initial KE loss during collision = 14% percentage of total initial KE retained after collision = 100 – 14 = 86 % total KE after collision = 86 % of initial total kinetic energy = (86/100) x ½ (0.096)$(1.4)^2$ total KE retained = KE of A after collision + KE of B after collision Hence, (86/100) x ½ (0.096)$(1.4)^2$ = ½(0.096)$(0.79)^2$ + KE of B after collision KE of B after collision = 0.08091- 0.02996 = 0.0510 = 0.051 J **Examiners' Comments:** This was well-answered, the most common mistake being to apply the 14% to the wrong sphere or to apply it after the collision to the resulting kinetic energy of sphere A rather than before the collision.
8	d	i	**Essential Question(s):** ▪ How do you relate speed to KE and momentum? **Solution:** Momentum of B, $p = MV$ = 0.21 kg m s^{-1} Kinetic energy of B = ½ MV^2 = 0.051 J Kinetic energy of B = ½ MV^2 = ½ (MV) V = ½ p V 0.051 = ½ (0.21) V V = 0.486 = 0.49 m s^{-1} **Examiners' Comments:** Many candidates performed well.
8	d	ii	**Essential Question(s):** ▪ What is momentum? **Solution:** momentum of B = MV = 0.21 kg m s^{-1} from part d(i), V = 0.486 m s^{-1} hence M (0.486) = 0.21

			$M = 0.432$ $= 0.43$ kg **Examiners' Comments:** This was usually correct.
8	e		**Essential Question(s):** ▪ What is the total momentum of the spheres before collision? ▪ What does "both spheres are stationary" tell us about the total momentum of the spheres? **Solution:** The total momentum of the system (A and B) is NOT zero <u>just before collision</u>. / Total <u>initial</u> momentum of the system (A and B) is NOT zero. By the principle of conservation of momentum, the total momentum of the system <u>before, during and after</u> the collision is conserved. Hence total momentum of the bodies in NOT zero during the collision. When both bodies stop at any instant during the collision, the total momentum is zero. This violates the principle of conservation of the momentum. **Examiners' Comments:** Many candidates referred to the conservation of momentum only a minority stated that it is conserved **throughout** the event. Most candidates stated that sphere A has an initial momentum; although some simply referred to velocity rather than momentum. A significant number tried to explain their answer in terms of energies, which was the wrong approach. A weak response would be, 'both spheres are not stationary at the same time because of conservation of momentum. The momentum after the collision is the same as that before the collision.' **Stronger responses made reference to the momentum being conserved throughout the event as well as the <u>initial</u> momentum of the system**.
8	f		**Essential Question(s):** ▪ What is impulse? ▪ How do we calculate impulse? **Solution:** Impulse on A = change in the momentum of A = mass x change in velocity of A $= (0.096)\,[\,0.79 - (-1.4)]$ **to the left** $= 0.21$ kg m s^{-1} **Examiners' Comments:** This was generally well-answered.
8	g		**Essential Question(s):** ▪ When two large spheres collide, where is the point of contact of the bodies and the direction of the force due to the impulse? **Solution:** When A and B have their centres at the same horizontal level, then only the impulse on A and on B will be horizontal in direction during the collision. Impulse on A and B must always be in opposite directions in accordance to Newton's 3rd law of motion.

			Since impulse is the change of momentum, the direction of impulse is the same as the direction of the change of momentum (Δp), and hence the direction of the change of velocity (Δv) since $\Delta p = m\Delta v$. When Δp of A is horizontal to the left, Δp and hence Δv of B will be horizontal to the right. **Examiners' Comments:** Most candidates simply repeated phrases from the question rearranged into a different order. A number did not mention impulse at all, even though the question states, 'By reference to the direction of the impulse…'. Many seemed to find it easier to answer in terms of forces but did not link force to impulse. A weak response would be 'the force on B is horizontal because the centres of the spheres are on the same horizontal level.' The candidate has made no reference to impulse and has simply repeated the question.
9			**General examiners' comments:** This question was answered by the majority of candidates.
9	**a**	**i**	**Essential Question(s):** ▪ What is meant by a field of force? **Solution:** It is the region in space where an object possessing a certain property experiences a force. **Examiners' Comments:** This was generally well-answered.
9	**a**	**ii**	**Essential Question(s):** ▪ What is the field that produces a force on a body with mass and charge? **Solution:** 1. Gravitational field 2. Electric field and gravitational field **Examiners' Comments:** Candidates often said that the uncharged particle felt the gravitational force, they neglected to say that the charged particle also felt the gravitational force. Some also added that the stationary charged particle would feel a magnetic force, which is incorrect.
9	**b**	**i**	**Essential Question(s):** ▪ What is the path of the electron when it is projected perpendicularly into a uniform electric field? **Solution:** Consider horizontal motion, the electron moves with uniform velocity because the electric force acts vertically upwards using "$s_x = u_x t$" $t = s_x / u_x$ $= 0.12 / 6.7 \times 10^7$ $= 1.79 \times 10^{-9}$ s $= 1.8 \times 10^{-9}$ s **Examiners' Comments:** This was straightforward and answered correctly by nearly all candidates.
9	**b**	**ii**	**Essential Question(s):** ▪ Why does a body experience an acceleration in an electric field?

			▪ How do we determine the acceleration of the electron? **Solution:** Electric force $F = qE = qV / d$ By Newton's 2nd Law of Motion: net force $F = ma$ $F = ma = qV / d$ $a = qV / dm$ $= (1.60 \times 10^{-19} \times 960) / (0.024 \times 9.11 \times 10^{-31})$ $= 7.03 \times 10^{15}\ \mathrm{m\ s^{-2}}$ $= 7.0 \times 10^{15}\ \mathrm{m\ s^{-2}}$ **Examiners' Comments:** Most candidates found this straightforward. There were some who tried to use the equations of motion and some who used the horizontal velocity, but they were very few.
9	**c**		**Essential Question(s):** ▪ How do you determine whether the electron hits the plate during its motion? **Solution:** Consider vertical motion: The motion is a uniformly accelerated motion because a constant net force provided by the electric force acts upwards. The acceleration was found to be $7.03 \times 10^{15}\ \mathrm{m\ s^{-2}}$ upwards. Take direction upwards as positive, Using $s_y = u_y t + \frac{1}{2} a_y t^2$, $s_y = 0 + \frac{1}{2}(7.03 \times 10^{15})(1.79 \times 10^{-9})^2$ $= 0.0113$ m $= 1.13$ cm To hit the plates the electron must travel <u>vertically</u> a distance <u>more than half</u> the distance between the plates (= 2.4 cm / 2 = 1.2 cm) since the electrons are projected along the middle line between the plates. Since the vertical displacement moved when the electrons reaches the end of the plates (=1.13 cm) is less than half of the width (=1.2 cm), it passes through the region between the plates. **Examiners' Comments:** This was well answered by most candidates. Candidates could either work out the deflection and compare it with 1.2 cm (half the distance between the plates) or work out the time and compare it with 1.79×10^{-9} s. The only mistake made was that some candidates compared their distance with 2.4 cm instead of 1.2 cm.
9	**d**	**i**	**Essential Question(s):** ▪ What do you know about the force acting on a body moving in a uniform circular motion? **Solution:** The **magnetic force <u>always</u> acts perpendicularly to the velocity of the particle <u>throughout its time in the field</u>**, hence it **does not change its speed but it changes its velocity direction continuously**. **Since the speed *v* is constant** (and the magnetic flux density B is uniform and charge of the particle *q* is also constant), the **<u>magnitude</u> of the <u>magnetic force</u> (*F = Bqv*) <u>remains constant</u>**.

			The magnetic force provides the net force on the particle. **A net force of <u>constant magnitude</u> acting perpendicularly to the velocity at every instant causes the particle to move in circular motion of a <u>fixed radius</u>**. **Examiners' Comments:** Lack of sufficient detail was evident. Almost all candidates realised that a force acts perpendicular to the velocity of the particle; few stated that this occurs throughout its time in the field. Others referred to 'the motion of the particle' rather than 'the direction of motion of the particle.' A minority of candidates stated that the speed and force would remain constant throughout.
9	d	ii	**Essential Question(s):** ▪ What is the force that provides the centripetal force on a body in uniform circular motion in a magnetic field? **Solution:** Magnetic force provides for the centripetal force. $Bqv = mv^2 / r$ *where B is the magnetic flux density* *q is the charge of the particle* *m is the mass of the particle* *v is the speed of the particle* *r is the radius of the circular motion.* $m = Bqr / v$ $= (0.090)(1.60 \times 10^{-19})(0.074) / (4.6 \times 10^4)$ r = 14.8 / 2 = 7.4 cm $= 2.317 \times 10^{-26}$ kg $= (2.317 \times 10^{-26}) / (1.66 \times 10^{-27})$ u $1 \text{ u} = 1.66 \times 10^{-27}$ kg = 13.95 u = 14 u **Examiners' Comments:** There were very few errors here. Some candidates did not convert their answer in kilograms to atomic mass units. A small number correctly stated that $m = B\,q\,r / v$ but in their substitution wrote u instead of q. Others began with the correct expression but substituted a value of 1 for charge rather than 1.60×10^{-19}.
9	e	i	**Essential Question(s):** ▪ How does the mass affect the radius of the uniform circular path of a charge in a magnetic field? **Solution:** Magnetic force = centripetal force $Bqv = mv^2 / r$ *making r the subject* $r = mv / Bq$ since B,q and v are constants r is proportional to m When mass m is smaller, the radius r will be smaller **Final answer:** Since the magnetic flux density, particle's charge and speed are all constants, the radius of the circular path is proportional to the particle's mass. Hence particles with smaller mass will travel along a circular path of smaller radius. **Examiners' Comments:** This was mostly correct.
9	e	ii	**Essential Question(s):**

			▪ How does the charge affect the radius of the uniform circular path of a charge in a magnetic field? **Solution:** Magnetic force = centripetal force $Bqv = mv^2 / r$ *making r the subject* $r = m\,v / Bq$ since B, m and v are constant r is inversely proportional to q When charge q is double, the radius r will be halved. Diameter = 2r When r is halved, diameter will also be halved. Diameter = 14.8 /2 = 7.4 cm **Final answer:** Since the magnetic flux density, particle's mass and speed are all constants, the radius of the circular path is inversely proportional to the particle's charge. Hence particles with double the charge will travel along a circular path of half the radius and therefore half the diameter. So the **diameter** would be 14.8 /2 = 7.4 cm. ***Be careful – question asked for the diameter NOT radius.*** **Examiners' Comments:** A small number of candidates did not give a quantitative value for the diameter.