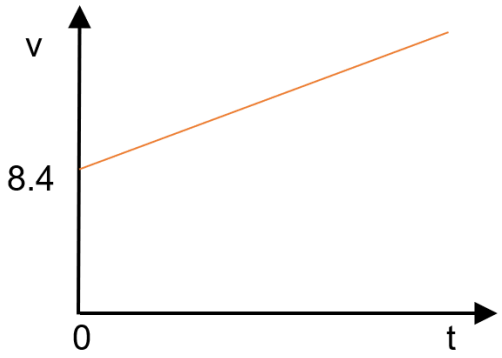
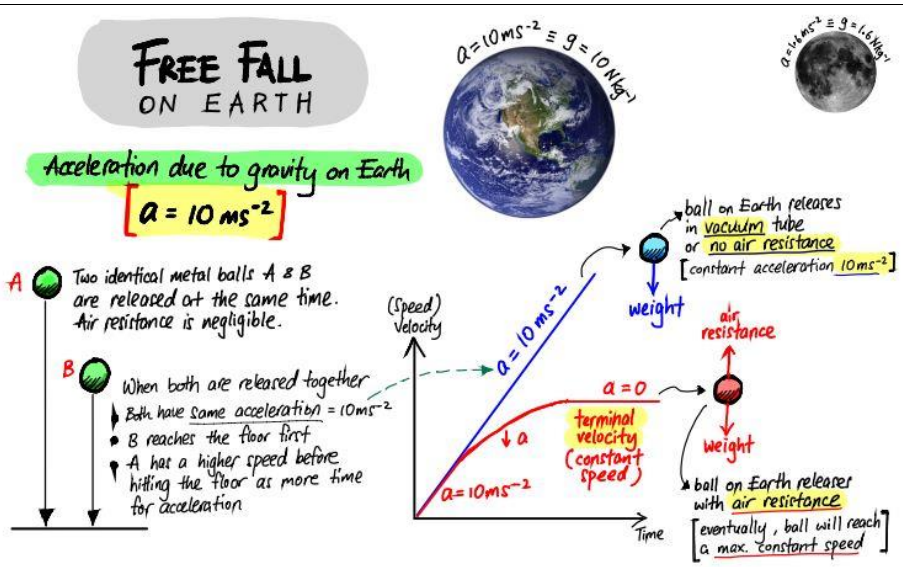
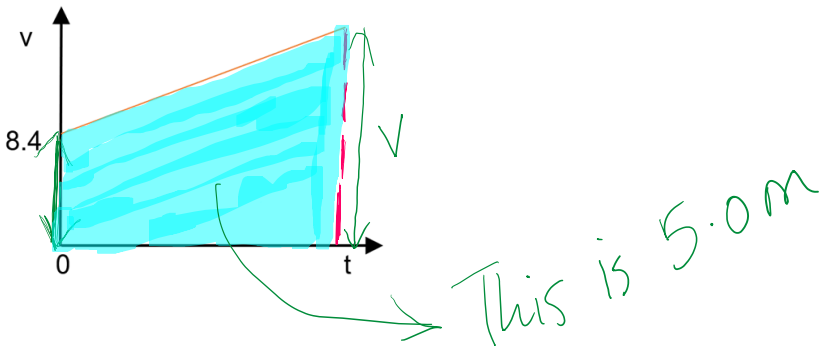
Solution to 2024 Sec 4 Physics Prelim Exam Paper 2

Qn	Solution
1(a)	 1m for labelling v, 8.4, t 1m for straight line **Marker's Comments** Students need to read the question carefully. A ball is **thrown vertically down at a speed of 8.4 m/s (initial velocity)** from point A which is 5.0 m above the ground. Assuming that **air resistance is negligible (object falls with acceleration due to gravity – constant acceleration)**, the ball hits the ground at a speed of *v* m/s **(final velocity)** after *t* seconds. Once you are clear of this: The concepts being tested on a v-t graph of: a = (v-u)/t Distance travelled = Area under the graph (this is a trapezium) If you have clarity of the concepts, attempting this question is straightforward.

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	 Many students drew the graph for terminal velocity which showed lack of understanding. The question already mentioned that air resistance is negligible.
1(b)(i)	a = (v-u)/t OR 10 = (v – 8.4)/t [1] t = (v – 8.4)/10 [1] **<u>Marker's Comments</u>** If the question has been comprehended correctly, The gradient of the graph will be the acceleration due to gravity.
(ii)	Distance travelled = area under the graph = Area of trapezium = ½ x (sum of parallel sides) x (height) ½(8.4 + v)t = 5 [1] ½(8.4 + v)(v-8.4)/10 = 5 v = 13.1 m/s [1] Allow ecf **<u>Marker's Comments</u>** If the question has been comprehended correctly, Area under the graph is the distance travelled which is from point A to the ground (5.0 m). Common mistake:

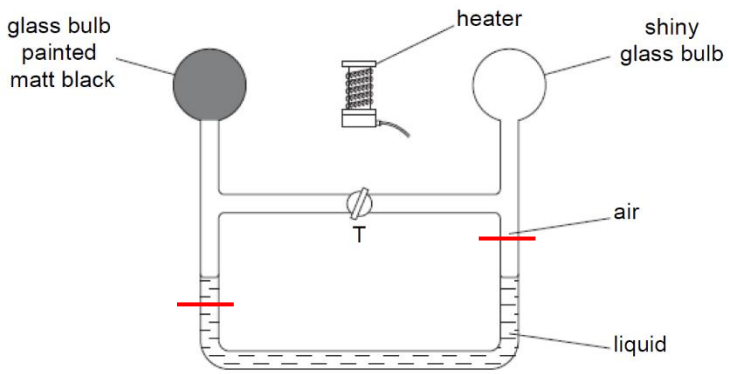
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	Many students used t = d/s to calculate the speed. This can only be done for objects/bodies moving at constant speed. This is the case where the velocity is increasing at a constant rate (constant acceleration). 
2(a)	Principle of moments states that when a body is in equilibrium, the sum of clockwise moments is equal to the sum of anticlockwise moments [1] about the same pivot [1]. **Marker's Comments** This is a recall question. However, many students could not get the full 2 marks. Physics Syllabus, 6091, y2024, Learning Outcome: 4(c) state the principle of moments for a body in equilibrium
(b)(i)	CW moments = ACW moments 700 x 1 + 500 x 3 = F_2 x 4 [1] F_2 = 550 N [1] **Marker's Comments** Physics Syllabus, 6091, y2024, Learning Outcome: 4(d) apply the principle of moments to new situations or to solve related problems Students who did not get this question right, must take note that perpendicular distance is from the pivot to the line of action of force.
(ii)	F_1 + F_2 = 700 +500 F_1 + 550 = 1200 [1] F_1 = 650 N [1] Allow ecf **Marker's Comments**

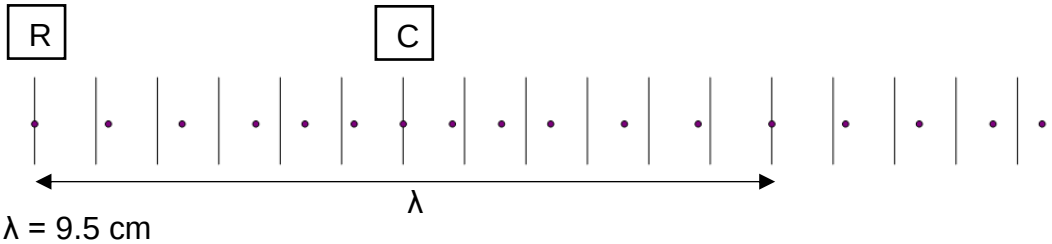
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	When a system is in equilibrium, you need to focus on 2 things: Equilibrium of moments (which was done in 2b(i)) And Equilibrium of forces (in this context, sum upward forces = sum downward forces)
(c)	Stand with feet apart OR stand with slightly bended knees [1] **Marker's Comments** Basic concept of stability. Increase base area and lower centre of gravity of the student.
3(a)	Principle of conservation of energy state that energy cannot be created of destroyed but transferred from one store to another OR converted from one form to another [1]. The total energy of an isolated system is constant. [1] Do not accept "transferred from one form to another" and "converted from one store to another". **Marker's Comments** Students can give either one of the 2 definitions given below. But, **the words in red cannot be mixed up between the definitions**. Definition 1: The principle of conservation of energy states that energy cannot be created nor destroyed, but it can be **converted from one form to another**. The total energy in an isolated system is constant. Definition 2: [Energy stores and Energy transfers] The principle of conservation of energy states that energy cannot be created nor destroyed. It can be **transferred from one energy store to another**. process. The total energy of an isolated system is constant.
(b)	Total energy = GPE + KE = 0.30 x 10 x 45 + ½ x 0.30 x 8^2 [1] = 144.6 ~145 J [1] **Marker's Comments** Students need to read the question carefully.

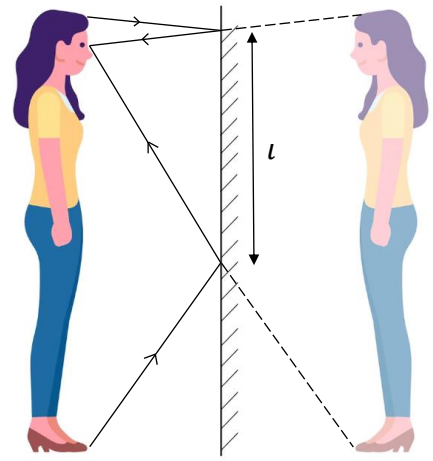
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	A ball of mass 0.30 kg is **projected horizontally with a speed of 8.0 m/s** from the top of a building AD which is **45 m above the level ground** DC. The ball has an initial speed and height. So, it has BOTH gravitational potential store and kinetic store. Many students only focused on one type of store.
(c)	Energy is transferred through work done by gravity [1] from the gravitational potential store of the ball to the kinetic store of the ball [1]. **Marker's Comments** There are 2 versions to the answer. Stick to one version of answering. Do not mix up the terminologies. **1)** The ball has energy in both gravitational potential store and kinetic store at A. Energy is transferred through workdone by gravity from the gravitational potential store of the ball to the kinetic store of the ball. Work is also done against air resistance and the energy is transferred to the internal store of the surroundings. **2)** The ball has both gravitational potential energy and kinetic energy at A. As it follows the parabolic path, gravitational potential energy is converted to kinetic energy. Work is also done to overcome air resistance.
4	 **Marker's Comments** There are 2 concepts being tested here. Thermal processes and Kinetic Model. The mention of colour must indicate that there is heat being ABSORBED by the matt black glass bulb. Since there is no contact, students should not mention 'conduction'.

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	Once the tap is closed, we are also looking at the effect of temperature on a fixed mass of gas. (pg 143 and 144 of TB)
(b)	Matte black surface is better absorber of heat than a shiny one, thus heat is absorbed faster through radiation [1]. This causes the air on the left side to have more frequent collisions with greater force due to higher kinetic energy (more energy in the kinetic store) [1]. The larger air pressure on the left forces the liquid level lower [1]. **Marker's Comments** A simple way to remember this: For a fixed mass of gas (enclosed container), Temperature increases → average kinetic energy of the particles increases → frequency of collisions with the inner walls and the liquid increases, hence increasing the average force exerted by the particles per unit area → Pressure increases.
5(a)	 λ = 9.5 cm Accept 9.6 cm **Marker's Comments** Well attempted in general. The compression is a region where particles are close together while rarefaction is a region where particles are spread apart. A wavelength is from one compression to the next compression or one rarefaction to the next rarefaction. Some students did not know that the diagram was drawn to scale and so were not able to obtain the magnitude of the wavelength. A ruler should be used to measure the wavelength marked on the diagram.
(b)	v = fλ = 200 x 9.5 cm [1] = 1900 cm/s or 19 m/s [1] Accept 19.2 m/s for λ = 9.6 cm Allow ecf

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	Marker's Comments A common mistake was to express the final answer with the wrong unit (m/s instead of cm/s, or vice versa). Some students incorrectly interpreted "oscillates 200 times per second" to mean that the period was 200 s. The correct interpretation is that the frequency of the oscillation is 200 Hz.
6(a)	It should be increasing frequency OR decreasing wavelength Infra-red and microwaves are in the wrong order Visible light is missing from the spectrum Choose any two **Marker's Comments** Very well attempted.
(b)	It causes the human cell to ionise resulting in cell damage/mutation [1]. **Marker's Comments** Students who did not obtain full credit lacked the description on the ionising effect of gamma rays.
(c)	Speed decreases [1] while frequency remains unchanged [1] **Marker's Comments** Frequency of a wave does not change unless the source of the wave changes. The speed decreases as the it transfers it energy to the surrounding cells as it passes through the body.
7(a) **(b)**	 (a)(i) 1m for correct lines drawn (a)(ii) 1m for correct lines drawn (a)(i)(ii) 1m for correct direction of arrows for both lines

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	(b) Length is correctly indicated at the mirror **Marker's Comments** Many students could not recall how to draw ray diagrams for reflection. Common mistakes included – wrong direction of arrows (from eye to head/feet instead of the other way), missing incident rays, and not knowing when to draw with dotted (virtual) or solid (real) lines. The minimum length of the mirror needed to see the full body corresponds to the section where the light rays intersect the mirror. That is to say, if the other parts of the mirror outside of this section were to be removed, the lady would still be able to see herself fully in the mirror.
(c)	Upright, virtual, laterally inverted, equal in size to the lady, equal distance from the mirror as the lady Choose any two **Marker's Comments** Well attempted. Some students wrote inverted instead of laterally inverted. These two characteristics are different. The former is the opposite of upright while the latter implies the apparent reversal of the image's left and right.
8(a)(i)	Total resistance = $(1/6 + 1/3)^{-1}$ = 2.0 Ω [1] emf = IR = 3 x 2 = 6.0 V [1] **Marker's Comments** Many students could not obtain the correct value for resistance as they were not able to see that the resistors in PQR was in parallel with the resistors in PSR. Some students forgot the formula for calculating resistors in parallel.
(ii)	V = IR 6 = I x 6 I = 1.0 A [1] Or using the ratio method, 3.0 A x 1/3 = 1.0 A **Marker's Comments** Well attempted. Some students who used the ratio method multiplied with 6.0 V instead of 3.0 A. While the ratio method works, students are advised to use V = IR to avoid confusion.
(b)	No current will flow [1]. The potential difference across QS is 0 V [1].

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	Marker's Comments Very poorly attempted. Students who claimed that current would flow in QS explained that current flowed in the path of least resistance because • QS has no resistance OR • SR has lower resistance than QR. Both explanations are incorrect. For the first one, while there are no resistors along QS, it is in series with SR which has a 2.0 Ω resistor. The second one is true if there is a potential difference. Potential difference is the work done to drive a unit charge across a component. Without the p.d., the charge is unable to be moved across the component and thus no current can flow.
9(a)	The readings in the newton metres increase. [1] Using Fleming's left hand rule, when the current flows from P to Q and magnetic field points from left to right, a downward force is produced [1]. OR The magnetic field is stronger above PQ than below it, producing a downward force. [1] The resultant force is larger than the weight of PQ. [1] **Marker's Comment:** First, students need to understand that it is the interaction of magnetic fields leading to a magnetic force acting downwards on the rod. Do not mix up with EMI, which is an induced emf due to the changing magnetic flux.
(b)	Place a variable resistor in the circuit [1]. This will allow the current to be controlled and thus control the force produced [1].
(c)	The rod will oscillate up and down [1] once every two seconds. [1] **Marker's Comment:** The key to the answer is to vary the current. To do this, it is important to realise that the most straightforward method is to add a variable resistor / rheostat in series with the existing circuit. Note that potentiometer has a different meaning and usage (it is for finding the unknown emf using the voltage divider rule). Students likely wanted to say potential divider rule.
10(a)	Vol of rod = 5 x π $(2.66/2)^2$ = 27.78 / 27.8 cm^3 [1] Mass = 27.78 x 2.7 = 75 g [1]
(b)	Q = mcΔθ = (75/1000) x 880 x 650 [1] = 42900 J [1] Allow ecf based on (a)

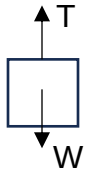
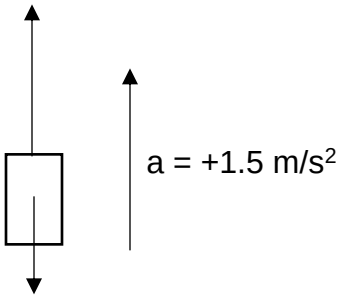
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(c)	The internal potential energy increases as molecules are further apart [1]. Vibration of the aluminium particles do not affect the amount of energy in the kinetic store as the temperature is constant [1]. **Marker's Comment:** It is important that students memorised the definition of internal energy which is the sum of kinetic energy due to the random motion of the particles and potential energy associated with the relative positions of the particles. If the definition is well understood, students would know that energy in kinetic store is unchanged (temp constant) and energy in potential store will increase / decrease during a change in state.
(d)	$Q = ml_f$ $71.5 \times 400 = (75/1000)l_f$ [1] $l_f = 381$ kJ/kg (3sf) [1] Allow ecf based on (a) **Marker's Comment:** Some students included the change in temperature which shows that they did not understand the meaning of latent heat.
(e)	$(mc\Delta\theta)_{Al} = (mc\Delta\theta)_{water}$ $(75/1000) \times 880 \times (70-30) = (350/1000) \times 4200 \times (30-\theta)$ [1] $2640 = 1470 \times (30-\theta)$ $\theta = 28.2$ °C [1] Allow ecf based on (a) **Marker's Comment:** It is important to note that θ, which is the initial temperature is smaller than 30 °C. Based on COE, when one gains energy, the other loses energy.
11(a)(i)	It means that carbon-14 has the **same number of protons** but **different number of neutrons** as other carbon isotopes. [1] **Marker's Comment:** Well attempted
(ii)	It takes **5730 years** for **half** the number of nuclei to decay. [1] **Alternate answer:** It takes 5730 years for the radioactive activity of the nuclei to reduce by half. **Marker's Comment:** Well attempted
(b)	N: 14, 7 [1] e^-: 0, -1 [1]

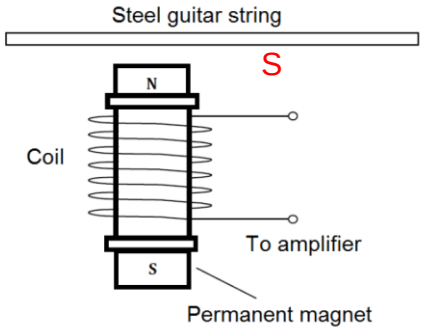
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	Marker's Comment: Well attempted.
(c)(i)	Constant exposure to beta radiation can cause **cell damage** which leads to **mutation or cell death** due to the **ionising nature** of beta radiation. [1] Accepted answer should include the mention of ionisation effect on cells, however, this has been tested at Q6b. Thus, students were not penalised for this question, if it was not mentioned. **Marker's Comment:** Well attempted. A large handful of students are extremely vague. Just mentioning that there is cell damage but fail to mention how the ionising property of the radiation resulted in this damage to occur.
(ii)	Work behind a lead shield / wear thick(er) clothing / wear a film badge / avoid direct contact with the radioactive samples by using tongs/ wearing protective gear/ reduce duration of exposure/ proper storage of material [1] Other accepted answer: Wearing thick clothing (answer will not be accepted if it is gamma radiation) **Marker's Comment:** Well attempted.
(d)	Evidence/working showing 80 units to 5 units of carbon-14 is 4 half-lives [1] **1st half live: 80 → 40** **2nd half live: 40 →20** **3rd half live: 20→ 10** **4th half live: 10 → 5** Age = number of half-lives x half-live = 4 x 5730 = 22920 years [1] Other accepted answers: 22900 years, 23000 years Side note: As the question ask for age, students are not penalised if they do not round off their answers. **Marker's Comment:** Fairly attempted. Most students who are not able to answer the following questions were not able to correctly calculate the correct number of half-lives that has occurred. A simple method to do so correctly is by using the above bolded method.

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(e)(i)	I disagree as nuclear decay is **spontaneous** [1] and is **not affected by external factors** such as pressure [1]. Reject answers relating to randomness. **Marker's Comment:** Fairly attempted. Radiactive decay is a random and spontaneous process. **- Random:** Occurs randomly and it is impossible to predict which nuclei and when it will decay. **- Spontaneous:** Process is not affected by an external factors like temperature, pressure etc.
12(a)(i)	 **Marker's Comment:** Well attempted. A small handful of students indicated the direction of the Tension downwards instead of up and a few others included normal contact force in the free body diagram. Note: Normal contact force is only present when the surface of the object is in contact with another surface, which in the above case, it doesn't.
(ii)	(750/ 1000) kg x 10 N/kg = 7.5 N **Marker's Comment:** Well attempted. A good portion of students who were not able to answer this question correctly, did not convert the mass of 750 g to kilograms, before finding the weight in newton.
(iii)	By N(II) Laws: **1. F_{net} = m x a** Vector addition/ subtraction: **2. F_{net} = T – W** Hence, F_{net} = m x a = T - W T – W = ma T – 7.5 = 0.75 x 1.5 [1] T = 8.63 N  **Marker's Comment:** Fairly attempted. A good portion of the cohort did not manage to use Newton's 2nd law, coupled with simple vector addition correctly to find the net force.

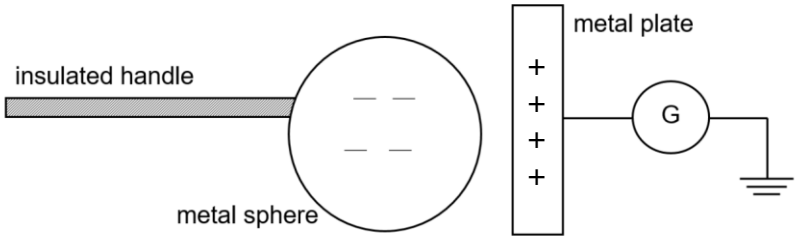
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	Another common mistake noted, include the use of W – T, instead of T- W. T-W should be used in this case, as the object is moving upwards and acceleration is taken to be positive in the upward direction. Thus, T will be positive and W will be negative, giving rise to T-W.
(b)(i)	 **Marker's Comment:** Fairly attempted. Most students who did not answer the following question correctly has forgotten about the concept on magnetic induction, resulting in the side of the string closest to the coil to be in opposite poles.
(ii)	The permanent magnet **induces a polarity** in the steel guitar string [1]. As the string vibrates, the **magnetic field of the steel guitar string** creates a **changing magnetic flux** that cuts the coil [1] By Faraday's law, this **induces an electromotive force** in the coil [1] Since the coil is connected to the amplifier, an **induced current will flow** to the amplifier [1]. **Marker's Comment:** Poorly attempted. Most students who did not understood the context of the question and applied the wrong concept to answer the question. Common mistakes - Assumption that the induced current flow is a result of the interaction between the magnetic field of the steel string and the permanent magnet. **Correction: The magnetic flux cutting the coil is due to the magnetic field from the steel string. The magnetic field is changing because the string is vibrating.** - Wrong use of the Lenz law to explain the concept. Since, there is no need to mention about the direction of induced current. **Correction: Only Faraday's law should be mentioned in this case, to explain how a current is induced resulted, which causes an induced current to flow to the amplifier.**
(iii)	Increase the number of turns in the coil [1] OR Place the string closer to the coil OR Pluck the string with a greater force.

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	Marker's Comment: Well attempted.
13(a)(i)	Pressure at A = Pressure at B $P_{atm} + (h\rho g)_{oil} = (h\rho g)_{water} + P_{atm}$ 0.272 x ρ x 10 = 0.245 x 1000 x 10 [1] ρ = 901 kg/m^3 [1] **Marker's Comment:** Fairly attempted. Students who are not able to answer the following question are still not able to understand the concept of a manometer and how pressure across a manometer varies and can be used to calculate for the unknown. General guide on solving questions pertaining to a barometer/ manometer 1. Draw a horizontal line across the lowest meniscus across barometer/ manometer. Pressure of points along this line will be all be equal. 2. For each point along this horizontal line, identify ALL the pressure acting at them. a. Pressure due to liquid above the point can be calculated using hρg. b. Open surfaces will always have P_{atm} acting on them. 3. Formulate the equation to solve for unknown by equating the pressure along the horizontal line drawn in point 1.
(ii)	Pressure at B = $(h\rho g)_{oil} + P_{atm}$ or $(h\rho g)_{water} + P_{atm}$ 0.272 x 900.7 x 10 + 101000 OR 0.245 x 1000 x 10 +101000 = 103450 ≈ 103000 Pa (3sf) [1] **Marker's Comment:** Fairly attempted. Most students who are wrong were still able to apply P = hρg to calculate for the pressure. However, they have issues calculating for the correct answer due to the mistakes below. Common mistakes - Not converting the height of the liquid column from cm to m. height in m is required since, pressure calculated is express in Pa. - Not including the pressure due to the atmosphere
(iii)	Height should be equal/ the same [1] Pressure is independent of volume/cross sectional area [1] Alternative: Since P = hρg and density + gravitational field strength are constant, Pressure will be dependent on the height of the liquid column.

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	Marker's Comment: Poorly attempted. Most of the students are not certain of the context provided. Thus, were not able to solve the question. Common mistakes - Assumed that the cross-sectional area of the funnel will affect the pressure due to the P = F/A, since A increases, P will decrease. **Correction: Since P is due to the liquid column, P = hρg, which is affect by the height, density and gravitational field strength.**
(b)(i)	The negative charges were repelled to the right and into the ground [1] as like charges repel [1]. **Marker's Comment:** Fairly attempted. Most of the students are not certain of the context provided and confused about the purpose of a galvanometer as use of the galvanometer is mainly only mentioned in Electromagnetic induction (EMI), students assumed that there will be EMI occurring. Thus, a good handful of students explained using magnetic flux cutting the plate, resulting in induced emf.
(ii)	 There should be four positive charges on the left side of the plate. **Marker's Comment:** Poorly attempted. Number of positive charges on plate should be the same as the number of negative charges on sphere. There should not be any negative charges on the metal plate, as all of them would have been grounded due to the earth wire.
(iii)	The excess negative charges in the sphere will flow through the hand and into the ground. [1] The metal sphere becomes neutral, and the galvanometer does not deflect. [1] **Marker's Comment:** Well attempted.

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