# VCE Physics 2024

# Units 3 & 4 Trial Examination

# Assessment Guide & Suggested Solutions

## Multiple Choice Answer Sheet

These solutions are provided as a guide only. Some questions may have alternative solution pathways which are also valid but are not shown.

**SECTION A: Multiple Choice Answers**

| Q | Answer | Explanation |
|---|---|---|
| 1 | **B** | Only **b)** involves point charges. **c)** & **d)** show magnetic fields, **a)** is in a uniform electric field. |
| 2 | **D** | For constant speed $F_{net} = 0$ so $\Sigma F_{right} = 500 = \Sigma F_{left} = 400 + F_{farmer} = 500$ <br> $\Rightarrow F_{farmer} = 100$ N to the left |
| 3 | **C** | $(Orbital\ radius)\ r = altitude + Earth\ radius = 3630 + 6370 = 10{,}000\ km = 10^7\ m$ <br> $F = \frac{GMm}{r^2} = \frac{4\pi^2 rm}{T^2} \Rightarrow T^2 = \frac{4\pi^2 r^3}{GM}$ <br> $\Rightarrow T^2 = \frac{4\pi^2(10^7)^3}{6.67 \times 10^{-11} \times 5.97 \times 10^{24}} = \frac{3.95 \times 10^{22}}{3.98 \times 10^{14}} = 9.92 \times 10^7$ <br> $\Rightarrow T = \sqrt{9.90 \times 10^7} = 9962\ s = 2.77\ hours$ |
| 4 | **D** | $F_c = \frac{mv^2}{r} \Rightarrow v = \sqrt{\frac{F_c r}{m}} =$ <br> $\sqrt{\frac{260 \times 25}{65}} = \sqrt{100} = 10\ m\ s^{-1} = 36\ km\ h^{-1}$ |
| 5 | **A** | $m_1u_1 + m_2u_2 = m_1v_2 + m_2v_2$ <br> $\Rightarrow 250 \times 4 + 200 \times 0 = 1000 = 250 \times 1 + 200v$ <br> $\Rightarrow v = (1000 - 250) \div 200 = 3.75$ m s$^{-1}$ |
| 6 | **B** | To be elastic $E_{K(initial)} = E_{k(final)}$ <br> $E_{K(initial)} = ½ \times 250 \times 4^2 = 2000$ J <br> $E_{K(final)} = ½ \times 250 \times 1^2 + ½ \times 200 \times 3.75^2 = 125 + 1406.25 = 1531.25$ J <br> Collision is inelastic since $E_{K(initial)} > E_{k(final)}$ |
| 7 | **D** | Air resistance opposes the motion at all points in the flight. So less height, less horizontal range occur compared to the theoretical. |

| | | |
|---|---|---|
| 8 | **D** | Gravitational fields are always attractive to monopole<br>Magnetic fields only exist between North and South Poles (dipole)<br>Electric fields can be around a single charge (monopole) or between charged particles (dipole) |
| 9 | **A** | $g = \frac{GM}{r^2} \Rightarrow g_1 = \frac{GM}{(2r)^2} = \frac{GM}{4r^2}$ and $g_3 = \frac{GM}{(4r)^2} = \frac{GM}{16r^2}$<br>so $\frac{g_1}{g_3} = \frac{\frac{GM}{4r^2}}{\frac{GM}{16r^2}} = \frac{16}{4} = 4$ |
| 10 | **D** | No motion as current will be parallel to magnetic field. |
| 11 | **B** | $v^2 = u^2 + 2as \Rightarrow v = \sqrt{19.6s}$ at 6m $v = 10.84$ m/s at 12 m $v = 15.34$ m/s<br>$\frac{10.84}{15.34} = 0.71 = 71\%$ |
| 12 | **D** | $I_{primary} = \frac{P}{V} = \frac{60}{240} = 0.25\ A_{RMS} \Rightarrow I_{secondary} = \frac{N_1}{N_2} I_{primary}$<br>$\Rightarrow I_{secondary} = \frac{30}{120} \times 0.25 = 0.0625\ A_{RMS}$<br>$= 0.0625 \times \sqrt{2} = 0.0884\ A_{peak} = 88.4\ A_{peak}$ |
| 13 | **C** | Inverters convert the DC current supplied from the photovoltaic cells in to AC so it is compatible with household circuitry |
| 14 | **B** | Nodes are ½ $\lambda$ apart on a standing wave so distance from end point to 2nd node = $\lambda$ = ½ × 3.6 = 1.8 m |
| 15 | **C** | Red light has a longer wavelength than green. Since $\Delta x = \frac{\lambda L}{d}$ increasing $\lambda$ increases spacing $\Delta x$. |
| 16 | **D** | Cannot see diffraction with this experiment only interference effects. Diffraction was occurring but could not be seen. |
| 17 | **A** | $-5.6 - -10.4 = 4.8 = \frac{hc}{\lambda} \Rightarrow \lambda = \frac{hc}{4.8} = \frac{4.14\times10^{-15} \times 3\times10^{8}}{4.8}$<br>$= 2.5875 \times 10^{-7} = 259\ nm$ |
| 18 | **A** | $E_{k(max)} = hf - \phi \Rightarrow \phi = hf - E_{k(max)} = 6.63\times10^{-34} \times 9.66\times10^{14} - 4.0\times10^{-19}$<br>$\Rightarrow \phi = 6.4\times10^{-19} - 4.0\times10^{-19} = 2.4\times10^{-19}$ J<br>$\Rightarrow \phi = (2.4\times10^{-19}) \div (1.6\times10^{-19}) = 1.5$ eV |
| 19 | **C** | The null result of M-M experiment failed to provide evidence to support the existence of an aether through which everything travelled. Instead it showed the speed of light was the same no matter where you measured it from, or your velocity. Thus supporting Einstein's 2nd postulate of special relativity. |
| 20 | **B** | $E_k = (\gamma - 1)mc^2 \Rightarrow 1.065\times10^{-13} = (\gamma - 1) \times 9.11\times10^{-31} \times (3.00\times10^{8})^2$<br>$\Rightarrow (\gamma - 1) = \frac{1.065\times10^{-13}}{9.11\times10^{-31} \times 9.00\times10^{16}} = 1.3 \Rightarrow \gamma = 2.3$ |

**END OF SECTION A**

## SECTION B: Short Answer Questions

### Question 1 (7 marks)

**a)** Since car is travelling at constant speed a = 0 ⇒ $F_{net} = 0$

⇒ $F_{net} = 0 = \text{Thrust} - 200 - 300$. ①

⇒ Thrust = 500 N. ①

**b)** Consider boat

$F_{net} = 0 = T - 300$ ①

⇒ T = 300 N ①

**OR** Consider car

$F_{net} = 0 = \text{Thrust} - T - 200$ ①

⇒ T = 500 – 200 = 300 N ①

**c)** Speed is still constant so a = 0

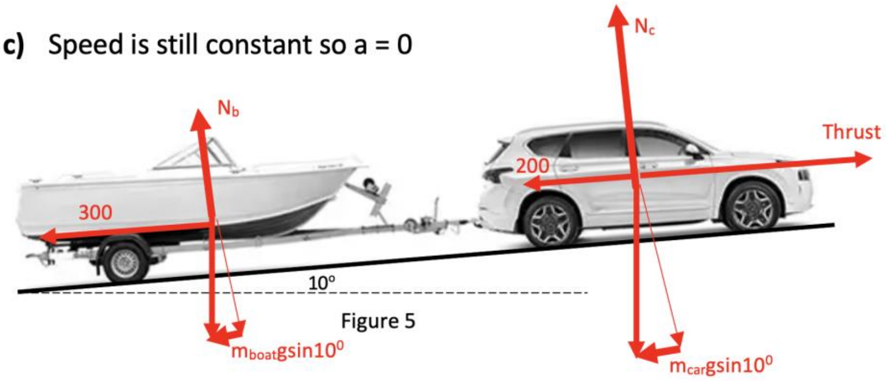


Figure 5

$F_{net} = 0 = \text{Thrust} - 200 - m_{car}\,g\sin10^o - 300 - m_{boat}\,g\sin10^o$ ①

⇒ $\text{Thrust} = 200 + m_{car}\,g\sin10^o + \mathbf{300} + m_{boat}\,g\sin10^o$ ① **Consequential on (b)**

⇒ Thrust = 500 + (2000 + 1200)×9.81×sin10.0° = 500 + 5451.2 = 5951.2 = $5.95 \times 10^3$ N ①

### Question 2 (10 marks)

**a)** $F = \frac{mv^2}{r} \Rightarrow r = \frac{mv^2}{F} = \frac{2 \times 30^2}{1500}$ ①

$\Rightarrow r = 1.2\ m$ ①

**b)** Net force = mg = 2.0 × 9.8 = 19.6 = 20 N ①

vertically down ①

**c)** Horizontal velocity $v_H$ is constant at 30.0 cos62° = 14.08 m s$^{-1}$. ①

Range = $v_H\,t$ = 30.0 cos62° × 5.50 = 77.46 = 77.5 = 76 m. ①

**d)** $At\ point\ of\ release\ Total\ energy = mgh + \frac{1}{2}mv^2$

$\Rightarrow\ E_{Total} = 2.0 \times 9.81 \times 2.25 + \frac{1}{2} \times 2.0 \times 30.0^2$ ①

$= 944.1\ J$ ①

$No\ energy\ losses$ $\Rightarrow 944.1$ = Total energy when discus strikes ground

$\Rightarrow \frac{1}{2} \times 2.0 \times v^2 = 944.1$ ①

$\Rightarrow v = \sqrt{\frac{2\times944.1}{2}} = 30.73 = 31\ m\ s^{-1}$ ①

**Question 3 (5 marks)**

**a)** $\Sigma p_{before} = \Sigma p_{after} \Rightarrow 2 \times 3 + 3 \times (-2) = 2v + 3(0)$ ①

$\Rightarrow 6 - 6 = 0 = 2v$

$\Rightarrow v = 0\ m\ s^{-1}$ ①

**b)** $\Sigma p_{before} = \Sigma p_{after}$

- The masses sticking together after the collision does not change the initial conditions. $\Rightarrow 2 \times 3 + 3 \times (-2) = 6 - 6 = 0$ ①
- Since the total momentum before the collision is still zero the total momentum after the collision must remain at zero. $\Rightarrow 0 = (2 + 3)v$ ①
- Hence the blocks will be stationary after the collision. $\Rightarrow v = 0$ ①

**Question 4**

**a)** At top $F_{Net} = F_c = \frac{mv^2}{r} = mg + T$ at minimum speed $T$ = 0

$\Rightarrow v = \sqrt{rg} = \sqrt{0.20 \times 9.81}$ ①

$\Rightarrow v = 1.4\ m\ s^{-1}$ ①

**b)** **(i)** At top $E_{total} = KE + GPE = ½mv^2 + mg\Delta h$

$\Rightarrow E_{total} = ½ \times 0.050 \times 2.5^2 + 0.050 \times 9.81 \times 0.40$ ①

$= 0.15625 + 0.1962 = 0.352$ J ①

At bottom $E_{total} = ½mv^2 = 0.352$

$\Rightarrow v = \sqrt{\frac{2\times0.35225}{0.050}} = \sqrt{14.09}$ ① $= 3.75\ m\ s^{-1}$

**(ii)** At bottom $F_{Net} = F_c = \frac{mv^2}{r} = T - mg$ ①

$\Rightarrow T = \frac{mv^2}{r} + mg = \frac{0.050\times3.75^2}{0.20} + 0.050 \times 9.81$

$\Rightarrow T = 4.0\ N$ ①

**Question 5**

**a)** $F = \frac{GMm}{r^2} = \frac{4\pi^2 rm}{T^2} \Rightarrow R^3 = \frac{GMT^2}{4\pi^2}$ where $T$ = 120 × 24 × 3600 = 10368000 s. ①

$\Rightarrow R^3 = \frac{GMT^2}{4\pi^2} = \frac{6.67\times10^{-11} \times 95\times5.97\times10^{24} \times(10368000)^2}{4\pi^2}$ ①

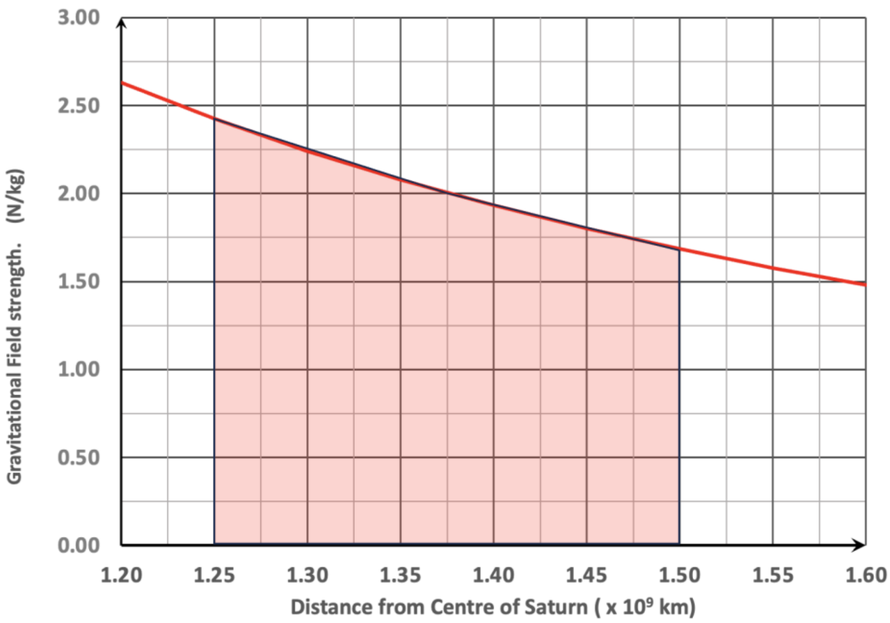
$\Rightarrow R^3 = \frac{4.066\times10^{30}}{4\pi^2} = 1.030 \times 10^{29}$ ①

$\Rightarrow R = \sqrt[3]{1.030 \times 10^{29}}$

$\Rightarrow R = 4.69 \times 10^9$ m. ①

$\Rightarrow R = 4.7 \times 10^6$ km = 4.7 million km

**b)** Number of squares under the graph from 1.25 to 1.50 (×$10^9$ km) = 81 approx. ①
Accept 80 to 81 small squares or about 20 large squares.




Each small square
= 0.25 ×0.025 ×$10^{12}$ = 6.25×$10^9$ J $kg^{-1}$ ①

OR

Each large square
= 0.5 ×0.05 ×$10^{12}$ = 2.5×$10^{10}$ J $kg^{-1}$ ①

Gain in KE = loss in GPE = area x mass of Cassini ①
= 80 ×6.25×$10^9$ × 2125
= 1.0625 ×$10^{15}$ J ①
Use 81 answer = 1.076×$10^{15}$ J

OR

= 20 ×2.5×$10^{10}$ × 2125
= 1.0625 ×$10^{15}$ J ①

Accept values between 1.06 and 1.08 ×$10^{15}$ J

**Question 6**

**a)** $\Delta KE = \Delta SPE$

$\Rightarrow \frac{1}{2}mv^2 = \frac{1}{2}kx^2$ ①

$\Rightarrow \frac{1}{2}0.250v^2 = \frac{1}{2}100 \times 0.20^2$ ①

$\Rightarrow v^2 = 16$ ①

$\Rightarrow v = 4.0$ m $s^{-1}$

**b)** Ideal conditions assume all spring potential energy is transferred to the cart in the form of kinetic energy.

In the real world some of the Spring potential energy is converted into other forms such as sound and heat. ①

As the cart travels from the spring to the rough surface a small amount of work is done against air resistance. ①

**c)** Workdone = ΔKE $\Rightarrow Fx = \frac{1}{2}mv^2$

Average velocity $v = \frac{3.94+3.95+3.97}{3} = 3.953\ m\,s^{-1}$ ①

Average stopping distance $x = \frac{2.03+2.10+2.02}{3} = 2.05\ m$ ①

$\Rightarrow Fx = \frac{1}{2}mv^2$

$\Rightarrow 2.05F = \frac{1}{2}0.250 \times 3.953^2$ ①

$\Rightarrow F = \frac{1.9533}{2.05} = 0.953 = 0.95\ N$ ①

**d)**

| | | |
|---|---|---|
| Independent | Velocity at **C** / rough surface | ① |
| Dependent | Distance travelled | ① |
| Controlled | Spring constant/compression | ① |

**e)** Ari's and Ciri's statements are true ①

(Billi's statement is false)

A of the velocities are close together (precise) and also close to the expected value of 4.0 m $s^{-1}$ (accurate). ①

The distance travelled on the rough surface is also precise as the values are close to each other but they cannot be accurate as the frictional force of the surfaces is not known so there is no expected value to which they can be compared. ①

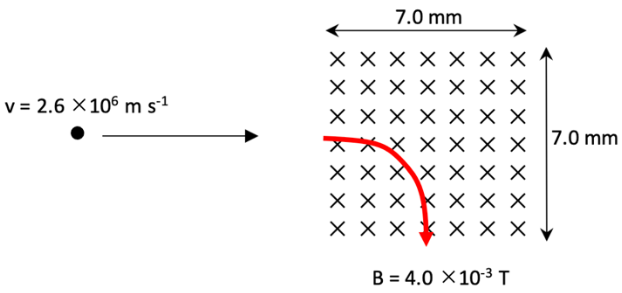
## Question 7

**a)** $r = \frac{mv}{qB} = \frac{9.11\times10^{-31} \times 2.6\times10^{6}}{1.60\times10^{-19} \times 4.0\times10^{-3}}$ ①

$\Rightarrow r = 0.0037\ m = 3.7\ mm$ ①

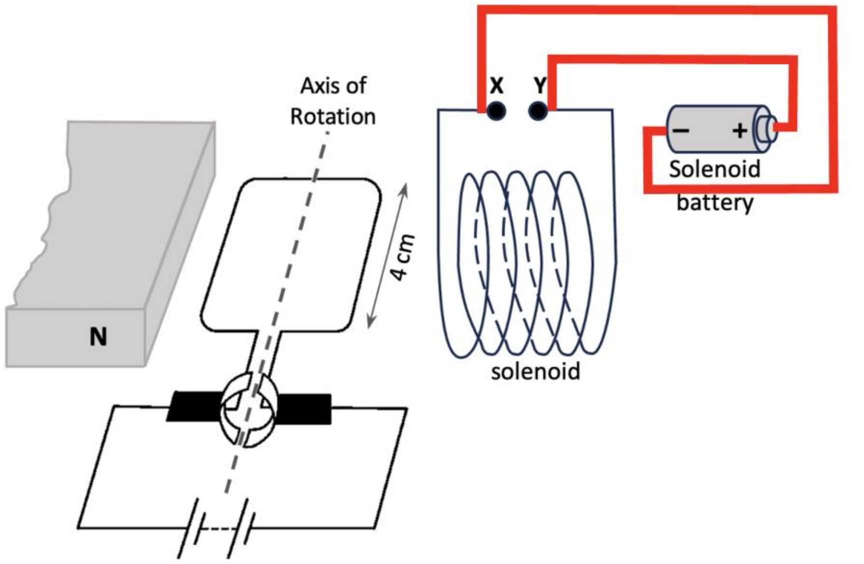
**b)** ① For downward curve

① for exiting near midpoint of field




## Question 8

**a)** South pole of solenoid is on left so current must flow from **Y** to **X** through solenoid so terminal **Y** will be attached to the positive and **X** to the negative of the battery. ①




**b)** Anticlockwise ①

By the righthand slap rule ①

Since magnetic field is to the right and the current flows into the page on lefthand side of coil force must be downwards on this side ①

**c)** $F = nBIL \Rightarrow I = \frac{F}{nBL} = \frac{3.0\times10^{-6}}{50 \times 6\times10^{-4} \times 0.040}$ ①

$\Rightarrow I = 0.0025 = 2.5 \times 10^{-3}\ A$ ①

**d)** $\tau = r_{\perp}F$

After rotating 90° the commutator will disengage the current so $F$ = 0

$\Rightarrow \tau = 0.015 \times 0$ ① **Note:** Can consider r = 0 as no force is acting

$\Rightarrow \tau = 0\ N\ m$ ①

**Question 9**

**a)** Component X is set of Slip rings ①

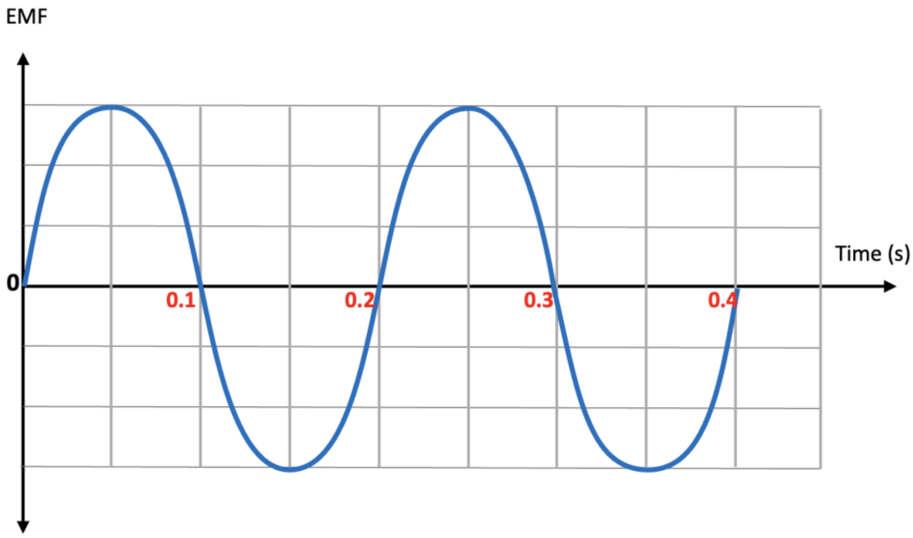
- Keep the same side of the loop connected to the same side of the external circuit ①
- Transfer the current induced in the loop to the external circuit ①
- Ensure the load resistor (external circuit) experiences an alternating current ①

**b)** $\Delta t = \frac{1}{4} \times \frac{1}{5} = 0.05\ s$ ①

$\Delta \emptyset_B = BA = 4.0 \times 10^{-6} \times 0.04 \times 0.04 = 6.4 \times 10^{-9}\ Wb$ ①

$EMF = -N\frac{\Delta \emptyset_B}{\Delta t} = -20 \times \frac{6.4\times10^{-9}}{0.05} = 2.56 \times 10^{-6}\ V = 2.6 \times 10^{-6} V$ ①

**c)**




① for correct period

① for sinusoidal waveform (can be inverted)

① for zero EMF at t = 0

**Question 10**

**a)** In order to get an interference pattern (see fringes) diffraction must occur as light exits the pinholes. ①

The pinholes are too large compared to the wavelength of light used ie $\frac{\lambda}{w} << 1$.①

The slits are small enough so that $\frac{\lambda}{w} = \frac{540\times10^{-9}}{1.75\times10^{-7}} = 3.09$ ie $\lambda > 1$ so significant diffraction occurs. ①

**b)** $\Delta x = \frac{\lambda L}{d} = \frac{540\times10^{-9}\times1.5}{15.0\times10^{-6}}$ ①

$\Rightarrow \Delta x = 54 \times 10^{-3}\, m = 54\, mm$ ①

3rd dark band = 2.5Δx

Distance from central maxima = 2.5 ×54 = 135 mm ①

**Question 11**

Any **two** of:

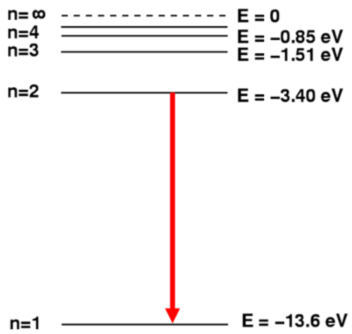
1. ***Observation***: No time delay when effect occurs. ①
   ***Contradiction***: Wave model predicts at low intensity it will take time for enough energy to accumulate in electrons before they escape the metal. ①

2. ***Observation***: Increasing light intensity increases number of photoelectrons released of the same energy. ①
   ***Contradiction***: Wave model predicts higher intensity delivers more energy so photoelectrons should be more energetic. ①

3. ***Observation***: There is a minimum frequency for the effect to occur. ①
   ***Contradiction***: Wave model predicts any frequency of light will eventually provide enough energy to release an electron from the metal. ①

**Question 12**

$$E = \frac{hc}{\lambda} = \frac{4.14\times10^{-15}\times3.00\times10^{8}}{122\times10^{-9}} = 10.18 = 10.2\, eV$$




13.6 – 3.4 = 10.2 so transition is from n = 2 to n = 1

Arrow is between n=2 and n = 1. ①

Photon emitted so electron is returning to lower energy level (state). Arrow points downward ①

**Question 13**

$p = \sqrt[2]{2mE_k} = \sqrt{2 \times 9.11 \times 10^{-31} \times 15000 \times 1.60 \times 10^{-19}}$ ①
$\Rightarrow p = \sqrt{4.368 \times 10^{-45}} = 6.61 \times 10^{-23}$ ①
$\lambda = \frac{h}{p} = \frac{6.63 \times 10^{-34}}{6.61 \times 10^{-23}}$ ①
$\Rightarrow \lambda = 1.003 \times 10^{-11} m$
$\Rightarrow \lambda = 0.01\, nm$ ①

**Question 14**

Emission and absorption spectra show discrete lines which represent the difference in energy levels/states when electrons transition between them (absorption for jumping to higher levels/states and emission for dropping to lower levels/states) ①
Since these transitions are at specific wavelengths then the energy of each level/state must be discrete. E = hc/ $\lambda$ . ①
For the electrons to exist in these excited states they must form standing waves for stability by having an exact number of de Broglie wavelengths fitting into the circumference of their orbit n $\lambda$ = 2$\pi$r. ①
The electrons hence display both wave and particle properties supporting the theory of the dual nature of matter.

**Question 15**

**a)** $\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{1}{\sqrt{1-\frac{(0.80c)^2}{c^2}}} = \frac{1}{\sqrt{1-0.80^2}}$ ①
$\gamma = 1.67$ ① $\approx 1.7$

**b)** $t = \frac{d}{v} = \frac{4.25c}{0.80c} = \frac{4.25}{0.80}$ ①
$t$ = 5.3125 = 5.31 years ①

**c)** $l = \frac{l_0}{\gamma} = \frac{300}{1.7}$ ①
$l = 176.5 = 177 = 1.8 \times 10^2$ m ①

**d)** Spaceship ① Since crew on spaceship will experience length contraction in distance to Proxima Centuri they cannot also experience time dilation.